ECONOMIC ANNALS, Volume LXV, No. 226 / July – September 2020
UDC: 3.33 ISSN: 0013-3264

https://doi.org/10.2298/EKA2026103B

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DETERMINANTS OF FOREIGN EXCHANGE RESERVES IN SERBIA AND NORTH MACEDONIA

ABSTRACT: *This paper employs a quantile regression approach to explore the determinants and properties of international foreign exchange reserves in Serbia and North Macedonia, at various foreign exchange levels. The observed period covers quarterly data for 2005q1–2019q1. The results reveal quantile-dependent determinants of foreign exchange reserves and enable comparison between the two countries, showing co-movements between monetary policy and economic fluctuations. Following the estimates obtained in this research, the paper compares the role of foreign exchange reserves in Serbia and North Macedonia.*

KEY WORDS: *international foreign exchange reserves, quantile regression, foreign exchange rate, GDP, monetary aggregates*

JEL CLASSIFICATION: E43, E44, E52, F34, F37, F32, G15

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1. INTRODUCTION

Foreign exchange reserves serve as a cushion that maintains foreign exchange stability and the liquidity of external positions, and consequently the overall strength of the national economy to resist exogenous shock. As national economies have become more globalised and integrated the role of foreign exchange reserves has become more important, especially in small and open economies. One strand of literature discusses the adequacy of reserve holdings (Dabla-Norris et al., 2011; Moore & Glean, 2016). Another strand examines the determinants of reserve accumulation (Sula, 2011; Fang-Yuan & Jun-Guo, 2013; Bošnjak et al., 2019) and the appropriateness of the quantile regression approach to illustrate the effects of the determinants on different levels of foreign exchange reserves. This paper uses quantile regression to compare the determinants of foreign exchange reserves in two small and open economies, Serbia and North Macedonia, thus contributing to the existing body of literature on the topic.

The rest of this paper is organised as follows. Section 2 summarises the existing literature related to the research topic. Section 3 introduces the research data and methodology, while Section 4 illustrates the empirical analysis. The final section summarizes the main findings of the research.

2. BRIEF LITERATURE OVERVIEW

The literature on exchange reserves is wide, starting with discussion of the optimality of and motivation for reserve accumulation. The growth trend in exchange reserves observed during the past decades raises numerous questions regarding its optimality and effect on the national economy, including the motivation behind reserve accumulation and reserve management (Heller, 1966; Kenen & Yudin, 1965; Kelly, 1970; Frenkel & Jovanovic, 1981; Dooley et al., 2003; Aizenman & Lee, 2007; for a detailed discussion see Bošnjak et. al. (2019)).

Rodrik (2006) observes the growing accumulation of reserves in developing countries during the late 1990s, calculates the social costs of such a strategy, and discusses the optimality of this policy. The paper concludes that the strategy of accumulating reserves in developing countries is not optimal because of the high costs, while on the other hand developing countries under-invest in reducing short-term foreign liabilities. Mohanty and Turner (2006) focus on emerging

economies and their use of exchange reserves to control appreciation of the national currency. This strategy includes risks other than inflation, such as additional costs, monetary imbalances, overheating in credit and asset markets, and potential problems in the banking sector. Moore and Glean (2016) research exchange reserve adequacy using a cost–benefit approach, starting with the common assumption that the optimal level of reserves is 12 weeks of imports. They use a dynamic random effects probit model of financial crises to evaluate the benefits and a panel growth equation to determine the costs. The results for small states show that the optimal level of reserve holdings is 25 weeks of imports and is connected to characteristics of the national economy, so that countries with a more prudent fiscal stance can hold lower levels of exchange reserves. Chutasripanich and Yetman (2015) analyse different foreign exchange intervention strategies and come to no conclusion regarding a dominant strategy, while Korinek and Serven (2016) observe the undervaluation effects of reserve accumulation. Benecká and Komarek (2018) try to solve the problem of model uncertainty when determining the factors behind holding international reserves, using Bayesian model averaging on a sample of 104 countries for the 1999–2010 period. They confirm a positive relation between the level of reserves and trade openness and broad-money-to-GDP ratio, while increased financial development decreases the need for reserves. Adler et al. (2019) find that the effects of foreign exchange intervention on FX purchases and sales are persistent and symmetric. Blanchard et al. (2015) point out that greater foreign exchange intervention corresponds to less exchange rate appreciation as a consequence of gross inflows. Aizenman et al. (2015) confirm the connection between international reserves and trends in the global economy, observing the influence of financial crisis. Bošnjak et al. (2019) use a quantile regression model to define the determinants of exchange reserves in Croatia. Jovanovikj and Andonova (2017) examine the optimality of the level of exchange reserves in Macedonia using a cost-benefit welfare model. They conclude that the existing level is below but close to the optimal level.

3. RESEARCH DATA AND METHODOLOGY

The data on Serbia's foreign exchange reserves, nominal effective exchange rate (FXN), and real effective exchange rate (with consumer prices) were retrieved from the National Bank of Serbia, while gross domestic product (GDP) and

imports at constant prices came from the Serbian Bureau of Statistics. Foreign exchange reserves, real effective exchange rate with consumer prices, and real effective exchange rate with producer prices for North Macedonia were retrieved from the National Bank of the Republic of North Macedonia, while GDP and imports at constant prices were retrieved from the State Statistical Office. The observed period covers quarterly data from 2005q1 to 2019q1. Figures A1 and A2 in the Appendix show the development of the observed series in Serbia and North Macedonia. A real effective exchange rate index above 100 is a sign of appreciation, while below100 indicates depreciation.

Tables A1 and Table A2 in the Appendix summarise the descriptive statistics of the observed series for Serbia and North Macedonia. Like previous studies (Sula, 2011; Fang-Yuan & Jun-Guo, 2013; Bošnjak et al., 2019), we follow a quantile regression approach and specify the model in Equation (1):

$$\ln\left(FXR_i\right) = \beta_0 + \beta_1 \ln\left(GDP_i\right) + \beta_2 \ln\left(REER_i\right) + \beta_3 ln\left(M2_1 / GDP_i\right) + \varepsilon_i \qquad (1)$$

where FXR_i is foreign exchange reserves of a country at quarter i, GDP_i is GDP at constant prices of a country at quarter i, $REER_i$ is real effective exchange rate (with consumer prices), and M2 is monetary aggregates of a country at quarter *i*. Depending on data availability, we further considered nominal effective exchange rate and real effective exchange rate (with producer prices) as determinants of foreign exchange reserves in Serbia and North Macedonia.

The paper also provides results from a more conventional time series approach. We employed several unit root tests to examine whether the observed time series were stationary, and then tested for the existence of a cointegrating relationship between reserves and their determinants for both countries. Since standard unit root tests are well known to have low power, in order to improve the validity of the results we employed several different unit root tests, namely the Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979), the Phillips–Perron (PP) test (Phillips & Perron, 1988), the Generalised Least Squares and Dickey-Fuller test by Elliot, Rothenberg and Stock (ERS) (Elliot et al., 1996) and the Kwiatkowski, Phillips, Schmidt and Shin test (KPSS) (Kwiatkowski, et al., 1992). We then employed the Johansen (1995) cointegration approach to test the existence of cointegration between foreign exchange reserves and their determinants for each

sample country. The coverage ratio of imports by foreign exchange reserves for the recent period was obtained using Equation (2):

$$CR_i = \frac{FXR_i}{IMP_i} \tag{2}$$

where FXR_i is foreign exchange reserves of a country at year i, IMP_i is average monthly imports of goods and services at constant prices in a country in year i, and consequently CR_i represents the coverage ratio of imports by foreign exchange reserves for a country at year i.

4. EMPIRICAL ANALYSIS

Following Equation (1), we first provide estimates for Serbia, which are summarized in Table 1.

Table 1: determinants of foreign exchange reserves

Quantile	Intercept		GDP		REER		M2/GDP	
	Estimates (standard error)	p-value	Estimates (standard error)	p-value	Estimates (standard error)	p-value	Estimates (standard error)	p-value
0.10	−9.33771 (6.94758)	0.18467	0.85257 (0.53452)	0.11666	1.46086 (0.46743)	0.00288	0.33025 (0.11296)	0.00508
0.20	1.43735 (5.22328)	0.78425	0.00759 (0.39217)	0.98463	1.64073 (0.41656)	0.00024	0.42929 (0.09591)	0.00004
0.30	−2.04080 (7.08724)	0.77450	0.18454 (0.53716)	0.73255	1.85965 (0.46234)	0.00018	0.31841 (0.11125)	0.00601
0.40	−2.95392 (5.85151)	0.61578	0.39386 (0.44347)	0.37848	1.46110 (0.44234)	0.00172	0.29287 (0.09611)	0.00360
0.50	−3.74642 (5.29641)	0.48245	0.47366 (0.40744)	0.25022	1.40537 (0.36814)	0.00035	0.31160 (0.08696)	0.00074
0.60	−0.66230 (3.99844)	0.86907	0.32248 (0.23386)	0.17370	1.19518 (0.42663)	0.00709	0.25919 (0.06411)	0.00017
0.70	1.57820 (6.52056)	0.80969	0.16071 (0.44617)	0.72013	1.19314 (0.48290)	0.01673	0.28710 (0.10956)	0.01143
0.80	7.95434 (4.81329)	0.10433	−0.14170 (0.30234)	0.64122	0.71891 (0.40166)	0.07919	0.15557 (0.07544)	0.04412
0.90	6.80275 (2.14788)	0.00255	− 0.10377 (0.16021)	0.51996	0.84995 (0.19175)	0.00005	0.10017 (0.03867)	0.01234

The estimates in Table 1 illustrate the effects of real effective exchange rates (with consumer prices), GDP levels, and M2/GDP on foreign exchange reserves at different quantiles of exchange rate reserves in Serbia. Real effective exchange rate indexes above 100 indicate an appreciation of the dinar, and indexes below 100, indicate a depreciation. Therefore, the appreciation of the real effective exchange rate of the dinar corresponds to an increase in foreign exchange reserves and the relationship is statistically significant across all the considered quantiles. Serbia's GDP level was not found to be a significant determinant of foreign exchange reserves, while monetary aggregates M2/GDP was significant. Therefore, the accumulation of foreign exchange reserves in Serbia can be explained by changes in the real effective exchange rate and monetary aggregates M2/GDP, with the former showing more prominent effects.

While some papers observe the effects of real exchange rates on foreign exchange reserves (e.g. Sula, 2011), other papers (e.g., Bošnjak et al., 2019) examine the effects of nominal exchange rate on foreign exchange reserves. To get a clearer picture, we estimated the specification for Serbia with foreign exchange reserves as the dependent variable and nominal effective exchange rate level, GDP level, and monetary aggregates M2/GDP as independent variables. The results are provided in Table A3 in the Appendix, which shows that the GDP level only has a significant effect at the lowest quantile of foreign exchange reserves. The nominal effective exchange rate was a significant determinant at the lower levels of foreign exchange reserves, while M2/GDP was significant at both lower levels and the highest levels. Following the same procedure, Table 2 provides the estimates for North Macedonia.

Table 2: North Macedonia: determinants of foreign exchange reserves

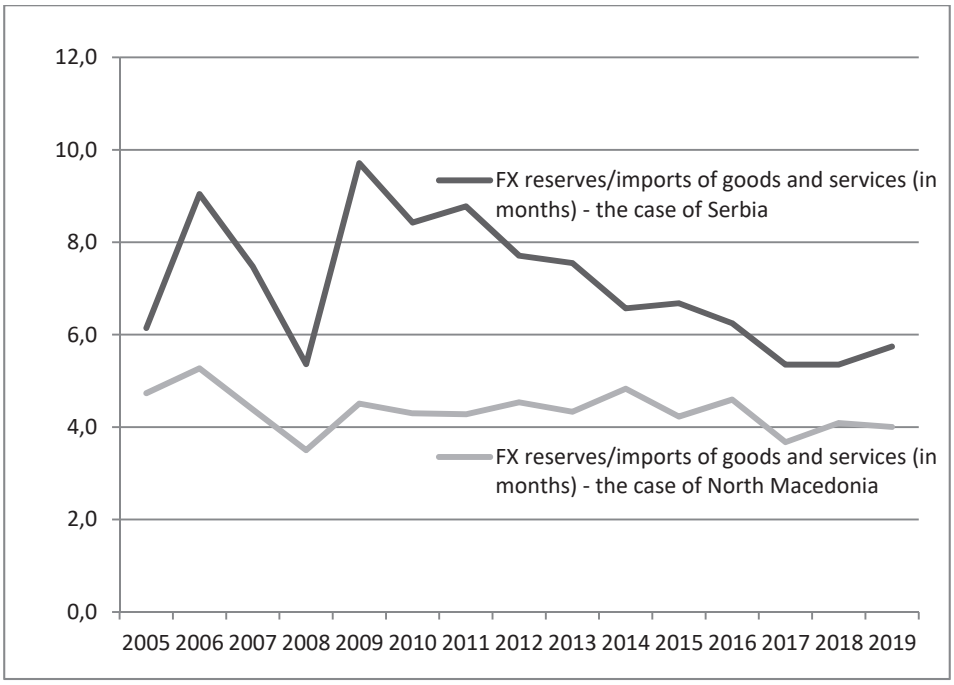
Quant.	Intercept		GDP		REER		M2/GDP	
	Estimates (standard error)	p-value	Estimates (standard error)	p-value	Estimates (standard error)	p-value	Estimates (standard error)	p-value
0.10	4.69340 (5.71781)	0.41542	1.26501 (0.19460)	0.00000	–2.70602 (1.66524)	0.11009	0.73523 (0.32918)	0.02976
0.20	3.85095 (4.75524)	0.42166	1.23635 (0.10809)	0.00000	–2.47441 (1.20060)	0.04423	1.02548 (0.18936)	0.00000
0.30	4.39448 (4.65766)	0.34971	1.20310 (0.11677)	0.00000	–2.47315 (1.19222)	0.04291	0.76264 (0.18869)	0.00017
0.40	5.46445 (5.32301)	0.30929	1.21622 (0.15105)	0.00000	–2.74379 (1.43270)	0.06088	0.84456 (0.26753)	0.00263
0.50	3.57882 (4.22092)	0.40032	1.19423 (0.12302)	0.00000	–2.27999 (1.14534)	0.05168	0.88622 (0.23590)	0.00043
0.60	1.38314 (3.94201)	0.72707	1.11096 (0.11577)	0.00000	–1.54938 (1.06314)	0.15092	0.61830 (0.21806)	0.00646
0.70	1.94031 (4.34728)	0.65718	1.08278 (0.11302)	0.00000	–1.59722 (1.10079)	0.15268	0.62275 (0.23851)	0.01171
0.80	1.02882 (4.20131)	0.80749	1.07700 (0.11066)	0.00000	–1.36043 (1.06979)	0.20904	0.47260 (0.21684)	0.03376
0.90	–0.36967 (4.22486)	0.93060	1.20822 (0.07842)	0.00000	–1.36572 (0.96190)	0.16152	0.36193 (0.17088)	0.03887

The estimates in Table 2 find a different effect of real effective exchange rates (with consumer prices) on foreign exchange reserves in the case of North Macedonia. The effects were significant below the median level of foreign exchange reserves. At the lowest level and above the median level of foreign exchange reserves the effects from the real effective exchange rate vanished. The effects of the level of GDP on foreign exchange reserves in North Macedonia were significant and counter-cyclic across all quantiles. The National Bank of North Macedonia also provides data on real effective exchange rates (with producer prices). Therefore, an alternative specification for North Macedonia has foreign exchange reserves as the dependent variable and real effective exchange rates (with producer prices) and GDP level as independent variables. The results are given in Table A4 in the Appendix, which illustrates that in North Macedonia the

effect of GDP levels on foreign exchange reserves remains significant and counter-cyclic across all quantiles. The effect of monetary aggregates M2/GDP was significant and positive across all quantiles. However, the effect of the level of real effective exchange rates (with producer prices) was positive and significant at higher levels of foreign exchange reserves.

The quantile regression results reveal the determinants of foreign exchange reserves in Serbia and North Macedonia and that the magnitude of the determinants' effects differs across foreign exchange reserve quantiles. To establish a link with the conventional approach to time series analysis, Table A5 in the Appendix provides unit root test results for Serbia and North Macedonia, which show that each of the considered series is integrated of order 1, taking intoaccount both trend and constant. Consequently, the Johansen (1995) cointegration test was performed and the results are summarised in Table A6 and Table A7 in the Appendix, for Serbia and North Macedonia respectively. The results in Table A6 indicate two significant cointegrating relationships in the case of Serbia, while the results in Table A7 show the existence of one cointegrating relationship in the case of North Macedonia. Thus, in these two cases the relationship between foreign exchange reserves and their determinants could be examined using conventional time series analysis and cointegration. In both cases, foreign exchange reserves were determined using effective exchange rate level and monetary aggregates M2/GDP, while effects from GDP were found to be significant and not pro-cyclical only for North Macedonia. However, we still know nothing about the adequacy of foreign exchange reserves. To shed some light on this we use Equation (2) in the research data and methodology section of this paper, while recognising that the international economics literature often assumes that a country should maintain sufficient reserves to cover at least one-quarter of imports (Moore and Glean 2016). The results for the case of Serbia are provided in Figure 1.

Figure 1: Coverage of imports by foreign exchange reserves



As illustrated in Figure1, in the case of Serbia foreign exchange reserves cover almost two quarters of imports, which can be considered satisfactory. The Croatian National Bank holds even higher amounts of foreign exchange reserves compared to the level of imports (Bošnjak et al. 2019). Figure 1 shows that the coverage of imports by foreign exchange reserves in North Macedonia is lower than in Serbia. However, the foreign exchange reserves cover the level of imports for more than one quarter and therefore can be considered satisfactory.

5. CONCLUDING REMARKS

Several conclusions can be drawn from the research presented in this paper. First, in North Macedonia the foreign exchange reserves are significantly determined by the real effective exchange rate, monetary aggregates M2/GDP, and the level of GDP. In Serbia the effect of GDP on foreign exchange reserves is not significant, while the level of real exchange rate and monetary aggregate M2/GDP

is significant at some quantiles. In North Macedonia the effect of foreign exchange reserve accumulation on the national economy is counter-cyclical.

The quantile regression approach was confirmed as useful for revealing the difference between effects on the foreign exchange reserves and its determinants across various quantiles, while the traditional cointegration approach to time series analysis can also provide results in these two cases. Following the usual assumption in the literature on international economics, the foreign exchange reserves in Serbia and North Macedonia are satisfactory. However, the level of foreign exchange reserves compared to the level of goods and services imports is slightly lower in North Macedonia than in Serbia. Furthermore, in both countries the reserve coverage of imports is lower than in Croatia (Bošnjak et al. 2019). These results address the question of reserve adequacy, taking into account reserves arising from foreign exchange rate stability and other economic structures as well as the standard criterion of import levels.

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Received: November 11, 2019
Accepted: July 06, 2020

APPENDIX

Figure A1: Development of the observed series, Serbia

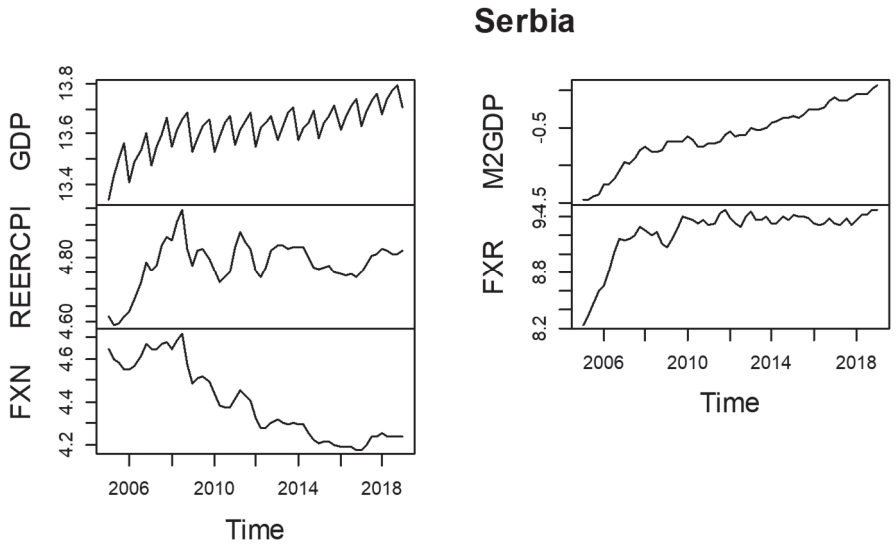

Figure A2: Development of the observed series, North Macedonia

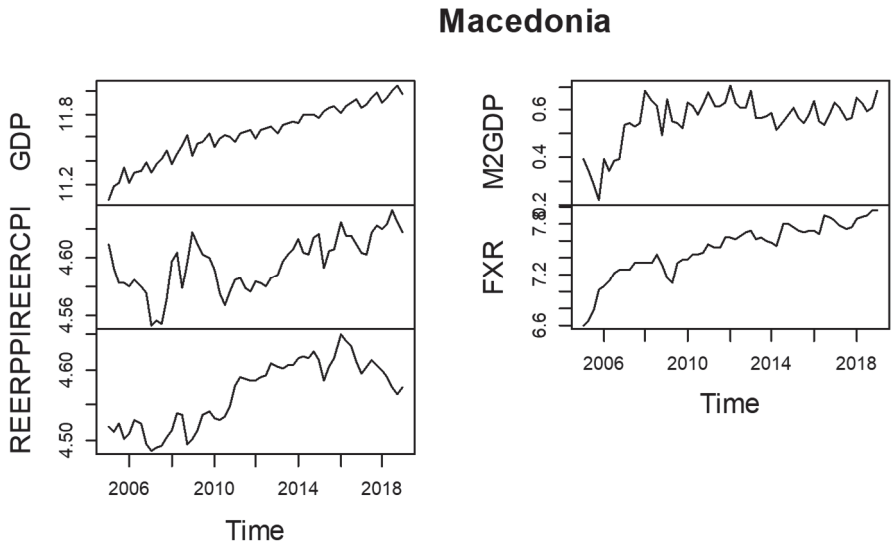

Table A1: Descriptive statistics of the observed variables in (natural) log levels, Serbia

	FXR	REERCPI	REERPPI	GDP	M2GDP
Min.	8.248	13.34	4.177	4.592	–1.46190
1st Q	9.204	13.57	4.237	4.752	–0.79017
Media	9.321	13.63	4.331	4.781	–0.58860
Mean	9.237	13.62	4.395	4.780	–0.59178
3rd Q	9.381	13.68	4.554	4.826	–0.31318
Max.	9.473	13.79	4.720	4.947	0.08809

Table A2: Descriptive statistics of the observed variables in (natural) log levels, North Macedonia

	FXR	REERCPI	REERPPI	GDP	M2GDP
Min.	6.603	4.553	4.485	11.06	0.2166
1st Q	7.328	4.582	4.524	11.49	0.5414
Media	7.571	4.598	4.584	11.65	0.5798
Mean	7.504	4.596	4.567	11.64	0.5601
3rd Q	7.726	4.609	4.608	11.82	0.6219
Max.	7.961	4.633	4.651	12.05	0.7073

Table A3: Serbia: nominal effective exchange rate, GDP, and M2/GDP as reserve determinants

Qu.	Intercept		GDP		FX		M2GDP	
	Estimates (standard error)	p-value	Estimates (standard error)	p-value	Estimates (standard error)	p-value	Estimates (standard error)	p-value
0.10	–7.43093 (5.45322)	0.17875	0.88424 (0.42601)	0.04280	1.11182 (0.27350)	0.00016	0.80319 (0.16127)	0.00001
0.20	0.73252 (8.74863)	0.93359	0.37196 (0.67151)	0.58197	0.84968 (0.28186)	0.00394	0.74532 (0.22676)	0.00180
0.30	–2.81231 (6.91174)	0.68573	0.73775 (0.51849)	0.16063	0.50716 (0.22861)	0.03083	0.51115 (0.14422)	0.00083
0.40	–2.38379 (4.94778)	0.63194	0.82129 (0.38438)	0.03726	0.13654 (0.23738)	0.56759	0.28783 (0.18201)	0.11973
0.50	3.59236 (5.25109)	0.49688	0.42715 (0.39726)	0.28714	0.00181 (0.24546)	0.99415	0.23376 (0.16558)	0.16387
0.60	4.10004 (5.70692)	0.47565	0.43209 (0.43277)	0.32261	–0.13260 (0.20438)	0.51928	0.16689 (0.14954)	0.26944
0.70	8.00665 (2.86892)	0.00729	0.17038 (0.20904)	0.41867	–0.20767 (0.16236)	0.20643	0.13657 (0.07188)	0.06289
0.80	6.89781 (5.48150)	0.21377	0.25652 (0.41085)	0.53508	–0.22375 (0.20670)	0.28394	0.09991 (0.13115)	0.44955
0.90	7.31144 (2.16869)	0.00140	0.12777 (0.16003)	0.42818	0.09703 (0.10725)	0.36970	0.14578 (0.04608)	0.00258

Table A4: North Macedonia: real effective exchange rate (PPI), GDP, and M2/GDP as reserve determinants

Qu.	Intercept		GDP		REER		M2GDP	
	Estimates (standard error)	p-value	Estimates (standard error)	p-value	Estimates (standard error)	p-value	Estimates (standard error)	p-value
0.10	–7.42079 (2.51188)	0.00467	0.97979 (0.23900)	0.00014	0.59257 (1.04446)	0.57287	1.29143 (0.23641)	0.00000
0.20	–6.66121 (1.81206)	0.00055	1.05587 (0.13676)	0.00000	0.24165 (0.60032)	0.68891	1.25202 (0.15477)	0.00000
0.30	–6.72365 (1.55650)	0.00007	1.09538 (0.09410)	0.00000	0.16382 (0.45546)	0.72052	1.19407 (0.22346)	0.00000
0.40	–6.57317 (1.60615)	0.00015	1.08722 (0.07828)	0.00000	0.20382 (0.44037)	0.64538	0.82269 (0.27860)	0.00468
0.50	–6.99333 (1.77075)	0.00023	0.97040 (0.06241)	0.00000	0.61649 (0.43811)	0.16522	0.72699 (0.22668)	0.00227
0.60	–6.91716 (1.80594)	0.00034	0.91857 (0.07046)	0.00000	0.75307 (0.44999)	0.10012	0.59413 (0.30373)	0.05573
0.70	–7.11332 (1.45986)	0.00001	0.86351 (0.06470)	0.00000	0.94995 (0.37678)	0.01474	0.52039 (0.20765)	0.01531
0.80	–7.52372 (1.17604)	0.00000	0.87828 (0.07187)	0.00000	1.00507 (0.34382)	0.00508	0.51851 (0.13987)	0.00050
0.90	–7.39751 (1.13799)	0.00000	0.81716 (0.06070)	0.00000	1.14953 (0.30430)	0.00040	0.45795 (0.15765)	0.00535

Table A5: Unit root tests results

Country	Variable	ADF test		PP test		KPSS test		ERS test	
		in levels	in first differences	in levels	in first differences	in levels	in first differences	in levels	in first differences
Serbia	FXR	–4.156628	–5.134988	–5.132148	–5.874207	0.202598	0.166133	–1.379861	–5.870315
	GDP	–2.995651	–2.434635	–7.194879	–21.21190	0.178495	0.181943	–1.665226	–0.658511
	FXN	–1.540971	–6.294224	–1.870615	–5.016980	0.131298	0.082816	–1.680600	–5.920211
	REERCPI	–3.586732	–6.333394	–2.462531	–5.242706	0.130342	0.081822	–1.956483	–5.864765
	M2/GDP	–3.297893	–2.431605	–2.522962	–6.939331	0.123176	0.122676	–2.047954	–2.546579
North Macedonia	FXR	–4.088525	–6.106526	–4.274519	–7.022392	0.152750	0.106065	–2.179140	–7.040507
	GDP	–2.552490	–4.176320	–6.944425	–20.11255	0.244564	0.124874	–0.924322	–0.745516
	REERPPI	–0.157092	–5.308247	–1.609222	–8.122750	0.176593	0.156815	–2.291124	–5.981324
	REERCPI	–3.783321	–6.521547	–3.822466	–8.850594	0.098318	0.094725	–2.673578	–6.229208
	M2/GDP	–3.882422	–2.680639	–3.070697	–16.20661	0.182085	0.135798	–2.728272	–1.632092

Table A6: Johansen (1995) cointegration test, Serbia

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 CriticalValue	p-value
None	0.632315	87.64196	47.85613	0.0000
At most 1	0.333010	32.61291	29.79707	0.0231
At most 2	0.169546	10.33903	15.49471	0.2555
At most 3	0.002198	0.121000	3.841466	0.7279
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 CriticalValue	p-value
None	0.632315	55.02905	27.58434	0.0000
At most 1	0.333010	22.27388	21.13162	0.0344
At most 2	0.169546	10.21803	14.26460	0.1980
At most 3	0.002198	0.121000	3.841466	0.7279

Table A7: Johansen (1995) cointegration test, North Macedonia

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 CriticalValue	p-value
None	0.549527	75.43532	47.85613	0.0000
At most 1	0.258549	31.57523	29.79707	0.0309
At most 2	0.168360	15.12221	15.49471	0.0568
At most 3	0.086611	4.982621	3.841466	0.0256
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 CriticalValue	p-value
None	0.549527	43.86010	27.58434	0.0002
At most 1	0.258549	16.45301	21.13162	0.1995
At most 2	0.168360	10.13959	14.26460	0.2029
At most 3	0.086611	4.982621	3.841466	0.0256