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Monetary and Fiscal Policy Interactions in the Czech Republic

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Abstract: The paper provides empirical analysis of interactions between monetary and fiscal policy in the Czech Republic and document changes in policy conduct across the time. To this end, we build and estimate a six-variable Bayesian VAR and propose some refinements to the modelling framework. These improvements make it possible to better capture the main features of the economic system populated by both macroeconomic policy authorities. The results point to the lack of complementarity between policy actions adopted by the authorities and suggest that there is still enough room for enhancing the effectiveness of economic policies.

1. Introduction

The optimal mix of monetary and fiscal policy contributes to a smooth operation of the economy and fosters social and economic welfare. Despite formal independence of monetary and fiscal authority, they could hardly ignore measures adopted by its counterpart or fully offset these measures by their own policies. Close co-ordination between the authorities responsible for macroeconomic performance is vital for predictable and stable economic development.

In practice, however, mutual co-ordination may pose considerable challenges due to the high complexity of the economic system where dozens of dynamic interactions between economic agents and economic policy authorities arise. Predictability of outcomes resulting from policy actions is further blurred by the existence of feedback loops. Under these conditions, it might be difficult to co-ordinate both policies—notably, if one takes into account paucity of reliable data available in real time. Against this backdrop, empirical analysis of mutual interactions between monetary and fiscal policy represent an important area of research which can supply policy makers with the necessary guidance and back up their decision-making process. Given the complexity of the economic system, usefulness of such an analysis crucially hinges on robust modelling tools as well as a great portion of prior experience.

This paper provides thorough empirical analysis of monetary and fiscal policy interactions in the Czech Republic and investigates whether the nature of these interactions has changed in the aftermath of the global financial crisis. To achieve the goal, Bayesian VAR model for the Czech economy is estimated and interactions are studied through the lens of impulse-response analysis. Particular focus in the paper is paid to refinements in the modelling framework and estimation. VAR models [1] represent a popular class of models which are commonly used for the analysis of economic policy effects. However, they are very greedy when it comes to the number of estimated parameters. In this context, Bayesian approach facilitates incorporation of experts' knowledge into the model and alleviates the problem with short

time series and a low number of degrees of freedom. This problem can hardly be solved by any other means in the Czech conditions as the underlying data virtually does not exist prior to the year 1993 (the year of the split of Czechoslovakia into two separate entities).

Our contribution to earlier literature is threefold and covers both the theoretical and empirical domain. First, we pay particular attention to a proper specification of the VAR model in its reduced form. This phase of the estimation process is often overlooked in empirical research but we argue that it is as crucial as the phase of shock identification. As noted by Andrle and Brůha [2]: If a reduced form of the VAR model is mis-specified, then no identification wizardry can save it. Second, we employ a novel approach to the formulation of priors on the reduced-form coefficients which takes into account cyclical nature of the time series used in the analysis. Our approach produces more intuitive shapes of impulse-response functions when compared to traditional Minnesota-style priors proposed by Litterman [3]. Last but not least, our study is one of the first to provide thorough assessment of monetary and fiscal policy interactions in the Czech economy and—to our knowledge—it is the very first study which also documents changes in mutual co-operation across time.

The paper is organized as follows. Section 2 reviews related literature. Section 3 describes the model and discusses our approach to shock identification. Necessary details on data and formulation of priors are also provided here. Section 4 briefly summarizes the results. The final section concludes and discusses possible extensions. These are, however, left for future research.

2. Literature Review

VAR models have often been used for an analysis of monetary policy effects [4–6] and along with DSGE models they still belong to the most popular tools in this domain. Works focusing on the effects of fiscal policy later followed suit [7–10]. All these works, however, only analyse the effects of economic policies in isolation and include either monetary or fiscal authority into the model. Perhaps surprisingly, the number of existing works trying to capture the economic landscape populated by both authorities is still quite limited.

This situation is suboptimal as the analysis of simultaneous policy effects and their mutual co-ordination provides additional insights on how the economy operates. In addition, ignoring one of the authorities in the model (be it central bank or central government) complicates the interpretation of the results. As shown by Rossi and Zubairy [11], leaving one of the authorities out of the model leads to a severe parameter bias because macroeconomic developments are driven by both policies. As a result, reaction functions implied by the estimated parameters are imprecise and may suffer from greater uncertainty.

Implementing both authorities into the model and analysing US macroeconomic fluctuations, Rossi and Zubairy [11] found that monetary and fiscal shocks have different effects on the economy, depending on frequencies. In particular, fiscal policy seems to have the largest impact on medium-term fluctuations in output, whereas monetary policy mainly affects business cycle fluctuations.

Gerba and Hauzenberger [12] analysed the interactions of US authorities within a time-varying parameter VAR model. Allowing for smooth changes in parameters might be necessary as modern economies undergo considerable changes over time and the new economic environment may affect the nature of stabilization policies adopted by the authorities. Gerba and Hauzenberger [12] found that there exist significant differences in authorities' responses to shocks. In particular, it is possible to observe huge differences in policy reactions between the Volkers period and the Great Recession. Taking into account the severity of the recent global financial crisis and its impact on the Czech economy, time-varying framework might also be useful in Czech conditions.

In parallel with the VAR modelling framework, interactions between monetary and fiscal policy were also analysed with other approaches [13–15], but VAR models still seem to be a predominant way of capturing this phenomenon.

Empirical evidence on monetary-fiscal interactions in the Czech economy is scant. Similar to situations in other countries, empirical studies analysing isolated effects of either monetary or fiscal

policy prevail. Havránek et al. [16] and Franta et al. [17] use the VAR model to assess the impact of monetary policy shocks and analyse the effectiveness of the transmission mechanism in the Czech economy. On the other hand, Radkovský and Štiková [18] and Franta [19] focus on the effects of fiscal policy. The issue of economic policy interactions between Czech authorities has, however, not been addressed before. Řežábek [20] studies the problem of monetary and fiscal policy interactions within a game theory framework and estimates a model based on the outlined theoretical concept. This work provided useful insights, but the model still lacks fully dynamic specification and results only cover the pre-crisis period. This approach was later elaborated by Janků et al. [21] and applied to all Visegrad countries (Czech Republic, Slovakia, Poland and Hungary).

3. Methodology and Estimation

3.1. The Model and Identification of Shocks

The k-dimensional vector $y_t = (g_t, gdp_t, p_t, tr_t, r_t, ex_t)$ of quarterly time series includes six variables: government spending (g_t), gross domestic product (gdp_t), inflation rate (p_t), government revenues (tr_t), monetary policy rate (r_t) and exchange rate (ex_t). Exact definitions of the variables are presented in the next subsection. We included both government spending and revenues into the model to cover all possible fiscal policy tools able to curb cyclical fluctuations. The remaining four time series are traditionally considered a basic set of variables necessary for a description of monetary policy effects in a small open economy [17]. We limit our attention to this basic (but fully sufficient) set of variables due to a large number of parameters in the VAR model.

Our basic VAR has the following form:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-l} + e_t, \tag{1}$$

in which A_i are $k \times k$ matrices of coefficients, l is the number of lags and e_t are reduced-form random errors with variance-covariance matrix Σ_e. Note that a vector of constants is left out from the specification as we only focus on the cyclical part of the series which has zero mean (see below).

Specification and estimation of the reduced form (1) is generally considered unproblematic within the context of monetary and/or fiscal policy analysis. Our ambition here is to demonstrate that such a view is unwarranted and proper care needs to be paid to this phase of the modelling process.

In applied research, variables usually enter the model (1) either in (log) levels or in first differences. This practice also holds for empirical studies analysing the Czech economy. Although from the statistical point of view, both approaches are possible [22], their use is conceptually flawed in our context [2].

Let us summarize the main concerns. First, if the model is estimated in levels, one cannot define any steady-state towards which the system would converge after a shock. Under these conditions, shocks may have explosive nature and do not fade away even after many periods. Permanent nature of such shocks (say monetary policy shock), however, is economically implausible.

The lack of clearly defined steady-state is also crucial in situations when the steady-state serves as a policy target of the authorities. As demonstrated by Andrle and Brůha [2], the price level cannot be included in the VAR model if inflation-targeting countries are considered since the central bank does not target the level. Application of such a model would lead to false conclusions.

Another problem is that the trend and cyclical fluctuations around it are generally driven by different economic forces. While the variables at business cycle frequencies might echo the effects of implemented policies, trends in the Czech economy do mirror different phenomena such as gradual changes in the inflation target or economic convergence. For example, cyclical fluctuations in the real exchange rate have dramatically different implications for inflation, economic activity and interest rates than its trend which mainly reflect differences in productivity. Similarly, changes in inflation resulting from the time-varying inflation target cannot be attributed to cyclical fluctuations in the domestic product or interest rates. If trends and cycles are estimated within one model by the same set of parameters, the resulting estimates of policy reaction functions are severely biased and commonly

exhibit unintuitive economic features such as price puzzle (the price puzzle is always a sign of poorly specified variables in the reduced-form VAR).

The estimation of the monetary-fiscal policy VAR model on first differences is also undesirable. It should be stressed that first differences represent a filtering technique (application of linear filter) which amplifies information on short-term frequencies and attenuates other frequencies. From the perspective of macroeconomic analysis, short-term frequencies are uninteresting and the main focus is placed on business-cycle frequencies which are, however, attenuated by the differencing operation. Moreover, observed macroeconomic trends seem to be too complex to be successfully removed by using first differences. Fox example, a change in the inflation target might again be falsely attributed to the developments in other variables in the model which would lead to a bias in parameter estimates.

The proposed solution to this issue is to decompose all series into a trend and cycle and use a different set of parameters for both components. Since long-term movements in variables are not of the main interest in the context of monetary-fiscal policy analysis, we do not model the trend explicitly and remove it by applying the band-pass filter [23]. More concretely, we filter out the frequencies longer than 32 quarters (8 years) which are unlikely to be related to policy actions aimed at curbing business cycle fluctuations. To our best knowledge, this approach is unique in the Czech conditions and represents a novel way of analysing interactions between policies adopted by the Czech National Bank and central government.

Once the reduced form (1) has been properly specified, we proceed with the identification of a set of economic shocks and analyse policy reactions to these shocks. Identification process needs to rely on additional theory-based assumptions because it is impossible to estimate structural shocks purely from data. As such, this process may always be subject to controversy as there are many possible ways to obtain responses to shocks from the estimated model. In this paper, we rely on recursive identification scheme and Cholesky decomposition of the variance-covariance matrix Σ_e.

Since recursive identification depends on the ordering of the variables, economic theory needs to be used to support this choice. Our preferred ordering in the pre-crisis period is $y_t = (g_t,\ hdp_t,\ p_t, tr_t,\ r_t,\ ex_t)$ which is also the most commonly used ordering in the existing literature [7,10]. As a robustness check we also estimated the model using alternative orderings, however, this had little effect on the results. Slight change in the ordering of variables needs to be adopted for the post-crisis period to account for the fact that the monetary policy interest rate hit the lower bound quickly after the crisis and remained there ever since. The central bank could no longer react to worsening economic conditions via additional changes in the interest rate which implies that the monetary policy rate became the "least endogenous" variable in the model. This situation is therefore better captured by the ordering $y_t = (r_t, g_t,\ hdp_t,\ p_t,\ tr_t, ex_t)$.

Although recursive identification is popular, it still might be considered a rough approximation of the reality. A conceptually different approach to shock identification, which is not sensitive to the ordering of variables, consists in specifying economically-motivated sign restrictions on (usually) contemporaneous relations between the variables [24,25]. Although we do not make direct use of this approach during the estimation process, we compare our results with economically-founded sign restrictions as a robustness exercise. In practice, we check ex post that the responses to shocks coincide in sign with the assumed co-movements between variables. When the estimated response is not in line with imposed sign restrictions, we refrain from interpreting this specific shock and consider it poorly identified. As a reference guide, we use definitions of shocks proposed in Gerba and Hauzenberger [12]. These are summarized in Table 1.

Although sign restrictions presented in Table 1 are (strictly speaking) only imposed for contemporaneous relations between variables, we interpret them in broader terms—as a theory-implied guideline for the overall path of the response.

Table 1. Imposed Sign Restrictions on Monetary-fiscal policy VAR model.

	Government Spending	Government Revenues	GDP	Inflation	Interest Rate
Spending shock	+		+		
Tax shock		+	−		
Business cycle shock		+	+		
Monetary policy shock			−	−	+

Source: [12], Note: A blank cell indicates no restrictions on the specific combination of shock and response.

3.2. Data

Following earlier literature [16,19], we use quarterly data covering a time span from Q1 1999 to Q4 2015. While all data series are available for a given period, exploitation of data prior the year 1999 is problematic because of poor data quality. The first half of the decade was marked by substantial changes in the Czech economy due to the transition from command to free market economy. This period includes a number of one-off shocks that may blur systematic pattern in the data. An additional argument for choosing the year 1999 as our starting point is the adoption of the new monetary policy regime—inflation targeting—during 1998. Our sample, therefore, only contains a period where the central bank applies consistent policy to economic shocks which facilitates interpretation of the results.

To assess changes in mutual interactions between monetary and fiscal policy across time, the sample is split into two subsamples and the model is estimated separately for each of them. The subsamples can be labelled as "pre-crisis" and "post-crisis" period, respectively. The borderline between the subsamples is the year 2009. In fact, the year 2009 which coincides with a sizeable economic downturn of the Czech economy is completely left out from the analysis. This decision is driven by the fact that the crisis was caused by the external environment which is not modelled explicitly. As such, it would have a very undesirable impact on estimated reaction functions. Moreover, from the purely statistical point of view, the crisis year represents an "outlier" that violates the traditional assumptions on the error term of the model.

We note that both subsamples are quite short (in particular the "post-crisis" subsample) and estimation of the model would not be possible without recourse to informative prior information (see next subsection). We do not follow time-varying parameter VAR methodology which is commonly applied in similar settings. There are two main reasons for that. First, this approach can be too susceptible to the noise present in the data which might lead to false changes in parameters. Second and more importantly, we need to adopt specific prior restrictions on parameters which must hold for every quarter of the post-crisis period. These restrictions should account for the zero-lower bound problem and the fact that the Czech National Bank decided to use the exchange rate as an additional monetary policy tool (one-sided commitment to maintain the exchange rate close to the level of CZK 27 to the euro). It would be complicated to adopt such restrictions in a time-varying parameter framework as priors for one period can be overridden by data via Kalman filter recursions.

All data were downloaded from the Czech statistical office and Czech National Bank (ARAD database). All series were seasonally adjusted prior to the analysis. If the seasonally-adjusted series was not available directly from the source, X12 ARIMA procedure was applied. For reasons explained above, the time series were detrended using a band-pass filter proposed by Christiano and Fitzgerald [23] and only frequencies shorter than 8 years were retained. The only exception is the series of inflation rates where long-term trend is given directly by the inflation target.

Variables entering the VAR model are defined in the following way:

Government spending (in real terms): In line with earlier literature [8,19] we define government spending as a sum of government gross fixed capital formation and final consumption. This implies that automatic stabilizers are not considered in the analysis and only purposeful actions to counteract cyclical fluctuations are taken into account. Log transformation was taken prior to the application of

the Christiano-Fitzgerald filter. The series was adjusted for the one-off reclassification of institutional unit (SŽDC s.o.) into the central government sector in Q1 2003.

Government revenues (in real terms): We again follow recommendations based on earlier literature and define revenues in a narrower sense. In practice, government revenues are set equal to net taxes (taxes plus social security contributions minus net transfers). The series was transformed into logs prior to the application of the Christiano-Fitzgerald filter.

Gross domestic product (in real terms): Officially published series taken in logs and detrended by the Christiano-Fitzgerald filter.

Inflation rate: We define inflation as a year-on-year change in modified CPI where items related to administered prices are excluded from the consumer basket and the price index is adjusted for the first round effects of indirect taxes (this corresponds to net inflation). This definition may help better describe actual monetary policy actions because the CNB traditionally disregards the impact of indirect taxes on price level in its decision-making process.

Monetary policy interest rate: Although the main monetary policy tool of the CNB is a 2W REPO rate, this rate is routinely replaced by 3M PRIBOR (interbank rate) in empirical research due to the discontinuous character of the former. This discontinuity causes problems for the estimation of parameters. Quarterly averages of the 3M PRIBOR are used in the analysis and the time series is filtered by the Christiano-Fitzgerald filter (no log transformation).

Exchange rate: In our analysis, we make use of real effective exchange rate where upward shifts denote appreciation of Czech koruna. The series was transformed into logs prior to the application of the Christiano-Fitzgerald filter. However, the trend for quarters coming after Q3 2013 was fixed to the value attained in Q3 2013 to account for the exchange rate commitment adopted by the CNB in November 2013.

3.3. Parameter Priors and Model Estimation

Formulation of prior views is technically based on independent Normal-Inverse Wishart prior [26]. The specific formulation of priors for the pre-crisis and post-crisis period, however, differ. This particularly relates to the autoregressive parameters contained in matrix A_i. For the pre-crisis period, we use a modification of traditional Minnesota prior [3]. Changes to this system of priors are small but important. Let us recall that original Minnesota prior uses normal distribution for autoregressive parameters where the parameters are centred around zero except for the elements lying on the main diagonal of the matrix A_1. These are set to 1 if the series is believed to be a random walk or to 0.95 if an AR(1) process is believed to be a better representation of the reality. Variances of normal priors are set according to the following rules [27]:

$$
\begin{aligned}
&\left(\frac{\lambda_1}{l^{\lambda_3}}\right)^2 \text{if } i = j \\
&\left(\frac{\sigma_i \lambda_1 \lambda_2}{\sigma_j l^{\lambda_3}}\right)^2 \text{if } i \neq j
\end{aligned}
\tag{2}
$$

where i refers to the dependent variable in ith equation and j denotes independent variables in that equation. Symbols σ_i and σ_j represent variances of the error terms arising from univariate AR regressions applied to all variables in the VAR model, l is the lag length and parameters λ_1, λ_2 and λ_3 control the tightness of the prior. We set these parameters to: $\lambda_1 = 0.2$; $\lambda_2 = 0.5$ and $\lambda_3 = 1$ as recommended in the literature [27].

Our modifications to the original Minnesota prior can be described as follows. Priors for all parameters are defined as before, except for elements lying on the main diagonal of parametric matrices A_1 and A_2. These are set to 1.1 and -0.4, respectively, and prior variance is set to $\left(\frac{\lambda_1}{1^{\lambda_3}}\right)^2$ for both the first and the second lag. The rationale behind this modification is the following: Since long-term trends from all series were filtered out before the analysis, the variability of the transformed macroeconomic series is mainly driven by business-cycle frequencies. This follows from the very

nature of the underlying phenomenon these series try to capture. It then seems natural to use this information on the cyclical nature of the series in order to obtain reasonable parameter estimates and this is exactly what we do. Setting prior values on parameters of an AR(2) process equal to 1.1 and −0.4 corresponds to a belief that the process is dominated by business-cycle oscillations (see for details [28]). Prior variances are chosen so as to roughly cover a range of values leading to similar frequency characteristics of the process. Outside the VAR-modelling literature, priors with identical motivation were already used by Jarociński and Lenza [29] who tried to elicit reasonable priors about parameters of the AR(2) process when modelling an output gap. However, we are yet unaware of its use in the VAR context.

Specification for the pre-crisis period is completed by a formulation of priors for variance-covariance matrix of the error terms. Since no specific information is available, we use a completely uninformative prior and set the scale matrix to unity matrix and use one degree of freedom.

For the post-crisis period, a different approach is adopted. In this case, more informative priors are needed because of extremely short time series available. Formulation of informative priors in this case is based on elementary principles of Bayesian statistics. In particular, we rely on the fact that posterior distribution may become a new prior distribution of parameters before some new data arrives. This means that we take estimates from the pre-crisis period as a useful starting point for the specification of priors describing the post-crisis period. However, we inflate prior uncertainty (increase variances of the former posterior distributions by a factor of 1.5) in order to give data a greater chance to speak. If posterior distribution remains the same after arrival of the "post-crisis" data, then it can be interpreted as little evidence in data on changes in the behaviour of monetary and fiscal authority after the crisis. Conversely, if the data lead to a significant update of prior distribution (at least in some aspects), then there is a signal of change.

On the top of the approach described above, we need to make one additional step to account for the zero lower-bound problem which occurs when policy rates cannot decrease any further (into a negative territory) to ease monetary conditions. Although the rates were not at zero bound for the whole post-crisis period, they decreased quickly to very low levels and remained on zero level for the large part of the period. For this reason, a prior view that restricts the behaviour of the model in this way is an acceptable simplification of the reality.

As described earlier, we changed causal ordering of the variables to $y_t = (r_t, g_t, hdp_t, p_t, tr_t, ex_t)$, but it only eliminates contemporaneous reaction of the interest rate to other variables. To account for the zero lower bound, we also need to eliminate its reactions to other variables that occur with a time lag. This feature can be modelled by setting all parameters in A_i measuring the reaction of interest rate to other variables in the interest-rate equation to zero. Technically, we set prior mean of the parameters in question to zero and use the prior variance very close to zero (10^{-6}).

Priors for the variance-covariance matrix of the error terms in the post-crisis period are more informative than before, but still loose enough to let the data speak. We set prior scale matrix to the posterior mean of individual elements observed in the pre-crisis period and increased the degrees to freedom to 5.

Computation of posterior distributions is based on traditional Gibbs sampler. Its implementation in the R package BMR [30] was used to obtain the results. In total, 15.000 of posterior draws were generated from the posterior distribution and first 10.000 draws were discarded as a burn-in period. Retained draws are then used to calculate the posterior distribution of impulse-response (IR) functions. Economic assessment is based on median IR function and 68% credible interval. This interval width is preferred in the case of IR functions [26] due to potentially highly asymmetric shape of the IR distribution.

The number of lags in the VAR model was set to two. This is in line with the majority of relevant empirical literature (see for example [6]), but it is also supported by economic reasoning and statistical criteria (i.e., highest marginal likelihood). We recall that autoregressive processes of order two are traditionally used for modelling business cycle fluctuations because their statistical properties suit

well to these needs [31]. This is also reflected in the form of our modified Minnesota prior (see above). Moreover, given a short time span and the number of parameters growing fast with every additional lag included in the model, it would be quite challenging to estimate the VAR with more than two lags since the parameter uncertainty might become unacceptably large.

4. Results

Economic assessment is based on the estimated impulse-response functions. However, taking into account the limited length of the paper their thorough one-at-a-time description would be cumbersome. The six-variable VAR model implies that in theory 36 different impulse-response functions can be obtained. Moreover, as the sample was split into two periods, the total number of responses doubles to 72. It would be, therefore, quite time-consuming to present the impulse-response functions in full and this holds even if we limit our attention to the most relevant policy responses. For the sake of brevity, we summarize the most interesting findings only via comprehensive Table 2 and pay particular emphasis to interactions between monetary and fiscal policy. The full set of impulse-response functions can be found in Reference [32] or obtained from the authors upon request. Interested readers may also find there a set of sensitivity checks and comparisons with alternatively specified priors.

Table 2. Comprehensive summary of the results.

Pre-Crisis Period		Post-Crisis Period
➢ Post-transformation economy, prevalence of demand-driven shocks	**Economics**	➢ Economy hit by the crisis, low inflation environment, impact of supply shocks
➢ Efficient on the horizon of monetary policy ➢ countercyclical, smoothing and curbing the business cycle *Reaction to fiscal policy* ➢ Weak, acting as a substitute	**Monetary policy**	➢ Limited efficiency, zero lower bound problem, weakening of the exchange-rate channel, efficiency on shorter than MP horizon ➢ remains countercyclical *Reaction to fiscal policy* ➢ Strengthening of substitutional effect
➢ No evidence for systematic impact on economic activity or results subject to huge uncertainty ➢ Neutral or slightly procyclical *Reaction to monetary policy* ➢ Proactive and substitutional by its nature	**Fiscal policy**	➢ No evidence for systematic impact on economic activity, results influenced by specific shocks in the post-crisis period ➢ Mildly countercyclical *Reaction to monetary policy* ➢ Weak and rather passive

To steer the discussion below, we define two main categories of policy interactions. In line with Reference [12], the policies act as *complements* if actions of both authorities go in the same direction (i.e., they both have expansionary or contractionary effects) and the policies operate as *substitutes* if the actions of one of the authorities are offset by actions heading in the opposite direction. It should be stressed that substitutive and complementary character of interactions may depend on the nature of shocks. This follows from different tools available to both authorities as well as from their potentially different policy objectives.

4.1. Pre-Crisis Period

We first analyse the reaction of the authorities to the (exogenous) shock to the business cycle. The results suggest that the central bank reacted to a positive business-cycle shock in line with its mandate by increasing the policy interest rate. This reaction was driven by an objective to cool down additional inflation pressures related to higher-than-expected economic growth. The results also confirm high efficiency of monetary policy in the pre-crisis period—both through the interest rate as well as the exchange rate transmission channel.

On the contrary, the reaction of fiscal policy to a positive shock to economic activity seems to be procyclical according to the results. This implies that fiscal policy acted as a substitute to monetary policy in the pre-crisis period once a shock to economic activity occurred. A potential explanation might be that the central government wanted to take advantage of favourable economic conditions that contributed to an increase in government revenues to achieve its other objectives (lower unemployment or further development of necessary infrastructure). Moreover, the results also reveal that the timing of the purposeful fiscal policy actions were quite unsystematic in the pre-crisis period and had little relation to the business-cycle. While such a result is unpleasing from the policy perspective, it was corroborated by other studies on the Czech economy (see for example Reference [33]). This finding is also in line with general perceptions of fiscal-policy conduct in the Czech Republic [34].

So far, we analysed reactions to a shock which originated in the economic system but was not triggered by the authorities themselves. Now, let us focus on a direct reaction of the authorities to the measures adopted by their counterpart. Again, the results suggest that fiscal policy acts as a substitute to monetary policy actions. In particular, the results indicate that monetary restriction aiming at reducing inflation pressures was followed by an increase in government spending and a decrease in government revenue, i.e., by measures that imply loosening of the fiscal policy stance. This underlines little co-ordination of fiscal policy with monetary policy in the Czech Republic in the pre-crisis period. It should be stressed, however, that substitutive effects of fiscal policy to monetary policy tightening is commonly observed in all major economies [12,13,35].

The opposite case, when monetary policy reacts to fiscal policy measures, also suggests the rather substitutive character of policies in the pre-crisis period. However, the reaction of the central bank seems to be very mild or even negligible where estimated responses are subject to a huge uncertainty. In general, a conjecture can be made that there is at least some reaction of monetary policy to the expansionary government spending shock in order to curb the associated inflation pressures while there is virtually no reaction of monetary policy to the government tax shock. These results are roughly in line with international empirical evidence [12], as well as with some theory-based DSGE models [36].

4.2. Post-Crisis Period

Economic landscape and financial conditions have changed after the crisis and the results show that the crisis also had some impact on the conduct of economic policies. Although the results should be interpreted with some caution due to the lack of long time series, the data seem to carry some evidence on changes in monetary and fiscal policy.

The results confirm that monetary policy remained countercyclical in the post-crisis period in a bid to increase inflation pressures and support aggregate demand. This corresponds with the highly proactive approach of central bankers worldwide who took a leading role in mitigating the consequences of economic downturn. The room for manoeuvre shrunk in the Czech conditions once the main policy tool (interest rates) hit a zero floor. Under these conditions, the central bank decided to use exchange rate commitment as its additional policy tool. The exchange-rate transmission channel of monetary policy still remained functional, but the results reveal that its efficiency has diminished in comparison with the pre-crisis period. Plausible explanation for lower efficiency might be that positive supply shocks (decreasing prices of energies and crude oil) partially offset increases in prices of imported goods caused by deliberate exchange-rate depreciation.

Inclination to a more proactive monetary policy conduct in the post-crisis period is also mirrored in its reaction to the conservative fiscal policy stance during the years shortly after the crisis (i.e., the policy of Petr Nečas' cabinet). While fiscal policy tried to limit the spending in order to maintain sound levels of government debt, monetary policy reacted to this situation by strong monetary stimulus to compensate for little co-ordination between fiscal and monetary policies. On the other hand, evidence on the immediate monetary policy reaction to tax (revenues) shocks is considerably weaker, although some shift towards a more proactive approach can be observed even in this case.

Similar to the pre-crisis period, the results do not show the systematic nature of fiscal policy with respect to the business-cycle fluctuations. Even though the revenues' responses to economic shocks changed substantially, their shape is most likely blurred by the presence of specific foreign shocks which are not modelled explicitly in our VAR model. It is thus difficult to relate these changes in the responses to a particular adjustment in fiscal-policy conduct. With some caution, however, a conjecture can be made that the procyclical nature of government spending in the pre-crisis period has changed and shows a mildly countercyclical pattern in the post-crisis period. Nevertheless, we stress that this conclusion only holds on average and conceals the fact that the situation was in reality quite heterogeneous with both procyclical and countercyclical policy actions being taken. Namely, the two governments which were in power during the post-crisis period did not share the same opinions on optimal fiscal policy conduct (fiscal restriction in order to maintain sound public finance vs. mild fiscal expansion in order to support economic recovery).

The results also indicate that fiscal policy did not directly react to policy actions carried out by the central bank which is in contrast to the practice in the pre-crisis period. In some sense, the two authorities switched their roles over the periods. While fiscal policy reacted to monetary policy actions quite strongly in the pre-crisis period to partially offset its effects, no such reaction was observed after the crisis. On the contrary, monetary policy showed only limited reactions to fiscal policy in the pre-crisis period, whereas the reaction intensified considerably after the crisis—following the globally proactive approach of central banks in advanced countries.

To conclude, it should be noted that the analysis provided no evidence on the complementary character of policy interactions neither in the pre-crisis nor in the post-crisis period. It might be quite surprising as such interactions should be beneficial for the economy, particularly in the post-crisis period. This possibly reflects different objectives pursued by the two authorities but it may also point to a different real-time assessment of the position of the economy in the business-cycle. Řežábek [20] shows that real-time estimates of the output gap produced by the authorities differ substantially and are only reconciled with a considerable time lag. Different estimates arise from different modelling approaches used by the authorities. Such practice may lead to a situation where one of the authorities sees the economy as overheating while the second authority considers the economy as operating under its potential. Under these circumstances the authorities may naturally use conflicting policy tools even if their common ambition is to achieve stabilization of the economy. Mutual co-operation between monetary and fiscal authority in the area of macroeconomic modelling thus seems a desirable way to go.

5. Concluding Remarks and Discussion

In this paper we built a six-variable VAR model and estimated its parameters by Bayesian techniques. The model was then used to study the conduct of monetary and fiscal policy. Particular attention was paid to interactions between these two policies as well as to their evolution within the changing economic landscape.

Our contribution to earlier literature covers both the methodological and empirical domain. In the area of macroeconomic modelling we focus on the proper specification of the reduced form of the VAR model and discuss why commonly-used specifications are wrong in the context of monetary/fiscal VARs. We then propose a modification to Minnesota priors to capture the cyclical nature of the underlying time series and also explicitly account for the problem of zero lower-bound in the post-crisis period. On the empirical level, we are the first to document changes in monetary and fiscal interactions in the Czech economy.

The most important message conveyed by the results is the lack of complementarity between the actions adopted by the central bank and the government. Moreover, the results confirm the unsystematic pattern of fiscal policy with respect to business-cycle fluctuations. This suggests that there is still enough room for improvements in the state's economic policy. The authorities should co-operate more closely when adopting their own policies to promote greater social welfare. This becomes particularly urgent in times of economic crisis when quick recovery from an initial shock is needed.

Importantly, the co-operation should already start at the level of macroeconomic modelling so as to obtain a unifying view on the current state of the economy.

Although we tried to make the best possible choices during the modelling process, our approach is not immune to criticism. The most relevant drawback of the model is the absence of the foreign sector. This point is important since the Czech Republic belongs to small open economies where a high share of variability in the variables is driven by shocks imported from abroad. If foreign variables are not present in the model, then these shocks are falsely explained by the movements in domestic variables which may produce bias in the results.

We are aware of this fact but it is important to realize that adding the foreign sector into the model implies a need to estimate very large number of additional parameters. There is a clear trade-off between the parameter bias and the variance of the estimates. Since only very short time series (especially in the post-crisis period) are available, we decided to reduce the variance at a cost of some bias. Otherwise the credible intervals would have been too wide and no economic interpretation would be possible. Nevertheless, once new data arrives and longer series become available, inclusion of foreign variables would be a natural extension of our model. Therefore, it is worth returning back to our analysis in the future, taking the advantage of a hindsight look and greater evidence gathered through newly collected observations.

Another possible extension relates to the identification scheme of economic shocks. Recursive identification is the most commonly used approach but other options should be explored as well to confirm robustness of the results. Although the results did not seem to be sensitive to alternative orderings of the variables, a recursive system is still quite restrictive in terms of plausible macroeconomic dynamics. As new data arrives, alternative approaches to identification can be used to estimate responses (reactions) of the authorities to economic shocks. The most popular choice would be to estimate a structural VAR model identified by sign restrictions. Even though, the attempts to use sign-identified VARs in Czech conditions are not fully satisfactory at the current juncture (see for example [19]), the situation may improve once enough data is collected.

Last but not least, the role and effectiveness of automatic (fiscal) stabilizers can be explored more thoroughly. In this paper, we abstracted from automatic stabilizers, because our primary interest was to study purposeful reactions of one authority to the actions taken by the second authority. This allowed us to assess the degree and nature of their mutual co-operation. Automatic stabilizers clearly do not fit to this analysis as they are triggered automatically following economic developments. However, a detailed analysis of their contribution to the stabilization of the economy in different phases of the business cycle is important and might be a subject of future research.

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