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Preliminary Communication

CAUSALITY BETWEEN EXCHANGE RATES AND FOREIGN EXCHANGE RESERVES: SERBIAN CASE

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Abstract. *The aim of this paper is to determine the relationship between the exchange rate (nominal and real) and foreign exchange reserves based on monthly data for the period from September 2006 to April 2019, using unit root tests and cointegration tests that take into account the possibility of structural break existence. The results of the causality test indicate that there is a long-term relationship between the nominal exchange rate and foreign exchange reserves. On the other hand, the existence of a long-term relationship between the real exchange rate and the foreign exchange reserves has not been confirmed, but there is a short-term causality, that is, the real exchange rate Granger-causes foreign exchange reserves.*

Key words: *exchange rate, foreign exchange reserves, unit root tests, cointegration tests, Granger causality, Vector Error Correction Model*

JEL Classification: C22, E44, F31

1. INTRODUCTION

Exchange rate is one of the most important determinants of the economic policy of each country. Although in the literature the most frequent is the fixed and floating exchange rate, there are several regimes of exchange rates between them. The Republic of Serbia has opted for such a regime, which implies free formation of the exchange rate on the foreign exchange market, but with certain interventions of the National Bank of Serbia. It is a regime of managed floating exchange rate. In this regime there is monetary independence, so that the central bank can influence external shocks by spending foreign

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currency reserves. The National Bank of Serbia has the task of intervening in the foreign exchange market mainly to prevent excessive daily oscillations of the nominal exchange rate. This is to prevent possible speculative attacks since there is a higher degree of uncertainty due to a change in the exchange rate. If there is pressure on the foreign exchange market, which conditioned on the excessive growth of the exchange rate on a daily basis, the central bank will initiate the sale of foreign exchange, while, if the appreciation pressures are expected, the central bank will in that case buy foreign currency on the foreign exchange market. Such a policy allows for a certain degree of flexibility for the central bank and does not imply directing or holding a foreign exchange rate in certain oscillation zones. In addition to maintaining the stability of the foreign exchange rate of the dinar against the euro, the National Bank of Serbia (National Bank of Serbia, 2019) is used for: the settlement of the obligations of the Republic of Serbia towards foreign creditors, maintaining the stability of the banking system and financing deficit in foreign trade.

For forecasting the future movements in the exchange rates and foreign exchange reserves, and timely undertaking of corrective actions, it is desirable to determine the type and direction of their interdependence. Therefore, the objective of this paper is to investigate the relationship between the exchange rates (real and nominal) and foreign exchange reserves in the Republic of Serbia. However, when analysing economic time series, stationarity issues should be taken into consideration. Analysis of time series that do not meet the requirement of stationarity can lead to biased results and wrong conclusions about the results of statistical testing. Therefore, with the intention of proper establishment of the dependency among the time series, they should first be reduced to stationary ones. However, if the structural break is present, traditional test may be biased, therefore, it is necessary to account for the possible structural break while conducting unit root tests and cointegration tests. For that reason, in order to assess interdependence between foreign exchange reserves and exchange rate unit root tests and cointegration tests that allow for a structural break will be applied.

The paper is structured as follows: the second section discusses the theoretical background and provides a brief review of previous research regarding the relation of foreign exchange reserves and exchange rates. The third section describes the econometric methodology used for the analysis. The data set and empirical results are presented in the fourth section. Lastly, concluding remarks are provided.

2. THEORETICAL BACKGROUND

In the first decade of the 21st century, there was a significant increase in the amount of foreign exchange reserves held by central banks (Gantt, 2010). The stockpiling of reserves is the practice of many countries and the question is whether such policy is justified. On the one hand, holding high volume of reserves is costly, while on the other hand, the cost of holding reserves is insignificant relative to the economic consequences of a crisis (Aizenman & Marion, 2003). Nowak et al. (2004) state two main benefits rising from a high level of reserves: i) reduction of the likelihood of currency crises or a "sudden stop" (an unexpected reluctance by international creditors to renew their credit lines at times of market uncertainty); ii) lower external borrowing costs.

The motivation for the enhanced increase in the level of foreign exchange reserves in emerging economies in recent years was twofold. On the one hand, increasing security in the event of a currency crisis, while on the other hand it reflects the tendency of policy makers to prevent the appreciation of the exchange rate and maintain the competitiveness of their economies (Krusković & Maričić, 2015). However, central banks do not have the ability to mount up reserves indeterminately. Disproportionate reserve stockpiling involves substantial sterilization costs, due to the negative spread between the interest earned on reserves and the interest paid on the country's public debt, which enlarges with reserve accumulation (Gosselin & Parent, 2005). Regarding the optimal level of foreign exchange reserves Heller (1966) claims that it should be determined in the way that will make a balance between the costs of macroeconomic adjustment that may arise in the situation of a deficiency of reserves with the opportunity cost of holding reserves.

There is a universal view that the reserve requirements must be kept at an optimum level. However, this level can be determined in several ways. It is mostly a level that does not exceed the value of six-month imports of goods and services, or not lower than the value of the quarterly import. A surplus or shortfall in these resources can cause some repercussions on the national economy and make it more difficult for economic policy makers. Firstly, the low level of foreign exchange reserves is a serious problem. They are limited, and the transition below their minimum can lead to a reduction in the credit rating and the ability to borrow in the foreign market, and in the event of a serious shortfall, currency crises can occur. However, even a higher level is not a problem to be underestimated, especially when the country is burdened with price instability problems. In the absence of reserves, balance of payment deficits would have to be rectified through (Aizenman et al., 2012): a reduction in aggregate expenditures, imposition of macroeconomic adjustment costs, and a change in relative prices or "expenditure switching".

Edwards (1983) claims, based on the examination of previous studies, that demand for international reserves is a function of the scale of the country (measured by its total imports or total income), the variability of its payments, its degree of openness and the opportunity cost of holding reserves. The reserves are kept to finance international transactions, and also as a buffer stock to deal with unanticipated payment difficulties. If the aspect of international transaction financing is considered, the level of optimal reserves depends on the variability of international transactions. As reserves serve as buffered, whose role is to offset fluctuations in international transactions, it is expected that the optimal reserve stock is positively dependent on the magnitude of these fluctuations (Frenkel & Jovanovic, 1981). Flood and Marion (2002) state that are three trends in the international economy that may possibly have a significant influence on reserve holdings: 1) increasing capital mobility; 2) increasing frequency and intensity of currency and financial crises; and 3) increasing number of countries reporting a switch to flexible exchange rates.

A vast number of research has addressed the role of reserves and their relation to the exchange rate. Aizenman and Riera-Crichton (2008) indicated that international reserves soften the influence of terms of trade shocks on the exchange rate, and that this effect is important for developing but not for industrial countries. Nowak et al. (2004) investigated whether higher volume of reserves may decrease the volatility of the real exchange rate independently of the impact of the selected exchange rate regime or of the role of foreign exchange intervention, and provided the evidence of a negative non-linear effect of reserves on the short-term volatility of the real effective exchange rate, for a sample of

emerging market countries. Adler et al. (2019) examined the effect of foreign exchange intervention on the level of the exchange rate using an instrumental-variable panel approach and discovered that intervention affects the exchange rate in a meaningful way from a macroeconomic perspective. Viola et al. (2019) state that countries that adopt inflation targeting and a floating exchange rate typically intervene in the foreign exchange market through various mechanisms, both sterilized and non-sterilized, wherein one of the most common that lead a central bank to intervene in the foreign exchange market is recomposing reserves and smoothing out long-term exchange rate movements. Volatility of exchange rate may cause difficulties in international trade and investment decisions. Engel and Hakkio (1993) identified changes in expectations due to new information, the volatility of market fundamentals and speculative movements as main determinants of exchange rate volatility. Frömmel et al. (2011) state that with the intention to influence on the exchange rate changes the central bank can essentially use two instruments: foreign exchange interventions and interest rate changes. Several authors have examined the usefulness of foreign exchange interventions (Dominguez, & Frankel, 1990; Ito, 2002; Fatum, & Hutchison, 2003; Neely, 2005; Basu, 2012). Additionally, there is evidence of reduction of volatility due to foreign exchange interventions (Abenoja, 2003; Viola et al., 2019).

Serbia has been applying a managed-float exchange rate regime, and the inflation targeting regime has been in place since 2009. Under the inflation-targeting and managed-float framework, market forces are allowed to determine the value of the currency which reflect demand and supply for that currency in the foreign exchange markets (Bouraoui & Phisuthtiwatcharavong, 2015). The joint movements in EUR/RSD exchange rate and foreign exchange interventions of the National Bank of Serbia are presented in figure 1.

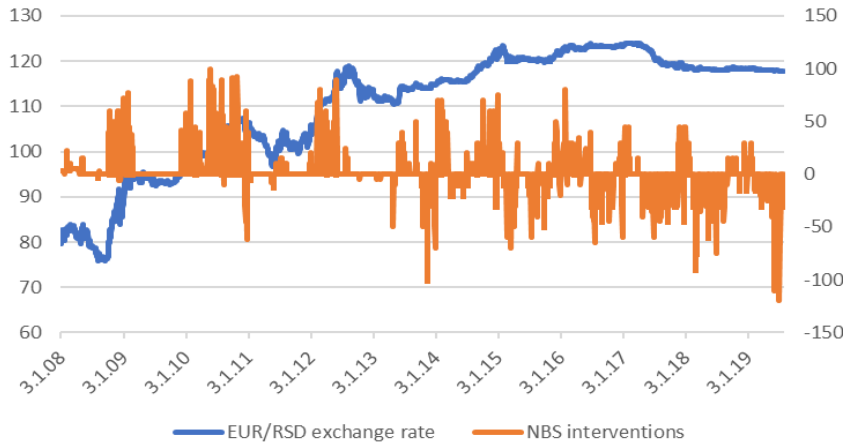

Fig. 1 Movements in EUR/RSD exchange rate and NBS foreign exchange interventions (on a daily basis)
Source: Authors presentation based on the data of the National bank of Serbia, 2019b.

Regarding factors that determine the level of foreign exchange reserves, in addition to the balance of payments, an important determinant of foreign exchange reserves is the applied exchange rate regime. It depends on the movement of a set of macroeconomic

variables over time (inflation, certain transmission channels, euroization of the economy, labour flexibility). Economies with internal problems and high inflation rates are generally opting for the fixed exchange rate regime, while countries that have a balance of payments problem choose a floating exchange rate. In a fixed exchange rate regime, the central bank is obliged to defend the established level of the exchange rate. The sustainability of this regime depends on the value of available foreign exchange reserves. With the floating exchange rate regime, there is no obligation on the central bank to maintain a certain level of the exchange rate, and the degree and number of foreign exchange interventions is lower. Foreign exchange reserves in this case fluctuate less, but since in this exchange rate regime it is possible for currency crises to emerge due to the formed negative expectations of market entities, their level will depend on the successful conduct of economic policy. The level and movement of foreign exchange reserves is shown in figure 2.

Fig. 2 Evolution of foreign exchange reserves of the National Bank of Serbia in the period from September 2005 to April 2019
Source: Authors' presentation based on the data of the National Bank of Serbia, 2019a.

The level of the exchange rate in the regime of floating exchange rate is formed on the basis of supply and demand in the foreign exchange market. Certainly, foreign trade flows (exports and imports of goods and services) are the most significant factors in exchange rate formation. Next, inflation is one of the important factors, as is the inflow and outflow of remittances from abroad. In addition, capital transactions (foreign direct investment, portfolio investment) have a strong impact, primarily in developing countries. Finally, one of the factors is the intervention of monetary authorities in order to mitigate smaller or larger fluctuations in the foreign exchange market, in regimes other than purely floating exchange rates. Other factors include interest rate, national income, investor expectations, and the state of the world economy.

On the other hand, the causal relationship between the exchange rate and the foreign exchange reserves is not a common topic of research, and there are only a few studies that have dealt with the examination of the short-term and long-term relationship between the stated variables.

Gokhale and Raju (2013) have investigated causality among exchange rate and foreign exchange reserves in India using a time series data during the period between 1980 and 2010. Their intention was to determine the influence of foreign exchange reserves on the exchange rate using the unit root test, Johansson cointegration test and Vector Auto Regression (VAR). The results of their study indicate that there is no long and short-term relation between exchange rate and foreign exchange reserves. Bearing in mind that India has managed floating exchange rate system they conclude that foreign exchange reserve accumulation in India could have been carried out with the aim of providing an adequate response to the possible currency crisis rather than a tool for regulating the exchange rate.

Kim (2003) has developed the structural VAR model to inspect together the effects of foreign exchange intervention and conventional monetary policy on the exchange rate. The results of the study specify that foreign exchange intervention has considerable influence on the exchange rate and responds to stabilize the exchange rate.

Bayat et al. (2014) have analysed exchange rates and foreign exchange reserves in Turkey using nonlinear and frequency domain causality approach during the period from January 2003 until January 2014. Their findings reveal that there is a nonlinear cointegration between analysed variable and that causality is running from nominal and real exchange rate to foreign exchange reserves. Kasman and Ayhan (2008) have examined the association between exchange rates and foreign exchange reserves in Turkey, on the basis of monthly data during the period from January 1982 until November 2005 using unit root and cointegration tests, which allow for structural breaks. Their results reveal the existence of a long-run relationship between foreign exchange reserves and exchange rates and that the both long and short-run causality is running from foreign exchange reserves to real effective exchange rate. Concerning the relationship between nominal exchange rate and foreign exchange reserves, the results indicate that in the long-run nominal exchange rate Granger cause foreign exchange reserves.

Regarding methodology used in the studies related to the exchange rate relation to some other variables, few studies took into account possible structural break during the period of the analysis (Dropsy, 1996; Baum et al., 1999; Granger et al. 2000; Kočenda, 2005; Akinboade & Makina, 2006; Rapach & Strauss, 2008; Byrne & Nagayasu, 2010; Chowdhury, 2012; You & Sarantis, 2012; Mensi et al., 2015; Ahmad & Aworinde, 2016; Ojede & Lam, 2017; Salisu et al., 2019). Failure to consider a possible structural break can lead to inadequate conclusions and, consequently, to the wrong recommendations. Therefore, in this paper the tests that take into account possible structural break will be applied to assess interdependence between foreign exchange reserves and exchange rate. We expect that the results will indicate that there is causality between the analysed variables, directed from the foreign exchange reserves towards the exchange rate.

For that purpose, the following hypotheses were developed:

H1: There is no long-run relationship between the real exchange rate and foreign exchange reserves;

H2: There is no long-run relationship between the nominal exchange rate and foreign exchange reserves;

H3: There is no short-run relationship between the real exchange rate and foreign exchange reserves;

H4: There is no short-run relationship between the nominal exchange rate and foreign exchange reserves.

3. METHODOLOGY

In order to examine the existence and nature of the relationship between the exchange rate and the foreign exchange reserves, a three-step methodology proposed by Kasman and Ayhan (2008) will be applied. In the first step, using the Zivot-Andrews unit root test the level of integration of time series in situations where there is an indefinite structural breakdown will be examined. The second step of the analysis is dedicated to examining the existence of cointegration in a situation where there is an unsteadiness in long-term relations using Gregory and Hansen cointegration test. In the final step, causality is tested using a Granger causality test.

3.1. Unit root test

The traditional unit root tests, such as ADF unit root test, may lead to invalid conclusions in situations where there is a structural break. Such assumptions are firstly stated by Perron (1989). He has created a unit root test which takes into the consideration possibility of a single external structural break (Umit, 2016). Yet, the flaw of the proposed test is that it requires the moment of structural break to be predefined and in situations where that moment is not accurately determined, the wrong results may occur. Bearing in mind the shortcomings of the Perron's test, Zivot and Andrews (1992) have developed a test that takes into account the existence of a single structural break which can be designated internally. The Zivot and Andrews test detects endogenously the moment of the particular most important structural break in each time series tested (Waheed et al. 2006). The critical values in Zivot and Andrews test diverge from the ones provided by Perron (Glynn et al. 2007). The null hypothesis of a unit root with a break is rejected if the computed *t* statistics exceed the critical values of Zivot and Andrews test in absolute terms. There are three models of Zivot and Andrews test (Waheed et al. 2006):

- model A: allows a one-time shift in the series level;
- model B: allows for a one-time shift in the slope of the trend function;
- model C: represents a combination of previous models.

3.2. Cointegration tests

Economic time series most often has a stochastic trend, that is, it moves unpredictably over time. The term of cointegration relates to non-stationary time series, among which there is such a linear combination that is stationary (Kovačić, 1995). In other words, the term cointegration indicates the stationarity of a linear combination of separately non-stationary time series. From an economic point of view, two time series will be cointegrated if there is a long-term equilibrium relationship between them. Cointegration was first investigated in works by Granger (1983), Granger and Weiss (1983) and Engle and Granger (1987). These works provide an adequate basis for analysing long-term and short-term economic relationships.

The conventional cointegration test examines the null hypothesis of no cointegration through examining the null of a unit root in the residuals, and if the null of a unit root is not accepted, the null of no cointegration is also not accepted (Phillips & Ouliaris, 1990). However, most of the conventional cointegration tests, such as Engle and Granger test and Johansen test, do not consider the possibility of structural breaks in the long-run relationship,

meaning that such test presumes that the cointegrating vectors do not fluctuate over time (Ndoricimpa, 2013). In order to address these shortcomings of conventional tests, Gregory and Hansen (1996) have developed cointegration test that takes into account the possibility of a single structural break that can be considered as an extension of the Engle and Granger two-step test (Liu & Wan, 2012). Gregory and Hansen (1996) propose four different models in order to account for the single endogenous break (Ndoricimpa, 2013):

- Model 1: Level shift – the structural break influences only on the intercept;
- Model 2: Level shift with trend – the structural break influences only the intercept but the model encompasses a trend.
- Model 3: Regime shift – the structural break influences the intercept and the slope coefficient, jointly.
- Model 4: Regime shift with trend – the structural break influences the intercept, the slope coefficient and the trend function.

3.3. Causality test

The presence of cointegration shows the existence of a long-run relationship between variables. On the other hand, the absence of the cointegration between two time series in the long run, does not mean that there is no short-run causal interrelationship (Lodha, 2017). Short-run interrelationship can be inspected by performing the Granger causality test.

In the literature, one can find the definition of Granger's causality stating that X causes Y in Granger's sense if the present value of the variable Y can be predicted with greater accuracy using the past values of the variable X, and not only the past values of the variable Y, with other conditions unchanged (Watson & Teelucksingh, 2002).

Granger causality test was originally developed to identify the impact of one time series on the other. Granger causality test is based on two basic principles (Granger, 1969):

- The cause occurs before the effect;
- Cause creates unique changes to the effect, that is, the causal series contains unique information about the time series which it affects, which are not available otherwise.

The causality test application is determined by the fact whether there is cointegration between variables or not (Kasman & Ayhan, 2008). If there is a cointegration then a Vector Error Correction model (VECM) should be applied to determine the long and the short-run relationship between variables, and if there is no cointegration, the Vector Autoregression model (VAR) should be used.

4. DATA AND ANALYSIS

The time series data for the nominal exchange rate and foreign exchange reserves for the period from September 2005 until April 2019 were collected from the National Bank of Serbia database in order to examine the existence and nature of the relationship between the exchange rate (nominal and real) and foreign exchange reserves. The real exchange rate is obtained using the equation:

$$RER = NER * \frac{P_{EU}}{P_{SER}}, \tag{1}$$

where NER signifies the nominal exchange rate, P_{EU} and P_{SER} symbolize consumer price indexes in the EU and Serbia, respectively.

The first step in the analysis is to test the stationary of time series and to determine the order of integration in the case of nonstationary series. For that purpose, the augmented Dickey–Fuller unit root test (ADF) has been applied and the results are presented in the Table 1. According to the obtained value of test statistics it can be determined that all analysed time series are not level stationary. On the other hand, their first differences are stationary.

Table 1 Calculated ADF statistics

	Nominal exchange rate		Real exchange rate		Foreign exchange reserves	
	no trend	trend	no trend	trend	no trend	trend
level	-1.538	-1.337	-3.104	-3.117	-2.864	-3.355
first difference	-13.496	-13.607	-12.908	-12.865	-11.330	-11.312

Source: Authors' calculation

Note: Optimal number of lags revealed based on AIC; Critical values are (MacKinnon, 1991): -3.493 (99%) and -4.023 (99%) with no trend and with trend, in that order

However, the existence of structural break reduces the power of the ADF test (Kasman & Ayhan, 2008). Therefore, to detect potential structural break the Zivot and Andrews test has been applied and the obtained results are presented in Table 2. The results endorse results obtained by ADF test. Hence, all time series are I (1).

One of the research assumptions is that the periods of the identified structural break will coincide with the periods of the financial and economic crises in the Republic of Serbia. Since the third model which includes both, the single shift in the intercept and the trend, is the most restrictive, this model is tested first, and if there the null is rejected, then other two models are tested. The results of the Zivot-Andrews unit root test indicate that nominal exchange rate, real exchange rate and foreign exchange reserves show that the estimated break occurred in the February 2012, December 2008 and May 2009, respectively, which is consistent with the stated assumption. This is also consistent with the assumption that the structural breaks occur due to political or economic factors related to the specific country.

Table 2 Zivot-Andrews unit root test

	Nominal exchange rate	Real exchange rate	Foreign exchange reserves
Break point	2012m2	2008m12	2009m5
Minimum t-statistic	-4.150	-4.639	-4.768
lags	3	3	3

Source: Authors' calculation

Note: Optimal number of lags obtained based on AIC;
Critical values are: 1%: -5.57, 5%: -5.08, 10%: -4.82

The structural breaks detected in the December 2008 and May 2009 were caused by instability due to the effects of the global economic and financial crisis. Firstly, the negative effects of the crisis were transferred from abroad which has resulted in the occurrence of deflation, leading to an increase in the real exchange rate. Secondly, after several months

the recovery started in terms of transferring positive effects from abroad, which improved the current account balance and suddenly increased foreign exchange reserves. The structural break in February 2012 had a different character and was caused by internal economic problems (first of all, inflation).

Since the unit root test have revealed that all analysed time series are *I* (1), it is necessary to perform further analysis in terms of cointegration testing. The cointegration testing will be conducted in two steps. In the first step conventional Engle-Granger cointegration test (Engle & Granger, 1987) will be applied which does not take into account structural break. The obtained results are presented in Table 3 and indicate that the null hypothesis of no cointegration cannot be rejected at the 1% level. Therefore, analysed time series in all models are not cointegrated.

Table 3 Engle–Granger cointegration test

Models	ADF	Lags
$FER=\alpha+\beta NER+\varepsilon$	-3.963	3
$NER=\alpha+\beta FER+\varepsilon$	-3.383	3
$FER=\alpha+\beta RER+\varepsilon$	-2.206	3
$RER=\alpha+\beta FER+\varepsilon$	-3.745	3

Source: Authors' calculation
Note: Critical values are: -3.970 (99%), -3.377 (95%), -3.073 (90%)

Kasman and Ayhan (2008) state that in the situation when conventional cointegration tests fail to reject the null hypothesis of no cointegration and Gregory-Hansen procedure rejects the null, it indicates the presence of the structural shift in the long-run co-movements between analysed time series. Therefore, in the second step, a Gregory-Hansen test was applied in order to consider possible structural shift during examination of the cointegration existence (Gregory & Hansen, 1996). The results are presented in the Table 4.

First panel examines the relationship between foreign exchange reserves and nominal exchange rate, where foreign exchange reserves represent dependent variable. The first and the second model detect the presence of cointegration, which is not discovered by the conventional cointegration test. Second panel investigates the relationship between nominal exchange rate and foreign exchange reserves, where the nominal exchange rate is the dependent variable. The test results of the model that allows for regime switch do not support the results obtained by conventional cointegration test of no cointegration. Therefore, there is a long-run relationship between nominal exchange rate and foreign exchange reserves. Third panel inspects the association between foreign exchange reserves and real exchange rate, where foreign exchange reserves represent dependent variable. The results indicate the existence of a long-run relationship between analysed variables. Fourth panel inspects the association between the real exchange rate and foreign exchange reserves, where the real exchange rate is the dependent variable. The results for all models support the results obtained by the conventional cointegration test of no cointegration.

Table 4 Gregory-Hansen cointegration test

Models	ADF	BP	Z_t	BP	Z_α	BP	Lags
Panel A: FER=α+βNER+ε							
level	-4.50***	2010m3	-4.89**	2009m9	-36.38***	2009m9	3
trend	-5.17**	2009m8	-5.56*	2009m9	-44.55***	2009m9	3
regime	-4.71***	2014m2	-4.95***	2009m8	-37.68	2009m8	3
regime trend	-4.95	2009m8	-5.25	2009m9	-44.13	2009m9	0
Panel B: NER=α+βFER+ε							
level	-4.24	2012m11	-3.32	2012m9	-17.65	2012m9	3
trend	-3.86	2009m8	-3.85	2009m8	-27.74	2009m8	0
regime	-4.82***	2014m1	-4.71***	2014m3	-23.64	2014m3	3
regime trend	-4.21	2017m1	-3.89	2009m9	-28.18	2009m9	3
Panel C: FER=α+βRER+ε							
level	-5.03**	2009m8	-5.36*	2009m9	-44.02**	2009m9	0
trend	-4.98***	2009m8	-5.34**	2009m9	-43.44***	2009m9	0
regime	-5.04**	2009m8	-5.31**	2009m9	-44.71***	2009m9	0
regime trend	-4.93	2009m8	-5.15	2009m8	42.99	2009m8	0
Panel D: RER=α+βFER+ε							
level	-4.43	2009m6	-3.93	2009m8	-28.23	2009m8	3
trend	-4.88	2009m6	-4.31	2009m8	-33.17	2009m8	3
regime	-4.30	2017m5	-3.89	2009m8	-28.03	2009m8	3
regime trend	-4.97	2009m2	-4.39	2008m12	-34.66	2008m12	3

Source: Authors' calculation

Note: *, ** and *** indicate significance at 1%, 5% and 10%, in that order

The Gregory-Hansen cointegration test results disclose that different model assumptions reveal different time points of structural break. Yet, most of the break points have been detected in the second half of 2009. In that period, the basic macroeconomic indicators specify the recovery of the Republic of Serbia from the global economic crisis and transition into a state of macroeconomic stability. Hence, it may be considered that the recovery from the global economic crisis made the long-term mechanism between Serbian foreign exchange reserves and exchange rates fundamentally change.

In order to determine the causality in the presence of cointegration, it is necessary to apply VECM, which encompasses an error correction term in order to describe the short-run deviancies of series from their long-run equilibrium path. On the other hand, when cointegration is not present a VAR model can be applied in order to determine Granger causality between variables.

Moreover, there is a need to identify the number of lags to be included in the model, with the aim of adjusting to the VECM model. Lütkepohl (2005) states that Hannan–Quinn information criterion (HQIC) and Schwarz's Bayesian information criterion (SBIC) give consistent estimations of the true lag length, compared to final prediction error (FPE) and Akaike's information criterion (AIC) which overestimate the true lag length in the infinite sample. However, there is no notation what can be considered as a finite sample, therefore, since most of the studies apply AIC in the optimal lag selection, the authors will utilize that information criterion in the further course of the analysis.

For the model that examines the relationship between foreign exchange reserves and nominal exchange rate, where foreign exchange reserves represent dependant variable, the results of VECM are presented in Table 5.

Table 5 Vector error-correction model: Long and short-run causality between foreign exchange reserves and nominal exchange rate

	Coef.	Std.Err.	z	P>|z|	95% Conf. Interval	
ECT_{t-1}	-.085	.037	-2.33	0.020	-.158	-.013
ΔFER_{t-1}	.076	.081	0.94	0.348	-.083	.235
ΔFER_{t-2}	-.052	.081	-0.64	0.522	-.212	.108
ΔNER_{t-1}	-.115	.122	-0.95	0.344	-.353	.123
ΔNER_{t-2}	-.442	.121	-3.65	0.000	-.680	-.205
Constant	.003	.002	1.12	0.265	-.002	.007

Source: Authors' calculation

Note: ECT_{t-1} – lagged error correction term, ΔFER_{t-1} first lagged difference of foreign exchange reserves value, ΔFER_{t-2} second lagged difference of foreign exchange reserves value, ΔNER_{t-1} first lagged difference of nominal exchange rate value, ΔNER_{t-2} second lagged difference of nominal exchange rate value

The validity of the model is confirmed by the lagged error correction term (ECT_{t-1}), since it meets two necessary conditions: it is significant and has a negative sign. Hence, in the long-run nominal exchange rate Granger-cause foreign exchange reserves. The error correction term suggests that the adjustment of foreign exchange reserves to changes in the nominal exchange rate is slow, since the value of ECT_{t-1} is relatively small (-0.085).

The short-run influence can be evaluated based on the coefficients of lagged differenced terms. It can be noticed that the value of the nominal exchange rate is significantly influenced only by the ΔNER_{t-2} variable, meaning that past values of nominal exchange rate (two month prior the estimation) have statistically significant influence on the current value of nominal exchange rate.

Regarding the model that examines the relationship between the nominal exchange rate and foreign exchange reserves, where nominal exchange rate represents dependant variable, the results of VECM are presented in Table 6. The lagged error correction term

Table 6 Vector error-correction model: Long and short-run causality between nominal exchange rate and foreign exchange reserves

	Coef.	Std.Err.	z	P>|z|	95% Conf. Interval	
ECT_{t-1}	-.0389	0.147	-2.64	0.008	-.0678	-.010
ΔNER_{t-1}	-.109	.082	-1.32	0.185	-.271	.052
ΔNER_{t-2}	.084	.082	1.02	0.308	-.077	.245
ΔFER_{t-1}	-.055	.055	-1.00	0.316	-.163	.053
ΔFER_{t-2}	.021	.055	0.38	0.703	-.087	.129
Constant	.004	.002	2.13	0.033	.0003	.007

Source: Authors' calculation

Note: ECT_{t-1} – lagged error correction term, ΔFER_{t-1} first lagged difference of foreign exchange reserves value, ΔFER_{t-2} second lagged difference of foreign exchange reserves value, ΔNER_{t-1} first lagged difference of nominal exchange rate value, ΔNER_{t-2} second lagged difference of nominal exchange rate value

in this model is significant at the 1% level with a negative sign, signifying that in the long-run, foreign exchange reserves Granger-cause the nominal exchange rate. However, since the value of the error correction term is rather small (−0.0389), the adjustment of nominal exchange rate to the changes in foreign exchange reserves is relatively slow.

Based on the values of the lagged differenced terms, it can be concluded that there is no statistically significant influence of past values of nominal exchange rate nor foreign exchange reserves on the current value of the nominal exchange rate.

Concerning the model which examines the long-run relationship between foreign exchange reserves (as dependant variable) and the real exchange rate, the error correction term is negative -0.0002634, but statistically insignificant (p value is 0.952), meaning that there is no long-run relationship between variables in this model. Therefore, their short-run relation will be examined using a Granger causality test. Also, since the cointegration tests have not discovered cointegration between the real exchange rate (as a dependant) and foreign exchange reserves, their short-run relation will also be tested using a Granger causality test.

Table 7 Granger causality test

Dependent variable	Independent variable	
	ΔFER	ΔRER
ΔRER	1.1523	
	(0.3188)	
ΔFER		4.5834
		(0.0118)

Source: Authors' calculation
Note: p-value in parenthesis

The F-statistics indicates that there is a short-run causality running from real exchange rate towards foreign exchange reserves. On the other hand, foreign exchange reserves do not Granger-cause real exchange rate.

Therefore, concerning the relationship between foreign exchange reserves and the real exchange rate, there is no long-run interdependence, and first hypothesis cannot be rejected. Regarding their short-run dynamics, the Granger-causality test has detected causality in one direction, from real exchange rate towards foreign exchange reserves. Hence, the third hypothesis is rejected.

Relating to the relationship between foreign exchange reserves and nominal exchange rate there is evidence of long-run interdependence, meaning that the second hypothesis is rejected. However, the values of the coefficients of lagged differenced terms indicate that there is no short-run causality between these variables. Hence, the fourth hypothesis cannot be rejected.

Despite expectations, based on the previous literature review, that exchange rate fluctuations are caused by the movement of foreign exchange reserves, the results indicate that, in the case of the Republic of Serbia, there is no causality in this direction, but rather there is a causality directed from the exchange rate (real exchange rate in short-term and nominal exchange rate in the long-term) to foreign exchange reserves. As there is a significant long-term relationship between foreign exchange reserves and the nominal exchange rate, the accumulation of foreign exchange reserves is more than

necessary to mitigate the negative effects of future crises on the exchange rate and for the sustainability of the managed exchange rate regime. The stockpiling of foreign exchange reserves may also reflect the aspirations to improve Serbia's credit rating in order to attract foreign direct investment and portfolio investments.

Low inflation, which is a long standing result of the implementation of the inflation targeting strategy, as well as the improvement of the economic and fiscal situation, are domestic factors that, on the other hand, will enable a stable exchange rate and preserve an adequate level of foreign exchange reserves in the event of potential external shocks, thereby increasing resilience to future currency crisis.

5. CONCLUSION

The aim of this paper was to provide a comprehensive analysis of the co-movement between the exchange rates (real and nominal) and foreign exchange reserves. Most of the conventional cointegration approaches disregard the possibility of structural break, which could result in mistaken conclusion. Therefore, the research methodology took into account the possible structural break, in order to avoid biased results.

The paper focused on the long and the short-run relationship between exchange rate and foreign exchange reserves. The results revealed that all analyzed variables were non-stationary at level, but stationary at first difference, and that there was a single structural break in the series, which coincides with the periods of financial and economic crises in the Republic of Serbia. Conventional cointegration test (Engle-Granger test) have not detected cointegration between analyzed variables. However, Gregory-Hansen test, which allows for a single shift in the series, has detected the existence of cointegration. The causality tests have proven the existence of a long-run interdependence between foreign exchange reserves and nominal exchange rate. Conversely, there was no evidence of long-run interdependence between foreign exchange reserves and the real exchange rate. Yet, the results of Granger-causality test indicated that there was unidirectional short-run causality, from real exchange rate towards foreign exchange reserves. This causality indicates that the prediction of the future values of foreign exchange reserves would be better if the past values of real exchange rate are also considered.

This paper contributes to the literature on the interdependence between exchange rates and foreign exchange reserves in the developing countries, on an example of the Republic of Serbia. However, the research faces some limitations. The first limitation concerns the methodology applied. The results of the analysis are affected by the applied lag length, and since there are various methods for determination of the lag length, it is possible that the application of different information criterion would indicate different lag length which could result in different conclusions. The second limitation concerns the scope of the study, since there may be some other macroeconomic variables whose influence was not taken into consideration.

In order to respond to these limitations, research can be extended in various directions. Firstly, some new macroeconomic variables can be introduced into the analysis. Secondly, it is possible to examine the impact of lag length determined by different information criteria on the obtained results.

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UZROČNOST IZMEĐU DEVIZNIH KURSEVA I DEVIZNIH REZERVI: PRIMER SRBIJE

Cilj ovog rada jeste utvrđivanje odnosa između deviznog kursa (nominalnog i realnog) i deviznih rezervi na osnovu mesečnih podataka za period od septembra 2006 do aprila 2019. godine, primenom testova jediničnog korena i testova kointegracije koji uzimaju u obzir mogućnost postojanja strukturnog loma. Rezultati testa uzročnosti ukazuju da postoji dugoročna veza između nominalnog deviznog kursa i deviznih rezervi. Sa druge strane, nije utvrđeno postojanje dugoročne veze između realnog deviznog kursa i deviznih rezervi, ali da postoji kratkoročna uzročnost, odnosno da realni devizni kurs Granger-uzrokuje devizne rezerve.

Ključne reči: *devizni kurs, devizne rezerve, testovi jediničnog korena, testovi kointegracije, Granger uzročnost, vektorski model sa korekcijom greške*