sciendo

UDK: 338.23:336.74]:339.74
DOI: 10.2478/jcbtp-2022-0014

Journal of Central Banking Theory and Practice, 2022, 2, pp. 77-96
Received: 24 March 2021; accepted: 02 August 2021

Nikola Fabris [*]**, *Milena Lazić*** [**]

[*] *Faculty of Economics, University of Belgrade, Belgrade, Serbia and Central Bank of Montenegro, Podgorica, Montenegro*

E-mail: nikola.fabris@cbcg.me

[**] *Institute of Economic Sciences, Belgrade, Serbia*

E-mail: milena.lazic@ien.bg.ac.rs

Evaluating the Role of the Exchange Rate in Monetary Policy Reaction Function of Advanced and Emerging Market Economies

Abstract: The subject of this paper is the evaluation of monetary policy reaction function on panel data of 37 world economies, both advanced and emerging markets, during the period of 1995Q1 – 2018Q3. The paper aims to evaluate the role and importance of the exchange rate in monetary policy reaction function depending on the level of economic development. For this purpose, a relevant set of unbalanced panel data was formed with a balanced relationship between developed and emerging market economies. The methodology of empirical research is based on the econometric assessment of monetary policy reaction function within which the central bank adjusts its key policy rate to the dynamics of inflation, output gap and fluctuations of the real effective exchange rate. The research results confirm the hypothesis that the exchange rate represents a statistically significant variable only in the monetary policy reaction function of emerging market economies. In contrast, adequate specification of developed economies' monetary policy rule includes only standard macroeconomic fundamentals – inflation and output gap.

Keywords: monetary policy reaction function, Taylor rule, panel data analysis, exchange rate, developed countries, emerging market economies.

JEL Classification: C820, E430, E520.

Acknowledgement: This paper is financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

Introduction

The analysis of monetary policy rules has been in the focus of the research interest of a large number of influential domestic and foreign authors for decades now. In general, the monetary policy rule represents a function between the target variable (interest rate or monetary aggregate) and a set of information on selected macroeconomic indicators (determinants of the monetary policy reaction function) that policymakers have at their disposal when making decisions (Svensson, 2003). Hence, policy decisions can be predicted in a more systematic way. Moreover, the literature suggests that a central bank can gain credibility by adhering to a policy rule while at the same time eliminating the time-inconsistency problem (Guller, 2021). On the contrary, discretionary monetary policy decisions aimed at fine-tuning the economy in the short run are more ad hoc and, consequently, less predictable (Taylor, 2012).

The literature on monetary policy rules is enormous. Many research papers have tried to describe the central banks' monetary policy conduct, but Taylor's research (1993) was the most influential. In that regard, the Taylor-type monetary policy rules represent the most prominent group of monetary rules in which the key policy rate (alternatively, the money market interest rate) appears as a dependent variable. Considering that it describes the central bank's response to changes in the value of key macroeconomic fundamentals, the Taylor-type monetary policy rule is in relevant literature commonly identified with the monetary policy reaction function of contemporary central banks (Svitak, 2013). It is believed that the simple Taylor rule significantly alleviates the uncertainty of monetary policies' future course and prevent macroeconomic instability (Gerlach & Schnabel, 2000). Furthermore, the analysis of the monetary policy reaction function can provide valuable insights into the factors influencing monetary policy, i.e. whether inflation targets dominate or there is room for other factors such as output and asset price stabilization to influence central banks' interest rate setting behaviour (OECD, 2010).

The basic specification of the Taylor-type monetary policy rule implies that changes in the key policy rate are determined by the deviation of the inflation rate from its target level (inflation gap) and deviation of the GDP growth rate from its potential level (output gap). Modification of the basic Taylor rule involves the inclusion of additional explanatory variables in the model, i.e. the first lag of dependent variable (Clarida, Gali & Gertler 1999, 2000;), the exchange rate (Ball, 2000; Svensson, 2000; Taylor, 2001; Calvo & Reinhart, 2002; Mohanty & Klau, 2004; Moura & Carvalho, 2010; Petrović & Nojković, 2015; Caporale, Helmi, Catik, Ali & Akdeniz, 2018, etc.), indicators of financial stability, such as other assets prices (Baxa, Horvath & Vasiček, 2013; Lee & Son, 2013), different types of spreads (Martin & Milas, 2013), etc.

There is a growing consensus that the Taylor rule in its basic or augmented (modified) form adequately describes contemporary central banks' interest rate setting behaviour, regardless of the country's economic development level. However, in recent years, it has been of particular interest to investigate the role of the exchange rate in contemporary central banks' monetary policy reaction function. Accordingly, the findings of the extensive empirical literature suggest that the Taylor-type regression in its basic form (including the first lag of dependent variable) represents an adequate specification of the monetary policy reaction function of developed countries with a large internal market (Taylor, 2000; Mishkin, 2002; Vasiček, 2007).

In contrast, due to the specific characteristics of emerging market economies, certain modifications of the basic specification of the Taylor-type monetary policy rule are necessary and justified. Findings of a large number of empirical studies (Ball, 2000; Obstfeld & Rogoff, 2000; Corbo, 2000; Taylor, 2001; Filosa, 2001; Svensson 2003; Ostry, Ghosh & Chamon, 2012; Ghosh, Ostry & Chamon, 2016; Caporale et. al, 2018) suggest that the exchange rate plays a significant role in the monetary policy reaction function of emerging market economies. The interest rate responds strongly to the exchange rate in the part of emerging market economies characterized by a high level of the exchange rate pass-through (Goldberg & Campa, 2010). The statistical significance of this determinant of the monetary policy reaction function is even higher in the case of dollarized economies which, due to their specifics, are more exposed to the exchange rate risk.

Considering the importance and topicality of the topic, the subject of this paper is the analysis and estimation of the monetary policy reaction function on panel data of 37 world economies (developed and emerging market economies) in the period 1995Q1 - 2018Q3. The paper aims to evaluate the role and importance of the exchange rate in the monetary policy reaction function depending on the country's economic development level.

Following the review of the relevant theoretical and empirical literature, empirical analysis in this paper is organized around testing the following research hypothesis:

H0: Compared to developed countries, emerging market economies attach relatively greater importance (weight) to the exchange rate in the monetary policy reaction function.

The remainder of the paper is organized as follows. After the introductory remarks, comprehensive review of relevant theoretical and empirical literature has been presented in Section 2. Section 3 describes the methodological framework. In Section 4, formal statistical tests are performed and main research results presented. Section 5 concludes the paper.

Literature Review

Even though the importance of rules in evaluating the central banks' interest rate setting behaviour is indisputable, the vast majority of empirical studies is still mainly focused on estimating the monetary policy reaction function of the advanced economies (Mohanty & Klau, 2004). In that regard, Clarida, Gali and Gertler (1998) examined the monetary policy reaction functions of the United States (USA), Germany, Japan, the United Kingdom (UK), Italy, and France. The research results indicated that central banks of the USA, Germany and Japan could be identified as inflation targeters with the key policy rate moving in accordance with the Taylor principle. On the other hand, the authors identified the monetary policy`s stronger reaction to the foreign (German) interest rate than domestic inflation developments in the case of the UK, Italy, and France. Moreover, in his paper, Edwards (2000) implied that if the nature of external shocks appears to be connected to the exchange rate regime, countries with more credible FX regimes face milder shocks.

The long tradition of conducting a credible monetary policy in the advanced economies implies a higher quality of available data, more extended time series and, on that basis, the possibility of applying more sophisticated statistical methods and techniques. In contrast, considering the scarcity and frequent revisions of data, as well as significant changes in the methodology of data collection, the evaluation of the monetary policy reaction function in less developed countries represents a far greater challenge. Furthermore, for developing and emerging market economies that (explicitly or implicitly) operate in the inflation targeting regime, determining the adequate role of the exchange rate represents a sensitive and challenging issue. It is especially the case on the part of developing countries that operated under the exchange rate targeting regime immediately before the adoption of the inflation targeting. Due to the lack of developed foreign exchange markets, less developed countries are frequently exposed to the phenomenon addressed as "fear of floating" (Krušković, 2022). Moreover, a series of different factors could create and lead to a currency crisis and several years period is needed to eliminate these factors (Yazdani and Nikzad, 2021).

Over time, two approaches to analysing the exchange rate regime within the inflation targeting framework have been differentiated (Rajković & Urošević, 2016). Proponents of the first, conventional approach believe that complete exchange rate flexibility represents an integral part of the inflation targeting regime, while the primary role of the exchange rate is to serve as an absorber to adverse external shocks. The extent to which monetary authorities are willing to allow free exchange rate fluctuations is an indicator of the level of credibility that central banks operating under the inflation-targeting regime enjoy (Masson, Savastano & Sharma, 1997). Consequently, according to the supporters of the conventional approach, frequent central bank interventions in the FX market signal insufficient commitment of policymakers to establishing and maintaining price stability. The authors Mishkin and Savastano (2001) went a step further by stating that the central bank should not systematically intervene in the FX market even if the country's monetary system is characterized by markedly high levels of the exchange rate pass-through.

However, episodes of crisis combined with the rising popularity of inflation targeting adoption by the less developed countries questioned the basic postulates of the conventional approach (Ghosh, Ostry & Chamon, 2016). Considering that developing and emerging market countries are usually characterized by the high levels of the exchange rate pass-through, the fluctuations of this significant macroeconomic indicator must not be left to the free market (Svensson 2000; Goldberg & Campa, 2010). Furthermore, excessive exchange rate fluctuations may trigger inflation targeters of emerging market economies to conduct tighter monetary policy and, consequently, induce domestic currency appreciation which could potentially harm national competitiveness at the global market (Bailliu & Fujii, 2004; Gagnon & Ihrig, 2004; Ghosh, Ostry & Chamon, 2016).

Accordingly, pursuing an adequate exchange rate policy to amortize external shocks that threaten to jeopardize the achievement of price stability is becoming increasingly important. Moreover, the belief that the inflation targeting regime is immanent exclusively free-floating exchange rate is gradually becoming obsolete. In that regard, a recent and growing body of literature argued that policymakers cannot achieve multiple goals simultaneously using one instrument (in this case, the key policy rate). Instead, the central banks of emerging market economies make decisions within two goals - low and predictable inflation and stable exchange rate; and two instruments - key policy rate and FX interventions (Benes, Berg, Portillo & Vavra, 2015; Ghosh, Ostry & Chamon, 2016).

Along with the positive trend of inflation targeting adoption and based on the experience gained after the episodes of turbulent economic and financial turmoil in the 1990s, policymakers in emerging market economies have focused on creating a more transparent macroeconomic environment and strengthening the credibility of monetary and fiscal policy institutions. Accordingly, the findings of some recent empirical studies support the hypothesis that deviations of fundamental macroeconomic indicators from their target values represent a standard component of the monetary policy reaction function of central banks in emerging market economies (Bernanke & Miskin, 1997; Taylor, 2000; Amato & Gerlach, 2002; Calvo & Mishkin, 2003). Nevertheless, considering the specifics of emerging market economies, the question arises whether the interest rate setting behaviour of central banks in this group of countries differs significantly from its setting by the central banks in advanced market economies? More precisely, does the usage of the Taylor-type monetary policy rule in its basic form make sense in the case of emerging market economies?

In that regard, Taylor (2000) believes that applying monetary policy rules brings the same benefits to the central banks of emerging market economies as it is empirically shown to bring to the advanced ones. In addition, according to Taylor, a flexible exchange rate combined with a monetary policy rule and inflation targeting framework (the so-called "Holy Trinity") is the only reasonable solution for developing and emerging market countries. Nevertheless, the author agrees that certain modifications of the basic specification of the Taylor-type monetary policy rule are justified due to the specific characteristics of less developed countries.

Taylor's theoretical views are supported by the findings of some empirical studies (Svensson 2000; Svensson 2003), which indicated that the usage of the Taylor-type monetary policy rule in its basic form is not an adequate solution for small open economies exposed to frequent external shocks. In that case, the inclusion of the exchange rate in the monetary policy reaction function is necessary and justified (Ball, 2000; Svensson 2000; Svensson 2003; Ostry, Ghosh & Chamon, 2012; Ghosh, Ostry & Chamon, 2016; Caporale, Helmi, Catik, Ali & Akdeniz, 2018).

From a methodological aspect, the inclusion of the exchange rate in the Taylor-type regression contributes to lowering the volatility of the inflation rate (Ball, 1999) and the inflation rate and the GDP growth rate (Debelle, 1999). From a practical point of view, the findings of several empirical studies (Mohanty & Klau, 2004; Aizenman, Hutchison & Noy, 2011) confirmed that the exchange rate represents a significant determinant of the monetary policy reaction function of central banks in emerging market countries operating (explicitly or implicitly) under the inflation-targeting framework.

In contrast, the research results of several studies (Fabris, 2006; de la Torre, Levy Yeyati & Pienknagura, 2013; Mohanty, 2013) suggested that to reduce excessive fluctuations of the exchange rate, inflation targeters in emerging market economies simultaneously apply some implicit (or even explicit) form of the exchange rate targeting. Moreover, Calvo and Reinhart (2002), Galimberti and Moura (2013), and Catalan-Herrera (2016) share the opinion that the implementation of inflation targeting and the central bank's commitment to the reference rate as a key policy instrument does not diminish the importance of FX interventions as another critical monetary policy instrument. The opinion was also confirmed by Daude, Levy Yeyati and Nagengast (2016) and Ghosh, Ostry and Chamon (2016) who showed that central banks in less developed countries operating within the framework of some flexible form of exchange rate arrangement are prone to frequent FX interventions.

Research Methodology

A relevant set of unbalanced panel data based on a representative sample of 37 world's economies with a balanced relationship between the advanced and emerging market countries was formed to empirically test the previously defined research hypothesis. For classifying panel units into the category of "Developed" or "Emerging" the World Bank country classification by income level (World Bank, 2018) was used so that high-income countries were classified as "Developed", and upper- and lower-middle income countries were classified in the group of "Emerging" economies.

Following the World Bank classification standards, the sample includes 22 developed and 15 emerging market economies, i.e. Argentina, Australia, Brazil, Canada, Chile, Colombia, Croatia, Czech Republic, Denmark, Eurozone, Hong Kong, Hungary, Iceland, India, Indonesia, Israel, Japan, South Korea, Macedonia, Malaysia, Mexico, New Zealand, Norway, Peru, Philippines, Poland, Romania, Russia, Saudi Arabia, Serbia, South Africa, Sweden, Switzerland, Thailand, Turkey, UK, USA.

Quarterly data on relevant macroeconomic variables (the key policy rate, inflation rate and real effective exchange rate) were dominantly collected from the unique databases of credible international organizations and institutions, i.e. OECD, IMF, ECB, and BIS, while statistics from relevant national institutions were used as additional data sources. In contrast, the values of the output gap were derived from seasonally adjusted data on real GDP. In situations where there were no existing data on seasonally adjusted values of real GDP, the real values of this indicator were seasonally adjusted based on trend correction by the average value of seasonal deviation for the observed quarter. Potential GDP was estimated using the Kalman filter, and in case of unsatisfactory results, the HP filter was used as an alternative estimation method.

Following the theoretical specification of the initial research hypothesis, the central part of the empirical research is based on the econometric evaluation of the panel regression model of the monetary policy reaction function within a previously defined sample. As a starting point for econometric modelling of the central bank's monetary policy reaction function, the model proposed by the authors Mohanty and Klau (2004) was used. The basic idea of this model is an empirical assessment of the monetary policy reaction function in which the central bank adjusts its policy rate to the dynamics of inflation, the output gap, and fluctuations of the exchange rate.

The model used by the authors Mohanty and Klau (2004) is econometrically specified as follows:

$$i_{i,t} = \alpha + \beta_1 \pi_{i,t} + \beta_2 og_{i,t} + \beta_3 \Delta fx_{i,t} + \gamma_1 i_{i,t-1} + \gamma_2 \Delta fx_{i,t-1} + \varepsilon_{i,t},$$

with the following legend:

$i_{i,t}$ – nominal key policy rate of the country *i* in quarter *t*;
$\pi_{i,t}$ – inflation rate of the country *i* in quarter *t*;
$og_{i,t}$ – output gap of the country *i* in the quarter *t*, expressed as a percentage of the absolute value of the output gap (differences of seasonally adjusted values of current and potential values of GDP) in relation to potential GDP;
$\Delta fx_{i,t}$ – the first difference of the real effective exchange rate of the country *i* in the quarter *t*;
$\varepsilon_{i,t}$ – random error of the model.

In addition, the model takes into account the first lag of the key policy rate and the first difference of the exchange rate as explanatory variables. The estimated regression coefficients with the inflation rate, output gap, and the first difference of the real effective exchange rate quantitatively measure the intensity, direction, and statistical significance of these macroeconomic indicators within the monetary policy reaction function.

The presented empirical specification of the monetary policy reaction function enables the qualitatively defined research hypothesis to be statistically operationalized. Accordingly, two models were evaluated within the observed period – one for a subsample of developed countries (D in a superscript) and the other for emerging market economies (E in a superscript). After evaluating these two models, the initial research hypothesis can be operationally tested as follows:

$|\beta_3^D| < |\beta_3^E|$ – The exchange rate plays a more significant role in the monetary policy reaction function of emerging market economies than developed countries.

The model was estimated for the entire sample using a seemingly unrelated regression (SUR) model. The SUR model can be represented as follows:

$$\begin{bmatrix} y_1 \\ \dots \\ y_N \end{bmatrix}_{NTx1} = \begin{bmatrix} X_1 & \dots & 0 \\ \dots & \ddots & \dots \\ 0 & \dots & X_M \end{bmatrix}_{NTxM} \begin{bmatrix} \beta_1 \\ \dots \\ \beta_M \end{bmatrix}_{Mx1} + \begin{bmatrix} u_1 \\ \dots \\ u_N \end{bmatrix}_{NTx1},$$

where M represents the number of respective subsamples in the estimation.

The hypothesis testing procedure consists of the following three steps:

1. **Segmentation of the sample into subsamples according to the country's economic development level.** Consequently, the observations are classified into a subsample of developed countries (D) and a subsample of emerging market economies (E):

   observations of a subsample D: $[Y^D \; X^D]_{N^DTx(K+1)}$, where N^DT represents the total number of observations within the subsample D;

   observations of a subsample E: $[Y^E, X^E]_{N^ETx(K+1)}$, where N^ET represents the total number of observations within the subsample E, and $N^DT + N^ET = NT$.

2. **Evaluation of the relevant SUR model**. The following relation represents the suitable SUR model:

   $$\begin{bmatrix} Y^D \\ Y^E \end{bmatrix}_{NTx1} = \begin{bmatrix} X^D & \mathbf{0} \\ \mathbf{0} & X^E \end{bmatrix}_{NTx2K} \begin{bmatrix} \beta^D \\ \beta^E \end{bmatrix}_{2Kx1} + \begin{bmatrix} u^D \\ u^E \end{bmatrix}_{NTx1},$$

   where 0 is a vector whose elements are all zero. Estimating such a specified model is equivalent to estimating a system of the following regression equations:

   $$Y^D = X^D\beta^D + u^D$$

   $$Y^E = X^E\beta^E + u^E$$

   with a difference that instead of two separate covariance matrices, SUR estimation assumes a unique covariance matrix of random errors, $\Omega_{uu} = E[uu^{'}], u = [u^D \; u^E]^{'}$.

3. **Hypothesis condition testing**. As the conditions of the hypotheses are given in the form of inequalities, due to which testing cannot be carried out by a simple asymmetric t or z test, the decision-making is based on a combination of the following two criteria:
   - Is the condition met in a mathematical sense?
   - Is there a statistically significant difference between the left and right sides of the inequality?

Considering that empirical evaluation of the second criterion requires formal statistical tests, the standard Wald F test for FE OLS estimation and the Wald Hi-square test for PCSE OLS and GLS estimation were used for this purpose. Both tests assume that testing the hypothesis of the existence of a limit on the value of the coefficient can be formulated in a matrix form, where R denotes the linear restriction operator, and r the vector of the limit on the value of the coefficient, mathematically represented as:

$$H_0: R\beta = r.$$

If, for example, a restriction is introduced into an OLS estimation, an OLS estimator with a restriction $\hat{\beta}_{OLS,R}$ can be represented as a function of an OLS estimator without the constraint $\hat{\beta}_{OLS,}$:

$$\hat{\beta}_{OLS,R} = \hat{\beta}_{OLS,} + (X'X)^{-1}R'[R(X'X)^{-1}R']^{-1}(r - R\hat{\beta}_{OLS,}).$$

The Wald F statistic that tests the existence of a statistically significant difference in the explanatory power of the model with and without restrictions can be formulated as:

$$F = \frac{1}{p}(R\hat{\beta}_{OLS,} - r)'\left(R\hat{V}ar(\hat{\beta}_{OLS})R'\right)^{-1}(R\hat{\beta}_{OLS,} - r),$$

where p is the number of linear restrictions, i.e. the dimensions of the vector r. Under the assumption of the valid null hypothesis, the Wald F statistic has an F distribution. The asymptotic generalization of F statistics represents Wald Chi-square statistics, which is given by the expression:

$$\mathrm{W} = (R\hat{\beta}_{OLS,} - \mathrm{r})'\left(\mathrm{R}A\hat{V}ar(\hat{\beta}_{OLS})\mathrm{R}'\right)^{-1}(R\hat{\beta}_{OLS,} - \mathrm{r}),$$

In the case of the null hypothesis, the Wald Chi-square statistic has an asymptotic $\mathcal{X}^2$ distribution.

Results and Discussion

The basic descriptive statistics for developed and emerging market economies are presented in Table 1 and Table 2, respectively. The results of the standard pre-estimation tests are shown in the Appendix.

Table 1: Descriptive statistics for the key macroeconomic variables in the subsample of developed countries, %

Statistics/Variable	Key policy rate	Inflation	Output gap	Exchange rate
Average	4.56	2.99	-0.37	-0.07
Median	3.25	2.12	-0.06	0.18
Maximum	200.03	40.31	14.02	28.18
Minimum	-0.75	-5.89	-14.39	-98.91
Standard deviation	7.02	4.24	3.03	4.31
Skewness	12.66	3.95	-0.37	-8.88
Kurtosis	315.37	24.87	5.41	187.23
Number of observations	1,964	2,090	1,910	2,068

Source: Authors' calculations

Table 2: Descriptive statistics for the key macroeconomic variables in the subsample of emerging market economies, %

Statistics/Variable	Key policy rate	Inflation	Output gap	Exchange rate
Average	10.38	11.01	1.73	0.04
Median	7.25	5.31	0.97	0.27
Maximum	200.00	1,033.64	19.37	22.60
Minimum	1.25	-3.40	-19.98	-36.85
Standard deviation	14.44	34.69	4.52	4.15
Skewness	7.55	20.36	0.25	-1.41
Kurtosis	81.90	560.82	3.81	13.73
Number of observations	1,221	1,397	1,001	1,354

Source: Authors calculations

The specified SUR model was evaluated by FE OLS, PCSE OLS, and FGLS estimators following the previously defined empirical strategy. Comparing the estimation results of these three estimators provides an insight into the robustness of the values and statistical significance of the estimated regression coefficients. The estimation results are presented in Table 3.

Table 3: Evaluation of SUR model by FE OLS, PCSE and FGLS estimators

	FE OLS	PCSE OLS	FGLS
$\pi_{i,t}^{D}$	0.0683***	0.1307***	0.0721***
	(0.0235)	(0.0130)	(0.0094)
$\pi_{i,t}^{E}$	0.1113***	0.1322***	0.1165***
	(0.0135)	(0.0161)	(0.0132)
$og_{i,t}^{D}$	0.0437***	0.0279***	0.0413***
	(0.0132)	(0.0066)	(0.0057)
$og_{i,t}^{E}$	0.0395***	0.0381***	0.0295***
	(0.0086)	(0.0099)	(0.0090)
$\Delta fx_{i,t}^{D}$	-0.0114	-0.0160***	0.0017
	(0.0151)	(0.0026)	(0.0023)
$\Delta fx_{i,t}^{E}$	-0.0646***	-0.0707***	-0.0333***
	(0.0169)	(0.0078)	(0.0058)
$\Delta fx_{i,t-1}^{D}$	-0.0002	-0.0086***	0.0062***
	(0.0099)	(0.0025)	(0.0021)
$\Delta fx_{i,t-1}^{E}$	-0.0276**	-0.0342***	-0.0123**
	(0.0135)	(0.0077)	(0.0057)
$i_{i,t-1}^{D}$	0.9163***	0.8479***	0.8961***
	(0.0187)	(0.0106)	(0.0084)
$i_{i,t-1}^{E}$	0.8485***	0.8142***	0.8171***
	(0.0144)	(0.0166)	(0.0140)
_cons	0.1999***	0.8043***	0.9923**
	(0.0374)	(0.2525)	(0.4592)
No. of Obs.	2,715	2,715	2,715
R-Squared	0.93	0.95	

* Significance level of 10%, ** Significance level of 5%, *** Significance level of 1%; standard errors are presented in parentheses.

Source: Authors' calculations

According to the results presented in Table 3, the assumption that central banks of emerging market economies react to the exchange rate volatility is strongly supported. The first difference of the real effective exchange rate has a robust negative impact in the subsample of emerging market countries. For all three estimators, the estimated values of the regression coefficients for the subsample of emerging market economies are significant at the confidence level of 1% range from -0.033 to -0.071. The impact of the first lag differential of the real effective exchange rate is also statistically significant in the subsample of emerging market economies, but with slightly lower values of the estimated regression coefficients.

When it comes to the advanced countries, there are indications that the exchange rate had an adverse impact on interest rate dynamics within the observed period. Still, the statistical significance of this impact is questionable. In addition, the values of the estimated regression coefficients in the subsample of advanced countries are in absolute terms significantly lower than those assessed in the subsample of emerging market economies.

In addition to the estimation of the short-term impact of the exchange rate to the key policy rate, long term effects for all key determinants of monetary policy reaction function were also calculated, based on which the following results were obtained:

Table 4: Estimated values of the long-term impacts

Variable	Formula	Developed			Emerging		
		FE OLS	PCSE	FGLS	FE OLS	PCSE	FGLS
Inflation	$\beta_1/(1-\gamma_1)$	0.82	0.86	0.69	0.73	0.71	0.64
Output gap	$\beta_2/(1-\gamma_1)$	0.52	0.18	0.40	0.26	0.21	0.16
Exchange rate	$(\beta_2+\gamma_2)/(1-\gamma_1)$	-0.14	-0.16	0.08	-0.61	-0.56	-0.25

Source: Authors' calculations

As expected, the differences in the monetary policy response to the exchange rate between the advanced and emerging market economies become even more pronounced in the long run.

In the case of testing the short-term impact of the first exchange rate difference on the interest rate, the inequality condition can be mathematically expressed as $|\beta_3^D| - |\beta_3^E| < 0$, and the Wald test restriction as:

$$[1 \quad -1]\begin{bmatrix}|\beta_3^D|\\|\beta_3^E|\end{bmatrix} = 0$$

The mathematical verification of the inequality condition for the defined research hypothesis (Table 5) confirms that the inequality condition was met independently of the estimator used.

Table 5: Fulfilment of inequality conditions for the Hypothesis

Estimator	Variable and the type of impact	Inequality condition $\|\beta_3^D\| - \|\beta_3^E\| < 0$	Fulfilment of inequality condition
FE	FX, short-term	-0.0532	TRUE.
	FX, long-term	-0.4700	TRUE.
PCSE	FX, short-term	-0.0547	TRUE.
	FX, long-term	-0.4028	TRUE.
FGLS	FX, short-term	-0.0316	TRUE.
	FX, long-term	-0.1733	TRUE.

Source: Authors' calculations

The Wald test (Table 6) tested the null hypothesis $|\beta_3^D| - |\beta_3^E| = 0$. The results of the Wald test unequivocally reject the null hypothesis, which implies the existence of a statistically significant difference between the monetary policy reaction to the exchange rate between advanced and emerging market economies.

Table 6: Formal tests of statistical significance of inequality conditions for the hypothesis

	FE OLS	PCSE OLS	FGLS
FX, short-term	F(1, 36) = 5.49**	chi2(1) = 42.47***	chi2(1) = 31.56***
	Prob > F = 0.0248	Prob > chi2 = 0.0000	Prob > chi2 = 0.0000
FX, long-term	chi2(1) = 2.72*	chi2(1) = 19.06***	chi2(1) = 26.21***
	Prob > chi2 = 0.0990	Prob > chi2 = 0.0000	Prob > chi2 = 0.0000

Note: * Significance level of 10%, ** Significance level of 5%, *** Significance level of 1%
Source: Authors' calculations

The econometric analysis confirmed the existence of a robust negative impact of the exchange rate in the monetary policy reaction function of emerging market economies. Moreover, formal statistical tests unequivocally confirmed that this impact is much more emphasized and statistically significantly higher in a subsample of emerging market economies compared to the advanced ones. Consequently, the research results support the hypothesis that the exchange rate plays a more significant role in the monetary policy reaction function of the emerging market economies than developed countries.

Conclusion

The paper analyses the monetary policy reaction function on panel data of 37 world economies, both advanced and emerging markets, during 1995Q1 – 2018Q3. The research results of the empirical investigation suggest that adequate specification of the Taylor-type monetary policy rule in developed countries include standard determinants - inflation rate, output gap and the first lag of the interest rate, which is in accordance with the findings of numerous empirical studies in this field. In contrast, the exchange rate represents a statistically significant variable only in the monetary policy reaction function of the emerging market economies.

The importance of the exchange rate in the monetary policy reaction function of the emerging market economies can be justified by the higher levels of the exchange rate pass-through, recent hyperinflation episodes and crisis and, consequently, less stable inflation expectations. Nevertheless, the positive trend of the inflation targeting adoption and experience gained after the transition period (South-Eastern European countries) or economic and financial turmoil are predicted to positively impact the strengthening of the monetary policy credibility and anchoring inflation expectations.

References

1. Aizenman, J., Hutchison, M., & Noy, I. (2011). Inflation Targeting and Real Exchange Rates in Emerging Markets. *World Development*, 39(5), 712-724.
2. Amato, G., & Gerlach, S. (2002). Inflation Targeting in Emerging and Transition Economies: Lessons after a Decade. *European Economic Review*, 46, 781-790.
3. Bailliu, J., & Fuji, E. (2004). Exchange Rate Pass-Through and the Inflation Environment in Industrialized Countries: An Empirical Investigation, Bank of Canada, Working Paper 2004-21.
4. Ball, L. (1999). Policy Rules for Open Economies. In *Monetary Policy Rules*, ed. John B. Taylor, 127-156. Chicago: University of Chicago Press.
5. Ball, L. (2000). Policy Rules and External Shocks, NBER, Working Paper Series 7910.
6. Baxa, J., Horvath, R., & Vasiček, B. (2013). Time-Varying Monetary Policy Rules and Financial Stress: Does Financial Instability matter for Monetary Policy? *Journal of Financial Stability*, 9(1), 117-138.
7. Benes, J., Berg, A, Portillo, R.A., & Vavra, D. (2015). Modelling Sterilised Interventions and Balance Sheet Effects of Monetary Policy in a New-Keynesian Framework. *Open Economies Review*, 26, 81-108.
8. Bernanke, B.S., & Mishkin, F.S. (1997). Inflation Targeting: A New Framework for Monetary Policy?. *Journal of Economic Perspectives*, 11(2), 97-116.
9. Calvo, G.A., & Mishkin, F.S. (2003). The Mirage of Exchange Rate Regimes for Emerging Market Countries. *Journal of Economic Perspectives*, 17(4), 99-118.
10. Calvo, G.A., & Reinhart, C.M. (2002). Fear of Floating. *The Quarterly Journal of Economics*, 117(2), 379-408.
11. Caporale, G.M., Helmi, M.H., Catik, A.N., Ali, F.M., & Akdeniz, C. (2018). Monetary Policy Rules in Emerging Countries: Is there an Augmented Nonlinear Taylor Rule?. *Economic Modelling*, 72, 306-319.
12. Catalan-Herrera, J. (2016). Foreign Exchange Market Interventions Under Inflation Targeting: The Case of Guatemala. *Journal of International Financial Markets, Institutions & Money*, 42, 101-114.
13. Clarida, R., Gali, J. and Gertler, M. (1998). Monetary Policy Rules in Practice: Some International Evidence. *European Economic Review*, 42(6), 1033-1067.
14. Clarida, R., Gali, J., & Gertler, M. (1999). The Science of Monetary Policy: A New Keynesian Perspective. *Journal of Economic Literature*, XXXVII, 1661-1707.

15. Clarida, R., Gali, J., & Gertler, M. (2000). Monetary Policy Rules and Macroeconomic Stability: Evidence and some Theory. *The Quarterly Journal of Economics*, 115(1), 147-180.
16. Corbo, V. (2000). Monetary Policy in Latin America in the 90s, Central Bank of Chile, Working Papers 78.
17. Daude, C., Levy Yeyati, E., & Nagengast, A.J. (2016). On the Effectiveness of Exchange Rate Interventions in Emerging Markets. *Journal of International Money and Finance*, 64, 239-261.
18. De la Torre, A., Levy Yeyati, E., & Pienknagura, S. (2013). Latin America's Deceleration and the Exchange Rate Buffer. The World Bank LAC, Semi-Annual Report, October.
19. Debelle, G. (1999). Inflation Targeting and Output Stabilization, Reserve Bank of Australia, Research Discussion Papers 1999-08.
20. Edwards, S. (2000). Exchange Rate Regimes, Capital Flows and Crisis Prevention. National Bureau of Economic, Working Paper 8529.
21. Fabris N. (2006). Inflation Targeting With Special Review on Application in Serbia. *Panoeconomicus, 53*(4), 389-405.
22. Filosa, R. (2001). Monetary Policy Rules in some Emerging Market Economies. *BIS paper*, 8, 39-68.
23. Gagnon, J.E. & Ihrig, J. (2004). Monetary Policy and Exchange Rate Pass-Through. *International Journal of Finance and Economics*, 9(4), 315-338.
24. Galimberti, J.K. & Moura, M.L. (2013). Taylor Rules and Exchange Rate Predictability in Emerging Economies. *Journal of International Money and Finance*, 32, 1008-1031.
25. Gerlach, S. & Schnabel, G. (2000). The Taylor rule and interest rates in the EMU Area: A Note. *Economic Letters*, 67(2), 165-171.
26. Ghosh, A.R., Ostry, J.D. & Chamon, M. (2016). Two Targets, Two Instruments: Monetary and Exchange Rate Policies in Emerging Market Economies. *Journal of International Money and Finance*, 60, 172-196.
27. Goldberg, L.S. & Campa, J.M. (2010). The Sensitivity of the CPI to Exchange Rates: Distribution Margins, Imported Inputs and Trade Exposure. The *Review of Economic Statistics*, 92(2), 392-407.
28. Guller, A. (2021). Does Monetary Policy Credibility Help in Anchoring Inflation Expectations? Evidence from Six Inflation Targeting Emerging Economies. *Journal of Central Banking Theory and Practice*, 10 (1), 93-111.
29. Krušković, B. (2022). Central Bank Intervention in the Inflation Targeting. *Journal of Central Banking Theory and Practice*, 11(1), 67-85.
30. Lee, D.J. & Son, J.Ch. (2013). Nonlinearity and Structural Breaks in Monetary Policy Rules with Stock Prices. *Economic Modelling*, 31, 1-11.
31. Martin, Ch., & Milas, C. (2013). Financial Crises and Monetary Policy: Evidence from the U.K. *Journal of Financial Stability*, 9(4), 654-661.

32. Masson, P.R., Savastano, M.A., & Sharma, S. (1997). The Scope for Inflation Targeting in Developing Countries, IMF, Working Paper 97/130.
33. Mishkin, F.S. (2002). The Dangers of Exchange-Rate Pegging in Emerging Market Countries. *International Finance*, 1(1), 81-101.
34. Mishkin, F.S., & Savastano, M. (2001). Monetary Policy Strategies for Latin America. *Journal of Developing Economics*, 66, 415-444.
35. Mohanty, M.S. (2013). Market Volatility and Foreign Exchange Intervention in EMEs: What Has Changed? BIS, Working Paper 73.
36. Mohanty, M.S., & Klau, M. (2004). Monetary Policy Rules in Emerging Market Economies: Issues and Evidence, BIS, Working Paper 149.
37. Moura, M.L., & de Carvalho, A. (2010). What can Taylor Rules say about Monetary Policy in Latin America? *Journal of Macroeconomics*, 32(1), 392-404.
38. Obstfeld, M., & Rogoff, K. (2000). New Directions for Stochastic Open Economy Models. *Journal of International Economics*, 50(1), 117-153.
39. Ostry, M.J.D., Ghosh, M.A.R., & Chamon, M.M. (2012). Two Targets, Two Instruments: Monetary and Exchange Rate Policies in Emerging Market Economies, IMF, Staff Discussion Note 12/01.
40. Petrović, P., & Nojković, A. (2015). Monetary Policy Rule in Inflation Targeting Emerging European Countries: A Discrete Choice Approach. *Journal of Policy Modeling*, 37(4), 577-595.
41. Rajković, I., & Urošević, B. (2016). Politika deviznog kursa u dvovalutnom monetarnom sistemu. In *Ekonomska politika Srbije u 2016. godini*, ed. Dejan Šoškić and Milojko Arsić, 355-369. Beograd: Naučno društvo ekonomista Srbije.
42. Sutherland, D. (2010). Monetary policy reaction functions in the OECD. Working paper ECO/WKP 2010/17.
43. Svensson, L.E.O. (2000). Open-Economy Inflation Targeting. *Journal of International Economics*, 50(1), 155-183.
44. Svensson, L.E.O. (2003). What is wrong with Taylor Rules? Using Judgment in Monetary Policy through Targeting Rules. *Journal of Economic Literature*, 41(2), 426-477.
45. Svitak, J. (2013). Empirical Estimates of the Taylor Rule: A Meta-Analysis. Bachelor Thesis, Prague: Charles University in Prague, Faculty of Social Sciences, Institute of Economic Studies.
46. Taylor, J. B. (1993). Discretion versus Policy Rules in Practice. *Carnegie-Rochester Conference Series on Public Policy*, 39(1), 195-214.
47. Taylor, J.B. (2000). Using Monetary Policy Rules in Emerging Market Economies. In *Stabilisation and Monetary Policy - The International Experience: Proceedings of the 75th Anniversary Conference of the Bank of Mexico*, 1-19, Mexico City, Mexico.

48. Taylor, J.B. (2001). The Role of the Exchange Rate in Monetary-Policy Rules. *The American Economic Review*, 91(2), 263-267.
49. Taylor, J.B. (2012). Monetary Policy Rules Work and Discretion Doesn't: A Tale of Two Eras. *Journal of Money, Credit and Banking*, 44(6), 1017-1032.
50. Vasiček, B. (2007). The Monetary Policy Rules in Europe: Heterogeneity and Common Patterns. Documents de Recerca del Programa de Doctorado, Barcelona: Universitat Autonoma de Barcelona, Economía Aplicada.
51. Yazdani, M. and Nikzad, M. (2021). Output Losses from Currency Crises and the Role of Central Bank. *Journal of Central Banking Theory and Practice*, 10 (3), 79-97.

Appendix

Table 1.1: Cross-Sectional Dependence test

Variable	Pesaran CD statistics	p-value	Correlation
Key policy rate	131,714	0,00	0,59
Inflation	61,717	0,00	0,30
Output gap	51,602	0,00	0,32
Exchange rate	8,617	0,00	0,20

Source: Authors' calculations

Table 1.2: Cross-Sectionally Dependent Panel Unit Root Tests

Variable	Const		Const + trend	
	Lag	Z(t-bar)	Lag	t-stat
Key policy rate	0	2,10**	0	-0,25
	1	-7,65***	1	-7,20 ***
Inflation	0	-9,11***	0	-6,21***
	1	-14,00***	1	-11,80***
Output gap	0	-6,39***	0	-4,09***
	1	-5,07***	1	-2,95***
Exchange rate	0	-28,90***	0	-28,70***
	1	-27,55***	1	-26,70***

Note: * Significance level of 10%, ** Significance level of 5%, *** Significance level of 1%
Source: Authors' calculations

Table 1.3: Residual tests - FE estimation

Test	Test statistics	p-value
Modified Wald statistic for groupwise heteroskedasticity	chi2 (37) = 4.0702,55	0,00
Wooldridge Serial Correlation Test	F(1, 36) =50,237	0,00
Pesaran CD test	z = 20,592	0,00

Source: Authors' calculations