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Reviewed by: Anisa Tiza Mimun (European Central Bank)
Stanislav Tvrz (Czech National Bank)
Project Coordinator: Volha Audzei

Non-Linearity of Government Spending Multiplier: The Case of a Small Open Economy

Daniel Štodt*

Abstract

This study focuses on the non-linearity of fiscal multipliers in the Czech Republic and their dependence on the phase of the economic cycle. Using an STVAR model, the variability of fiscal multipliers across different economic phases is analyzed. The findings show that fiscal multipliers are higher during recessions (1–1.5) and lower during expansions (0–0.5), aligning with the general scientific consensus. The study also suggests that as the strength of an economic expansion gradually declines, multipliers gradually increase. These results emphasize the effectiveness of fiscal policy during recessions and its importance in stabilizing aggregate demand. However, the research highlights limitations caused primarily by the short available data series and the limited number of recessionary episodes in the Czech Republic, which may impact the generalizability of the findings.

JEL Codes: C32, E62, H30

Keywords: Business cycle, fiscal multipliers, STVAR.

* Daniel Štodt, Czech National Bank, e-mail: daniel.stodt@cnb.cz;

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1. Introduction

One of the central roles of the government is to manage the state budget, through which it can advance not only its political objectives but also significantly influence the economic development of the country. By employing discretionary measures such as changes in government spending or taxation, the government can, for example, stimulate aggregate demand during an economic downturn, thereby aiding the economy's return to its potential output. To assess the effectiveness of these measures, the concept of fiscal multipliers is employed, which refers to the change in gross domestic product relative to the change in government spending or tax revenues. Explicitly, this represents the change in gross domestic product resulting from a unit change in government spending (or tax revenues).

Since the time horizon of monetary policy is forward-looking, policymakers must rely on forecasts of future developments when making decisions. This places high demands on the accuracy of the predictions, which must necessarily account for the impacts of anticipated economic shocks. Discretionary fiscal policy measures constitute a significant source of these shocks. Therefore, better estimates of fiscal multipliers can contribute to improving forecasts and thus achieving the goal of price stability.

In small open economies with an independent currency, fiscal multipliers may differ from those in larger economies due to greater trade openness, higher exposure to external shocks, and the role of exchange rate adjustments as a shock absorber. These factors influence the transmission mechanisms of fiscal policy and merit particular attention in empirical analysis. Building on this, the present paper contributes to the literature by measuring the government spending multiplier in such an economic environment using the STVAR model, which enables the identification of different phases of the economic cycle.

Although discretionary policy has historically been widely used to stimulate aggregate demand, the magnitude of its resulting effect has not yet been entirely clear,[1] nor how this effect changes depending on the economic cycle. The economic crisis between 2007 and 2009 brought this issue to the forefront, significantly influencing both political and scientific debates. The severe decline in economic activity caused by this crisis led many governments to implement measures to stimulate aggregate demand through expansionary fiscal policy. This in turn, spurred research debates on the impact of fiscal stimulus on a country's gross domestic product depending on the economic cycle (recession) with the aim of jump-starting the economy. Once the main phase of the economic crisis subsided, questions arose regarding the appropriate methods for consolidating public budgets during periods of expansion, in a way that would minimize potential output losses.

The underlying intuition behind the variability of fiscal multipliers depending on the economic cycle stems from traditional Keynesian theory, which posits the counter-cyclical influence of fiscal policy. Specifically, during a recession, when the economy suffers from higher unemployment and lower capital utilization—i.e., lower utilization of production factors—fiscal stimulus is more effective than during periods of expansion, and thus there is also a lower likelihood of crowding out private consumption or investment.

[1] As it depends on the specifics of the given economy, see Section 2.

A review of the economic development of the Czech Republic in recent years suggests that changes in the economic cycle occur relatively frequently, albeit at irregular intervals depending on the nature of the shocks. Given that the Czech Republic is a small open economy, a significant portion of these shocks originates from external developments, making the economy particularly susceptible to global fluctuations. Recent examples include the COVID-19 pandemic and the war in Ukraine, both of which had a profound impact on economic stability and development. In the case of such events, all central bank forecasts must promptly quantify the impacts of both unanticipated shocks (such as the closure of the economy) and anticipated ones (such as fiscal stimulus).

For this reason, the objective of this research is to highlight the variability of fiscal multipliers depending on the cyclical position of the economy and to improve forecasts by providing an estimate of these multipliers based on data from the Czech Republic.

The obtained results from the STVAR model clearly indicate that the values of fiscal multipliers are dependent on both the business cycle itself and the magnitude of the cycle. The results for the Czech Republic are in line with the scientific consensus, showing fiscal spending multiplier values in the range of 0–0.5 during periods of expansion and 1–1.5 during recessions. Since small open economies are highly exposed to external shocks, an additional variable - the exchange rate - was introduced into the model to capture its potential influence on business cycle dynamics. Although external demand played a significant role in driving recessions and expansions, the inclusion of the exchange rate did not lead to substantial changes in the estimated multipliers. This suggests that while external factors may influence macroeconomic conditions, their direct impact on fiscal multiplier estimates within the analyzed framework remains limited.

The paper is structured as follows. Section 2 provides a literature review focusing on the theoretical background and previous research on fiscal multipliers and their dependence on economic cycles. It discusses key studies and methodologies applied in estimating multipliers and highlights differences in results across various contexts. Section 3 details the methodology and data used. Section 4 presents the empirical results, including impulse responses and corresponding fiscal multipliers. Section 5 includes sensitivity analyses to assess the robustness of results concerning changes in model parameters and data sample size. Section 6 extends the model by incorporating an additional variable capturing the influence of external economic conditions. Finally, Section 7 offers a conclusion, summarizing the main findings and discussing the implications for economic policy and forecasting.

2. Literature Review

When examining fiscal multipliers, it is first necessary to distinguish the multiplier effects according to the specific fiscal instrument. Discretionary measures on the expenditure side of the state budget comprise government spending on consumption and investment. These instruments have a similar immediate impact on aggregate demand, but government investments have much more persistent effects on the economy through the long-term increase in the capital stock and thus the productive capacity (Coenen et al., 2012; Ilzetzki, Mendoza, and Végh, 2013; Alichi, Shibata, and Tanyeri, 2021), thereby influencing the potential level of gross domestic product in the long run. On the revenue side of the state budget, similar effects on stimulating aggregate demand (through an increase in household disposable income) as government consumption can be seen with changes in the value-added tax rate. An analogous effect in the short term is also observed with changes in the income tax rate, which, however, simultaneously affects household labor supply in the long-term horizon. On the other hand, changes in the capital tax rate have a negligible effect in the short term, but the effects emerge in the long term, where lower rates stimulate the inflow of both domestic and foreign investment (Coenen et al., 2012; Zubairy, 2014; Alichi, Shibata, and Tanyeri, 2021).

However, the type of fiscal instrument is not the only determinant of the resulting multiplier effect. The current literature concludes that the magnitude of individual fiscal multipliers is not universal and depends on the macroeconomic specifics of a given country or the nature of the shock. For instance, anticipated fiscal shocks have different effects than unanticipated ones. Mertens and Ravn (2012) highlight these distortionary effects in their research focused on changes in the tax system. While unanticipated tax cuts have an immediate positive response on GDP, anticipated tax cuts initially lead to a cooling of economic activity as firms and consumers delay their activity until the period of lower rates. Ramey (2011) reaches similar conclusions, though she examines the impact of expectations regarding changes in government spending (particularly in defense) instead of tax reforms. Besides the magnitude of the effect at a given time, the persistence of the shock is also crucial. A critical factor in this context is the distinction between the duration of fiscal measures. Permanent changes have far more persistent effects than temporary ones, with the responses to temporary changes tending to be shorter than the shock itself (Coenen et al., 2012).

Within macroeconomic specifics, the method of financing the discretionary measure and the pace of subsequent consolidation are of primary importance, as highlighted by Zubairy (2014). Aggressive consolidation tends to reduce long-term multiplier effects. Therefore, to achieve a higher stimulative effect, it is desirable that the discretionary measure be temporarily financed through a budget deficit, specifically via government debt. However, the level of government debt itself is another determinant of the multiplier effect. Particularly high government debt tends to diminish multiplier effects in the economy (Ilzetzki, Mendoza, and Végh 2013; Hernández de Cos and Moral-Benito, 2013; Auerbach and Gorodnichenko, 2017), in line with the concept of Ricardian equivalence. The impact of legislation, such as nominal rigidities and automatic stabilizers, also significantly influences multiplier effects by tending to reduce the response in output. In practice, this often results in higher fiscal multipliers being measured in U.S. data than in European data, where these factors play a greater role (Coenen et al., 2012). Another important factor is the openness of the economy. Larger or less open countries generally have higher multipliers due to the lower dependence of aggregate demand on imports (Barrell, Holland, and Hurst, 2012; Ilzetzki, Mendoza, and Végh, 2013; Alichi, Shibata, and Tanyeri, 2021). Besides the economy's openness itself, the exchange rate regime also matters, as a flexible exchange rate can absorb part of the fiscal impulse (Born, Juessen, and Müller, 2013).

The second key player in economic policy, specifically the response of monetary policy, also plays a crucial role in this context. Monetary accommodation has the potential to significantly enhance the stimulative effect of most discretionary measures (Zubairy, 2014); however, it simultaneously leads to an increase in the price level (Coenen et al., 2012). Numerous studies (Cogan et al., 2010; Christiano, Eichenbaum, and Rebelo, 2011; Fahri and Werning, 2016) highlight a significant rise in multiplier effects in extreme cases where monetary policy is constrained (zero lower bound).

Another significant determinant of the multiplier effect, which remained unexplored for many years, is the phase of the economic cycle in which the economy finds itself. Although the intuition regarding the variability of the fiscal multiplier depending on economic performance is rooted in established theoretical assumptions, this relationship received little attention for many years. This changed with the onset of the Great Recession, which spurred a surge in research on this topic. The central study in this field became that of Auerbach and Gorodnichenko (2012), followed by additional authors (such as Hernández de Cos and Moral-Benito, 2013; Owyang, Ramey and Zubairy, 2013; Herbert, 2014; Caggiano et al., 2015; Ramey and Zubairy, 2018). All these studies conclude that multiplier effects are higher during recessions than during expansions. However, discrepancies existed in the measured values.

The core of the academic debate primarily centered around the low values of the fiscal multiplier during periods of economic expansion, contrasted with the significantly high values observed during recessions (see Table 1). The primary opposing perspectives in this debate were represented by Auerbach and Gorodnichenko (2012, 2013) on one side, and Owyang, Ramey, and Zubairy (2013), as well as Ramey and Zubairy (2018), on the other. Auerbach and Gorodnichenko estimated high values of the government spending multiplier (exceeding 2), whereas ORZ13 and RZ18 obtained values slightly below 1. Although all these conclusions were drawn from U.S. data, they diverged chiefly in terms of the time horizons considered and the methodologies employed. Caggiano et al. (2015) and Lee et al. (2020) highlighted that the estimation of the fiscal multiplier critically depends on the severity of the defined recession (which was one of the factors where the opposing viewpoints diverged), as deep recessions lead to a substantial increase in fiscal multipliers compared to mild recessions. Moreover, while Auerbach and Gorodnichenko (2012) utilized a dataset starting from the post-war period, Ramey and Zubairy (2018) included data from World War II. During this period, however, households and firms faced constraints.[2] The labor market experienced a shortage of workers, and a significant portion of resources (materials) was prioritized for military production, thereby crowding out private consumption. These limited opportunities for the utilization of production factors consequently led to the lower estimated multipliers (Auerbach et al., 2022).

As indicated in Table 1, the values of the spending multiplier are generally found to range between 0 and 0.5 during expansion periods, and between 1 and 1.5 during recessions (Auerbach and Gorodnichenko, 2012). However, it is important to note that the specific estimated values are highly contingent on the period under consideration (as other factors also exert influence), the definitions of government spending and net taxes (which these authors defined in a different manner), and the empirical methods applied.

A variety of approaches have been employed to estimate the causal effect of fiscal policy on economic activity. Ramey (2019) categorizes these approaches into the following three groups:

1. Time-series or panel estimates on aggregate data (at the national level).
2. New Keynesian dynamic stochastic general equilibrium (DSGE) models.
3. Cross-sectional or panel estimates on subnational data.

Each of these approaches has its strengths and weaknesses, and no scientific consensus has emerged regarding a best practice. On the contrary, we observe the use of a wide range of these methods

[2] Similar constraints were faced by households during the COVID-19 pandemic.

depending on the determinants of fiscal multipliers, while new measurement methods are continually emerging.

Table 1: Estimates of Government Spending Multipliers Over the Business Cycle

Authors	Method	Sample	Expansion	Recession	Comments
Auerbach and Gorodnichenko (2012)	STVAR	US: 1947q1-2008q4	-0.33	2.24	cumulative multiplier over 5 years
Auerbach and Gorodnichenko (2013)	forecast error approach, local projection method	OECD countries: 1985q2-2007q2	0.34	3.27	average multiplier over 3 years
Hernández de Cos and Moral-Benito (2013)	STVAR	Spain: 1986q1-2012q4	0.6	1.4	cumulative multipliers over 3 years
Owyang, Ramey and Zubairy (2013)	threshold regression model, local projection method	US: 1890q1-2010q4 Canada: 1921q1-2011q4	0.88 0.46	0.78 1.16	multiplier over 4 years
Herbert (2014)	STVAR	US: 1947q1-2012q2 France: 1960q1-2012q2 Germany: 1970q1-2012q2	-0.95 0.23 0.84	2.11 1.56 1.14	cumulative multiplier over 5 years
Caggiano et al. (2015)	STVAR	US: 1981q3-2013q1	-2.27 -3.28 (strong) -2.37 (weak)	1.00 1.09 (deep) 0.83 (mild)	cumulative multiplier over 5 years
Ramey and Zubairy (2018)	threshold regression model, local projection method	US: 1889q1-2015q4	0.67 (news shock) 0.35 (BP02 shock)	0.68 (news shock) 0.77 (BP02 shock)	multiplier over 4 years
Lee et al. (2020)	threshold regression model, local projection method	US: 1889q1-2015q4	0.61 (news shock) 0.4 (BP02 shock)	0.94 (news shock) 1.23 (BP02 shock)	multiplier over 4 years
Rich (2022)	MS-BVAR	US: 1960q1-2019q4	1	1.5	cumulative multiplier over 5 years

Note: STVAR = Smooth Transition Vector Autoregression, MS-BVAR = Markov-Switching Bayesian Vector Autoregression

Specifically, for the estimation of fiscal multipliers depending on the economic cycle, there has been a shift away from linear models, with nonlinear models such as Threshold Vector Autoregression (TVAR), Markov Switching Vector Autoregression (MSVAR), and Smooth Transition Vector Autoregression (STVAR) coming to the forefront (Herbert, 2014). However, the fundamental challenge in estimating the causal effect lies in identifying genuine exogenous shocks of fiscal policy on real variables, as shocks to these variables are often contemporaneously correlated. To address this issue, the following identification strategies have been developed (Hernández de Cos and Moral-Benito, 2013):

Cholesky ordering

The assumption incorporated into the model is derived from the ordering of variables in the VAR. In this case, the first variable in the order is considered exogenous to the remaining variables and responds to them only with a lag.

Blanchard and Perotti (2002)

According to this approach, the total shock to variables consists of three components:

a. The automatic response of fiscal variables to a shock in output.
b. The discretionary fiscal response to a shock in output.
c. A random shock to the fiscal variable that is uncorrelated with any structural shock (as the target shock).

BP02 first subtracts component a. (using a cyclically adjusted fiscal shock derived from exogenously determined elasticities) and then proceeds with the Cholesky ordering, placing the fiscal variable first.

Narrative approach

In contrast to the previous methods, this approach does not attempt to estimate an exogenous shock. Instead, it utilizes various sources of information (such as political speeches, public opinion) to construct and incorporate the shock into the model.

Sign restriction

Instead of imposing zero restrictions (as in the Cholesky ordering), positive and negative restrictions are predetermined (e.g., that the response of the fiscal variable to a shock in output must be non-negative).

Among these strategies, the BP02 and Narrative Approach hold the most prominence in scientific publications (Hernández de Cos and Moral-Benito, 2013).

3. Methodology and Data

3.1 Methodology

To estimate the causal effect of the economic cycle phase on gross domestic product, it is necessary to employ a model that facilitates switching between different states of the economy (recession and expansion). In this context, primarily TVAR and STVAR models are considered. While both approaches satisfy the given specifications, the TVAR model is based on the principle of discrete switching between regimes, in which it estimates causal effects separately. In practice, sufficiently large data samples containing an adequate number of observations in both regimes are required to ensure robust estimates. In contrast, the STVAR model allows individual parameters to transition smoothly between regimes via a probabilistic function, thereby utilizing the entire data sample simultaneously.

Given the limited scope of the dataset (see point 2 of this chapter), the STVAR model was employed, following the Auerbach and Gorodnichenko (2012) specification:

$$X_t = F(z_{t-1})\Phi_R(L)X_{t-1} + \big(1 - F(z_{t-1})\big)\Phi_E(L)X_{t-1} + \varepsilon_t, \tag{1}$$

$$\varepsilon_t \sim N(0, \Omega_t), \tag{2}$$

$$\Omega_t = \Omega_R F(z_{t-1}) + \Omega_E(1 - F(z_{t-1})), \tag{3}$$

$$F(z_t) = \frac{\exp(-\gamma z_t)}{1+\exp(-\gamma z_t)}, \gamma > 0, \tag{4}$$

$$var(z_t) = 1, E(z_t) = 0. \tag{5}$$

The model is based on a vector of log-transformed endogenous variables X_t, where $X_t = [G_t, T_t, Y_t]$. G_t represents government spending, T_t net tax revenues, and Y_t gross domestic product. Placing G_t in the first position enables the identification of a true exogenous shock based on the BP02 approach. This setup assumes that shocks in T and Y do not have a contemporaneous effect on G, focusing the analysis on unexpected shocks.[3]

$F(z_{t-1})$ is the transition function, which serves to switch states between recession and expansion based on probability and the smoothing parameter γ. The threshold variable z denotes the seven-quarter weighted average of the quarter-on-quarter growth rate of the product, normalized to have a zero mean and unit variance. This threshold variable is expressed with a lag to avoid economic rigidities and to prevent contemporaneous responses following a policy shift. The value of the smoothing parameter γ is set exogenously to 2.5 in order to imply the proportion of time the economy is in recession at a level of 12.5%, as was the case for the Czech Republic during the observed period.

Φ_R and Φ_E represent the coefficients of the lag polynomials of the VAR, capturing the system's dynamics during recession and expansion, respectively. ε_t are the residuals with a zero mean and finite variance Ω_t, whose components Ω_R and Ω_E denote the variance-covariance matrix of the shocks in the respective regimes.

[3] Studying expected shocks would, however, necessitate the use of the Narrative approach.

The number of lags in the model is determined based on statistical criteria, specifically the Akaike and Schwarz Information Criteria (AIC and BIC). The model is then estimated using the Monte Carlo Markov Chain (MCMC) method, with priors specified through the Minnesota prior.[4] The prior is then updated within the Bayesian inference framework through the maximum likelihood function, resulting in a posterior distribution of the model parameters, from which impulse responses are subsequently constructed (see Appendix A).

The construction of the impulse responses involves two steps. The first step derives contemporaneous responses based on the Cholesky decomposition of Ω_t. In the second step, the estimated coefficients of the lag polynomials Φ_R and Φ_E are used to propagate responses of the variables over time and across individual regimes.

In their influential study, Auerbach and Gorodnichenko (2012) constructed impulse responses without incorporating changes in the transition variable z_t. This approach assumes that once a shock occurs, the economy remains in the same regime until the shock fully dissipates. While this simplification speeds up computation significantly, it imposes a strong assumption on the model, namely that a fiscal shock cannot reverse the phase of the business cycle.

Such an assumption, however, not only contradicts the core idea of the countercyclical influence of fiscal policy but may also markedly impact the calculated multipliers. Therefore, it is preferable for the model to forgo this assumption. For this purpose, Generalized Impulse Responses were computed (see Appendix B) following Koop, Pesaran, and Potter (1996), which allow for interaction between the analyzed variables and the transition variable z_t through its now endogenous probability $F(z_t)$.

The corresponding fiscal multiplier can then be determined from the obtained impulse responses. The resulting cumulative multiplier is calculated as the integral of the output response divided by the integral of the government spending response over a chosen horizon, i.e., $\sum_{q=1}^{Q} Y_q \,/\, \sum_{q=1}^{Q} G_q$, where Q is a chosen horizon in quarters. The resulting percentage changes are subsequently converted into currency terms using the sample mean ratio of the levels of output to public spending.

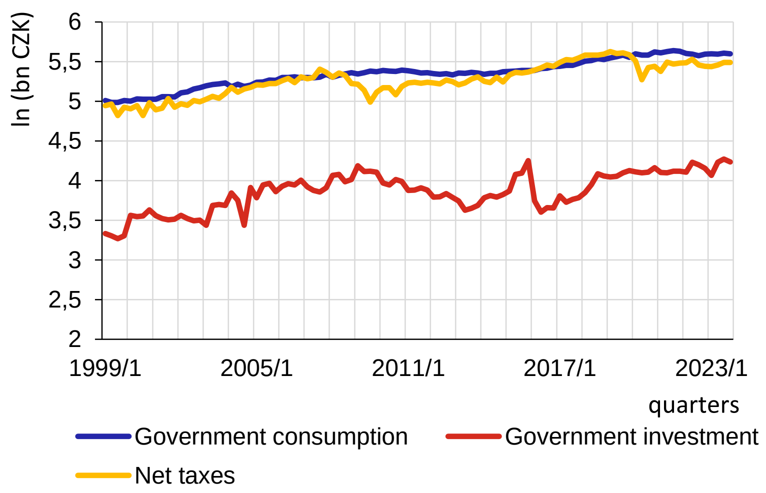
3.2 Data

Data from the Czech Republic were used as an example of a small open economy that is deeply integrated into global trade and financial markets, making it particularly exposed to external shocks. The dataset consists of three log-transformed variables: real government expenditures G_t, real net taxes T_t, and real gross domestic product Y_t from 1999 to the end of 2023, at a quarterly frequency. The government spending series comprises Final Consumption Expenditures (P3) + Gross Capital Formation (P5), while net taxes include Current Taxes on Income (D5) + Taxes on Production and Imports (D2) + Capital Taxes (D91) + Net Social Contributions (D61) - Social Benefits other than Social Transfers in Kind and Social Transfers in Kind adjusted for market production purchased by government institutions (D6M), according to the ESA 2010 definition. All variables are seasonally

[4] The Minnesota prior is employed due to the non-stationarity of the variables, which are transformed into logarithms rather than first differences.

adjusted and converted into real terms using the GDP deflator (index 1=2015). To distinguish between recessionary and expansionary regimes, seven-quarter weighted averages of quarter-on-quarter real GDP growth were utilized. The data were sourced from the Czech Statistical Office (CSO).

Figure 1: Endogenous Variables of the Model



Source: CSO

The main limitation of this research lies in the dataset's scope and length. The Czech economy began its transition to a market-based system in the early 1990s, following the dissolution of Czechoslovakia in 1993, when the Czech Republic became a separate state. During this period, the Czech economy underwent a transformation process, which impacted variables such as government expenditures, tax revenues, and GDP, introducing specific structural adjustments that continued to influence economic indicators throughout the 1990s.

Additionally, most available datasets for the Czech Republic only begin in 1996 or 1999, further constraining the analysis. Throughout the examined period, there were only three recessionary episodes (2008q4–2009q4, 2012q1–2013q1, and 2020q1–2020q2), limiting the number of downturns within the sample. In contrast, other studies on similar topics often utilize larger datasets with a greater number of recession episodes, allowing for a more comprehensive assessment of fiscal multipliers across business cycles.

3.3 Sensitivity Tests

To assess the robustness of the results based on model specification, estimates were generated for alternative values of γ (specifically, $\gamma = 1.5$) and using a different data sample (1999q1–2019q4). The gamma parameter is crucial in differentiating between expansion and recession phases and governing the transition between them. Higher values of γ, especially in shorter and more volatile time series, reduce the model's error component, thereby providing more precise estimates. Thus, when γ is reduced, the model transitions more slowly between recessionary and expansionary phases, and the error component of the model increases. Previous studies using this model have applied γ values in the range of 1.5–2.5 (for example, Auerbach and Gorodnichenko, 2012;

Hernández de Cos and Moral-Benito, 2013; Herbert, 2014; Caggiano et al., 2015). Given that a relatively high γ parameter of 2.5 was used in the baseline specification, a lower γ value of 1.5 was employed for the sensitivity test.

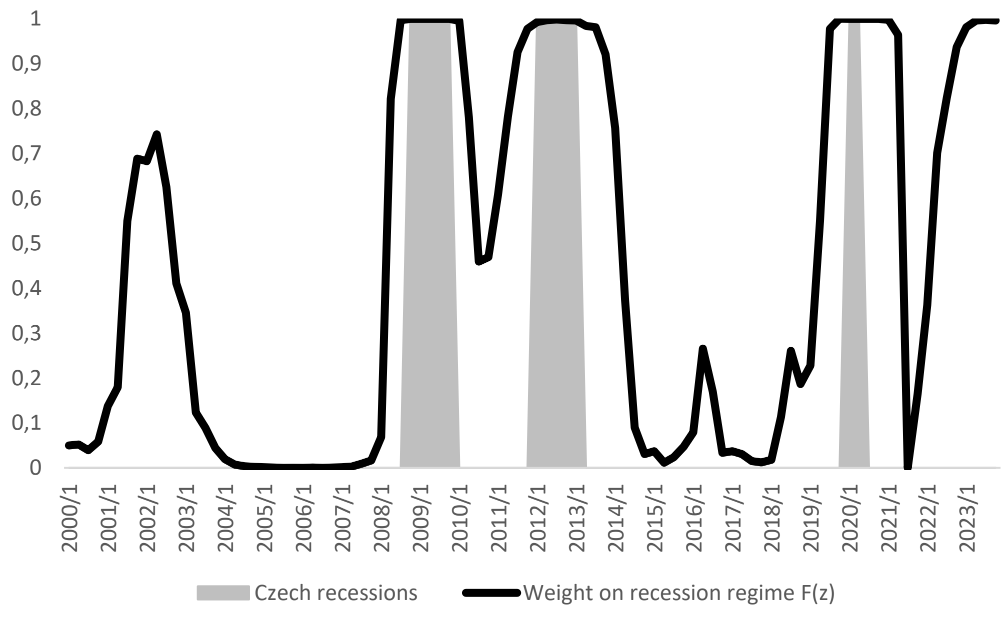
Using a different data sample is one of the fundamental methods for examining robustness; however, it presents specific challenges in this context. The Czech Republic's history as a market economy is comparatively brief compared to Western countries. As previously mentioned, the vast majority of available datasets begin around 1996 or 1999, including the fiscal data in quarterly format. It is also essential to consider that the model was designed to work with longer time series containing several decades of alternating business cycle phases. Consequently, the chosen data sample spans from 1999q1 to 2019q4, deliberately omitting the (post-)COVID-19 period, during which the Czech economy faced limited access to production factors due to the partial shutdown of some sectors.

4. Results

4.1 Recession Dates and Weight on Recession Regime F(z)

Figure 2 illustrates the probability of recessions induced by the baseline specification in comparison with actual recessions. It can be seen that the model captures the recessions of 2008–2009 and 2012–2013 relatively well. However, it also indicates a prolonged recession during the (post-)COVID-19 period, which was further exacerbated by the outbreak of the war in Ukraine.

Figure 2: Probability of a Recessionary Phase in the Baseline Scenario

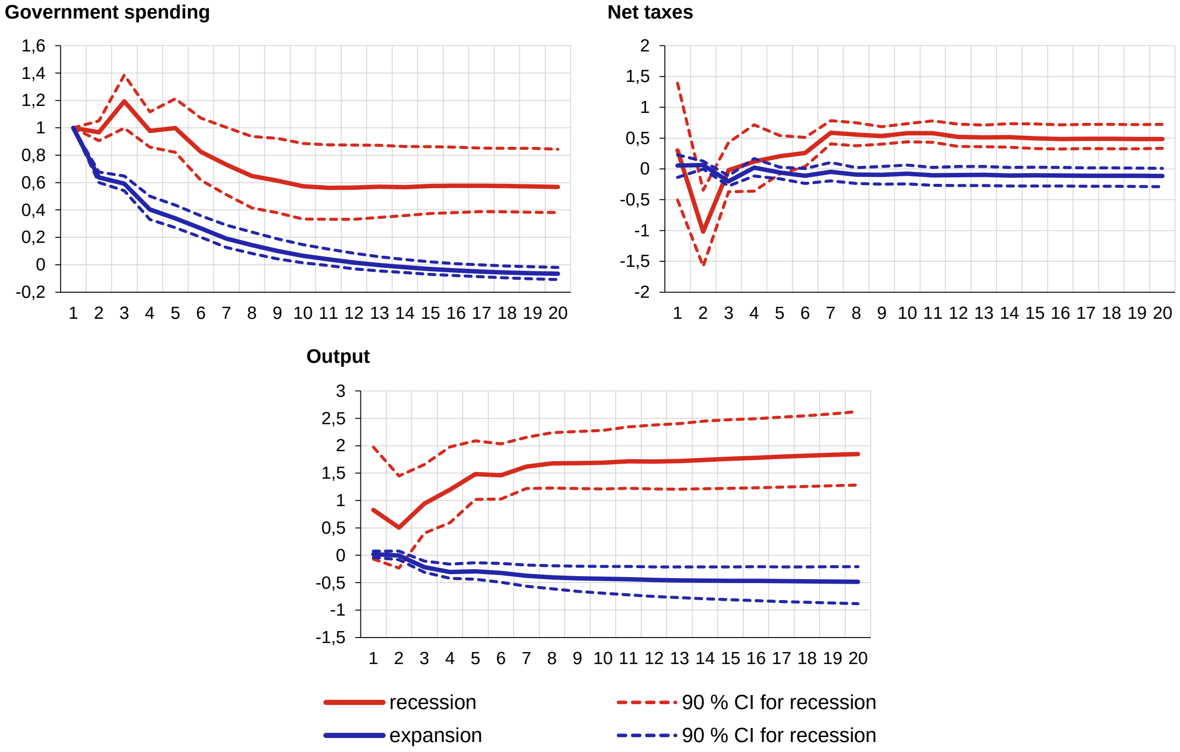


Source: CNB and CSO

4.2 Impulse Responses in Expansions and Recessions

This section presents the responses of the endogenous variables X_t to a unit shock in government spending[5]. The baseline construction of impulse responses captures the reactions of the variables in the case of a deep recession ($F(z) = 1$) and high expansion ($F(z) = 0$), under the condition that no regime change occurs during the analyzed period.

Figure 3: IRFs in Expansions and Recessions in the Baseline Scenario with an Exogenous Probability of a Recession



Source: Own calculation

The impulse responses show that the shock to government spending is persistent, especially during a recession, where it is also significantly stronger (even amplified in the short term) compared to an expansion. This profile corresponds to the typical reaction of fiscal policy in response to a recession, aiming to counteract it. The response of taxes indicates that, particularly in a recession, fiscal expansion is financed through deficit spending, as tax revenues decrease in the initial quarters following the shock (simultaneously with the increase in government spending, tax revenues also decline). The fiscal impulse, in the form of increased government consumption and investment, is often accompanied by an increase in transfers, which further reduces net taxes at the onset of the response. Subsequently, tax revenues in the recessionary regime increase in line with rising output, whereas, in the expansionary regime, tax revenues initially increase but later decline over the longer term due to decreasing output. The response of output itself to the shock in government spending is also very persistent, particularly in a recession, where output exhibits significant growth.

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[5] Besides shocks to government spending, shocks to taxes, government consumption and investment were examined. However, all these extensions provided inconclusive results.

Table 2 presents the spending multipliers, calculated over a 12-quarter horizon only, as the effects of fiscal shocks over a longer term may be distorted by other factors. The values indicate that the crowding-out effect is lower during a recession compared to an expansionary period.

Table 2: Government Spending Multipliers in the Baseline Scenario with an Exogenous Probability of a Recession

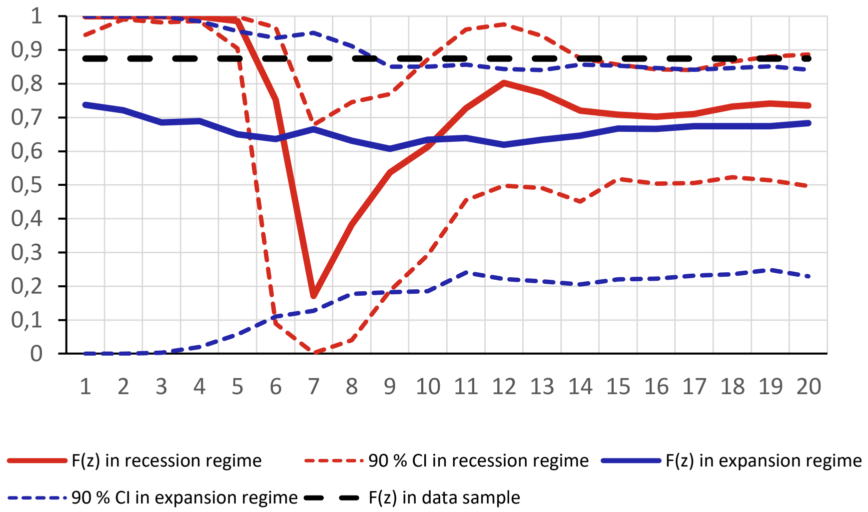
Horizon	Expansion	S.E.	Recession	S.E.
4	-0.19	0.05	0.90	0.46
8	-0.52	0.08	1.37	0.37
12	-0.95	0.10	1.75	0.35

Source: Own calculation

4.3 Generalized Impulse Responses in Expansions and Recessions

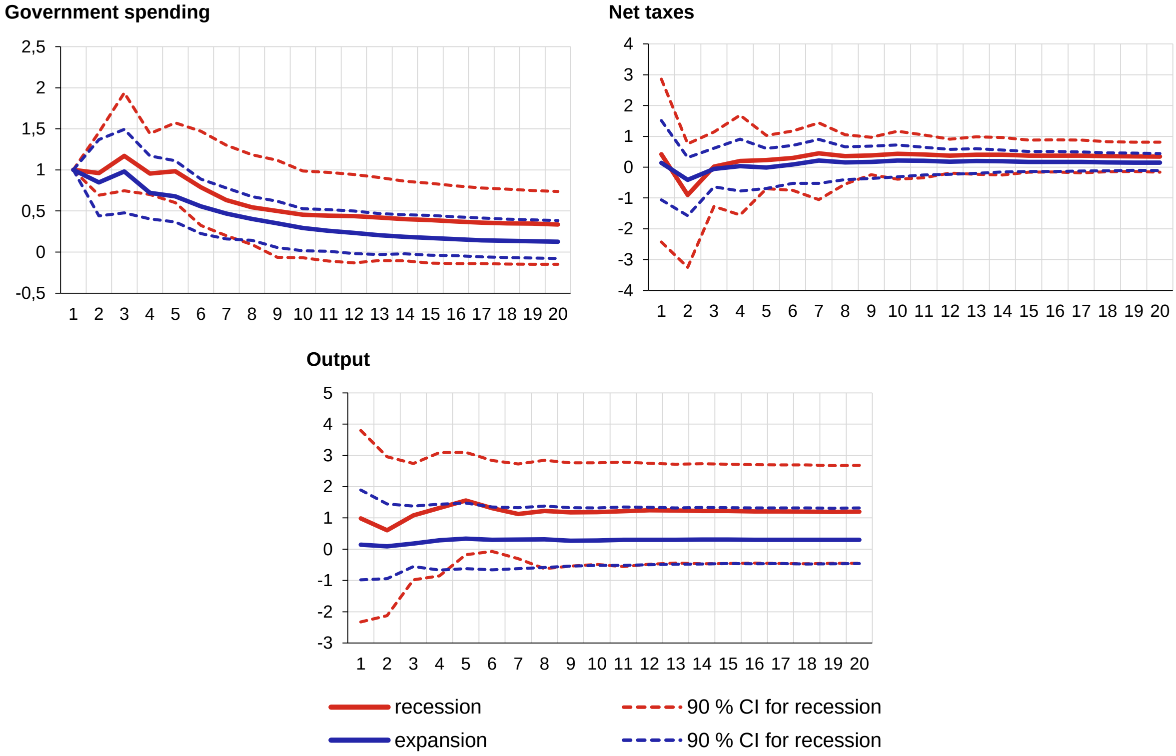
When using the GIRF, the probability of a recession $F(z)$ is endogenized throughout the impulse response. Figure 4 illustrates the transition function $F(z)$ implied by the model, where the threshold $F(z) = 0.875$ corresponds to the proportion of expansions within the data sample. Compared to the baseline IRF construction, it is evident that in the expansionary regime $F(z) \neq 0$ but instead oscillates around 0.65, indicating a weak expansion. An interesting pattern is also observed in the recessionary regime, where $F(z)$ initially equals 1, but after 5 quarters, the economy briefly shifts into a strong expansion, consistent with the typical duration of recessions in the observed data sample. For the remaining quarters, $F(z)$ resembles the pattern in the expansionary regime.

Figure 4: Evolution of the Probability of a Recession in the Baseline Scenario



Source: Own calculation

Figure 5: GIRFs in Expansions and Recessions in the Baseline Scenario with an Endogenous Probability of a Recession



Source: Own calculation

The profile of impulse responses in the recessionary regime, despite the varying $F(z)$, is very similar to the scenario where $F(z)$ was held constant at 1. However, endogenizing $F(z)$ yielded significantly different results for the expansionary regime, which now more closely resembles the recessionary regime. Specifically, the fiscal shock is more persistent, and the responses of taxes and output reach positive values.

The differing responses of the fiscal shock during expansion are also reflected in the calculated spending multipliers, whose values have increased. In a recession, we obtain similar multiplier values as those derived with a constant probability of recession.

Table 3: Government Spending Multipliers in the Baseline Scenario with an Endogenous Probability of a Recession

Horizon	Expansion	CI low Exp	CI up Exp	Recession	CI low Rec	CI up Rec
4	0.24	-0.65	2.34	1.07	-1.03	2.95
8	0.43	-0.74	2.47	1.35	-0.96	3.11
12	0.57	-1.06	2.57	1.63	-1.27	3.22

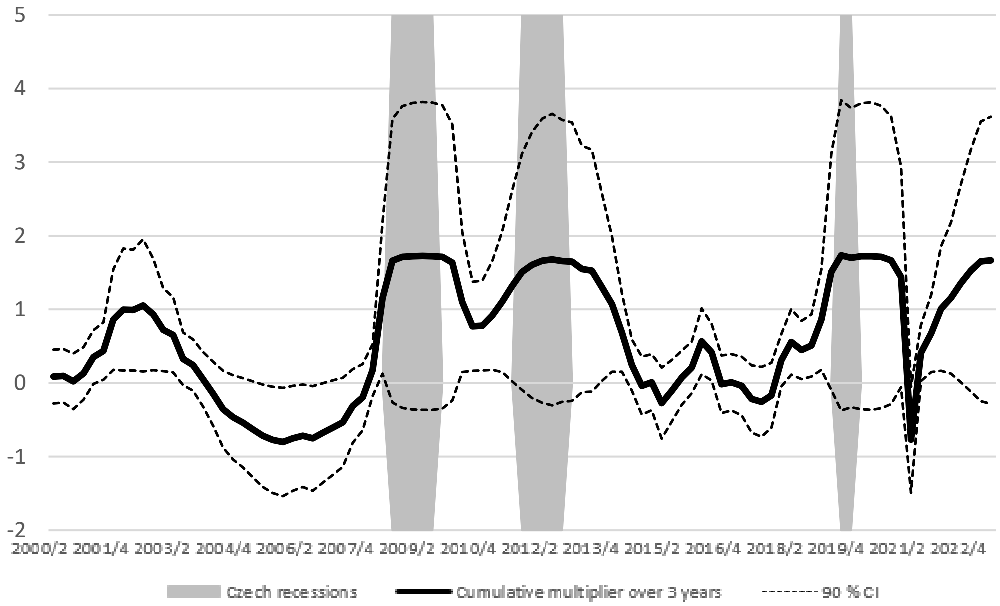
Source: Own calculation

The results above indicate that fiscal multipliers depend not only on the economic cycle itself but also on the magnitude of that cycle, with fiscal multiplier values increasing as economic performance declines and vice versa.

4.4 The Evolution of the Government Spending Multipliers

The findings are further corroborated by the calculated historical values of the cumulative multiplier (over three years) displayed in Figure 6. The results align with traditional Keynesian theory, indicating that multiplier effects are substantially higher during periods of economic downturn.

Figure 6: Values of Government Spending Multiplier in History



Source: Own calculation

5. Sensitivity Tests

Given that the size of the multiplier effect depends on the magnitude of the economic cycle, it is also necessary to test the sensitivity of the obtained values to the model's ability (or speed) to switch between different phases—in other words, to the size of the gamma parameter. Additionally, the sensitivity of the results to the selected data sample was also evaluated. The results can be found in Appendix C.

The reduction of gamma leads to a slower transition compared to the baseline specification. However, no substantial change in the identification of recessions was observed, similar to the results with the shorter sample, as shown in Figure C1.

In both versions of the exogenous impulse responses (Figures C2 and C3), a deterioration in the estimation quality is evident, particularly over a longer horizon, as indicated by increased response volatility and wider confidence intervals. This deterioration was caused by an increase in the model's random component when gamma was reduced from 2.5 to 1.5 (due to an inadequate parameterization) in the first case, and by an insufficiently long data sample in the second case.[6] Nevertheless, the response profile (especially in the initial quarters) closely resembles the baseline specification. These issues also impacted the calculated multipliers through higher standard errors

[6] Typically, datasets spanning around 30 years with sufficient recessionary and expansionary phases are used.

in the recession scenario (Table C1). Additionally, the multipliers themselves reach lower values due to the model's slower switching (lower γ).

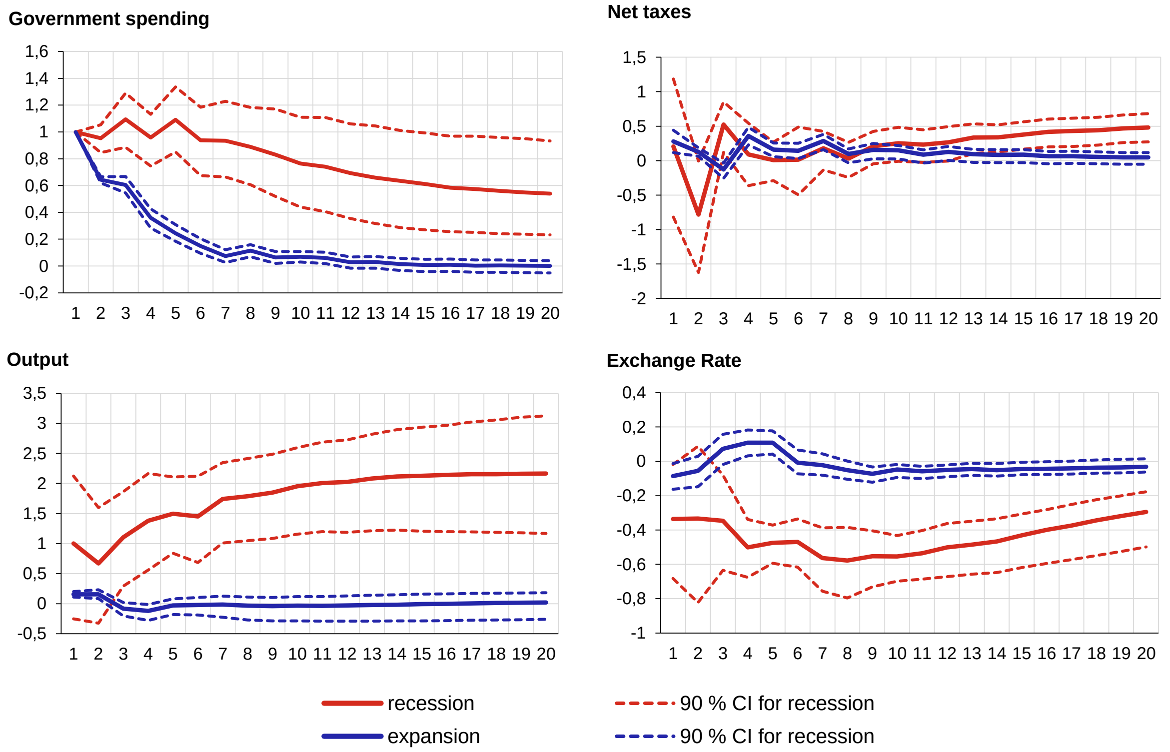
Similarly, with the GIRFs (Figures C5 and C6), the estimates become less reliable with the change in specification, as indicated by the wider confidence intervals shown in Table C2. As with the exogenous probability of a recession, a reduction in the gamma parameter led to a decrease in the multiplier in the recessionary regime. This represents another manifestation of the model´s slower switching.

6. Small Open Economy

As a small open economy, the Czech Republic is particularly exposed to external economic fluctuations. Neglecting this factor could result in an omitted variable problem, potentially leading to biased estimates. To address this issue, the koruna/euro exchange rate was incorporated into the model as a proxy variable capturing the influence of external economic conditions.

6.1 Impulse Responses in Expansions and Recessions

Figure 7: IRFs in Expansions and Recessions with the Inclusion of the Exchange Rate and an Exogenous Probability of a Recession



Source: Own calculation

Profiles of impulse responses with an exogenous probability of a recession (Figure 7) closely resemble the baseline scenario with three variables at first glance. However, there are a few notable differences: first, the fiscal shock is less persistent; second, the confidence intervals in recessions are wider; and third, the output response in expansions reaches positive values.

These results are reflected in the calculated multipliers presented in Table 4. The most significant change occurs in expansions, where the multipliers reach zero. Such values would be expected during a strong expansion, in contrast to the negative values obtained in the baseline scenario. Conversely, in recessions, the multipliers remain very similar to those in the baseline scenario, albeit with larger standard errors.

Table 4: Government Spending Multipliers with the Inclusion of the Exchange Rate and an Exogenous Probability of a Recession

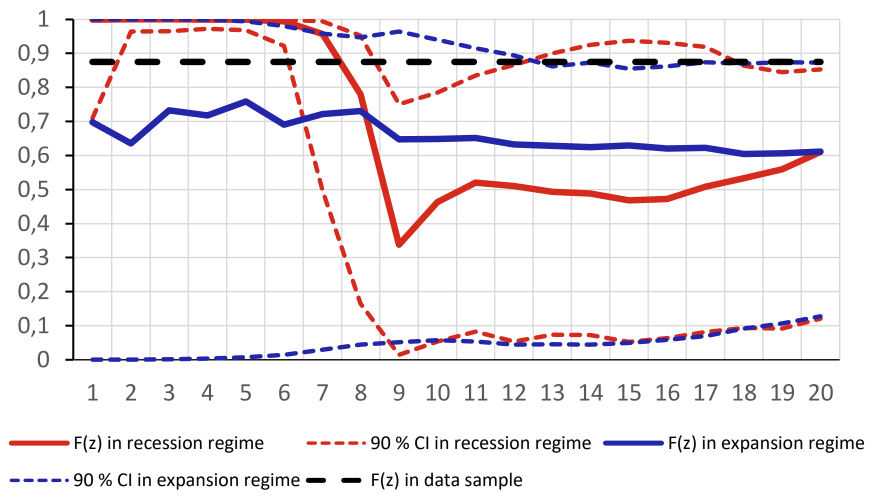
Horizon	Expansion	S.E.	Recession	S.E.
4	0.04	0.05	1.04	0.55
8	0.00	0.07	1.35	0.46
12	-0.04	0.09	1.70	0.42

Source: Own calculation

6.2 Generalized Impulse Responses in Expansions and Recessions

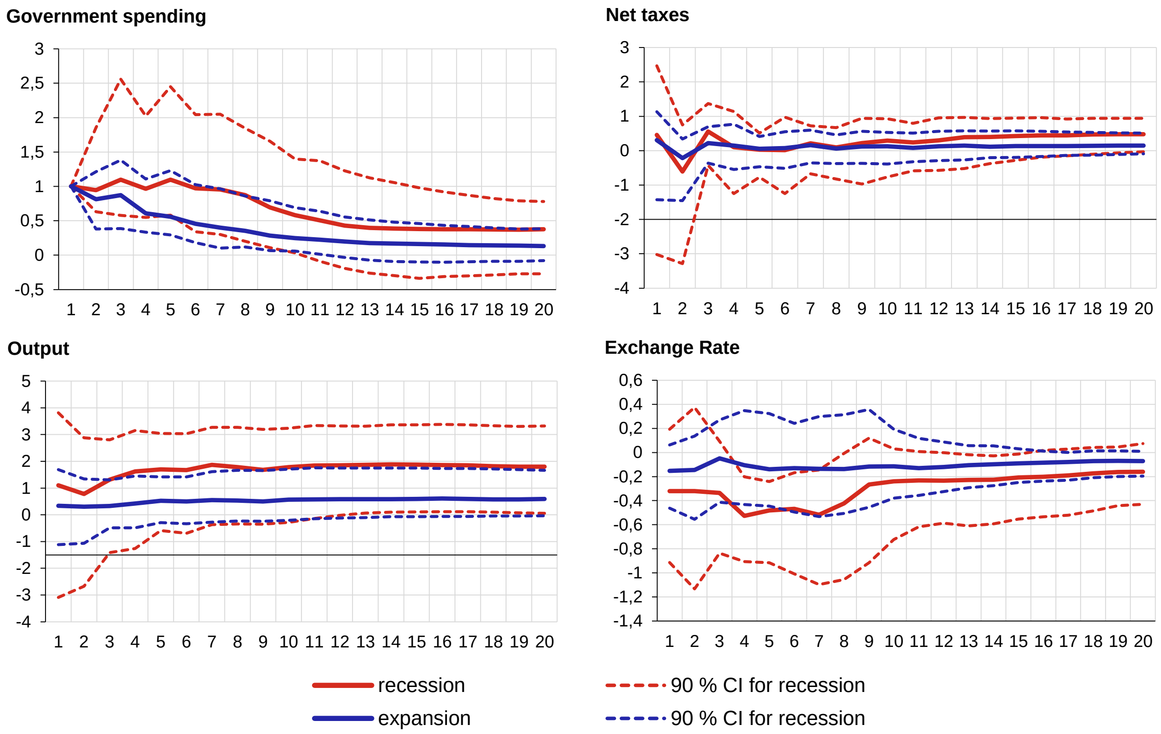
With an endogenous probability of a recession, the recessionary period is prolonged (Figure 8). However, the impulse responses (Figure 9) are closely aligned with those in the baseline scenario.

Figure 8: Evolution of the Probability of a Recession with the Inclusion of the Exchange Rate



Source: Own calculation

Figure 9: GIRFs in Expansions and Recessions with the Inclusion of the Exchange Rate and an Endogenous Probability of a Recession



Source: Own calculation

The similarity of the results to the baseline scenario is further highlighted by the table of calculated multipliers (Table 5), which are in line with those in the baseline scenario. It can be observed that adding a fourth variable primarily improved the model's explanatory power in expansions (narrower confidence intervals) but, conversely, worsened the estimates for recessions (wider confidence intervals).

Table 5: Government Spending Multipliers with the Inclusion of the Exchange Rate and an Endogenous Probability of a Recession

Horizon	Expansion	CI low Exp	CI up Exp	Recession	CI low Rec	CI up Rec
4	0.44	-0.82	1.92	1.15	-1.70	2.95
8	0.52	-1.18	1.91	1.45	-1.52	3.11
12	0.64	-1.31	2.29	1.82	-1.65	3.51

Source: Own calculation

While the change in specification did not lead to a significant shift in conclusions, it underscores the limitations of this research, particularly the constraints imposed by the small sample size. The baseline model specification thus provided reliable results, which were further refined—particularly for expansions—by the four-variable model. Table 6 builds on these findings by presenting the recommended values of the fiscal spending multiplier, contingent on economic performance as measured by quarter-on-quarter real GDP growth.

Table 6: Recommended Values of Fiscal Spending Multipliers

	Expansion		Recession
Horizon	$g_Y \approx 2$ %	$g_Y \approx 0.5$ %	$g_Y \approx -2$ %
4	0.04	0.44	1.07
8	0.00	0.52	1.35
12	-0.04	0.64	1.63

Source: Own calculation

7. Conclusion

This paper investigates the non-linearity of fiscal multipliers in a small open economy, emphasizing their dependence on the business cycle phase and magnitude. Using an STVAR model, the study demonstrates that fiscal multipliers vary significantly across economic phases, aligning with the scientific consensus that government spending multipliers are lower in expansion (0–0.5) and higher in recession (1–1.5). The results also confirm that the scale of economic fluctuations affects multiplier values, with larger multipliers observed when economic performance declines sharply.

The findings highlight the effectiveness of fiscal policy during recessions, where multipliers are notably higher, underscoring the role of government spending in supporting aggregate demand and mitigating economic downturns. However, the study also acknowledges limitations, particularly the shorter data sample for the Czech Republic and the limited number of recessionary episodes within the sample period. These constraints suggest caution in generalizing the results and indicate that further research with extended data could strengthen the robustness of the findings.

Future research could explore alternative identification strategies, such as the Narrative approach, to analyze expected fiscal shocks. Additionally, expanding this research to consider the influence of public finance conditions—specifically, examining the effects of fiscal expansion during budget deficits or surpluses across different economic phases—would provide valuable insights. However, even in this case, the limited availability of data, particularly on budget surpluses in the Czech Republic, may present challenges.

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Appendix A: Estimation Procedure

This section presents a concise overview of the estimation procedure. For more detailed information, see Auerbach and Gorodnichenko (2012), where the authors provide an in-depth description of the methodology.

The model is estimated using the maximum likelihood method, represented by the expression:

$$log\,L = const - \frac{1}{2}\sum_{t=1}^{T} log|\Omega_t| - \frac{1}{2}\sum_{t=1}^{T} \varepsilon_t' \Omega_t^{-1} \varepsilon_t, \quad \text{(A1)}$$

where residuals ε_t with variance Ω_t are derived from equations (1) and (3). Since the model is linear in lag polynomials $\{\Phi_R(L), \Phi_E(L)\}$ for given values of $\{\gamma, \Omega_R, \Omega_E\}$, it is possible to estimate $\{\Phi_R(L), \Phi_E(L)\}$ using weighted least squares for a given estimate of $\{\gamma, \Omega_R, \Omega_E\}$. The weights are given by Ω_t^{-1}, and the estimates $\{\Phi_R(L), \Phi_E(L)\}$ minimize $\frac{1}{2}\sum_{t=1}^{T} \varepsilon_t' \Omega_t^{-1} \varepsilon_t$.

The model thus iterates over different values of $\{\gamma, \Omega_R, \Omega_E\}$ until an optimum is reached. However, due to the model's nonlinearity, multiple local optima are possible. This is addressed by using the Hastings-Metropolis algorithm to implement the Markov Chain Monte Carlo (MCMC) method for determining parameters and their posterior distributions.

The MCMC algorithm proceeds as follows:

1) First, the model in equations (1)-(5) is approximated. From this approximation, residuals are extracted and used to fit equation (3) using maximum likelihood estimation to obtain Ω_R and Ω_E, which serve as initial parameter estimates.
2) Next, a candidate vector of parameter values with i.i.d. shocks is drawn.
3) The acceptance probability of these candidate values depends on the ratio θ of the log-likelihood of this new candidate vector of parameters to the log-likelihood of the previous vector. If $\theta \geq 1$, the new candidate is accepted; if $\theta < 1$, the candidate is accepted with probability θ.
4) The algorithm then tests 100,000 draws for the estimates, discarding the first 20,000 draws as a "burn-in" period to ensure robustness of the estimates.

Appendix B: Construction of Generalized Impulse Response Functions

The construction of the GIRF is based on the approach proposed by Koop, Pesaran, and Potter (1996) and has been adopted and modified for this research following Caggiano et al. (2015). It consists of the following steps:

1. In the first step, recessionary and expansionary phases are separated using the transition variable. If $z_{\lambda_i} > -0.75$,[7] then the observation λ_i falls into the expansionary regime; conversely, if $z_{\lambda_i} \leq -0.75$, the observation λ_i falls into the recession.
2. A random observation λ_i is then drawn from the recession sample, where Ω_{λ_i} is calculated according to:
$$\Omega_{\lambda_i} = \Omega_R F(z_{\lambda_i}) + \Omega_E(1 - F(z_{\lambda_i})). \quad \text{(B1)}$$
3. The estimated variance-covariance matrix Ω_{λ_i} is then decomposed using Cholesky decomposition to obtain orthogonalized structural shocks. These shocks serve as a basis for generating bootstrapped realizations, capturing variations in recessionary and expansionary histories.
4. The GIRF is then calculated based on the history λ_i and shock v_i, where the calculation is repeated B times ($B = 500$) to obtain an average GIRF, reducing the impact of random fluctuations:
$$GIRF_i(z_{\lambda_i}, v_i) = B^{-1} \sum_{j=1}^{B} GIRF_i\,(z_{\lambda_i}, v_i). \quad \text{(B2)}$$
5. Steps 2 through 4 are repeated for each of $i = 1, \dots, 500$ randomly drawn histories in recession. From these, the average response in recession is calculated.
6. Steps 2 through 5 are then repeated for all 500 randomly drawn histories in expansion.

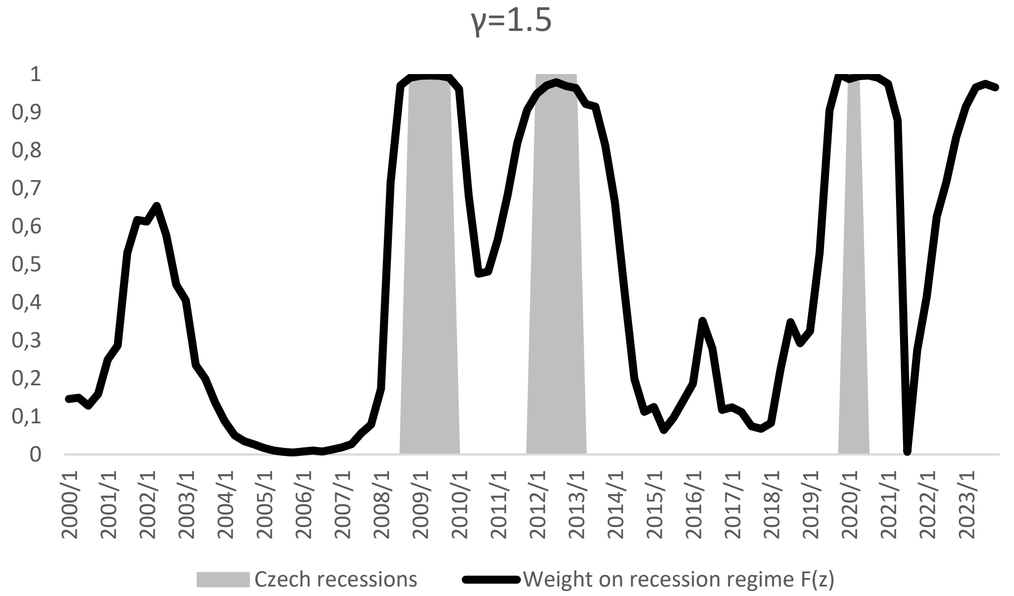
[7] The value of -0.75 was chosen to correspond to actual recession periods in the sample.

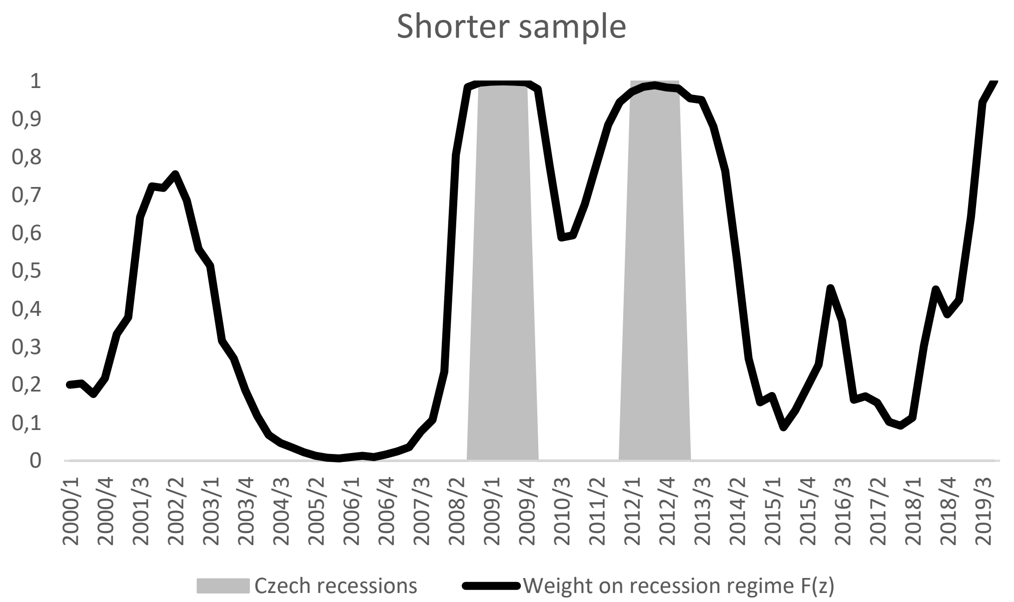
Appendix C: Sensitivity Tests

This section contains the results of the conducted sensitivity tests, including changes in the switching parameter γ and the reduction of the data sample.

C.1 Recession Dates and Weight on Recession Regime F(z)

Figure C1: Evolution of the Probability of a Recession in Sensitivity Tests

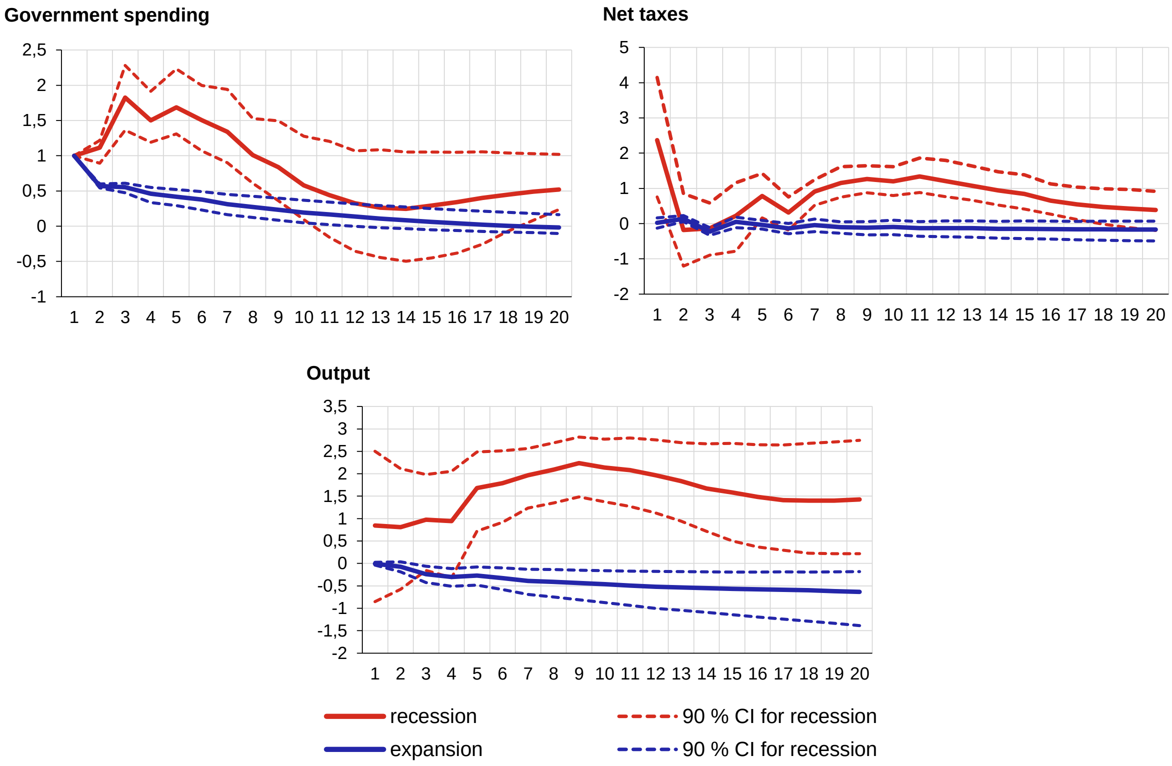




Source: Own calculation

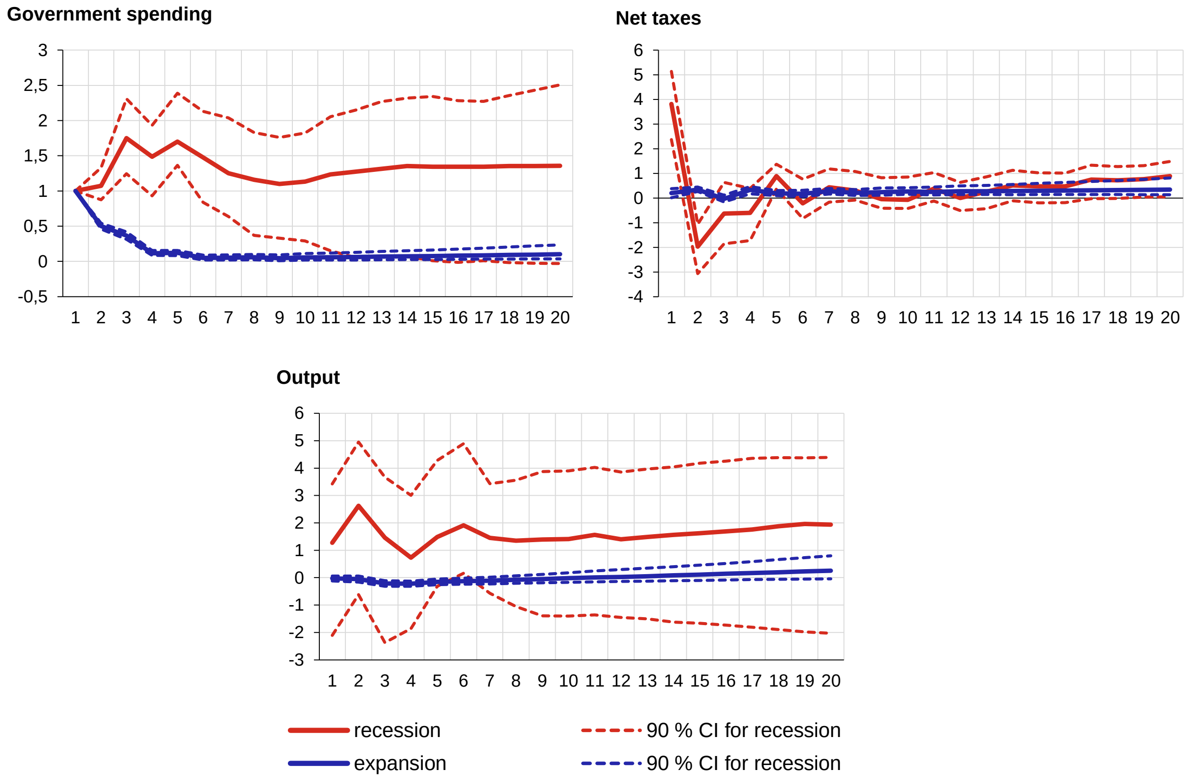
C.2 Impulse Responses in Expansions and Recessions

Figure C2: IRFs in Expansions and Recessions with the $\gamma = 1.5$ and an Exogenous Probability of a Recession



Source: Own calculation

Figure C3: IRFs in Expansions and Recessions with the Shorter Sample and an Exogenous Probability of a Recession



Source: Own calculation

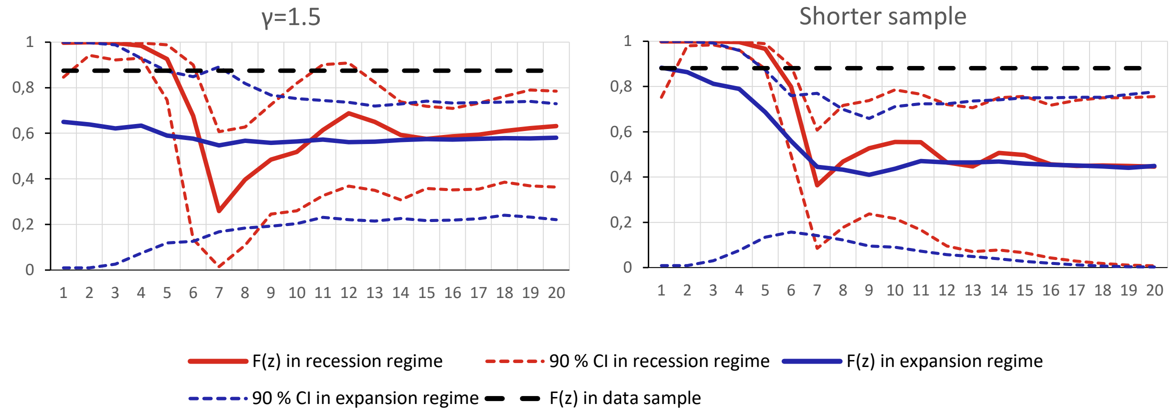
Table C1: Government Spending Multipliers in Sensitivity Tests with an Exogenous Probability of a Recession

	Horizon	Expansion	S.E.	Recession	S.E.
γ = 1.5					
	4	-0.23	0.07	0.26	0.72
	8	-0.49	0.12	0.74	0.56
	12	-0.80	0.16	1.25	0.50
Shorter sample					
	4	-0.26	0.06	1.15	0.54
	8	-0.44	0.06	1.13	0.41
	12	-0.41	0.08	1.16	0.52

Source: Own calculation

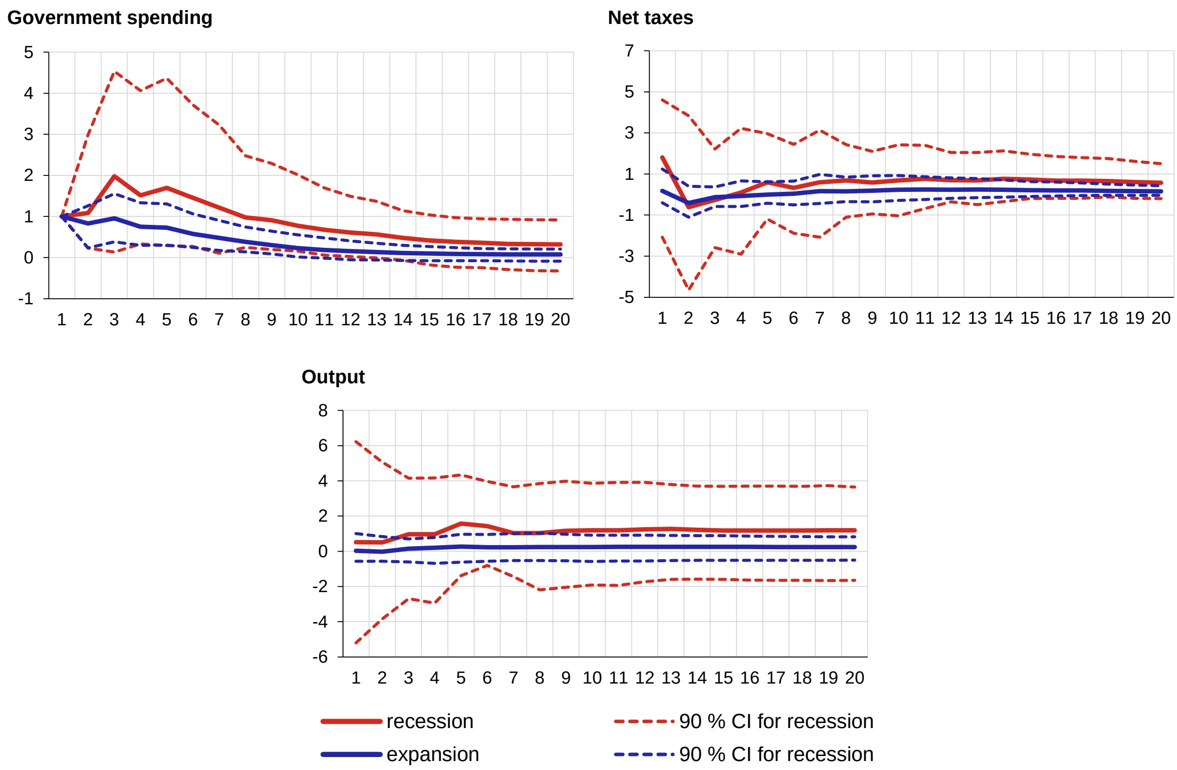
C.3 Generalized Impulse Responses in Expansions and Recessions

Figure C4: Evolution of the Probability of a Recession in Sensitivity Tests



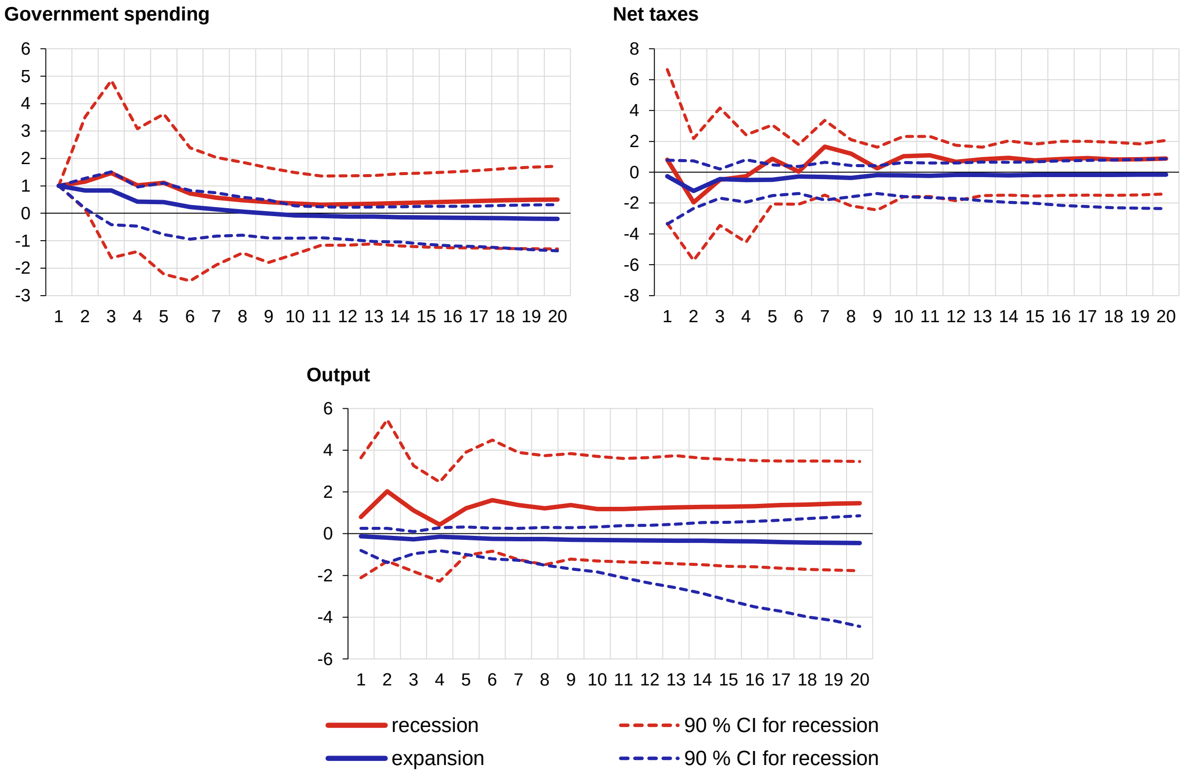
Source: Own calculation

Figure C5: GIRFs in Expansions and Recessions with the $\gamma = 1.5$ and an Endogenous Probability of a Recession



Source: Own calculation

Figure C6: GIRFs in Expansions and Recessions with the Shorter Sample and an Endogenous Probability of a Recession



Source: Own calculation

Table C2: Government Spending Multipliers in Sensitivity Tests with an Endogenous Probability of a Recession

	Horizon	Expansion	CI low Exp	CI up Exp	Recession	CI low Rec	CI up Rec
γ = 1.5							
	4	0.19	-0.78	2.06	0.46	-2.56	4.76
	8	0.35	-0.80	2.32	0.67	-1.84	4.33
	12	0.49	-1.07	2.65	0.85	-2.20	4.23
Shorter sample							
	4	-0.11	-3.71	3.62	0.94	-2.18	4.24
	8	0.03	-2.33	4.16	1.30	-1.79	4.08
	12	0.16	-3.57	4.75	1.65	-1.02	4.61

Source: Own calculation

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CZECH NATIONAL BANK
Na Příkopě 28
115 03 Praha 1
Czech Republic

ECONOMIC RESEARCH DIVISION
Tel.: +420 224 412 321
Fax: +420 224 412 329
http://www.cnb.cz
e-mail: research@cnb.cz

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