**Macroeconomic Effects of Fiscal Policy in the Czech Republic: Evidence Based on Various Identification Approaches in a VAR Framework**

Franta, Michal
2012

2012

# WORKING PAPER SERIES 13

Michal Franta:

Macroeconomic Effects of Fiscal Policy in the Czech Republic:
Evidence Based on Various Identification Approaches in a VAR Framework

CZECH NATIONAL BANK

# WORKING PAPER SERIES

**Macroeconomic Effects of Fiscal Policy in the Czech Republic: Evidence Based on Various Identification Approaches in a VAR Framework**

Michal Franta

13/2012

**CNB WORKING PAPER SERIES**



Reviewed by: Jesus Crespo Cuaresma (Wirtschafts Universität Wien)
Francisco de Castro Fernández (Bank of Spain)
Róbert Ambriško (Czech National Bank)

Project Coordinator: Kamil Galuščák

# Macroeconomic Effects of Fiscal Policy in the Czech Republic: Evidence Based on Various Identification Approaches in a VAR Framework

Michal Franta*

## Abstract

The paper analyzes the macroeconomic effects of fiscal policy shocks in the Czech Republic. The low number of observations available for fiscal variables significantly affects the setup of the analysis. Firstly, a small-scale VAR is considered. Secondly, the model is estimated using Bayesian techniques. Finally, all identification approaches that are currently employed by the literature and that are applicable to the Czech Republic are used. The estimation results suggest that the fiscal policy transmission mechanism in the Czech Republic exhibits some standard features (e.g., a rise in GDP and inflation after unexpected government spending, and an increase in government spending after a positive shock to government revenues). However, the uncertainty associated with the results is substantial. Furthermore, it is discussed how the identification strategy itself may represent an additional source of uncertainty of the results.

**JEL Codes:** E62, H30.

**Keywords:** Bayesian vector autoregression, fiscal shocks identification.

---

*Michal Franta, Czech National Bank, Economic Research Department, e-mail contact: michal.franta@cnb.cz

I thank Róbert Ambriško, Francisco de Castro Fernández, Jesus Crespo Cuaresma, Christophe Kamps, and seminar participants at the Czech National Bank for comments and helpful discussions. The views expressed in this paper are not necessarily those of the Czech National Bank. This research was supported by Czech National Bank Research Project D1/11.

## Nontechnical Summary

Fiscal policy shocks are important for monetary policy as they affect variables crucial for policy-makers in a central bank. Given their high importance to the central bank, it is surprising that there is no consensus about the quantitative, or even qualitative, properties of most effects of fiscal policy shocks.

Another important aspect of fiscal policy analysis relates to data. Fiscal data are often available for only a short period of time and are usually of quarterly frequency. So, model estimation often relies on a low number of observations. This feature of the data is especially relevant to the Czech Republic – the subject of study of this paper.

This paper attempts to provide an answer to the question of how unexpected changes in government spending/revenues affect the Czech economy. Great emphasis is put on the robustness of the results. In particular, the way in which fiscal policy shocks are identified draws on all standard approaches that have been employed so far in the literature and are applicable to the Czech Republic. The aim of this general approach is to deal with the academic disagreement on the proper approach to identifying fiscal policy shocks. Moreover, results based on various identification schemes may enhance the discussion on the fiscal shock identification strategy suitable for the Czech Republic.

The econometric approach in this paper reflects the low number of observations: the model is based on a minimal set of endogenous variables and is estimated using the Bayesian approach. The advantage of the Bayesian technique is that it allows prior information to be imposed on the system, i.e., additional information on top of that provided by the data.

The estimation results suggest that the fiscal policy transmission mechanism in the Czech Republic exhibits some standard features. For example, a positive response of inflation and GDP after unexpected government spending and a rise in government spending after a positive shock to government revenues can be viewed as standard macroeconomic consequences of fiscal shocks. However, the uncertainty associated with the results is substantial and the results are not robust to the identification strategy employed. Furthermore, the identification strategy may itself represent an additional source of uncertainty.

# 1. Introduction

The effects of fiscal policy shocks are still a subject of lively debate, as neither theoretical nor empirical studies have reached a consensus on either the qualitative or quantitative properties of such effects. Regarding the empirical research, the problem of diverging results is intensified when the analysis is carried out for a country with only short time series of fiscal data available. A low number of observations leads to imprecise estimates and presumably to sparse occurrence of shocks to identify. The uncertainty associated with the empirical findings can then be large, usually implying weak conclusions.

The aim of this study is to estimate the macroeconomic effects of fiscal policy shocks for the Czech economy. For that purpose we estimate a vector autoregressive (VAR) model and identify fiscal shocks using various approaches. Similarly to Caldara and Kamps (2008) we employ basically three well-established identification schemes – recursive identification, SVAR formulated in terms of the AB model, and sign restrictions.

While the purpose of the comparative analysis of identification approaches in Caldara and Kamps (2008) is primarily to explain diverging results from empirical studies based on VAR models, our reason here is different. We consider the examination of various identification schemes to be a way of partially overcoming the uncertainty of the results. The effects of fiscal shocks that are robust to the identification procedure can be regarded as more likely. Firstly, the data cannot discriminate between identification approaches. The data used for the estimation of the model are related solely to the reduced-form VAR, which is the same regardless of the identification assumptions (observational equivalence). Secondly, there may not be broad agreement on the assumptions underlying a particular identification approach, but if all identification schemes yield the same effect, the result can be viewed as reliable. Another reason to consider various fiscal shock identification schemes is to enhance the discussion about the appropriate identification method for a country with short fiscal time series.

The robustness of the results with respect to the identification approach relates to the uncertainty of the identification. The uncertainty associated with the estimation of the reduced-form VAR is another aspect. To address this problem the reduced-form model is estimated using Bayesian techniques. A hierarchical Bayesian VAR is set up to find the optimal informativeness of the priors used.

Our motivation stems from an effort to extend the set of empirical studies that deal with fiscal policy analysis for the Czech Republic. So far, only a few studies provide this type of analysis. Moreover, some features of the methodology used in this paper have not been applied to Czech fiscal policy analysis yet. Specifically, Bayesian estimation of the reduced-form VAR and sign-restrictions identification approach could improve our understanding of the transmission of fiscal policy shocks.

Empirical estimates suggest that the fiscal policy transmission mechanism in the Czech Republic exhibits some standard features (an increase in output and inflation after an unexpected rise in spending, and an increase in government spending after a positive shock to government revenues). However, the uncertainty associated with the results is substantial. Moreover, the results are often not robust to the identification approach employed. It has also been shown that even if we overcome the problem of short time series by imposing extraneous information in the form of priors, the identification procedure can itself represent another substantial source of uncertainty.

The rest of the paper is structured as follows. The next section provides a survey of the relevant literature. Sections 3 and 4 deal with the model, its estimation, and the approaches used for the identification of fiscal shocks. The estimation results are discussed in Section 5, and Section 6 concludes. Appendix A contains graphs of endogenous variables, Appendix B compares the median responses for all identifications, Appendix C presents fiscal balances, Appendix D shows dynamic fiscal multipliers, and Appendix E shows estimates of free parameters in the AB model.

## 2. Literature Review

In vector autoregressions the identification of fiscal shocks is usually based on an assumption of a lagged response of a fiscal variable to changes in macroeconomic conditions. For example, Fatás and Mihov (2001) employ the traditional recursive assumption with government spending ordered first in the vector of endogenous variables. For the analysis of Czech fiscal shocks the recursive assumption is considered in Mirdala (2009) and Baxa (2010).

Blanchard and Perotti (2002) estimate an SVAR model imposing additional information in the form of elasticities of government spending and taxes with respect to GDP and prices. The approach of Blanchard and Perotti (2002) has become a standard and has been applied many times since then – for example, Perotti (2004) for the US, Germany, Canada, Australia, Japan, and the UK, Giordano et al. (2007) for Italy, de Castro and de Cos (2008) for Spain, and Heppke-Falk et al. (2010) for Germany. For the Czech Republic analyses conducted along the lines of Blanchard and Perotti (2002) can be found in Radkovský and Štiková (2008), Valenta (2011), and Cuaresma et al. (2011).

Recently, several authors have extended the set of possible identification approaches to include sign restrictions (Mountford and Uhlig, 2009; Canova and Pappa, 2007; Dungey and Fry, 2009). In this approach qualitative information underlying the identification of shocks is imposed directly on the impulse responses of some endogenous variables.

Finally, fiscal shocks can also be identified by looking directly at the effects of fiscal spending related to specific events, government military spending during wars being a typical example. The narrative approach to fiscal shock identification is introduced for US fiscal policy shock analysis in Ramey and Shapiro (1998) and also in Burnside et al. (2004).

Apart from vector autoregressions, fiscal policy can be analyzed by drawing on either structural models (for the Czech Republic see Klyuev and Snudden, 2011, and Ambriško et al., 2012b) or various types of fiscal indicators (e.g., Ambriško et al., 2012a, and Bezděk et al., 2003, examine the Czech case).

## 3. Model and Data

We start with a traditional reduced-form vector autoregressive model:

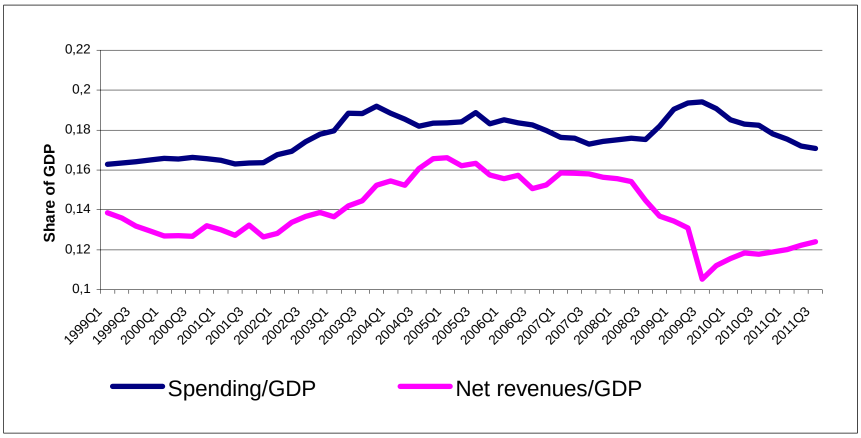
$$y_t = C + \sum_{j=1}^{p} A_j y_{t-j} + e_t \,, \tag{1}$$

where $C$ includes deterministic terms (constant and linear trend), $y_t$ for $t = 1,\ldots,T$ is an $M \times 1$ vector of endogenous variables, $A_j$ is an $M \times M$ matrix of coefficients, and $e_t$ is an $M \times 1$ vector of innovations. We assume that the innovations are i.i.d. $N(0,\Sigma)$. Finally, let $A \equiv \left[C, A_1,\ldots, A_p\right]'$ and $\alpha \equiv vec(A)$.

The choice of endogenous variables to a large extent follows the literature originated by Blanchard and Perotti (2002), i.e., the vector of endogenous variables consists of government spending, GDP, inflation, government revenues, and the interest rate. So, the model consists of five endogenous variables ( $M = 5$ ), which are ordered as listed above.

The data set is of quarterly frequency, covering the period 1999Q1–2011Q3. The data are seasonally adjusted (TRAMO/SEATS). Government spending and revenues and GDP are in log real terms (deflated by GDP[1]). Data on government spending and revenues are from the Czech Statistical Office. Government spending consists of government consumption and investment. More specifically, it includes intermediate consumption, compensation of employees, and gross fixed capital formation.[2] Government revenues are net of transfers and are referred to as net revenues in the following text. Government spending and net revenues as a share of GDP are presented in Figure 1, and all endogenous variables in levels are shown in Appendix A.

***Figure 1: Government Spending and Net Revenues as a Share of GDP***




[1] We use the same price index to transform government spending and revenues and GDP into real terms because the impulse responses are presented as shares of GDP.

[2] In the gross fixed capital formation component a peak can be observed in the raw data in 2003Q1. The peak relates to the reclassification of the railway company into the general government sector. The data on government spending are adjusted for this change.

The endogenous variables enter the analysis in levels. Since we estimate the reduced-form model (1) by Bayesian techniques, possible unit roots in the variables do not represent a problem (see, e.g., Sims, 1980, or Uhlig, 1994). Moreover, for the short time series available, stationarity and cointegration tests are often inconclusive. The next reason for using variables in levels is that we take the calibration of the matrices in the AB model from papers that consider variables in levels (Cuaresma et al., 2011, and Valenta, 2011).

### 3.1 Estimation

Model (1) is estimated by Bayesian techniques – a Normal-Wishart prior is used:[3]

$$\Sigma^{-1} \sim W\left(S_{PR}(c_1), d\right)$$
$$\alpha \mid \Sigma \sim N\left(0, \Sigma \otimes V_{PR}(c_2)\right),$$

where the parameter $d \in \mathbb{R}$ denotes the degrees of freedom and parameters $c_1 \in \mathbb{R}$ and $c_2 \in \mathbb{R}$ drive the shrinkage of the relevant parts of the prior scale matrix and the prior variance, respectively. The degrees of freedom $d$ are set to $M+2$, which is the minimum value that guarantees the existence of a prior mean for the inverse of variance-covariance matrix $\Sigma$.

The scale matrix specification $S_{PR}(c_1) \equiv diag([1,1,c_1,1,c_1]$ reflects the fact that the variances of the two groups of endogenous variables differ remarkably.[4]

The prior variance on the vector of coefficients takes a form that imposes an uninformative prior on the intercepts:

$$V_{PR}(c_2) \equiv diag\left(\left[10^4, c_2, \ldots, c_2, \frac{c_2}{k}, \ldots, \frac{c_2}{k}, \frac{c_2}{k^2}, \ldots., \frac{c_2}{k^p}\right]\right).$$

Furthermore, it shrinks the prior variance with the lag of explanatory variable ($1/k^{lag}$). The prior variance specification is very close to the standard setting as introduced in Kadiyala and Karlsson (1997). Finally, a tighter prior variance for the lags of other variables than the variable on the left-hand side of the equation is not employed, as it does not affect the results.

The Normal-Wishart priors are the natural conjugate priors, i.e., the posterior distribution of the autoregressive parameters $A_j$ and the vector of intercepts $C$ are distributed normally (given $\Sigma$) and the inverse of the variance-covariance matrix, $\Sigma^{-1}$, is distributed as a Wishart distribution (see, e.g., Koop and Korobilis, 2010):

[3] The same type of prior distributions is used in Caldara and Kamps (2008).

[4] The operator $diag(z)$ denotes a matrix with the diagonal equal to the vector z and with off-diagonal elements equal to zero.

$$\Sigma^{-1} \mid y \sim W\left( S_{PR}(c_1) + \hat{e}'\hat{e} + \left(A^{POST}\right)' V_{PR}^{-1}(c_2)\left(A^{POST}\right), T-p+d \right)$$

$$\alpha \mid \Sigma, y \sim N\left(\alpha^{POST}, \Sigma \otimes \left(V_{PR}^{-1}(c_2) + x'x\right)^{-1}\right),$$

where $x_t \equiv \left[1, y'_{t-1}, ..., y'_{t-p}\right]'$, $x \equiv \left[x_{p+1}, ..., x_T\right]'$, $A^{POST} = \left(V_{PR}^{-1}(c_2) + x'x\right)^{-1}(x'y)$, $\alpha^{POST} \equiv vec\left(A^{POST}\right)$.

The posterior distribution of the model parameters is simulated by taking 10,000 draws. For each draw the shock identification procedure is carried out. The effects of identified shocks are then summarized by certain quantiles of the impulse response distributions at a particular horizon.

The hyperparameters $c_1$ and $c_2$ are set according to Giannone et al. (2012), who proposed a hierarchical method of choosing shrinkage parameters based on maximization of the marginal likelihood, which for conjugate priors is available in a closed form:

$$\left(\frac{1}{\pi}\right)^{\frac{M(T-p)}{2}} \frac{\Gamma_M\left(\frac{T-p+d}{2}\right)}{\Gamma_M\left(\frac{d}{2}\right)} c_2^{-\frac{M}{2}} c_1^{-\frac{d}{2}} \left|x'x + V_{PR}(c_2)\right| \left|S_{PR}^{-1}(c_1) + \hat{e}'\hat{e} + \left(A^{POST}\right)' V_{PR}^{-1}(c_2)\left(A^{POST}\right)\right|^{-\frac{T-p+d}{2}}.$$

Apart from the effect of data-based choice of prior informativeness on forecasting performance, Giannone et al. (2012) also show that impulse responses are more accurate in comparison with VARs with a flat prior even for small-scale VARs.

The value of the marginal likelihood is also taken into consideration when setting the lag length (parameter $p$). Other aspects taken into account include the short period of available data and the frequency of the data. The quarterly frequency of the data suggests the use of at least four lags in the model. On the other hand, a high number of lags is not necessarily appropriate, since the total number of observations equals 51 only and shortening the data sample can affect the analysis. The marginal likelihood for five lags is lower than that for four lags and thus we stick to four lags. Finally, note that Blanchard and Perotti (2002), Mountford and Uhlig (2009) and others also consider four lags.

## 4. Identification

The task of identifying structural shocks is equivalent to finding a linear relationship between the reduced-form residuals from model (1), $e_t$, and uncorrelated structural shocks, $\varepsilon_t$. Following Caldara and Kamps (2008), recursive identification, structural VAR based on the AB model, and sign-restrictions identification are employed. The three approaches are standard tools currently used in fiscal policy analysis based on VARs. We do not carry out an analysis built on the narrative approach because we suppose that the short time span of the data does not cover any period of exceptional government spending (see also Figure 1).

### 4.1 Recursive Identification

The first identification approach follows Fatás and Mihov (2001). Structural shocks are determined recursively, i.e., the reduced-form model variance-covariance matrix, $\Sigma$, is decomposed by Cholesky decomposition into the product of a lower triangular matrix and its transpose. The lower triangular matrix defines the relationship between the structural and reduced-form residuals, i.e., endogenous variables ordered first affect contemporaneously variables ordered last but not vice versa. Government spending is ordered first in the vector of endogenous variables, and thus we assume that the government does not react contemporaneously to a business cycle shock or monetary policy shock.

### 4.2 AB Model

The second identification approach follows Blanchard and Perotti (2002), who draw on extraneous information about the elasticities of government spending and net revenues to GDP and prices. The elasticities are imposed directly as coefficients into the linear relationships between structural and reduced-form residuals. The framework is also called the AB model (e.g., Breitung, 2004):

$$Ae_t = B\varepsilon_t.$$

The elements of matrix A can be interpreted as capturing the immediate effect of a change in a variable on another variable (elasticity), while the elements of matrix B represent the immediate effect of a structural shock on a variable. We impose two sets of restrictions. First, we adopt the restrictions of Cuaresma et al. (2011), who apply the approach of Blanchard and Perotti (2002) to Central and Eastern European economies. Second, we apply the restrictions from Valenta (2011), which are suited for the analysis of Czech fiscal transmission. A detailed reasoning for the restrictions imposed can be found in the two papers.

So, we use the following specifications:

$$\begin{bmatrix} 1 & 0 & 0.5 & 0 & 0 \\ -\alpha_{yg} & 1 & 0 & -\alpha_{y\tau} & 0 \\ -\alpha_{\pi g} & -\alpha_{\pi y} & 1 & -\alpha_{\pi\tau} & 0 \\ 0 & -0.8(-0.9) & -0.5(0) & 1 & 0 \\ -\alpha_{ig} & -\alpha_{iy} & -\alpha_{i\pi} & -\alpha_{i\tau} & 1 \end{bmatrix} \begin{bmatrix} e_t^g \\ e_t^y \\ e_t^\pi \\ e_t^\tau \\ e_t^i \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ \beta_{\tau g} & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^g \\ \varepsilon_t^y \\ \varepsilon_t^\pi \\ \varepsilon_t^\tau \\ \varepsilon_t^i \end{bmatrix},$$

where the specification from Valenta (2011) is in parenthesis if different from Cuaresma et al. (2011). The main difference between the two specifications is that Valenta (2011) assumes zero elasticity of net revenues to inflation within a quarter.

The parameters of matrices A and B are estimated by FIML estimation implemented by the scoring algorithm (see, e.g., Amisano and Giannini, 1997).

### 4.3 Sign Restrictions

The sign-restrictions identification approach is similar to Mountford and Uhlig (2009) and Caldara and Kamps (2008). The approach is based on the fact that in the relationship between reduced-form residuals and structural shocks an orthonormal matrix $Q$ rotates uncorrelated structural shocks while leaving reduced-form residuals intact:

$$e_t = A^{-1}B\varepsilon_t = A^{-1}BQQ^T\varepsilon_t = A^{-1}BQ^T\eta_t .$$

So, the vector $\eta_t$ represents another set of uncorrelated structural shocks that yields the same reduced-form residuals. Nevertheless, the impulse responses of the new set of structural shocks are different from the original ones.

The implementation of sign restrictions draws on Givens rotations (e.g., Fry and Pagan, 2011). Givens rotations are orthonormal matrices of the following form:

$$Q_{ij}(\theta) = \begin{pmatrix} 1 & \cdots & 0 & \cdots & 0 & \cdots & 0 \\ \vdots & \ddots & \vdots & & \vdots & & \vdots \\ 0 & \cdots & \cos(\theta) & \cdots & -\sin(\theta) & \cdots & 0 \\ \vdots & & \vdots & \ddots & \vdots & & \vdots \\ 0 & \cdots & \sin(\theta) & \cdots & \cos(\theta) & \cdots & 0 \\ \vdots & & \vdots & & \vdots & \ddots & \vdots \\ 0 & \cdots & 0 & \cdots & 0 & \cdots & 1 \end{pmatrix}$$

with $\theta \in [0,\pi]$ denoting the rotation angle and indices $i, j \in \{1,...,M\}$ denoting the row and column occupied by the corresponding goniometric functions. The whole set of Givens rotations is then produced by the product of all possible $Q_{ij}(\theta_{ij})$ such that $i < j$:

$$Q = \prod_{\substack{i,j=1 \\ i<j}}^{M} Q_{ij}(\theta_{ij}), \quad \theta_{ij} \in [0,\pi].$$

The sign-restrictions identification approach consists of a set of qualitative restrictions that say what Givens rotations (i.e., impulse response functions) to leave for further analysis. Our first restriction imposed is that a business cycle shock (whatever its nature) does not contemporaneously affect government spending. The interpretation of the inertia of government spending to business cycle shocks is usually based on decision lags inherently included in the fiscal policy decision-making process. Practically, the first restriction is implemented by using a subset of the set of all Givens rotations that delivers zero on impact for government spending after a business cycle shock occurs. So,

$$Q = Q_{24}(\theta_{24})Q_{14}(\theta_{14})Q_{25}(\theta_{25})Q_{45}(\theta_{45})Q_{23}(\theta_{23})Q_{35}(\theta_{35})Q_{34}(\theta_{34})Q_{15}(\theta_{15})Q_{13}(\theta_{13}).$$

Next, the rest of the sign restrictions imposed are the same as in Caldara and Kamps (2008). We identify a business cycle shock, government spending shock, and net revenues shock. For the business cycle shock, a positive reaction of output and net revenues for four quarters after the shock is assumed. The government spending (net revenues) shock is identified by imposing a positive reaction of spending (net revenues) for at least four quarters following the shock.

## 5. Results

The impulse response functions for the government spending shock and net revenues shock are presented in turn. We present the responses implied by four identification approaches: the recursive approach, the AB model with two specifications of matrices A and B according to Cuaresma et al. (2011) and Valenta (2011), and the sign-restrictions approach. The responses of government spending, net revenues, and GDP are reported as percentages of GDP. The responses of the interest rate and inflation are expressed in percentage points.

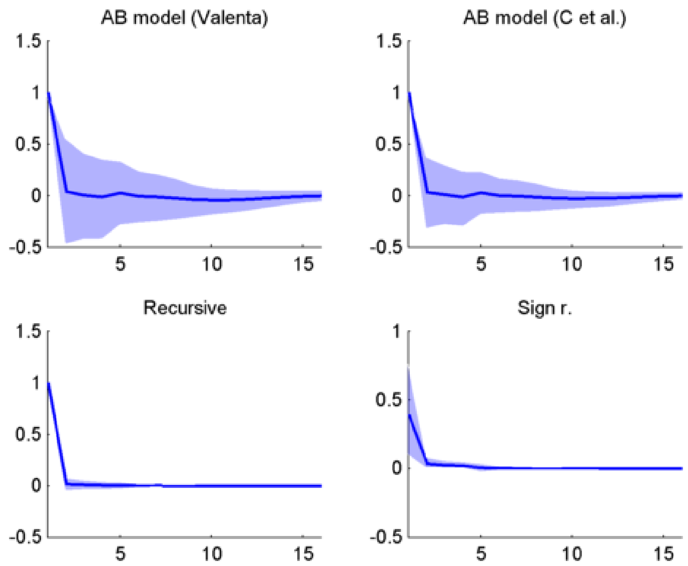
Both shocks are normalized to be 1% of GDP in size, except when the sign-restrictions identification approach is applied. As pointed out by Fry and Pagan (2011) sign restrictions cannot identify the magnitudes of structural shocks and thus normalization (and comparison with other approaches) is not possible. However, the signs of the response and the periods of its minimum/maximum/switch of sign are identified properly. Therefore, when the magnitudes of shocks is dealt with in the following text, the responses obtained by sign restrictions are not discussed.

To summarize the distribution of the impulse responses, the median along with the $16^{th}$ and $84^{th}$ quantiles of the impulse responses at a particular horizon are presented. A direct comparison of the medians of the impulse responses provided by all the identification approaches considered can be found in Appendix B. The horizon of the responses is up to 16 quarters. The implied fiscal balance for the government spending and net revenues shocks can be found in Appendix C.

### 5.1 Government Spending Shock

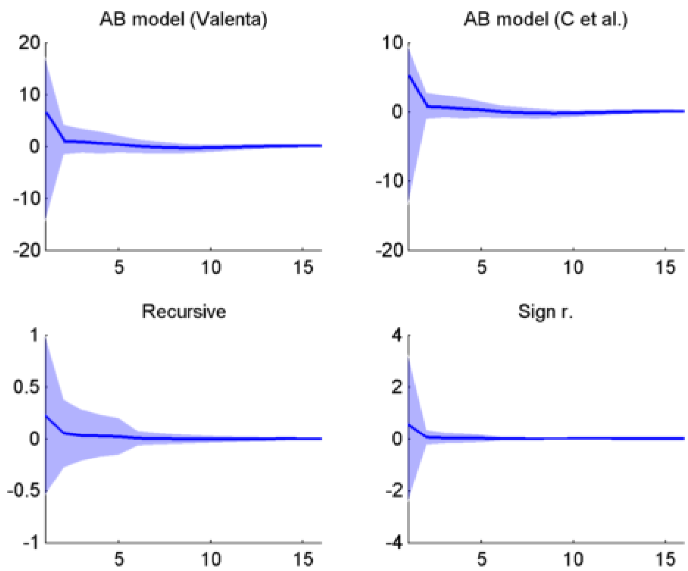
All the identification approaches exhibit a very similar pattern of government spending after a government spending shock of size 1% of GDP (Figure 2). The figure suggests that the government spending process is not persistent and the effect of the shock is almost zero from the second quarter onwards. Nevertheless, the uncertainty – reflected by credible intervals – means that the possibility of a persistent effect of the shock for identifications based on the AB model cannot be ruled out.

***Figure 2: Responses of Government Spending after the Government Spending Shock***




The immediate median reaction of GDP after the unexpected spending shock is positive for all identifications. The credible intervals accompanying the median response of GDP contain zero over the whole horizon and for all identification schemes. So, either GDP reacts to unexpected spending only marginally or our data set/identification does not allow the reaction of GDP to the spending shock to be estimated precisely. Since government spending is a part of GDP the second explanation is more plausible. The first explanation would be consistent with the presence of a crowding-out effect of government spending. Finally, the profiles of the responses suggest that the possible effect, regardless of whether we detect it or not, is short-lived. After five quarters the effect of the shock is zero.

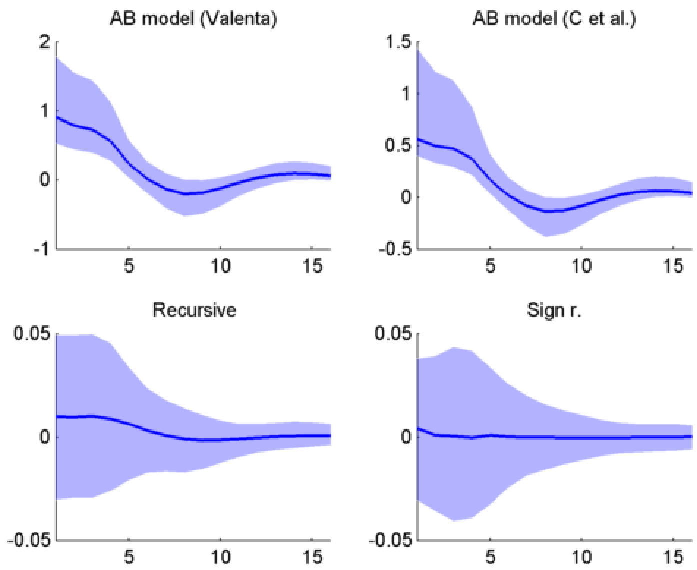
***Figure 3: Responses of GDP after the Government Spending Shock***



The high uncertainty associated with the responses of GDP (at least within a few quarters after the shock) makes our conclusions about the effect rather weak. So, the implied output multipliers cannot be viewed as reliable either. However, in Appendix D the cumulative dynamic fiscal multipliers are reported.

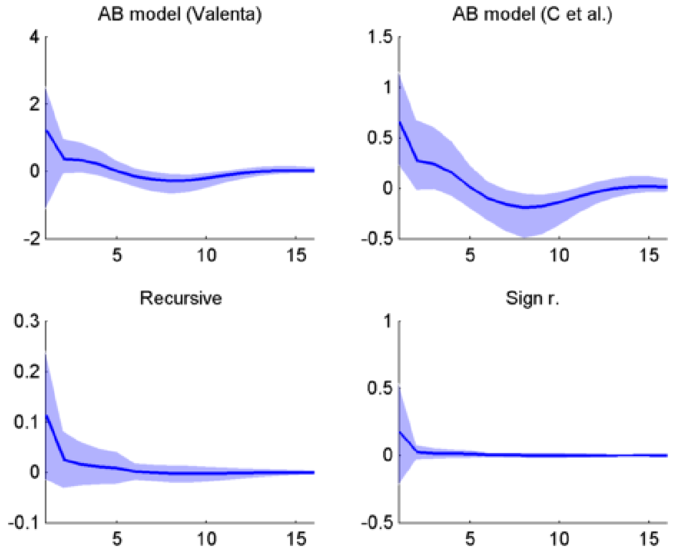
Both specifications of the AB model provide an immediate positive reaction of inflation after the spending shock (Figure 4). In the quarter when the spending shock occurs inflation rises by 0.5–1 p.p. and the effect dies out after five quarters. The credible intervals do not cover zero in the quarter of the shock, so the conclusion of a positive response of inflation can be viewed as relatively strong. On the other hand, the sign restrictions and recursive identification imply a very weak response of inflation. Nevertheless, we do not observe the puzzle of decreasing prices after a government spending shock that can be found, for example, in Fatás and Mihov (2001) for recursive identification and in Mountford and Uhlig (2009) for sign-restrictions identification.

***Figure 4: Responses of Inflation after the Government Spending Shock***



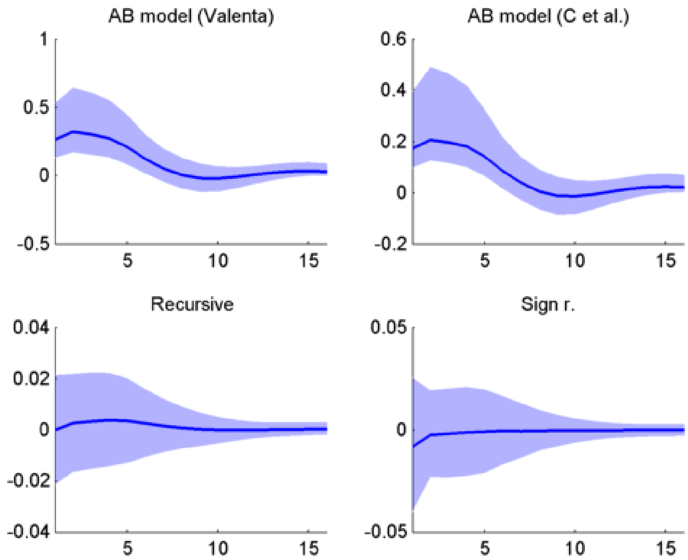

The response of net revenues is in general positive (Figure 5). In terms of credible intervals this conclusion can be stated only for the identification approach drawing on the AB model specified as in Cuaresma et al. (2011). This specification suggests that the immediate reaction of net revenues slightly exceeds 0.5% of GDP.

***Figure 5: Responses of Net Revenues after the Government Spending Shock***




Finally, the responses of the interest rate, reported in Figure 6, are positive for the AB model identification and achieve values of around 0.2 p.p. The other identifications do not suggest any reaction of the interest rate. The positive reaction of the interest rate is in line with the behavior of an inflation-targeting central bank which responds to an increase in inflation.

***Figure 6: Responses of the Interest Rate after the Government Spending Shock***



VAR studies dealing with the effects of fiscal policy shocks in the Czech Republic provide both a negative (Radkovský and Štiková, 2008) and a positive (Mirdala, 2009; Baxa, 2010) immediate reaction of GDP to a government spending shock. The reaction of net revenues is usually reported as being positive.

### 5.2 Net Revenues Shock

While Caldara and Kamps (2008) demonstrate that various identification schemes provide similar responses for a government spending shock and diverging results for a net revenues shock, one cannot find similar responses for either a spending shock or a net revenues shock in the analysis of Czech fiscal shocks.

***Figure 7: Responses of Net Revenues after the Net Revenues Shock***

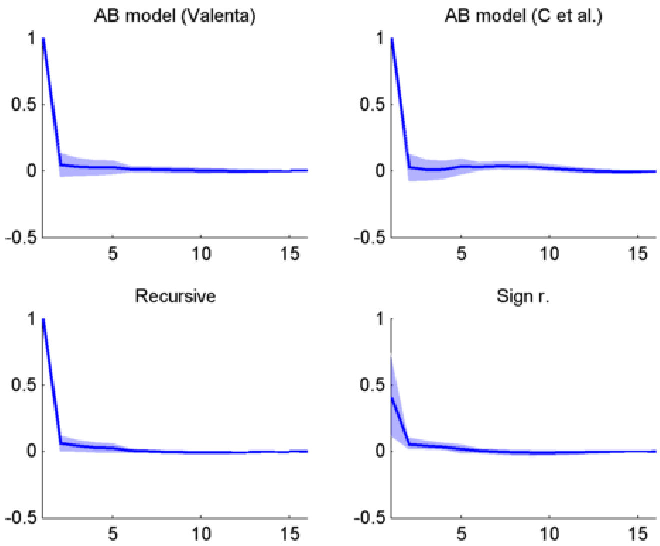
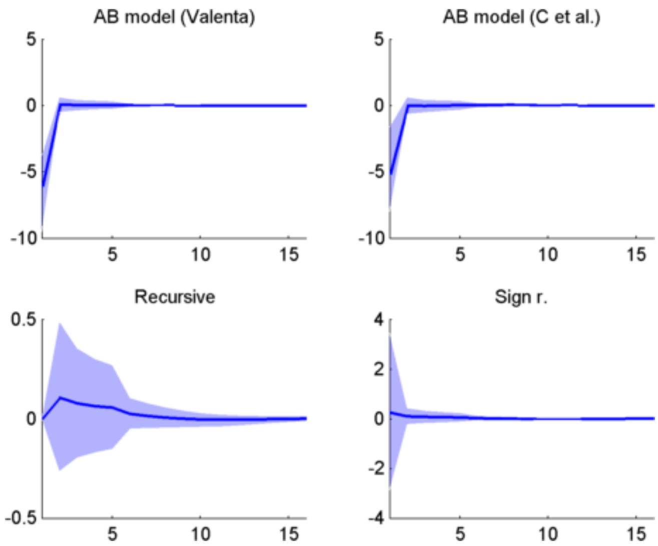



Figure 7 presents the response of net revenues to a net revenues shock of size 1% of GDP. The profile of net revenues is similar to that of government spending after the government spending shock (Figure 2). The difference lies in lower uncertainty associated with the profile – low persistence of net revenues can be concluded even taking into account the corresponding credible intervals.

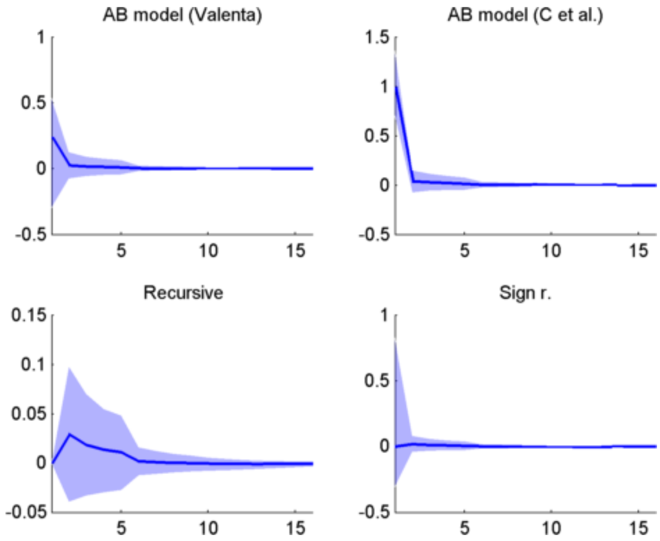
***Figure 8: Responses of GDP after the Net Revenues Shock***




For the response of GDP the credible intervals suggest that the sign of the response in the few quarters after the shock cannot be determined for recursive and sign-restrictions identification (Figure 8). The two variants of the AB model provide a strong negative immediate effect of GDP, which is in line with a supposed decline of real activity as a consequence of possible distortionary effects of higher taxes. The size of the effect, however, is puzzling. A net revenues shock of 1% of GDP implies a fall in GDP of around 5%. This observation reflects the estimated elasticity of output with respect to net revenues ( $\alpha_{y\tau}$ ) in matrix A. An example of a set of estimated values of the parameter can be found in Appendix E.

The negative immediate reaction of GDP is similar to the one reported for the Czech Republic by Radkovský and Štiková (2008). On the other hand, Mirdala (2009) shows a positive effect of GDP after a net revenues shock.

***Figure 9: Responses of Government Spending after the Net Revenues Shock***




Government spending increases either immediately or within a few quarters after the net revenues shock. Only the AB model calibrated according to Cuaresma et al. (2011) provides a credible interval not containing zero and a reaction that is of approximately the same size as the net revenues shock (Figure 9). The same identification approach also suggests a decrease in inflation (Figure 10) and the interest rate (Figure 11). Such responses are in line with the declining economic activity observed after the net revenues shock for this identification approach.

***Figure 10: Responses of Inflation after the Net Revenues Shock***

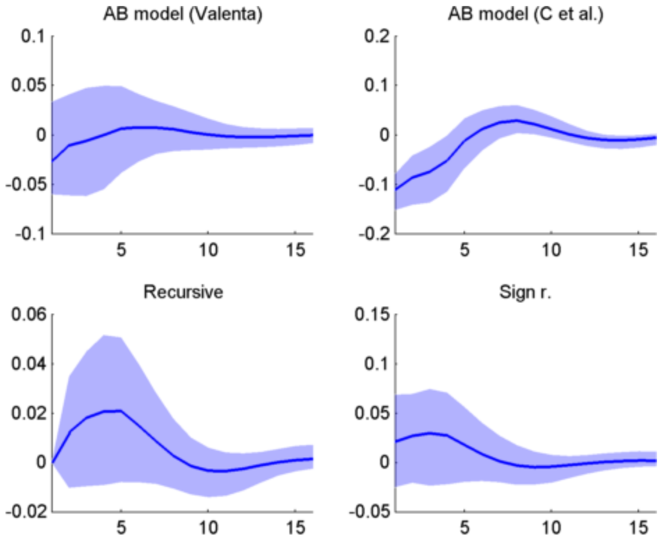
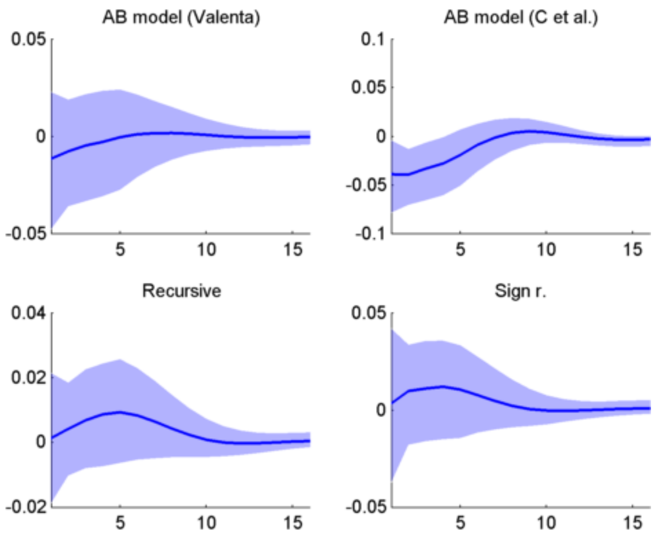


***Figure 11: Responses of the Interest Rate after the Net Revenues Shock***




## 5.3 Uncertainty

As noted in the introduction, robust impulse responses imply reliable results. Moreover, a comparison of the results implied by the identification schemes can serve as a basis for discussion about the appropriate identification approach for a country with a short time series of fiscal data. The impulse responses presented in the previous section are not in general robust to the identification approach. Moreover, high uncertainty is usually associated with the results.

Part of the uncertainty, as reflected by the centered 68% of the impulse response distribution, is associated with the reduced-form model estimation. However, some fraction can be assigned to the identification procedure. Therefore, it is interesting to compare the four identification approaches with respect to the uncertainty associated with the results. The uncertainty stemming from the reduced-form model estimation is the same for all approaches. The differences, therefore, originate solely from the identification schemes. For example, the sign-restrictions identification approach is viewed as 'weak' in the sense of a potentially high number of structural models that satisfy the sign restrictions imposed (Fry and Pagan, 2011). In contrast, the recursive assumption yields just one structural model and the uncertainty associated with this approach should be lower.

The responses presented in the previous section show that the uncertainty associated with the identification strategy dominates. The responses based on recursive identification are accompanied by the 'narrowest' credible intervals, which reflects the tight prior we are forced to impose. On the other hand, the uncertainty associated with the AB model seems to be substantial. Appendix E presents estimates of the parameters of matrices A and B for 100 arbitrarily chosen draws of reduced-form coefficients of the benchmark model. It shows that the uncertainty is especially large in the case of elasticities of output. Not surprisingly, the uncertainty then moves to the corresponding impulse responses.

The reason for the high variation of the estimates of matrices A and B is that the estimation procedure is based basically on likelihood maximization. With a low number of observations and a high number of parameters, likelihood function maximization can be a difficult task.

## 6. Conclusions

In this paper a small-scale vector autoregressive model is estimated to analyze the effects of fiscal policy shocks in the Czech Republic. The setup of our analysis is driven to a great extent by the fact that quarterly fiscal data are available for the Czech Republic only since 1999Q1. The lack of a sufficiently long time span of data is reflected in several aspects. First, we choose a small-scale VAR model. More precisely, we work with the smallest model that is viewed by the relevant literature as being suitable for fiscal policy analysis. Interestingly, a majority of the most important contributions in the field are built on such a minimal setting. Second, the reduced-form model is estimated using a hierarchical Bayesian VAR with a data-driven choice of prior informativeness. The shrinkage parameters are set to maximize the one-step-ahead pseudo out-of-sample forecasting performance of the VAR model. Finally, almost all standard identification approaches within VAR modeling are employed. The robustness of the results to the identification scheme employed is an important aspect of the discussion of the results.

The findings suggest that the transmission channel of fiscal policy is in many respects standard in the Czech economy, i.e., GDP and net revenues increase after an unexpected increase in government spending, and inflation behaves similarly. Regarding the net revenues shock, a subsequent increase of government spending can be observed. However, the uncertainty associated with the results is substantial and so the above-mentioned conclusions can rarely be stated also in terms of credible intervals. Moreover, the results are often not robust to the identification procedures used.

Regarding the identification procedure, it turns out that even though SVARs based on the AB model are now the most popular vector autoregression approach, for countries with short time series of fiscal data this approach is not necessarily the most suitable one. This is because, in contrast to recursive identification and sign restrictions, the estimation of the AB model is based on data as the model likelihood is maximized, which can represent an important additional source of uncertainty in the results.

## References

AMBRIŠKO, R., V. AUGUSTA, D. HÁJKOVÁ, P. KRÁL, P. NETUŠILOVÁ, M. ŘÍKOVSKÝ, AND P. SOUKUP (2012A): "Fiscal Discretion in the Czech Republic in 2001–2011: Has It Been Stabilizing?" Czech National Bank Research and Policy Note 1/2012, Czech National Bank.

AMBRIŠKO, R., J. BABECKÝ, J. RYŠÁNEK, AND V. VALENTA (2012B): "Assessing the Impact of Fiscal Measures on the Economy." Czech National Bank Working Paper No 15/2012, Czech National Bank, forthcoming.

AMISANO, G. AND C. GIANNINI (1997): *Topics in Structural VAR Econometrics*, second edition, Springer Verlag, New York.

BAXA, J. (2010): "What the Data Say about the Effects of Fiscal Policy in the Czech Republic?" In: Houda, M., and J. Friebelova (eds.), *Mathematical Methods in Economics 2010*, University of South Bohemia, Ceske Budejovice, pp. 24–29.

BEZDĚK, V., K. DYBCZAK, AND A. KREJDL (2003): "Czech Fiscal Policy: Introductory Analysis." Czech National Bank Working Paper 7/2003, Czech National Bank.

BLANCHARD, O., AND R. PEROTTI (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.

BREITUNG, J., R. BRÜGGEMANN, AND H. LÜTKEPOHL (2004): „Structural Vector Autoregressive Modeling and Impulse Responses," In: Lütkepohl, H., and M. Krätzig (eds.), *Applied Time Series Econometrics*, Cambridge, pp. 159–196.

BURNSIDE, C., M. EICHENBAUM, AND J. FISHER (2004): "Fiscal Shocks and Their Consequences." *Journal of Economic Theory* 115, pp. 109–117.

CALDARA, D. AND C. KAMPS (2008): "What Are the Effects of Fiscal Shocks? A VAR-based Comparative Analysis." ECB Working Paper Series, 877, European Central Bank.

CANOVA, F. AND E. PAPPA (2007): "Price Differentials in Monetary Unions: The Role of Fiscal Shocks." *The Economic Journal* 117, pp. 713–737.

CUARESMA, J. C., M. ELLER, AND A. MEHROTRA (2011): "The Economic Transmission of Fiscal Policy Shocks from Western to Eastern Europe, Focus on European Economic Integration." Oesterreichische Nationalbank.

DE CASTRO, F. AND P. H. DE COS (2008): "The Economic Effects of Fiscal Policy: The Case of Spain." *Journal of Macroeconomics* 30(3), pp. 1005–1028.

DUNGEY, M. AND R. FRY (2009): "The Identification of Fiscal and Monetary Policy in a Structural VAR." *Economic Modelling* 26, pp. 1147–1160.

FATÁS, A. AND I. MIHOV (2001): "The Effects of Fiscal Policy on Consumption and Employment: Theory and Evidence." CEPR Discussion Paper Series, 2760.

FRY, R. AND A. R. PAGAN (2011): "Sign Restrictions in Structural Vector Autoregressions: A Critical Review." *Journal of Economic Literature* 49(4), pp. 938–960.

GIANNONE, D., M. LENZA, AND G. E. PRIMICERI (2012): "Prior Selection for Vector Autoregressions." Working Papers ECARES, 2012-002, Universite Libre de Bruxelles.

GIORDANO, R., S. MOMIGLIANO, S. NERI, AND R. PEROTTI (2007): "The Effects of Fiscal Policy in Italy: Evidence from a VAR Model." *European Journal of Political Economy* 23(3), pp. 707–733.

HEPPKE-FALK, K. H., J. TENHOFEN, AND G. B. WOLFF (2010): "The Macroeconomic Effects of Exogenous Fiscal Policy Shocks in Germany: A Disaggregated SVAR Analysis." *Journal of Economics and Statistics* 230(3), pp. 328–355.

KADIYALA, K. R. AND S. KARLSSON (1997): "Numerical Methods for Estimation and Inference in Bayesian VAR-Models." *Journal of Applied Econometrics* 12, pp. 99–132.

KLYUEV, V. AND S. SNUDDEN (2011): "Effects of Fiscal Consolidation in the Czech Republic." *Czech Journal of Economics and Finance (Finance and uver)* 61(4), pp. 306–326.

KOOP, G. AND D. KOROBILIS (2010): "Bayesian Multivariate Time Series Methods for Empirical Macroeconomics." *Foundations and Trends in Econometrics* 3(4), pp. 267–358.

MIRDALA, R. (2009): "Effects of Fiscal Policy Shocks in the European Transition Economies." MPRA Paper 19481, University Library of Munich, Germany.

MOUNTFORD, A. AND H. UHLIG (2009): "What Are the Effects of Fiscal Policy Shocks?" *Journal of Applied Econometrics* 24(6), pp. 960–992.

PEROTTI, R. (2004): "Estimating the Effects of Fiscal Policy in OECD Countries." Working Paper 276, IGIER – Universitá Bocconi.

RADKOVSKÝ, Š. AND R. ŠTIKOVÁ (2008): "Kvantifikace účinků fiskální politiky v ČR pomocí modelu SVEC." (in Czech) Internal Discussion Paper 4/2008, Czech National Bank.

RAMEY, V. A. AND M. D. SHAPIRO (1998): "Costly Capital Reallocation and the Effects of Government Spending." Carnegie-Rochester Conference Series on Public Policy, Elsevier 48(1), pp. 145–194.

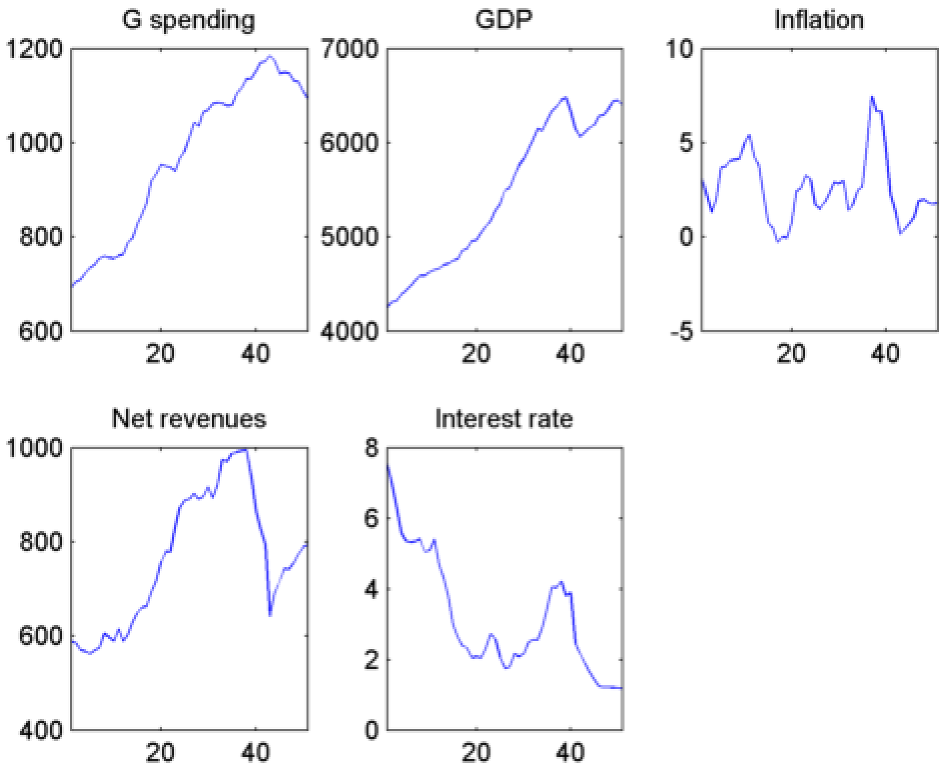
SIMS, C. A. (1980): "Macroeconomics and Reality." *Econometrica* 48(1), pp. 1–48.

UHLIG, H. (1994): "What Macroeconomists Should Know about Unit Roots." *Economic Theory* 10, pp. 645–671.

VALENTA, V. (2011): "Interactions between Fiscal Policy and Real Economy in the Czech Republic: A Quantitative Analysis." Dissertation at University of Economics Prague.

# Appendix A: Data

***Figure A1: Data. Government Spending, GDP, and Net Revenues in Real Terms***



## Appendix B: Medians of IRFs

***Figure B1: Impulse Responses after the Government Spending Shock (median) for Identification Based on two Specifications of the AB Model, Recursive Assumption, and Sign Restrictions***

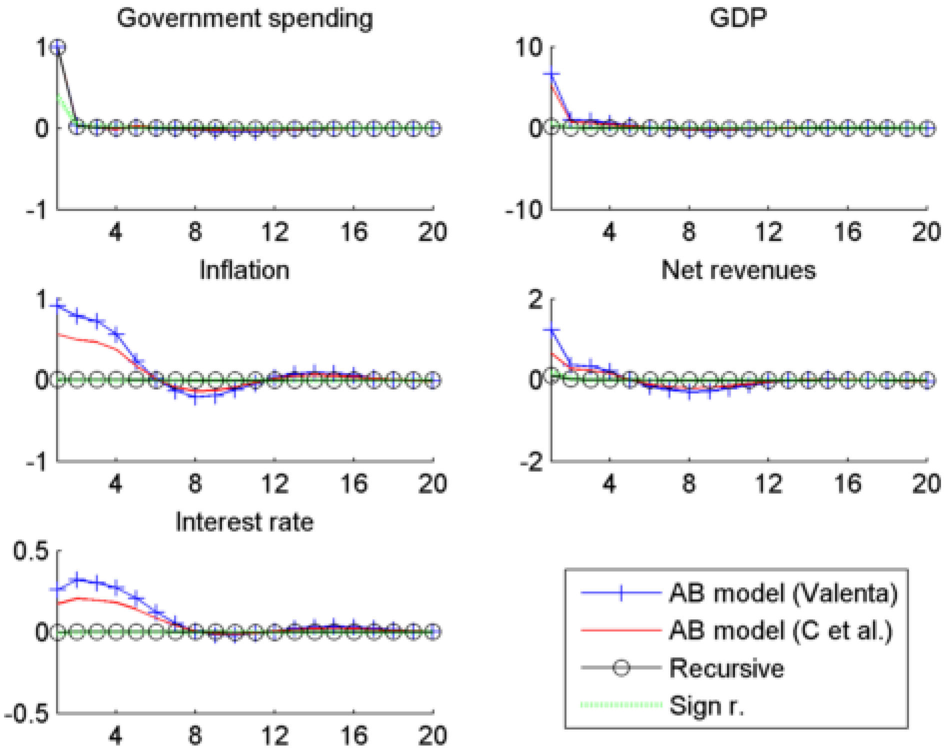
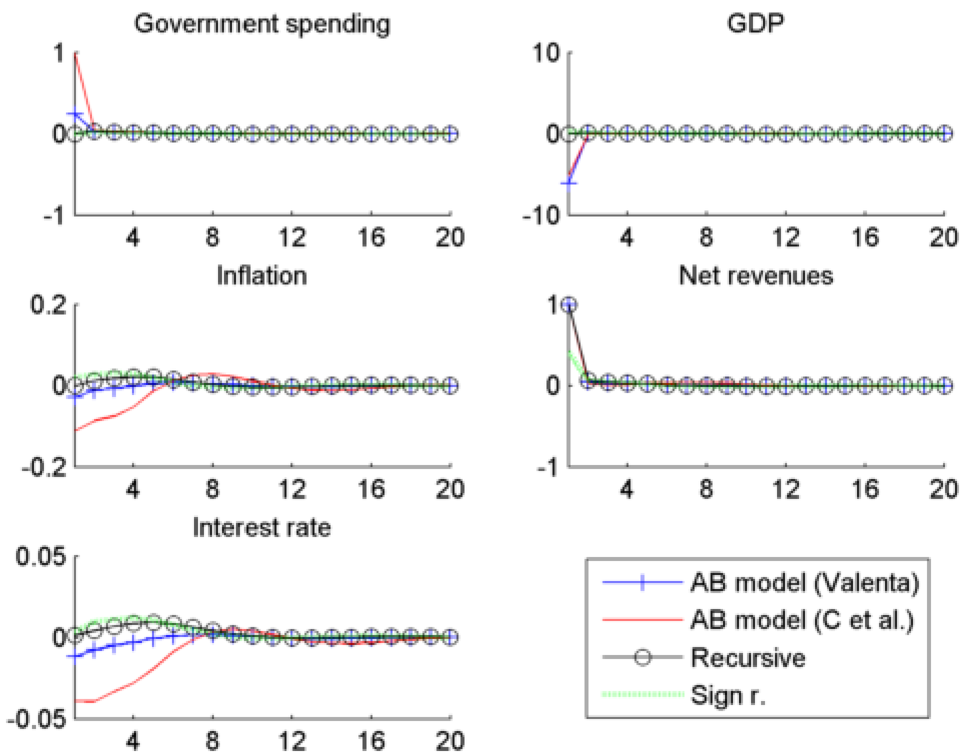


***Figure B2: Impulse Responses after the Net Revenues Shock (median) for Identification Based on two Specifications of the AB Model, Recursive Assumption, and Sign Restrictions***



## Appendix C: Implied Fiscal Balance for Government Spending and Net Revenues Shock

***Figure C1: Fiscal Balance (% of GDP) after the Government Spending Shock***

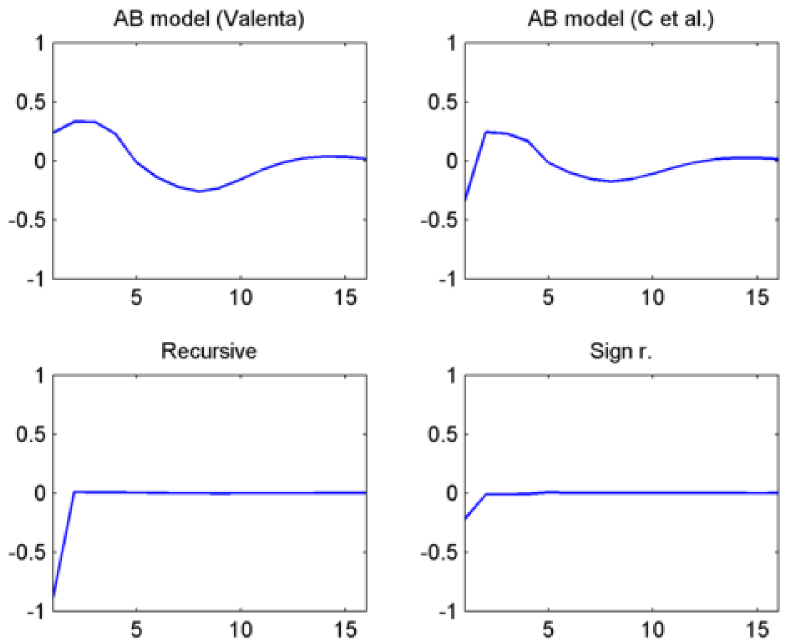
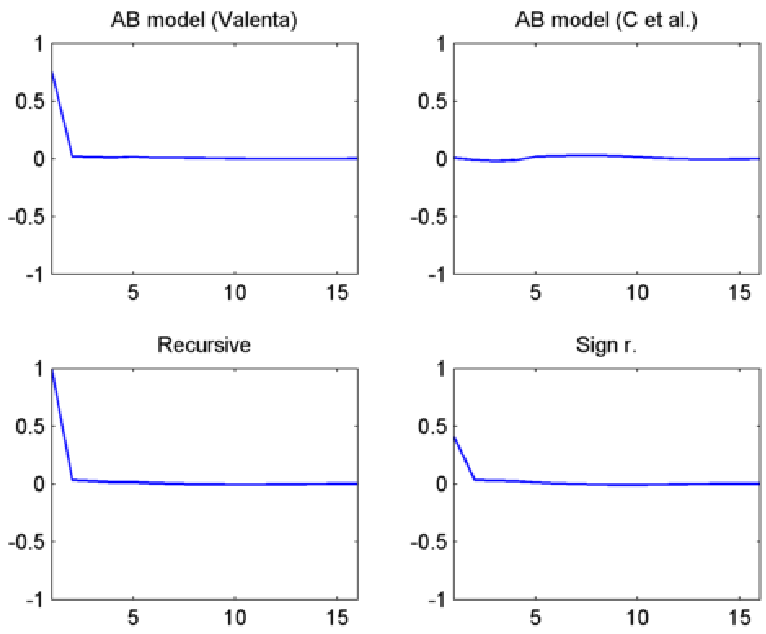



***Figure C2: Fiscal Balance (% of GDP) after the Net Revenues Shock***



## Appendix D: Output Fiscal Multipliers

The multipliers are computed as the ratio of the cumulative responses of GDP and government spending/net revenues for a given quarter. Note that even though the size of a shock cannot be identified by sign restrictions, the ratio of the cumulative responses already represents a meaningful value.

For government spending the output multipliers reflect the short influence of the spending shock on both spending and GDP. Therefore, the cumulative multipliers do not change much after the fourth quarter. Regarding the magnitudes, sign restrictions provide more realistic values for the first and fourth quarters, while in the medium run the recursive approach is close to the values found for other countries – see, for example, Table 3 in de Castro and de Cos (2008) for output multipliers estimated for Spain. Note that high uncertainty associated with the responses of government spending/net revenues and output significantly weakens the results for the multipliers. Table D2 presents the output multipliers for the net revenues shock.

***Table D1: Cumulative Output Multipliers to Government Spending Shocks***

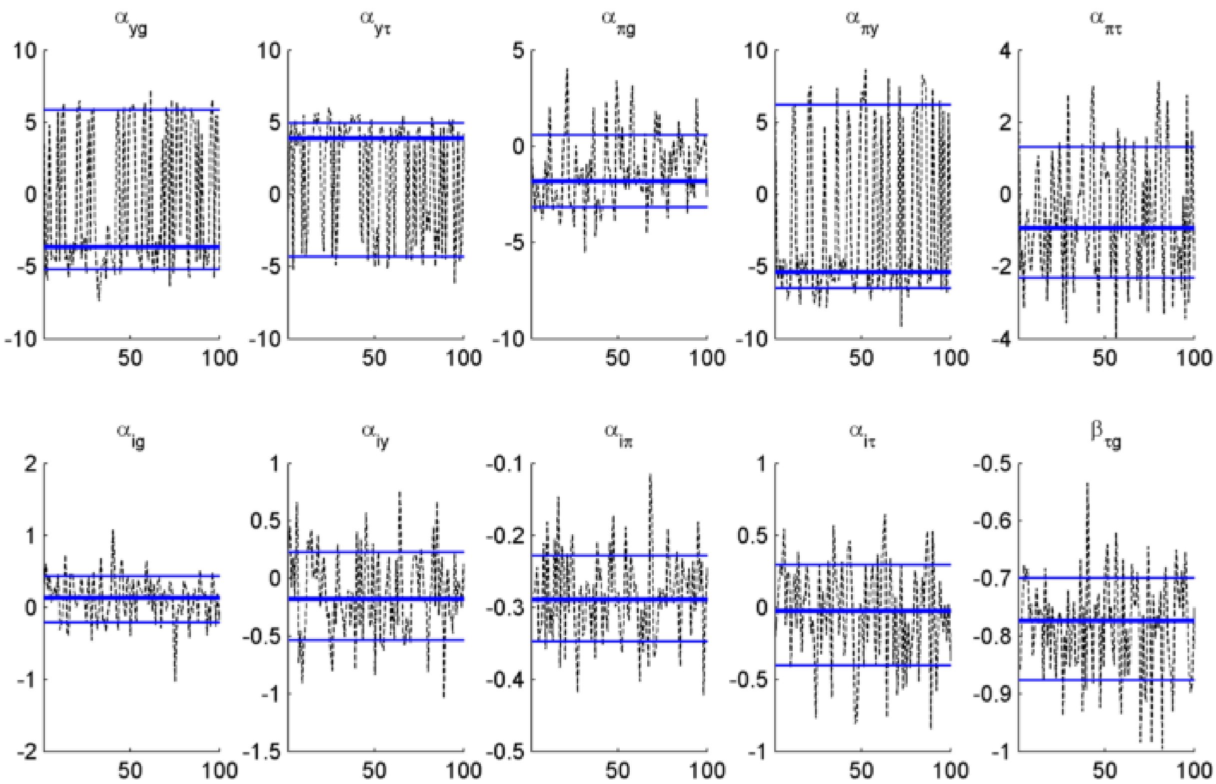
| | Quarters | | | |
|---|---|---|---|---|
| | 1st | 4th | 8th | 20th |
| Recursive | 0.23 | 0.32 | 0.35 | 0.35 |
| Sign r. | 1.43 | 1.43 | 1.46 | 1.47 |
| AB model (C et al.) | 5.28 | 6.89 | 6.83 | 7.52 |
| AB model (Valenta) | 6.65 | 8.90 | 9.09 | 10.76 |

***Table D2: Cumulative Output Multipliers to Net Revenues Shocks***

| | Quarters | | | |
|---|---|---|---|---|
| | 1st | 4th | 8th | 20th |
| Recursive | 0.00 | 0.22 | 0.30 | 0.29 |
| Sign r. | 0.62 | 0.91 | 1.04 | 1.05 |
| AB model (C et al.) | -5.21 | -5.02 | -4.35 | -4.13 |
| AB model (Valenta) | 6.11 | -5.42 | -5.09 | -5.08 |

# Appendix E: Estimates of the Free Parameters of Matrices A and B

***Figure E1: Estimates of the Free Parameters of Matrices A and B for 100 Arbitrarily Chosen Draws of Reduced-form VAR Model Coefficients***




***Note:*** The lines represent the median and the 16th and 84th quantiles of the corresponding set of parameter estimates.
The specification of Cuaresma et al. (2011) is used.

## CNB Working Paper Series

| | | |
|---|---|---|
| 13/2012 | Michal Franta | *Macroeconomic effects of fiscal policy in the Czech Republic: Evidence based on various identification approaches in a VAR framework* |
| 12/2012 | Konstantin Belyaev<br>Aelita Belyaeva<br>Tomáš Konečný<br>Jakub Seidler<br>Martin Vojtek | *Macroeconomic factors as drivers of LGD prediction: Empirical evidence from the Czech Republic* |
| 11/2012 | Adam Geršl<br>Petr Jakubík<br>Tomáš Konečný<br>Jakub Seidler | *Dynamic stress testing: The framework for testing banking sector resilience used by the Czech National Bank* |
| 10/2012 | Tomáš Havránek<br>Marek Rusnák | *Transmission lags of monetary policy: A meta-analysis* |
| 9/2012 | Volha Audzei<br>František Brázdik | *Monetary policy and exchange rate dynamics: The exchange rate as a shock absorber* |
| 8/2012 | Alexis Derviz<br>Jakub Seidler | *Coordination incentives in cross-border macroprudential regulation* |
| 7/2012 | Peter Claeys<br>Bořek Vašíček | *Measuring sovereign bond spillover in Europe and the impact of rating news* |
| 6/2012 | Michal Franta<br>Jan Libich<br>Petr Stehlík | *Tracking monetary-fiscal interactions across time and space* |
| 5/2012 | Roman Horváth<br>Jakub Seidler<br>Laurent Weill | *Bank capital and liquidity creation: Granger causality evidence* |
| 4/2012 | Jaromír Baxa<br>Miroslav Plašil<br>Bořek Vašíček | *Changes in inflation dynamics under inflation targeting? Evidence from Central European countries* |
| 3/2012 | Soňa Benecká<br>Tomáš Holub<br>Narcisa Liliana Kadlčáková<br>Ivana Kubicová | *Does central bank financial strength matter for inflation? An empirical analysis* |
| 2/2012 | Adam Geršl<br>Petr Jakubík<br>Dorota Kowalczyk<br>Steven Ongena<br>José-Luis Peydró Alcalde | *Monetary conditions and banks' behaviour in the Czech Republic* |
| 1/2012 | Jan Babecký<br>Kamil Dybczak | *Real wage flexibility in the European Union: New evidence from the labour cost data* |
| 15/2011 | Jan Babecký<br>Kamil Galuščák<br>Lubomír Lízal | *Firm-level labour demand: Adjustment in good times and during the crisis* |
| 14/2011 | Vlastimil Čadek<br>Helena Rottová<br>Branislav Saxa | *Hedging behaviour of Czech exporting firms* |

| | | |
|---|---|---|
| 13/2011 | Michal Franta<br>Roman Horváth<br>Marek Rusnák | *Evaluating changes in the monetary transmission mechanism in the Czech Republic* |
| 12/2011 | Jakub Ryšánek<br>Jaromír Tonner<br>Osvald Vašíček | *Monetary policy implications of financial frictions in the Czech Republic* |
| 11/2011 | Zlatuše Komárková<br>Adam Geršl<br>Luboš Komárek | *Models for stress testing Czech banks´ liquidity risk* |
| 10/2011 | Michal Franta<br>Jozef Baruník<br>Roman Horváth<br>Kateřina Šmídková | *Are Bayesian fan charts useful for central banks? Uncertainty, forecasting, and financial stability stress tests* |
| 9/2011 | Kamil Galuščák<br>Lubomír Lízal | *The impact of capital measurement error correction on firm-level production function estimation* |
| 8/2011 | Jan Babecký<br>Tomáš Havránek<br>Jakub Matějů<br>Marek Rusnák<br>Kateřina Šmídková<br>Bořek Vašíček | *Early warning indicators of economic crises: Evidence from a panel of 40 developed countries* |
| 7/2011 | Tomáš Havránek<br>Zuzana Iršová | *Determinants of horizontal spillovers from FDI: Evidence from a large meta-analysis* |
| 6/2011 | Roman Horváth<br>Jakub Matějů | *How are inflation targets set?* |
| 5/2011 | Bořek Vašíček | *Is monetary policy in the new EU member states asymmetric?* |
| 4/2011 | Alexis Derviz | *Financial frictions, bubbles, and macroprudential policies* |
| 3/2011 | Jaromír Baxa<br>Roman Horváth<br>Bořek Vašíček | *Time-varying monetary-policy rules and financial stress: Does financial instability matter for monetary policy?* |
| 2/2011 | Marek Rusnák<br>Tomáš Havránek<br>Roman Horváth | *How to solve the price puzzle? A meta-analysis* |
| 1/2011 | Jan Babecký<br>Aleš Bulíř<br>Kateřina Šmídková | *Sustainable real exchange rates in the new EU member states: What did the Great Recession change?* |
| 15/2010 | Ke Pang<br>Pierre L. Siklos | *Financial frictions and credit spreads* |
| 14/2010 | Filip Novotný<br>Marie Raková | *Assessment of consensus forecasts accuracy: The Czech National Bank perspective* |
| 13/2010 | Jan Filáček<br>Branislav Saxa | *Central bank forecasts as a coordination device* |
| 12/2010 | Kateřina Arnoštová<br>David Havrlant<br>Luboš Růžička<br>Peter Tóth | *Short-term forecasting of Czech quarterly GDP using monthly indicators* |
| 11/2010 | Roman Horváth<br>Kateřina Šmídková<br>Jan Zápal | *Central banks´ voting records and future policy* |

| | | |
|---|---|---|
| 10/2010 | Alena Bičáková<br>Zuzana Prelcová<br>Renata Pašaličová | *Who borrows and who may not repay?* |
| 9/2010 | Luboš Komárek<br>Jan Babecký<br>Zlatuše Komárková | *Financial integration at times of financial instability* |
| 8/2010 | Kamil Dybczak<br>Peter Tóth<br>David Voňka | *Effects of price shocks to consumer demand. Estimating the QUAIDS demand system on Czech Household Budget Survey data* |
| 7/2010 | Jan Babecký<br>Philip Du Caju<br>Theodora Kosma<br>Martina Lawless<br>Julián Messina<br>Tairi Rõõm | *The margins of labour cost adjustment: Survey evidence from European firms* |
| 6/2010 | Tomáš Havránek<br>Roman Horváth<br>Jakub Matějů | *Do financial variables help predict macroeconomic environment? The case of the Czech Republic* |
| 5/2010 | Roman Horváth<br>Luboš Komárek<br>Filip Rozsypal | *Does money help predict inflation? An empirical assessment for Central Europe* |
| 4/2010 | Oxana Babecká Kucharčuková<br>Jan Babecký<br>Martin Raiser | *A gravity approach to modelling international trade in South-Eastern Europe and the Commonwealth of Independent States: The role of geography, policy and institutions* |
| 3/2010 | Tomáš Havránek<br>Zuzana Iršová | *Which foreigners are worth wooing? A Meta-analysis of vertical spillovers from FDI* |
| 2/2010 | Jaromír Baxa<br>Roman Horváth<br>Bořek Vašíček | *How does monetary policy change? Evidence on inflation targeting countries* |
| 1/2010 | Adam Geršl<br>Petr Jakubík | *Relationship lending in the Czech Republic* |
| 15/2009 | David N. DeJong<br>Roman Liesenfeld<br>Guilherme V. Moura<br>Jean-Francois Richard<br>Hariharan Dharmarajan | *Efficient likelihood evaluation of state-space representations* |
| 14/2009 | Charles W. Calomiris | *Banking crises and the rules of the game* |
| 13/2009 | Jakub Seidler<br>Petr Jakubík | *The Merton approach to estimating loss given default: Application to the Czech Republic* |
| 12/2009 | Michal Hlaváček<br>Luboš Komárek | *Housing price bubbles and their determinants in the Czech Republic and its regions* |
| 11/2009 | Kamil Dybczak<br>Kamil Galuščák | *Changes in the Czech wage structure: Does immigration matter?* |
| 10/2009 | Jiří Böhm<br>Petr Král<br>Branislav Saxa | *Percepion is always right: The CNB´s monetary policy in the media* |
| 9/2009 | Alexis Derviz<br>Marie Raková | *Funding costs and loan pricing by multinational bank affiliates* |

| | | |
|---|---|---|
| 8/2009 | Roman Horváth<br>Anca Maria Podpiera | *Heterogeneity in bank pricing policies: The Czech evidence* |
| 7/2009 | David Kocourek<br>Filip Pertold | *The impact of early retirement incentives on labour market participation: Evidence from a parametric change in the Czech Republic* |
| 6/2009 | Nauro F. Campos<br>Roman Horváth | *Reform redux: Measurement, determinants and reversals* |
| 5/2009 | Kamil Galuščák<br>Mary Keeney<br>Daphne Nicolitsas<br>Frank Smets<br>Pawel Strzelecki<br>Matija Vodopivec | *The determination of wages of newly hired employees: Survey evidence on internal versus external factors* |
| 4/2009 | Jan Babecký<br>Philip Du Caju<br>Theodora Kosma<br>Martina Lawless<br>Julián Messina<br>Tairi Rõõm | *Downward nominal and real wage rigidity: Survey evidence from European firms* |
| 3/2009 | Jiri Podpiera<br>Laurent Weill | *Measuring excessive risk-taking in banking* |
| 2/2009 | Michal Andrle<br>Tibor Hlédik<br>Ondra Kameník<br>Jan Vlček | *Implementing the new structural model of the Czech National Bank* |
| 1/2009 | Kamil Dybczak<br>Jan Babecký | *The impact of population ageing on the Czech economy* |
| 14/2008 | Gabriel Fagan<br>Vitor Gaspar | *Macroeconomic adjustment to monetary union* |
| 13/2008 | Giuseppe Bertola<br>Anna Lo Prete | *Openness, financial markets, and policies: Cross-country and dynamic patterns* |
| 12/2008 | Jan Babecký<br>Kamil Dybczak<br>Kamil Galuščák | *Survey on wage and price formation of Czech firms* |
| 11/2008 | Dana Hájková | *The measurement of capital services in the Czech Republic* |
| 10/2008 | Michal Franta | *Time aggregation bias in discrete time models of aggregate duration data* |
| 9/2008 | Petr Jakubík<br>Christian Schmieder | *Stress testing credit risk: Is the Czech Republic different from Germany?* |
| 8/2008 | Sofia Bauducco<br>Aleš Bulíř<br>Martin Čihák | *Monetary policy rules with financial instability* |
| 7/2008 | Jan Brůha<br>Jiří Podpiera | *The origins of global imbalances* |
| 6/2008 | Jiří Podpiera<br>Marie Raková | *The price effects of an emerging retail market* |
| 5/2008 | Kamil Dybczak<br>David Voňka<br>Nico van der Windt | *The effect of oil price shocks on the Czech economy* |

| | | |
|---|---|---|
| 4/2008 | Magdalena M. Borys<br>Roman Horváth | *The effects of monetary policy in the Czech Republic: An empirical study* |
| 3/2008 | Martin Cincibuch<br>Tomáš Holub<br>Jaromír Hurník | *Central bank losses and economic convergence* |
| 2/2008 | Jiří Podpiera | *Policy rate decisions and unbiased parameter estimation in conventionally estimated monetary policy rules* |
| 1/2008 | Balázs Égert<br>Doubravko Mihaljek | *Determinants of house prices in Central and Eastern Europe* |
| 17/2007 | Pedro Portugal | *U.S. unemployment duration: Has long become longer or short become shorter?* |
| 16/2007 | Yuliya Rychalovská | *Welfare-based optimal monetary policy in a two-sector small open economy* |
| 15/2007 | Juraj Antal<br>František Brázdik | *The effects of anticipated future change in the monetary policy regime* |
| 14/2007 | Aleš Bulíř<br>Kateřina Šmídková<br>Viktor Kotlán<br>David Navrátil | *Inflation targeting and communication: Should the public read inflation reports or tea leaves?* |
| 13/2007 | Martin Cinncibuch<br>Martina Horníková | *Measuring the financial markets' perception of EMU enlargement: The role of ambiguity aversion* |
| 12/2007 | Oxana Babetskaia-Kukharchuk | *Transmission of exchange rate shocks into domestic inflation: The case of the Czech Republic* |
| 11/2007 | Jan Filáček | *Why and how to assess inflation target fulfilment* |
| 10/2007 | Michal Franta<br>Branislav Saxa<br>Kateřina Šmídková | *Inflation persistence in new EU member states: Is it different than in the Euro area members?* |
| 9/2007 | Kamil Galuščák<br>Jan Pavel | *Unemployment and inactivity traps in the Czech Republic: Incentive effects of policies* |
| 8/2007 | Adam Geršl<br>Ieva Rubene<br>Tina Zumer | *Foreign direct investment and productivity spillovers: Updated evidence from Central and Eastern Europe* |
| 7/2007 | Ian Babetskii<br>Luboš Komárek<br>Zlatuše Komárková | *Financial integration of stock markets among new EU member states and the euro area* |
| 6/2007 | Anca Pruteanu-Podpiera<br>Laurent Weill<br>Franziska Schobert | *Market power and efficiency in the Czech banking sector* |
| 5/2007 | Jiří Podpiera<br>Laurent Weill | *Bad luck or bad management? Emerging banking market experience* |
| 4/2007 | Roman Horváth | *The time-varying policy neutral rate in real time: A predictor for future inflation?* |
| 3/2007 | Jan Brůha<br>Jiří Podpiera<br>Stanislav Polák | *The convergence of a transition economy: The case of the Czech Republic* |
| 2/2007 | Ian Babetskii<br>Nauro F. Campos | *Does reform work? An econometric examination of the reform-growth puzzle* |
| 1/2007 | Ian Babetskii | *Measuring and explaining inflation persistence:* |

| | | |
|---|---|---|
| | Fabrizio Coricelli<br>Roman Horváth | *Disaggregate evidence on the Czech Republic* |
| 13/2006 | Frederic S. Mishkin<br>Klaus Schmidt-Hebbel | *Does inflation targeting make a difference?* |
| 12/2006 | Richard Disney<br>Sarah Bridges<br>John Gathergood | *Housing wealth and household indebtedness: Is there a household 'financial accelerator'?* |
| 11/2006 | Michel Juillard<br>Ondřej Kameník<br>Michael Kumhof<br>Douglas Laxton | *Measures of potential output from an estimated DSGE model of the United States* |
| 10/2006 | Jiří Podpiera<br>Marie Raková | *Degree of competition and export-production relative prices when the exchange rate changes: Evidence from a panel of Czech exporting companies* |
| 9/2006 | Alexis Derviz<br>Jiří Podpiera | *Cross-border lending contagion in multinational banks* |
| 8/2006 | Aleš Bulíř<br>Jaromír Hurník | *The Maastricht inflation criterion: "Saints" and "Sinners"* |
| 7/2006 | Alena Bičáková<br>Jiří Slačálek<br>Michal Slavík | *Fiscal implications of personal tax adjustments in the Czech Republic* |
| 6/2006 | Martin Fukač<br>Adrian Pagan | *Issues in adopting DSGE models for use in the policy process* |
| 5/2006 | Martin Fukač | *New Keynesian model dynamics under heterogeneous expectations and adaptive learning* |
| 4/2006 | Kamil Dybczak<br>Vladislav Flek<br>Dana Hájková<br>Jaromír Hurník | *Supply-side performance and structure in the Czech Republic (1995–2005)* |
| 3/2006 | Aleš Krejdl | *Fiscal sustainability – definition, indicators and assessment of Czech public finance sustainability* |
| 2/2006 | Kamil Dybczak | *Generational accounts in the Czech Republic* |
| 1/2006 | Ian Babetskii | *Aggregate wage flexibility in selected new EU member states* |
| 14/2005 | Stephen G. Cecchetti | *The brave new world of central banking: The policy challenges posed by asset price booms and busts* |
| 13/2005 | Robert F. Engle<br>Jose Gonzalo Rangel | *The spline GARCH model for unconditional volatility and its global macroeconomic causes* |
| 12/2005 | Jaromír Beneš<br>Tibor Hlédik<br>Michael Kumhof<br>David Vávra | *An economy in transition and DSGE: What the Czech national bank's new projection model needs* |
| 11/2005 | Marek Hlaváček<br>Michael Koňák<br>Josef Čada | *The application of structured feedforward neural networks to the modelling of daily series of currency in circulation* |
| 10/2005 | Ondřej Kameník | *Solving SDGE models: A new algorithm for the sylvester equation* |
| 9/2005 | Roman Šustek | *Plant-level nonconvexities and the monetary transmission mechanism* |

| | | |
|---|---|---|
| 8/2005 | Roman Horváth | *Exchange rate variability, pressures and optimum currency area criteria: Implications for the central and eastern european countries* |
| 7/2005 | Balázs Égert<br>Luboš Komárek | *Foreign exchange interventions and interest rate policy in the Czech Republic: Hand in glove?* |
| 6/2005 | Anca Podpiera<br>Jiří Podpiera | *Deteriorating cost efficiency in commercial banks signals an increasing risk of failure* |
| 5/2005 | Luboš Komárek<br>Martin Melecký | *The behavioural equilibrium exchange rate of the Czech koruna* |
| 4/2005 | Kateřina Arnoštová<br>Jaromír Hurník | *The monetary transmission mechanism in the Czech Republic (evidence from VAR analysis)* |
| 3/2005 | Vladimír Benáček<br>Jiří Podpiera<br>Ladislav Prokop | *Determining factors of Czech foreign trade: A cross-section time series perspective* |
| 2/2005 | Kamil Galuščák<br>Daniel Münich | *Structural and cyclical unemployment: What can we derive from the matching function?* |
| 1/2005 | Ivan Babouček<br>Martin Jančar | *Effects of macroeconomic shocks to the quality of the aggregate loan portfolio* |
| 10/2004 | Aleš Bulíř<br>Kateřina Šmídková | *Exchange rates in the new EU accession countries: What have we learned from the forerunners* |
| 9/2004 | Martin Cincibuch<br>Jiří Podpiera | *Beyond Balassa-Samuelson: Real appreciation in tradables in transition countries* |
| 8/2004 | Jaromír Beneš<br>David Vávra | *Eigenvalue decomposition of time series with application to the Czech business cycle* |
| 7/2004 | Vladislav Flek, ed. | *Anatomy of the Czech labour market: From over-employment to under-employment in ten years?* |
| 6/2004 | Narcisa Kadlčáková<br>Joerg Keplinger | *Credit risk and bank lending in the Czech Republic* |
| 5/2004 | Petr Král | *Identification and measurement of relationships concerning inflow of FDI: The case of the Czech Republic* |
| 4/2004 | Jiří Podpiera | *Consumers, consumer prices and the Czech business cycle identification* |
| 3/2004 | Anca Pruteanu | *The role of banks in the Czech monetary policy transmission mechanism* |
| 2/2004 | Ian Babetskii | *EU enlargement and endogeneity of some OCA criteria: Evidence from the CEECs* |
| 1/2004 | Alexis Derviz<br>Jiří Podpiera | *Predicting bank CAMELS and S&P ratings: The case of the Czech Republic* |

## CNB RESEARCH AND POLICY NOTES

| | | |
|---|---|---|
| 1/2012 | Róbert Ambriško<br>Vítězslav Augusta<br>Dana Hájková<br>Petr Král<br>Pavla Netušilová<br>Milan Říkovský<br>Pavel Soukup | *Fiscal discretion in the Czech Republic in 2001-2011: Has it been stabilizing?* |
| 3/2011 | František Brázdik<br>Michal Hlaváček<br>Aleš Maršál | *Survey of research on financial sector modeling within DSGE models: What central banks can learn from it* |
| 2/2011 | Adam Geršl<br>Jakub Seidler | *Credit growth and capital buffers: Empirical evidence from Central and Eastern European countries* |
| 1/2011 | Jiří Böhm<br>Jan Filáček<br>Ivana Kubicová<br>Romana Zamazalová | *Price-level targeting – A real alternative to inflation targeting?* |
| 1/2008 | Nicos Christodoulakis | *Ten years of EMU: Convergence, divergence and new policy priorities* |
| 2/2007 | Carl E. Walsh | *Inflation targeting and the role of real objectives* |
| 1/2007 | Vojtěch Benda<br>Luboš Růžička | *Short-term forecasting methods based on the LEI approach: The case of the Czech Republic* |
| 2/2006 | Garry J. Schinasi | *Private finance and public policy* |
| 1/2006 | Ondřej Schneider | *The EU budget dispute – A blessing in disguise?* |
| 5/2005 | Jan Stráský | *Optimal forward-looking policy rules in the quarterly projection model of the Czech National Bank* |
| 4/2005 | Vít Bárta | *Fulfilment of the Maastricht inflation criterion by the Czech Republic: Potential costs and policy options* |
| 3/2005 | Helena Sůvová<br>Eva Kozelková<br>David Zeman<br>Jaroslava Bauerová | *Eligibility of external credit assessment institutions* |
| 2/2005 | Martin Čihák<br>Jaroslav Heřmánek | *Stress testing the Czech banking system: Where are we? Where are we going?* |
| 1/2005 | David Navrátil<br>Viktor Kotlán | *The CNB's policy decisions – Are they priced in by the markets?* |
| 4/2004 | Aleš Bulíř | *External and fiscal sustainability of the Czech economy: A quick look through the IMF's night-vision goggles* |
| 3/2004 | Martin Čihák | *Designing stress tests for the Czech banking system* |
| 2/2004 | Martin Čihák | *Stress testing: A review of key concepts* |
| 1/2004 | Tomáš Holub | *Foreign exchange interventions under inflation targeting: The Czech experience* |

| CNB ECONOMIC RESEARCH BULLETIN | |
|---|---|
| November 2012 | *Financial stability and monetary policy* |
| April 2012 | *Macroeconomic forecasting: Methods, accuracy and coordination* |
| November 2011 | *Macro-financial linkages: Theory and applications* |
| April 2011 | *Monetary policy analysis in a central bank* |
| November 2010 | *Wage adjustment in Europe* |
| May 2010 | *Ten years of economic research in the CNB* |
| November 2009 | *Financial and global stability issues* |
| May 2009 | *Evaluation of the fulfilment of the CNB's inflation targets 1998–2007* |
| December 2008 | *Inflation targeting and DSGE models* |
| April 2008 | *Ten years of inflation targeting* |
| December 2007 | *Fiscal policy and its sustainability* |
| August 2007 | *Financial stability in a transforming economy* |
| November 2006 | *ERM II and euro adoption* |
| August 2006 | *Research priorities and central banks* |
| November 2005 | *Financial stability* |
| May 2005 | *Potential output* |
| October 2004 | *Fiscal issues* |
| May 2004 | *Inflation targeting* |
| December 2003 | *Equilibrium exchange rate* |

Czech National Bank
Economic Research Department
Na Příkopě 28, 115 03 Praha 1
Czech Republic
phone: +420 2 244 12 321
fax: +420 2 244 14 278
http://www.cnb.cz
e-mail: research@cnb.cz
ISSN 1803-7070