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Narrow Money Demand in Indonesia and in Other Transitional Economies – Model Selection and Forecasting

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Abstract:

Purpose: *This paper aims to incorporate model uncertainty in variable selection and forecasting in the monetarist money demand model and check whether the emerging economies such as the Czech Republic, Poland, Hungary, Russia, Mexico, Brazil, Turkey, India, Republic of South Africa, and Indonesia follow this model in the long-run. The case of the United Kingdom serves as a benchmark for the study.*
Design/Methodology/Approach: *In dynamic econometric modeling, the number of potential explanatory variables increases rapidly, and model uncertainty grows very fast. Consequently, empirical modeling of money demand needs a comprehensive strategy for model selection and forecasting. We use Bayesian averaging of classical estimates (BACE) as an appropriate model reduction strategy. The monetary model serves as the theoretical basis for empirical equilibrium error-correction models (EqCM) and employing the Bayesian averaging of classical estimates (BACE) approach for variable and model selection and forecasting.*
Findings: *Four theoretical and competitive model specifications are proposed and empirically tested. We found that monetary systems in Indonesia and other analyzed economies are both stable and theory consistent. The forecasts generated for Indonesia are accurate. The robustness of the model selection based on the BACE procedure was strongly confirmed.*
Practical Implications: *The proposed procedure is valid for practical application, particularly in dynamic model selection and forecasting.*
Originality/Value: *The novelty of this research lies in employing the BACE approach to model the demand for money with the equilibrium error correction (EqCM) mechanism.*

JEL Classification: *E41, P24, C52.*

Keywords: *Model uncertainty, BACE, variables selection, forecasting, gretl.*

Paper type: *Research study.*

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1. Introduction

This paper was motivated by whether Milton Friedman and Anna Schwartz's model of the demand for money (Friedman and Schwartz, 1982) is appropriate for contemporary transition economies, which exhibit an immense potential of growth acceleration (Pritchett, 2000). These are the Czech Republic, Poland, Hungary, Russia, Mexico, Brazil, Turkey, India, Republic of South Africa, and Indonesia. Additionally, the case of the United Kingdom has been taken as a benchmark of a developed economy.

This paper aims to consider both economic and econometric issues. The first aspect, closely related to motivation, focuses on whether Indonesia and other emerging economies follow in the long-run money demand model proposed by Friedman and Schwartz (1982). The second aspect, related to an econometric methodology, is to incorporate model uncertainty in variable selection and forecasting. In order to do it, we use Bayesian averaging of classical estimates (BACE), introduced by Sala-i-Martin, Doppelhofer, and Miller (2004), as an automatic model reduction strategy.

The specification of the demand for money model is in error correction form, and it bases on the approach proposed by Hendry and Ericsson (1991b). There is particular interest in the relation's stability taking into account both negative and significant parameters of the error correction terms.

This research's novelty lies in employing the BACE approach to model the demand for money with the equilibrium error correction (EqCM) mechanism. In the autoregressive distributed lags model, which includes many variables, we face high model uncertainty because many variables are potential covariates. It is crucial in the case of modeling money demand, where we consider a large number of potential determinants and many competitive models with almost the same explanatory power. An example of applying this procedure for dynamic modeling can be found in (Błażejowski, Kufel, and Kwiatkowski, 2020).

2. Literature Review

It should be mentioned that econometric modeling of the demand for money is part of a very long tradition because it has a strong economic background in both monetarist and new Keynesian theories (see: Friedman, 1956; Tobin, 1956). This type of modeling was very popular in 1980s and 1990s; seminal papers were written by (Hendry and Ericsson, 1991a; 1991b; Serletis, 1991; Baba, Hendry, and Starr, 1992; Ericsson and Sharma, 1998; Hendry and Mizon, 1998; Mulligan and Sala-i-Martin, 2000). It is worth mentioning that the Empirical Economics journal's special issue was edited in 1998 to emphasize the most important aspects and examples of modeling money demand. The papers by (Hendry and Mizon, 1998) and (Ericsson, 1998) addressed the methodological issues of modeling money demand. In eight other papers, the authors discussed the practical aspects of modeling money demand in several European countries: (Ripatti, 1998) for Finland, (Eitrheim, 1998) for Norway, (Scharnagl, 1998) and (Lütkepohl and Wolters, 1998) for Germany, (Vega, 1998) for Spain, (Ericsson, Hendry, and Prestwich, 1998a) for the UK, (Ericsson and Sharma, 1998) for Greece, (Peytrignet and Stahel, 1998) for Switzerland and (Juselius, 1998; Fagan and Henry, 1998; Fase and Winder, 1998) for the European Union.

An important stream of analysis is applying econometric techniques for modeling money demand in emerging economies, contributing to country-specific explanations of long- and short-run tendencies. In (Bahmani-Oskooee and Rehman, 2005), the demand for money in India, Indonesia, Malaysia, Pakistan, the Philippines, Singapore, and Thailand was estimated. It was shown that while in India, Indonesia, and Singapore, the M1 monetary aggregate is cointegrated with its determinants, in the remaining countries, the M2 aggregate exhibits cointegration. James (2005) used the ARDL approach to investigate the influence of financial liberalization on Indonesia's money demand. He found that including deterministic trend controlling financial liberalization is a crucial strategy for properly modeling the long-run money demand.

We can also find many papers devoted to money demand and monetary policy in Indonesia, especially after the Asian Crisis of 1997-1998. Fane (2000) analyzed the policy of the central bank during that crisis. McLeod (2003) analyzed the relation between inflation and money growth, and he found that deep Rupiah decline during the Asian Crisis was due to the wrong monetary policy adopted by the central bank. Cheong Tang (2007) used annual data for the period 1967-2005 in ARDL modeling for real M2 aggregate. He found that final consumption expenditure, exchange, and inflation rates are not cointegrated in Indonesia's case.

Moreover, he stated that the estimated money demand function was not stable in the short-run. Narayan (2007) used annual data in the years 1970-2005 for estimating money demand using M1 and M2 aggregates in the cash-in-advance form, and he found that real exchange rate has a negative impact on real M1 and real M2. Nevertheless, he stated that the estimated money demand function is not stable, which was in line with previous findings. Hossain (2007) used annual data in the years 1970-2005 for partial adjustments model of narrow money for Indonesia. He found that deposit interest rates do not influence the demand for money in Indonesia.

Achsani (2010) used VECM, and ARDL approaches to investigate Indonesia's M2 money demand in 1990:1-2008:3. He found a cointegrating relationship between real money aggregate, real income, and interest rate in Indonesia. Prawoto (2010) used monthly data in the years 1990-2008 for ECM models specified according to both: Keynesian and Friedman theories, and he found that the Monetarist approach is preferable for Indonesia. He also stated that Indonesia operated as an open economy in the analyzed period. Sasongko and Huruta (2018) used monthly series ranging from 2007.1 to 2017.7 to investigate the causality between CPI and money supply by estimating the EqCM model. They found a one-direction causal relationship that was related to the Inflation Targeting Framework set by the Bank of Indonesia. Finally, (Yien, Abdullah, and Azam, 2019) used the ARDL approach to examine the effectiveness of monetary policy in Indonesia during the years 1970-2015. They justified the long-run equilibrium relationship between monetary policy and economic growth along with the positive influence of money supply on economic growth in the short-run.

Research related to other transition economies can be found in the following papers. Choudhry (1995) looked for a stationary long-run money demand function for M1 and M2 aggregates in Argentina, Israel, and Mexico. Bahmani-Oskooee, Kutan and Xi (2013) considered the experiences of certain emerging countries: Armenia, Bulgaria, the Czech Republic, Hungary, Poland, Russia, Bolivia, South Africa, Colombia, and Malaysia. Saatçioğlu and Korap (2005) estimated a vector error correction (VEC) model. The results indicated that in Turkey, inflation is responsible for the instability of aggregate M2 in the long run.

The remainder of this paper is organized as follows. In Section 2, the model foundations are explained, and the BACE methodology is briefly presented. Section 3 describes the data characteristics and empirical model specifications. In Section 4, the empirical results are shown and discussed. Detailed results of the extended analysis for Indonesia are in Section 5. The robustness check results are presented in Section 6. Finally, Section 7 concludes.

3. Methodological Backgrounds

The tradition of econometric modeling demand for money spans back to the concept introduced by Fisher, who, at the beginning of the 20th century, formulated the foundations of the quantitative theory of money developed by Friedman in the 1950s and 1960s. In its original form, the demand for money was generated by the demand for cash and bank deposits, while Fisher's equation of exchange described money circulation. According to Friedman's theory, wealth is understood as the discounted source of any income, and consumer goods is an essential motive for man's actions.

The factors determining income and leading directly to an increase in wealth are money, bonds, shares, physical goods, and human capital. Because Friedman's monetary theory concerns real terms, nominal changes cannot interact with money demand. This assumption ensures the stability of Friedman's theory.

The contemporary approach used for the econometric modeling of the demand for money assumes that examining the cointegration between the processes has been considered in the analysis, which means that both long-run and short-run paths are considered (Engle and Granger, 1987). Here, cointegration is considered as a measure of the stability of monetary processes in the long run. The results of empirical modeling the demand for money have been published in several papers.

From our perspective, the most interesting papers are those for which the equilibrium error-correction (EqCM) mechanism was used. In the articles of (Hendry and Ericsson, 1991a; Ericsson *et al*., 1998a) and (Ericsson, Hendry and Prestwich, 1998b), the authors analyzed congruent single equation error-correction models using an annual time series, while (Hendry and Mizon, 1998) used a bivariate VAR system. Univariate EqCM models for quarterly time series can be found in (Hendry, 1988; Hendry and Ericsson, 1991b; Ericsson, 1998; and Ericsson and Sharma, 1998), while the use of multivariates can be found in (Kontolemis, 2002).

Assuming that M represents nominal money demand and P stands for its deflator (price level), we follow the general specification so that the following function might explain money demand:

$$M/P = f(Y, IR)\,, \tag{1}$$

where IR is a measure of the opportunity cost of holding money represented by the nominal interest rate (understood as an alternative cost for keeping the money) and Y is real economic activity (for example the GDP or consumer expenditures). Taking variables in logarithms (lower cases hereafter), we assume that function 1 can be written as a basic equation of the demand for money in the following form (Hendry and Ericsson, 1991b):

$$mp = \delta \cdot y + \gamma \cdot IR, \tag{2}$$

where $mp = m - p$. It should be noted that different economic measures can express the mentioned variables. In the present study, the following variables are analyzed: Y is real total final expenditures (TFE), M represents the nominal narrow money supply (M1), P is the consumer price index (CPI), and IR is a combination of short-term and immediate (interbank call money) interest rates. Taking the above into account, relation 2 can be written as an error-correction general unrestricted model (GUM) in the following form:

$$\begin{aligned}\Delta mp_t = \beta_0 + \sum_{s=1}^{4} \beta_{1,s}\, \Delta mp_{t-s} + \sum_{s=0}^{4} \beta_{2,s}\, \Delta y_{t-s} + \sum_{s=0}^{4} \beta_{3,s}\, \Delta p_{t-s} + \beta_4 ECM_{t-1} \\ + \sum_{s=0}^{4} \gamma_s\, IR_{t-s} + \alpha I_t + \varepsilon_t\end{aligned} \tag{3}$$

where ECM_{t-1} represents the error-correction term, I_t is a matrix of country-specific dummy variables, α, β_i and γ_s are slope coefficients, $\varepsilon_t \sim IID$ is an error term and $\Delta x_t = x_t - x_{t-1}$ for any variable x_t. The lag order is the same for all variables (excluding the error-correction term and the deterministic variables). It is set to 4 because we use a quarterly time series. It is in line with the work of (Hendry and Ericsson, 1991b). Moreover, constant term in model 3 is divided into two periods, which represent different monetary regimes, i.e., the domination of Washington Consensus (up to 2008:3) and Quantitative Easing policy (starting from 2008:4). We assume then $\delta = 1$ and $\gamma = 0$ in (2), which corresponds to Friedman's quantity theory (see Friedman, 1956). Taking the above, an error-correction term in model 3 can be defined as:

$$EMC_t = m_t - p_t - y_t \tag{4}$$

One of the fundamental problems in econometric modeling is the identification of the determinants of the dependent variable. Building a model with many explanatory variables can potentially lead to decision-making problems that can significantly complicate this process. It is difficult to determine which model includes the most appropriate number of explanatory variables. Moreover, different types of modeling approaches can lead to different estimates and conflicting conclusions (see: Raftery, Madigan and Hoeting, 1997).

One potential solution to overcome this issue is using the BACE approach, which enables measuring the importance of particular potential determinants. This method was suggested by (Sala-i-Martin *et al*., 2004) and is an approximation of the earlier Bayesian model averaging (BMA) technique presented by (Fernández, Ley and Steel, 2001). In BACE, we use Schwarz approximation to compute the probability of competing models and determinants (see: Lamla, 2009; Simo-Kengne, 2016).

In the BACE approach, we define the prior expected model size E(Ξ), representing our belief concerning model size Ξ. If we set E(Ξ) = *k*/2 (where *k* is the number of variables in a given GUM), we will obtain a uniform prior to the model space. It means that all linear combinations are a priori equally probable. In the BACE case, the posterior odds ratio between the two competitive models M_0 and M_1 is given by:

$$\frac{\Pr(M_0|y)}{\Pr(M_1|y)} \approx \frac{\Pr(M_0)}{\Pr(M_1)} T^{(k_1-k_0)/2} \left(\frac{SSE_0}{SSE_1}\right)^{-T/2}, \tag{5}$$

where $\frac{\Pr(M_0)}{\Pr(M_1)}$ is the prior odds ratio, k_i is the number of parameters, and SSE_i is the sum of the squared errors in model M_i. The general formula of the posterior probability of model M_l is given by:

$$\Pr(M_l|y) \approx \frac{\Pr(M_l) T^{-\frac{k_l}{2}} SSE_l^{-\frac{T}{2}}}{\sum_{r=1}^{2^K} \Pr(M_r) T^{-\frac{k_r}{2}} SSE_r^{-\frac{T}{2}}}, \tag{6}$$

where 2^K denotes the total number of all linear combinations of the explanatory variables and $\sum_{l=1}^{2^K} \Pr(M_{l|y}) = 1$.

In addition to calculating the models' posterior probability, we obtain a few attractive posterior measures that help us understand the estimation results, such as the posterior mean of the model parameters and posterior inclusion probability (PIP) model uncertainty measures. The posterior mean of the model parameters across the model space is a weighted average of the posterior means of the individual models:

$$E(\beta|y) \approx \sum_{r=1}^{2^K} \Pr(M_r|y)\hat{\beta}_r \tag{7}$$

while the posterior variance is given by:

$$Var(\beta|y) \approx \sum_{r=1}^{2^K} \Pr(M_r|y) Var(\beta_r|y, M_r) + \sum_{r=1}^{2^K} \Pr(M_r|y)\big(\beta_r - E(\beta|y)\big)^2 \tag{8}$$

where $\beta_r = E(\beta_r|y, M_r)$ and $Var(\beta_r|y, M_r)$ are the OLS estimates of β_r from model M_r .

The posterior inclusion probability (PIP) i.e. $\Pr(\beta_i \neq 0|y)$ is the probability that, conditional on the data but unconditional with respect to a specific model, x_i, which is associated with β_i, is the relevant explanatory variable used in (see Leamer, 1978; Doppelhofer and Weeks, 2009). The posterior inclusion probability is calculated as the sum of the posterior model probabilities for all the models, including explanatory variable x_i:

$$Pr(\beta_i \neq 0|y) = \sum_{r=1}^{2^K} \Pr(M_r|\beta_i \neq 0, y) \ . \tag{9}$$

3.1 Model Specification and Data Characteristics

Because of the unobservability of the demand for money, it is proxied by the real money supply, assuming that the money market is balanced. Taking the above, money demand is defined here as the demand for narrow money and is measured as aggregate M1. The rationale for selecting this aggregate comes from the fact that it contains the same monetary categories across the entire sample for all economies being investigated. According to (Hendry, 1995), the narrow money category is appropriate when the stability is checked in the long run. In our research, the sample covers the years 1995-2018 and contains 96 quarterly observations.

Using this time frame, we ensure the comparability of both the data and the results. The following macroeconomic time series were collected from the OECD.Stat database via DBnomics proxy[6]:

– GDP_t – nominal gross domestic product, expenditure approach: seasonally adjusted an- nual levels in current prices (national currency).

[6] *DBnomics database is available at https://db.nomics.world.*

- P_t – price deflator of the GDP: a seasonally adjusted index with the reference year 2010 = 100.
- M_t – narrow money aggregate: a seasonally adjusted index with the reference year 2010 = 100.
- IMP_t – imports of goods and services: national currency, current prices, annual levels, seasonally adjusted.
- R_t – three months interest rates expressed in percent per annum taken from Economic Outlook survey[7].
- imR_t – immediate interest rates (< 24 hrs): the interbank call money rate expressed in percent per annum.

Based on the original time series, the following variable was calculated. Real TFE, according to the formula: $Y_t = (GDP_t + IMP_t)/P_t$, which is equivalent to TFE, as defined by Hendry and Ericsson (1991b). The variables M_t, P_t, Y_t are taken in logs and denoted as m_t, p_t, y_t, respectively, and mp_t denotes the real demand for narrow money. In the years 2008-2009, many economies experienced a deep economic recession, so additionally, a dummy variable Cr_Fin08_t for this period was employed and defined as follows:

$$Cr\_Fin08_t = \begin{cases} 1 & \text{for } 2008q3 - 2009q2, \\ 0 & \text{otherwise.} \end{cases} \tag{10}$$

The interest rates in model 3 may be included in different ways. In our research, *IR* is a set of 4 different combinations of interest rate measures. It takes one of the following specification forms:

$$IR_t = \begin{cases} \sum_{s=0}^{4} \gamma_{1,s} R_{t-s} + \sum_{s=0}^{4} \gamma_{2,s} imR_{t-s}, & \text{'a'} \\ \sum_{s=0}^{4} \gamma_{1,s} \Delta R_{t-s} + \sum_{s=0}^{4} \gamma_{2,s} \Delta imR_{t-s}, & \text{'b'} \\ \sum_{s=0}^{4} \gamma_{1,s} dR_{t-s}, & \text{'c'} \\ \sum_{s=0}^{4} \gamma_{1,s} \Delta R_{t-s}, & \text{'d'} \end{cases} \tag{11}$$

In the specification 'a' – two interest rate levels are assumed, while in the specification 'b', their dynamics are taken into account. In specifications 'c', we use interest rate defined as $dR_t = R_t - imR_t$, which is the premium of holding money in three-month deposits. This variable corresponds to Friedman's differential yield on money. In specification 'd', the first differences of this interest rate are considered. These two specifications are in line with those in (Friedman and Schwartz, 1982, pp. 259-280) and (Hendry and Ericsson, 1991b).

Taking 11 into account, we have four possible forms of a general unrestricted model defined in 3 for each analyzed country. Since the number of possible coefficients in

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[7] *In Russia's case, we used the three-month interbank offer rate because of incomplete data in Economic Outlook.*

each GUM is at least 28 and the total number of linear combinations is equal to 268,435,456, we decided to use the BACE model selection approach proposed by (Sala-i-Martin *et al*., 2004) for variable selection. In this case, our analysis was performed for all possible GUMs using the BACE 1.1 package[8]

In this program, we perform a Monte Carlo experiment with 1,000,000 iterations (including 10 percent burn-in draws) and assuming that all possible specifications are equally probable (expected model size is equal to $k/2$, where k denotes the number of variables in a given GUM).

4. The Empirical Results

In this section, the empirical results obtained using the research strategy described in sections 2 and 3 are presented and discussed. As it has been mentioned in section 1 the analysis was performed for Indonesia (IDN) and the others countries such as: Czech Republic (CZE), Poland (POL), Hungary (HUN), Russia (RUS), Mexico (MEX), Brazil (BRA), Turkey (TUR), India (IND), Republic of South Africa (ZAF). Since the UK's monetary system (when narrow money is measured by M1) was stable (see Hendry and Ericsson, 1991b), it was considered a benchmark for our procedure. Before starting the procedure of model selection, the time series were tested for stationarity. The ADF-GLS test (Elliott, Rothenberg, and Stock, 1996) confirmed that the series m_t, p_t, y_t, R_t, and imR_t, are integrated of order 1 ($I(1)$) at the 0.05 significance level, which is presented in Table 1.

In the next step, we assumed a cointegration relation as defined in 4. As it has been already mentioned, it allows checking Friedman's monetary hypothesis. Since we know that the error-correction term (ECM_{t-1}) is included in model 3, we have to define the minimum conditions that must be met by the posterior results for a given specification to be taken into account in further considerations. The following restrictions for ECM_{t-1} variable are imposed: the sign of the mean value of the coefficient estimate must be negative and, at the same time, the minimum value of PIP must exceed 2/3 (0.66). Parameter's negativity comes directly from EqCM model construction, whereas PIP> 0.66 (although arbitrary) is a reasonable starting point for empirical analysis. Table 2 (in the annex) shows the mean values of the coefficient estimates and the PIPs for the ECM_{t-1} variable in all model specifications.

The results in Table 2 indicate that for Indonesia, the Czech Republic, Turkey, and UK the results are stable (means of the coefficient estimates are negative) for all four interest rate specifications. In the cases of Brazil and India, none of the interest rate

[8] *The package is available at http://ricardo.ecn.wfu.edu/gretl/cgi-bin/gretldata.cgi?opt=SHOW_FUNCS. (see Błażejowski and Kwiatkowski, 2018) for the gretl program. Gretl is open-source software that is used for econometric analysis and is available at http://gretl.sf.net (see Cottrell and Lucchetti, 2018).*

specification met the assumptions. For Russia specifications 'b' and 'd' are have too low PIP values, while in the case of Mexico – specification 'c' should be excluded. In the case of ZAF, the first specification ('a') can be disregarded. For specifications 'a' and 'b' in Poland, 'b' in Hungary and 'a' in Mexico we obtained positive signs of ECM_{t-1} parameter's estimates. It is worth mentioning that model for the UK is in line with the results presented in (Hendry and Ericsson, 1991b). Although numerous external and internal shocks in the UK economy have occurred since Hendry's model was developed, our model selection procedure confirms that it is still valid: the most likely specification is Friedman's model incorporating a 'spread or net opportunity cost' of holding money. Taking into account, four interest rate specifications variant 'd' should be considered as highly likely.

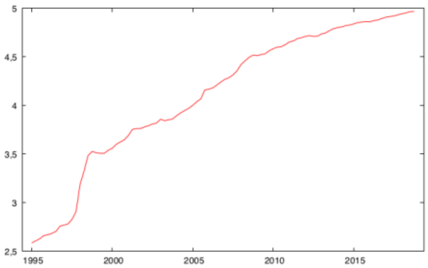
4.1 The Case of Indonesia

The monetary policy of Bank Indonesia was prepared in the working framework known as the Inflation Targeting Framework (ITF). This framework was formally adopted in July 2005, and replaced the previous monetary policy using base money as the monetary policy target. This selection is related to getting creditability of Indonesia's monetary policy, and the public easily understands it. Furthermore, taking inflation targeting does not require an assumption of stability in the relationship between money supply, output, and inflation, as it is assumed by standard monetary economics. The above information is essential as money demand in Indonesia is modeled for two reasons. Firstly, only in 2005, the ITF was introduced, which means that the monetary policy of Bank Indonesia has changed the regime in the considered period. Secondly, as the narrow money is considered, the stability and theory-consistence are more critical than in the case of broad money, where many variables on the economy's condition can be considered. Thus we decided to examine Friedman's approach to modeling demand for narrow money in Indonesia in the following steps:

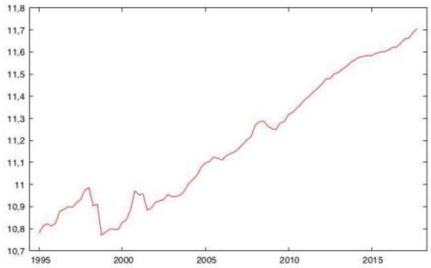
- Checking stationarity and structural breaks of time series in interest.
- Constructing single equation error correction models in four specifications defined by equations 3, 4 and 11.
- Application of BACE to determine most likely set of determinants of demand for narrow money.
- Estimation of median models for each specification (see Barbieri and Berger, 2004).
- Forecasting demand for narrow money and calculating forecasts' errors.

The time series, covered the period 1995-2018 with quarterly observations, are illustrated in Figure 1.

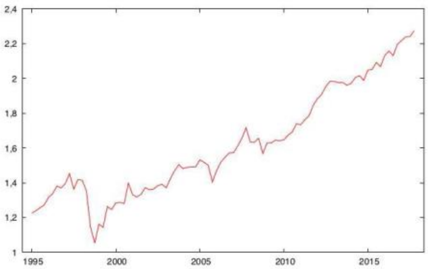
Figure 1. *Times-series p_t, y_t, mp_t and ECM_t used in the money demand model for Indonesia.*



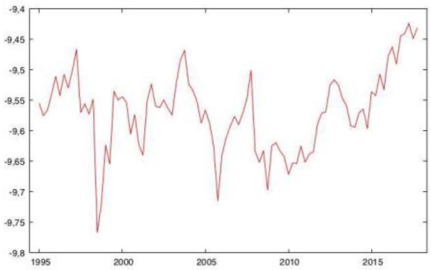
(a) p_t in Indonesia



(b) y_t in Indonesia



(c) mp_t in Indonesia



(d) ECM_t in Indonesia

Source: *Own calculations.*

The time series for Indonesia were integrated of order 1 (see Table 1 in the annex). Real money demand series has been checked for structural breaks taking into account the aforementioned structural change in 2005. The p-values of the test for change of the slope in sequent quarters in 2005 are as follows: 0.057 for change in 2005:1; 0.035 in 2005:2; 0.029 in 2005:3 and 0.038 in 2005:4. These results weakly exhibit structural breaks in the second, third, and fourth quarters in 2005 at a 5% significance level. At 1% significance level, we cannot reject the null of no structural break related to the introduction of inflation targeting policy.

The results of the sequent steps are presented in the following tables presented in the annex. Tables 3, 4, 5, and 6 present posterior inclusion probabilities, mean, and standard deviation obtained from BACE analysis for specifications: 'a', 'b', 'c' and 'd'. Additionally, the variables with different probabilities were indicated, i.e., highly probable ($PIP \geq 2/3$), medium probable ($2/3 < PIP \leq 1/3$), and lowly probable ($PIP < 1/3$).

If the variables with PIP values below 0.5 are discarded, we will get a single equation median model, which is easy to interpret. This kind of model is described in (Barbieri and Berger, 2004) and contains only variables that have a significant impact on the dependent variable, taking into account the whole model space. The detailed results from median models for each specification are presented in Table 7.

The results of both model selection and estimation of a median model for each specification of the interest rate revealed many alternative specifications for the demand for narrow money in Indonesia. Taking into account specification 'a' levels of long and short interest rates: first differences of prices and lagged by one demand for money were included. In the case of specification 'b' first differences of individual interest rates were considered. In this case, only four variables are highly likely. These are ΔR_t, Δmp_{t-1}, Δp_t and ECM_{t-1}. TFE variable denoting economic output (y_t-1) is among medium probable variables, but its PIPs exceed the limit 0.5. Specification 'c' includes a premium for holding money instead of individual interest rates. It is similar to specification 'b' because only dR_{t-1} is highly probable instead of ΔR_t, and the remained variable is the same as in 'b'. The last specification 'd' includes ΔdR_{t-1}, Δp_t, and ECM_{t-1} as highly likely. On the other hand, the median model can be extended by adding lagged differences for Δp_{t-2} and Δp_{t-3}. It is worth noting that structural breaks related to inflation targeting policy introduced in 2005 were fully rejected in all median models.

The signs of parameter estimates related to ECM_{t-1}, Δp_t current, and lagged are negative, which is in line with monetary theory. Δy_{t-4} present in specification 'b' has a positive impact on money demand. Considering individual interest rates in specifications, 'a' and 'b' result in both positive and negative signs of parameter estimates while using a premium for holding money (spec. 'c') and its dynamics (spec. 'd') show positive signs.

Forecasting was the final step of our analysis of the demand for narrow money in Indonesia. The forecasts were calculated across the entire space of possible models within a given specification 'a', 'b', 'c' and 'd' and weighted using a posterior probability for each model according to formula (6). Then the forecast does not rely on a single model, but it is averaged across all possible models. To evaluate forecast errors the sample was shortened till 2017. Forecasts were calculated for four quarters of 2018. Taking into account standard measures of forecasting error such as absolute and percentage ex-post errors, Root Mean Square Error (RMSE), and Mean Absolute Percentage Error (MAPE) it can be stated that the results of forecasting are satisfactory because the MAPE values do not exceed 2%. The detailed results are presented in Table 8.

The lowest levels of individual forecasting errors for each quarter and average are related to the specification 'd'. It shows that Indonesia's monetary policy is, in the short run, more related to the changes of premium for holding money that to its value. The second-best model is related to specification 'b', considering changes in analyzed interest rates. Two remained specifications can be excluded from the analysis. The economic interpretation of specification 'd' is more straightforward than 'b' because, in this case, only price changes (inflation rate) and changes of premium for holding money are significant in the short run. The speed of adjustment to the long-run equilibrium equals -0.0033 is very slow but significant. In specification 'b' in the short run the following variables are significant ΔR_t, Δp_t, Δp_{t-3}, Δy_{t-4}, lagged endogenous variable Δmp_{t-1}, and error correction term (ECM_{t-1}). The variables and parameter estimates are reasonable and can be used to analyze the monetary system in Indonesia.

4.2 Robustness Analysis

To confirm the empirical findings, we performed a robustness check. Since the analysis addresses variable and model selection issues, we decided to apply Occam's razor rule. In our analysis, the prior average model size was set to $E(\Xi) = k/2$ (where k is the number of variables in a given GUM). It means that we do not prefer any specification, so all possible models are equally probable. For the BACE approach, the use of Occam's razor rule is straightforward, and the only change we have to make is to set the prior average model size to a reasonably small value to penalize the large models (in terms of the number of variables). If the resulting average size of the posterior model is similar for both regular and small $E(\Xi)$ values, the empirical results are robust. Table 9 (in the annex) presents the values of the average size of the posterior model for different specifications in the two cases of the prior average model size: regular ($E(\Xi) = k/2$) and small ($E(\Xi) = k/4$).

In all cases, for $E(\Xi) = k/2$ (uniform prior on model space), the values of the average size of the posterior model are smaller than the corresponding values of the average size of the previous model. This result means that the most parsimonious specifications are preferred, and the BACE results are in line with Occam's razor rule. Moreover, the differences between the values of the average size of the posterior model for different $E(\Xi)$ are small. The maximum difference is equal to to 2.42, but the median difference is equal to 0.84. When the values of Pearson's correlation coefficients between the corresponding values of PIP in regular and small values of $E(\Xi)$ are compared, they are very close to 1 in all cases. The same conclusions are valid for the means of the parameters' estimates in the same models. It means that the empirical results are powerfully robust.

5. Conclusions

The research aimed to analyze the demand for narrow money in Indonesia and other selected emerging economies, such as the Czech Republic, Poland, Hungary, Russia, Mexico, Brazil, Turkey, India, and the Republic of South Africa, observed in the years 1995-2018 from the perspective of stability. We followed the Friedman monetary model in the long run and an error correction specification in the short one. We applied a nonstandard methodology based on Bayesian averaging of classical estimates (BACE). It was used to select among many specifications of the model. The BACE method takes into account model uncertainty and generates reasonably accurate predictions.

It has been found that for the Czech Republic, Turkey, Indonesia, and the UK, the results of modeling are stable (negative) for all four specifications concerning different interest rates' forms. In Brazil and India, none specification confirmed stability, which means that their monetary systems are not stable or do not follow Friedman's model. In Hungary and the Republic of South Africa, three specifications proved the stability of the results. For Poland, Russia, and Mexico, two specifications are satisfactory. In four cases (two in Poland, one in Hungary, and one in Mexico), we found a lack of stability due to the positive sign of ECM_{t-1} simultaneously with PIP's high value. Concerning a theory-consistent specifications, a model denoted as' was indicated as the best one because even in India, it gave the satisfactory PIP value of 0.6227.

Having confirmed the stability of the monetary system, we applied the procedure of evaluating money demand models in Indonesia. After checking stationarity and structural breaks, we obtained sets of most likely factors. Then the median models were constructed to enable economic interpretation of the results. Forecasting, based on the entire space of possible models, showed that the selected procedure was proper. The forecast errors lay in the interval from 1.4% to 2% and are highly satisfactory. The best specification for Indonesia is denoted with the letter 'd' outperforms the other in forecasting results. Specification 'b' is the second-best, and it gives theory consistent economic interpretation.

The robustness check has been provided based on Occam's razor. The results lead us to conclude that the BACE approach provides both parsimonious model representations and reasonable parameter estimates with high posterior inclusion probabilities. It also extends inference for the scope of possible empirical models, increasing flexibility of model specification.

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Annex:

***Table 1**. Results of testing for integration using ADF-GLS test*

	IDN	CZE	POL	HUN	RUS	MEX	BRA	TUR	IND	ZAF	UK
m_t	-0.784	-2.363	-1.646	-2.271	-1.842	-1.481	-0.653	-1.936	-2.190	-0.774	-0.980
P_t	-1.309	-1.234	-1.401	-1.530	-1.091	-1.859	-1.628	-2.225	-2.648	-0.616	-2.551
Y_t	-1.697	-1.753	-1.311	-1.157	-0.937	-1.670	-1.842	-1.803	-1.806	-1.282	-1.095
mp_t	-1.332	-2.771	-2.252	-1.945	-1.015	-1.362	-0.774	-1.912	-1.918	-1.192	-0.917
R_t	-2.042	-2.509	-0.819	-1.277	-1.016	-0.365	-1.544	-0.807	-1.758	-2.022	-2.732
imR_t	-2.054	-1.197	-0.899	-1.136	-1.500	-0.629	-2.160	-1.421	-1.366	-1.814	-2.453

Critical value for 0.05 significance level is -3.03. Higher values do not reject the null of I(1). Source: own calculation.

***Source:** Own calculation.*

***Table 2**. Posterior inclusion probabilities (PIP) and means of the coefficient estimates for ECM_{t-1} term*

		IDN	CZE	POL	HUN	RUS	MEX	BRA	TUR	IND	ZAF	UK
a	PIP	**0.719**	**0.747**	0.723	**0.889**	**0.703**	0.888	0.312	**0.924**	0.533	0.5516	**0.706**
a	Mean	**-0.031**	**-0.004**	0.007	**-0.003**	**-0.005**	0.002	-0.007	**-0.016**	-	-	**-0.017**
b	PIP	**0.729**	**0.839**	0.851	0.744	0.574	**0.893**	0.250	**0.731**	0.561	**0.956**	**0.948**
b	Mean	**-0.008**	**-0.001**	0.012	0.0006	-0.002	**-0.005**	-0.001	**-0.015**	-	**-0.096**	**-0.024**
c	PIP	**0.875**	**0.660**	**0.704**	**0.775**	**0.777**	0.580	0.232	**0.964**	0.622	**0.937**	**0.913**
c	Mean	**-0.027**	**-0.000**	**-0.001**	**-0.001**	**-0.004**	-0.003	-0.002	**-0.066**	-	**-0.063**	**-0.020**
d	PIP	**0.889**	**0.788**	**0.764**	**0.790**	0.6423	**0.903**	0.255	**0.792**	0.623	**0.927**	**0.924**
d	Mean	**-0.038**	**-0.002**	**-0.001**	**-0.001**	-0.0135	**-0.014**	-0.001	**-0.016**	-	**-0.080**	**-0.020**

***Source:** Own calculation.*

***Table 3**. BACE estimates for narrow money demand model in Indonesia (specification a: R_t, imR_t)*

		PIP.	Mean	Std. Dev.	
highly probable	R_{t-1}	**0.924**	1.2200	0.7335	median model
	Δp_t	**0.829**	-0.3627	0.2342	
	Δmp_{t-1}	**0.780**	-0.2466	0.1696	

	R_t	**0.770**	-0.7696	0.5954
	ECM_{t-1}	**0.719**	-0.0308	0.0668
	imR_{t-1}	**0.663**	-0.2826	0.2504
medium probable	imR_{t-3}	**0.557**	-0.2075	0.2396
	Δy_t	0.405	0.1620	0.2454
	Reg_WashConsens	0.387	-0.2693	0.6349
	Reg_QuantEasing	0.383	-0.2751	0.6382
	imR_{t-2}	0.360	-0.1152	0.2285
	Δp_{t-1}	0.351	0.1369	0.2474
lowly probable	Δy_{t-4}	0.328	0.1075	0.1945
	R_{t-2}	0.238	0.1238	0.3822
	imR_t	0.200	-0.0285	0.1010
	Δp_{t-2}	0.190	-0.0409	0.1317
	Cr_Fin08	0.171	-0.0033	0.0111
	Δp_{t-3}	0.161	-0.0360	0.1315
	Δy_{t-1}	0.159	0.0256	0.1062
	Δmp_{t-2}	0.150	-0.0129	0.0598
	imR_{t-4}	0.145	-0.0050	0.0652
	R_{t-3}	0.133	-0.0061	0.1011
	Δmp_{t-4}	0.132	0.0070	0.0426
	Δy_{t-2}	0.132	0.0125	0.0879
	Δy_{t-3}	0.125	-0.0120	0.0820
	Δp_{t-4}	0.115	0.0027	0.0856
	R_{t-4}	0.115	0.0005	0.0418
	Δmp_{t-3}	0.113	0.0005	0.0383

Source: *Own calculation.*

Table 4*. BACE estimates for narrow money demand model in Indonesia (specification b: ΔR_t, ΔimR_t)*

		PIP.	Mean	Std. Dev.	
highly probable	ΔR_t	**0.915**	-0.8771	0.3663	median model
	Δmp_{t-1}	**0.834**	-0.2453	0.1484	
	ECM_{t-1}	**0.729**	-0.0077	0.0308	
	Δp_t	**0.677**	-0.231	0.2080	
medium probable	Δy_{t-1}	**0.581**	0.2468	0.2569	
	Δp_{t-2}	**0.523**	-0.1788	0.2115	
	Δy_t	0.475	0.2007	0.2617	
	Δp_{t-3}	0.420	-0.1352	0.1988	
lowly probable	ΔR_{t-4}	0.313	-0.0961	0.1882	
	Δp_{t-1}	0.246	0.0679	0.1884	
	ΔR_{t-2}	0.243	0.1366	0.3644	
	ΔimR_{t-3}	0.240	-0.0699	0.1861	
	ΔimR_t	0.230	0.0303	0.1051	
	Reg_QuantEasing	0.223	-0.0551	0.2933	
	ΔimR_{t-4}	0.218	-0.0415	0.1274	
	ΔimR_{t-1}	0.206	-0.0406	0.1458	
	Reg_WashConsens	0.204	-0.0545	0.2923	
	Δy_{t-1}	0.195	0.0408	0.1292	
	ΔR_{t-3}	0.195	0.0692	0.2750	
	Δmp_{t-2}	0.176	-0.0169	0.0682	
	ΔR_{t-1}	0.157	0.0178	0.1424	
	Δy_{t-2}	0.149	0.0194	0.0965	

	ΔimR_{t-2}	0.147	0.0056	0.0641
	Δp_{t-4}	0.129	-0.0108	0.0878
	Δmp_{t-3}	0.127	0.0023	0.0463
	Δmp_{t-4}	0.117	0.0045	0.0392
	Cr_Fin08	0.110	-0.0009	0.0069
	Δy_{t-3}	0.110	-0.0052	0.0704

Source: *Own calculation.*

Table 5. *BACE estimates for narrow money demand model in Indonesia (specification c: $dR_t = R_t - imR_t$)*

		PIP.	Mean	Std. Dev.	
highly probable	dR_t	**0.999**	0.6153	0.1133	median model
	Δp_t	**0.967**	-0.3828	0.1323	
	Δmp_{t-1}	**0.947**	-0.3014	0.1191	
	ECM_{t-1}	**0.875**	-0.0268	0.0628	
medium probable	Δy_t	0.378	0.1156	0.1830	
	Reg_WashConsens	0.335	-0.2346	0.5996	
lowly probable	*Reg_QuantEasing*	0.327	-0.2370	0.6007	
	Cr_Fin08	0.203	-0.0047	0.0125	
	dR_{t-1}	0.192	0.0240	0.0685	
	Δy_{t-4}	0.170	0.0298	0.0933	
	Δp_{t-3}	0.161	-0.0213	0.0853	
	Δy_{t-1}	0.154	0.0258	0.0920	
	R_{t-1}	0.153	0.0173	0.0669	
	Δp_{t-1}	0.134	-0.0043	0.0888	
	Δy_{t-3}	0.132	-0.0162	0.0756	
	Δp_{t-2}	0.127	-0.0115	0.0700	
	dR_{t-1}	0.126	-0.0088	0.0426	
	Δy_{t-1}	0.122	-0.0069	0.0423	
	Δmp_{t-2}	0.121	0.0056	0.0361	
	Δmp_{t-3}	0.119	-0.0006	0.0601	
	Δp_{t-4}	0.112	-0.0046	0.0432	
	Δy_{t-2}	0.111	0.0065	0.0625	
	dR_{t-1}	0.099	-0.0010	0.0283	
	Δy_{t-2}	0.999	0.6153	0.1133	
	Δmp_{t-4}	0.967	-0.3828	0.1323	

Source: *Own calculation.*

Table 6. *BACE estimates for narrow money demand model in Indonesia (specification d: ΔdR_t)*

		PIP.	Mean	Std. Dev.	
highly probable	Δp_t	**0.950**	-0.3916	0.1565	median model
	ΔdR_{t-1}	**0.946**	0.3496	0.1392	
	ECM_{t-1}	**0.890**	-0.0383	0.0736	
medium	Δp_{t-2}	**0.539**	-0.1927	0.2238	

probable	Δp_{t-3}	**0.526**	-0.1888	0.2229
	Δy_t	0.475	0.1878	0.2431
	Δmp_{t-1}	0.451	-0.1019	0.1416
	ΔdR_{t-3}	0.451	0.0837	0.1142
	Reg_WashConsens	0.413	-0.3349	0.7007
	Reg_QuantEasing	0.413	-0.3398	0.7031
lowly probable	ΔdR_{t-2}	0.217	0.0296	0.0869
	ΔdR_t	0.189	-0.0177	0.0787
	Δy_{t-3}	0.184	-0.0384	0.1200
	Δmp_{t-2}	0.178	-0.0221	0.0886
	ΔdR_{t-4}	0.163	-0.0122	0.0498
	Δp_{t-4}	0.158	0.0156	0.1083
	Δp_{t-1}	0.154	0.0145	0.1125
	Δy_{t-1}	0.154	0.0232	0.1091
	Δmp_{t-3}	0.143	-0.0063	0.0550
	Cr_Fin08	0.134	-0.002	0.0089
	Δy_{t-2}	0.128	-0.0053	0.0867
	Δmp_{t-4}	0.118	-0.0013	0.0391
	Δy_{t-4}	0.111	0.00870	0.0676

Source: *Own calculation.*

Table 7. *Median models for Indonesia for different interest rate specifications*

	spec. 'a'		spec. 'b'		spec. 'c'		spec. 'd'	
	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.
ECM_{t-1}	-0.0032	0.0007	-0.0026	0.0006	-0.0022	0.0005	-0.0033	0.0005
Δmp_{t-1}	-0.3682	0.0873	-0.2648	0.0870	-0.3117	0.0833		
Δp_t	-0.2450	0.1150	-0.2728	0.1053	-0.3923	0.0985	-0.3875	0.1150
Δp_{t-2}							-0.1987	0.1352
Δp_{t-3}			-0.3779	0.1024			-0.2105	0.1258
Δy_{t-4}			0.3746	0.1576				
R_t	-0.4715	0.2113						
R_{t-1}	0.8331	0.1366						
ΔR_t			-0.9498	0.1486				
imR_{t-1}	-0.4616	0.1282						
dR_{t-1}					0.6540	0.0936		
ΔdR_{t-1}							0.3741	0.0782

Source: *Own calculation.*

Table 8. *Actual and forecasts values of narrow money demand (in logs) for Indonesia with forecast errors*

Date	actual	spec. 'a'	spec. 'b'	spec. 'c'	spec. 'd'
2018:1	2.2923	2.2992	2.2934	2.2953	2.2924
2018:2	2.2784	2.3229	2.3128	2.3169	2.3098
2018:3	2.2819	2.3411	2.3297	2.3324	2.3245

2018:4	2.2873	2.3594	2.3466	2.3507	2.3448
RMSE		0.0518	0.0418	0.0449	0.0391
MAPE		2.00%	1.56%	1.70%	1.44%

Source: *Own calculation.*

Table 9. *Values for the prior and posterior average model size for selected specifications*

E(Ξ)			IND	CZE	POL	HUN	RUS	MEX	BRA	TUR	IND	ZAF	UK
‘a’	k/2	*prior*	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
		posterior	9.74	9.79	10.70	9.31	10.22	8.74	7.93	9.79	6.23	8.77	7.47
	k/4	*prior*	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
		posterior	8.21	8.95	9.07	8.29	8.84	7.47	5.50	8.96	4.88	7.04	5.64
‘b’	k/2	*prior*	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
		posterior	8.89	9.42	9.35	9.40	10.46	9.47	8.16	9.59	6.05	9.77	7.40
	k/4	*prior*	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
		posterior	7.35	8.40	7.88	7.90	9.12	8.10	6.46	7.89	4.89	8.87	5.97
‘c’	k/2	*prior*	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
		posterior	7.07	9.11	8.11	7.13	8.52	7.94	6.45	9.59	5.36	8.35	5.91
	k/4	*prior*	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75
		posterior	6.58	8.60	7.50	6.60	7.85	7.44	5.63	9.36	4.75	7.79	5.25
‘d’	k/2	*prior*	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
		posterior	8.08	8.58	7.73	7.40	8.54	8.52	6.87	8.52	5.27	8.65	5.84
	k/4	*prior*	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75
		posterior	7.34	8.17	7.09	6.79	7.97	8.12	6.03	7.82	4.69	8.27	5.19

Source: *Own calculations.*