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ARTICLE



Debt management when monetary and fiscal policies clash: some empirical evidence

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ABSTRACT

We explore the effects of fiscal and monetary policy shocks on key debt management variables and provide empirical evidence supporting the notion of a strict separation of economic policy from the debt management agenda. We find that a tighter monetary policy coupled with fiscal expansion increases the risk that government debt will have to be rolled over at unusually high cost. This is especially the case in a downturn, where low or even negative interest rates often provide incentives for debt managers to invest predominantly in short-term bonds. Our findings echo the post-crisis environment of low or even negative interest rates, where many debt managers altered their portfolios' structure in favor of short-term bonds. In this respect, we argue that debt managers should use a longer optimization horizon and base their strategy on the medium- and long-term economic outlook.

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Czech Republic; debt management; monetary policy; fiscal policy; FAVAR

1. Introduction

Historically, debt management was not a stand-alone policy, but was considered a part of fiscal or monetary policy. In 2001, the IMF and World Bank published a set of guidelines on public debt management for policymakers, which were later revised in response to financial sector regulatory changes and macroeconomic policy developments (IMF and WB, 2014). These guidelines stress the importance of formulating a sound debt management strategy for the optimal allocation of government debt and the need to separate debt management from other policies.

In this paper, we assess how fiscal and monetary policy measures may influence public indebtedness, debt service costs, and sovereign default risk in a small open economy. We show that increasing government spending coupled with rise of the monetary policy rate (for instance, during an economic boom) could increase the risk that the government debt will have to be rolled over at unusually high cost if the economy slows down in the future. Our findings may have some major policy implications given the policy actions following the global financial crisis in 2008. After the crisis, debt managers took advantage of an all-time low nominal interest rate environment and altered the government debt portfolio structure in favor of short-term bonds.¹ However, such an investment

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¹Wheeler (2004) shows that short-term bonds are usually associated with higher market risk.

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choice may increase the debt service costs and endanger debt sustainability once the monetary policy stance returns to neutral levels.² In this respect, we argue that debt managers should use a longer optimization horizon and base their strategy on the medium- and long-term economic outlook.³

Moreover, our modelling approach may be of some appeal to debt managers as it allows taking into consideration a broad set of variables representing the macroeconomic environment. Quantification of the potential impacts of changes in macroeconomic policy on key debt variables may help debt managers better anticipate changes in the debt portfolio and debt service costs, allowing them to take timely steps to optimize the portfolio and achieve the primary debt management objective. For example, in the Czech Republic the goal is to cover the borrowing requirements and payment obligations of the government while reaching the lowest possible service cost in the medium- to long-term horizons at a specific level of accepted risk. Therefore, our model may be considered as a complement to the Asset Liability Management (ALM) approach applied by debt managers to achieve optimal debt composition.

We rely mostly on Czech data; the Czech economy is an interesting example because of a long-standing environment of low interest rates on government bonds and recent experience with an exchange rate commitment, which was in place from 2013 to 2017. In the Czech Republic, a department for the management of government debt and financial assets was established in 2005 under the Ministry of Finance, and the Czech National Bank (CNB) now acts as the market supervisor. The primary objective of Czech monetary policy is price stability (inflation targeting). The CNB uses mostly the two-week repo rate to keep inflation close to the target.

The remainder of the paper is organized as follows: [Section 2](#) lists the existing studies and discusses our contribution to the literature. [Section 3](#) provides stylized facts about the development of government debt, its servicing, and the macroeconomic environment in the Czech Republic; [Section 4](#) outlines the theoretical underpinnings of the applied framework and describes the data employed; [Section 5](#) discusses the empirical results, and [Section 6](#) concludes.

2. Literature review

Our research fits into the strand of literature focusing on policy coordination and potential conflicts among fiscal, monetary, and debt management policies, a topic that has been studied in various frameworks. Generally, a conflict between monetary policy and debt management may arise due to a shortage of independent policy instruments (Togo, 2007). In addition, procyclical fiscal policy, expansionary in booms and contractionary in recessions, may in the long run increase macroeconomic volatility and uncertainty, harm economic growth, and raise debt service costs. Therefore, we examine the effects of monetary and fiscal policy on variables relevant to the debt manager.

Starting with the classic studies, Barro (1995) finds that debt management could be helpful in tax smoothing. Calvo and Guidotti (1990) point out the role of debt

²Faraglia et al. (2008) state that policymakers are usually more concerned with minimizing costs instead of risk. Angeletos (2002) claims that public debt management can be an important tool for reducing fiscal vulnerability.

³The Medium-Term Debt Management Strategy (MTDS) framework assessment can be found in IMF (2017).

management as a commitment device in ensuring a time-consistent monetary policy. Among more recent studies, Canzoneri, Cumby, and Diba (2016) highlight the need for the debt manager to satisfy liquidity demand and accommodate a smooth tax rate. However, they add that if government bonds provide liquidity, conflicts may arise. Bianchi and Melosi (2019) claims that monetary and fiscal policies are not completely independent and there is a need for their coordination. Some public debt management choices and large fiscal deficits endanger inflation management and the interest rate policy, and even the independence of the central bank. The monetary policy setting may therefore influence the cost of deficit financing and even the size of the public debt. Moore and Skeete (2010) find that negative monetary policy shocks could significantly raise the debt service costs and the future setting of economic policy needs to be coordinated. Cavalcanti, Vereda, de Doctors, and Lima (2018) call for higher policy coordination and find high correlation between the monetary policy rate and the interest rate on public debt in Brazil.

Togo (2007) illustrates the importance of policy separation and coordination to achieve a consistent policy mix. According to his study, separation does not preclude the need for policy coordination because of frequent policy interactions in the real world. Poor fiscal policy may produce high deficits that need to be financed by new debt. Excessive debt levels will lead to high risk premia demanded by investors and will limit the debt manager in issuing the debt instruments needed to achieve optimal debt composition.⁴ Monetary policy may constrain debt management through exchange rate and interest rate policy, as these policies directly influence the amount of foreign currency and floating rate debt that can be issued. Togo argues that separation of debt management policy may reduce trade-offs among these three policy objectives and enhance the credibility and effectiveness of policy implementation. The presented ALM framework suggests that the debt manager should act counter-cyclically to help minimize the risk of tax increases, expenditure cuts, or debt defaults. Based on policy games under fiscal and monetary dominance, Togo concludes that weak debt management without a separate policy goal could produce an inconsistent policy mix. Moreover, as Sight (2015) states, the coordination of fiscal, monetary, and debt management policies is even more important in developing countries. To broaden the scope, Dottori and Manna (2016) study strategy and tactics in debt management and argue in favor of a broader perspective of coordination that also includes financial stability. According to Das, Papapioannou, Pedras, Ahmed, and Surti (2010), debt management influences financial stability through five channels – stock of debt, debt profile, investor base, debt market structure, and institutional aspects. We contribute to this strand of literature by studying the policy interactions in a data-rich environment while taking into consideration alternative debt manager goals.

In the Czech Republic, numerous studies focus on fiscal discipline and debt sustainability, see e.g., Ambrisko et al. (2012), Bulir (2004), European Commission (2012), IMF (2013), Komarkova, Dingova, and Komarek (2013), or Dybczak and Melecky (2014). Yet there is a shortage of studies focusing directly on government debt management. The

⁴Faraglia, Marcet, and Scott (2010) in their search for a theory of debt management criticize the idea of complete market approach to debt management. Specifically, that the fiscal policy and debt structure should be jointly determined. According to them, this theory focusses only on fiscal insurance and abstracts from fundamental features of market incompleteness.

Czech Ministry of Finance regularly publishes progress reports on debt management,⁵ including results of the cost-at-risk model. Pavelek (2005) contributes to the debate on advances in risk management of government debt with the Czech experience and suggests a more proactive approach. Matalik and Slavik (2005) concentrate on government debt management in the Czech Republic and its development during the transition period (from the centrally-planned economy of the country's communist past) of the 1990s and early 2000s. They stress the need for domestic capital market development to better manage the foreign exchange risk of government debt.

We may summarize the findings from the literature review as follows: Individual policies should be politically separated in terms of their objectives and accountability, in line with the Tinbergen principle, to provide an optimal policy mix. Nevertheless, information sharing and cooperation should be further promoted, including sharing forecast data and developing strategies in coordination with other policies. The government debt management should not be neglected in this process. Our paper aims to address the gap in the literature on government debt management in the Czech Republic, help inform Czech debt management policy, and provide an example of the use of a theoretical framework for the practical allocation of government debt.

3. Stylized facts

To achieve inflation targets in the post-crisis period, central banks created an environment of low or even negative interest rates and applied various unconventional monetary policy tools, such as quantitative easing, which influences government bond yield curves (Corradin & Maddaloni, 2017; Ferdinandusse, Freier, & Ristiniemi, 2017; Schlepper, Riordan, Hofer, & Schrimpf, 2017). In 2013, the CNB adopted an exchange rate commitment to intervene in the foreign exchange market.⁶ The central bank had weakened the Czech koruna (CZK) exchange rate to close to 27 CZK/EUR (from pre-intervention levels around 25.50 CZK/EUR) in order to avoid deflation. Such actions influence the cost of unhedged foreign-currency-denominated debt. Melecký (2012) provides a review of policy approaches to the choice of currency structure of foreign currency debt. A change in inflation dynamics may also affect the cost of the debt portfolio and government debt through a change in short-term interest rates. In the Czech Republic, inflation-linked bonds are issued only within a retail program and make up a negligible part of the government debt portfolio. However, inflation-linked bonds may be at least partially substituted by bills indexed to the short-term interest rate, as is done in the Czech Republic.

Debt management performance should be regularly evaluated, as is done by the Czech Ministry of Finance in annual reports. First of all, prediction of interest expenditure on debt service should be provided and relevant risks should be evaluated, including refinancing, interest rate, and currency risk. For instance, an excessive proportion of short-term floating rate debt could significantly increase refinancing costs or even make

⁵Regular publications by the Czech Ministry of Finance regarding debt management include Funding and Debt Management Strategy, Government Debt Management Annual Report, Debt Portfolio Management Quarterly Report, and Performance Evaluation of Primary Dealers; for details please see <http://www.mfcr.cz/en/themes/state-debt/publications-and-presentations>.

⁶For more details on the exchange rate commitment, please refer to Bruha and Tonner (2018).

refinancing impossible in extreme cases of weak debt management. This happens especially in emerging or highly indebted countries. An excessive proportion of unhedged foreign currency bonds in the government debt portfolio may significantly influence debt service costs during currency depreciation. However, debt management should not be evaluated based solely on economic criteria. For the purpose of comprehensive evaluation of debt management, the World Bank in cooperation with other relevant institutions developed the Debt Management Performance Assessment (DeMPA) methodology.⁷

Figure 1 shows the development of government debt and debt interest payments in the Czech Republic. During the 2000–2012 period, Czech government debt exhibited an obvious upward trend, accompanied by rising debt interest payments. After 2012, government debt growth was significantly reduced due to a concomitant rise of the economy and wealth of economic agents. Debt interest payments peaked in 2014 and thereafter declined due to the “escape from risk” effect, wherein investors buy bonds of relatively “safe” countries with stable currency, such as the Czech Republic was at the time. This effect was intensified by the existence of CNB’s one-sided foreign exchange commitment and investor speculation on future appreciation of the koruna. This environment led to negative bond yields. The Czech Ministry of Finance, which controls the majority of government debt as the debt manager, used the environment of negative yields on medium- and long-term government bonds to, in December 2015, auction off government bonds maturing in 2017 at an all-time low yield of -0.35% p.a. The total public budget revenue from this investment activity, lending facilities with government bonds, and from the negative yields

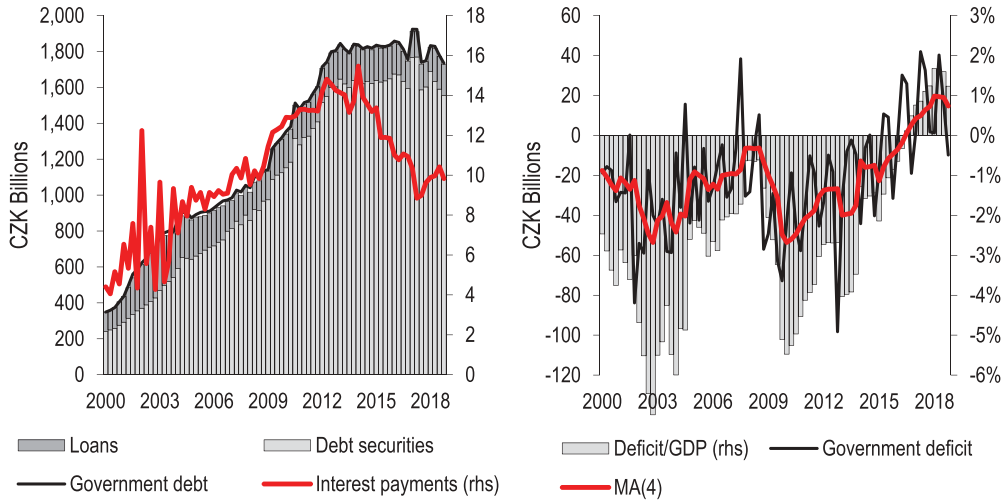


Figure 1. Government debt, deficit, and interest payments (CZK billion).

Note: $MA(4)$ denotes a four-quarter moving average; *rhs* = right-hand scale.

⁷Although the primary focus of this tool is on developing countries, it can be applied to others as well. The methodology evaluates debt management according to fourteen performance indicators that can be summarized into five key areas (Governance and Strategy Development, Coordination with Macroeconomic Policies, Borrowing and Related Financing Activities, Cash Flow Forecasting and Cash Balance Management, and Debt Recording and Operational Risk Management). For more details, see Panzer et al. (2015).

of government bonds amounted to CZK 524.9 million (approximately EUR 19.4 million) in 2015 (Ministry of Finance, 2017) and a similar trend continued the following year.

However, operations of this type significantly reduced the average maturity of government debt, down to about 5 years (Figure 2, panel A). The largest changes occurred in the segment with residual maturity of up to 3 years. Between 2010 and 2016, the shares in the debt portfolio changed as follows: T-bills dropped from 8.9% to 0.3%, the share of government bonds with residual time to maturity of up to 1 year increased from 8% to 14.4%, and bonds with residual time to maturity between 1 and 3 years increased from 17% to 29.6% (Figure 2, panel B). The value of the share of net foreign-currency exposure to government debt with impact on the level of interest expenditure on government debt reached 11.5% at the end of 2016 and remained under the strategic limit of the Czech Ministry of Finance (15% +2 p.p.). The net foreign-currency exposure of government debt with impact on government debt service was denominated solely in EUR at the end of 2016. Further details about the debt composition are available in Ministry of Finance (2017).

Several empirical studies highlight the importance of strategic interaction between monetary and fiscal policies (Franta, Libich, & Stehlik, 2018; Hodula & Pfeifer, 2018; Kirsanova & le Roux, 2013).⁸ Moreover, the relationship between monetary and fiscal policy is expected to grow over time because of increased budget financing pressures resulting from population ageing (see also Komarkova et al., 2013; Ambrisko et al., 2017). This could be a serious issue for the Czech Republic, as government spending on pensions jumped from CZK 222 bn. in 2008 to CZK 315 bn. in 2015, i.e., an increase of more than 40% over an 8-year period.

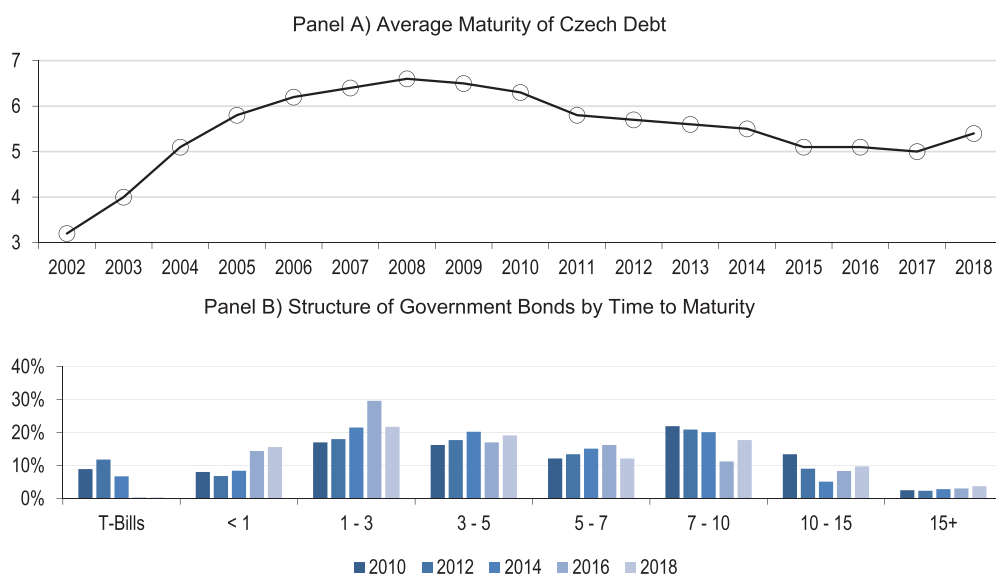


Figure 2. Czech government bonds.

Note: The data are taken from the Czech Republic government debt management annual report 2018.

⁸The theoretical examination of monetary-fiscal interactions dates back to the seminal paper of Sargent and Wallace (1981).

4. Modelling approach and data

To find out how changes in the economic policy setting may influence the debt management-related set of variables, we use the factor-augmented vector autoregression model (FAVAR) introduced in Bernanke, Boivin, and Elias (2005). The FAVAR model has several appealing properties that make it an ideal candidate for our empirical exercise. First, it allows us to avoid information bias when identifying the set of economic policy innovations. For example, when trying to identify a monetary policy shock in a VAR model, the shock may actually not be truly exogenous, as it may also capture instances when the central bank endogenously reacts to changing inflation expectations.⁹ This gives rise to the infamous “price puzzle”.

In contrast to the basic VAR model, the FAVAR model includes unobserved low-dimensional factors in the autoregression, reducing the information bias. The FAVAR model uses the advantages of a data-rich environment while remaining tractable in terms of the number of parameters to be estimated. The restriction of a small number of latent factors is consistent with standard dynamic equilibrium macroeconomic theories (Stock & Watson, 2016). To obtain the factors, we follow Bernanke et al. (2005) who employed the Stock and Watson (1998, 1999, 2002) dynamic factor model, which is estimated using the static principal components approach. Here, it is crucial to distinguish between the static and dynamic representation of a dynamic factor model in order to avoid confusion. The static approach relies on the time-domain forecasting method of Stock and Watson (1998, 1999, 2002). The estimates are based on contemporaneous covariances only and, as such, do not exploit the potential information contained in the leading-lagging relations between the variables. However, as the authors show, the space of factors is still consistently estimated by the static approach, provided the number of variables and the time dimension are large.

The FAVAR modelling framework is used in many economic applications. For instance, Forni and Gambetti (2010) use a FAVAR model to study the effects of monetary policy in the US. Similarly, Eickmeier and Hofmann (2013) apply a FAVAR model to US data with the aim of analyzing monetary transmission via private sector balance sheets, credit risk spreads, and house prices and of exploring the role of monetary policy in the housing and credit boom prior to the global financial crisis. Hodula and Pfeifer (2018) extend the FAVAR framework to study strategic policy interactions between fiscal and monetary policy and financial stability.

4.1. The FAVAR model specification

We specify an $M \times 1$ vector of macroeconomic time series Y_t and a $K \times 1$ vector of unobserved factors F_t . We assume that the joint dynamics of (Y_t, F_t) are given by the following equation:

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + \varepsilon_t \quad (1)$$

⁹The use of many variables to span the space of the shocks mitigates the “invertibility problem” of structural vector autoregressions (SVARs). For more detailed discussions, see Forni, Giannone, Lippi, and Reichlin (2009) and Leeper, Walker, and Yang (2013).

where $\Phi(L)$ is a lag polynomial and ε_t is an error term with zero mean and covariance matrix Q . Equation (1) is a standard VAR model that can be interpreted as a reduced form of a linear rational-expectations model with both observed and unobserved variables. However, the unobserved variables make the model impossible to estimate. Therefore, we assume that additional informational time series X_t are linked to the unobservable factors F_t and the observable factors Y_t by the following (static) representation of a dynamic factor model:

$$X_t = \Lambda^f F_t + \Lambda^y Y_t + e_t \quad (2)$$

where Λ^f and Λ^y are matrices of factor loadings and e_t is a serially uncorrelated error term with zero mean (innovation shock). The static representation implies that X_t depends only on the current values of F_t , and not on the lagged ones. Equation (2) captures the idea that both vectors Y_t and F_t are pervasive forces that might drive the common dynamics of X_t . As the static factors incorporate information from a large number of economic variables, the information set of the structural factor model is far greater than that of a standard VAR. Thus, it becomes unlikely that the information set of economic agents would be superior to our information set (Table 1A).

The model estimation procedure consists of five steps. First, as in all factor models, we determine the optimal number of factors. One possibility is to use the Bai and Ng (2002) information criterion to determine the number of factors present in the macroeconomic data vector X_t . However, as shown by Tuzcuoglu and Hoke (2016), different time spans might lead to different numbers of factors. Also, the Bai-Ng criterion does not solve the issue of how many factors we should include in the VAR model itself. We recommend employing the following *general-to-specific* approach:

- (1) Estimate the model with a large number of factors.
- (2) Check the correlations of every single variable with the estimated factors.
- (3) Eliminate those factors which do not yield a statistically significant correlation with any group of variables in X_t .
- (4) Check that the simplified model remains congruent.

In our application, we have used from 3 to 7 factors. The model with 3 latent factors shows the highest explanatory power and its results are therefore reported in the main text. In Table 2A, we check the correlations of sub-groups of variables with the estimated factors, which we interpret by visual inspection. The first factor loads on real economic variables, coupled with prices. The positive correlations accumulated in the second factor correspond at most to credit- and financial sector-related variables. The third factor accounts for external development, of great importance to a small open economy such as the Czech Republic. The remaining factors are mostly insignificant in terms of correlations, which justifies estimating the FAVAR model with just the three latent factors described above.

Second, we use a two-step principal components approach, which is a nonparametric way of estimating the space spanned by the factors of X_t , i.e., $C_t = (F_t, Y_t)$ in (2). The common components C_t are estimated using the first $K + M$ principal components of X_t . Note that we impose the factor restriction (as in Bernanke et al., 2005) which identifies the

Table 1. Sub-groups in the dataset.

Data Sub-groups	Slow/Fast moving	Number of Variables
External environment	(S)	12
Real economy	(S)	33
Labor market	(S)	17
Government	(S)	15
Prices and price expectations	(S)	20
Interest rates and credits	(F)	29
Financial sector	(F)	13
Exchange rates	(F)	6

Note: Appendix A lists the time series included in these sub-groups. Sub-groups highlighted in bold contain variables used as the source of an identified shock. Such variables are never included in the dataset from which we extract the factors.

factors against any rotations. \hat{F}_t is obtained as the part of the space covered by $\hat{C}_t = (F_t, Y_t)$ that is not covered by Y_t , that is, by removing Y_t from the space covered by the principal components. In this step, we divide our panel into two groups: slow- and fast-moving variables (see Table 1). The former are those that are assumed not to respond contemporaneously to unanticipated changes (innovations). The latter are those allowed to respond without a lag. Next, we need to obtain $\hat{C}^*(F_t)$ as an estimate of all the common components other than Y_t . Since the slow-moving variables are assumed to respond to changes in Y_t with a lag, $\hat{C}^*(F_t)$ is obtained by extracting principal components from this set of variables. The following regression is estimated in the process: $\hat{C}_t(F_t, Y_t) = a\hat{C}^*(F_t) + bY_t + u_t$. Finally, \hat{F}_t is calculated as $\hat{C}_t(F_t, Y_t) - \hat{b}Y_t$.

Third, the loading matrices are fitted into a VAR framework with F_t being replaced by \hat{F}_t :

$$\hat{\Psi}(L) \begin{bmatrix} \hat{F}_t \\ \hat{Y}_t \end{bmatrix} = \varepsilon_t f \quad (3)$$

Fourth, the VAR model is estimated and identified recursively using the ordering specified in the next chapter. Fifth, confidence bands of the impulse response functions are constructed using a bootstrap-after-bootstrap technique proposed by Kilian (1998). The impulse responses of the estimated factors and of the observed variables included in Y_t are calculated as follows:

$$\begin{bmatrix} \hat{F}_t \\ \hat{Y}_t \end{bmatrix} = \hat{\delta}(L)\varepsilon_t \quad (4)$$

where $\hat{\delta}(L) = [\hat{\Psi}(L)]^{-1}$. From equation (2), the X_t estimator is $\hat{X}_t = \hat{\Lambda}^f \hat{F}_t + \hat{\Lambda}^y \hat{Y}_t$, and thus impulse response functions may be calculated for each variable included in X_t :

$$X_t^{IRF} = \begin{bmatrix} \hat{\Lambda}^f & \hat{\Lambda}^y \end{bmatrix} \begin{bmatrix} \hat{F}_t \\ \hat{Y}_t \end{bmatrix} = \begin{bmatrix} \hat{\Lambda}^f & \hat{\Lambda}^y \end{bmatrix} \hat{\delta}(L)\varepsilon_t \quad (5)$$

4.2. Data

Our vector X_t for factor extraction consists of a balanced panel of 145 quarterly time series representing the Czech economy and the rest of the world. The data is drawn

mainly from the Czech National Bank, Czech Statistical Office, and ECB databases and spans the period 2000:Q1 – 2018:Q4. Note that throughout the paper, we work with government debt data on an accrual basis.¹⁰

Generally, it is not required to perform any *ex-ante* categorization of data, but stacking data into sub-groups in accordance with the different classes of economic variables can benefit the clarity of our computational process. The data sub-groups and corresponding numbers of variables are presented in Table 1 below. By modelling the impact of economic policy measures on debt management dynamics in a data-rich environment, we can control for real economy development, changes in fiscal and monetary policy, financial sector development, and external influences. Prior to estimation, the time series are seasonally adjusted using the X-12 Autoregressive Integrated Moving Average (X-12-ARIMA) and transformed to assure stationarity of the time series using first differences of natural logarithms. To avoid polluting the factor extraction process due to different scales of the various time series, all informational time series in vector X_t are standardized to have zero mean and unit variance. Nevertheless, the FAVAR estimation itself is carried out using non-standardized variables in Y_t .

4.3. Identification of policy innovations

To identify policy innovations, we divide our panel into two groups: slow- (S) and fast-moving (F) variables. Blocks describing the external environment, real economy, labor market, fiscal variables, and prices are classed as slow-moving (in the order seen in Table 1). A slow-moving variable is one that is largely predetermined in the current period. The rest of the blocks are classed as fast-moving, which are variables assumed to be highly sensitive to contemporaneous economic news or shocks. Variables from which we extract the innovations are always ordered last in the covariance matrix (and treated as a factor in their own right). This means that we assume each of the innovations to affect our latent factors with a lag of one quarter. Since we want to avoid a shortage of degrees of freedom, we prefer to use a smaller model with a lower number of lags. The standard information criteria tests suggest three lags, but using a more sensitive exclusion-based general-to-specific approach, we find that two lags are sufficient. Therefore, our baseline FAVAR model contains two lags. Nevertheless, we check the robustness of our results later.

We consider two types of economic policy shocks: monetary policy restriction and fiscal policy expansion. Together, they serve as the empirical representation of a “game of chicken”. Given that both economic policies are partial substitutes in stimulating the economy, governments and central banks may engage in a tug-of-war. Whereas the monetary policy is supposed to act countercyclically, the fiscal policy is often found to behave procyclically (Alesina, Campante, & Tabellini, 2008). In fact, politicians often use monetary contraction to justify a fiscal expansion.

From the debt management policy standpoint, increasing government spending (in excess of government revenues) generates deficit, which is usually financed through bills and bonds and thus increases the size of the public debt. Restrictive monetary policy, on

¹⁰Under the accrual principle, transactions are recorded at the time when the economic value is created, transformed or ceases to exist or when receivables and liabilities increase or decrease regardless of the moment when the realized transaction will be settled in money terms (Ministry of Finance, 2012).

the other hand, is reflected in interest rates on securities, thus increasing the cost of refinancing and debt repayment, as well as associated risks (see for instance Wheeler, 2004, pp. 7 for a discussion of the risks encountered in the management of government debt). The need for immediate bond issues beyond the longer-term plan captured in the fiscal outlook for the next 3 years may increase the cost of debt financing and may lead to repayment issues. Increasing government spending may also, through the crowding-out effect, cause a decline in private spending and increase the debt-to-GDP ratio.

The main policy tool of the CNB is a two-week repo rate. However, the repo rate does not change continuously, only by decree of the CNB Board of Governors. Thus, we use the inter-bank rate to proxy for the CNB's key monetary policy rate, similar to how it is done in the CNB's own forecasting system. Hence, we identify a contractionary monetary policy shock as an increase in the PRIBOR 3 M. This is a fairly common approach in the literature (see Bernanke et al., 2005; Borys, Franta, & Horv  th, 2009; Soares, 2013; among others). From the debt management point of view, interest rate hikes threaten debt sustainability, which is reflected in rising interest rates on debt securities, thereby increasing the cost of refinancing and debt repayment and raising the associated risks. In this application, we assume that the only observable variable is the policy instrument, i.e., the PRIBOR 3 M (R_t), so that $Y_t = R_t$. To test for robustness of our model specification, we redefine the specification so that also the output (GDP_t), inflation (CPI_t), and real effective exchange rate ($REER_t$) are included in the vector $Y_t = (GDP_t, CPI_t, R_t, REER_t)$.

The main fiscal policy variables are government revenue from taxes and total government expenditure, either of which may be used as a source of the innovation. In the literature, there is a plurality of approaches to the identification of structural fiscal shocks. However, during the selection process, we must bear in mind the following limitations for the Czech Republic data: (i) relatively short length of time series available; (ii) extensive structural changes in the period of economic transition; and (iii) methodological instability of the time series. For instance, the narrative case-study approach of Romer and Romer (2010) and Ramey (2011) would be hard to implement, given the relative scarcity of episodes of exogenous shifts in fiscal policy (such as tax shocks and defense news shocks). Another approach is the application of sign restrictions. Fry and Pagan (2011) provide a critical review of sign restrictions as an identification method for structural shocks. While they generally conclude that sign restrictions are a useful technique, they note that in some cases, such as isolating monetary policy shocks, using institutional knowledge to provide parametric restrictions is sufficient. Dybczak and Melecky (2014) extend their suggestion to isolating fiscal policy shocks and use short-run restriction as their preferred identification method for fiscal revenue and expenditure shocks. Franta (2012) estimates a vector autoregressive (VAR) model and identifies fiscal shocks using various approaches with Czech data. He shows that even if one overcame the problem of short time series by, for instance, imposing extraneous information in the form of priors, the identification procedure can itself represent another substantial source of uncertainty. Furthermore, using government revenue from taxes as a source variable increases the risk of endogeneity, since government revenue growth is associated with expansion of the business cycle. On the basis of these shortcomings, we identify an expansionary fiscal policy shock as an increase in total government expenditures. Similarly to the monetary policy application, we assume

government expenditures (GE_t) to be the only observable variable in vector Y_t , i.e., $Y_t = GE_t$. Since government expenditures are planned on an annual basis, they are not likely to respond to contemporaneous quarterly innovations in other variables within one or two quarters. For the sake of robustness, we also consider an alternative specification in which output (GDP_t), private consumption (C_t), inflation (CPI_t), and net government revenues from taxes (TAX_t) are also included in vector Y_t .

Furthermore, one must bear in mind that government debt management might follow certain alternative goals, such as: (i) supporting government investment plans (in particular, infrastructure projects), (ii) smoothing the tax burden on taxpayers over the long run, and (iii) supporting financial market development by expanding the supply of financial instruments to investors. To account for these parallel or alternative goals, we consider shocks to the government debt-to-GDP ratio ($DEBT_t$), so that $Y_t = DEBT_t$. In general, one might assume that increase in indebtedness (higher debt-to-GDP ratio) should have a positive impact on capital accumulation in the economy and should be correlated with deepening of the financial market. On the other hand, taxpayers should not be punished for higher debt by tax increases. Therefore, a debt-to-GDP shock should not significantly influence the tax burden.

5. Estimation results

The effects of the contractionary monetary policy and fiscal expansion shocks are presented in Figures 3 and 4 using impulse response functions (IRFs) over a time window of four years (16 quarters). We plot the median responses to show the central tendency of the estimated response functions. The responses were normalized to represent a 1 percentage point increase in the 3 M PRIBOR and government expenditure, respectively. The IRFs show the response of selected variables to an identified shock and its propagation over time. Accurate confidence intervals are calculated via a bootstrap procedure as in Kilian (1998), which accounts for the uncertainty in the factor estimation. One of the main advantages of the FAVAR approach is that IRFs can be constructed for any variable in the information set. Due to space constraints, we only report those IRFs that are relevant to the causal relations under question.

5.1. Transmission of monetary and fiscal policy shocks to the real economy

To see if the model captures relevant theoretical responses of the main macroeconomic variables to the two economic policy shocks, we show the response of real GDP, unemployment rate, prices, real effective exchange rate, gross capital formation, and tax incomes (Figure 3). A contractionary monetary policy shock has the expected impact on real economic activity: real GDP declines, bottoming out after 5 quarters. Following the decrease in GDP, the unemployment rate increases, peaking after 10 quarters. The annualized consumer price index exhibits a lagged decrease after a monetary policy shock, probably due to inflation undershooting in the post-crisis period (see Borys et al., 2009, for analysis of monetary policy transmission in the Czech Republic). Our model does not produce a price puzzle as is often the case with smaller VAR models. Lower company incomes reduce investment and gross capital formation declines. The unfavorable economic environment is reflected in the decline of tax collection. Reaction

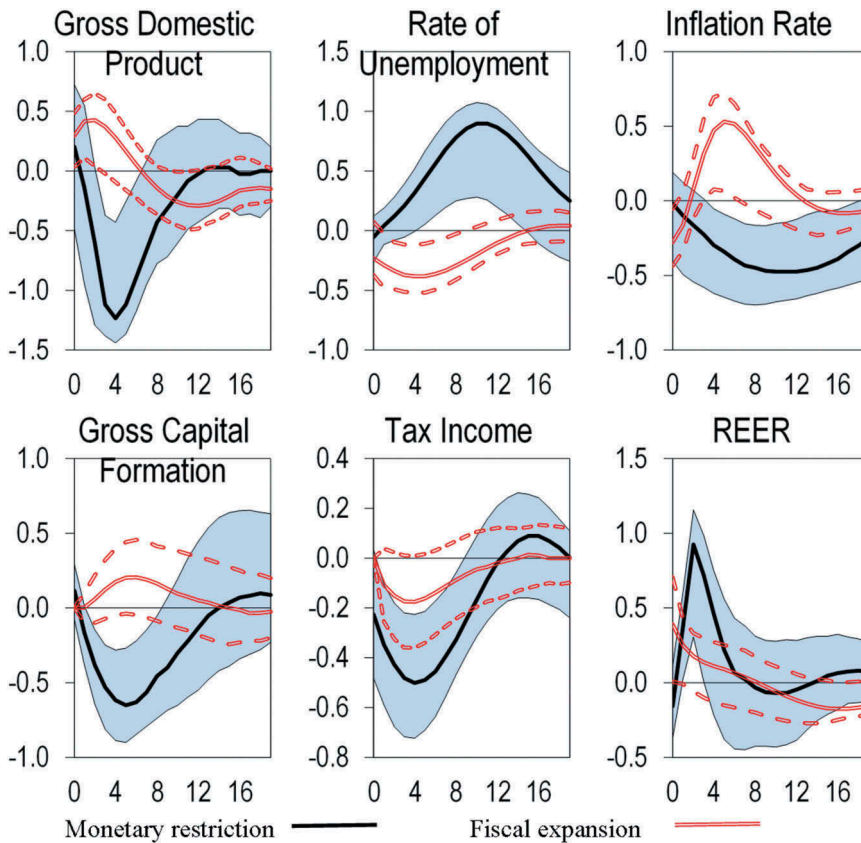


Figure 3. Monetary and fiscal policy transmission into the real economy.

Note: Median impulse responses of the FAVAR model with 2 lags are reported with 90% confidence bounds; responses are in percentage points; all variables except rate of unemployment and PRIBOR 3 M enter the model as annualized percentage growth; the x-axis is in quarters after the shock.

of the real effective exchange rate to the monetary policy shock is in line with economic theory; a higher interest rate differential leads to an appreciation of the domestic currency.

Turning to the effects of a fiscal expansion, we report a gradual increase in real GDP growth and a decrease in the rate of unemployment. However, real GDP growth subsequently slows down, possibly due to a crowding-out effect.¹¹ Similar results for the Czech Republic were reported by Franta (2012) and Ambrisko, Babecky, Rysanek, and Valenta (2015). As a result of increased economic activity, the inflation rate increases with a peak 5 quarters after the shock.¹² Fiscal expansion also seems to have positive effect on gross capital formation. On the contrary, we document a negative, rather than positive, effect in tax incomes, probably due to the crowding-out effect of government spending. The

¹¹The existence of a partial crowding-out effect of government spending is also visible from the response of private consumption (see Figure 1B in the Appendix). However, in a low interest rates environment with excess market liquidity, the crowding-out effect is less likely. Such market conditions apply to the post-GFC period which forms about half of our estimation period. Therefore, the crowding-out effect is estimated to be relatively weak.

¹²Note that this may trigger a restrictive reaction from the central bank, which may cause the effects under consideration to multiply.

response of the real effective exchange rate is rather ambiguous, with relatively wide confidence intervals.

5.2. Monetary restriction, fiscal expansion, and debt management

Concerning responses of variables linked to debt management (Figure 4), the contractionary monetary policy shock produces an immediate increase of government bond yields, which further affects the yield curve of the government debt portfolio. Due to increase in government bond yields, debt service costs increase, peaking at 2 quarters after the shock. Higher debt service costs are also reflected in increased debt interest payments. Increased cost of financing, together with declining GDP growth, means higher government borrowing needs and greater indebtedness as measured by the debt-to-GDP ratio. The aforementioned is in line with findings stemming from derivation of fiscal debt dynamics. The effect of tighter monetary conditions is stronger for higher initial government debt-to-GDP ratios and lower GDP dynamics, which are negatively affected by tighter monetary conditions. Note that the exchange rate appreciation following a contractionary monetary policy shock may suggest that some foreign-currency debt can be issued as a hedge against interest-rate risk affecting short-term debt.

As expected, the IRFs projected in Figure 4 well document the faster and slightly higher reaction of 2Y bond yields (0.65 pp at impact) compared to yields of 5Y (0.43 pp at impact) and 10Y bonds (0.33 pp at impact). A higher share of 2Y bonds in the

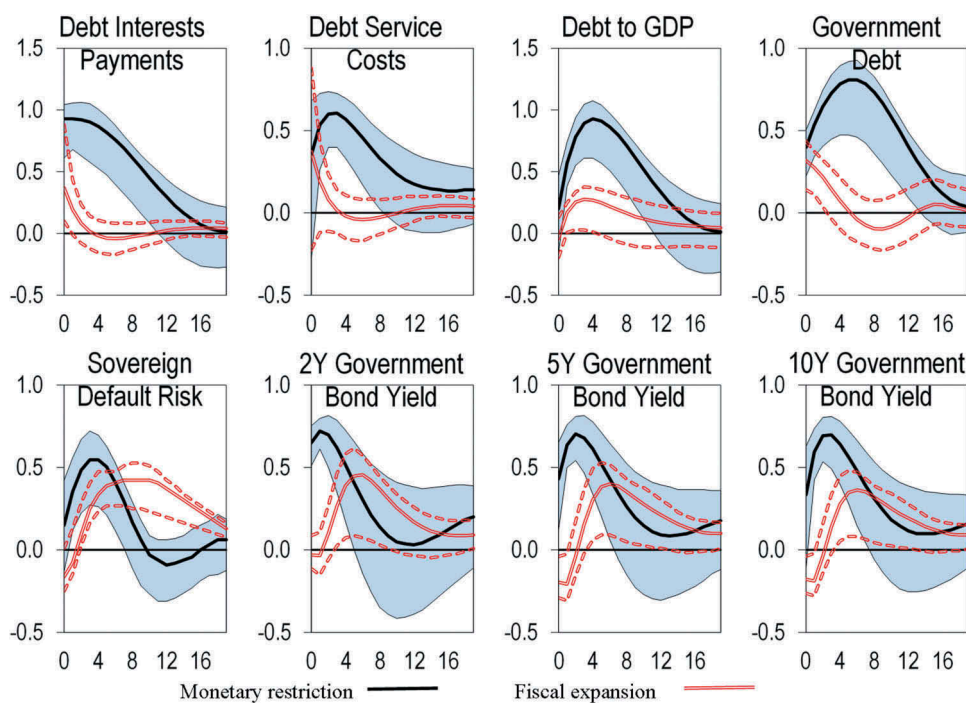


Figure 4. Monetary restriction, fiscal expansion, and debt management.

Note: Median impulse responses of the FAVAR model with 2 lags are reported with 90% confidence bounds; responses are in percentage points; the x-axis is in quarters after the shock.

government debt portfolio could increase its riskiness due to undesirable development of debt service costs. This finding supports the idea that short-term bonds are riskier than long-term bonds, especially because of higher interest rate and refinancing risks. This fact should be considered in the preparation of the government's debt management strategy. Indeed, debt managers in many countries took advantage of the negative interest rate environment¹³ to extend the average maturity of their underlying debt. For instance, Switzerland and the United Kingdom dramatically increased the average maturity of their debt, and a similar trend is seen in many other countries (see [Figure 1C](#) in the Appendix). However, the Czech Republic and a few other countries (Hungary and Sweden) adopted a different strategy and changed the structure of the debt portfolio in favor of short-term bonds, resulting in the Czech Republic in a drastic drop in average maturity from 6.4 years in 2007 to 5.1 years in 2016,¹⁴ far below the international average. The only countries with lower average maturity in 2016 were Hungary and Norway.¹⁵ The relatively small savings from the issuance of short-term bonds may be canceled out (or even overcome) by higher debt service costs in the long term due to accumulating debt issues and increased refinancing and interest rate risks. Still, the Czech Republic enjoys good credit standing and debt management remains prudent.

Turning to fiscal expansion, simulated through an increase in total government expenditures, we document three effects. First, we identify a partial crowding-out effect, i.e., the increase in government spending is not completely canceled out by the decline of private expenditures and leads to GDP growth. Second, faster GDP growth decreases relative indebtedness as measured by the debt-to-GDP ratio. Nevertheless, a hike in government spending generates deficit, which needs to be financed by issuance of new bonds. Accordingly, we document an increase in government debt, both in absolute and relative terms, accompanied by rising debt interest payments and debt service costs. Unlike the first two effects, the third appears with a lag, probably because the market needs some time to appreciate the higher risk and reflect it in higher rates. Increasing both government expenditures and debt increases the risk associated with debt sustainability and leads to a higher sovereign default risk, which is reflected in higher bond yields.

5.3. Alternative objectives of the debt manager

One must also bear in mind that the debt manager may follow secondary (alternative) goals. Debt management may support government investment plans focused on large infrastructure projects, construction of nuclear power plants, and other government priorities that requires large-scale and long-running investments. This is especially true if debt management is not completely independent (for instance, falls under the Treasury). Several studies also refer to tax smoothing as one of the government goals that may affect the debt management (see Canzoneri et al., 2016; Faraglia, Marcet, & Scott, 2008). The government may even directly cooperate with the debt manager in order to spread out the tax burden (which may be associated with tax reforms) into a longer time period. In addition, in countries with underdeveloped financial markets,

¹³Figure 2C in the Appendix shows the average government bond yields in the Eurozone.

¹⁴This drop in average maturity has continued in 2017.

¹⁵Still, Norway is in a different position due to massive income from oil-related wealth funds.

the debt manager may stimulate the supply of investment products (especially government bonds) to deepen the financial market. To account for these alternative debt management goals, we consider a positive shock to the debt-to-GDP ratio and track the impulse responses of gross capital formation, tax burden (defined as tax revenues over GDP), and financial market depth index.

The responses are depicted in Figure 5. First, following the immediate increase in the debt-to-GDP ratio, we document a gradual growth of gross capital formation. Judging by that, the simulated increase in indebtedness may bring along some positive long-run effects for the economy. Growth in the debt-to-GDP ratio may therefore be the result of government investment plans, which are beyond the decision-making power of the debt manager, but which it would have to take into account when deciding on the optimal debt strategy. Second, we focus on the reaction of tax burden to the debt shock. In terms of tax smoothing, we may conclude that government debt seems to be a suitable instrument for distributing the tax burden across generations. An increase in indebtedness did not lead to significant changes in taxation in the Czech Republic. Third, we consider the response of financial market depth, measured by the financial market depth index taken from the IMF.¹⁶ Given the fact that one of the secondary goals of government debt management in the Czech Republic is to support the development of financial markets, a positive reaction of the financial market depth index shortly after the debt shock shows that it is possible to develop financial markets by issuing government bills and bonds.

We conduct a number of robustness checks to verify our results. First, we test whether our results are affected by changing the number of factors that enter the FAVAR model. In particular, we try estimating the model with 5 and 7 factors. Most of the estimated median IRFs from the models with 5 and 7 factors lie inside the 90% confidence interval of the FAVAR model with 3 factors. The only difference is a slightly slower reaction of the variables to the monetary policy shock for models with a larger number of factors. Second, we use an alternative identification strategy for fiscal and monetary policy shocks. Results are robust to use of other plausible orderings of the variables in the

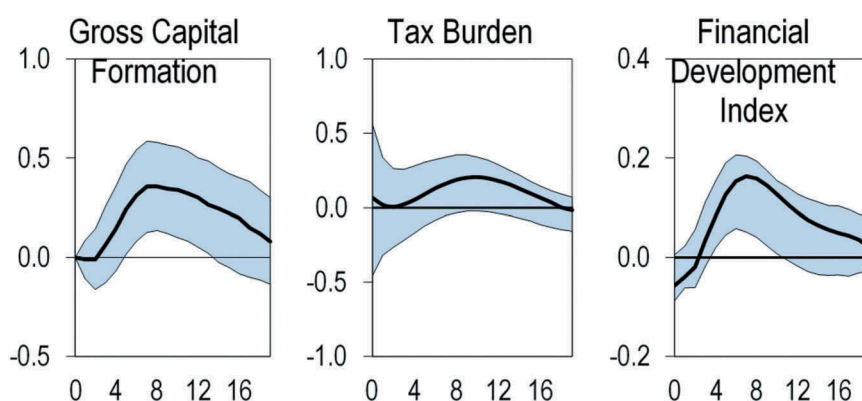


Figure 5. Responses to a positive shock to debt-to-GDP ratio.

Note: Median impulse responses of the FAVAR model with 2 lags are reported with 90% confidence bounds; responses are in percentage points; the x-axis is in quarters after the shock.

¹⁶For details regarding the estimation procedure of the financial development index, please refer to Svirydzienka (2016).

FAVARs. None of the above has a significant impact on our results. The associated impulse response functions are available in Appendix D, [Figures 1D, 2D, 3D and 4D](#). We also compare the estimates from a large FAVAR model with those from small-scale VAR models to show the computational gains from modelling the system in a data-rich environment (see Appendix B for the estimates). Further robustness checks include an increased number of lags in the FAVAR model (up to 4), which yields results that are both qualitatively and quantitatively similar.

6. Conclusion

The monetary and fiscal policies are inherently intertwined. This statement is generally accepted and holds even for countries where the central bank has a long history of independence from the government. In this paper, we take advantage of the mutually-reinforcing interlinkages of these economic policies and study the impact of fiscal and monetary policy shocks on debt management in the Czech Republic. We use a data-rich FAVAR model to study the responses of key debt management variables to economic shocks. The FAVAR model helps ensure that the estimated impulse responses are invariant with respect to extensions of the information set – an issue that often plagues impulse response results.

The Czech Republic is an interesting case for a study as the national debt manager took advantage of the low-interest environment between 2010 and 2017 and altered the debt portfolio structure in favor of short-term bonds. With the upcoming normalization of nominal interest rates and continuous economic growth that allow fiscal policy to expand, we provide some key policy findings regarding the relationship between the main policy and debt management variables.

We report several findings: (i) We find that a tightening of monetary policy alters the yield curve of government bonds, causing rapid yield increase; (ii) following this, debt service costs increase and, coupled with decreasing economic activity, lead to an increase in the overall public debt burden. Turning to the effects of fiscal policy expansion, (iii) it comes as no surprise that a hike in government expenditures increases the level of government debt; (iv) nevertheless, the effects might be even more pronounced in the Czech Republic, as we also find evidence for a partial crowding-out effect. In this respect, we identify an extremely unfavorable policy mix (monetary contraction with fiscal expansion) that might significantly increase debt service costs and, in the long-term, may endanger government debt sustainability. Furthermore, we show that increasing government indebtedness could cater to some of the alternative (parallel) goals of debt management, such as deepening the country's financial market and supporting government investment plans.

Our analysis suggests that changes in both monetary and fiscal policy shocks significantly affect debt management policy, but the time evolution of the studied impulse responses is different for each. This calls for a forward-looking debt management strategy, i.e., a longer optimization horizon. The debt manager should incorporate possible changes in current economic policy into its decisions about the debt portfolio structure and reflect the medium- and long-term outlook in its strategy. In doing so, the debt manager should intensively coordinate its actions with the central bank, e.g., through sharing economic forecasts of the likely future trajectory of interest rates. Any increase in the monetary policy rate or growth of government expenditures may quickly transmit to the service costs and size of government debt, especially when the debt manager favors short-term bills over long-term government bonds in the government

debt portfolio. Looking at recent data on the average term-to-maturity of outstanding government debt across multiple countries (Figure 2C), there are certain other countries (Hungary, Sweden) that took the same approach of lowering their average maturities; this has left them more susceptible to monetary and fiscal policy-like shocks in the long term. Our data might thus be of some value to these countries as well.

Our results largely support the separation of the individual economic policies. They need to be separated politically in terms of their objectives and accountability, in line with the Tinbergen principle. This holds especially for the fiscal and debt management policies. However, the policymakers involved need to share information to make informed long-term decisions and coordinate their actions.

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Appendices

A. Data description

Table 1A. Shows all time-series incorporated in the analysis. Abbreviations stand for: CSO – Czech Statistical Office, CNB – Czech National Bank database ARAD, IMF – International Monetary Fund database, ECB – European Central Bank Statistical Data Warehouse. The transformation codes (TC) are: 1 – no transformation; 2 – first difference of logarithm. An asterisk, “*”, next to the transformation code number denotes seasonally-adjusted variables using CENSUS X13. S/F ranks variables as slow or fast moving in the estimation.

Group	No.	Series description	Unit	Source	TC	S/F
Real economy	1	Industrial production index, industry total	2010 = 100	CSO	2*	S
	2	Industrial production index, mining and quarrying	2010 = 100	CSO	2*	S
	3	Industrial production index, manufacturing	2010 = 100	CSO	2*	S
	4	Industrial production index, electricity, gas, steam and air conditioning	2010 = 100	CSO	2*	S
	5	Sales from industrial activity, industry total	2010 = 100	CSO	2*	S
	6	Sales from industrial activity, mining and quarrying	2010 = 100	CSO	2*	S
	7	Sales from industrial activity, manufacturing	2010 = 100	CSO	2*	S
	8	Sales from industrial activity, electricity, gas, steam	2010 = 100	CSO	2*	S
	9	Direct export sales, industry total	2010 = 100	CSO	2*	S
	10	Direct export sales, mining and quarrying	2010 = 100	CSO	2*	S
	11	Direct export sales, manufacturing	2010 = 100	CSO	2*	S
	12	Domestic sales, industry total	2010 = 100	CSO	2*	S
	13	Domestic sales, mining and quarrying	2010 = 100	CSO	2*	S
	14	Domestic sales, manufacturing	2010 = 100	CSO	2*	S
	15	Domestic sales, electricity, gas, steam	2010 = 100	CSO	2*	S
	16	New industrial orders, industry total	2010 = 100	CSO	2*	S
	17	Non-domestic new orders	2010 = 100	CSO	2*	S
	18	Domestic new orders	2010 = 100	CSO	2*	S
	19	Construction production index	2010 = 100	CSO	2*	S
	20	Construction production index, buildings	2010 = 100	CSO	2*	S
	21	Construction production index, civil engineering works	2010 = 100	CSO	2*	S
	22	Retail trade receipts	2010 = 100	CNB, ARAD	2*	S
	23	Gross domestic product, market prices	Millions CZK	CSO	2*	S
	24	Gross fixed capital formation	Millions CZK	CSO	2*	S
	25	GDP deflator	2010 = 100	CNB, ARAD	2*	S
	26	Final consumption expenditures, total, current prices	Millions CZK	CSO	2*	S
	27	Final consumption expenditures, households, current prices	Millions CZK	CSO	2*	S
	28	Final consumption expenditures, government, current prices	Millions CZK	CSO	2*	S
	29	Final consumption expenditures, non-profit organizations, current prices	Millions CZK	CSO	2*	S
	30	Gross capital formation, total, current prices	Millions CZK	CSO	2*	S
	31	Export, current prices	Millions CZK	CSO	2*	S
	32	Import, current prices	Millions CZK	CSO	2*	S
	33	Real gross domestic income	Millions CZK	CSO	2*	S

(Continued)

Table 1A. (Continued).

Group	No.	Series description	Unit	Source	TC	S/F
Labor market	34	Industry total, average number of persons employed (ANPE)	No. of persons	CSO	2*	S
	35	Industry, mining and quarrying, ANPE	No. of persons	CSO	2*	S
	36	Industry, manufacturing, ANPE	No. of persons	CSO	2*	S
	37	Industry, electricity, gas, steam and air conditioning supply, ANPE	No. of persons	CSO	2*	S
	38	Industry total, average gross nominal wage (AGNW)	CZK per person	CSO	2*	S
	39	Industry, mining and quarrying, AGNW	CZK per person	CSO	2*	S
	40	Industry, manufacturing, AGNW	CZK per person	CSO	2*	S
	41	Industry, electricity, gas, steam and air conditioning supply	CZK per person	CSO	2*	S
	42	Construction total, average number of persons employed (ANPE)	No. of persons	CSO	2*	S
	43	Construction total, average gross nominal wage (AGNW)	CZK per person	CSO	2*	S
	44	Employees total, hours worked	Thousand hours	CSO	2*	S
	45	Employees, Agriculture, forestry and fishing	Thousand hours	CSO	2*	S
	46	Employees, Manufacturing, mining and quarrying and other	Thousand hours	CSO	2*	S
	47	Employees, Construction	Thousand hours	CSO	2*	S
	48	General unemployment rate among those aged 15 to 64	%	CNB, ARAD	1*	S
	49	Job Vacancies	Thousand	CNB, ARAD	2*	S
	50	Unplaced job seekers	Thousand	CNB, ARAD	2*	S
Government	51	Government debt, total	Millions CZK	CSO	2*	S
	52	Debt securities, total	Millions CZK	CSO	2*	S
	53	Debt securities, short-term	Millions CZK	CSO	2*	S
	54	Debt securities, long-term	Millions CZK	CSO	2*	S
	55	Government loans, total	Millions CZK	CSO	2*	S
	56	Government loans, short-term	Millions CZK	CSO	2*	S
	57	Government loans, long-term	Millions CZK	CSO	2*	S
	58	Debt interests paid	Millions CZK	CSO	2*	S
	59	Government expenditures, total	Millions CZK	CSO	2*	S
	60	Government revenue, total	Millions CZK	CSO	2*	S
	61	Debt to GDP ratio	Ratio	CSO	1	S
	62	Debt service costs = interests paid in t/debt in t-1	Ratio	CSO	1	S
Prices and price expectations	63	Government revenues from taxes	Millions CZK	CSO	2	S
	64	Tax quota = government revenues from taxes/GDP	Ratio	CSO	2	S
	65	Consumer Price Index (CPI), total	2005 = 100	CNB, ARAD	2*	S
	66	CPI, food and non-alcoholic beverages	2005 = 100	CNB, ARAD	2*	S
	67	CPI, alcoholic beverages, tobacco	2005 = 100	CNB, ARAD	2*	S
	68	CPI, clothing and footwear	2005 = 100	CNB, ARAD	2*	S
	69	CPI, housing, water, electricity, gas and other fuels	2005 = 100	CNB, ARAD	2*	S
	70	CPI, furnishings, household equipment, routine maintenance	2005 = 100	CNB, ARAD	2*	S
	71	CPI, health	2005 = 100	CNB, ARAD	2*	S
	72	CPI, transport	2005 = 100	CNB, ARAD	2*	S
	73	CPI, communications	2005 = 100	CNB, ARAD	2*	S
	74	CPI, recreation and culture	2005 = 100	CNB, ARAD	2*	S
	75	CPI, education	2005 = 100	CNB, ARAD	2*	S
	76	CPI, restaurants and hotels	2005 = 100	CNB, ARAD	2*	S
	78	CPI, miscellaneous goods and services	2005 = 100	CNB, ARAD	2*	S
	79	Industrial Producer Prices (IPP), total	2005 = 100	CNB, ARAD	2*	S

(Continued)

Table 1A. (Continued).

Group	No.	Series description	Unit	Source	TC	S/F
Interest rates and credits	80	IPP, mining and quarrying	2005 = 100	CNB, ARAD	2*	S
	81	IPP, manufacturing	2005 = 100	CNB, ARAD	2*	S
	82	IPP, electricity, gas, steam and air conditioning supply	2005 = 100	CNB, ARAD	2*	S
	83	IPP, water supply; sewerage, waste management and remediation	2005 = 100	CNB, ARAD	2*	S
	84	Inflation expectations of non-financial corporations for 1Y ahead	%	CNB, ARAD	1*	F
	85	Financial market inflation expectations for 1Y horizon	%	CNB, ARAD	1*	F
	86	Repo rate – 2 weeks	%	CNB, ARAD	1	F
	87	PRIBOR 3 M	%	CNB, ARAD	1	F
	88	PRIBOR 1Y	%	CNB, ARAD	1	F
	89	Government bond yield 2Y	%	CNB, ARAD	1	F
	90	Government bond yield 5Y	%	CNB, ARAD	1	F
	91	Government bond yield 10Y	%	CNB, ARAD	1	F
	92	Bank interest rates on CZK-denominated loans, non-financial corporations	%	CNB, ARAD	1	F
	93	Bank interest rates on CZK-denominated loans, households total	%	CNB, ARAD	1	F
	94	Bank interest rates on CZK-denominated loans, consumer credit	%	CNB, ARAD	1	F
	95	Bank interest rates on CZK-denominated loans, credit for house purchase	%	CNB, ARAD	1	F
	96	Bank interest rates on CZK-denominated loans, other loans – total	%	CNB, ARAD	1	F
	97	Bank interest rates on CZK-denominated loans, NFC, up to 1Y	%	CNB, ARAD	1	F
	98	Bank interest rates on CZK-denominated loans, NFC, up to 5Y	%	CNB, ARAD	1	F
	99	Bank interest rates on CZK-denominated loans, NFC, over 5Y	%	CNB, ARAD	1	F
	100	Monetary base, monthly average	Billions CZK	CNB, ARAD	2	F
	101	Monetary aggregate M1	Millions CZK	CNB, ARAD	2	F
	102	Monetary aggregate M2	Millions CZK	CNB, ARAD	2	F
	103	Loans to private sector, total	Millions CZK	CNB, ARAD	2	F
	104	Net foreign assets	Millions CZK	CNB, ARAD	2	F
	105	Loans to residents and non-residents – MFIs	Millions CZK	CNB, ARAD	2	F
	106	Loans to non-financial corporations – MFIs	Millions CZK	CNB, ARAD	2	F
	107	Loans to financial corporations – MFIs	Millions CZK	CNB, ARAD	2	F
	108	Loans to government	Millions CZK	CNB, ARAD	2	F
	109	Loans to households	Millions CZK	CNB, ARAD	2	F
	110	Loans, short-term (up to 1Y)	Millions CZK	CNB, ARAD	2	F
	111	Loans, medium-term (up to 5Y)	Millions CZK	CNB, ARAD	2	F
	112	Loans, long-term (over 5Y)	Millions CZK	CNB, ARAD	2	F
	113	Consumption loans, total	Millions CZK	CNB, ARAD	2	F
	114	Mortgages, total	Millions CZK	CNB, ARAD	2	F
Financial sector	115	Capital adequacy ratio, large banks	%	CNB	1*	F
	116	Leverage ratio, large banks	%	CNB	1*	F
	117	Risk-weighted assets, large banks	%	CNB	1	F
	118	Non-performing loans, large banks	%	CNB	1	F
	119	Credit spread, large banks	%	CNB	1	F
	120	Composite indicator of sovereign stress	0–1 interval	ECB	1	F
	121	Financial cycle indicator	0–1 interval	CNB	1	F
	122	Difference between credit-to- GDP ratio and the minimum ratio	%	CNB	1	F
	123	Index PX	Value	PSE	2	F
	124	Credit-to-GDP gap, (since 2000), HP filter, lambda = 200,000	p. p.	Own calculation	1	F
	125	MFI total assets	Millions CZK	CNB – ARAD	2	F
	126	House price index	2010 = 100	CSO	2	F
	127	Financial markets development index		IMF	2	F

(Continued)

Table 1A. (Continued).

Group	No.	Series description	Unit	Source	TC	S/F
Exchange rates	128	Real effective exchange rate	2010 = 100	CNB, ARAD	2*	F
	129	Nominal exchange rate CZK/EUR, monthly average	value	CNB, ARAD	2	F
	130	Nominal exchange rate CZK/GBP, monthly average	value	CNB, ARAD	2	F
	131	Nominal exchange rate CZK/USD, monthly average	value	CNB, ARAD	2	F
	132	Nominal exchange rate CZK/JPY, monthly average	value	CNB, ARAD	2	F
External environment	133	Nominal effective exchange rate	2010 = 100	CNB, ARAD	2	F
	134	Government bond yield 10Y – euro area	%	CNB, ARAD	1	F
	135	Crude oil, Brent, \$/bbl, current	USD/barrel	EIA	2	F
	136	Crude Oil Production, World	thousand barrels	EIA	2	F
	137	Composite indicator of systemic stress, euro area	index 0–1	ECB	1	F
	138	GDP, current prices, euro area	Millions EUR	ECB	2	F
	139	DAX index	value	Datastream	2	S
	140	Industrial production index, total Germany	2005 = 100	Eurostat	2	S
	141	World, price index, all commodities	2005 = 100	IMF	2	S
	142	World, price index, all commodities excluding fuels	2005 = 100	IMF	2	S
	143	World, price index, fuels	2005 = 100	IMF	2	S
	144	World, price index, agriculture	2005 = 100	IMF	2	S
	145	Oil prices, Brent	2005 = 100	IMF	2	S

Table 2A. Correlations of the estimated factors and data blocks.

Data Sub-groups	F1	F2	F3	F4	F5	F6	F7
Real economy	0.464	0.148	−0.191	−0.070	−0.015	−0.035	0.101
Labor market	0.289	0.151	0.110	−0.096	0.072	0.056	−0.081
Government	0.233	−0.546	−0.108	−0.016	0.031	0.168	−0.170
Prices	0.415	−0.102	0.087	0.083	0.199	0.068	0.011
Interest rates and credits	−0.107	0.313	0.197	0.063	−0.054	−0.083	0.015
Financial sector	0.006	0.240	0.188	0.108	−0.069	0.081	0.043
Exchange rates	−0.153	−0.031	−0.015	−0.014	0.025	0.134	0.034
External environment	0.128	0.136	0.413	0.210	−0.004	0.091	0.071
Factor 1	1						
Factor 2	0.068	1					
Factor 3	0.006	−0.061	1				
Factor 4	0.031	0.057	−0.056	1			
Factor 5	0.023	−0.013	−0.011	0.002	1		
Factor 6	0.019	−0.008	−0.019	0.009	0.006	1	
Factor 7	−0.020	0.084	−0.028	0.010	0.018	0.074	1

Note: Table shows correlations between sub-groups of variables with five estimated factors. Correlations significantly different from zero are highlighted in bold. Note that we estimate three independent models using 3, 5, and 7 factors.

B. Searching for the price puzzle and the government spending puzzle

As part of our robustness exercise, we compare the outcomes of simple fiscal and monetary policy VAR models with the ones from a FAVAR model. In particular, we are interested in finding out if the infamous fiscal and monetary policy puzzles emerge when using the small three-variable VAR model. Figure 1B shows the results confirming the existence of both puzzles. In the monetary policy small VAR model, the restrictive monetary policy shock causes an increase in the level of inflation. This violates the standard theoretical assumption that a surprise increase in the short-term interest rate will lower price inflation. In the fiscal policy VAR model, on the other hand, increasing government spending increases private consumption, thus showing some crowding-in effect opposed to the expected crowding-out effect. By contrast, no such puzzles emerge when estimating the information-rich FAVAR model.

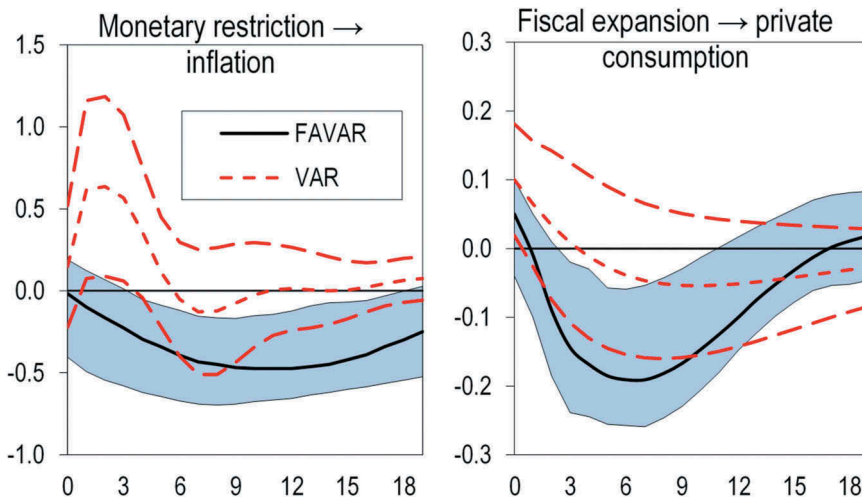


Figure 1B. VAR-FAVAR comparison.

Note: The standard monetary policy VAR model consists of real GDP, the CPI index, and the PRIBOR 3M. The fiscal policy VAR model based on Blanchard and Perotti (2002) loads on government spending, taxes, real GDP, and private consumption. All variables enter the model in a log-annualized form, except for the PRIBOR 3M, which is left in levels.

C. Data on term-to-maturity across multiple countries

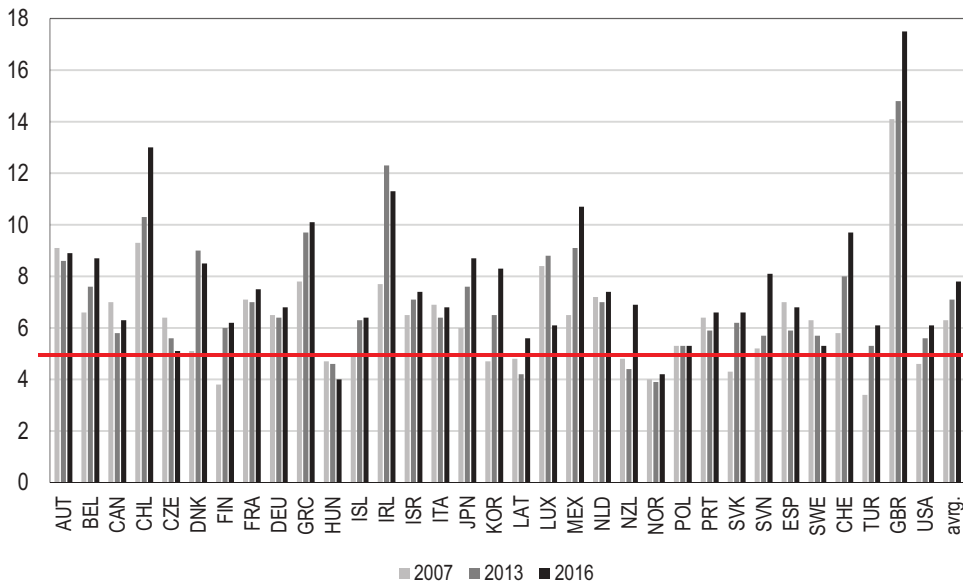


Figure 1C. Average term-to-maturity of outstanding marketable debt in selected OECD countries.

Note: Data is taken from the OECD Sovereign Borrowing Outlook 2017. The solid horizontal line represents the Czech average term-to-maturity as of end-2016.

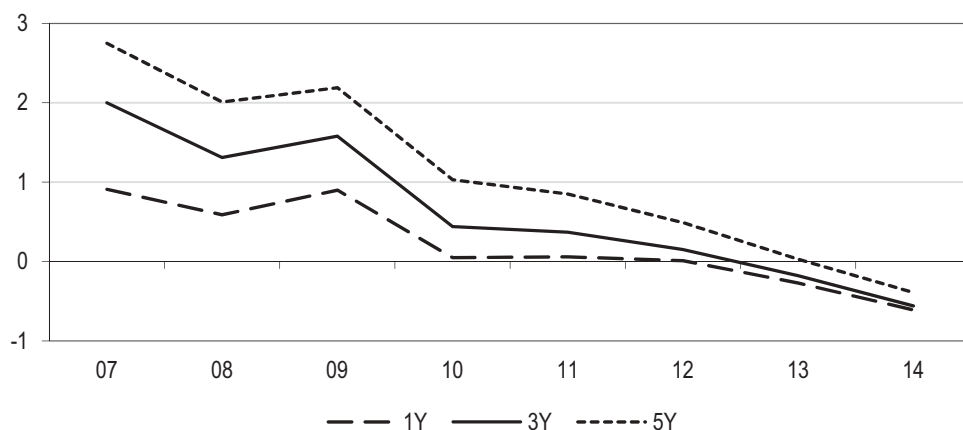


Figure 2C. Average government bond yields in the euro area.

Note: Euro area composition changes throughout the period.

D. Robustness check with respect to different model specification and number of factors

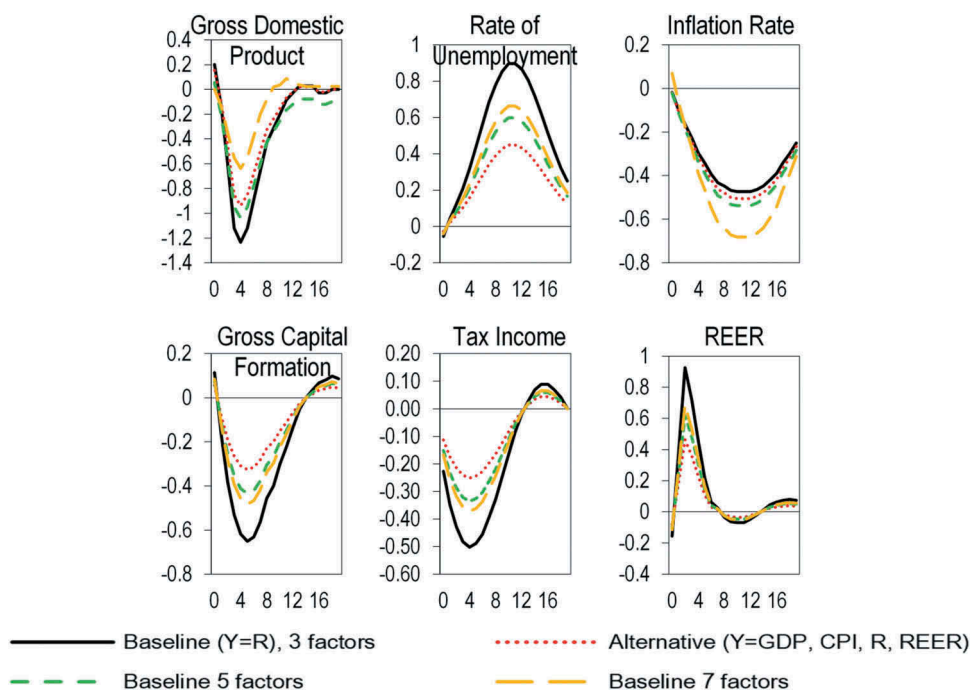


Figure 1D. Monetary transmission into the real economy – alternative model specifications.

Note: Median impulse responses of the FAVAR model with 2 lags are reported; responses are in percentage points; all variables except rate of unemployment and PRIBOR 3M enter the model as annualized percentage growth; the x-axis is in quarters after the shock.

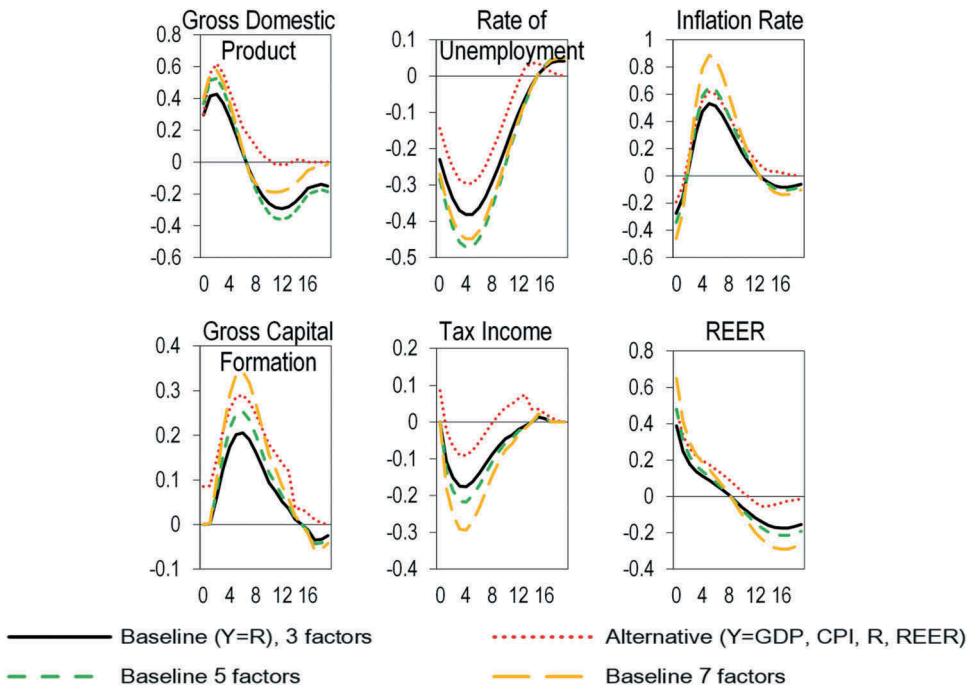


Figure 2D. Fiscal transmission into the real economy – alternative model specification.

Note: Median impulse responses of the FAVAR model with 2 lags are reported; responses are in percentage points; all variables except rate of unemployment enter the model as annualized percentage growth; the x-axis is in quarters after the shock.

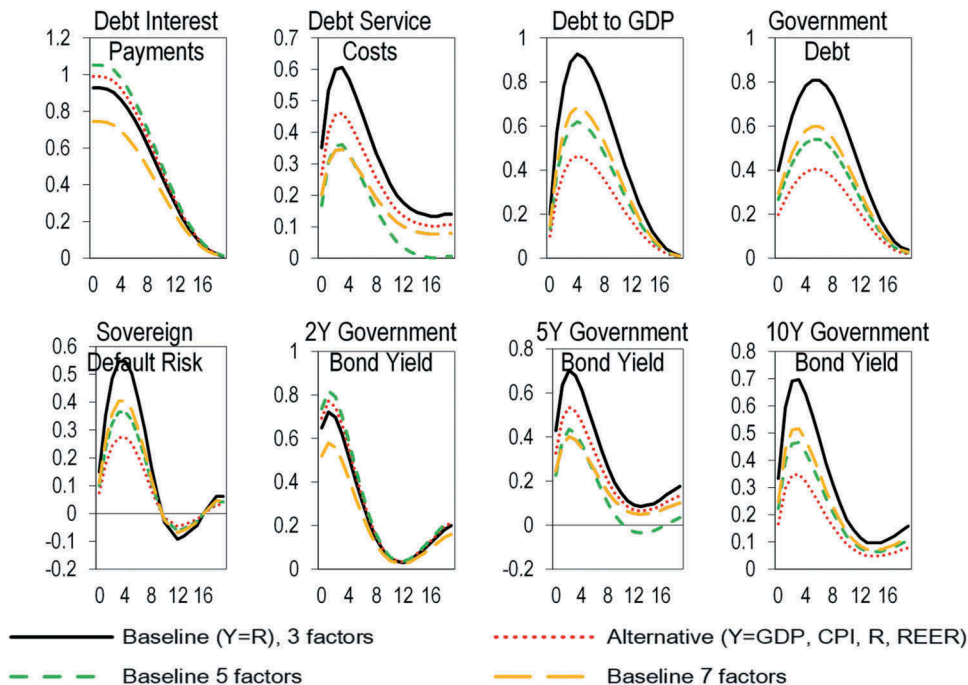


Figure 3D. Monetary restriction and debt management – alternative model specification.

Note: Median impulse responses of the FAVAR model with 2 lags are reported with 90% confidence bounds; responses are in percentage points; the x-axis is in quarters after the shock.

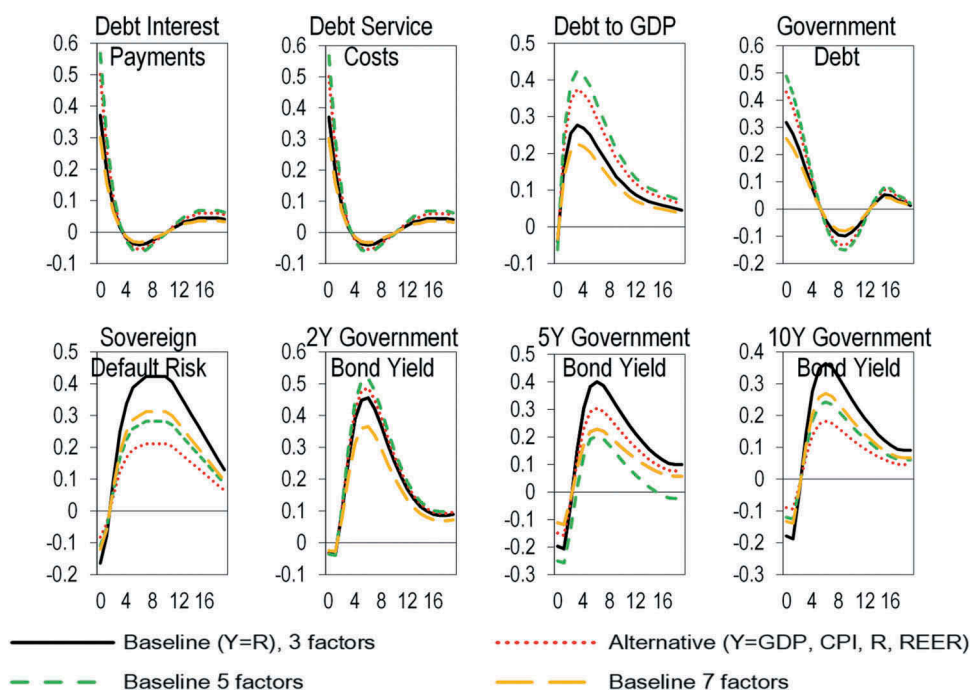


Figure 4D. Fiscal expansion and debt management – alternative model specification.

Note: Median impulse responses of the FAVAR model with 2 lags are reported with 90% confidence bounds; responses are in percentage points; the x-axis is in quarters after the shock.