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Foreign Exchange Reserves as a Shock Protection – the Example of Bosnia and Herzegovina

Девизне резерве као заштита од шока – примјер Босне и Херцеговине

Summary

Significant increase in foreign exchange reserves in recent decades, including the period of the global financial crisis of 2008 and 2009, has intensified research on the importance and role of foreign exchange reserves and their adequate level. Although the financial crisis has emphasised the importance of maintaining an adequate level of foreign exchange reserves, there is insufficient consensus on the level of foreign exchange reserves that should be maintained in the event of crises and shocks.

This paper explores foreign exchange reserves of Bosnia and Herzegovina and their adequate level over the period from 2005 to 2015 as well as in the event of a shock which can be generated by internal or external factors.

The aim of this paper is to examine whether foreign exchange reserves of Bosnia and Herzegovina were sufficient in the observed period as well as in the event of shocks that national economy could be exposed to.

For the research purposes, comparative method and the application of sensitivity analysis and scenarios were used to analyse and evaluate the adequacy of foreign exchange reserves of Bosnia and Herzegovina. The final results demonstrate that

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during the observed period foreign exchange reserves of Bosnia and Herzegovina were adequate. However, in the case of extreme shocks Bosnia and Herzegovina does not possess the sufficient level of foreign exchange reserves. Such findings recommend to the Central Bank of Bosnia and Herzegovina, together with other economic policies, additional efforts to accumulate foreign exchange reserves in the medium term.

Key words: *foreign exchange reserves, shock, adequacy, Bosnia and Herzegovina.*

Резиме

Значајан раст девизних резерви посљедњих декада, не изузимајући ни период током глобалне финансијске кризе 2008/09. године, интензивирао је истраживања о важности и улози девизних резерви, те њиховом адекватном нивоу. Иако је финансијска криза додатно ставила акценат на важност одржавања адекватног нивоа девизних резерви, постоји мало сагласности око тога који је ниво девизних резерви потребно одржавати у случају кризних стања и шокова.

У контексту важности девизних резерви, овим радом се истражује обим девизних резерви Босне и Херцеговине и ниво њихове адекватности током периода од 2005. године до 2015. године и у случају шока, који може да буде генерисан унутрашњим или спољашњим факторима.

Циљ је испитати да ли су девизне резерве БиХ биле достатне у посматраном периоду, као и у случају шокова којима босанскохерцеговачка економија може бити изложена.

Методом компарације, примјеном анализе осјетљивости и сценарија, истражује се и оцјењује степен адекватности девизних резерви БиХ. Исходи примјењених метода показују да су током посматраног периода девизне резерве БиХ биле адекватне, али да у случају екстремних шокова БиХ не располаже достатним нивоом девизних резерви. Овакви налази препоручују Централној банци БиХ, у координацији са другим економским политикама, додатне напоре за акумулацију девизних резерви у средњорочном периоду.

Кључне ријечи: *девизне резерве, шок, адекватност, Босна и Херцеговина.*

1 Introduction

Foreign exchange reserves play a dominant role in the majority of small and open economies, since they are an insurance tool against shocks which open econo-

mies can be exposed to. If foreign exchange reserves act in accordance with good economic policies in the country, they can help reduce the crisis of the balance of payments and serve as a basis for ensuring economic and financial stability.

Foreign exchange reserves are the most important in economies which apply the policy of fixed exchange rate. In that case, foreign exchange reserves should ensure the stability of the currency, and also be the capital base in the event of shocks.

The Central Bank of Bosnia and Herzegovina applies the currency board policy which is based on the fixed exchange rate of the domestic currency pegged to the euro, whereby the emitted currency must be fully covered by foreign exchange reserves. Such policy calls for the necessity of careful monitoring and management of foreign exchange reserves, which, in addition to covering the domestic currency, have to provide a certain level of protection in the event of shocks generated by internal and external factors.

The study assessed the adequacy of foreign exchange reserves of Bosnia and Herzegovina in the period from 2005 to 2015, as well as their sufficiency in the case of extreme shocks BiH economy may be exposed to.

The research problem was set in the form of a scientific question and defined as follows: What is the optimal level of foreign exchange reserves of Bosnia and Herzegovina in situations of sudden external shocks?

The assessment of adequacy of foreign exchange reserves was performed by using standard metrics (foreign exchange reserves should cover three months of imports, 20% of the widest monetary aggregate and 100% of short-term foreign debt) and the analysis of sensitivity and scenarios developed by Jeanne and Rancière (2008), which, in this assessment of the adequacy of foreign exchange reserves, include shocks that the economy may be exposed to.

Based on the defined research problem, a research hypothesis is determined:

– Foreign exchange reserves of Bosnia and Herzegovina are not sufficient in the case of strong external shocks.

The hypothesis has been proved by using the method of scenarios based on the model developed by Jeanne and Rancière (2008).

This study is divided into several parts: in addition to the introduction, the second part defines the term, role and importance of foreign exchange reserves. The third part analyses the methods and models used in evaluating the adequacy of foreign exchange reserves. The fourth part shows the results of the research, that is, the adequacy of foreign exchange reserves during the analysed period as well as the required level of foreign exchange reserves in the case of external shocks. The fifth part presents research findings and recommendations. This paper gives an explanation of the methodology of the model that was used to evaluate the optimality of foreign reserves.

2 Foreign exchange reserves: concept and role

2.1 Foreign exchange reserves

Foreign exchange reserves are defined as foreign assets which are controlled by monetary authorities and directly available for the purpose of financing the imbalance of balance of payments, interventions in the foreign exchange market or for other purposes, such as maintaining confidence in the domestic economy and currency or as a basis for borrowing abroad (Mwase, 2012).

Foreign exchange reserves have different purposes and one of the most important is the protection from external shocks in conditions of high degree of euroisation, as well as high external imbalances. Crispolti and Tsibouris (2011) find that foreign exchange reserves are one of the most important insurances against external shocks if there is no structural support of fiscal policy in the country.

The Central Bank of Bosnia and Herzegovina holds and manages foreign exchange reserves in order to preserve the fixed exchange rate of the domestic currency, implementing the currency board policy. The currency board policy implies that primary money must be 100% covered by net foreign currency reserves[3]. Starting from this rule, it is clear that foreign exchange reserves play an essential role in BiH monetary policy, that is, the primary role in the functioning of monetary policy. The Central Bank of Bosnia and Herzegovina should maintain an optimal level of foreign exchange reserves in order to ensure the implementation of monetary policy, but also to have a certain capital base in the event of shocks, both internal and external.

2.2 Role of foreign reserves

There are many reasons why countries have foreign exchange reserves and manage them. Some of the explanations are strengthening confidence in the national currency, mitigation of strong market distortions, support for the conduct of monetary policy, building financial assets for international purposes and influencing the exchange rate. Foreign exchange reserves can provide a number of benefits for the country that owns them, but possessing and managing them is not without risk and costs, especially in the case of crisis when yields on foreign exchange reserves are significantly reduced.

[3] Gross foreign reserves consist of the balance sheet positions of short-term foreign assets of the CBBH (gold, CBBH SDR holdings, foreign currencies in the CBBH vault, short-term foreign exchange deposits with non-resident banks and other) and investments in long-term securities. Source: Central Bank Annual Report BiH 2015, p. 138. Net foreign exchange reserves are gross exchange reserves reduced by liabilities to non-residents.

Research conducted on low-income countries[4] has shown that foreign exchange reserves can effectively help limit macroeconomic volatility and instability that are a result of exogenous shocks (Becker et al. 2007). According to Becker et al. (2007), these countries are exposed to a number of shocks, but they are particularly sensitive to external shocks.

The costs incurred as a result of external shocks are enormous and differ depending on the structural characteristics of the economy (Berg et al. 2011). In such situations, foreign exchange reserves can play an important role in avoiding the effects of shock and macroeconomic volatility (IMF, 2011).

The external shock is an event that causes a significant deterioration in the overall economy, terms of trade, external demand, inflows of foreign direct investment and inflows of foreign aid (Aizenman, 2004). For each mentioned shock it is possible to determine its economic impact as well as costs and effects of GDP and GDP per capita (Aizenman, 2004).

Aizenman (2004) points out that the economic impact of the shock can be assessed by using a five-year framework, which includes the movement of relevant macroeconomic variables from one year before the shock and from three years after the shock. The economic loss that is associated with shocks was determined by the sum of estimated losses, taking into account the trend before and after the shock episode.

Crispolti and Tsibouris (2012) analysed the macroeconomic trends of low-income countries between 1980 and 2007, and concluded that in this period analysed countries faced significant shocks which appeared approximately every ten years. According to the same authors, the probability of shock in FDI inflows was 16%, while the probability of deterioration of climate conditions and trade conditions amounted to 13% and 11% respectively. On the other hand, shocks of external demand were less common. The size of the shock varied depending on its nature. Typically, external demand as well as trade conditions had an impact of approximately two standard deviations relative to the medium value, which implies a decrease in relative prices by approximately 29% in the case of the shock in trade conditions. On the other hand, aid inflows and FDI had a smaller impact, approximately one standard deviation, which is a drop by 3% to 5% in relation to GDP respectively (Crispolti and Tsibouris, 2012).

Crispolti and Tsibouris (2012) also conclude that the episodes of shock are followed by visible deterioration of the macroeconomic situation. The average GDP growth rate slowed down after all types of shock.

[4] Low-income economies, according to the World Bank, are those economies where GDP per capita is 1,025 USD or below that level. More details on: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (Retrieved 04/20/2017).

According to the same authors, during the crisis period the average GDP per capita was crushed, mainly due to a significant deterioration in external demand, while the current account deficit generally increased, and stayed at these levels usually for about two years before returning to pre-crisis levels.

One of the measures assessing the adequacy of foreign exchange reserves is the three-month coverage of imports by foreign exchange reserves. Mwase (2012) investigated the role of foreign exchange reserves during external shocks and came to the conclusion that those countries whose foreign exchange reserves covered more than three months of imports suffered fewer losses in the case of external shocks.

Crispolti and Tsibouris (2012) concluded that countries with a higher level of foreign exchange reserves, in the year preceding the shock, had a better basis for the economic activity. On the other hand, economies whose foreign exchange reserves covered less than three months of imports, mainly recorded significant costs during the period of the shock. Furthermore, the higher level of foreign exchange reserves was associated with simpler adjustment of real GDP per capita and consumption growth.

Crispolti and Tsibouris (2012) investigated the role of foreign exchange reserves during the crisis period of 2008 and 2009. They concluded that countries that accumulated the higher level of foreign exchange reserves during 2007, with foreign exchange reserves covering more than three months of exports, had a better basis for strengthening economic activities and spending, compared to the countries with lower levels of foreign exchange reserves.

3 Models for assessment of foreign exchange reserves as a shock protection

There are different models that evaluate and determine the adequacy of foreign exchange reserves. For the purpose of this report, certain traditional models will be explained, as well as the model developed by Jeanne and Rancière (2008) which presupposes an open economy, highly 'euroised' (the case of BiH) and possibly affected by various internal and external shocks. Such economy must ensure enough foreign exchange reserves which will alleviate the impact of the shock. Also, holding foreign exchange reserves does not come without cost; therefore, this circumstance is also taken into account.

3.1 Metrics for assessing foreign exchange reserves

Considering the importance of foreign exchange reserves as a basis for protection in the event of shocks and crisis, various metrics have been developed on

the basis of which the adequate level of foreign exchange reserves is determined, particularly for developing and transition countries.

The most common measures used for these purposes are:

- Countries that implement restrictions on the inflow and outflow of capital through the capital account often consider the import an appropriate measure, while striving to ensure that imports are sustained in the event of a shock. Foreign exchange reserves are adequate if they cover a minimum of three months of imports. However, this measure has become less important for those countries that have financially opened and whose financial ties have become stronger.
- The ratio between foreign exchange reserves and short-term external debt is another indicator that has been very often used when evaluating the adequacy of foreign exchange reserves. This measure is commonly applicable to the countries with large foreign short-term transactions. The rule is also known as the 'Greenspan-Guidotti' and it is most often used for emerging markets (Greenspan, 1999). Foreign exchange reserves should cover the total short-term foreign debt.
- Economies that have a large banking sector and are open in capital accounts, use the ratio between foreign exchange reserves and the widest monetary aggregate as a measure of adequacy of foreign exchange reserves. It is mostly aggregate M2[5]. Foreign exchange reserves should cover 20% of the monetary aggregate M2.

There are also combined metrics aimed at reaching the level of credit risk of a specific economy. Another commonly used measure is the Greenspan-Guidotti's extended rule, which, in addition to the existing measures, includes the coverage of the current account deficit, which should reflect the need for funding for the period of 12 months.

Wijnholds and Kapteyn (2001) developed a model for assessing the adequacy of foreign exchange reserves which takes into account internal and external crises and shocks. The model comprises of the following components:

- The first measure is similar to the Greenspan-Guidotti rule which implies an external interruption of financing and inability to fulfil commitments.
- The second measure relates to the internal lack of funds or a sudden conversion of the domestic currency into other foreign currencies, whereby this volume can be approximated by a certain percentage of the broadest money supply.

[5] The monetary aggregate M2 represents the money supply in a broader sense. It is the sum of the monetary aggregate M1 and quasi money. M1 includes demand deposits in domestic currency and cash outside banks. Quasi money consists of time deposits in domestic and foreign currency and demand deposits in foreign currency.

The indicator proposed by Wijnholds and Kapteyn (2001) shows that foreign reserves should cover the total amount of the short-term external debt by remaining maturity, which should be increased by 5% to 10% of the broadest monetary aggregate.

Predescu et al. (2011) developed a model for evaluating the adequate level of foreign exchange reserves identifying four potential outflows of financial resources from the country as a result of the crisis.

The first represents the losses that occur as a result of decline in demand for export in foreign currency or a change in the foreign trade. If such changes occur, they reduce export revenues.

Another problem that arises is the impossibility of restoring the external, short-term debt. If such situation occurred it would affect the reduction of foreign exchange reserves through servicing liabilities that are due in the short term. Another way of financing is funding from portfolio investments. In periods of crisis, investors reduce portfolio investment to developing countries. Thus, the third channel of withdrawal or reduction of foreign reserves during the crisis is the withdrawal of portfolio investments.

Also, Predescu et al. (2011) included in their model a part of the biggest money supply used to identify the risk of a sudden movement of residents' capital from the domestic currency to other currencies. The weights for each of the above elements are evaluated for each country in relation to the effects and the development of the crisis. On the basis of the metrics, the crisis that caused the bankruptcy of the Lehman Brothers, caused problems in external financing that lasted for half a year. Based on the above, weights for the short-term external debt are 50% and include all short-term liabilities that mature within next 6 months.

The required coverage of portfolio investment in foreign exchange reserves should be at least 50%, while the coverage of the broadest monetary aggregate should be 5%. The safe level of the coverage of metrics is over 100% (Predescu et al. 2011).

3.2 Model of optimal foreign exchange reserves: sensitivity analysis

An estimate of the adequate size of foreign exchange reserves in most cases is based on the need for foreign exchange reserves to cover three months of imports, the short-term external debt in total and the widest monetary aggregates with 20%. These measures are quite simple, but not applicable in all situations. Also, they are not appropriate for projections of the required amount of foreign exchange reserves in the case of sudden shocks that the economy can encounter. These indicators identify minimum levels of foreign exchange reserves, but do not indicate the preferred upper limit of foreign exchange reserves that should be maintained.

One of the newer and more efficient models that have been developed to indicate the optimal amount of foreign exchange reserves that can amortize shocks is the model developed by Jeanne and Ranciere (2008). The model was developed to determine the optimal level of foreign exchange reserves for a small and open economy that is susceptible to sudden interruptions of capital inflows caused by shocks. The model starts from the fact that the state needs to ensure uninterrupted consumption for the private sector in times of crisis. The assumption is that economy can be in one of the two states - either in a normal state or in a crisis, that is, a state of sudden interruption of foreign financing. The private sector can be protected from external shocks by using foreign exchange reserves. In the event of a sudden suspension of such financing, the state should have the total amount of accumulated reserves at its disposal.

If it is assumed that foreign reserves and external debt are in a foreign currency, then the budget constraint of consumers is expressed in the following way:

$C_t = Y_t + Q_t\left(L_t - (1+r)L_{t-1} + Z_t\right)$ (Jeanne and Ranciere, 2008)

The following applies:
C_t – consumption
Y_t – income
L_t – funds borrowed from abroad - interest on foreign debt
R – interest rate
Z_t – foreign exchange reserves available for consumption
Q_t – foreign exchange rate

The state maximises overall prosperity, taking into account the budget constraint. With this maximisation we calculate the optimal level of foreign exchange reserves (ρ) which compensate for consumption in the case of shock, that is, in the case of a crisis that arises with a certain probability (π), in which case damage occurs (γ) as well as real depreciation (ΔQ). In addition, the optimal level of foreign exchange reserves is determined by the magnitude of external shock (λ), risk aversion (σ) and the country's yield on foreign exchange reserves (r), the index of the bond market of developing countries (δ) and the relative growth of GDP (g), that is:

$$\rho = \frac{\lambda + \gamma - (1 - \frac{(r-g)}{(1+g)}\lambda)(1 - p^{\frac{1}{\sigma}}) + \frac{1+r}{1+g}\lambda\Delta Q}{1 - \frac{\pi}{\pi + p(1-\pi)}(1 - p^{\frac{1}{\sigma}}) + (1 - \frac{\pi}{\pi + p(1-\pi)})\Delta Q}$$ (Detailed model performance is given in the appendix)

Where following applies:

$$p = (1 - \frac{\delta}{(\pi + \delta)(1 - \pi)}(1 + \Delta Q)$$

The final result, expressed by the given formula, indicates the optimal level of foreign exchange reserves as a share of GDP in the specific economy.

4 Results

Based on the presented models, metrics, the optimal level of foreign exchange reserves for Bosnia and Herzegovina has been calculated. The adequacy of foreign exchange reserves has been determined based on the traditional models for the period from 2005 to 2015, as well as the estimate of the required level of foreign exchange reserves as a share in GDP in the case of extreme shocks by using the model developed by Jeanne and Ranciere (2008).

4.1 Traditional metrics of optimal foreign exchange reserves

Based on the presented metrics and models for assessing the adequacy of foreign exchange reserves, the degree of adequacy of foreign exchange reserves of Bosnia and Herzegovina has been calculated. The traditional metrics for assessing the adequacy of foreign exchange reserves, applied by most central banks, are based on the following indicators:

- Coverage of the short-term public foreign debt with foreign exchange reserves - 100% coverage
- Coverage of the three-month imports with foreign exchange reserves - minimum three months of imports
- Coverage of 20% of the monetary aggregate M2 with foreign exchange reserves.

Chart 1 demonstrates the extent to which foreign exchange reserves of Bosnia and Herzegovina were sufficient to cover the mentioned measures during the observed period.

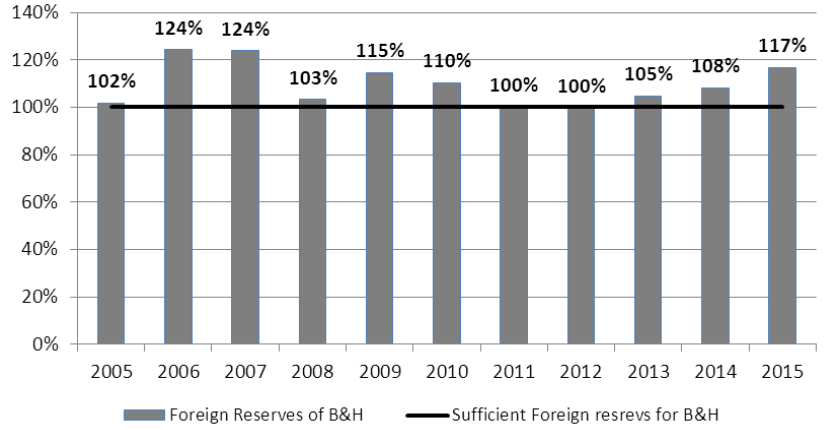

Chart 1: Optimal foreign exchange reserves by standard metrics. Source: Statistics of the Central Bank of Bosnia and Herzegovina, Panorama Necto, authors

For the purpose of calculating the indicators, the real movements of BiH foreign exchange reserves were used to compare them with the total amount of the short-term debt, the average value of quarterly imports, as well as 20% of the value of the monetary aggregate M2 in all observed years. Foreign exchange reserves are adequate if the sum of individual measures is not higher than the total value of foreign exchange reserves.

In this case, the calculated data are shown in percentages for simpler illustration and analysis. The necessary foreign exchange reserves for the whole period are presented with the straight line showing the adequate level of foreign exchange reserves for the observed periods and it is determined at the level of 100%. During 2006 and 2007 foreign currency reserves were 24% higher than required, while after 2008 this percentage decreased. Thus, in 2009 foreign currency reserves were 15% higher than required, while in 2011 and 2012 they were at the lower level of adequacy. After 2012, foreign exchange reserves gradually increased even above the minimum required level.

Although, total foreign exchange reserves steadily increased during the observed period[6] (Chart 3 which demonstrates the movement of gross foreign exchange reserves in relation to GDP), the degree of their adequacy also decreased. There are several reasons for this. After 2008, domestic authorities started rapidly borrowing, both in the country and abroad, while the level of imports also in-

[6] By the end of 2005, gross foreign reserves accumulated to 4.2 billion BAM, while by the end of 2015 they amounted to 8.6 billion BAM.

creased[7]. These two indicators had the greatest impact on the reduction of the adequacy of foreign exchange reserves.

Since the level of debt is something that can be controlled, but can also cause significant shocks, the model was expanded and instead of the measure of covering the short-term external debt, a measure of full coverage of the public debt, both internal and external, was included. It was assumed that the domestic authorities were not able to finance the debt due to domestic and foreign creditors, and that foreign reserves were used for these purposes. An estimate of the adequacy of foreign exchange reserves was carried out in the case the total short-term public debt was covered by foreign exchange reserves, while the other parameters remained unchanged. The results are shown in Chart 2.

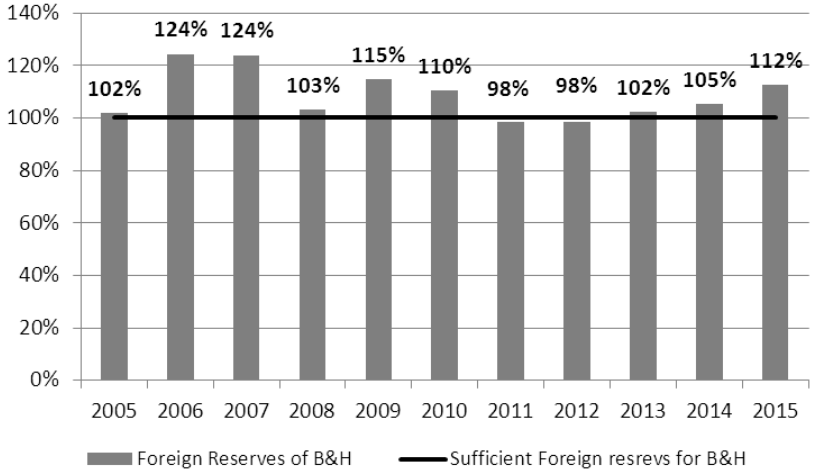

Chart 2: Foreign exchange reserves by standard metrics, increased by internal public debt. Source: Statistics of the Central Bank of Bosnia and Herzegovina, Panorama Necto, authors

If the total short-term debt (both internal and external) was covered by foreign exchange reserves, with the coverage of other elements (three months of import and 20% of M2), foreign reserves would not be adequate in 2011 and 2012 because their level was 2% lower than required. However, in the following year these data improved, and this trend continued until 2015. By the end of 2015 foreign reserves were adequate and covered 20% of the monetary aggregate M2 over three months of import as well as the total short-term external debt of BiH.

[7] By the end of 2005 the total value of imports was 9.92 billion BAM, while by the end of 2015 this figure amounted to 14.3 billion BAM. Data taken from the official statistics of the Central Bank of Bosnia and Herzegovina, see the section: Export and import of goods on the basis of the balance of payments.

The standard metrics used on this occasion to evaluate foreign exchange reserves are based on *ex post* ratings. This means that they show if foreign exchange reserves were adequate in the previous periods and do not give an *ex ante* estimate, i.e., they are unable to forecast the level of foreign exchange reserves needed in the event of sudden shocks. The measures calculated in this way represent the guiding principle of the necessary level of foreign exchange reserves in the conditions of certain parameters (public debt, import and M2). Thus, in the case of BiH, it turned out that if it had been necessary to finance the short-term domestic and external debt from foreign exchange reserves, their level would not have been sufficient in 2011 and 2012.

4.2 Optimal level of foreign exchange reserves – method of scenarios

In addition to the traditional metrics for assessing the adequacy of foreign exchange reserves in previous periods, to estimate foreign exchange reserves we used the model by Jeanne and Ranciere (2008) which determines the required level of foreign exchange reserves as a share of GDP that would be sufficient in the case of a shock or sudden interruption of capital inflows into the economy.

Chart 3 shows the movement of gross foreign exchange reserves, nominal GDP and the share of gross foreign exchange reserves in GDP for the period from 2005 to 2015.

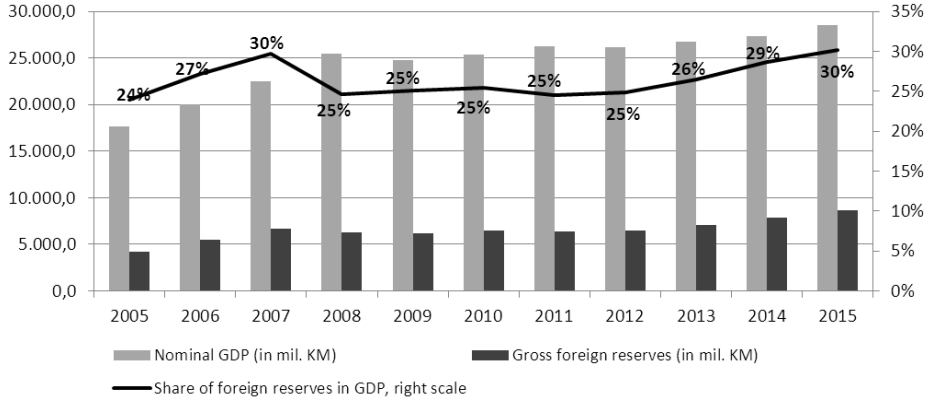

Chart 3: Gross domestic product, gross foreign exchange reserves and the share of foreign exchange reserves in GDP from 2005 to 2015. Source: Statistics of the Central Bank of Bosnia and Herzegovina, Panorama Necto, authors

In the period from 2005 to 2015, the share of foreign exchange reserves in GDP ranged from 24% in 2005 up to 30% in 2007 and 2015. The assessment of the level of foreign exchange reserves in the event of shock with the use of the

method of scenarios and sensitivity method, implies the identification of certain weights, based on which the share of foreign exchange reserves in GDP in BiH is determined. The results and data are shown in Table 1.

Table 1:
Stress scenario of foreign exchange reserves

Mark	Parameter / Scenario	1	2	3	4
Υ	Damage caused by a sudden interruption of capital inflows into the economy (in % of GDP)	7%	7%	7%	7%
r	Yield on reserves	0.40%	0.40%	0.40%	0.40%
g	Average real growth of GDP	1.50%	1.50%	0.00%	0.00%
σ	Risk aversion	2	2	2	2
δ	Bond index of emerging markets	3%	3%	3%	3%
π	Probability of a sudden interruption of capital inflows into the economy	10%	10%	10%	10%
λ	The size of the shock (in % of GDP)	30%	30%	35%	35%
ΔQ	Real depreciation of domestic currency	0%	10%	0%	10%
ρ	**Optimal level of foreign reserves (in % of GDP)**	29.97%	32.36%	35.53%	38.53%
ρ	**Optimal level of foreign reserves (in billions of BAM)**	**8,552.41**	**9,234.83**	**10,139.93**	**10,995.94**

Source: Authors

Four scenarios of potential crisis and shocks are presumed. Some of the measures presented here are taken from the authors who developed the model, tested and analysed the crisis and shocks in 34 developing countries (Jeanne and Ranciere, 2008). The authors covered the period from 1974 to 2003, taking into consideration sudden interruptions of capital caused by shocks in the countries included in the sample. Using the regression and correlation method, authors estimated the effects of shocks, expressed as a percentage relative to GDP, as well as other variables necessary for the above calculations. Given that these grades are calculated on the sample of a number of countries that have similarities with Bosnia and Herzegovina, some measures were taken for this calculation.

The measures taken from these authors are damages caused by a sudden interruption (γ), probability of interruption (π) and risk aversion (σ). Other parameters are estimated according to the current state and the scenario to be evaluated.

In all four scenarios it is assumed that the damage of a suddenly interruption is 7% of GDP, that risk aversion is set at the level of 2 and that the probability of realization of each scenario is 10%, which is in line with Jeanne and Ranicere's model and ratings.

The yield on foreign exchange reserves is fixed at 0.40% for all four scenarios, which is in line with general tendencies in the financial market[8]. Correspondingly, the additional reason for this yield rate is that the weighted interest rate on the total foreign exchange reserves of Bosnia and Herzegovina in 2014 was 0.43%, while in 2015 it amounted to 0.35%[9].

In the first two scenarios, GDP is projected to record real growth of 1.5%, while in the other two scenarios it is assumed that there will be no growth at all, i.e., it will be 0%. Real GDP growth for Bosnia and Herzegovina was negative in 2012, amounting to -0.9%. In 2013 real growth increased to 2.4%, in 2014 it dropped to 1.1% and in 2015 the figure rose again to reach 3%[10]. Considering the fairly volatile growth rates, the authors assume that there will be no economic growth in two scenarios, while in other two scenarios real growth of 1.5% is assumed.

The emerging market bond index refers to the level of yield on government securities that can be realized in these countries. As an index for this analysis, yield rates on China's government bonds were taken as the country is one of the best emerging market representatives. China's government bond yields, maturing between 3 and 30 years, are currently in the range from 3.02% to 3.80%[11].

It was assumed that real depreciation of the domestic currency (BAM) could be achieved by 10% in the second and fourth scenarios. The depreciation of the convertible mark can be observed against the non-euro currencies, due to the fixed exchange rate of the convertible mark against the euro. In 2015 the real exchange rate of BAM was depreciated by 10% against the Swiss franc, while it weakened against the US dollar by about 12% (these are annual changes in the exchange rate)[12].

The size of the shock compared to GDP is estimated at the level of the 30% of GDP for the first two scenarios, while for the third and fourth scenarios it is estimated at 35%. This percentage includes internal shocks that can be intensified, such as withdrawal of deposits or conversion of the domestic currency into the

[8] From 2014 to 2017, short-term interest rates on the EMU market have been negative and ranged from -0.40% to -0.90%. Long-term interest rates have been positive, and for example, the yield on German ten-year bonds at the time of writing this paper is about 0.40%. Nevertheless, the central banks have invested foreign exchange reserves over a longer period, and the projected yield of 0.40% is the result of the total weighted yield on foreign exchange reserves.

[9] Details: Annual Report of the Central Bank of Bosnia and Herzegovina for 2015, p. 44, available at: http://www.cbbh.ba/Content/Archive/36 (Retrieved 30.03.2017).

[10] According to the Central Bank of Bosnia and Herzegovina, Statistics of the Central Bank of Bosnia and Herzegovina: Panorama nectro

[11] According to data published by Bloomberg: www.bloomberg.com (Retrieved 30.03.2017)

[12] Details: Annual Report of the Central Bank of Bosnia and Herzegovina for 2015, p. 44, available at: http://www.cbbh.ba/Content/Archive/36 (30.03.2017).

foreign currency, or even the inability of the government to settle liabilities on the mature short-term debt[13].

Once the parameters for each element of the model were assessed, they were included in the previously given model.

Based on the given model, the required share of optimal foreign exchange reserves in relation to GDP was calculated. Table 1 shows the optimal level of foreign exchange reserves for each scenario calculated by the shown model. The obtained data demonstrate how much of foreign exchange reserves, in relation to GDP, should be maintained by Bosnia and Herzegovina in the event of extreme scenarios. Thus, in the most extreme scenario, the fourth one, foreign exchange reserves should amount to 38.53% of GDP. As a basis for the calculation, the data on the amount of GDP for Bosnia and Herzegovina for 2015, amounting to 28.5 billion BAM, were used.

The most extreme scenario, the fourth one, which implies the real depreciation of the domestic currency of 10% and the size of shock of 35% relative to GDP suggests that foreign exchange reserves should amount to about BAM 10.9 billion.

In the case of the least extreme scenario, the first one, foreign exchange reserves should amount to about 8.5 billion BAM. Data for 2016 show that foreign exchange reserves reached more than 9 billion[14] (Central Bank of Bosnia and Herzegovina, 2016), suggesting that in the case of this scenario foreign exchange reserves would be adequate. However, in the case of extreme scenarios, foreign exchange reserves are not sufficient and would not be sufficient as a protection against shock.

Thus, the hypothesis has been proven: foreign exchange reserves of Bosnia and Herzegovina in situations of strong external shocks would not be sufficient. This particularly applies to situations where strong external shocks would pull internal shocks, such as the rapid conversion of the domestic currency into the foreign currency or the accelerated withdrawal of deposits from banks. Although these scenarios are unlikely to happen, they are not impossible and merely theoretical assumptions. They should certainly be taken into consideration. This leads to the conclusion that the accumulation of foreign reserves should continue.

[13] Similar estimates of the size of shock are taken by Serbia (see: Financial Stability Report for 2015, available at: https://www.nbs.rs/internet/cirilica/90/fs.html). Given that this paper evaluates extreme situations and shocks, for the purpose of this calculation, the stated measures of shock are taken.

[14] On 27 September 2016 foreign exchange reserves of the Central Bank of Bosnia and Herzegovina amounted to BAM 9.37 billion.

5 Conclusion

Small and open economies in transition processes are exposed to numerous internal and external shocks. In the event of crisis situations, sudden interruptions of capital flows to a particular economy, internal shocks, such as the depreciation of domestic currency or the rapid withdrawal of deposits, foreign exchange reserves represent the first line of defence of the stability of the economy.

In this research, the level of adequacy of foreign exchange reserves of Bosnia and Herzegovina from 2005 to 2015 was assessed, using standard models for assessing the adequacy. In addition to the standard metrics, the model of the sensitivity analysis and scenarios was used in evaluating different elements of shocks, both internal and external, as it demonstrates the amount of foreign exchange reserves in Bosnia and Herzegovina necessary to provide insurance against such extreme shocks.

The research results indicate that in the period from 2005 to 2015, with the application of standard metrics, foreign exchange reserves were at the satisfactory level: coverage of 100% of the short-term external debt, coverage of 20% of the monetary aggregate M2 and coverage of three months of imports. In the situation when these measures were tightened and the total short-term debt (internal and external) was included in the level of coverage, foreign exchange reserves of Bosnia and Herzegovina were not adequate in 2011 and 2012. In addition, the analysis was conducted based on the assumed four scenarios of potential crisis and shock, thus proving the hypothesis that foreign exchange reserves of Bosnia and Herzegovina are insufficient in the case of strong external shocks.

The results are presented using different scenarios, four scenarios that point to the different impacts of shock which include a possible real depreciation of the domestic currency, as well as internal shocks measured by the change in GDP.

These findings call for continuous monitoring and checking the volume of foreign exchange reserves based on modelling their optimal rate, as well as constant checking the assumptions on which the budget is based taking into consideration real circumstances that change almost daily.

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Appendix

The assumptions of the model underlying the analysis are elaborated in this Appendix.

Sudden interruption of capital and reserves: some facts

While identifying a model for measuring the required optimal level of foreign exchange reserves, Jeanne and Rancière (2008) analysed the behaviour in domestic absorption, output and reserves in emerging markets that experienced sudden

interruptions in capital inflows. In an open economy, real local absorption can be represented as the difference between real output and trade balance:

$$A_t = Y_t - TB_t \quad (1)$$

In this case, trade balance can be represented as follows:

$$TB = -KA_t - IT_t + \Delta R_t \quad (2)$$

Where:
KA_t – Financial, capital account
IT_t – Foreign income and transfer
$\Delta R = R_t - R_{t-1}$ – Reserve change

Combination of the two above expressions results in the decomposition of domestic absorption as the sum of output, financial accounts, foreign income and a decrease in reserves, i.e.:

$$A_t = Y_t + KA_t + IT_t - \Delta R_t \quad (3)$$

Sudden interruption of capital inflows maintained through the capital account (KA), which, in the case other data are equal, reduces domestic absorption. The impact of sudden interruption of capital on domestic absorption can be enhanced through a decline in domestic output Y or avoided through a decrease in foreign exchange reserves, ΔR. Reserves may be used for the repayment of external credit lines which have not been restored in a situation of sudden interruption of capital inflows, alleviating the need to reduce domestic absorption.

Based on the given expression, the authors identified sudden interruption in year t if capital inflow relative to GDP ($k_t \equiv KA_t / Y_t$) was reduced by more than 5% of GDP in comparison to the previous year, i.e.:

Sudden interruption of capital inflow in year t: $t \Leftrightarrow k_t < k_{t-1} - 5\%$ (4)

Model assumptions

It is assumed that a small and open economy is in the discretion period t = 0, 1, 2,... There is only one commodity consumed in the country and abroad.

Domestic economy is composed of the private and public sectors. The domestic private sector is regarded as a representative consumer with a budget constraint that can be represented by the following expression:

$$C_t = Y_t + L_t - (1+r)L_{t-1} + Z_t \quad (5)$$

Wherein:
Y_t – Domestic output
L_t – Foreign debt of a representative consumer
Z_t – Transfers by the government

The interest rate r is constant while a representative consumer has no problems with the repayment of his foreign debt. Output, as well as the private foreign debt are growing at the same constant rate, g, until the moment of sudden interruption of capital. Sudden interruption of capital inflows is modelled as a crisis which is the result of the inability to re-borrow and the development of the crisis that is associated with a fall in output.

In the event of sudden interruption of capital inflows, two things might happen:

- A representative consumer is not able to borrow again
- Output is reduced by a certain measure (γ), below the long-term level of growth.

It is assumed that the foreign debt of a representative consumer is short-term, which means that L decreases at the moment when sudden interruption of capital occurs. The model assumes that after the moment of sudden interruption, the private foreign debt approaches zero, while output returns to the long-term growth. The assumption is that sudden interruption will occur with a probability π in each period. After sudden interruption of capital, all uncertainties are resolved and the economy is growing at the rate $g < r$.

Designations *b, d* and *a* indicate the flows and current trends before, during and after sudden interruption of capital inflows, respectively.

The designation λ represents the level of the private foreign debt as a share in output before sudden interruption and the assumptions are summarized as follows:

$$Y_t^b = Y_t^a = (1+g)^t Y_0, \quad Y_t^d = (1-\gamma)(1+g)^t Y_0, \tag{5}$$

$$L_t^b = \lambda(1+g)^t Y_0, \quad L_t^d = L_t^a = 0 \tag{6}$$

In this case λ represents the level of private foreign debt as a share in output in the period before sudden capital interruption.

The government, as a representative of public sector, can, unlike the private sector, issue long-term bonds that do not have to be paid at the time of sudden capital interruption. Government bonds have longer maturities with respect to their expected duration, $1/\pi$ providing that π is lower. For example, if π = 0,1 the expected duration of bonds is ten years. The bond price in the period before sudden interruption of capital becomes equal to the present value of discounted

cash flows of one unit of goods to be paid in the future, increased by the expected market value of bonds:

$$P = \frac{1}{1+r+\delta}\left[1+(1-\pi)\right] \tag{7}$$

Respectively:

$$P = \frac{1}{r+\delta+\pi} \tag{8}$$

It is assumed that the bond price is constant before sudden capital interruption, and that it decreases to zero at the moment when sudden capital interruption occurs. In addition, it is assumed that the interest rate used to calculate the current value of the bond is higher than the short-term interest rate *r*. The difference δ can be interpreted as a premium.

The government issues bonds to finance reserves, that is

$$R_t = PN_t \tag{9}$$

Where N_t represents the number of bonds issued by the government in the period t. Reserves must be accumulated before sudden capital interruption because the government cannot issue long-term debt at the moment of sudden capital interruption. If N_t is replaced with N_{t-1} and if applied to the budget constraint, the following is obtained:

$$Z_t + R_t + N_{t-1} = P(N_t - N_{t-1}) + (1+r)R_{t-1} \tag{10}$$

Further, the transfer before sudden interruption may be expressed as follows:

$$Z_t^b = -\left(\frac{1}{P} - r\right)R_{t-1} = -(\delta+\pi)R_{t-1} \tag{11}$$

At the moment when sudden capital interruption occurs, the government transfers reserves to support a representative consumer to repay the external debt that the consumer is unable to re-use:

$$Z_t^d = (1-\delta-\pi)R_{t-1} \tag{12}$$

It is assumed that $\delta + \pi < 1$ provides a positive transfer. After sudden interruption, the government becomes inactive: R_t, N_t, Z_t are equal zero.

By combining expressions 11 and 12 with Z_t in the expression, the level of domestic consumption is obtained before, during and after sudden capital interruption:

$$C_t^b = Y_t^b + L_t^b - (1+r)L_{t-1}^b - (\delta+\pi)R_{t-1}, \quad (13)$$

$$C_t^d = (1-\gamma)Y_t^b - (1+r)L_{t-1}^b + (1-\delta-\pi)R_{t-1} \quad (14)$$

$$C_t^a = Y_t^a \quad (15)$$

The model assumes that the government is trying to maximize the wealth of a representative consumer, which is expressed as follows:

$$U_t = \sum_{s=0,\ldots,+\infty} (1+r)^{-5} u(C_{t+s}) \quad (16)$$

The model also includes utility function that is constant in relation to risk aversion σ:

$$u(C) = \frac{C^{1-\sigma} - 1}{1-\sigma} \quad (17)$$

The inclusion of budget constraints of a representative consumer and the government can be shown as follows:

$$C_t = Y_t + (L_t - PN_t) - (1+r)(L_{t-1} - PN_{t-1}) + PN_t - (1+r+\delta+\pi)PN_{t-1} \quad (18)$$

This expression indicates that accumulation of reserves is equivalent to the replacement of the short-term debt (L) with the long-term debt (PN) in the country. Observed from the aspect of the aggregated budget constraint, holding reserves is equivalent to repaying the short-term external debt through issuing the long-term debt. The long-term debt reduces the risk of re-borrowing, but implies higher interest costs.

The government chooses the level of reserves R_t with the aim of maximizing U_t in each period t, before sudden capital interruption. The optimal level of reserves in the period t maximises the expected utility in period $t + 1$, i.e.:

$$R_t = \arg\max(1-\pi)u(C_{t+1}^b) + \pi u(C_{t+1}^d) \quad (19)$$

Considering previous expressions, indicated with 13 and 14, the first condition is defined as follows:

$$\pi(1-\delta-\pi)u'(C_{t+1}^d) = (1-\pi)(\delta+\pi)u'(C_{t+1}^d) \quad (20)$$

The left side of the expression represents the probability of sudden capital interruption in the period when marginal utility of reserves is a condition of sud-

den interruption. The right side represents the probability that no sudden interruption of capital inflows will occur and that marginal costs are not a precondition for sudden interruption of capital inflows.

If the marginal rate of substitution p_t is assumed to be the marginal rate between consumption in the event of sudden interruption of capital inflows and consumption in the event that there is no such interruption, the following is obtained:

$$p_t \equiv \frac{u'(C_t^d)}{u'(C_t^b)} \tag{21}$$

Furthermore, the first condition points out that in the case when reserves are optimal, this price should be constant and equal:

$$p \equiv \frac{1-\pi}{\pi}\frac{\delta+\pi}{1-\delta-\pi} = 1+\frac{\delta}{\pi(1-\delta-\pi)} \tag{22}$$

If the premium δ is zero, then p is equal to 1, which implies that domestic consumption is perfectly secured from the risk of sudden interruption $(C_t^d = C_t^b)$. If the premium is strictly positive, then p is greater than 1, which implies that domestic consumption is lower in the case of sudden interruption.

By simple manipulation of the first condition, it can be concluded that the optimal reserve level, in normal conditions, is a fixed fraction of the output level, namely:

$$R_t = \rho Y_{t+1}^b \tag{23}$$

And the optimal level of reserves ρ can be expressed as follows:

$$\rho = \frac{\lambda+\gamma-(1-\frac{(r-g)}{(1+g)}\lambda)(1-p^{\frac{1}{\sigma}})+\frac{1+r}{1+g}\lambda\Delta Q}{1-\frac{\pi}{\pi+p(1-\pi)}(1-p^{\frac{1}{\sigma}})+(1-\frac{\pi}{\pi+p(1-\pi)})\Delta Q} \tag{24}$$

Where:

$$p = (1-\frac{\delta}{(\pi+\delta)(1-\pi)}(1+\Delta Q) \tag{25}$$