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 to 2013q4 in six Central and East European economies: Slovakia, Czech republic, Hungary, Poland, Slovenia and Lithuania. The way the debt feedback is accounted for as well as the nonlinearities operating behind the government budget constraint matter for the understanding of the effects of fiscal policy shocks. The debt feedback dampens the effects on output and eliminates persistence in the responses over longer horizons. Simulations starting from various levels of the debt ratio suggest that high government indebtedness might imply a sacrifice in the policy effectiveness on output over the medium term. Simulated out-of-sample debt paths are stabilised if debt feedback is included, but strongly explosive otherwise.
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Keywords: fiscal policy, government indebtedness, debt dynamics, endogenous debt feedback, structural VAR model, VARX model, impulse response functions, historical decomposition of times series, nonlinearity, meta-analysis, CEE countries, new EU member states

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Non-technical summary

This paper upgrades the literature on new EU countries by examining the impact of government indebtedness on the effectiveness of fiscal policy. Analysing effects of fiscal shocks in these countries from different viewpoints remains rather appealing. Government budget, unlike e.g. the interest rate or the exchange rate, is a policy making tool over which the small members have retained control. Despite intensifying debates about further integration, the member countries would rather unlikely give up on their fiscal autonomy.

Among the challenges in the field of fiscal policy research, debt deserves closer attention. The debt ratios in the new EU members have substantially increased since the Great Recession. 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).

The obvious question that arises is what impact does debt exert to the effectiveness of fiscal policy in the new EU members. Interactions of government debt, fiscal policy and the economy have not deserved voluminous attention in the literature on new EU economies. With the aim to improve our knowledge on the role of debt, this paper analyses fiscal policy effects under explicit debt feedback over 1991q1 to 2013q4 in six Central and East European countries (CEE-6): Slovakia, Czech republic, Hungary, Poland, Slovenia and Lithuania. It makes use of the framework provided by Favero and Giavazzi (2007). The framework extends the traditional VAR setup of Blanchard and Perotti (2002) for a nonlinear equation, the government budget constraint.

Applying this framework in the CEE countries encounters difficulties given the counterintuitive relationship between the variables and the debt ratio. In particular, the bond yields have been steadily declining over the estimation horizon against increasing levels of public indebtedness. Moreover, stabilisation attempts after the onset of the crisis implied that fiscal variables were not responding to the rising debt ratios. Based on a detailed correlation analysis as well as considerations w.r.t. overall stability of the system of equations, plausibility of the impulse responses and of the forecasted debt trajectories, two empirical specifications of the variables are used, both in levels and transformed. In the latter case, the results are estimated over the pre-crisis sample.

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 have a qualitative impact on the behaviour of other variables. The debt feedback dampens the effects on output and eliminates persistence in the responses over longer horizons, especially following expenditure shocks. Simulations starting from various levels of the debt ratio suggest that high government indebtedness might imply a sacrifice in the policy effectiveness on output over the medium term. Simulated out-of-sample debt paths are stabilised under debt feedback, but strongly explosive if debt feedback is omitted.

1 Motivation

This paper upgrades the literature on new EU countries by examining the impact of government indebtedness on the effectiveness of fiscal policy. Analysing effects of fiscal shocks in these countries from different viewpoints remains rather appealing. Government budget, unlike e.g. the interest rate or the exchange rate, is a policy making tool over which the small members have retained control. Despite intensifying debates about further integration, the member countries would rather unlikely give up on their fiscal autonomy. Among the challenges in the field of fiscal policy research, debt deserves closer attention. The debt ratios in the new EU members have substantially increased since the Great Recession, to about 40-80 percent GDP. The crisis thus discontinued the long period over which the public debt ratios in the new EU countries were associated with levels of about 20-30 percent GDP. There were exceptions, such as e.g. Hungary and Poland, but as until the crisis, their relatively high debt ratios followed a declining trend.

Levels of debt may have important implications for the 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 recently in the enlarged part of the EU.

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

Interactions of government debt, fiscal policy and the economy have not deserved voluminous attention in the literature on new EU economies. Ilzetzki (2011) estimates, using the FG framework, fiscal policy effects under debt feedback for Estonia and four developing countries. Inclusion of the debt feedback for Estonia amplified and eventually changed the sign of the response of GDP and inflation to fiscal shocks. Melecky and Melecky (2011) and Eller and Urvova (2012) analyse macroeconomic determinants of the government debt paths. However, rather than characterising fiscal policy effects, they only discuss the responses of the debt ratio to shocks in other variables. 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, Clancy et al. (2014) for Slovenia, and Mucka and Horvath (2015) for Slovakia. 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. Empirical papers that investigate fiscal policy effects in new EU members mostly use the traditional VAR model following Blanchard and Perotti (2002). Details are listed in Table 1. With the exception of the model of Haug et al. (2013), government debt is not included in the specification.

With the aim to improve our knowledge on the role of debt, this paper analyses fiscal policy effects under explicit debt feedback over 1991q1 to 2013q4 in six Central and East European coun-

Table 1: Empirical papers on fiscal policy effects in the CEE-6

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
Haug et al. (2013)	Poland	1998q1-2012q4	GDP, CPI inflation, REER, interest rate, monetary aggregates, foreign GDP, foreign interest rate	revenue, spending, public debt
Jemec et al. (2011)	Slovenia	1995q1-2010q4	GDP	net taxes, spending
Pecsyova (2013)	Slovakia	1997q1-2012q1	GDP, inflation, interest rate	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. Haug et al. (2013) use an adapted AB identification approach. 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.

tries (CEE-6): Slovakia, Czech republic, Hungary, Poland, 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, the FG model without debt feedback, and a model with debt within the linear VAR. Coming up with meaningfully signed impulse responses proved cumbersome, given the counterintuitive relationships among the key variables and the debt ratio. Based on a detailed correlation analysis, the paper adopts two sorts of variables' specifications in the headline FG model, both in levels and transformed. Section 4 presents a rich set of empirical results, that have not been brought up before for the CEE countries, such as response functions generated at various levels of the debt ratio 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 have a qualitative impact on the behaviour of other variables. The debt feedback would dampen the effects on output and eliminate persistence in the responses over longer horizons, especially following expenditure shocks. 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.

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 ratio as an exogenous variable, and of the government budget constraint.

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

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

where X_t is a vector in inflation in the implicit GDP deflator (π_t), interest rate (r_t), real GDP (y_t), real government revenue (t_t), real government primary expenditure (x_t), and money growth (m_t); 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 the debt ratio by_t; U_t is a vector of reduced-form residuals.

The motion of government debt follows the nonlinear equation:

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

where b_t is real government debt. The debt ratio is defined as $by_t \equiv b_t/(4 \cdot y_t)$. The 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, the debt ratio becomes an endogenous variable within the system.

Reduced-form residuals are linked to the underlying structural shocks W_t as $P^{-1} \cdot U_t = W_t$, 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

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

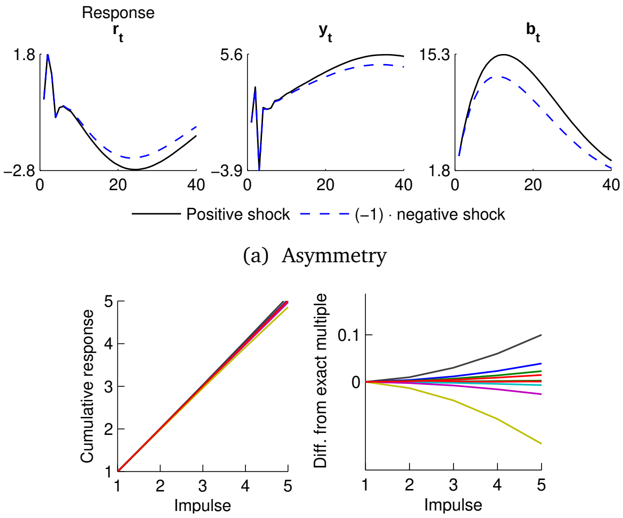
2. Compute government debt ratio using the simulated VAR variables.

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 Properties of the impulse response functions

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. (2010), 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.

Figure 1 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 they will depend on the initial conditions. Figure 1a illustrates that a negative fiscal shock of the same size will not yield an identical behaviour, just with an opposite sign. Figure 1b 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. 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

Figure 1: Properties of the response functions

Note: Shown are responses of the GDP to a government expenditure shock: (a) Lithuania, shocks of the size 40 and -40 percent GDP, (b) Czech republic, shocks of the size 1, 2, ..., to 5 percent GDP.

2.5 Alternative specifications

So far, the text discussed the model with debt feedback following FG (headline model). 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 the debt ratio as an exogenous variable, but in simulations the lags of the debt ratio 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, the debt ratio 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 Data and estimation issues

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. Some of the CEE countries could not be included in the paper because of insufficient availability of accrualised fiscal data. 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 (B1GM) 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. Government debt over 1999q1 to 1999q4 was interpolated from annual Eurostat figures. The data set spans over the period 1999q1 to 2013q4.

Figure 2 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.

3.2 Relationships among the variables

As suggested by the comments above, historical data for the CEE countries involve some anomalies. One of the problems is the steadily declining trend in the interest rate. Another problem is that the crisis distorted the relationships among the variables. Clearly, the fiscal variables were not responding to the government debt ratio for a period following the onset of the crisis.

Because of the anomalies, coming up with meaningful results in the FG framework is challenging. For the estimates of fiscal policy effects, the impulse responses need to reflect meaningful relationship among the variables, e.g. the interest rate and government debt shall be positively related to each other. To that end, some of the variables need to be transformed. The transforma-

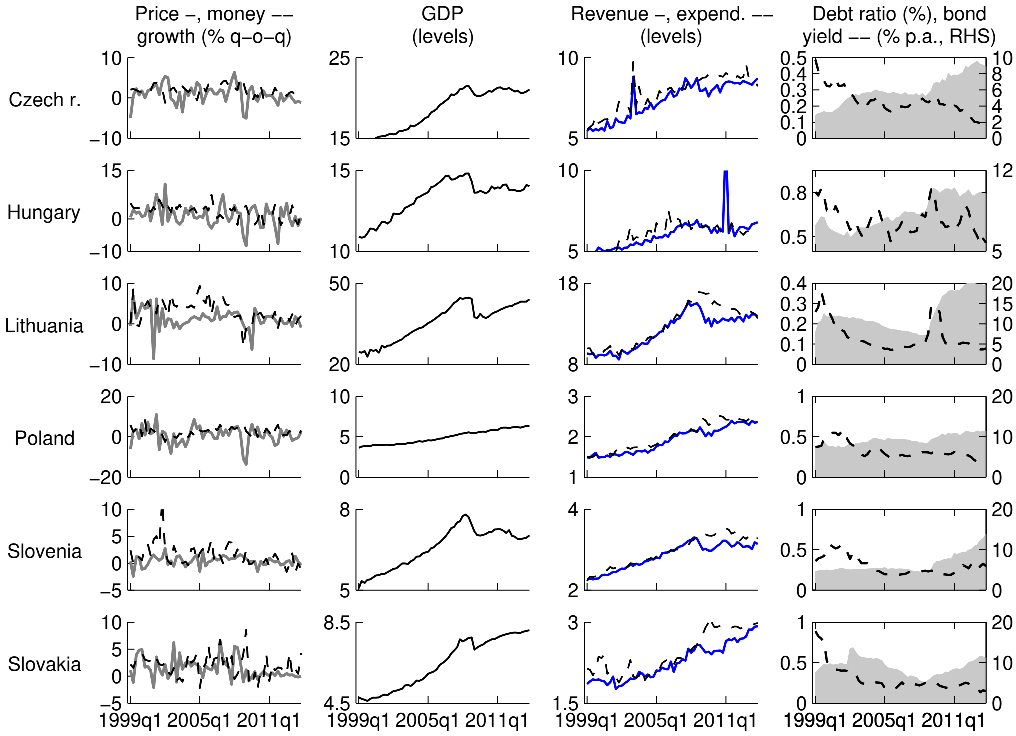


Figure 2: Historical data

tions, however, have cost for some of the model behaviours, such as out-of-sample debt forecast. The paper therefore adopts two sorts of empirical specifications of the variables in the headline FG model, both in levels and transformed (more details are explained in the next section).

The latter specification of variables results from an indepth correlation analysis with the aim to find the best possible combination for impulse response functions across the six countries. Simple detrending or inclusion of a time trend in the VAR regression would not do the job.

Table 2 summarises some of the results of the correlation analysis. It reports three sets of rank correlation coefficients between variables included in the VAR and the debt ratio. The first set of coefficients (upper panel) is computed for levels. The correlation is medium to strong positive in case of the GDP and fiscal variables, and mostly negative in case of the interest rate. Simple detrending (middle panel) implies a mostly positive correlation between the interest rate and the debt ratio, and a negative correlation in case of the fiscal variables. (For a discussion on true relationships among variables that contain a trend, cf. e.g. Chiarella and Gao, 2002.) The bottom panel reports coefficients computed for transformed variables. The correlation is medium positive in case of the interest rate and expenditure-to-GDP ratio, and negative or weak positive in case of the revenue-to-GDP ratio.

3.3 General remarks to specification and estimation

The goals with the empirical specification are two-fold. The model should reach a good balance between the fit in the linear VAR part and the fit of the nonlinear debt equation in levels. At the same time, the impulse responses generated by the model shall reflect meaningful relationships among the variables. In particular, the interest rate and government debt, the interest rate and expenditure, or expenditure and debt shall be positively related to each other. Moreover, the

Table 2: Correlation between the variables and debt ratio

	Czech r.	Hungary	Lithuania	Poland	Slovenia	Slovakia
(a) Levels						
r_t	-0.61	-0.04	0.12	-0.51	-0.14	0.09
y_t	0.56	0.34	-0.05	0.67	0.21	-0.18
τ_t	0.58	0.52	-0.08	0.62	0.32	-0.21
x_t	0.60	0.35	-0.12	0.65	0.39	-0.27
(b) Detrended						
r_t	-0.33	0.37	0.35	-0.12	0.47	-0.07
y_t	-0.61	-0.28	-0.65	-0.24	-0.85	-0.72
τ_t	-0.34	-0.11	-0.55	-0.27	-0.72	-0.11
x_t	-0.14	-0.16	-0.42	-0.13	-0.50	-0.16
(c) Transformed						
r_t	0.33	0.12	0.25	-0.00	0.19	0.34
y_t	-0.01	-0.14	0.14	-0.13	-0.12	0.19
τ_t	-0.11	-0.13	0.23	0.02	0.22	0.35
x_t	0.09	0.33	0.22	0.33	0.32	0.29

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

modeling choice involves considerations w.r.t. stability. Stability of the linear VAR part does not guarantee stability of the overall system of equations.

It appears that there are trade-offs among these goals. In particular, transformations of the variables help achieve more meaningful impulse responses, but have cost for some of the model behaviours, such as out-of-sample debt paths. To mention more considerations, inclusion of a time trend would not help the impulse responses, but it would impact the overall stability. Log transformations of variables appear to have cost for the model fit in levels.

Taking into account these trade-offs, the paper employs two empirical specifications of the variables:

- One specification is estimated over the pre-crisis sample (1999q1 to 2007q4) with variables transformed as follows: output gap (GDP detrended using the Hodrick Prescott filter with a standard lambda of 1600), ratio of government revenue to GDP, ratio of government primary expenditure to GDP, and first-differenced debt ratio. As for Hungary and Poland, also the interest rate is transformed, taking first differences. In the simulations, each of the variables is transformed back to its original form in order to compute the level of debt.
- A second specification is estimated over the full sample and works with variables and the debt ratio in levels.

In both specifications, inflation and money growth are the same, that is quarter-over-quarter growth rates of the GDP deflator and of the money aggregate, respectively.

Tables 7 to 10 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 in the headline model in levels is thus I(1). The Johansen test 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. The transformed variables are mostly I(0). Detrending or inclusion of deterministic trends is avoided and the VAR estimation proceeds as is (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. This suggestion has been confronted with the stability condition check, the Wald test on lag significance, as well as with trial simulations under debt feedback. As a result, the appropriate number of lags in the endogenous variables was determined as 1 in the specification with transformed variables, and 1 (Slovakia), 3 (Hungary and Slovenia) or 2 (remaining countries) in the specification with variables in levels. Lags in the exogenous variable, government debt ratio or its first difference, were set to 1 in either case.

The linear VAR model with debt as one of the endogenous variables ("debt in VAR") was estimated in 2 (Czech republic, Poland 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. The multivariate test rejected normality of the residuals for the specification in levels (Table 8). The specification with transformed variables passed the test relatively well for most of the countries. The Portmanteau test found that the residuals are mostly autocorrelated. The Lagrange multiplier test (Table 9) 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 10) 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). Table 11 in the Appendix reports the resulting fit of the headline FG model for the two specifications of the variables.

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 in the next section are computed under debt feedback, unless indicated otherwise.

4 Empirical results

4.1 Estimated coefficients at debt lags

Table 3 reports coefficients at debt ratio lags in the revenue and expenditure equation. The combination of the coefficients is stabilising w.r.t. government primary surplus. This has two-fold implications. First, debt paths generated by the model without taking account of the debt feedback will turn explosive. Second, inclusion of the debt feedback will affect the impulse response coefficients.

Table 3: VAR coefficients at lagged debt ratio

	t_t	x_t		t_t	x_t		t_t	x_t
Czech r.			Hungary			Lithuania		
b_{t-1}	0.6433	0.6338	b_{t-1}	2.9016	-0.7196	b_{t-1}	-1.8544	-2.8345
	1.046	1.365		0.745	1.384		0.973	1.221
Poland			Slovenia			Slovakia		
b_{t-1}	-0.0231	-0.8223	b_{t-1}	0.4421	0.0145	b_{t-1}	0.3840	0.0660
	0.269	0.256		0.194	0.234		0.129	0.180

Note: Reported are estimated coefficients, beneath are standard errors as supplied by EViews.

Figure 3 displays debt ratio 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. The 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-6 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 making. 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.

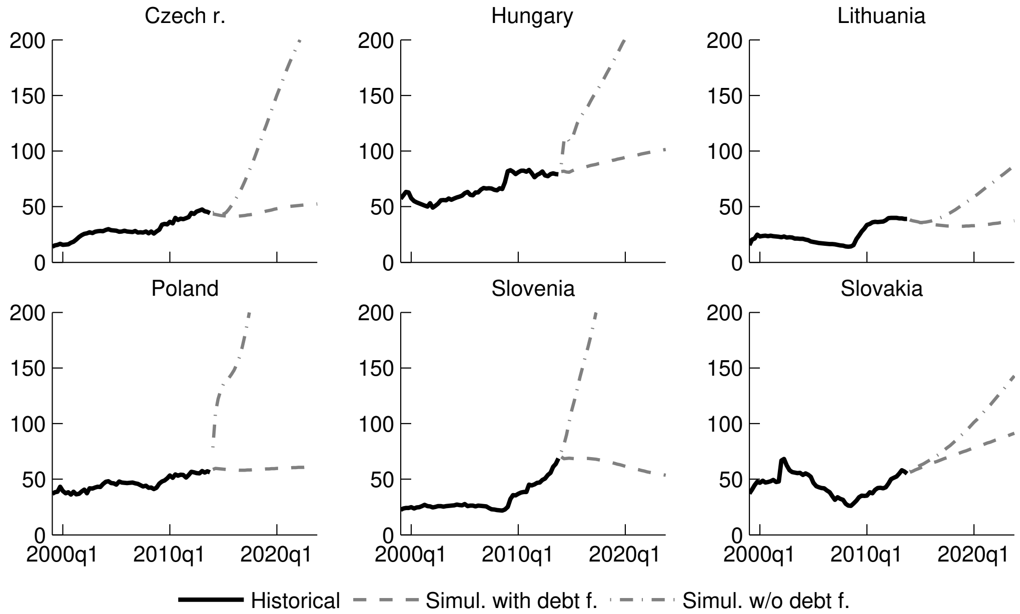


Figure 3: Historical and simulated debt ratios

The debt ratios presented in Figure 3 were simulated in the specification in levels. The specification with transformed variables yielded virtually no difference between the simulation with and without debt feedback and the generated debt ratio paths were implosive.

4.2 Effects of fiscal shocks

This section analyses effects of discretionary fiscal policy by means of impulse response functions (IRF). Figures 4 and 5 show responses of the six variables to unexpected shocks in revenue and expenditure for the model with transformed variables (shorthened sample 1999q1 to 2007q4). Figure 6 displays responses to expenditure shocks for the model in levels (full sample 1999q1 to 2013q4). 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 the GDP and debt ratio were set as the average over the last in-sample year. Assumed is a zero primary surplus, i.e. both revenue and expenditure equal the average of the two in the last in-sample year. Initial inflation and money growth are set to zero. In addition, the model with transformed variables assumes that the initial GDP is at its trend. Either of the figures presents three sorts of IRF: those in the headline model under debt feedback (coupled with 90 percent confidence bands), the headline model without debt feedback, and IRF generated by a linear VAR model.

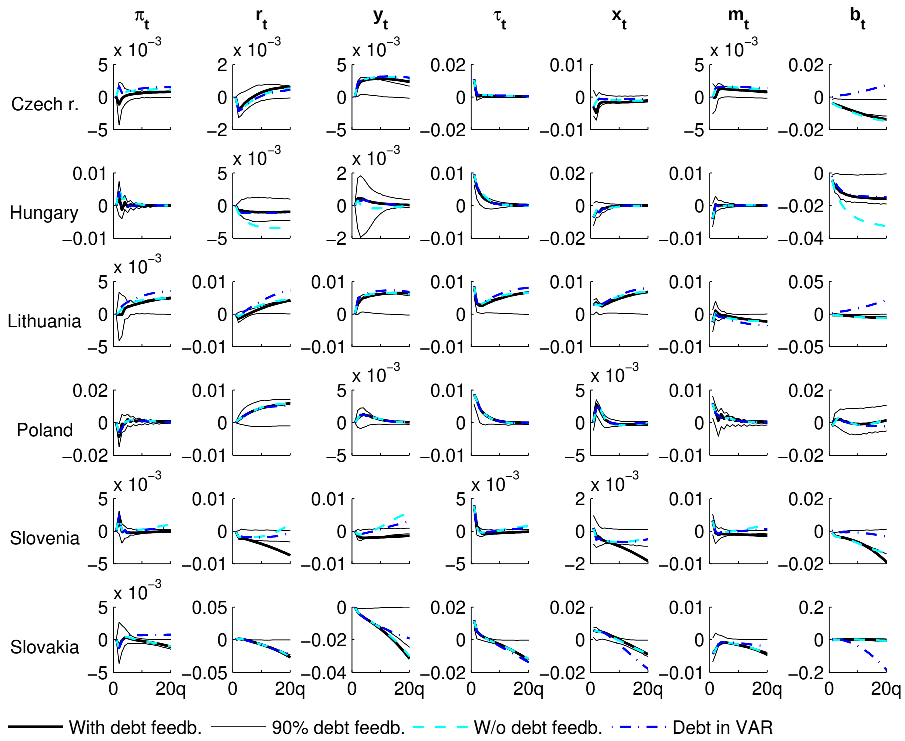


Figure 4: Responses to a revenue shock (headline model, transformed variables)

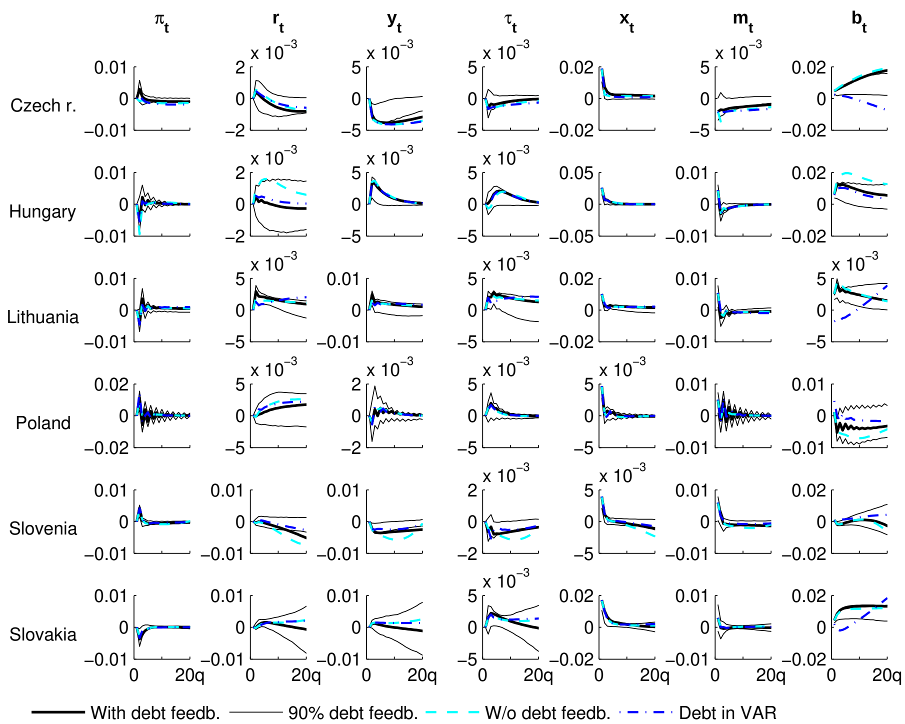


Figure 5: Responses to an expenditure shock (headline model, transformed variables)

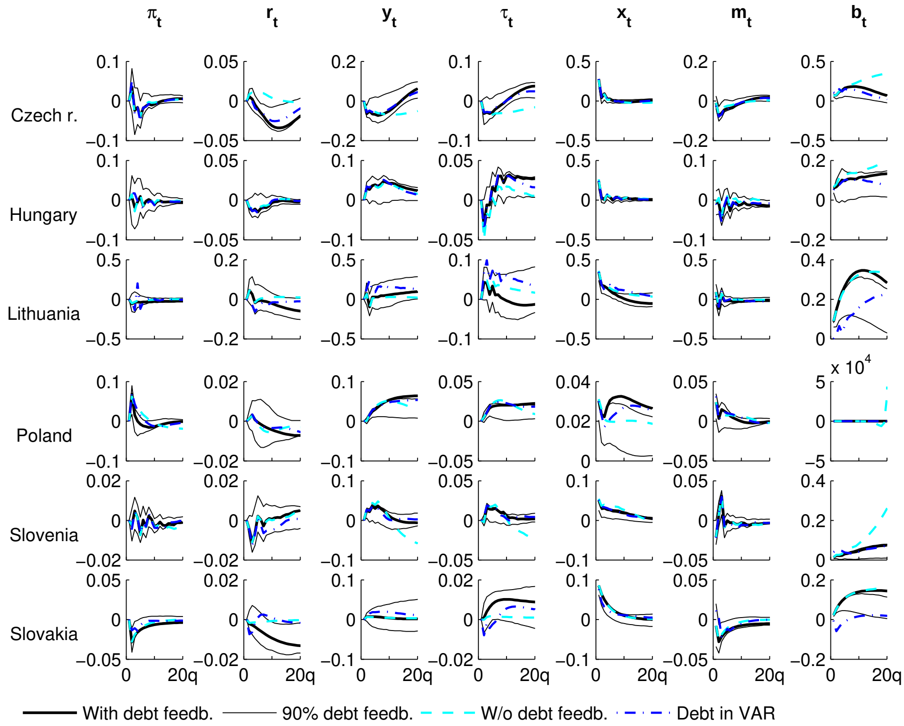


Figure 6: Responses to an expenditure shock (headline model, variables in levels)

As a general remark, the responses to a revenue shock show somewhat more variation in size and sign than those following an expenditure shock (cf. e.g. Petrovic et al. , 2014, and references herein). The heterogeneity in the responses may be attributed to the rather broad scope of the revenue variable. It also comprises transfers, which are differently correlated with the business cycle and price developments than revenue from various types of taxes. A revenue shock (Figure 4) mostly yields a positive response in itself, inflation, and money supply growth. The response of the interest rate, government expenditure and debt is mostly negative. The response of the GDP is found negative in Slovakia and Slovenia. The somewhat counterintuitive positive response of the GDP in the other countries might be associated with the broad specification of the revenue variable, but eventually also with changes in the tax structure (cf. e.g. Haug et al. , 2013).

An expenditure shock (Figure 5) mostly yields a positive response in itself, inflation, interest rate, GDP, government revenue, and debt. The response of money growth is mostly negative. Compared to the model in levels (Figure 6), the specification with transformed variables improves the IRF of the interest rate in the sense that it eliminates the negative sign. The literature mentions a possible explanation for an eventual decline in the interest rate, which may be due to a strong, positive response of the GDP following 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.). Such an explanation is plausible in the case of a supreme sovereign. However, in the context of the CEE countries, a positive estimated response is more plausible, reflecting the fact that a higher government deficit following an expenditure shock increases debt, making in turn its refinancing more costly.

Table 4 below and Table 12 in the Appendix summarise cumulative responses of the GDP to fiscal shocks up to three years ahead, estimated by the headline FG model in transformed variables and in levels. The cumulative coefficients are expressed in percent of the no shock scenario GDP.

The two specifications yield responses of a vastly different magnitude. In the transformed case (Table 4, bottom part), a one GDP-percent shock in government expenditure yields a 0.00 to 0.01 percent added GDP within the first year. The cumulative 3-year coefficients range between 0.00 and 0.03. The estimated response is negative and insignificant for the Czech republic and Slovenia, yielding a drop in the GDP of about -0.01 percent within the first year and -0.04 within three years. The model in levels (Table 12) yields positive responses to an expenditure shock for all countries except the Czech republic. It would yield 0.01 to 0.10 percent added GDP within the first year. The cumulative 3-year coefficients range between 0.06 and 0.42. In the Czech republic, the estimated 1-year response is -0.18, cumulative 3-year response is -0.64. Turning to the revenue side (Table 4, upper part), a one GDP-percent shock to government revenue implies a sacrifice in the GDP of about 0.01 percent in Slovakia and Slovenia. The estimated coefficients for other countries are positively signed (the GDP would increase following a positive shock to revenue). By costrast, the model in levels mostly implies negatively signed revenue multipliers (the GDP would decrease).

Table 4: Cumulative responses of output (headline model, transformed variables)

	Czech r.	Hungary	Lithuania	Poland	Slovenia	Slovakia
Revenue shock						
With debt feedb.						
1y	0.007	0.001	0.012	0.003	-0.005	-0.014
2y	0.017	0.002	0.034	0.007	-0.013	-0.050
3y	0.029	0.003	0.059	0.008	-0.021	-0.107
W/o debt feedb.						
1y	0.007	0.000	0.015	0.003	-0.003	-0.014
2y	0.019	-0.000	0.039	0.007	-0.003	-0.049
3y	0.031	-0.001	0.065	0.008	0.003	-0.104
Ratio						
	1.12	*0.27*	*1.18*	*1.01*	*0.52*	*1.00*
	1.09	*-0.12*	*1.13*	*0.99*	*0.23*	*0.98*
	1.09	*-0.32*	*1.09*	*1.01*	*-0.15*	*0.97*
Expenditure shock						
With debt feedb.						
1y	-0.010	0.009	0.010	-0.000	-0.009	0.003
2y	-0.025	0.016	0.018	0.001	-0.023	0.005
3y	-0.040	0.019	0.025	0.002	-0.036	0.005
W/o debt feedb.						
1y	-0.011	0.010	0.008	0.000	-0.010	0.004
2y	-0.027	0.018	0.016	0.002	-0.030	0.009
3y	-0.043	0.022	0.022	0.002	-0.052	0.015
Ratio						
	1.11	*1.11*	*0.80*	*-1.70*	*1.12*	*1.26*
	1.08	*1.13*	*0.87*	*1.43*	*1.29*	*1.83*
	1.09	*1.12*	*0.91*	*1.30*	*1.46*	*3.19*

Note: The responses are significant in the sense that the 90 percent confidence interval does not include a zero impulse response (for Czech republic and Slovakia up to 1 year after a revenue shock, for Czech republic and Slovenia up to 2 years after an expenditure shock). The bottom panels report ratios of the IRF generated without debt feedback to those under debt feedback.

The estimated difference in the IRF generated under debt feedback and without is small and mostly insignificant. It is somewhat more pronounced if the headline model is estimated in levels of the variables. In the setup with transformed variables the IRF diverge over more distant simulation horizon (starting with about 10 quarters). Reading the differences is further complicated by the heterogeneity of the responses and by the fact that for each of the variables there appear counterintuitive IRF in some of the countries, especially after revenue shocks. The counterintuitive sign of the IRF turns the magnitude across the alternative debt feedback specifications upside-down. Generally speaking, the debt feedback dampens the responses of output and debt,

Table 5: Estimates of GDP response coefficients for emerging markets

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		
		Poland	-0.00	0.00	0.02		
		Slovenia	0.01	0.02	0.02		
		Slovakia	-0.02	-0.05	-0.10		
	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.
	Haug et al. (2013)	Poland	0.09	0.14	0.15	0.12	
	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.
	Mucka and Horvath (2015)	Slovakia		-0.60	-1.70	-3.00	Implied multipliers. Average for various types of taxes.
	Kilponen (2015)						Short-run fiscal multipliers. Average for various types of taxes.
		Czech r.		-0.30	-0.20		
		Slovenia		-0.20	-0.20		
Expenditure side shock							
	Eller et al. (2011)						
		Czech r.	-0.00	-0.01	-0.04		
		Hungary	0.01	0.02	0.01		
		Poland	-0.00	-0.01	-0.02		
		Slovenia	0.01	0.00	-0.01		
		Slovakia	-0.01	-0.01	0.00		
	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.
	Haug et al. (2013)	Poland	0.14	0.14	0.42	0.48	
	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.
	Petrovic et al. (2014)	Emerging Europe	0.20	0.48			Impact and cumulative multipliers.
	Hory (2015)	Emerging markets.					Impact multiplier. PVAR: 0.40, IP-VAR: 0.39.
	Kilponen (2015)						Short-run fiscal multipliers.
		Czech r.		0.54	0.54		
		Slovenia		0.66	0.48		
	Mucka and Horvath (2015)	Slovakia		0.90	0.86	1.04	Implied multipliers.

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. For Kilponen (2015) and Mucka and Horvath (2015), the average revenue multiplier is my own calculation, based on Tables 2 to 4 and 3.1, respectively. 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 Notes. Abbreviations used: 0 - immediate response coefficient, 1y/2y/3y - cumulative 1 year (4 quarters) / 2 year (8 quarters) / 3 year coefficient (12 quarters).

and eliminates permanent effects in the IRF over longer horizons, especially following expenditure shocks. The bottom line to the change in the behaviour lies in the amplified adjustment in government revenue (so-called fiscal reversal) and in the stronger reaction of the bond yield. Notice the response of government revenue following an expenditure shock in Hungary, Lithuania, Poland and Slovakia, response of the interest rate to expenditure shocks in Lithuania and Slovakia (Figure 5), and response of government debt following an expenditure shock in the Czech republic, Hungary, Lithuania and Slovenia (Figure 6). For each percentage point of the GDP response to an expenditure shock under debt feedback, the specification omitting the feedback yields about 1.1 to 1.3 percentage points within the first year (Table 4, the bottom panel). These findings generally conform with the available applications of the FG framework in the sense that inclusion of the debt feedback dampens the effects of expenditure shocks on output and eliminates from the IRF persistent effects of the fiscal shocks on output and debt (cf. e.g. Favero and Giavazzi, 2007; and Ilzetzki, 2011).

The difference between the headline model and the linear VAR is small and mostly not significant for the IRF of the endogenous variables. However, the bias involved with the linear specification makes a significant difference in the IRF of government debt (Figures 4, 5 and 6, first column to the right).

Table 5 in this section and Table 13 in the Appendix provide evidence on fiscal policy effects in emerging economies, including the CEE-6, known from the literature. More specifically, Table 5 collects response coefficients of GDP to fiscal shocks up to three years ahead. Table 13 compares the signs of the response functions of GDP, inflation and interest rate. 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 (cf. 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.

Regarding the size of the GDP responses, the coefficients obtained in this paper 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; Ilzetzki et al. , 2013; Petrovic, 2014; and Hory, 2015).

The evidence available in the literature is rather heterogenous in terms of response signs (Table 13 in the Appendix). Generally speaking, the literate sees expenditure shocks to yield expansionary effects on output, inflation and the interest rate, whilst revenue shocks have contractionary effects on output. In this paper, the IRF following an expenditure shock match the literature if variables in the headline model are transformed. On the other hand, the estimated IRF after a revenue shock are closer to the literature if variables are specified in levels.

To comment on specific countries, the GDP response to an expenditure shock for the Czech republic is at odds with the majority of the papers. This result appeared robust to transformation of the variables and the sample period. In a contrast to papers which worked with government spending, the IRF in this paper may be affected by the rather broad scope of the expenditure variable. Some of the social contribution and transfer categories might contribute to the resulting crowding-out effect (cf. e.g. the positive multiplier after 2.5 year following a consolidation through general transfers in Klyuev and Snudden, 2011; or, the negative effect of unemployment benefits and other social benefits on GDP as from the 4th quarter in Ambrisko et al. , 2012). Similar as herein, several papers found a positive GDP response after a revenue side shock in Poland. As for Slovenia and Hungary, the significant difference in the IRF of the interest rate between the model with and without debt feedback (Figure 5) might help reconcile the findings when the literature is not unanimous about the sign of the GDP response.

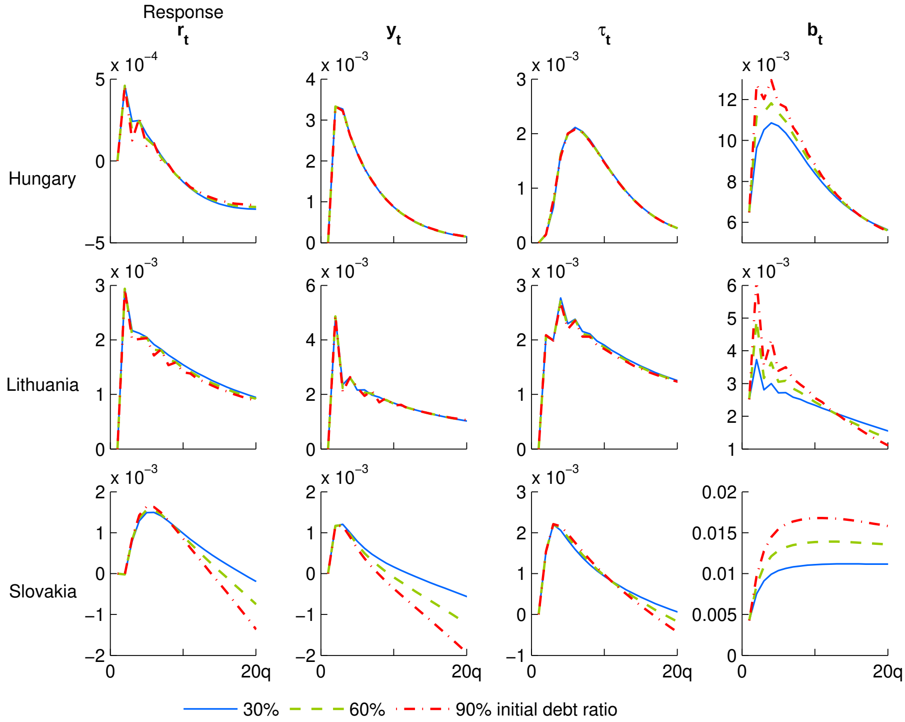


Figure 7: Responses to an expenditure shock conditional on government debt ratio

Table 6: Responses of output to an expenditure shock conditional on government debt ratio

	Min.	Max.	Median for CEE-6
30 percent GDP			
1y	-0.0096	0.0098	0.0017
2y	-0.0248	0.0180	0.0035
3y	-0.0397	0.0246	0.0041
60 percent GDP			
1y	-0.0096	0.0097	0.0016
2y	-0.0247	0.0179	0.0031
3y	-0.0395	0.0244	0.0031
90 percent GDP			
1y	-0.0096	0.0096	0.0015
2y	-0.0247	0.0177	0.0026
3y	-0.0394	0.0242	0.0020

Note: Reported are cumulative IRF generated by the headline model in transformed variables. The initial debt ratio is set as 30, 60 and 90 percent GDP.

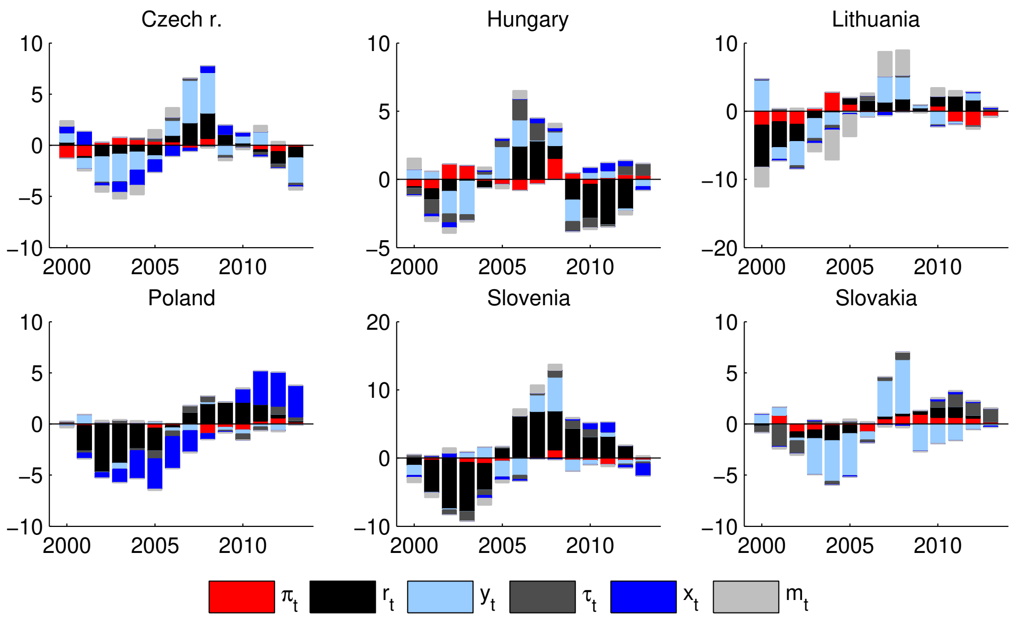


Figure 8: Decomposition of the GDP

4.3 Impact of government indebtedness on policy effectiveness

So far, the IRF were presented under the assumption that the initial debt ratio was at its level as in the last in-sample year. This section now compares effectiveness of discretionary fiscal shocks for various initial debt levels from low to high. Although the difference in the estimated IRF is small, it is possible to draw some general remarks. Figure 7 illustrates for some of the countries that, ceteris paribus, higher debt ratio will make public refinancing more costly, causing the debt rise to even higher levels (steeper curve) before it starts to decline. Estimated response coefficients in Table 6 suggest that higher debt ratios may imply a sacrifice in the policy effectiveness on output over the medium term. For an initial debt ratio of 90 percent, the median 3-year cumulative response of the GDP following an expenditure shock drops to about a half compared to the simulation with a 30 percent debt ratio. The result agrees with Ilzetzki (2011) who found that higher debt would have a negative impact on economic growth in Estonia.

4.4 Miscellaneous results

Figure 10 in the Appendix displays estimates of 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. They may be used as proxies of the cyclically-adjusted fiscal variables (cf. e.g. Parkyn and Vehbi, 2014). For instance, the CEE-6 recorded mostly negative shocks on the revenue side and positive expenditure shocks in the period from 2008 to 2010.

Figure 8 herein and Figure 11 in the Appendix show a historical decomposition of output and inflation, computed from initial conditions that replicate the historical pre-sample. (The decomposition of other macroeconomic variables is available upon request.) The decomposition suggests that the variables were driven mainly by macroeconomic shocks, and that structural shocks in government revenue and expenditure contributed to a lesser extent. The estimates are sensitive to initial conditions, identification matrix and overall stability.

Decomposition of the forecast error variance is available upon request. 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.

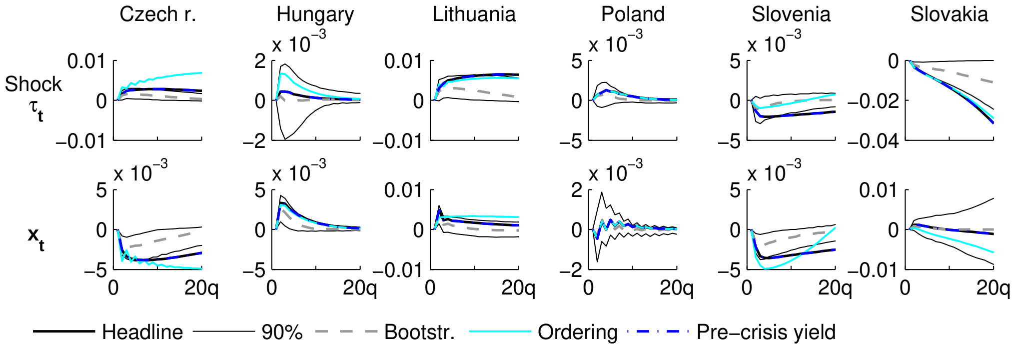


Figure 9: Comparison of response functions under modified specification

Note: Shown are responses of the GDP to fiscal shocks.

4.5 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 the revenue and expenditure being swapped. Ordering of the other variables is preserved.
3. The headline IRF are generated under the assumption that the bond yield is initially at its level as in the last in-sample year (2013). The recent bond yields have been affected by the ECB policy keeping the interest rate very low. As a third amendment, impulse responses are simulated starting with the pre-crisis level of the bond yield (2007).

Calibration of shocks and initial conditions (in the third case, initial conditions in all other variables except for the interest rate) are identical as in the headline estimates presented above (Section 4.2).

Figure 9 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 estimate.

Notwithstanding previous comments, a few caveats should be mentioned. Any empirical results that can be obtained for the CEE 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.

5 Conclusion

This paper estimates effects of fiscal policies under explicit debt feedback in six 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 public debt on policy effectiveness is still rather novel in the CEE-related literature.

Estimated coefficients of fiscal variables at lagged values of the debt ratio 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 estimated impulse responses.

Section 4 computes a rich set of empirical results, most of which have not been presented before for the CEE-6, such as response functions generated at various levels of the debt ratio and historical decomposition of the time series under debt feedback. Unlike in linear VAR models, the IRF 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 that finds low effectiveness of fiscal policy in small open economies (e.g. Auerbach and Gorodnichenko, 2012). The debt feedback would dampen the responses of the GDP and debt, and eliminate permanent effects in the responses over longer horizons. The bottom line to the qualitative change in the behaviour lies in the amplified adjustment on the revenue side (fiscal reversal) and in the reaction of the bond yield.
- Simulations starting from various levels of the debt ratio suggest that high government indebtedness might imply a sacrifice in the policy effectiveness on output over the medium term.
- Historical decomposition of the time series shows that the macroeconomic variables were driven mainly by macroeconomic shocks and to a minor extent by fiscal shocks.

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.

References

Afonso, Antonio, and Sousa, Ricardo M. (2012): The Macroeconomic effects of fiscal policy, Applied Economics, 44(34), pp. 4439-4454

Algozhina, Aliya (2012): Monetary and Fiscal Policy Interactions in an Emerging Open Economy: a Non-Ricardian DSGE Approach, CERGE-EI, Working paper No. 476

Ambrisko, Robert, Babecky, Jan, Rysanek, Jakub, and Valent, Vilem (2012): Assessing the Impact of Fiscal Measures on the Czech Economy, Czech National Bank, Working Paper No. 15/2012

Auerbach, Alan J., and Gorodnichenko, Yuriy (2013): Fiscal Multipliers in Recession and Expansion, pp. 63-98, in: Alesina, Alberto, and Giavazzi, Francesco (eds.): Fiscal Policy after the Financial Crisis, National Bureau of Economic Research, University of Chicago Press

Batini, Nicoletta, Eyraud, Luc, Forni, Lorenzo, and Weber, Anke (2014): Fiscal Multipliers: Size, Determinants, and Use in Macroeconomic Projections, International Monetary Fund, Technical Notes and Manuals

Baxa, Jaromir (2010): What the Data Say about the Effects of Fiscal Policy in the Czech Republic?, pp. 24-29, in: Houda, Michal, and Friebelova, Jana (eds.): Mathematical Methods in Economics, University of South Bohemia

Bencik, Michal (2014): Dual regime fiscal multipliers in converging economies - a simplified STVAR approach, National Bank of Slovakia, Working paper No. 2/2014

Benk, Szilard, and Jakab, Zoltan M. (2012): Non-Keynesian Effects of Fiscal Consolidation: An Analysis with an Estimated DSGE Model for the Hungarian Economy, OECD, Economics Department, Working Paper No. 945

Blanchard, Olivier, and Perotti, Roberto (2002): An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output, Quarterly Journal of Economics, 117(4), pp. 1329-1368

Bohn, Henning (1998): The Behaviour of U.S. public debt and deficits, Quarterly Journal of Economics, 113(3), pp. 949-963

Cherif, Reda, and Hasanov, Fuad (2012): Public Debt Dynamics: The Effects of Austerity, Inflation, and Growth Shocks, International Monetary Fund, Working Paper No. 12/230

Chiarella, Carl, and Gao, Shenhuai (2002): Type I Spurious Regressions in Econometrics, Finance Discipline Group, University of Technology, Sydney, Working Paper No. 114

Clancy, Daragh, Jacquinot, Pascal, and Lozej, Matija (2014): The Effects of Government Spending in a Small Open Economy within a Monetary Union, European Central Bank, Working Paper No. 1727/2014

Dinu, Marin, and Marinas, Marius-Corneliu (2014): Testing the Impact of the Fiscal Policy with the SVAR Model in Seven CEE Economies, ECECSR Journal, 48(1), pp. 23-48

Eller, Markus, Cuaresma, Jesus Crespo, and Mehrotra, Aaron (2011): The Economic Transmission of Fiscal Policy Shocks from Western to Eastern Europe, Oesterreichische Nationalbank, Focus on European Economic Integration Q2/2011

Eller, Markus, and Urvova, Jarmila (2012): How Sustainable Are Public Debt Levels in Emerging Europe? Evidence for Selected CESEE Countries from a Stochastic Debt Sustainability Analysis, Oesterreichische Nationalbank, Focus on European Economic Integration Q4/2012

Elmeskov, Jorgen, and Douglas, Sutherland (2012): Post-crisis debt overhang: growth and implications across countries, OECD, Economics Department, Mimeo, <http://www.oecd.org/dataoecd/7/2/49541000.pdf>

Favero, Carlo, and Giavazzi, Francesco (2007): Debt and the Effects of Fiscal Policy, National Bureau of Economic Research, Working Paper No. 12822

Franta, Michal (2012): Macroeconomic Effects of Fiscal Policy in the Czech Republic: Evidence Based on Various Identification Approaches in a VAR Framework, Czech National Bank, Working Paper No. 13/2012

Haug, Alfred A., Jedrzejowicz, Tomasz, and Sznajderska, Anna (2013): Combining monetary and fiscal policy in an SVAR for a small open economy, National Bank of Poland, Working Paper No. 168/2013

Hory, Marie-Pierre (2015): Fiscal multipliers in Emerging Market Economies: can we learn something from Advanced Economies?, Universite d'Orleans, France, Mimeo
<http://economics.soc.uoc.gr/macro/docs/Year/2015/papers/paper_1_29.pdf>

Ilzetzki, Ethan (2011): Fiscal Policy and Debt Dynamics in Developing Countries, Macroeconomics and Growth Team, World Bank, Policy Research Working Paper No. 5666

Ilzetzki, Ethan, Mendoza, Enrique G., and Vegh, Carlos A. (2013): How big (small?) are fiscal multipliers?, Journal of Monetary Economics, 60(2), pp. 239-254

Jemec, Natasa, Kastelec, Andreja Strojan, and Delakorda, Ales (2011): How do Fiscal Shocks Affect the Macroeconomic Dynamics in the Slovenian Economy?, Bank of Slovenia, Working Paper No. 2/2011

Karmelavicius, Jaunius, and Klyviene, Violeta (2012): Analysis of the Response of Macroeconomic Indicators to Fiscal Policy Shocks: The Case of the Baltic States, Bank of Lithuania, Monetary Studies, 16(1), pp. 30-48

Kilponen, Juha, et al. (2015): Comparing fiscal multipliers across models and countries in Europe, European Central Bank, Working Paper No. 1760/2015

Klucik, Miroslav (2015): Fiscal Adjustment in Slovakia - Findings from a Medium-Scale Econometric Model, Council for Budget Responsibility of the Slovak Republic, Working Paper No. 1/2015

Klyviene, Violeta, and Karmelavicius, Jaunius (2012): SVAR Analysis of the Impacts of Corporate Taxation on the Macroeconomy of Lithuania, Ekonomika, 91(4), pp. 107-124

Klyuev, Vladimir, and Snudden, Stephen (2011): Effects of Fiscal Consolidation in the Czech Republic, International Monetary Fund, Working Paper No. 11/65

Kotosz, Balasz, and Peak, Ajandek (2013): Economic Growth and Fiscal Expenditures in Hungary Stylized Facts Based on VAR Modelling, Ter-Gazdasag-Ember, 1(3), pp. 55-73

Lendvai, Julia (2007): The impact of fiscal policy in Hungary, European Commission, ECFIN Country Focus No. 4/11

Lutkepohl, Helmut (2013): Vector autoregressive models, pp. 139-164, in: Thornton, Michael A., and Hashimzade, Nigar (eds.): Handbook of Research Methods and Applications in Empirical Macroeconomics, Edward Elgar Publishing Limited

Lutkepohl, Helmut (2005): New Introduction to Multiple Time Series Analysis, Springer-Verlag, 764 p.

Melecky, Ales, and Melecky, Martin (2011): Analyzing the Impact of Macroeconomic Shocks on Public Debt Dynamics: An Application to the Czech Republic, Munich Personal RePEc Archive, Paper No. 34114

Mirdala, Rajmund (2013): Lessons Learned from Tax versus Expenditure Based Fiscal Consolidation in the European Transition Economies, Munich Personal RePEc Archive, Paper No. 46792

Mirdala, Rajmund (2009): Effects of Fiscal Policy Shocks in the European Transition Economies, Munich Personal RePEc Archive, Paper No. 19481

Mucka, Zuzana, and Horvath, Michal (2015): Fiscal Policy Matters - A New DSGE Model for Slovakia, Council for Budget Responsibility of the Slovak Republic, Discussion Paper No. 1/2015

Muir, Dirk, et al. (2010): Effects of Fiscal Stimulus in Structural Models, International Monetary Fund, Working Paper No. 10/73

Panizza, Ugo, and Presbitero, Andrea F. (2014): Public debt and economic growth: is there a causal effect?, Journal of Macroeconomics, 41(C), pp. 21–41

Parkyn, Oscar, and Vehbi, Tugrul (2014): The Effects of Fiscal Policy in New Zealand: Evidence from a VAR Model with Debt Constraints, Economic Record, 90(1), pp. 345–364

Pecsyova, Monika (2013): Estimated Impact of Fiscal Consolidation on GDP Growth in the SR, National Bank of Slovakia, Biatec Banking Journal, 21(4), pp. 20-27

Petrovic, Pavle, Arsic, Milojko, and Nojkovic, Aleksandra (2014): Fiscal Multipliers in Emerging European Economies, Fiscal Council of the Republic of Serbia, Working Paper No. 14/01

Nickel, Christiane, and Tudyka, Andreas (2014): Fiscal Stimulus in Times of High Debt: Reconsidering Multipliers and Twin Deficits, Journal of Money, Credit and Banking, 46(1), pp. 1313–1344

Sims, Christopher (1998): Econometric implications of the government budget constraint, Journal of Econometrics, 83(1-2), pp. 9-19

Stork, Zbynek, and Zavacka, Jana (2010): Macroeconomic implications of fiscal policy measures in DSGE, Ministry of Finance of the Czech republic, Working Paper No. 1/2010

Appendix

Table 7: Individual Phillips-Perron unit root test

	π_t	r_t	y_t	t_t	x_t	m_t	b_t
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
Poland	L	L (lin + c)	L (lin + c)	L (lin + c)	L (lin + c)	L	L (lin + c)
	0.0000	0.3525	0.5072	0.1821	0.2851	0.0000	0.5072
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 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: Multivariate tests of VAR residuals

	Skewness			Kurtosis			Jarque-Bera		
Transformed									
	Cs	Dof	Pv	Cs	Dof	Pv	Cs	Dof	Pv
Czech r.	19.9654	6	0.0028	42.8457	6	0.0000	62.8110	12	0.0000
Hungary	6.0276	6	0.4201	16.7722	6	0.0102	22.7997	12	0.0295
Lithuania	1.4162	6	0.9649	10.9137	6	0.0911	12.3299	12	0.4196
Poland	1.4843	6	0.9605	14.9082	6	0.0210	16.3926	12	0.1739
Slovenia	1.9512	6	0.9241	12.8812	6	0.0450	14.8325	12	0.2507
Slovakia	4.8923	6	0.5577	7.7095	6	0.2602	12.6018	12	0.3986
In levels									
	Cs	Dof	Pv	Cs	Dof	Pv	Cs	Dof	Pv
Czech r.	1.5596	6	0.9554	24.3808	6	0.0004	25.9403	12	0.0109
Hungary	1.5345	6	0.9572	46.3920	6	0.0000	47.9265	12	0.0000
Lithuania	32.9394	6	0.0000	44.5922	6	0.0000	77.5316	12	0.0000
Poland	3.9108	6	0.6887	20.6765	6	0.0021	24.5874	12	0.0169
Slovenia	11.1376	6	0.0842	44.7861	6	0.0000	55.9237	12	0.0000
Slovakia	80.7196	6	0.0000	432.4080	6	0.0000	513.1275	12	0.0000

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 9: Lagrange multiplier test on residual serial correlation

	Czech r.		Hungary		Lithuania		Poland		Slovenia		Slovakia	
Transformed												
Lag	LM-st.	prob.	LM-st.	prob.	LM-st.	prob.	LM-st.	prob.	LM-st.	prob.	LM-st.	prob.
1	51.6	0.04	38.4	0.36	79.1	0.00	55.9	0.02	44.2	0.16	23.8	0.94
2	48.1	0.09	31.1	0.70	44.8	0.15	41.5	0.24	39.5	0.32	34.3	0.55
3	52.6	0.04	28.6	0.80	31.0	0.71	21.9	0.97	44.2	0.16	38.0	0.38
4	46.9	0.11	43.0	0.20	29.7	0.76	25.4	0.91	59.5	0.01	30.1	0.74
5	41.1	0.26	36.4	0.45	31.6	0.68	50.0	0.06	32.2	0.65	32.6	0.63
6	51.1	0.05	36.1	0.47	37.3	0.41	38.6	0.35	50.7	0.05	38.6	0.35
7	32.9	0.62	36.0	0.47	28.1	0.82	31.0	0.70	45.9	0.13	24.7	0.92
8	35.6	0.49	39.4	0.32	29.5	0.77	24.6	0.93	39.3	0.32	22.5	0.96
9	36.1	0.46	28.0	0.83	38.3	0.36	40.6	0.28	30.6	0.72	40.3	0.29
10	37.7	0.39	31.2	0.70	28.9	0.79	33.7	0.58	33.1	0.61	27.0	0.86
In levels												
Lag	LM-st.	prob.	LM-st.	prob.	LM-st.	prob.	LM-st.	prob.	LM-st.	prob.	LM-st.	prob.
1	36.4	0.45	28.6	0.81	66.9	0.00	59.4	0.01	39.2	0.33	48.2	0.08
2	39.5	0.32	39.6	0.31	59.8	0.01	62.8	0.00	35.1	0.51	26.9	0.86
3	28.4	0.81	41.3	0.25	20.8	0.98	29.1	0.79	44.8	0.15	29.9	0.75
4	46.6	0.11	45.4	0.14	33.5	0.59	38.8	0.35	56.9	0.01	33.9	0.57
5	51.7	0.04	38.1	0.38	24.1	0.94	30.9	0.71	46.1	0.12	49.7	0.06
6	40.7	0.27	34.8	0.53	31.6	0.68	41.6	0.24	38.0	0.38	27.3	0.85
7	34.5	0.54	47.8	0.09	21.3	0.97	31.4	0.69	42.3	0.22	26.5	0.88
8	33.4	0.59	35.7	0.48	36.5	0.44	46.2	0.12	48.5	0.08	34.9	0.52
9	43.8	0.17	52.6	0.04	20.5	0.98	25.8	0.90	28.6	0.80	41.0	0.26
10	46.6	0.11	36.3	0.46	45.6	0.13	32.1	0.66	25.2	0.91	29.6	0.77

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 10: White test on heteroscedasticity of residulas

	LM-statistics	degress of freedom	p-value
Transformed			
Czech r.	310.5793	294	0.2424
Hungary	264.9157	294	0.8876
Lithuania	328.3284	294	0.0821
Poland	290.6640	294	0.5440
Slovenia	309.5259	294	0.2557
Slovakia	299.6479	294	0.3979
In levels			
Czech r.	565.8710	567	0.5055
Hungary	792.3231	819	0.7421
Lithuania	621.8290	567	0.0550
Poland	582.6468	546	0.1345
Slovenia	781.6303	819	0.8215
Slovakia	330.9787	294	0.0678

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.

Table 11: Fit of the headline model

	Czech r.	Hungary	Lithuania	Poland	Slovenia	Slovakia
Transf. pre-crisis						
π_t	216.6	68.5	31.6	60.7	100.0	43.6
r_t	6.8	4.2	7.0	5.8	69.8	26.9
y_t	0.7	0.1	0.5	0.1	2.4	2.1
τ_t	1.3	0.5	1.0	0.3	1.2	2.6
x_t	2.6	0.6	1.0	0.7	2.6	2.8
m_t	24.2	9.5	8.9	99.9	642.3	15.4
b_t	5.4	3.9	5.9	4.4	57.9	10.6
In levels						
π_t	47.9	50.4	393.0	112.4	46.6	43.4
r_t	9.7	3.5	18.6	2.2	24.7	7.2
y_t	1.3	0.8	3.9	0.5	2.8	0.2
τ_t	2.0	3.0	6.3	1.0	1.6	1.1
x_t	1.7	0.7	7.8	1.3	2.9	0.3
m_t	37.3	83.5	43.0	48.7	125.3	19.3
b_t	7.8	6.0	11.3	4.3	25.1	11.1

Note: Reported are average absolute deviations from the observed historical values in percent.

Table 12: Cumulative responses of output (headline model, variables in levels)

	Czech r.	Hungary	Lithuania	Poland	Slovenia	Slovakia
Revenue shock						
1y	-0.008	-0.122	0.107	0.038	-0.046	-0.098
2y	0.013	-0.272	-0.238	0.063	-0.105	-0.271
3y	0.024	-0.427	-0.696	0.044	-0.037	-0.432
Expenditure shock						
1y	-0.182	0.092	0.005	0.041	0.083	0.021
2y	-0.459	0.253	0.151	0.194	0.203	0.045
3y	-0.637	0.424	0.387	0.411	0.240	0.059

Note: The responses are significant in the sense that the 90 percent confidence interval does not include a zero impulse response (for Poland up to 1 year).

Table 13: Estimates of response functions for the CEE-6

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	-			+		
Poland	Mirdala (2009)	E	-	-+	-+	0+	+	+
	Eller et al. (2011)	E	-+	+	-+	-	+	+
	Haug et al. (2013)	E	+	+	+	+	-	-
	Mirdala (2013)	E	-			+		
	Dinu and Marinas (2014)	E	0+			+	+	
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				+	+-	+
Slovakia	Mirdala (2009)	E	+	+	+	+	+	+
	Eller et al. (2011)	E	-	+	-	-	+-	+
	Mirdala (2013)	E	-			+		
	Pecsyova (2013)	E	-	-	+	+-	-	+
	Dinu and Marinas (2014)	E	0-			-+	+	
	Klucik (2015)	T	-+	+-		+	+	
	Mucka and Horvath (2015)	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.

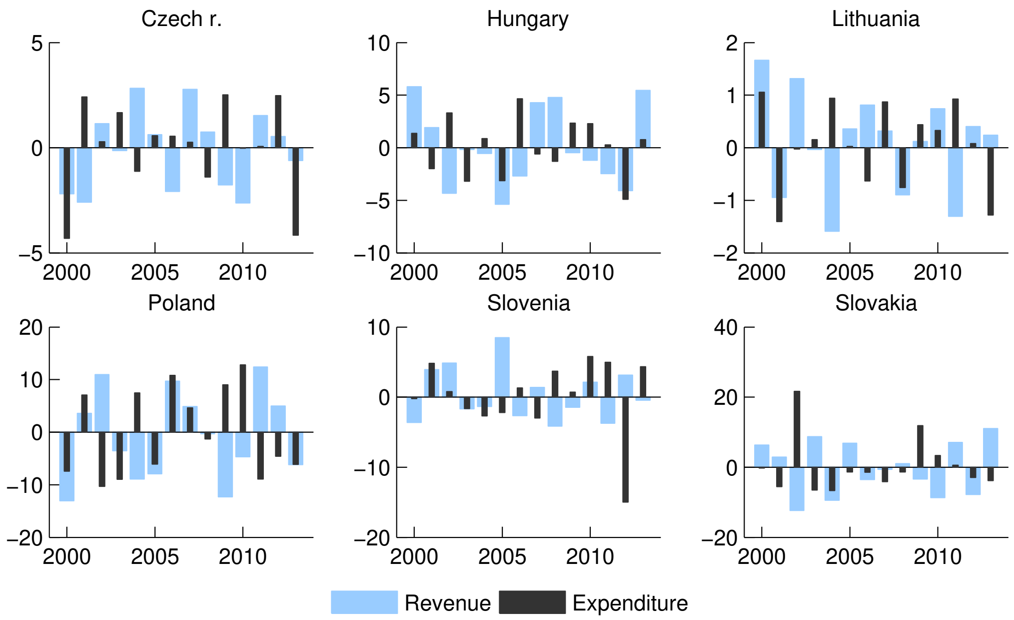


Figure 10: Estimated structural shocks

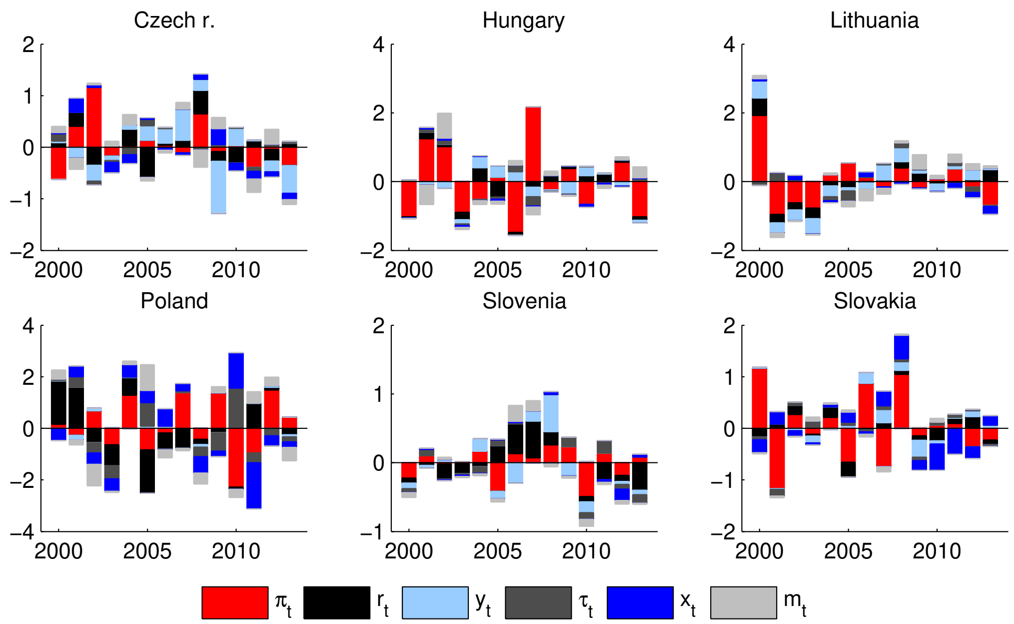


Figure 11: Decomposition of the GDP deflator growth rate