Effects of fiscal shocks in new EU members estimated from a SVARX model with debt feedback

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Abstract

This paper analyses in a VAR framework with debt feedback effects of fiscal policy over 1999q1-2013q4 in five Central and East European economies: Slovakia, Czech republic, Hungary, Slovenia and Lithuania. The results are compared to two alternative specifications, a model without debt feedback, and a model with debt within the linear VAR. Omitting the debt feedback would affect the magnitude and sign of the impulse response coefficients, especially those of GDP, government revenue and interest rate. Simulated out-of-sample debt paths are stabilised if debt feedback is included, but strongly explosive otherwise.
JEL: C32, E37, E62, H63.
Keywords: fiscal policy, structural VAR, debt dynamics, endogenous debt feedback, impulse response functions, historical decomposition of times series, meta-analysis, CEE countries, new EU member states

1 Motivation

As until the Great Recession 2008-09, public debt ratios in new EU member countries were typically associated with levels of about 20-30 percent GDP. There were exceptions, such as e.g. Hungary and Poland, but their relatively high debt ratios followed a declining trend. Fiscal stimuli with the aim to curtail the crisis led to a marked increase in government indebtedness. As a consequence, also in the Eastern part of the EU debt ratios of about 40-75 percent GDP became a rule rather than exception.

Levels of debt may have important implications for fiscal policy effects on the economy. Large panel studies find that high debt would limit the effectiveness of fiscal policy (e.g. Auerbach and Gorodnichenko, 2013, or Nickel and Tudyka, 2014). A related, puzzling problem is whether high debt itself poses a challenge for economic growth. Some authors, as e.g. Panizza and Presbitero (2014), deny a negative causal effect between debt and growth. Some other authors find that there are thresholds in the relationship of public debt and GDP, above which debt may have negative impact on subsequent growth. An example for the OECD countries is due to Elmeskov and Sutherland (2012), who identified such thresholds in the debt ratio at around 45 and 66 percent GDP. Notwithstanding the general disagreement on this issue, such debt ratios match those observed in the enlarged part of the EU. Therefore, government indebtedness deserves a closer attention.

The obvious question that arises is what impact does debt exert to effects of fiscal policy in the new EU members. The impact will translate into estimates of impulse response functions and joint forecasts of macroeconomic and fiscal variables.

A convenient framework to address this issue is provided by Favero and Giavazzi (2007), henceforth FG. The authors extended the traditional VAR setup of Blanchard and Perotti (2002) for a nonlinear equation, the government budget constraint. Keeping track of its implications for the

policy analysis is not a new problem, see e.g. Bohn (1998) and Sims (1998) and references herein. The FG framework can be viewed as a modeling minimum to get the economy, fiscal variables and debt to endogenously affect each other. If the nonlinear effects stemming from the debt dynamics are indeed significant, traditional models omitting debt will give misleading results. Recent applications of the FG model include e.g. Afonso and Souza (2012) for the U.S., the U.K., Germany and Italy, and Parkyn and Vehbi (2014) for the New Zealand.

Modified versions of the FG framework were applied to two countries of the Central and Eastern Europe (CEE). Ilzetzki (2011) estimates fiscal policy effects under debt feedback for Estonia and four developing countries. Inclusion of the debt feedback for Estonia amplified the response of GDP and inflation to fiscal shocks. In an application to the Czech republic, Melecky and Melecky (2011) work with a linearised budget constraint. However, rather than characterising fiscal policy effects, they only discuss the responses of the debt ratio to shocks in other variables. Overall, interactions of the government debt, fiscal policy and the economy have not prominently deserved attention in the CEE-literature. Empirical papers that investigate fiscal policy effects in new EU members use the traditional VAR model and identification scheme following Blanchard and Perotti (2002). Details are listed in Table 1. Government debt is not included in the specification. For some of the countries, effects of fiscal shocks were estimated by means of theoretical New-Keynesian models. Examples include Stork and Zavacka (2010), Klyuev and Snudden (2011) and Ambrisko et al. (2012) for the Czech republic, Algozhina (2012) and Benk and Jakab (2012) for Hungary, and Clancy, Jacquinot and Lozej (2014) for Slovenia. Such models are very data intensive, which makes estimation and comparison for a larger number of economies inconvenient. Rather than discussing the impact of debt, the main focus of the studies was to simulate propagation of fiscal shocks under a detailed break-down of the fiscal instruments.

With the aim to improve our knowledge on the role of debt dynamics, this paper analyses fiscal policy effects under explicit debt feedback over 1991q1-2013q4 in five Central and East European countries (CEE-5): Slovakia, Czech republic, Hungary, Slovenia and Lithuania. The model in Section 2 is an application of the FG framework. In order to track the impact of debt feedback, two alternative specifications are considered, a model without debt feedback, and a model with debt within the linear VAR. Section 3 presents a rich set of empirical results, that have not been brought up before, such as response functions of variables to debt shocks and historical decomposition of the time series under debt feedback. Unlike in linear VAR models, the response functions depend on the size and sign of the shocks and on the initial conditions, pointing to nonlinearities involved with the government debt dynamics. Both inclusion of the debt feedback and the way it is implemented matter to the estimated behaviour of other variables. In particular, impulse responses of GDP, interest rate and government revenue are larger under debt feedback and might revert signs. Simulated out-of-sample debt paths are stabilised under debt feedback, but strongly explosive if debt feedback is omitted. The final section draws concluding remarks and suggests areas for further research.

Table 1: Empirical papers on fiscal policy effects in the CEE-5

Authors	**Coverage**	**Sample range**	**Macroeconomic variables**	**Fiscal variables (government)**
Baxa (2010)	Czech r.	1998q1-2009q2	GDP, GDP deflator, 3-m interest rate	revenue, expenditure
Franta (2012)	Czech r.	1999q1-2011q3	GDP, inflation, interest rate	net taxes, spending
Lendvai (2007)	Hungary	1997q1-2005q4	GDP, private consumption, investment, employment, GDP deflator, REER	net taxes, expenditure, consumption, investment, public wages
Kotosz and Peak (2013)	Hungary	1960-2011	GDP	expenditure
Klyviene and Karmelavicius (2012)	Lithuania	1997q1-2011q1	GDP, employment, FDI	corporate income tax revenue, revenue from other taxes, domestic and comparative effective corporate tax rate, spending
Pecsyova (2013)	Slovakia	1997q1-2012q1	GDP, inflation, interest rate	net taxes, spending
Jemec et al. (2011)	Slovenia	1995q1-2010q4	GDP	net taxes, spending
Mirdala (2009)	Czech r., Hungary, Poland, Slovakia, Bulgaria, Romania	2000q1-2008q4	GDP, inflation, short-term interest rate	revenue, expenditure
Eller et al. (2011)	Czech r., Hungary, Poland, Slovenia, Slovakia	1995q1-2009q4	GDP, short-term interest rate, NEER,inflation	net taxes, spending, foreign fiscal balance
Karmelavicius and Klyviene (2012)	Estonia, Latvia, Lithuania	1997q1-2011q4 (Lithuania)	GDP, employment, FDI	corporate income tax revenue, revenue from other taxes, spending
Mirdala (2013)	Bulgaria, Czech r., Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia	2000q1-2012q3	GDP, inflation, short-term interest rate	revenue, expenditure
Bencik (2014)	Visegrad countries	1997q4-2012q4	net exports, RER	spending
Dinu and Marinas (2014)	Czech r., Hungary, Poland, Slovenia, Slovakia, Bulgaria, Romania	1999q1-2012q2	GDP, inflation, interest rate	net taxes, spending

Note: Most of the papers follow in model specification and identification the structural approach of Blanchard and Perotti (2002). In addition, Mirdala (2009; 2013) and Klyviene and Karmelavicius (2012) also use a recursive Choleski scheme. Franta (2012) estimates the VAR reduced form by a hierarchical Bayesian approach and identifies the model using three various schemes: a structural approach, a recursive scheme and sign restrictions. Bencik (2014) uses a smoothed transition autoregressive model (STVAR) to compute dual regime fiscal multipliers for recessions and expansions.

2 Methodology

This section sets forth a fiscal VAR model with debt feedback in the vein of Favero and Giavazzi (2007). As a distinctive feature, this approach incorporates the government budget constraint, an identity that links dynamically and nonlinearly all variables included in the VAR model.

Omission of this constraint would have important consequences (cf. Favero and Giavazzi, 2007; Afonso and Souza, 2012; Cherif and Hasanov, 2012; Parkyn and Vehbi, 2014). It would assume zero effects of debt levels on output and inflation. It might bias the estimates of the VAR coefficients. Price level and long-term interest rates might not plausibly respond to fiscal shocks. Also, it would rule out the possibility that government revenue and expenditure will react to debt levels whenever fiscal authorities care about the sustainability of public finances. In turn, debt ratios simulated from a VAR without debt feedback might turn explosive.

2.1 Fiscal VAR model with debt feedback

The model employed is a system of equations which consists of a fiscal SVARX model with government debt as an exogenous variable, and of the government budget constraint.

The SVARX(k,l) model is specified in the reduced form as:

$$\mathrm{X}_t = \mathrm{A}_0 + \sum_{i=1}^{k} \mathrm{A}_i \cdot \mathrm{X}_{t-i} + \sum_{j=1}^{l} \Gamma_j \cdot b_{t-j} + \mathrm{U}_t \tag{1}$$

where X_t is a vector in π_t - inflation in the implicit GDP deflator, r_t - interest rate, y_t - real GDP, t_t - real government revenue, x_t - real government primary expenditure, and m_t - money growth; A_i denotes coefficient matrix at the i-th lag of the endogenous variables and Γ_j is coefficient vector at the j-th lag of real government debt b_t; U_t is a vector of reduced-form residuals.

The motion of government debt follows:

$$b_t = \frac{1 + r_t}{1 + \pi_t} \cdot b_{t-1} + x_t - t_t \tag{2}$$

The nonlinear government budget constraint is included in the system as an identity. The idea is to endogenise feedback from the debt dynamics in the linear SVARX. As a result, government debt becomes an endogenous variable within the system.

Reduced-form residuals are linked to the underlying structural shocks W_t as $\mathrm{P}^{-1} \cdot \mathrm{U}_t = \mathrm{W}_t$, where P is an identification matrix.

2.2 Estimation and identification

In a first step, (1) is estimated as a usual reduced form vector autoregression. The model is then identified using a triangular decomposition such that P is the lower Choleski factor of the residuals' covariance matrix. Given the small sample context, estimator for the covariance matrix was scaled down using the number of parameters.

Variables in the identification matrix are ordered as listed in X_t such that:
- inflation, interest rate and real GDP are predetermined w.r.t. fiscal policy shocks,
- government revenue is predetermined w.r.t. government expenditure,
- money growth responds contemporaneously to fiscal shocks (cf. Afonso and Souza, 2012).

2.3 Simulation

Simulation of the above system for a desired number of periods involves defining shocks E_t and initial conditions in X_t and b_t, and iterating the following steps:

1. Using estimated VAR coefficients and identification matrix, solve forward

$$X_t = A_0 + \sum_{i=1}^{k} A_i \cdot X_{t-i} + \sum_{j=1}^{l} \Gamma_j \cdot b_{t-j} + P \cdot E_t \tag{3}$$

2. Compute government debt using the simulated VAR variables.

Various simulation results are obtained as follows:

- In the baseline simulation, shocks are set zero.
- Structural impulse response functions are constructed as the difference between a shock scenario, where arbitrarily specified shocks occur at $t = 0$, and a baseline scenario.
- Confidence intervals under debt feedback are constructed as the 10-th and 90-th percentile of the impulse response distributions obtained by one-step bootstrapping in 1000 draws.
- Forecast error variance decomposition under debt feedback is obtained from the estimated impulse response coefficients and the covariance matrix of the reduced form residuals using the standard formulae.
- Historical decomposition of the variables is obtained as the difference between a shock scenario using as E_t the estimated structural shocks, and a baseline scenario.

2.4 Alternative specifications

In order to show the impact of debt feedback on the results, two alternative specifications are considered:

- First, a model labeled in further text as "without debt feedback". This specification is similar to traditional fiscal models that have been used in the previous CEE-related literature. It is estimated as (1) with debt as an exogenous variable, but in simulations the lags of debt are omitted. It was used for demonstration purposes e.g. by Favero and Giavazzi (2007) and Afonso and Souza (2012).
- Second, a model labeled in further text as "debt in VAR". In this case, debt (in levels) is included within the linear VAR as a seventh variable. This specification ignores the nonlinearity in the debt equation. It makes a possibly strong assumption that impulse responses do not depend on initial conditions. It was used for demonstration purposes e.g. by Cherif and Hasanov (2012).

3 Empirical results

3.1 Data

Major part of the data set was obtained from Eurostat. This ensures that the definition of data series is compatible across countries and that fiscal data are recorded on accrual basis. As a particular advantage, Eurostat provides debt data expressed in euros which ensures accounting consistency between EMEA and non-EMEA countries and across various currency denominations. The choice of the variables for the linear VAR part reflects which variables enter the government budget constraint. As y_t, quarterly gross domestic product (B1GQ) is used, t_t is the total general government revenue (TR), and b_t is the general government consolidated gross debt (GD). Primary government expenditure x_t was obtained as total general government expenditure (TE) minus interest payments (D41). GDP, government revenue, primary expenditure and debt were seasonally adjusted and deflated by the GDP deflator. Inflation and money growth were obtained as quarter-over-quarter growth rates of the seasonally adjusted GDP price deflator (CPI05) and of the money aggregate M2, respectively. Data on money supply were obtained from the central banks' databases and publications. Interest rate r_t is the EMU convergence criterion bond yield (MCBY) from Eurostat. Where unavailable (from 1999 to 2001 or 2002), the yields were approximated using long-term interest rates (IR3TIB) as obtained from the FRED database (Czech republic, Hungary and Slovakia) or from the central bank (Slovenia). In the vector of endogenous variables, r_t is measured in percent per annum. In the debt equation, it is transformed to percent per quarter. The data set spans over the period 1999q1-2013q4.

Figure 1 displays the historical evolution of the data series. Money and deflator growth rates were mostly positive and stable, occasional larger swings were associated with the financial turmoil in 2001-02 and the Great Recession in 2008-09. The evolution of GDP, government revenue and expenditure were linked rather closely as until 2008-09. Real GDP dropped sharply, given the dependence of these small open economies on external demand, hurting the stream of government revenue. From then on, government expenditure followed a diverging path, mostly exceeding the revenue. As a result, the previously stable debt ratios plummeted, rising by 2013 close to the 60 percent threshold (Slovakia) or exceeding it by about 10 percent (Hungary, Slovenia). The relation of interest rates and levels of debt seems inverted to what economic theory would dictate. The highest debt levels have been associated with the historically lowest interest rates. The declining trend in bond yields was distorted only by occasional crises, such as Slovenia 2001-02 (a turmoil spread from Latin America), Hungary and Lithuania 2008-09 (the Great Recession), and Hungary 2011-12 (bond yields suffered under tensions in Europe and, subsequently, under a country-specific crisis). Possible explanations for the steady decline in bond yields include the ongoing integration efforts of the new EU members, and, more recently, monetary policy of the ECB pushing the interest rates toward zero.

Table 2 reports rank correlation coefficients between variables included in the VAR and debt levels. There is a medium to strong positive rank correlation in case of GDP and fiscal variables and negative in case of the interest rate. Because the interest rate, GDP, fiscal variables and debt follow a trend, in addition, rank correlation is reported after the endogenous variables and debt were detrended (cf. e.g. Chiarella and Gao, 2002). This transformation reveals a positive correlation between the interest rate and debt, whereas a negative correlation in case of output and fiscal variables. Figure 2 captures these facts visually.

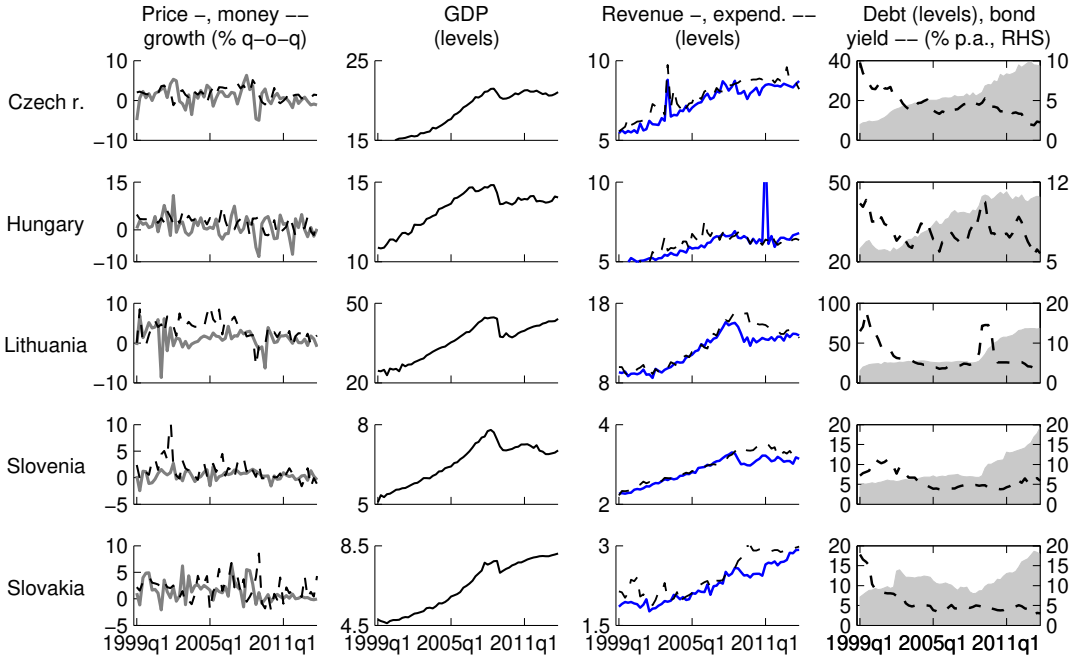


Figure 1: Historical data

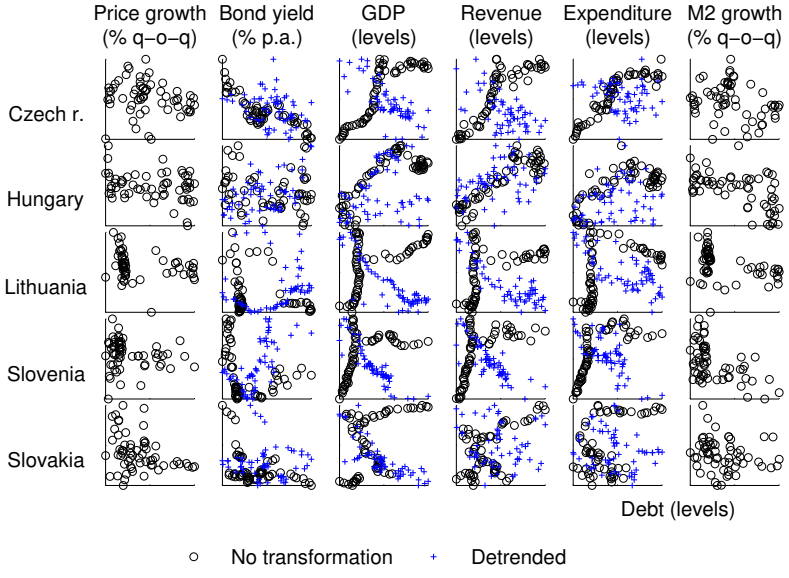


Figure 2: Phase graphs of the variables and government debt

Table 2: Correlation between the variables and debt levels

	(a)					(b)				
	π_t	r_t	y_t	τ_t	x_t	m_t	r_t	y_t	τ_t	x_t
Czech r.	-0.16	-0.60	0.78	0.78	0.78	-0.14	-0.24	-0.60	-0.37	-0.16
Hungary	-0.15	-0.12	0.47	0.62	0.42	-0.37	0.29	0.19	0.26	0.18
Lithuania	-0.32	-0.25	0.53	0.44	0.37	-0.29	0.31	-0.56	-0.55	-0.48
Slovenia	-0.12	-0.37	0.55	0.66	0.72	-0.31	0.46	-0.82	-0.69	-0.49
Slovakia	-0.23	-0.30	0.34	0.27	0.14	-0.15	-0.04	-0.66	-0.05	-0.15

Note: Reported are Kendall's rank correlation coefficients: (a) no transformation of the variables and of debt, (b) detrended variables and debt.

3.2 General remarks to specification and estimation

Tables 7 to 15 in the Appendix report results of various statistical tests performed in EViews. Prior to the VAR analysis, the data series were tested for unit roots using the Augmented Dickey-Fuller and Phillips-Perron test (Table 7). The latter test is better suited for small samples and therefore more informative in our context. Fiscal variables and GDP were found to be I(1), growth rates of the GDP deflator and money supply are I(0) or I(1). The vector of the six endogenous variables is thus I(1). The Johansen test (Table 8) suggests that multiple cointegration relations are present. However, examining further the cointegration relations is not the goal of this paper, also because the inherent relationships among the variables are modelled through the government budget constraint. Detrending or inclusion of deterministic trends is avoided and the VAR estimation proceeds in levels (cf. e.g. Lutkepohl, 2013).

A set of tests and information criteria were applied to determine the appropriate order of the VAR process. The tests suggest to include between 1 and 5 lags (Table 10). This suggestion has been confronted with the stability condition check (Table 9) as well as with the Wald test on lag significance (Table 11). As a result, the appropriate number of lags in endogenous variables has been determined as 2 (Czech republic, Lithuania and Slovakia) or 3 (Hungary and Slovenia). Lags in the exogenous variable, government debt, were set to 2 (Hungary) or 1 (all other countries). The alternative model with debt as one of the endogenous variables ("debt in VAR") was estimated in 2 (Czech republic and Slovakia) or 3 lags (Hungary, Lithuania and Slovenia). In order to deal with the outliers, the following shift dummies were included in the regression: 2001q4 for Slovenia (impact of the financial turmoil in Latin America), 2003q1 for the Czech republic (major revision of the national accounts), 2008q4-2009q4 for Lithuania (impact of the Great Recession) and 2011q1 for Hungary (transfer of private pension fund assets to the state).

Estimated VAR residuals were submitted to normality, autocorrelation and heteroscedasticity tests in EViews. As is often the case in applied analysis, the multivariate test rejected normality of the residuals (Table 12). The Portmanteau test (Table 13) found that the residuals are mostly autocorrelated. The Lagrange multiplier test (Table 14) indicated that residuals are serially independent. The latter test is better suited for small samples and therefore more relevant in our context. The White test (Table 15) did not reject homoscedasticity of the residuals' variance.

The remainder of the work was taken to Matlab. Estimation of the SVARX model follows the standard LS estimator as in Lutkepohl (2005, chapter 3). Having identified the reduced form, simulations then proceed as set forth in Section 2. Initial conditions to each of the simulations are described in detail below. In impulse response functions and historical decomposition, GDP, fiscal variables and debt are converted to percentages of the no shock scenario GDP. All other variables are expressed in original units. Results presented further in this section are computed under debt feedback, unless indicated otherwise.

3.3 Fiscal policy effects

3.3.1 Estimated structural shocks

Figure 3 displays balances obtained as a difference between the structural shocks in revenue and expenditure, which were uncovered in the identification step of the VAR exercise. By construction, the structural shocks in fiscal variables are cleaned for any systematic response to movements in GDP and other macroeconomic variables. These balances can thus be viewed as a possible measure of the cyclically-adjusted fiscal stance (cf. e.g. Parkyn and Vehbi, 2014). The year 2009 is an example when fiscal policy in the CEE-5 was loosened.

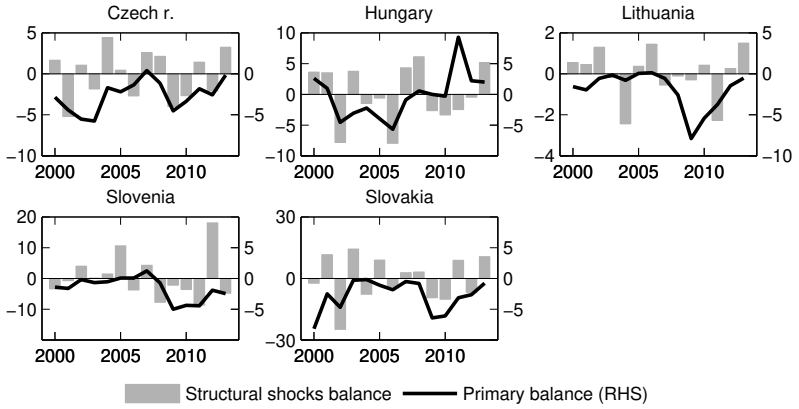


Figure 3: Structural primary balance

Note: Shown are balances constructed from the estimated structural fiscal shocks ($w_t^t - w_t^x$), and primary balances ($t_t - x_t$), in percent GDP.

3.3.2 Impulse response analysis

The next couple of figures and tables report the estimated impulse response functions and illustrate some of their properties. Response functions to fiscal shocks, and especially those of the GDP, are often referred to as so-called fiscal multipliers. That concept encourages a simple way to think about effects of policies. We would think of "constants" that will give us the resulting dollar added GDP if we multiply the additional dollar invested. In the context of linear VAR models, the multipliers are obtained from the estimated VAR coefficients by simple recursive multiplication. In this model, however, feedback from an external nonlinear equation feeds in the linear VAR part. The response coefficients cannot be obtained analytically. They are constructed as a difference between the shock and no shock scenario, both of which are simulated in levels, starting from non-zero initial conditions. Even if all else is equal, the response functions will depend on the sign and size of the shock (does the fiscal instrument increase or decrease when the shock occurs and by how much?), and on the initial conditions (how large is e.g. the starting debt ratio?). To borrow a wording from Muir et al., p. 8, "there is no such thing as a simple fiscal multiplier." Instead of point-wise constants, we should want to think of response functions as of dynamic behaviours that will follow given the set of critical conditions.

Figures 4 and 5 show response functions of the six variables to unexpected shocks in government revenue and expenditure. Either of the shocks was set up as a positive shock (increase) and was calibrated as one percent of the initial GDP. Initial conditions in GDP and debt were set as in the last in-sample year (2013). Assumed is a zero primary surplus, i.e. both t_t and x_t equal the

average of the two in the last in-sample year. Initial inflation and money growth are set to zero.

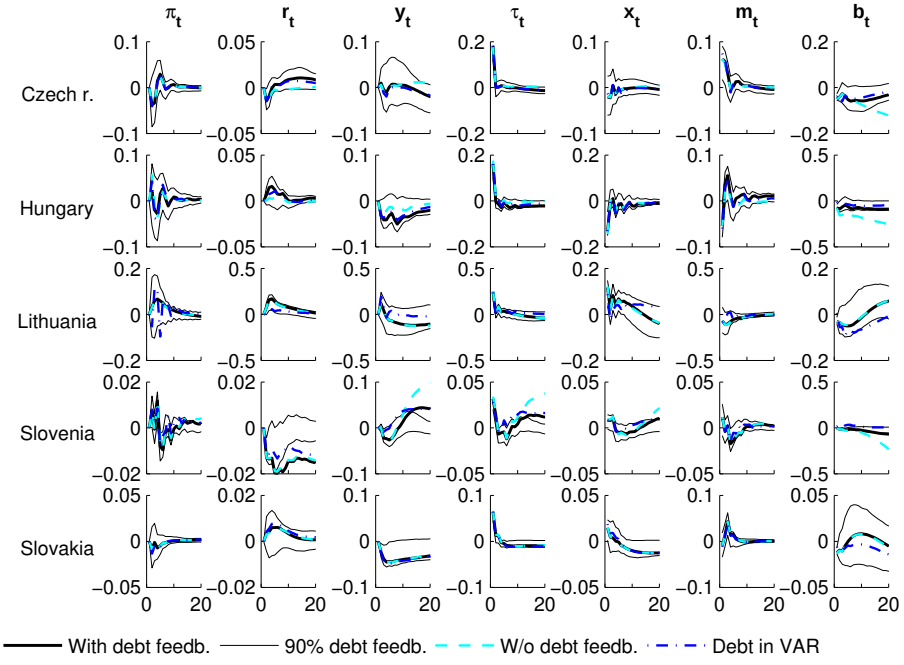


Figure 4: Responses to a government revenue shock

A revenue shock (Figure 4) mostly yields a positive response in itself, inflation, interest rate, and money supply growth. The response of GDP, government expenditure and debt is mostly negative. The somewhat mixed signs may be attributed to the rather broad scope of revenue, comprising also transfers, which are differently correlated with the business cycle and price developments than revenue from various types of taxes.

Effects of expenditure shocks on macroeconomic variables are quite similar across CEE-5. An expenditure shock (Figure 5) yields a positive response in itself, government revenue, GDP and debt, and a negative response in interest rate and money growth. The responses in inflation are mixed.

The negative response of the interest rate following an unexpected jump in expenditure is rather counter-intuitive. Economic intuition dictates that higher government deficits increase debt, making, in turn, its refinancing more costly. A possible explanation for the fall in interest rates may be the relatively stronger, positive response of GDP to the expenditure shock, coupled with a rise in government revenue (cf. e.g. Afonso and Souza, 2012, commenting on the results for the U.S.).

Table 3 summarises cumulative responses of GDP to fiscal shocks up to three years ahead. The cumulative coefficients are expressed in percent of the no shock scenario GDP. A one GDP-percent shock in government expenditure yields a 0.00 to 0.09 percent added GDP within the first year. The cumulative 3-year coefficients range between 0.18 and 0.42. For the Czech republic, the estimated 1-year response is -0.18 (GDP would fall after an expenditure shock), cumulative 3-year response is -0.66. A one GDP-percent shock to government revenue implies a sacrifice in GDP of 0.01 to 0.11 percent. In Lithuania, the estimated 1-year response is 0.13 (GDP would increase after a revenue shock), the cumulative 3-year coefficient is estimated at -0.62.

Figure 6 visualises some of the response functions properties. Unlike in linear VAR models, responses obtained in a VAR model with debt feedback will feature asymmetry and nonlinearity, and

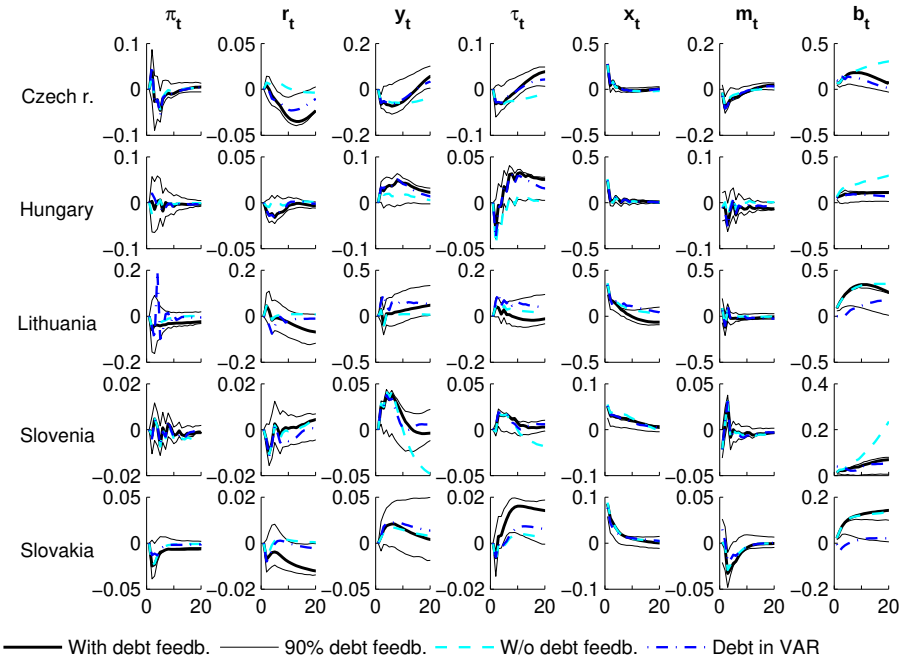


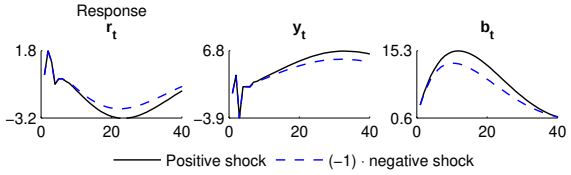
Figure 5: Responses to a government expenditure shock

Table 3: Cumulative response coefficients of GDP

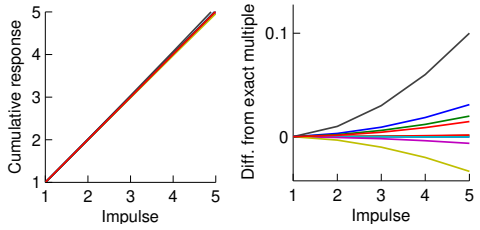
	Czech r.	Hungary	Lithuania	Slovenia	Slovakia
Revenue shock					
With debt feedb.					
1y	-0.01	-0.11	0.13	-0.05	-0.11
2y	0.01	-0.27	-0.18	-0.11	-0.28
3y	0.03	-0.41	-0.62	-0.05	-0.44
W/o debt feedb.					
1y	-0.02	-0.09	0.14	-0.05	-0.11
2y	-0.01	-0.17	-0.17	-0.11	-0.28
3y	0.03	-0.24	-0.62	0.03	-0.44
Expenditure shock					
With debt feedb.					
1y	-0.18	0.09	0.00	0.09	0.04
2y	-0.46	0.25	0.14	0.22	0.12
3y	-0.66	0.42	0.40	0.27	0.18
W/o debt feedb.					
1y	-0.16	0.07	-0.03	0.10	0.03
2y	-0.38	0.14	0.01	0.23	0.10
3y	-0.62	0.20	0.09	0.21	0.15

Note: The responses fall within the 90 percent confidence intervals obtained by bootstrapping.

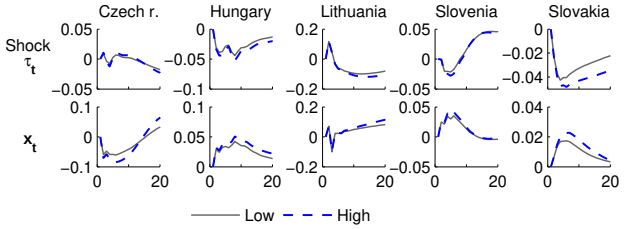
will depend on initial conditions. Figure 6a illustrates that a negative fiscal shock of the same size will not yield an identical behaviour, just with an opposite sign. Figure 6b shows that an n-times larger impulse will not yield an n-times larger response. The differences will grow with the size of the impulse and with the length of the simulation horizon. Figure 6c compares responses of GDP to fiscal shocks generated under two sorts of initial conditions: low interest rates and debt ratio and high interest rates and debt ratio. Levels do matter in the sense that they will generally amplify the response coefficients. Albeit being small, the differences between the responses illustrate more profound nonlinearities behind the government budget constraint, that will operate at higher levels of debt or in times of larger imbalances.



(a) Asymmetry



(b) Nonlinearities



(c) Dependance on itinial conditions

Figure 6: Properties of the response functions

Note: Shown are responses of GDP to a government expenditure shock (a-b) or to fiscal shocks (c).

Table 4 and 5 collect the evidence on fiscal policy effects in emerging economies, including the CEE-5, known from the literature. More specifically, Table 4 compares the signs of the response functions of GDP, inflation and interest rate. Table 5 collects response coefficients of GDP to fiscal shocks up to three years ahead. The definition of the fiscal instruments is not identical across the papers, though net tax revenue and spending are used in the majority of cases (recall Table 1 in the introductory section). The use of government revenue and expenditure in this paper is motivated by the inclusion of the government budget constraint.

Obviously, the evidence available in the literature is rather heterogenous in terms of response signs (Table 4). The model with debt feedback as the headline model in this paper gives results closer to theoretical models, or to relatively broader empirical specifications (Czech republic, Hungary). The debt feedback might be one of the critical factors that help reconcile the findings in cases where the literature is not unanimous. Examples include the response of GDP and interest rate to

a revenue shock in the Czech republic, the response of GDP to an expenditure shock in Hungary, or the response of GDP and inflation to an expenditure shock in Slovenia.

Regarding the size of GDP responses, the coefficients obtained under debt feedback conform to the literature (Table 5). The estimates for emerging economies are typically small, below 0.5 within the first year. One of the critical factors to the relatively lower effectiveness of fiscal policy, compared to advanced economies, is the higher degree of openness (cf. e.g. Auerbach and Gorodnichenko, 2012, and Ilzetzki, Mendoza, and Vegh, 2013).

Table 4: Estimates of response functions for CEE-5

Country	Authors	Model	(a) GDP	infla-tion	inter-est rate	(b) GDP	infla-tion	inter-est rate
Czech r.	Mirdala (2009)	E	+	+-	-	+	+-	+-
	Baxa (2010)	E	-			+		
	Eller et al. (2011)	E	+	-+	-	-	+	+-
	Franta (2012)	E						
	structural		-	-	-	+	+	+
	recursive		+	+	+	+	+	-
	sign restrictions		+0	+	+	+	+	-
	Mirdala (2013)	E	-			+		
	Dinu and Marinas (2014)	E	0			+	+	
	Stork and Zavacka (2010)	T	-	-	-	+-	-	+
	Klyuev and Snudden (2011)	T	-	-	-	+	+	+
	Ambrisko et al. (2012)	T	-	+	+	+	+	+
Hungary	Lendvai (2007)	E				-	-	
	Mirdala (2009)	E	+	+-	-+	+	+	-+
	Eller et al. (2011)	E	-	-	-	+	+	+
	Kotosz and Peak (2013)	E				-		
	Mirdala (2013)	E	-			+		
	Dinu and Marinas (2014)	E	0-			+	+	
	Algozhina (2012)	T				+-		
	Benk and Jakab (2012)	T	-			+		
Lithuania	Karmelavicius and Klyviene (2012)	E	-			-		
	Klyviene and Karmelavicius (2012)	E	-+					
	Mirdala (2013)	E	-			+		
Slovakia	Mirdala (2013)	E	-			+		
	Pecsyova (2013)	E	-	-	+	+-	-	+
Slovenia	Eller et al. (2011)	E	+	+	-+	+-	+	+-
	Jemec et al. (2011)	E	-+			+-		
	Mirdala (2013)	E	-			+		
	Dinu and Marinas (2014)	E	0-			+	0	
	Clancy et al. (2014)	T				+	+-	+

Note: Reported are signs of the response functions to a positive fiscal shock in the revenue side (a) and expenditure side variable (b). Symbols used: E stands for empirical (VAR) model, T denotes theoretical model, + positive response, - negative response, 0 response close to zero; combinations of the symbols denote sign reversion.

3.3.3 Historical decomposition of macroeconomic variables

Figure 7 below and Figures 11-13 in the Appendix show a historical decomposition of the macroeconomic variables, computed from initial conditions that replicate the historical pre-sample. The decomposition suggests that the variables were driven mainly by macroeconomic shocks, and that structural shocks in government revenue and expenditure contributed only to a minor extent. According to the estimates, during the Great Recession fiscal policy in the CEE-5 made mostly neutral or minor positive contributions to GDP. In the period afterwards, it contributed positively in Slovakia and Hungary. It needs to be said that these estimates are sensitive in various aspects, and

Table 5: Response coefficients in emerging markets and open economies

Type of shock	Authors	Coverage	0	1y	2y	3y	Notes
Revenue side shock							
	Eller et al. (2011)						
		Czech r.	0.00	0.01	0.03		
		Hungary	-0.00	-0.01	-0.01		
		Slovakia	-0.02	-0.05	-0.1		
		Slovenia	0.01	0.02	0.02		
	Franta (2012)	Czech r.	0.00	0.20	0.30		Recursive indentification.
	Klyviene and Karmelavicius (2012)	Lithuania	-0.17	0.18	0.49	0.26	Response to effective tax rate shock, Choleski identification.
	Pecsyova (2013)	Slovakia	-0.00	-0.15	-0.17	-0.23	
	Batini et al. (2014)	Emerging markets and low income countries					Short-term multipliers. Median value: 0.20, range: 0.00 to 1.00.
Expenditure side shock							
	Eller et al. (2011)						
		Czech r.	-0.00	-0.01	-0.04		
		Hungary	0.01	0.02	0.01		
		Slovakia	-0.01	-0.01	0.00		
		Slovenia	0.01	0.00	-0.01		
	Franta (2012)	Czech r.	0.23	0.32	0.35		Recursive indentification.
	Auerbach and Gorodnichenko (2012)	OECD countries				0.11 (0.96 / -0.58)	Estimate for open economies, country and time fixed effects. Mean response. In brackets recessions / expansions.
	Ilzetzki, Mendoza, and Vegh (2013)	High income and developing countries					Estimate for open economies. Impact multiplier -0.077, long-run multiplier -0.46.
	Pecsyova (2013)	Slovakia	0.14	0.39	0.65	0.39	
	Batini et al. (2014)	Emerging markets and low income countries					Short-term multipliers. Median value: 0.30, range: -0.40 to 2.35.

Note: Reported are estimates as provided by the authors in tables. In Ilzetzki, Mendoza and Vegh (2013), the estimates for open economies are reported in Figure 7. For Batini et al. (2014), the median value is my own calculation, based on Tables A.3.1 and A.3.2. Most of the estimates are impulse response coefficients based on VAR or theoretical models. If instead authors report multipliers or mean estimates, this is explicitly mentioned under the Notes. Abbreviations used: 0 - immediate response coefficient, 1y/2y/3y - cumulative 1 year (4 quarters) / 2 year (8 quarters) / 3 year coefficient (12 quarters).

depend on the initial conditions and identification matrix.

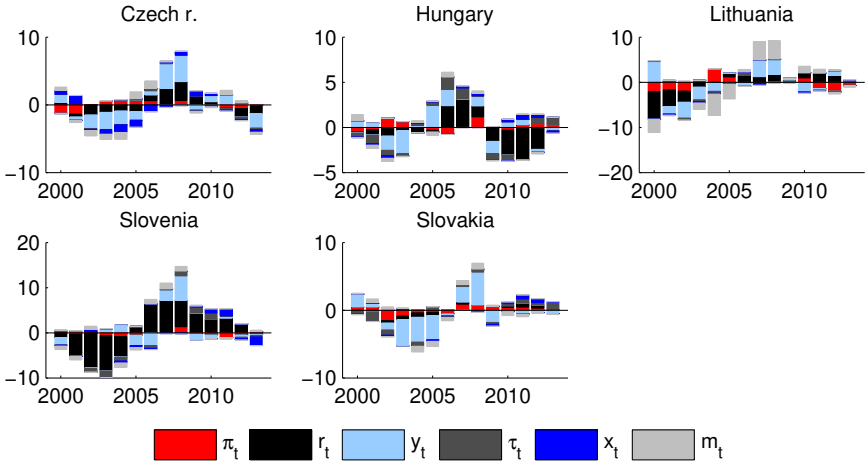


Figure 7: Decomposition of GDP

3.3.4 Forecast error variance decomposition

Decomposition of the forecast error variance is reported in Table 16 in the Annex. According to the estimates, fiscal shocks explain a minor part of the variance in macroeconomic variables. The estimates are sensitive to ordering of the variables in the VAR and to the identification matrix.

3.4 The role of debt

3.4.1 Coefficients at debt lags

Table 6 reports coefficients at debt lags in the revenue and expenditure equation. The combination of coefficients is stabilising w.r.t. government primary surplus in all of the CEE-5, though mostly not statistically significant. Size of the resulting impact on government primary surplus varies from country to country.

Table 6: VAR coefficients at lagged debt levels

	t_t	x_t		t_t	x_t		t_t	x_t
Czech r.			Lithuania			Hungary		
b_{t-1}	0.0050	0.0008	b_{t-1}	-0.0106	-0.0177	b_{t-1}	0.0524	0.0407
	-0.40	0.05		-1.85	-2.49		1.36	0.57
Slovenia			Slovakia			b_{t-2}	0.0041	-0.0614
b_{t-1}	0.0161	-0.0002	b_{t-1}	0.0163	0.0025		0.11	-0.88
	2.21	-0.02		3.17	0.33	*Sum*	*0.0566*	*-0.0207*

Note: Reported are estimated coefficients, beneath are t-statistics as supplied by EViews.

3.4.2 Effects of debt shocks

Impulse responses following government debt shocks are shown in Figure 8. The shock is calibrated as a one percent increase in terms of initial GDP. Initial conditions are identical as in the case of fiscal shocks (Section 3.3.2): GDP and debt as in the last in-sample year (2013), zero primary surplus and zero initial inflation and money growth. According to the estimates, a shock to debt mostly yields a positive response in itself, government revenue and GDP, and a negative response in interest rates, government expenditure and money supply growth.

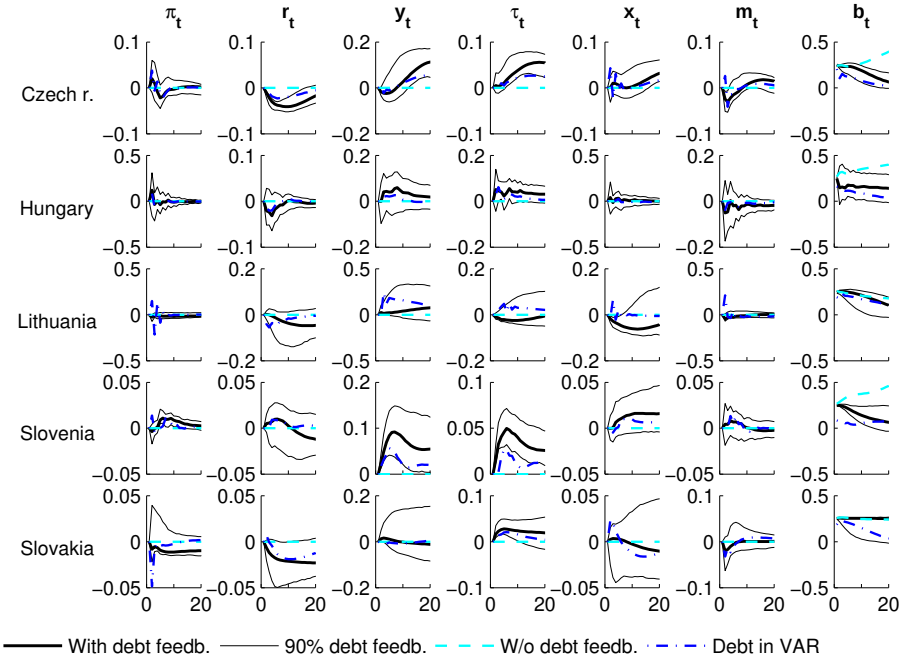


Figure 8: Responses to a shock in government debt

The behaviour of bond yields following an unexpected increase in debt is counter-intuitive, very much like in the case of an expenditure shock mentioned above. Economic intuition dictates that higher debts pose a higher risk and should be more costly to refinance. The negative estimated response reflects the inverted relation of bond yields and debt in levels which obviously dominates the positive relation thereof in detrended levels (recall Table 2).

3.4.3 Impact of debt feedback

The impulse response analysis in Section 3.3.2 and 3.4.2 showed that both inclusion of the debt feedback and the way it is implemented matter. The extent to which debt affects the rest of the system, varies from country to country, and from one variable to another. As a general observation, debt feedback most profoundly affects the responses of government revenue, GDP and interest rate, especially following an expenditure shock (Figure 5). It would amplify the size of the responses, and might also revert the sign. The estimated response of output is most strongly affected by debt feedback in Hungary and Lithuania following an expenditure shock (Table 3).

Regarding the responses following a debt shock (Figure 8), the headline model "with debt feedback" and the alternative specification "debt in VAR" are unanimous about the sign of the responses.

However, the size thereof is somewhere from a half to a double for interest rates, GDP, government revenue and expenditure.

Yet another way to illustrate the impact of the debt feedback provides Figure 9. It displays debt paths over the forecast horizon of ten years, generated under debt feedback and without. Initial conditions replicate the last few quarters of the sample period. Such an exercise was performed e.g. in Cherif and Hasanov (2012) for the U.S., and Parkyn and Vehbi (2014) for New Zealand. Similar to their results, the simulated out-of-sample debt path in the CEE-5 is stabilised under debt feedback, but strongly explosive if debt feedback is omitted. Though implausible in dimension, I think that the explosive debt path has something to say about fiscal policy. A future-oriented interpretation warns that without balancing carefully expenditure and revenue, governments would run into unbearably high indebtedness. Looking backwards, it were accumulated past deficits that brought the levels of debt to where they stand recently. In that sense, the explosive debt path extrapolates imbalances the historical data already contain. In analogy, the stabilised debt path extrapolates past episodes of consolidation or balanced budgeting.

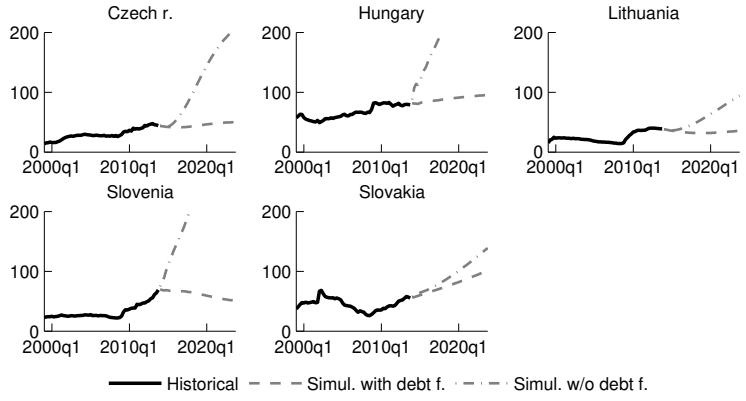


Figure 9: Historical and simulated debt ratios

3.5 Robustness check

The results have been submitted to three sorts of robustness check:

1. To assess sampling uncertainty, the impulse response coefficients are re-estimated using bootstrap methods (one-step bootstrap from VAR residuals in 1000 draws). Presented is the median response.
2. The assumption is challenged that government revenue is predetermined w.r.t. government expenditure within the VAR. Impulse response functions are generated using an alternative ordering with expenditure being predetermined w.r.t. revenue. Ordering of the other variables is preserved.
3. To understand how much the recent crisis changed the conduct of fiscal policy and its effects, impulse responses are generated based on VAR coefficients obtained from a shorter sample, ranging from 1999q1 to 2008q3 instead of 2013q4.

Calibration of shocks and initial conditions are identical as in the headline estimates presented above (Section 3.3.2).

Figure 10 shows that the headline estimates are robust in sign to either of the checks considered. The magnitude of the response functions differs slightly. The additional estimates mostly fall within the 90 percent confidence interval of the headline model.

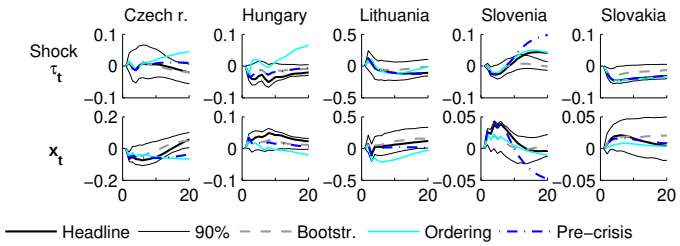


Figure 10: Comparison of response functions under modified specification

Note: Shown are responses of GDP to fiscal shocks.

Notwithstanding previous comments, a few caveats should be mentioned. Any empirical results that can be obtained for the CEE-5 countries, are based on a relatively short sample, and will hold so long the structural relationships of the economies remain unchanged. The estimated VAR coefficients represent average past behaviour, which in part resulted from factors beyond the model, such as integration process or economic convergence. The average estimates might disguise vulnerability of these economies that are largely dependent on external demand and bond market sentiment. It would thus be appropriate in policy and forecasting to evaluate this empirical setting to more in-depth theoretical models and consider a more complex set of country-specific shocks.

4 Conclusion

This paper estimates effects of fiscal policies under explicit debt feedback in five CEE economies. The SVARX model in Section 2, feeding in dynamics from the government budget constraint, follows Favero and Giavazzi (2007). Analysing the impact of debt dynamics on policy effectiveness is still rather novel in the CEE-related literature.

Estimated coefficients of fiscal variables at lagged values of government debt are stabilising w.r.t. the primary surplus. This has two major implications. First, simulated out-of-sample debt paths are stabilised under debt feedback, but strongly explosive if debt feedback is omitted. Second, both inclusion of the debt feedback and the way it is implemented matter to the rest of the model. In particular, responses of GDP, interest rate and government revenue are larger under debt feedback and might revert the sign. The estimated responses depend more strongly on debt feedback in countries where the debt ratios are relatively high (Hungary, Slovenia) or have expanded rapidly since the recent crisis (Lithuania).

Section 3 computes a rich set of empirical results, most of which have not been presented before, such as response functions of variables to debt shocks and historical decomposition of the time series under debt feedback. Unlike in linear VAR models, the impulse response functions depend on the size and sign of the shock and on the initial conditions. The paper therefore compares the results under a range of assumptions. Some of the results are highlighted as follows:

- Government expenditure shocks yield small, expansionary effect on output, which is a result in line with the previous literature. Inclusion of the debt feedback might help reconcile the findings in cases where the literature is not unanimous about the sign of the response (e.g. Hungary, Slovenia).
- Based on the estimates of structural primary balances, fiscal policy in the CEE-5 was loosened during the Great Recession 2008-09. Historical decomposition of output suggests that during the crisis, fiscal policy made mostly neutral or minor positive contributions. In the period afterwards, it contributed positively in Slovakia and Hungary. Overall, however, the macroeconomic variables were driven mainly by macroeconomic shocks and only to a minor extent by fiscal shocks.
- Impulse responses under debt feedback have trailed the rather counter-intuitive relation between government debt, GDP and interest rate, which was first pointed out in the correlation analysis. Simple regressions might obviously not detect any negative causal effect between government indebtedness and growth in the CEE-5. Of course, to draw serious conclusions on that issue, one needs to take into account the fact that these are converging economies and their bond yields have declined in the recent environment of low interest rates.

Further extensions of this work may proceed alongside several venues.

- As a possible refinement, the fiscal variables may be broken down in structure, to identify the effects of government consumption, investment, public employment, net taxes and various transfers.
- To further increase robustness of the findings, a set of alternative identification and estimation strategies might be employed, such as e.g. in Franta (2012).
- The specification in this model relied on the accounting consistency of the government debt data which were expressed in terms of euros. With the increasing foreign currency exposure of the public debt since the crisis, a break-down of debt to shares denominated in domestic and foreign currency, as e.g. in Ilzetzki (2011), is another possible extension.
- A further upgrade of the model might be tailored to address specific questions regarding the countries of interest. It may incorporate country-specific factors beyond the general setting, such as productivity growth, foreign direct investment, exposure to external demand shocks and others.

Acknowledgements

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Annex

Table 7: Individual unit root test - Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP).

	π_t	r_t	y_t	t_t	x_t	m_t	b_t
ADF							
Czech republic	L	L	L (lin + c)	L (c)	L (c)	L (lin + c)	L (lin + c)
	0.0000	0.0150	0.9581	0.5713	0.2173	0.2108	0.8147
Hungary	L	L	L (lin + c)	L (lin + c)	L (lin + c)	L	L (lin + c)
	0.0000	0.1736	0.9277	0.6871	0.9057	0.1736	0.8019
Lithuania	L	L (lin + c)	L (lin + c)	L (lin + c)	L (lin + c)	L (c)	1D (lin + c)
	0.0006	0.1864	0.8335	0.8818	0.9753	0.0695	0.2407
Slovenia	L	1D (c)	L (lin + c)	L (lin + c)	L (lin + c)	L	1D
	0.0001	0.0149	0.6047	0.8788	0.9052	0.0001	0.0332
Slovakia	L	L (lin + c)	L (lin + c)	L (lin + c)	L (lin + c)	L	L (lin + c)
	0.0049	0.0049	0.7807	0.0642	0.3749	0.0163	0.9579
PP							
Czech republic	L	L (lin + c)	L (lin + c)	L (c)	L (c)	L	L (lin + c)
	0.0000	0.0423	0.9675	0.4167	0.0869	0.0347	0.5099
Hungary	L	L (lin + c)	L (lin + c)	L	L (lin + c)	L	L (lin + c)
	0.0000	0.2388	0.9202	0.6712	0.2955	0.0008	0.8019
Lithuania	L	L (lin + c)	L (lin + c)	L (lin + c)	L (lin + c)	L	L (lin + c)
	0.0006	0.4683	0.803	0.8168	0.9683	0.0155	0.933
Slovenia	L	L (lin + c)	L (lin + c)	L (lin + c)	L (lin + c)	L	L (lin + c)
	0.0000	0.8842	0.9339	0.8553	0.9009	0.0001	1.0000
Slovakia	L	L	L (lin + c)	L (lin + c)	L (lin + c)	L	L (lin + c)
	0.0000	0.0000	0.6243	0.0883	0.4012	0.0002	0.9338

Note: The null hypothesis assumes that there is a unit root. Reported are one-sided p-values under the most extensive specification (transformation of the series and test equation) when the null hypothesis could not be rejected. Lag length is based on the Schwarz information criterion. The Phillips-Perron test uses a kernel sum-of-covariances estimator with Bartlett weights and Newey-West bandwith selection. Abbreviations used: L - level, 1D - 1st order difference, c - intercept, lin - linear trend.

Table 8: Johansen test on cointegration

	Data Trend: Test Type	None No Intercept No Trend	None Intercept No Trend	Linear Intercept No Trend	Linear Intercept Trend	Quadratic Intercept Trend
Czech republic	trace test	5	4	4	4	4
	max eig. test	5	4	4	2	2
Hungary	trace test	6	6	5	3	3
	max eig. test	3	2	2	3	3
Lithuania	trace test	5	5	2	2	2
	max eig. test	5	5	2	2	2
Slovenia	trace test	2	3	2	3	3
	max eig. test	2	2	2	3	3
Slovakia	trace test	4	5	4	4	6
	max eig. test	5	5	4	4	4

Note: Reported is the number of cointegrating relations per assumption on trend and type of test. Critical values are based on MacKinnon-Haug-Michelis (1999) at 5% level of significance, assuming no exogenous variables.

Table 9: Check of VAR stability

	Eigenvalue	Modulus
Czech republic	0.9102 - 0.0814i	0.9139
Hungary	0.9084	0.9084
Lithuania	0.9424 - 0.0263i	0.9428
Slovenia	0.9656 - 0.0342i	0.9662
Slovakia	0.9626	0.9626

Note: Reported are inverse roots of the characteristic polynomial with the largest modulus.

Table 10: VAR lag length

	LR	FPE	AIC	SC	HQ
Czech republic	2	2	2	1	1
Hungary	2	5	5	1	1
Lithuania	4	5	5	1	1
Slovenia	5	5	5	1	5
Slovakia	1	1	1	1	1

Note: Reported is the appropriate order of the VAR as suggested by the test, based on critical values at 5% significance level and allowing for 5 lags at maximum. Abbreviations used: LR - sequential modified likelihood ratio test, FPE - final prediction error, AIC - Akaike information criterion, SC - Schwarz information criterion, HQ - Hannan-Quinn information criterion.

Table 11: Wald test on lag exclusion

	1st lag Chi-squared	p-value	2nd lag Chi-square	p-value	3rd lag Chi-square	p-value
Czech republic	222.7	0.000	71.7	0.000		
Hungary	187.8	0.000	59.5	0.008	73.4	0.000
Lithuania	191.3	0.000	61.7	0.005		
Slovenia	302.5	0.000	80.6	0.000	72.4	0.000
Slovakia	154.8	0.000	32.8	0.622		

Note: The null hypothesis assumes that the coefficients at the specific lag are zero. Reported is the joint test statistics from Chi-square distribution with 36 degress of freedom.

Table 12: Multivariate tests of VAR residuals

	Skewness			Kurtosis			Jarque-Bera		
	Cs	Dof	Pv	Cs	Dof	Pv	Cs	Dof	Pv
Czech republic	1.7	6	0.947	23.0	6	0.001	24.7	12	0.016
Hungary	1.6	6	0.949	49.8	6	0.000	51.5	12	0.000
Lithuania	32.5	6	0.000	44.2	6	0.000	76.7	12	0.000
Slovenia	11.3	6	0.079	45.3	6	0.000	56.6	12	0.000
Slovakia	35.5	6	0.000	118.3	6	0.000	153.8	12	0.000

Note: The null hypothesis assumes that the residuals are multivariate normal. Reported are the joint test statistics, based on Choleski orthogonalisation of the residual variance-covariance matrix. Abbreviations used: Cs - Chi-square test statistics, Dof - degrees of freedom, Pv- p-value.

Table 13: Portmanteau test on autocorrelation of residulas

Lag	Czech r. adj. Q-st.	prob.	Hungary adj. Q-st.	prob.	Lithuania adj. Q-st.	prob.	Slovenia adj. Q-st.	prob.	Slovakia adj. Q-st.	prob.
3	81.4	0.000			83.7	0.000			61.3	0.005
4	132.1	0.000	128.0	0.000	121.0	0.000	117.9	0.000	102.5	0.011
5	179.0	0.000	167.3	0.000	148.7	0.006	161.1	0.000	152.1	0.003
6	221.2	0.000	211.0	0.000	183.1	0.015	198.0	0.000	176.9	0.033
7	256.0	0.000	255.9	0.000	208.4	0.072	232.9	0.000	215.9	0.035
8	292.7	0.000	287.1	0.000	249.7	0.058	281.9	0.000	250.7	0.053
9	338.2	0.000	336.8	0.000	274.5	0.158	314.6	0.000	304.2	0.014
10	382.2	0.000	377.5	0.000	322.0	0.082	339.6	0.000	338.8	0.021

Note: The null hypothesis assumes that there is no autocorrelation up to a specified number of lags. Reported are the adjusted Q-statistics and p-values. Tested are only lags larger than the VAR order.

Table 14: Lagrange multiplier test on residual serial correlation

Lag	Czech r. LM-st.	prob.	Hungary LM-st.	prob.	Lithuania LM-st.	prob.	Slovenia LM-st.	prob.	Slovakia LM-st.	prob.
1	34.4	0.546	28.8	0.798	68.6	0.001	39.2	0.327	44.1	0.165
2	39.9	0.300	40.8	0.266	60.0	0.007	35.0	0.517	37.0	0.423
3	26.5	0.875	45.8	0.128	20.7	0.981	44.9	0.146	26.9	0.863
4	46.6	0.110	47.8	0.090	33.1	0.608	56.7	0.015	35.7	0.481
5	53.3	0.032	37.4	0.404	24.4	0.930	45.8	0.127	43.3	0.187
6	42.6	0.208	38.7	0.348	31.0	0.707	38.3	0.365	23.5	0.946
7	35.5	0.493	49.0	0.073	21.4	0.974	42.2	0.220	31.3	0.693
8	32.5	0.637	43.9	0.171	36.5	0.444	48.4	0.082	28.8	0.796
9	41.8	0.233	55.8	0.019	21.2	0.976	28.5	0.811	48.2	0.084
10	44.4	0.159	37.7	0.390	46.0	0.122	25.3	0.910	28.5	0.807

Note: The null hypothesis assumes that there is no serial correlation at the specified lag. Reported are test statistics from the Chi-square distribution with 36 degrees of freedom.

Table 15: White test on heteroscedasticity of residulas

	LM-statistics	degrees of freedom	p-value
Czech republic	570.1	567	0.455
Hungary	840.4	861	0.686
Lithuania	620.1	567	0.061
Slovenia	782.4	819	0.816
Slovakia	544.7	546	0.508

Note: The null hypothesis assumes that the residual variance is homoscedastic. Reported are joint test statistics from Chi-square distribution with degrees of freedom as indicated, no cross-product terms are included.

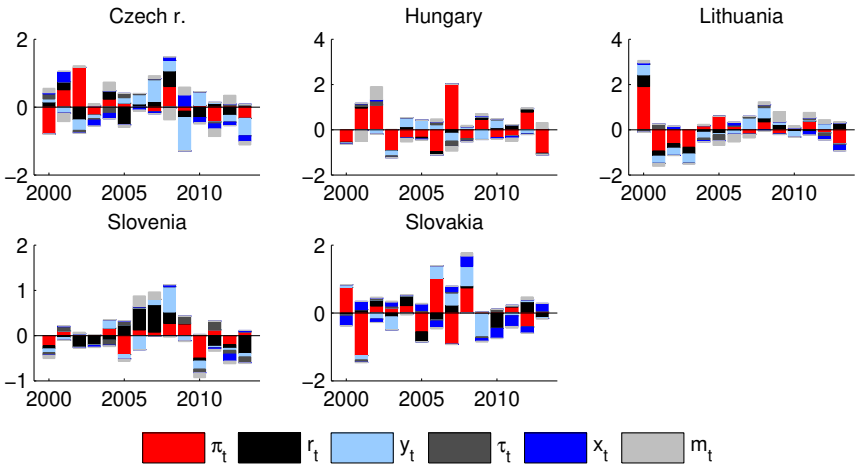

Figure 11: Decomposition of the GDP deflator growth rate

Table 16: Forecast error variance decomposition under debt feedback

Czech r.							**Hungary**							**Lithuania**							**Slovenia**							**Slovakia**						
	π_t	r_t	y_t	τ_t	x_t	m_t		π_t	r_t	y_t	τ_t	x_t	m_t		π_t	r_t	y_t	τ_t	x_t	m_t		π_t	r_t	y_t	τ_t	x_t	m_t		π_t	r_t	y_t	τ_t	x_t	m_t
π_t							π_t							π_t							π_t							π_t						
0	100	0	0	0	0	0	0	100	0	0	0	0	0	0	100	0	0	0	0	0	0	100	0	0	0	0	0	0	100	0	0	0	0	0
1y	81	6	1	0	0	13	1y	90	1	0	0	0	9	1y	93	3	2	0	0	2	1y	84	4	0	0	0	13	1y	94	6	0	0	0	1
5y	80	6	1	0	0	13	5y	89	1	0	0	0	10	5y	89	3	3	0	0	4	5y	76	10	0	0	0	14	5y	93	6	0	0	0	1
r_t							r_t							r_t							r_t							r_t						
0	1	99	0	0	0	0	0	10	90	0	0	0	0	0	3	97	0	0	0	0	0	2	98	0	0	0	0	0	9	91	0	0	0	0
1y	4	96	0	0	0	1	1y	6	93	0	0	0	1	1y	12	72	0	2	0	14	1y	14	86	0	0	0	0	1y	15	85	0	0	0	0
5y	49	46	1	0	2	1	5y	9	88	0	0	0	3	5y	19	61	2	2	1	15	5y	13	85	0	0	0	2	5y	16	83	0	0	0	0
y_t							y_t							y_t							y_t							y_t						
0	43	1	55	0	0	0	0	37	33	31	0	0	0	0	33	33	34	0	0	0	0	2	54	44	0	0	0	0	12	62	26	0	0	0
1y	42	7	13	0	1	37	1y	21	60	3	0	0	16	1y	27	41	12	0	0	19	1y	8	54	4	0	0	34	1y	64	12	6	1	0	17
5y	31	41	7	0	1	20	5y	12	84	1	0	0	3	5y	31	42	5	0	0	21	5y	12	84	0	0	0	4	5y	53	29	2	0	0	15
τ_t							τ_t							τ_t							τ_t							τ_t						
0	0	10	28	62	0	0	0	6	9	0	85	0	0	0	14	0	30	56	0	0	0	71	28	0	1	0	0	0	2	1	8	89	0	0
1y	15	45	12	12	1	15	1y	27	23	1	7	0	41	1y	17	32	20	9	0	22	1y	38	49	1	0	0	11	1y	47	19	5	11	0	18
5y	28	48	5	3	1	15	5y	20	68	0	2	1	9	5y	26	38	9	1	0	26	5y	18	78	0	0	0	4	5y	8	55	2	2	1	32
x_t							x_t							x_t							x_t							x_t						
0	36	18	1	0	45	0	0	45	46	0	2	7	0	0	4	30	0	7	59	0	0	88	8	0	0	4	0	0	6	92	0	0	2	0
1y	33	12	2	0	21	31	1y	46	48	0	1	3	2	1y	13	52	2	3	29	0	1y	83	5	0	0	2	11	1y	4	91	0	0	2	3
5y	27	30	6	0	8	28	5y	37	58	0	0	1	3	5y	20	38	12	0	2	27	5y	15	80	0	0	0	4	5y	30	54	1	0	1	13
m_t							m_t							m_t							m_t							m_t						
0	4	3	0	0	0	93	0	25	7	0	0	0	68	0	0	5	0	0	0	94	0	0	1	0	0	0	99	0	0	0	0	0	0	100
1y	14	3	1	1	1	81	1y	47	6	0	0	0	47	1y	5	10	0	1	1	84	1y	4	4	0	0	0	92	1y	3	5	0	0	0	92
5y	18	10	1	0	1	69	5y	50	8	0	0	0	42	5y	5	12	1	1	1	81	5y	8	6	0	0	0	86	5y	3	7	0	0	0	90

Note: Reported are percent contributions of the estimated structural shocks within the following forecast horizons: 0 - instantaneous, 1y - one year, 5y - five years.

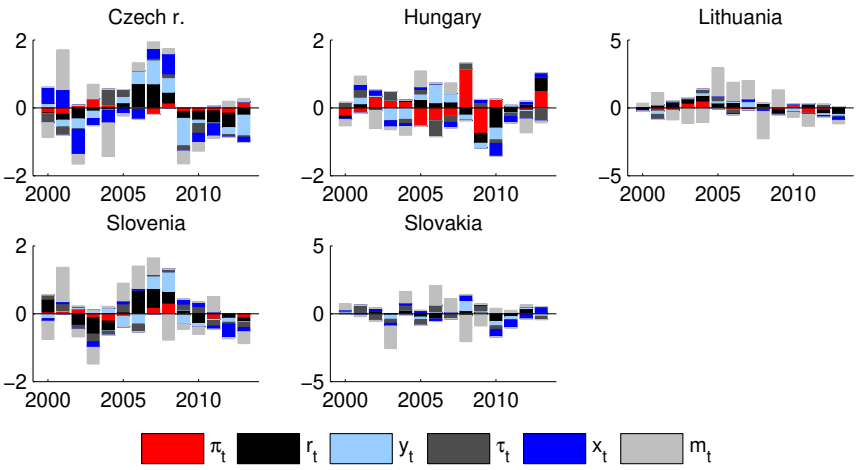

Figure 12: Decomposition of the M2 growth rate

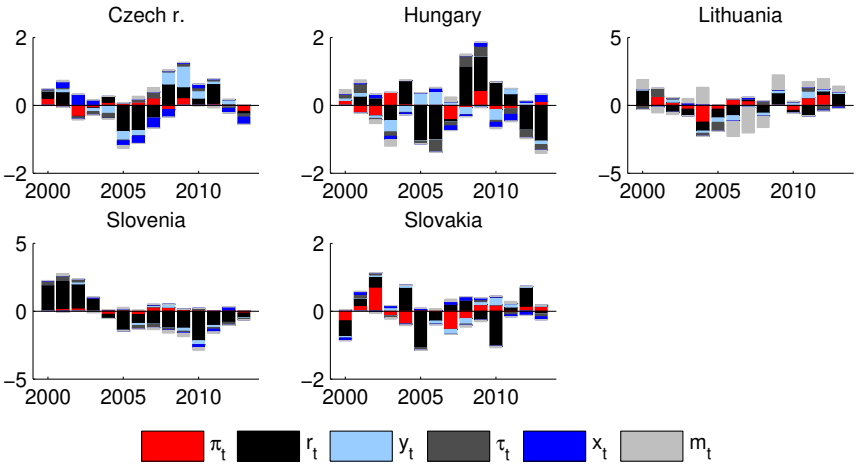

Figure 13: Decomposition of the government bond yield