

MODELING THE RA STATE DEBT USING THE VAR AUTOREGRESSION MODEL

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Introduction. State debt is one of the most important tools of budgetary regulation, contributing to the implementation of the economic strategy of the state. From the point of view of debt sustainability, the country should be able to fulfill its debt obligations in the medium term (solvency) and be able to fulfill the obligations whose repayment period has expired (liquidity). It is necessary to carry out the process of modeling public debt through multifaceted analysis, evaluate public debt using various models: deterministic, stochastic, as well as alternative approaches.

Methodology. The modeling of the debt of the RA government was carried out using the vector autoregression (VAR) econometric model, the results of which were presented through graphs and tables describing the results of impulse shock and variance decomposition. The basis of the model is the debt accumulation formula [IMF, 219-242], the approaches proposed by experts, where the non-fiscal factors affecting the public debt (real interest rate, real GDP growth, real effective exchange rate [CELASUN, 2007, 11-12]) and the primary balance as a function of the fiscal response are considered.

Literature review. There are 3 approaches for debt sustainability analysis and modeling: deterministic, stochastic and alternative. Deterministic models are based on the debt accumulation formula [IMF, 2013, 39-41] and simulations of shocks [IMF, 2013, 22] to its individual elements, as well as defined debt burden thresholds [IMF, 2013, 6-7, 44-45]. One of the most populars is the IMF and WB developed MAC DSA model.

Stochastic models are based on the interrelationships and patterns of debt-forming factors that are projected into the future. The stochastic approach also uses the debt accumulation formula to perform debt simulations [CELASUN, 2007, 22-27]. Joao Medeiros [2012] modeled public debt using a VAR model for several countries, projecting the results onto the fiscal response (primary balance) function. The main disadvantage of using this method is that it is quite difficult to give an economic interpretation for a specific country. For debt management, the World Bank and the International Monetary Fund have developed a systematic and comprehensive model to help countries develop an effective medium-term debt management strategy (MTDS) [IMF, 2012, 1-68].

Alternative approaches include the assessment of the "equilibrium debt/GDP" limit, the assessment of the "fiscal area", the assessment of the "fiscal response function", and other methods of econometric analysis. Note that unlike the deterministic approach, stochastic and alternative approaches generally require time series with sufficient parameters for econometric analysis. Most often, they do not replace, but complement each other. In particular, stochastic and other approaches complement the results of deterministic analysis by considering additional risk assessment tools [Roberta, 2017].

Scientific novelty. By studying foreign literature and international experience, the interaction of public debt and its forming factors was evaluated using the Vector autoregression VAR model. Taking into account the peculiarities of the factors affecting the RA state debt, as debt-forming factors we considered Real GDP growth, real interest rate, real effective exchange rate, and primary balance. The obtained results were compared with the results obtained using the MAC DSA deterministic model. Unlike the deterministic model, the effect of the exchange rate on the debt/GDP ratio is not so great. The real interest rate has a small effect on the primary balance and the debt/GDP ratio, which was also presented when assessing debt sustainability with the help of a deterministic model. These results can be the basis for increasing the rate of decrease of real GDP in the deterministic model for the interest rate shock

Analysis. As we mentioned, various authors have referred to the analysis of the relationship between the state debt and other macroeconomic indicators. It is necessary to take into account that the public debt for each country may have different degrees of sensitivity to changes of macroeconomic indicators (Real GDP growth, real interest rate fluctuations, exchange rate depreciation, changes in the primary balance). The MAC DSA deterministic model was used to estimate the sustainability of public debt, as a result of which it was shown that the public debt/GDP ratio is most sensitive to GDP growth and real exchange rate shocks [Aslanyan, 2021, 165-177]. We also need to evaluate the dependence of debt/GDP ratio on economic indicators using VAR model.

Government debt/GDP ratio, real GDP growth, real interest rate, exchange rate growth and primary balance (% of GDP) were considered as variables in the model. Before building the model, the stationarity of the specified series was checked. All series except the debt-to-GDP ratio and the real effective interest rate are stationary. The debt/GDP ratio is I(1), so its difference series was considered in the model. João Medeiros [2012, 4] considered the real effective exchange rate in a logarithmic version, but in the case of the RA real effective interest rate, it is not stationary and is I(1), so for economic interpretation, we will consider the series with the first-order differences of the ordinary series, which is stationary.

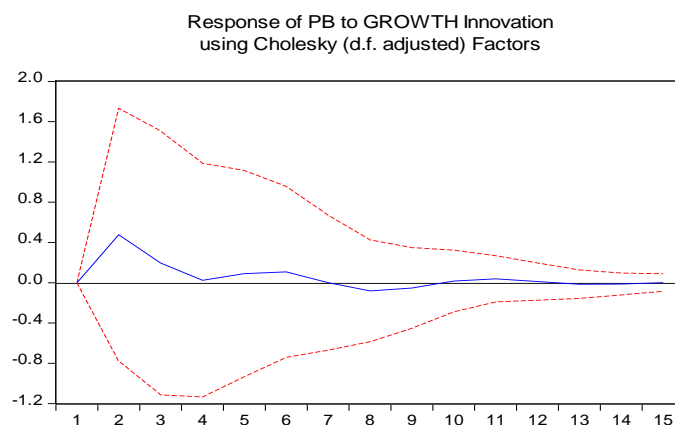
$$Y_t = \gamma_0 + \sum_{k=1}^p \gamma_k Y_{t-k} + \varepsilon_t, \quad t = \overline{2000, 2022} \quad (1),$$

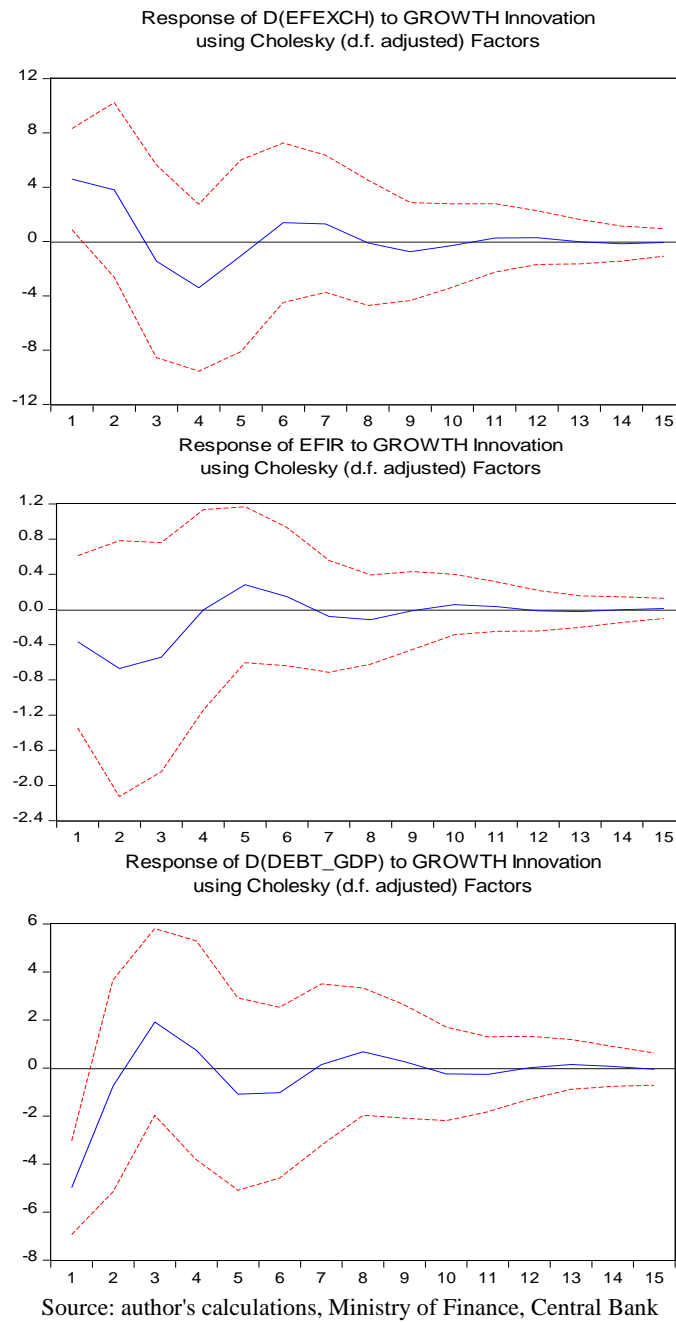
where $Y_t = (PB_t, GROWTH_t, EFIR_t, D(EFEXCH)_t, D(DEBT_GDP)_t)$, $GROWTH_t$ -real GDP growth, PB_t -primary balance (% of GDP), $EFIR_t$ -real effective interest rate, $D(EFEXCH)_t$ -first-order difference of real effective exchange rate, $D(DEBT_GDP)_t$ -first-order difference in the debt-to-GDP ratio.

The optimal number of lags in the model was determined by Akaike, Schwartz, Hannan-Quinn and other reference criteria. According to the test results, the optimal number of lags in almost all dimensions is equal to 1, so one lag was included in the model. For the quality of the model, as well as the reliability of the obtained results, the presence of autocorrelation in the residuals was checked using the serial correlation LM test. In order to check the stability of the model, the inverse root test of the autoregression coefficients was also performed. The estimated VAR is stable (stationary) if all the roots have an absolute value less than one and therefore lie within the unit circle. The results of the test show that the condition of maintaining stability is satisfied in the model, because no root is outside the unit circle [Lütkepohl, 2005, 15]. After ensuring the qualitative aspect of the model, let's present the analysis of the impulse-response functions obtained as a result of the evaluation, which gives an opportunity to evaluate the influence of the macroeconomic indicators included in the model on the public debt and their mutual relationship. Values on the vertical axis in the graphs correspond to the deviation of the variable from its equilibrium level in response to the observed shock. The values on the horizontal axis represent the time elapsed since the shock occurred.

First, let's consider the response of the variables included in the model to the positive shock of Real GDP growth. Thus, real GDP growth leads to an increase in the primary balance, which stabilizes in year 3. A positive shock to real GDP growth also leads to an increase in the exchange rate, which stabilizes in year 7. The effect of real GDP growth also has a minimal effect on the real interest rate. As predicted, real GDP growth leads to a decrease in the Debt/GDP ratio.

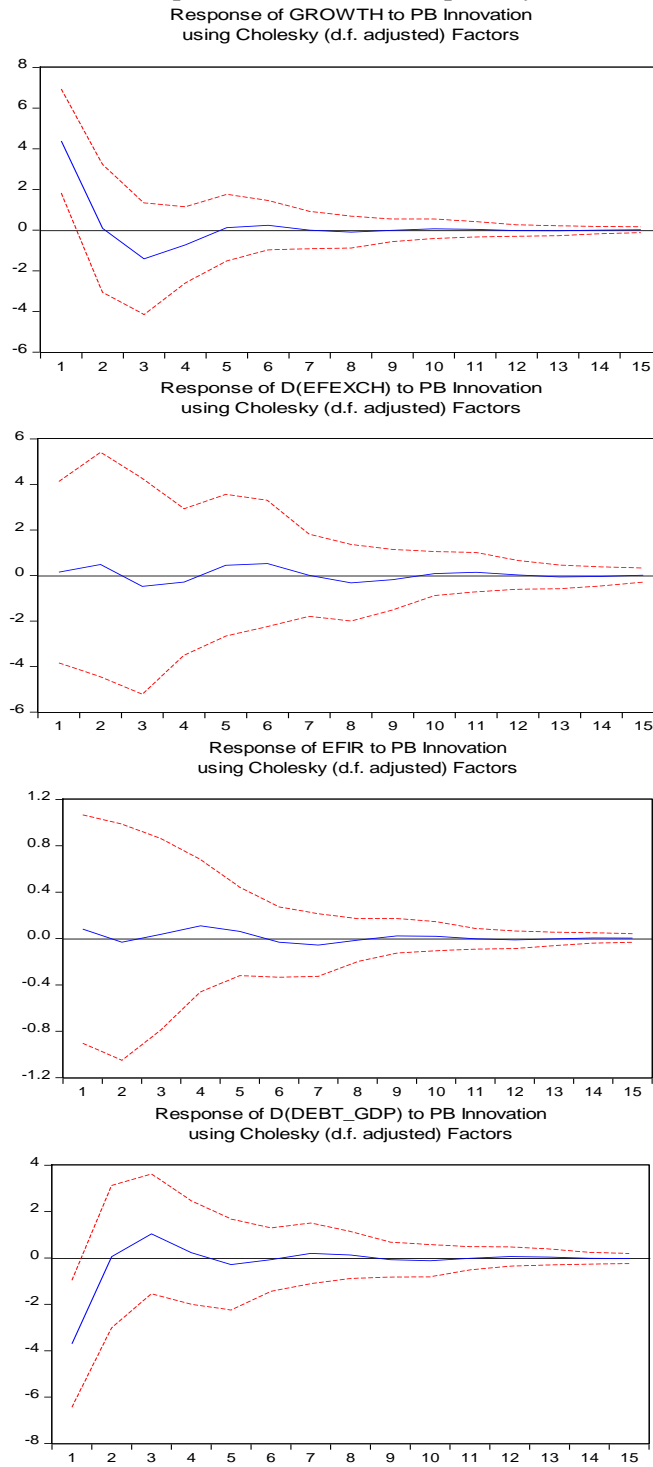
Figure 1. The Response of Variables to a Real GDP Growth Shock





A positive primary balance shock leads to Real GDP growth, which stabilizes in year 5. The effect of the primary balance on the real interest rate (contrary to the theoretical basis of the MAC DSA model) and the effective exchange rate is very small. According to the debt accumulation formula, an increase in the primary balance leads to a decrease in the debt/GDP ratio.

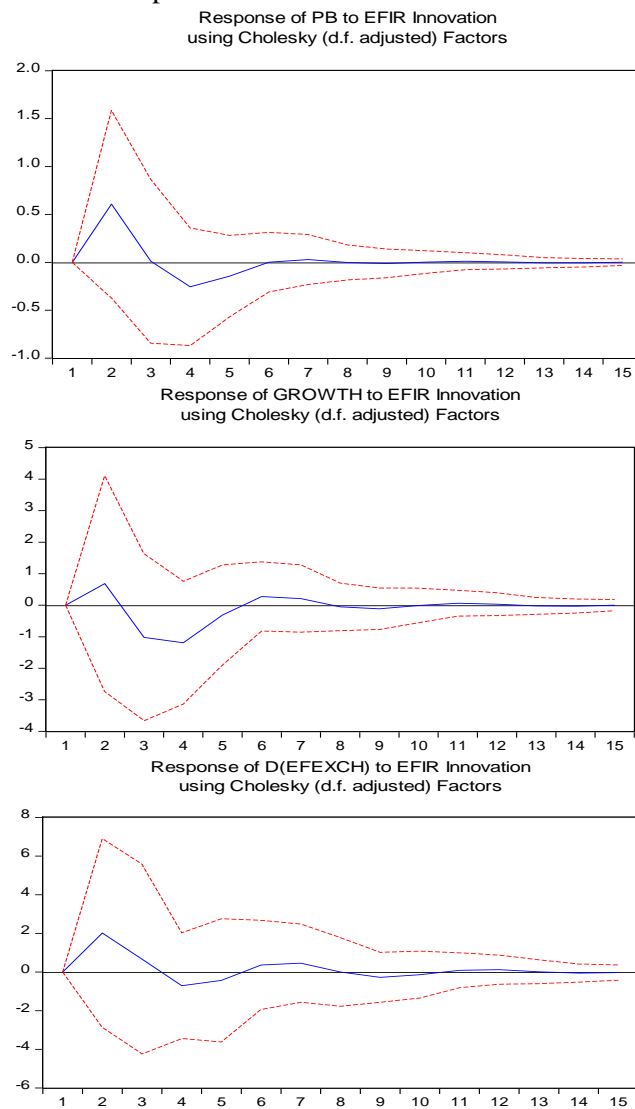
Figure 2. The response of variables to a primary balance shock

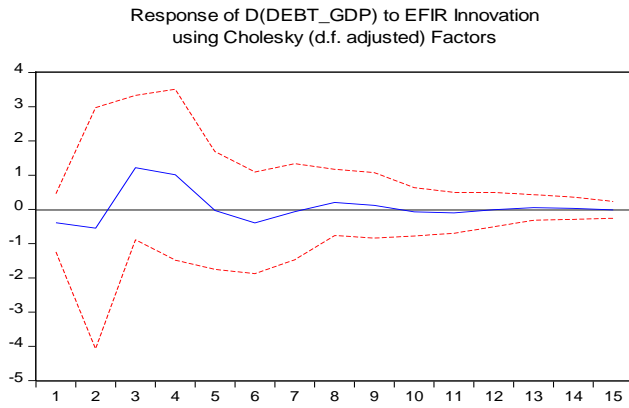


Source: author's calculations, Ministry of Finance, Central Bank

The real interest rate has a lagged negative effect on the exchange rate, the effect of which fades out in the 6th year. The effect of the real interest rate has a small effect on the primary balance and the debt/GDP ratio, which was also presented when assessing debt sustainability with the help of a deterministic model [Aslanyan, 2021, 165-177]. These results can be the basis for increasing the rate of decrease of real GDP in the event of an interest rate shock in the deterministic model.

Figure 3. The Response of Variables to a Real Interest Rate Shock

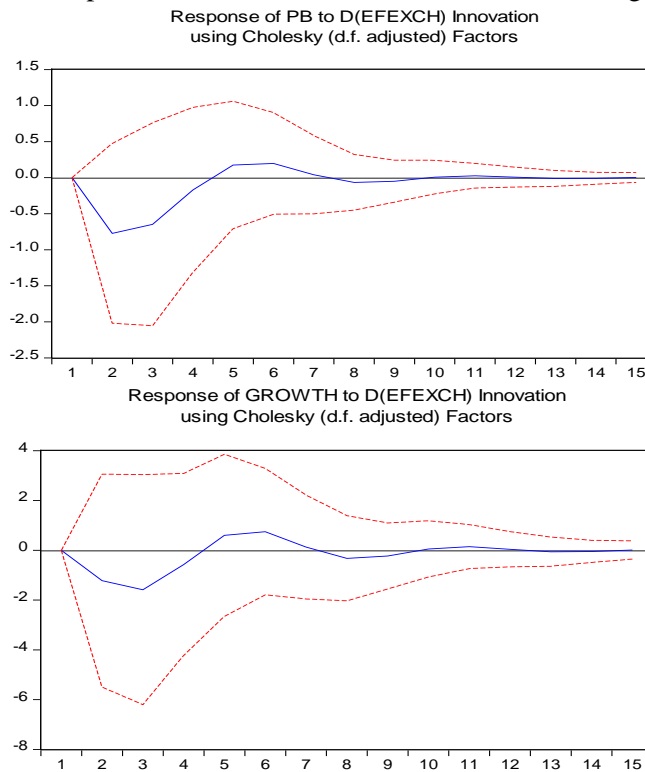


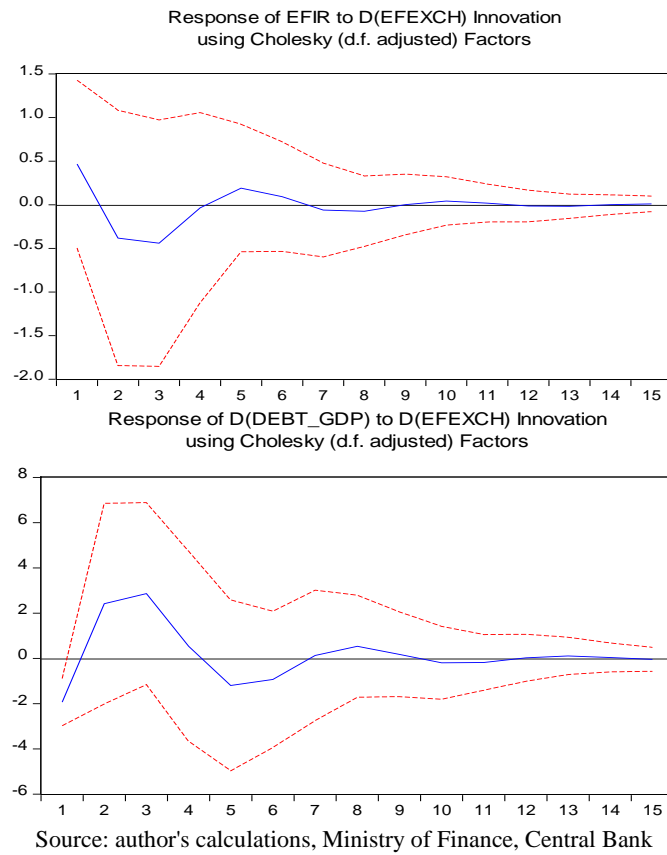


Source: author's calculations, Ministry of Finance, Central Bank

GDP growth and primary balance react negatively to a positive exchange rate shock starting from the 2nd year, we also notice that the debt/GDP ratio has also increased since the 2nd year, which was also confirmed when assessing the sustainability of the debt with the help of the deterministic model [Aslanyan, 2021, 165-177]. Unlike the deterministic model, in this case the effect of the exchange rate on the debt/GDP ratio is not so great.

Figure 4. The Response of Variables to a Real Effective Exchange Rate Shock





Examining the variance decomposition of the debt/GDP ratio, we notice that the change in debt mainly depends on the real GDP growth, the primary balance and also the exchange rate. It is noteworthy to mention that a similar result was also obtained as a result of assessing debt sustainability with the help of the MAC DSA model [Aslanyan, 2021, 165-177]. Thus, the variance decomposition of the debt depends 40-50% on GDP growth, 20-30% on the growth of the primary balance, 6-8% on the real effective exchange rate.

Table 1. Debt/GDP Variance decomposition

Variance
Decomposition of
D (DEBT_GDP):

Period	S.E.	PB	GROWTH	D(EFEXCH)	EFIR	D(DEBT_GDP)
1	6.791185	29.68397	53.82951	8.118375	0.332011	8.036135
2	7.347832	25.36299	46.99152	17.76117	0.838678	9.045638
3	8.286040	21.51181	42.30150	25.91884	2.827589	7.440261
4	8.453023	20.74390	41.39572	25.30682	4.148439	8.405124
5	8.613138	20.09142	41.47013	26.30442	3.997150	8.136884
6	8.748170	19.48288	41.58358	26.63014	4.076891	8.226510
7	8.761291	19.47574	41.48469	26.57263	4.070841	8.396096
8	8.807161	19.29414	41.64511	26.66180	4.081161	8.317792
9	8.817673	19.25538	41.63521	26.63890	4.089117	8.381389
10	8.824751	19.24289	41.64611	26.64574	4.088984	8.376279

Cholesky Ordering: PB GROWTH D(EFEXCH) EFIR
D(DEBT_GDP)

Source: author's calculations, Ministry of Finance, Central Bank

Conclusion. Summing up, we can mention:

- As predicted, real GDP growth leads to a sharp decline in the Debt/GDP ratio and has the greatest impact on the Debt/GDP ratio.

- A positive primary balance shock leads to Real GDP growth, which stabilizes in the 5th year. The effect of the primary balance on the real interest rate (contrary to the theoretical basis of the MAC DSA model) and the effective exchange rate is very small. An increase in the primary balance leads to a decrease in the debt/GDP ratio.

- the real interest rate has a small effect on the primary balance and the debt/GDP ratio, which was also presented when assessing debt sustainability with the help of a deterministic model.

- the exchange rate positive shock leads to an increase in the debt/GDP ratio, which was also confirmed when assessing the sustainability of the debt with the help of the deterministic model.

- Change in debt mainly depends on real GDP growth, primary balance and also exchange rate. The similar result was also obtained as a result of assessing debt sustainability using the MAC DSA model.

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It is necessary to carry out the process of modeling the public debt through a multi-faceted analysis. There is a need to evaluate it through different models: deterministic, stochastic and also alternative approaches. Most often, these approaches do not replace, but complement each other. In particular, stochastic and alternative approaches complement the results of deterministic analysis, considering them as an additional toolkit for risk assessment. In this article, the degree of interaction between the public debt and the factors forming it was evaluated using the vector autoregression VAR model. Taking into account the peculiarities of the factors affecting the RA state debt, Real GDP growth, real interest rate, real effective exchange rate, and primary balance were considered as debt-forming factors. According to the obtained results, the change in the debt/GDP ratio mainly depends on the real GDP growth, the primary balance and also the exchange rate. The similar result was also obtained as a result of assessing debt sustainability using the MAC DSA model. Unlike the deterministic model, in this case the effect of the exchange rate on the debt/GDP ratio is not so great.