The International Scientific Conference INPROFORUM 2015, *November 5 - 6, 2015, České Budějovice*, 156-160, ISBN 978-80-7394-536-7.

Macroeconomic Shocks and the Government Debt Dynamics: An Updated Czech Experience

Aleš Melecký

Abstract: *This paper studies how macroeconomic shocks affect the government debt dynamics in a small and highly open economy of the Czech Republic. Applying this modeling approach to the Czech data ranging from 2000 to 2014, the author derive some implications for fiscal policy. The modeling framework includes structural vector autoregression (SVAR) model with debt feedback, estimated using short-term identification restrictions, and non-linear specification of the government debt dynamics. The considered model variables are GDP, inflation, the effective interest rate on government debt, government revenues and expenditures, the exchange rate and government debt. The model estimation is carried out using the Bayesian approach. According to the results, allowing for a non-linear dynamics in the government debt to GDP ratio could imply stronger persistence and higher volatility in the responses of government indebtedness to macroeconomic shocks. Further, the fiscal stance of the Czech Republic seems to be most vulnerable to unexpected depreciation of the Czech crown, discretionary pro-cyclical increases in government expenditures and decrease in government revenues***.**

Key words: Government debt dynamics · Non-linear specification · Macroeconomic shocks · SVAR model · Bayesian estimation · Czech Republic

JEL Classification: E62 · H68 · E37

1 Introduction

The global financial and economic crisis and its impact on the fiscal area have highlighted the importance of regular monitoring and evaluation of fiscal risks and weaknesses of the fiscal system, including the sustainability of government debt, particularly in "normal times." Sensitivity analysis of government debt to macroeconomic shocks contribute significantly to the understanding of the risk associated with future development of government debt and help to identify the most likely causes of possible adverse development. Findings from such an analysis allow the authorities to carry out an analysis of adverse (critical) scenarios, develop and prepare plans for emergencies that can be effectively implemented, and ensure the sustainability of government debt through timely adopted economic policy measures. The ratio of government debt to GDP and its dynamics, including understanding of potential threats arising from unexpected shocks are important for management of government debt portfolio.

Bayesian approach for the estimation of the macroeconomic effects of fiscal policy is used e.g. in Afonso and Sousa (2009), who examined the economies of the USA, the UK, Germany and Italy. The influence of fiscal measures on GDP and government budgets with the use of SVAR model examine e.g. Breuer and Buettner (2010). Central and Eastern Europe (including the Czech Republic) is investigated e. g. in Stoian and Campeanu (2010). Beynet and Paviot (2012) focused on the sensitivity of the Hungarian government debt to macroeconomic shocks. On the basis of a simplified version of stochastic debt sustainability analysis and the adopted assumptions they conclude that for the sustainability of the government debt in Hungary the greatest risks in 5-year horizon comes from shocks to nominal GDP growth which volatility is particularly high in Hungary.

There is a number of articles dealing with the developed European economies, but in the case of the "new" EU member states the issue of government debt dynamics is much less studied. Favero and Giavazzi (2007) and Favero and Giavazzi (2009) investigated the effects of expenditure and revenue shocks on growth and highlight the need to include the equation for debt feedback effect into the model. This work is based on the model applied in Melecký and Melecký (2012) and models the Czech macroeconomy using a linear SVAR model, while allowing the government debt dynamics to behave nonlinearly (given the specification of government debt) and have an active impact on the real economy. A similar model was used in Cherif and Hasanov (2012) for the United States. The authors study the effects of the primary balance shocks, inflation shocks and GDP shocks on public debt dynamics. Cherif and Hasanov (2012) argue that incorporating debt feedback effect into the model is needed for stability of prediction of the future debt and due to persistence of impulse responses..

Ing. Ales Melecky, Ph.D., VSB-Technical University of Ostrava, Faculty of Economics, Department of Economics, Sokolska tr. 33, Ostrava, e-mail: ales.melecky@vsb.cz

2 Methods

The Czech economy is modeled with the use of vector autoregression (VAR) structure, similarly as in Favero and Giavazzi (2007), which includes nonlinear specification of government debt to GDP ratio. The structural VAR model is used to identify structural shocks using a short-term restrictions given by the ordering of the endogenous variables. The model can be written as follows:

$$\mathbf{A}\mathbf{y}_t = \sum_{i=1}^{k} \mathbf{B}_i \mathbf{y}_{t-i} + \sum_{i=1}^{k} \boldsymbol{\delta}_i \mathbf{d}_{t-i} + \boldsymbol{\varepsilon}_t \,, \qquad \text{where } \mathbf{y}_t = \begin{bmatrix} g_t \\ t_t \\ y_t \\ \Delta p_t \\ i_t \\ s_t \end{bmatrix}, \tag{1}$$

where $\mathbf{y}_t$ is the vector of endogenous variables with linear dynamics, including the logarithm of government expenditures (g_t), logarithm of government revenues (t_t), logarithm of real GDP (y_t), annualized percentage change in the consumer price index (Δp_t), the effective interest rate on government debt (i_t), and the annualized quarterly change in real effective exchange rate (s_t). Government debt to GDP ratio is denoted $\mathbf{d}_t$ and $\boldsymbol{\varepsilon}_t$ is a vector of structural shocks. **A** is a lower triangular matrix of estimated coefficients for the current endogenous variables, **B** a matrix of the estimated coefficients for the lagged endogenous variables, and $\boldsymbol{\delta}$ is a vector of estimated coefficients for the lagged government debt to GDP ratio.

Reduced form of the SVAR model can be written as follows:

$$\mathbf{y}_t = \sum_{i=1}^{k} \mathbf{C}_i \mathbf{y}_{t-i} + \sum_{i=1}^{k} \boldsymbol{\gamma}_i \mathbf{d}_{t-i} + \mathbf{u}_t \,, \tag{2}$$

where $\mathbf{C} = \mathbf{A}^{-1}\mathbf{B}$, $\boldsymbol{\gamma} = \mathbf{A}^{-1}\boldsymbol{\delta}$, $\mathbf{u_t}$ is reduce form shock and:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{bmatrix} \begin{bmatrix} u_t^g \\ u_t^t \\ u_t^y \\ u_t^p \\ u_t^r \\ u_t^s \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} \end{bmatrix} \begin{bmatrix} e_t^g \\ e_t^t \\ e_t^y \\ e_t^p \\ e_t^r \\ e_t^s \end{bmatrix}. \tag{3}$$

The model used in this chapter is structured vector autoregression model with one period lag SVAR (1), as suggested by Schwartz and HQ information criterion, see table 2 in appendix for details. For the chosen model structure it is easy to calculate the probability function and combined it with the a priori distribution of the parameters in order to obtain the posterior distribution. Specifically, there are given a priori assumptions concerning the probability distribution $p(\boldsymbol{\theta})$, where $\boldsymbol{\theta}$ is the vector containing the model parameters. Posterior distribution $p(\boldsymbol{\theta}/\mathbf{y})$ is therefore proportional outcome of probability function of the solved model and a priori assumptions:

$$p(\boldsymbol{\theta}/\mathbf{y}) \propto L(\boldsymbol{\theta}/\mathbf{y})\, p(\boldsymbol{\theta}) \tag{6}$$

where $L(\boldsymbol{\theta}/\mathbf{y})$ is the probability function dependent on the data **y**. A priori assumptions are mutually independent, $p(\boldsymbol{\theta})$ is therefore constructed based on individual a priori assumptions about the structural parameters indicated in the second column of table 3 presented in appendix.

3 Data

Detail description of the data series used in the analysis, i.e. government expenditures, government revenues, real GDP, inflation, interest rate, exchange rate and government debt to GDP ratio are provided in table 1. Primary data sources are the Czech National Bank's system ARAD and the database of the Czech Statistical office. Prior to the estimation, the data are demeaned.

Table 1 Description of model variables and their sources

Variable	Description
Government expenditures	According to ESA 2010 methodology, adjusted for the effect of population growth, seasonally adjusted using Census X-13; CSO bill. CZK, in logarithms
Government revenues	According to ESA 2010 methodology, adjusted for the effect of population growth, seasonally adjusted using Census X-13; CSO bill. CZK, in logarithms
Real GDP	Seasonally adjusted gross domestic product (GDP) at constant market prices with adjustments for the effect of population growth; ARAD, CNB. bil. CZK, in logarithms
CPI inflation	The percentage change in the consumer price index in local currency (year 2005 = 100, average of the period), compared to the previous year, seasonally adjusted using Census X-13; CSO
Interest rate	The effective interest rate on government debt i.e. Interest payments (D41) at time t, with respect to the quarterly government debt at time t-1, annualized, seasonally adjusted using Census X-13; CSO, ARAD
Exchange rate	Percentage change in the real effective exchange rate converted to a direct quotation, annualized, seasonally adjusted using Census X-13; ARAD, CNB
Debt to GDP	Consolidated quarterly government debt, based on quarterly data for the general government sector (S.13 CSO) relative to nominal GDP, seasonally adjusted using Census X-13; ARAD, CNB

Source: Own processing based on information from CSO and CNB

4 Discussion of results

Preliminary results gained from the solution of reduced form of the model with debt feedback effect shows high inertia of the debt to GDP ratio. Therefore, all macro shocks are expected to have long run effects on government debt to GDP ratio.

The impact of indebtedness on the Czech macroeconomy can be summarized as follows. First, the increased government debt to GDP ratio operate via a standard crowding out effect. The higher need for financing government debt leads to an increase of supply of government bonds and cause increase in the interest rates. Increased funding costs lead to lower project profitability and a decline in private investment.

Second, higher level of debt also decrease the willingness of businesses to finance government services and budgets and because of the reduced tax discipline the tax revenues declines. Third, the estimated negative impact of the debt to GDP ratio on the size of government expenditures is probably the result of the implementation of austerity measures which are adopted at higher levels of government debt in order to increase effort to consolidate government finances. Finally, the effects of the debt to GDP ratio on inflation, interest rates and the exchange rate are not statistically significant.

The results of the sensitivity analysis of the government debt to GDP ratio on macroeconomic shocks suggest that nonlinear specification of government debt dynamics may lead to increased inertia and long run deviations from the steady state after macroeconomic shocks. The fiscal position of the Czech Republic is the most vulnerable to the unexpected depreciation of the domestic currency. However, the depreciation of the Czech Crown creates more "revenues" because of higher income effect than "costs" connected with balance sheet effect and shouldn't therefore increase the cost of servicing government debt.

Second source of risk for the Czech fiscal position are strong pro-cyclical discretionary increases in government expenditures, which leads to an increase in government indebtedness. Third source of risk arises from the reduction in government revenues that could significantly affect government debt. Implementation of adequate fiscal rules may help to improve the situation even in this area. The planned establishment of an independent National Budgetary Board (called Národní rozpočtová rada státu) could also help.

5 Conclusions

This paper studied how macroeconomic shocks affect the government debt dynamics in a small and highly open economy of the Czech Republic. The modeling framework included structural vector auto-regression (SVAR) model with debt feedback effect on the real economy, estimated using short-term identification restrictions, and non-linear specification of the government debt dynamics.

The results supports the findings of Cherif and Hasanov (2012), that there is a need to include debt feedback into the model. Based on the estimation results and sensitivity analysis, the considered macro shocks have long run effects on the debt to GDP ratio.

Three main sources of potential risk for the Czech fiscal position are unexpected depreciation of the currency, which seem to be not too dangerous for the Czech fiscal position due to higher income effect than balance sheet effect. However, CNB policy aimed at smoothing exchange rates is important and should continue in the future. The highest risk comes therefore from two other sides, i.e. increase in government expenditures and decrease in government revenues, with similar size of the effects on debt to GDP ratio.

Acknowledgement

This paper has been elaborated in the framework of the project CZ.1.07/2.3.00/20.0296 supported by Operational Programme Education for Competitiveness and co-financed by the European Social Fund, and the Czech Science Foundation grant No.13-20613S.

References

Afonso, A., & Sousa, R. M. (2009). The Macroeconomic Effects of Fiscal Policy (online). *ECB Working Paper Series,* No 991. Retrieve from: https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp991.pdf?4749d9e68fafc5af0fca75faf24e4c26.

Beynet, P., & Paviot, E. (2012). Assessing the Sensitivity of Hungarian Debt Sustainability to Macroeconomic Shocks under Two Fiscal Policy Reactions (online). *OECD Economics Department Working Papers*, No. 946. Retrieve from: http://www.oecd-ilibrary.org/economics/assessing-the-sensitivity-of-hungarian-debt-sustainability-to-macroeconomic-shocks-under-two-fiscal-policy-reactions_5k9d195gtkf8-en.

Breuer, Ch., & Buettner, T. (2010). Fiscal Policy in s Structural VAR Model for Germany. Beiträge zur Jahrestagung des Vereins für Social Politik (online). In *Ökonomie der Familie – Session: Empirical Analyses of Fiscal Policy*, No. B9-V1, retrieve from: http://hdl.handle.net/10419/37402.

Cherif, R., & Hasanov, F. (2012). Public Debt Dynamics: The Effects of Austerity, Inflation, and Growth Shocks (online). *IMF Working Paper* WP/12/230, retrieve from: https://www.imf.org/external/pubs/ft/wp/2012/wp12230.pdf.

Favero, C., & Giavazzi, F. (2007). Debt and the Effects of Fiscal Policy (online). *NBER Working Paper Series* 12822, retrieve from: http://pcsi.pa.go.kr/files/w12822.pdf.

Favero, C., & Giavazzi, F. (2009). How Large Are the Effects of Tax Changes (online). *NBER Working Paper Series* 15303, retrieve from: http://www.nber.org/papers/w15303.pdf.

Melecky, A. & Melecky, M. (2012). The Impact of Macroeconomic Shocks on the Government Debt Dynamics: How Robust is the Fiscal Stance of the Czech Republic (in Czech). *Politická ekonomie* 60(6), 723-742.

Stoian, A., & Campeanu, E. (2010). Fiscal Policy Reaction in the Short Term for Assessing Fiscal Sustainability in the Long Run in Central and Eastern European Countries. *Finance a úvěr* 60(6), 501-518.

Appendix

Table 2 VAR model lag length selection

Endogenous variables: debt/GDP, government expenditures, government revenues, inflation, interest rate, exchange rate, GDP
Data sample: 2000Q2 –2014Q4
Number of observations: 55

Lag	SC	HQ
0	-21.888	-22.1566
1	-26.13829*	-27.21269*
2	-25.30933	-27.18952
3	-23.77222	-26.45822
4	-23.43048	-26.92228

SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion
**indicates lag order selected by the criterion
Source: Own calculations

Table 3 VAR model – Priors and estimation results

Parameters	Priors	Posterior mode	Posterior mean	90% Posterior Bayesian confidence interval
a_21	N (0.064; 0.042)	0.0027	0.0103	[-0.0536; 0.0741]
a_31	N (-0.004; 0.009)	-0.0067	-0.0061	[-0.0201; 0.0097]
a_32	N (0.018; 0.015)	-0.0055	-0.0022	[-0.0165; 0.0153]
a_41	N (-0.021; 0.037)	0.002	-0.0236	[-0.0638; 0.0151]
a_42	N (0.016; 0.059)	-0.0108	0.0068	[-0.0628; 0.0843]
a_43	N (0.552; 0.214)	0.3053	0.3368	[0.2049; 0.4469]

a_51	N (0.053; 0.017)	0.0387	0.0406	[0.0172; 0.0617]
a_52	N (0.120; 0.038)	0.0477	0.0461	[0.0076; 0.0893]
a_53	N (-0.021; 0.194)	0.0007	-0.0328	[-0.152; 0.0967]
a_54	N (0.262; 0.076)	0.1411	0.1403	[0.0499; 0.2229]
a_61	N (0.046; 0.076)	0.0448	0.0752	[0.0081; 0.1384]
a_62	N (0.079; 0.099)	0.0326	0.0259	[-0.1279; 0.1822]
a_63	N (1.084; 0.560)	0.2244	0.3737	[-0.1443; 0.8137]
a_64	N (0.221; 0.230)	0.2775	0.2607	[0.0177; 0.4894]
a_65	N (0.156; 0.519)	0.3937	0.569	[0.1409; 1.0523]
b_11	N (0.132; 0.090)	0.1047	0.0892	[-0.0239; 0.2041]
b_12	N (-0.062; 0.157)	-0.2045	-0.2319	[-0.3602; -0.0797]
b_13	N (1.913; 0.269)	1.0628	1.127	[0.9682; 1.2656]
b_14	N (-0.171; 0.184)	-0.3641	-0.3602	[-0.5827; -0.1262]
b_15	N (-0.247; 0.329)	-0.5718	-0.5412	[-0.8717; -0.1954]
b_16	N (-0.013; 0.142)	0.043	0.0435	[-0.0853; 0.1674]
b_21	N (-0.026; 0.079)	-0.0742	-0.0673	[-0.1639; 0.0212]
b_22	N (0.168; 0.086)	0.1492	0.162	[0.0749; 0.2553]
b_23	N (1.16; 0.171)	0.942	0.9258	[0.7922; 1.0629]
b_24	N (-0.086; 0.125)	-0.1512	-0.1126	[-0.2717; 0.0678]
b_25	N (0.224;0.223)	0.0374	0.097	[-0.2086; 0.3931]
b_26	N (0.095; 0.059)	0.0988	0.1061	[0.0465; 0.174]
b_31	N (0.013; 0.011)	0.0088	0.0109	[-0.0007; 0.0222]
b_32	N (0.026; 0.017)	0.0262	0.0243	[0.007; 0.0412]
b_33	N (0.929; 0.026)	0.9421	0.943	[0.9166; 0.9719]
b_34	N (-0.026; 0.029)	-0.0184	-0.0193	[-0.0557; 0.0184]
b_35	N (0.015; 0.044)	-0.0046	0.0142	[-0.0297; 0.0744]
b_36	N (0.025; 0.021)	-0.0122	-0.0075	[-0.021; 0.0079]
b_41	N (0.035; 0.039)	0.0274	-0.005	[-0.0391; 0.0296]
b_42	N (0.094; 0.082)	0.0603	0.0882	[0.0103; 0.1670]
b_43	N (0.145; 0.134)	0.1854	0.2165	[0.1123; 0.3447]
b_44	N (0.774; 0.084)	0.7163	0.6632	[0.5800; 0.7415]
b_45	N (0.182; 0.191)	0.2192	0.1871	[-0.0473; 0.4174]
b_46	N (-0.018; 0.056)	-0.0098	-0.0056	[-0.0581; 0.0464]
b_51	N (0.035; 0.037)	0.0013	-0.0026	[-0.0361; 0.0330]
b_52	N (0.074; 0.044)	-0.0016	0.0091	[-0.0258; 0.0464]
b_53	N (0.032; 0.082)	0.0454	0.0068	[-0.0708; 0.0836]
b_54	N (0.211; 0.056)	0.1565	0.1844	[0.1277; 0.2425]
b_55	N (0.383; 0.112)	0.2958	0.2385	[0.1105; 0.3677]
b_56	N (0.008; 0.044)	0.0205	0.0241	[-0.0093; 0.0566]
b_61	N (0.061; 0.110)	0.0941	0.0829	[-0.0241; 0.1952]
b_62	N (-0.068; 0.106)	-0.0516	-0.0099	[-0.1504; 0.1129]
b_63	N (0.177; 0.203)	0.2981	0.4286	[0.1705; 0.6881]
b_64	N (0.397; 0.139)	0.3264	0.3372	[0.2051; 0.4774]
b_65	N (0.198; 0.322)	0.0983	0.1211	[-0.3234; 0.5995]
b_66	N (0.156; 0.140)	0.1613	0.0922	[-0.0569; 0.2514]
δ_1	N (-0.006; 0.003)	-0.0054	-0.0046	[-0.0088; -0.0003]
δ_2	N (-0.005; 0.003)	-0.003	-0.0034	[-0.007; -0.0002]
δ_3	N (-0.002; 0.001)	-0.0014	-0.0019	[-0.0033;-0.0004]
δ_4	N (-0.001; 0.002)	-0.0004	-0.0005	[-0.0031; 0.0026]
δ_5	N (0.001; 0.001)	0.0011	0.0009	[-0.0003; 0.0021]
δ_6	N (-0.001; 0.002)	-0.0011	-0.0005	[-0.0024; 0.0016]
e_gg	IG(0.037; 0.500)	0.0575	0.0612	[0.0504; 0.0707]
e_tt	IG(0.021; 0.500)	0.0507	0.0534	[0.0444; 0.0619]
e_yy	IG(0.004; 0.500)	0.0099	0.0104	[0.0088; 0.0118]
e_pi	IG(0.167; 1.000)	0.0281	0.0289	[0.0247; 0.0332]
e_rr	IG(0.104; 1.000)	0.0138	0.0148	[0.0125; 0.0169]
e_ss	IG(0.445; 1.000)	0.0984	0.1029	[0.0883; 0.1179]
e_dd	IG(0.060; 1.000)	0.0277	0.052	[0.0135; 0.0933]

Where a_21 to a_65 are the elements of matrix A, b_11 to b_66 are the elements of matrix B and δ_1 to δ_6 the elements of vector δ in equation (1). Ordering of the model variables is as follows: government expenditures, government revenues, GDP, inflation, interest rate and exchange rate. N (*x*; *y*) denotes normal distribution with mean *x* and standard error *y*. IG (*a, b)* denotes inverse gama distribution with *a* and *b* parameters.

Source: Own calculations