Non-Linear Monetary Policy Modelling with Government Debt as a Threshold: The Case of the Czech Republic[1]

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Abstract

In this paper, we examine the extent to which monetary policy might be constrained by the evolution of government indebtedness. We employ a threshold vector autoregression (TVAR) model to capture the possible asymmetries in the relationship between monetary policy and the real economy, corresponding to a switch between low and high growth rates of the government debt-to-GDP ratio. The analysis is performed on Czech data over the 2001 – 2016 period. Results show that the reaction of a central bank to macroeconomic shocks can be regime-dependent. We find that a rising government debt could constrain monetary policy, which manifests through an altered monetary policy transmission to the real economy. Overall, our study demonstrates the advantages of using a non-linear approach to study the fiscal and monetary policy interactions.

Keywords: *government debt, monetary policy, policy innovations, threshold VAR*

JEL Classification: C32, E42, H63

Introduction

Following the global financial crisis (GFC) and the subsequent *Great Recession*, extraordinary measures were taken by central banks and governments to prevent a collapse of the financial sector. Support packages from governments

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and monetary authorities during and after the GFC reached unprecedented levels. These actions, combined with the cyclical deterioration of fiscal positions and discretionary fiscal expansions, have led to a substantial pick-up in public debt-to-GDP ratios in many countries (Sipko, 2014). Moreover, to achieve inflation targets in the post-GFC period, central banks created an environment of low or even negative interest rates and applied various unconventional monetary policy tools.[2] These monetary policy actions created even more room for increases in the level of government indebtedness, as they significantly decreased government debt servicing costs. These developments raised some important questions regarding the fiscal-monetary policy relationship. Is the government debt build-up related to monetary policy in some way? Does a high level of government debt influence the monetary policy transmission mechanisms?

We are not the first to ask such questions. Mitra (2007) claims that a high government debt could constrain monetary policy if government spending is expected to adjust in the future in line with debt service costs. Orphanides (2017) draws attention to the fact that central banks have, since the GFC's outbreak, purchased large amounts of government bonds in an attempt to support economic activity and suppress deflationary pressures, which only increased the interconnectivity between the fiscal and monetary policy. A separate strand of literature analyses the interaction between debt management policy and fiscal and monetary policies (Togo, 2007; Blommestein and Turner, 2012). However, most of the empirical literature on the topic imposes a linearity condition on macroeconomic relationships, which might be misleading. A prominent example is the interaction between the financial markets and the real economy, which many studies have found to be potentially non-linear, depending on the state of the financial system (Ravn, 2014; Hubrich and Tetlow, 2015; Franta, 2016). Several studies also examine the effects of monetary/fiscal policy measures during periods of low/high financial stability (Afonso, Baxa, and Slavík, 2018; Fry-McKibbin and Zheng, 2016).

In this paper, we examine how the possibly non-linear interactions among monetary policy and the macroeconomic environment change as the government debt dynamics moves through different phases. A threshold vector autoregression (TVAR) model is employed to capture the asymmetries in the relationship between monetary policy and the real economy, corresponding to a switch between low and high growth of government indebtedness. The threshold variable

[2] In the United States, the United Kingdom, Japan, and the Euro Area, large-scale purchases of financial assets (also known as quantitative easing) have been the centerpiece of non-standard monetary policy measures. Other countries, such the Switzerland and the Czech Republic, have accepted exchange rate commitments and started to use foreign exchange interventions as an additional instrument for easing monetary conditions.

chosen to endogenize the regime switching is the debt-to-GDP ratio. As pointed out in Afonso, Baxa, and Slavík (2018), the debt ratio represents well the overall configuration of fiscal policy, and has been central to many policy discussions about bailouts, fiscal stimuli, and consolidation efforts. The analysis is conducted for the Czech Republic, a small open economy that went through a transformation process from a centrally-planned to a market-based economy in the 1990s. The selection of country is purely pragmatic; the Czech Republic ranks among the most open economies in Europe and has a long-standing environment of low interest rates on government bonds.

By inducing non-linearities into the estimation, we contribute to several strands of literature. First, we contribute to literature that utilizes vector autoregression models to estimate the impacts (and responses) of monetary policy to real economy development. Specifically, we show that monetary policy responses to demand, supply, and fiscal shocks can be largely dependent on the evolution of government indebtedness. This finding is supported by the fact that we also detect significant asymmetries in the monetary policy response to changes in the debt-to-GDP ratio. This asymmetry in the monetary-real economy relationship would remain undetected if one only employed a linear model. Second, we provide some insight into the well-established literature that deals with fiscal-monetary policy interactions (Mountford and Uhlig, 2009; Rossi and Zubairy, 2011, to name a few). We find that the fiscal policy action might sometimes weaken the monetary policy transmission. This was found to be true in monetary policy transmission to real GDP and housing prices.

The remainder of the paper is organized as follows: Section 1 serves as a review of the literature published on the monetary policy transmission. Section 2 outlines the theoretical underpinnings of the empirical framework applied. Section 3 describes the data employed. Section 4 discusses empirical results, and last section concludes.

1. Conceptual Issues in Interpreting Monetary Policy Transmission to the Real Economy

Conceptual views on the estimated effects of monetary policy shocks differ, suggesting to striking differences in historical interpretations. A key question of monetary economics is the sensitivity of the economy to the set of monetary policy instruments. Quantifying this sensitivity, however, requires disentangling endogenous and exogenous changes behind the policy instruments.

The standard vector autoregression (VAR) literature has already provided a number of stylized facts about the effects of monetary policy on the real economy.

For example, Christiano, Eichenbaum, and Evans (2005) found that, in response to an increase in nominal interest rates, the real GDP and monetary aggregates decline, causing the price level to decrease as well. Bernanke, Boivin, and Eliasz (2005) estimated a factor-augmented vector autoregression model and found that a 100 basis point increase in the Federal Reserve Rate (FRR) lowers industrial production by a maximum of approximately 0.6% and raises the unemployment rate by 0.2 percentage points. Gorodnichenko (2004) proposed an alternative factor-based VAR analysis, which predicts a peak drop in real GDP of approximately 0.8%. Faust, Swanson, and Wright (2003) estimated the effects of monetary policy shocks using futures markets for the FRR and found a peak drop in GDP of 0.6%.

Romer and Romer (2004, R&R henceforth), on the other hand, reach a very different conclusion using a novel approach to identify monetary policy innovations, by first constructing a historical series of interest rate changes decided upon at meetings of the Federal Open Market Committee (FOMC), and then isolating the innovations to these policy changes that are orthogonal to the Federal Reserve's information set. R&R identify large effects of monetary policy shocks and indicate that these shocks can account for much of the historical fluctuations at business cycle frequencies in production, employment, and inflation. Through a deeper analysis of all mentioned approaches, the study of Coibion (2012) defined three key elements playing a significant role in accounting for the difference in the estimated effects of monetary policy shocks across the different methods. The differences are driven by three factors: the different contractionary impulse, the period of reserves targeting, and lag length selection.

While focusing on the Czech economy, Borys, Horváth, and Franta (2009) examined the effects of monetary policy within the vector autoregression (VAR), structural VAR (SVAR), and factor-augmented VAR (FAVAR) frameworks during the inflation targeting period in the Czech Republic. The authors focused on assessing the persistence and magnitude of monetary policy shocks on output, prices, and the exchange rate while controlling for a standard set of factors. They concluded that monetary transmission in the Czech Republic seems to be similar, in terms of persistence of the responses of economic variables to monetary shocks, to that seen in highly developed countries, including the Euro Area. Ryšánek, Tonner, and Vašíček (2011) studied the monetary policy implications of financial frictions in the Czech Republic. They developed a model which serves as a tool for understanding how a negative financial shock may spread to the real economy and how monetary policy may react.

However, the effects of monetary policy may differ in times of certain types of economic frictions. The literature dealing with the effects of monetary policy during periods of, for example, financial stress is relatively scarce, but growing. In a recent paper, Avdjiev and Zeng (2014) applied a threshold vector autoregression (TVAR) methodology to examine the non-linear nature of the interactions among credit market conditions, monetary policy, and economic activity. Results indicate that the impact of most shocks tends to be larger during periods of sub-par economic growth and smaller during times of moderate economic activity. By contrast, credit risk shocks have the largest impact when output growth is considerably above its long-term trend. In a similar study, Fry-McKibbin and Zheng (2016) analysed the impact and effectiveness of conventional monetary policy during periods of low and high financial stress in the US economy by estimating a TVAR model to capture switching between the low and high financial stress regimes. Afonso, Baxa, and Slavík (2018), on the other hand, analysed fiscal policy spillovers to the real economy. They found that the non-linearity in the response of output growth to a fiscal shock was mainly associated with differential behaviour across regimes.

As far as we can tell, there are no studies that investigate empirically the effects of monetary policy associated with periods of sharp increase in government debt. Melecký and Melecký (2012) analysed the effects of macroeconomic shocks on the government debt dynamics in the Czech Republic, and argued that allowing for non-linear dynamics in the government debt-to-GDP ratio could imply stronger persistence and higher volatility in the responses of government indebtedness to macroeconomic shocks.

2. The Two-Regime Threshold Model

We follow the approach first used by Balke (2000) and estimate a threshold vector autoregression (TVAR) model of monetary policy effectiveness with respect to possible bindings caused by the government debt dynamics. We augment the standard and widely used monetary policy VAR model with a threshold variable for which we have chosen the government debt-to-GDP ratio. The motivation for using the government debt-to-GDP ratio as a threshold stems from the fact that it is already used as one of the Maastricht convergence criteria and is currently considered as a target measure for the debt brake by the Czech and Slovak governments. The proposed value for this balanced budget amendment ratio is currently set to 55%.

The TVAR is a relatively simple way to capture any possible non-linearities in the data (such as the existence of multiple equilibria or asymmetry in variables' reactions to innovations). It also allows us to generate non-linear impulse response functions so we can better differentiate between the effects of monetary policy under different regimes (in our case the regime-switching is determined by government debt-to-GDP dynamics). These features make the TVAR model an attractive and useful approach for our purposes. The threshold VAR model can be expressed using the following notation:

$$Y_t = A_1 Y_t + B_1 (L) Y_{t-1} + A_2 Y_t + B_2 (L) Y_{t-1} I (y_{t-d} \geq \gamma) + e_t \quad (1)$$

where

Y_t – vector of endogenous variables,

$B_{1,2}(L)$ – lag polynomial matrices,

I – indicator function that takes the value of one if the threshold variable is larger than estimated threshold value γ and zero otherwise,

$A_{1,2} Y_t$ – contemporaneous structural terms,

e_t – vector of structural innovations.

In order to allow the system to change regimes during our simulation period, we compute the non-linear impulse response functions (NIRF) proposed by Koop, Pesaran, and Potter (1996). In a linear VAR model, the impulse response functions are computed directly from the estimated VAR coefficients and they are symmetric in sign and size of the respective structural shocks. However, in the class of non-linear models, the shocks may lead to switches between regimes. The NIRFs are defined as the difference between the forecast path of variables with and without a shock to the variable of interest. More formally, the NIRFs are defined as:

$$NIRF_k^{(i)} = E\left[Y_{t+k} \left| \varepsilon_t^{(i)}, \Omega_{t-1} \right.\right] - E\left[Y_{t+k} \left| \Omega_{t-1} \right.\right], \text{ for } k = 0,\ 1, \ldots, \quad (2)$$

where

Ω_{t-1} – regimes that the system is initially in,

Y_{t+k} – vector of variables at horizon *k*.

To obtain accurate NIRFs, the computational algorithm proceeds as follows: First, we chose an initial condition for the model, $\Omega_{n,t-1}$, which is the actual value of the lagged variables on a particular date. The conditional expectation of Y_{t+k} is dependent on $\Omega_{n,t-1}$ and the realized shock $\varepsilon_t^{(i)}$. Because of the fact that the shock $\varepsilon_t^{(i)}$ could result in a regime switch, different initial conditions and different sizes and signs of shocks can result in asymmetric impulse responses. Second, to compute $E\left[Y_{t+k} \left| \Omega_{t-1} \right.\right]$, we generate a random sample u_{t+k} by taking bootstrap samples from estimated model residuals $\hat{\varepsilon}_t$. Then, we simulate the model using the random sample u_{t+k}, which is conditional on the initial regime

$\Omega_{n,t-1}$. The above-mentioned steps of our simulation procedure are repeated in order to eliminate any asymmetry that may arise from sampling variation in the draw of the random sample u_{t+k}. Third, to compute $E\left[Y_{t+k}\middle|\varepsilon_t^{(i)},\ \Omega_{t-1}\right]$, we feed the model the specified shock $\varepsilon_t^{(i)}$ and apply the same simulation process as in the second step.

3. Data and Details on the TVAR Application

We estimate the TVAR model using quarterly Czech data that runs from 2001/Q1 to 2016/Q3. We use a recursive identification scheme for the TVAR. In our benchmark model, Y_t consists of five variables (see Table 1 for description) in the following order: (1) real GDP growth, (2) annualized rate of inflation, (3) government debt-to-GDP ratio, (4) housing price index, and (5) the 3-month inter-bank rate (PRIBOR 3M).[3] This particular ordering reflects some standard assumptions about the monetary policy reaction function. We order the inter-bank rate last, which implies that monetary policy reacts contemporaneously to all variables in the specified system. The ordering of the fiscal variables (government debt-to-GDP) is in line with Blanchard and Perotti (2002), who assume that all reactions of fiscal policy are automatic due to implementation lags and the policy cycle. We also test the sensitivity of our model by first placing the government debt-to-GDP last in the matrix, then placing it as the first variable in our Cholesky matrix. The number of lags in the TVAR model was set to two based on the Schwarz information criteria test.

Table 1

List of Variables

Mnemonic	Description	Source	Specification
RGDP	Real Gross Domestic Product	CNB	seasonally adjusted, 2010 = 100
CPI	Consumer Price Index	CSO	2010 = 100 index
DEBT	Government Debt-to-GDP	CSO	ratio, own calculation
IR	PRIBOR 3M	CNB	inter-bank rate, in %
HPI	Housing Price Index	CSO	2010 = 100 index

Note: Prior to entering the model, all variables were transformed using first logarithmic difference (except for the inter-bank rate, which was left in levels).

Source: Czech National Bank (CNB) and Czech Statistical Office (CSO).

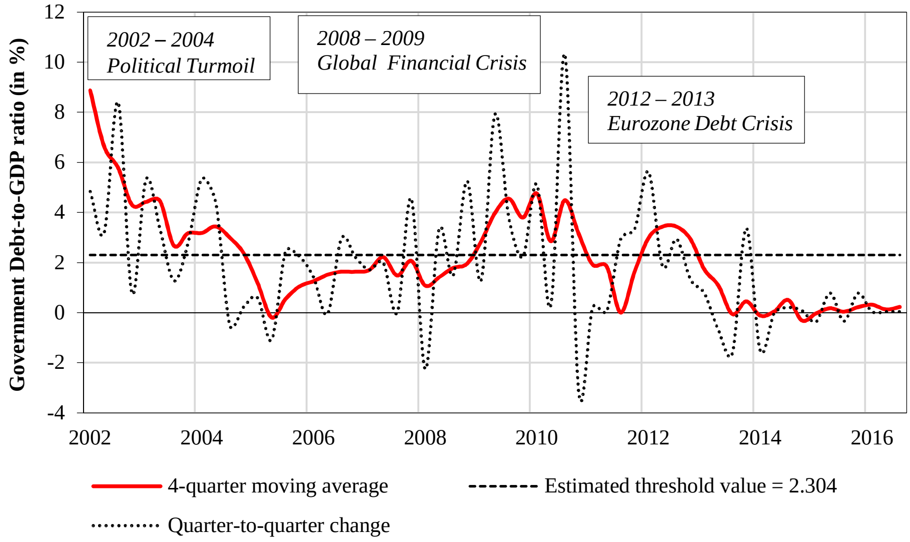
We use the four-quarter moving average of debt-to-GDP growth as the threshold variable. The motivation for filtering in this manner lies in the apparent

[3] Note that we use the PRIBOR rate to proxy for the CNB's key monetary policy rate, i.e. the two-week repo, similar to how it is done in the CNB's own forecasting system.

lumpiness of government revenues and expenditures (Dungey and Fry, 2009). The original data exhibits relatively high variance, which is not an outcome of seasonality, but more likely of the political cycle, especially in the early 2000s.

Figure 1

The Threshold Variable and Estimated Threshold Value



Source: Authors' calculations based on CSO data.

Figure 1 displays a plot of the government debt-to-GDP ratio and its four-quarter moving average which was used as the threshold variable. The estimated threshold value $\gamma = 2.30411$ splits the sample into two regimes (low and high). The first (high) regime is active when the government debt-to-GDP growth is over the estimated threshold value of 2.3%. This condition is satisfied for 24 observations. In turn, the second (low) regime includes periods during which government debt-to-GDP growth was below 2.3% (34 observations). Since we wished to avoid making prior assumptions about the threshold value, we decided to use a standard algorithm which explores several different threshold levels to provide a good fit to the data.

4. Results and Discussion

Before we discuss results, we need to test whether the estimated threshold value is statistically significant. In order to do so, we follow Hansen (1996) and Balke (2000) and compute three different Wald test statistics over all possible threshold values: the maximum Wald statistic (sup-Wald); the average Wald statistic (avg-Wald) and the sum-of-exponential Wald statistic (exp-Wald). The results are reported in Table 2, together with the respective p-values. Note that we have limited the possible threshold values so that each regime includes at least 15% of the observations, as in Hansen (1996).

Table 2

Wald Tests for Threshold Effects in the Benchmark Model

Threshold Variable: MA(4) of Debt-to-GDP ratio			
Estimated Threshold Value: $\gamma = 2.30411$	Estimated Delay: $\hat{d} = 2$		
Tests	sup-Wald	avg-Wald	exp-Wald
Linear versus 2-regime model	346.05 (0.000)	310.77 (0.000)	171.64 (0.000)

Note: MA(4) denotes a moving average of length of four. P-values in parentheses are based on the simulation method as in Hansen (1996) and are based on 1,000 repetitions.

Source: Authors' calculations.

It is evident from the values reported in Table 2 that the threshold is always significant, with a p-value of less than 0.0001 for all the Wald statistics. It should be noted that the results of the Wald statistics are robust with respect to alternative recursive restrictions on the coefficient matrices.

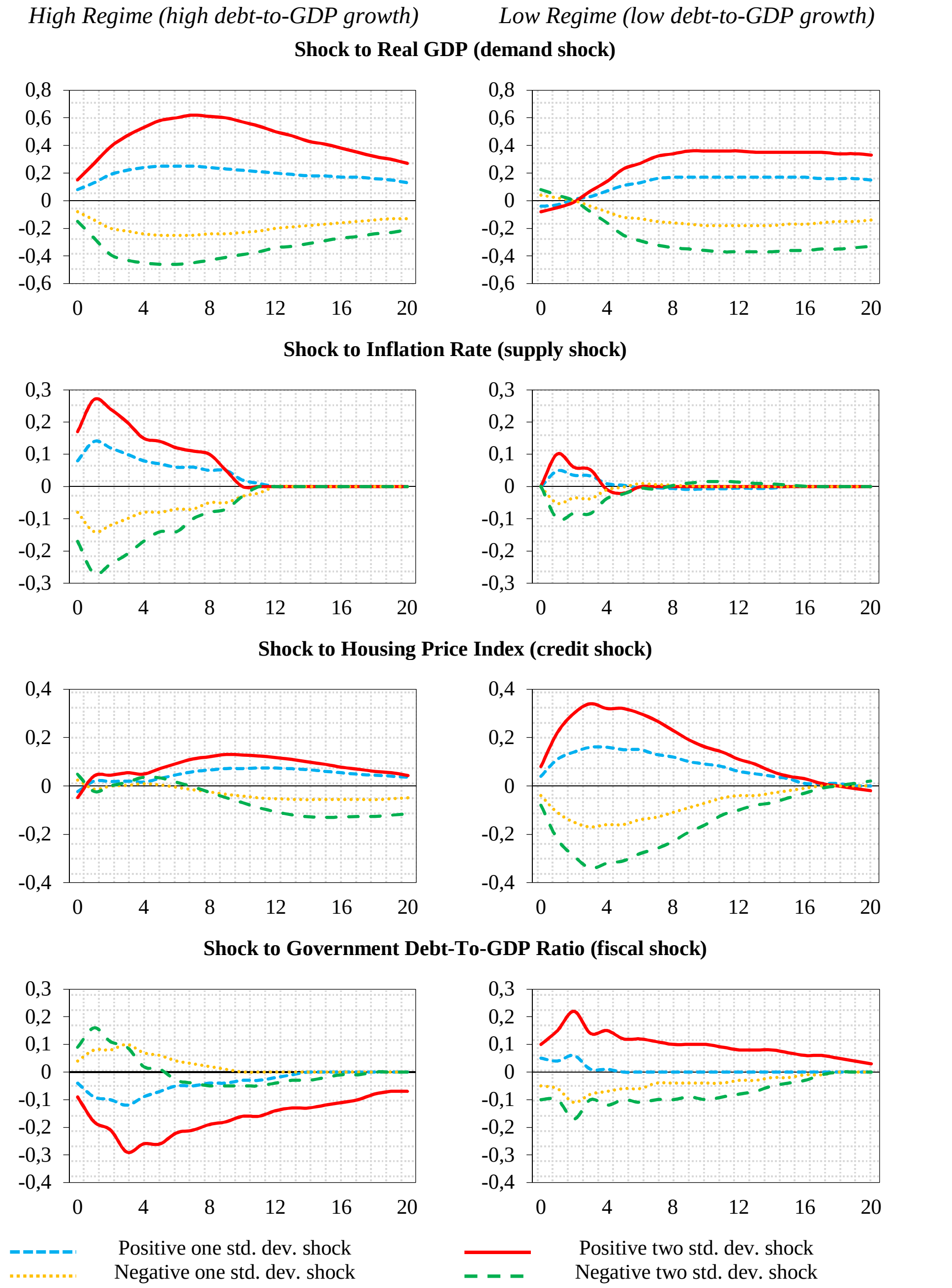
The following sections summarize the non-linear impulse responses of our variables of interest. We plot the median responses to show the central tendency of the estimated response functions. To capture the potential asymmetry in responses, we simulate structural shocks of different sign (positive or negative shock) and different sizes (one or two standard deviations). First, we show the responses of the inter-bank rate to various types of shocks. This exercise shows how the central bank might respond to different market disturbances while accounting (or not) for increases or decreases in government debt. Second, we measure the transmission of monetary policy measures in different government debt regimes.

4.1. The Non-Linear Responses of Monetary Policy to Various Types of Shocks

Figure 2 shows the responses of the inter-bank rate to shocks to real GDP (demand shock), inflation (supply shock), government debt (fiscal shock), and the housing price index (credit shock). Given the mutual close dependence of the inter-bank rate and the official two-week repo rate, we interpret the responses in Figure 2 as the monetary policy response.

Figure 2

The NIRFs of the Inter-Bank Rate to Specific Shocks



Note: graphs at left show responses in the high regime (high public debt growth); graphs at right show responses in the low regime (low public debt growth). Y-axis denotes median response to given shocks of different size (one or two standard deviations) and sign (positive or negative shock); x-axis is in quarters after the shock.

Source: Authors' calculations.

The impact of a demand shock on the monetary policy rate (Figure 2, first row) is greater in the high debt-to-GDP growth regime. This suggests that the CNB is more likely to react more aggressively to deviations of output in times when government debt is exhibiting a high growth rate. This can happen for two reasons: Either there is political turmoil of some kind that increases uncertainty in the economy, and hence the central bank will be more likely to intervene to signal its enduring commitment to stable inflation (thus bolstering the nominal anchor of the economy), or fiscal policy is also active and the government increases its expenditures, which in turn increases output. The second case also explains the fact that the responses of the monetary policy rate to large (two-standard-deviation) output shocks exhibit some asymmetry: In the high government debt growth regime, positive output shocks have a larger effect on the monetary policy rate than negative output shocks. This difference might well be explained by the above-mentioned fiscal expansion, which would reduce the decrease in output, thus making in unnecessary for the central bank to intervene so drastically. In the low regime, monetary policy reaction to output shocks is smaller than in the high regime.

The impact of a supply shock on the monetary policy rate (Figure 2, second row) exhibits small asymmetries in terms of size of the shock, but again there are some differences between the high and low government debt-to-GDP growth regimes. The central bank seems to react more aggressively when fiscal policy is also active and government debt is growing. As mentioned above, government debt might be growing due to an increase in government expenditures, which would also raise inflation.

The response of the monetary policy rate to a credit shock (Figure 2, third row) also appears to be heavily regime-dependent. Judging from the responses across regimes, the central bank appears to be reluctant to intervene against increasing (or decreasing) housing prices when government debt is growing rapidly (high regime). In case of a positive credit shock (increase in housing prices), the monetary policy response is lagged, but less so than in the case of a negative credit shock. When housing prices are falling and the government debt is growing (as a result of fiscal expansion), the central bank might not need to intervene to boost the economy and stabilize residential property prices, as the fiscal expansion might well do that on its own. This explanation is also supported by the monetary policy response in the low regime which is almost perfectly symmetric. In fact, the central bank needs to intervene only to the extent to which the change in housing prices would be transmitted into the respective consumer price index. Pfeifer and Pikhart (2014) show that during the 1996 – 2011 period, real estate prices were virtually uncorrelated with consumer prices. Subsequently, they argue that the real estate wealth effect is very weak in the Czech Republic.

The monetary policy response to a fiscal shock drawn from the government debt-to-GDP ratio (Figure 2, fourth row) points to some striking differences in mutual fiscal-monetary interactions and motivates a careful consideration of the sources of shocks to a debt-to-GDP ratio. A positive fiscal shock (increase in the level of indebtedness as a proportion of output) in the high regime causes a decrease in the monetary policy rate. This corresponds to the idea that the increase in the debt-to-GDP ratio might be caused by a decline in output, in which case the central bank would be responding to deflationary pressures in the economy. As a by-product, it also lowers the government debt service costs. In the low debt regime, the shocks differ, since positive fiscal shock causes increase in the monetary policy rate to ease inflationary pressures caused by a fiscal expansion.

4.2. The Non-Linear Responses of Macroeconomic Variables to Monetary Policy Shocks

The impulse responses of selected macroeconomic variables to positive and negative monetary policy shocks in different regimes are shown in Figure 3. Note that, for interpretation purposes, we must explicitly assume that the economy remains in the regime prevailing at the time of the shock. In general, it seems that the responses differ between the high and low regime mostly in terms of magnitude.

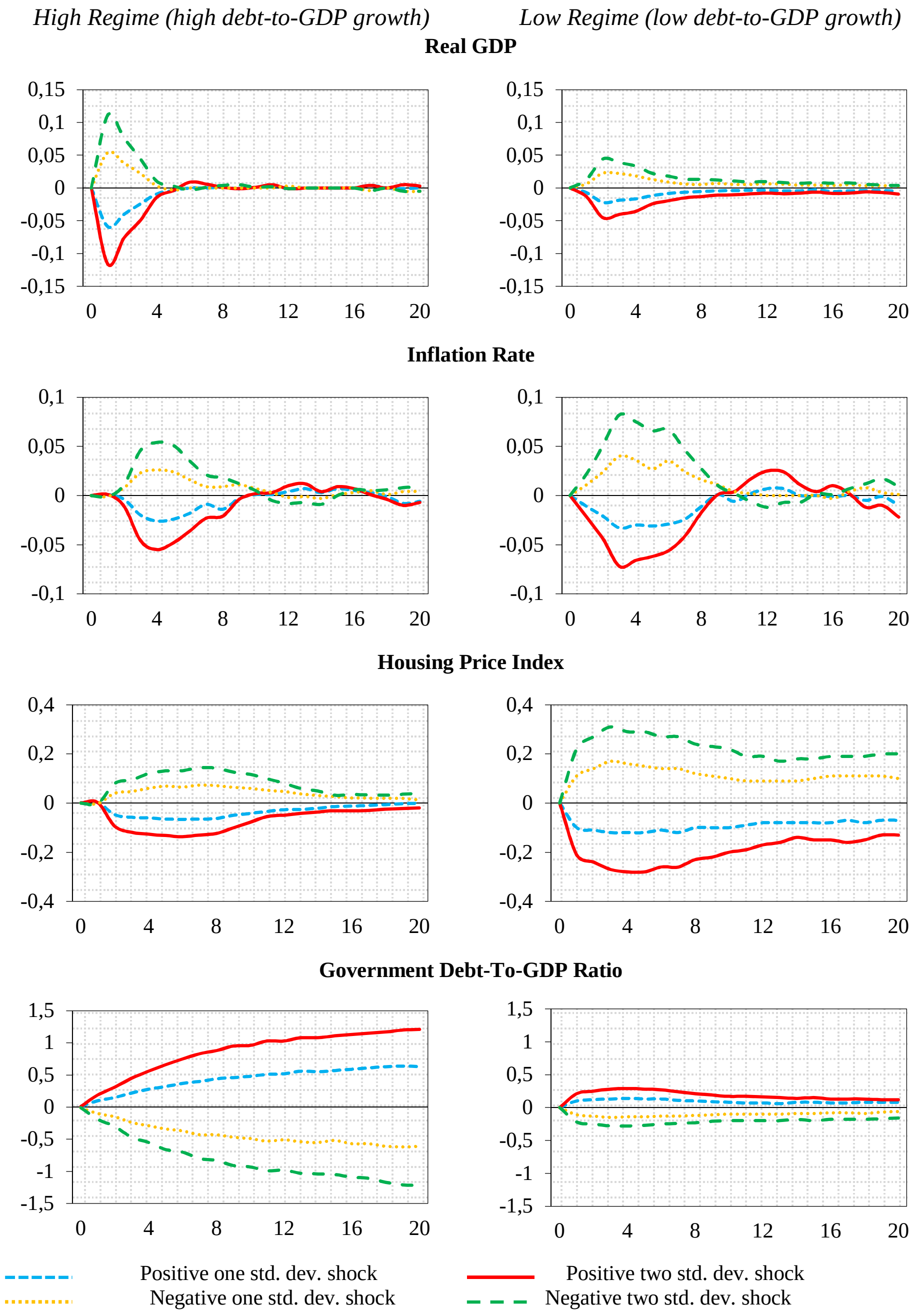
The impact of monetary policy shocks on real GDP growth is substantially larger when the economy is in the high government debt-to-GDP growth regime. This is consistent with the results in Avdjiev and Zeng (2014), who found that monetary policy shocks have stronger effects on output during periods of low economic growth, which would cause the debt-to-GDP ratio to increase.

The responses of the inflation rate are of the expected sign, meaning that after a positive monetary policy shock the inflation decreases and vice versa. The only difference is in a slightly stronger inflation rate response in the low regime. Note that we do not report any price puzzle, suggesting our model avoids this issue that so often plagues the VAR literature (see Rusnák, Havránek, and Horváth, 2013).

The effects of a monetary policy shock on residential property prices are of the expected sign; i.e., a monetary restriction reduces demand for new mortgage contracts, which in turn reduces demand for residential property purchases, and housing prices decrease (in line with recent evidence provided in Nocera and Roma, 2017, for the Euro Area). We find the responses to differ slightly between the two regimes. The response of the housing price index is more severe in the low regime, since the fiscal expansion or economic downturn in the high debt-to--GDP growth regime might weaken the monetary policy measures.

Figure 3

The NIRFS of Selected Variables to Monetary Policy Shocks



Note: Graphs at left show responses in the high regime (high public debt growth); graphs at right show responses in the low regime (low public debt growth). Y-axis denotes median response to given shocks of different size (one or two standard deviations) and sign (positive or negative shock); x-axis is in quarters after the shock.

Source: Authors' calculations.

Government debt-to-GDP ratio exhibits the greatest reaction to monetary policy shocks in the high regime as expected. An increase in the monetary policy rate reduces demand and, in turn, output, which increases the debt-to-GDP ratio, and vice versa.

Regime-dependent impulse responses have proven useful in describing the behaviour of the economy within each regime. The regime-dependent impulse responses in the previous sections provide a clear indication of the differences in responses across regimes, and analyse the overall impact of both monetary transmission and reaction to different shocks to the economy.

Conclusion

In this paper, we analyse how changes in government debt dynamics may influence the relationship between monetary policy and the macroeconomic environment. To this purpose, we estimate a non-linear threshold vector autoregression (TVAR) model of monetary policy with the government debt-to-GDP ratio as the threshold. In particular, we measure the responses of the inter-bank rate to shocks to real GDP (demand shock), inflation (supply shock), government debt (fiscal shock), and the housing price index (credit shock), and also the impulse responses of chosen macroeconomic variables to a positive and negative monetary policy shock in different fiscal regimes. Our results can be summarized as follows:

First, we show that the responses of monetary policy to demand, supply, credit, and fiscal shocks can be heavily regime-dependent. In general, we find that the central bank responds the most to a demand shock, while the response is more pronounced if the government debt exhibits a high growth rate (as a result of political turmoil or fiscal expansion). Similarly, we find that monetary policy responds less to expected inflation if government debt increases. Of course, this does not necessarily mean that the policy is accommodating; rather, the same expected inflation would require a more gradual response due to the extra constraints on the supply side. Note that this could easily translate into central bankers feeling pressured when government debt is growing. Obviously, these asymmetries across regimes would remain undetected if one only examines a linear model.

Second, we detect significant non-linearities in the monetary policy response to changes in the government debt-to-GDP ratio. If the level of indebtedness as a proportion of output exhibits a growing trajectory, we find that the central bank decreases its nominal interest rate in response. Note that it is unlikely for the central bank to respond directly to the worsening fiscal position. However, in case of, for instance, a negative macroeconomic shock that decreases real economic activity (which in turn increases the debt-to-GDP ratio), the monetary expansion would lower debt service costs as a by-product of its main purpose, i.e., to relieve deflationary pressure. This shows that fiscal and monetary policy coordination in the event of shocks to output is beneficial to both, monetary and fiscal policy, as it can be executed without excessive deterioration of the fiscal position.

Third, monetary policy transmission seems to be, at least to some extent, sensitive to government debt dynamics. In our model, a contractionary monetary policy shock, expressed by a positive innovation in the interest rate, causes a decline in real GDP, the government debt-to-GDP ratio, housing prices, and the inflation rate. When the system is allowed to switch between regimes, we find that the fiscal policy action might sometimes weaken monetary policy transmission. This was found to be true especially in the case of monetary policy transmission to real GDP and housing prices.

From a policy perspective, these results lend additional support to increased prudence at high public debt ratios because the effectiveness of fiscal stimuli to boost economic activity or resolve external imbalances may not be guaranteed.

Overall, our study demonstrates the advantages of using a non-linear approach to study the interactions of fiscal and monetary policy. From a policy perspective, we provide time-series evidence showing that monetary policy cannot view fiscal policy as Ricardian (passive), but must consider its actions to prevent potential conflict situations. In other words, we provide some support for the claim that debt constraints can alter the monetary policy transmission mechanism. This is of more than academic interest, as even the historically low-debt Czech Republic might find itself operating under a debt constraint if its public debt crosses a certain threshold level.

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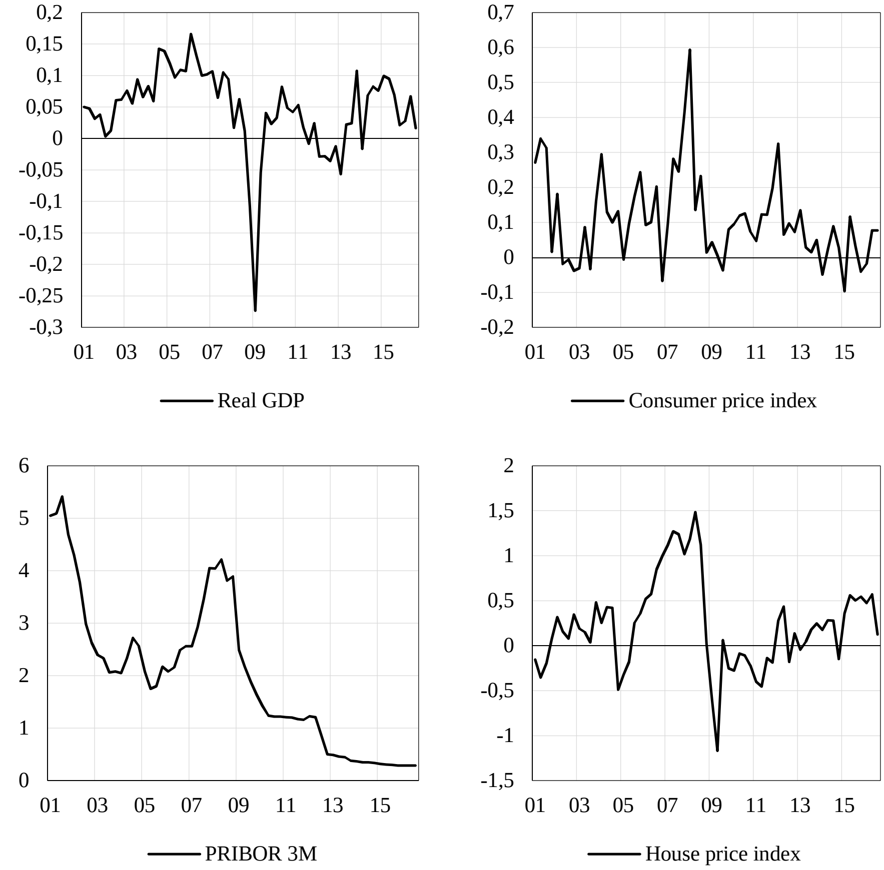
Appendix

F i g u r e 1A

Time Series Used in the Analysis

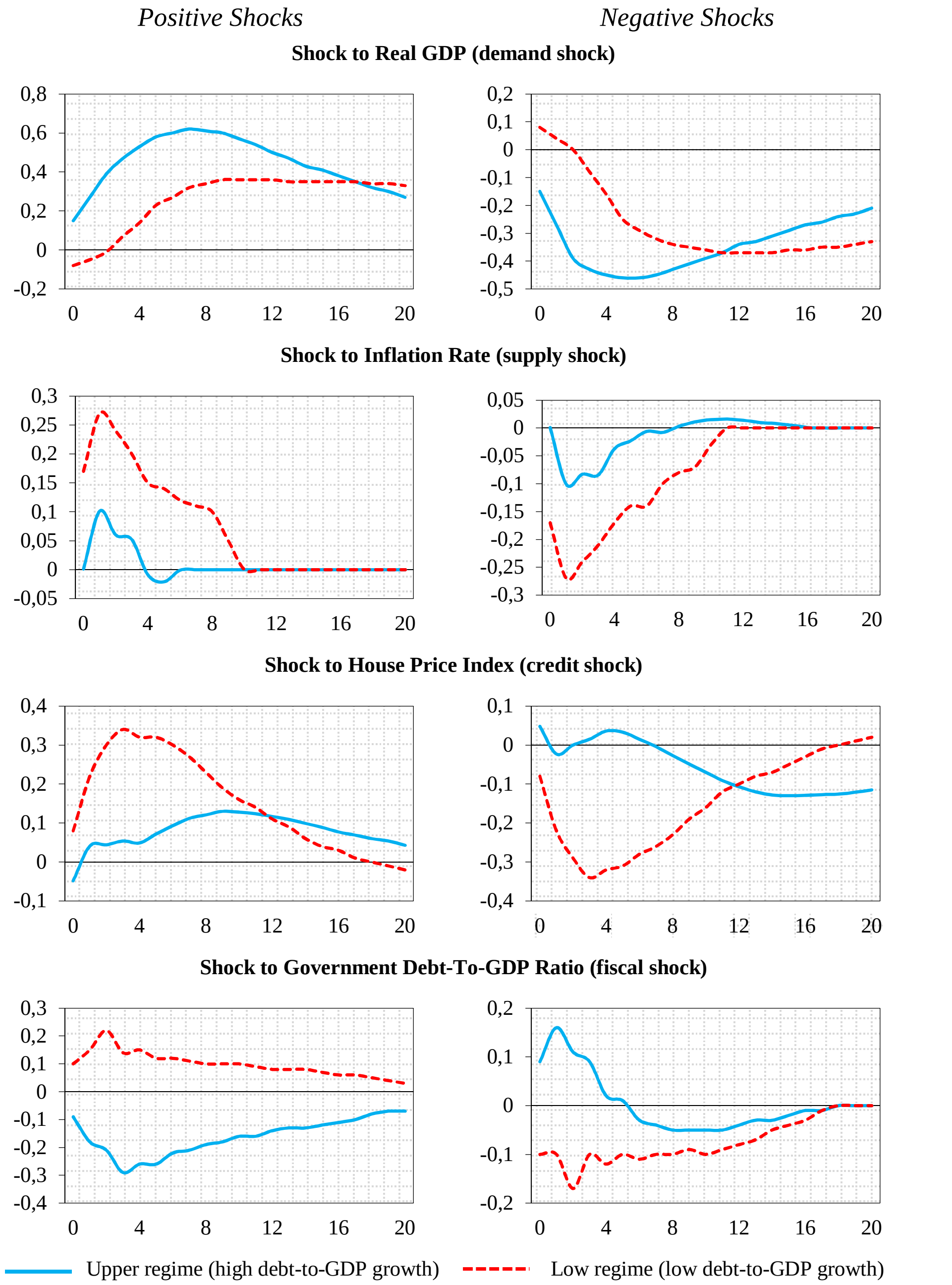


Note: Variables are depicted in quarter-to-quarter change.

Source: Czech National Bank (CNB) and Czech Statistical Office (CSO).

Figure 2A

The Non-Linear Impulse Response Functions of Monetary Policy Rate to Two Standard Deviation Macroeconomic Shocks in Different Regimes

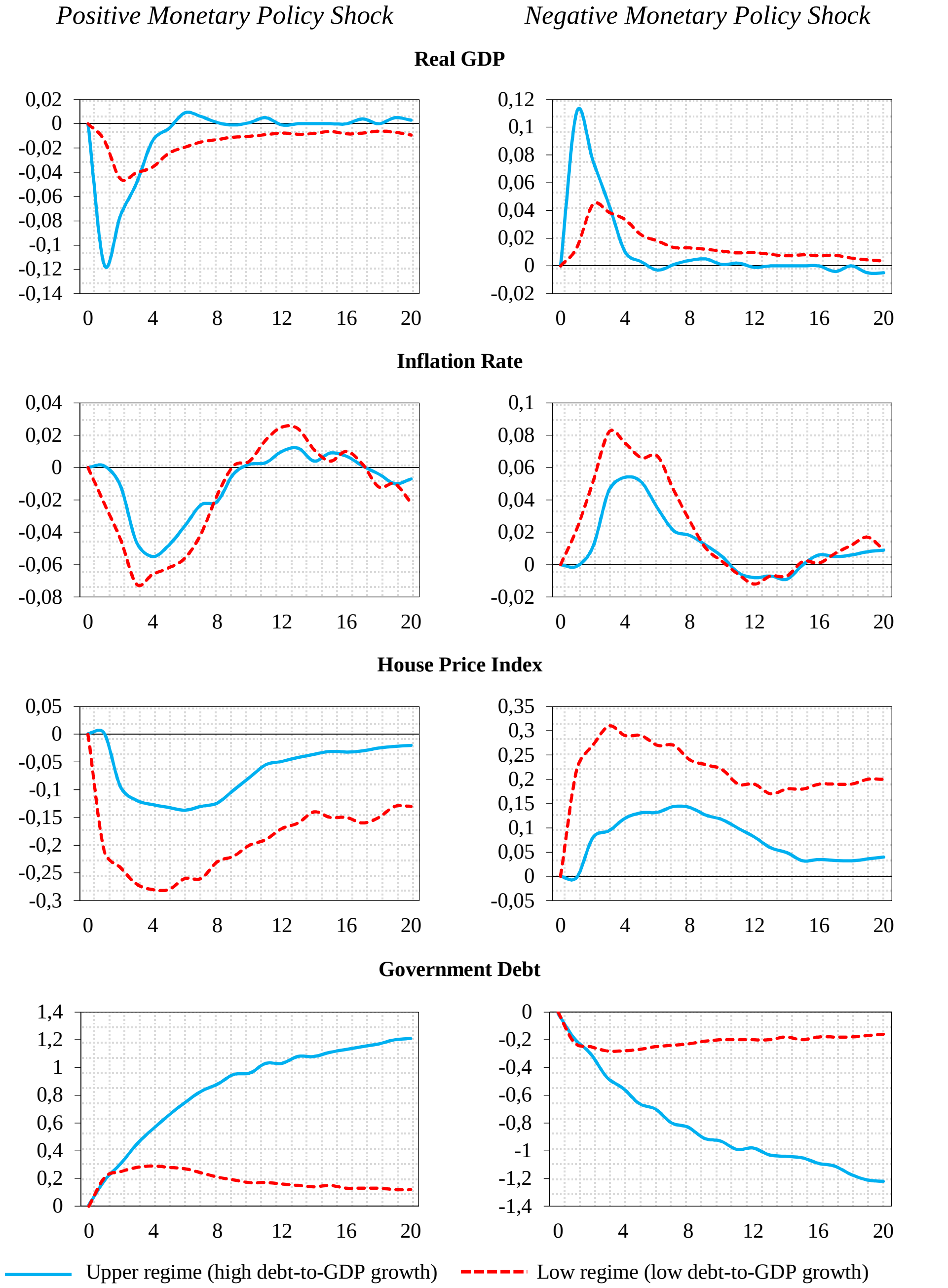


Note: Left-sided graphs show responses to positive two std. dev. shocks; right-sided graphs show responses to negative two std. dev. shocks. Red dotted line (low regime) and blue solid line (upper regime). Y-axis denotes median response to a given shock; x-axis is in quarters after the shock.

Source: Authors' calculations.

F i g u r e 3A

The Non-Linear Impulse Response Functions of Variables to Two Standard Deviation Monetary Policy Shocks in Different Regimes



Note: Left-sided graphs show responses to positive two std. dev. shocks; right-sided graphs show responses to negative two std. dev. shocks. Red dotted line (low regime) and blue solid line (upper regime). Y-axis denotes median response to a given shock; x-axis is in quarters after the shock.

Source: Authors' calculations.