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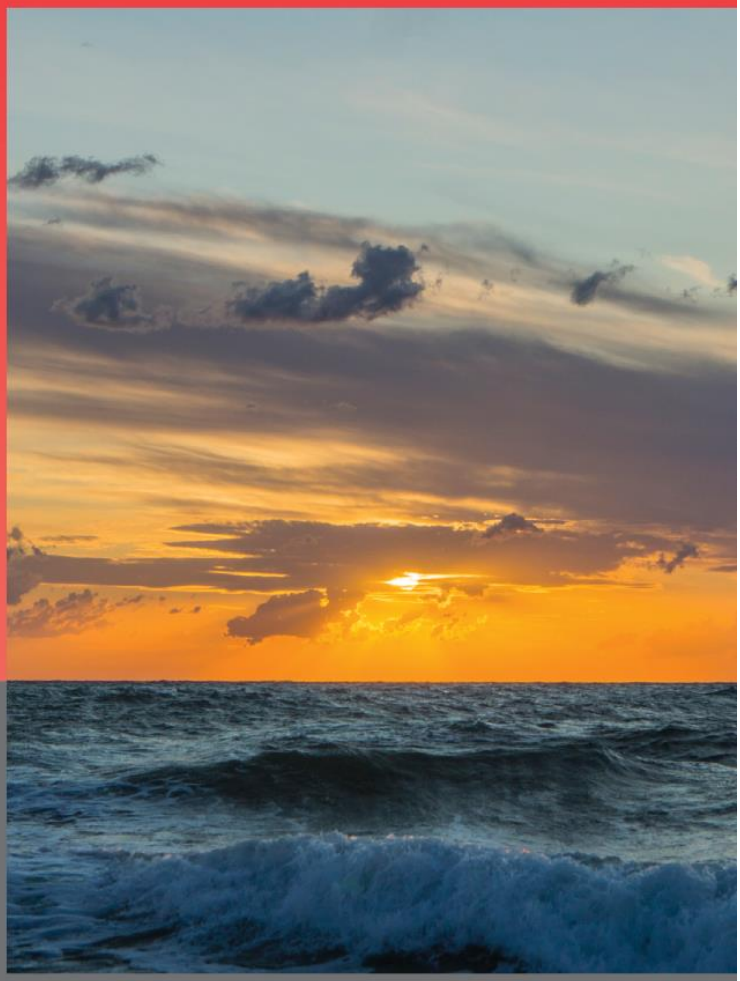

Deep habits and financing of government expenditure growth

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Abstract

This paper uses a stochastic general equilibrium model for a small open export-oriented economy to address two key issues. First, it analyses the impact of deep habits in such an economy. Habits refer to consumers' tendency to maintain a consumption level similar to previous periods, while deep habits indicate a tendency related to each consumed good rather than just the overall consumption level. We present a model in which the formulation of deep habits differs from the conventional one, taking into account imports in consumption. Second, we compare different financing options for growth in government spending.

The role of deep habits in response to economic shocks is reflected in the dampening of shifts in the household demand curve. The paper is the first to show that deep habits lead to lower volatility in output and consumption and to higher volatility in inflation. It also demonstrates that a *long-lasting* government spending shock results in a crowding-out effect on consumption and output, while a *temporary* shock leads to an accumulation effect.

The medium-term increase in government spending (and government consumption [1]) examined in this study, due to the subsequent need to balance public debt levels, results in decreasing government consumption in the long term. Based on two criteria (maximising welfare and government consumption in the long term), the most preferred financing options for growth in expenditure are the use of a national fund invested in foreign assets or the external debt market.

A key innovation of the study is the application of the concept of deep habits to an exporting economy where imports play a significant role in consumer demand; the differentiation between temporary and long-lasting government spending shocks; and the analysis of various financing options for public spending growth, which, as shown, influences the manifestation of either the accumulation or crowding-out effect.

Keywords: dynamic models, rational expectations, fiscal policy, habits, fiscal expansion, crowding-out effect.

JEL codes: D58, E47, E62, E63.

[1] This paper presents a model in which the only direction of public spending is government consumption. Therefore, when referring to an increase or decrease in public spending, we automatically imply a corresponding increase or decrease in government consumption.

1. Introduction

Deep habits, a concept introduced by *Ravn et al.* (2006), serve as a method for describing consumer preferences, aimed at capturing, within the framework of general equilibrium models, the consumer tendency to maintain a level of consumption for specific goods consistent with past levels. Mathematically, deep habits are represented by a consumer demand function (derived from assumptions) for a specific good c_t^i produced by firm i, which depends on past consumption c_{t-1}^i of this good, its current prices p_t^i, and the overall price level p_t: $c_t^i = F\left(c_{t-1}^i, p_t^i, p_t\right)$.

The literature on this subject (*Ravn et al.,* 2006; *Cantore et al.,* 2012; *Aloui,* 2013) suggests that a one-time deviation in consumption from the long-term level, due to habit formation, should create elevated demand for products over a certain period. Accordingly, one would expect that the economy's response to stimulus shocks would be stronger in the presence of habits than in their absence. International studies offer conflicting results on this point, while findings specific to export-oriented economies are yet to emerge.

In this paper, we primarily aim to analyse the effect of deep habits in an export-oriented economy, such as Russia. To achieve this, we use a dynamic stochastic general equilibrium (DSGE) model to investigate the transmission of two shocks to the dynamics of macroeconomic variables. The first is a terms-of-trade shock, which is considered the most significant for the Russian economy in recent decades, as documented in several Russian general equilibrium studies (*Ivashchenko,* 2020; *Kreptsev and Seleznev,* 2018; *Polbin,* 2014; *Andreyev and Polbin,* 2022; *Martyanova and Polbin,* 2023). This shock is used to analyse the impact of deep habits as well as to validate the model's adequacy. The second is a positive government spending shock, which has also repeatedly occurred in the Russian economy over the past decade. Another focal point of this study is the options for financing increased government spending and the related macroeconomic processes.

The relevance of analysing government spending shocks is underscored by the fact that, in 2022 and 2023, federal budget deficits exceeded ₽3 trillion (2.1% and 1.9% of GDP, respectively). In the coming years, Russia's Ministry of Finance also anticipates budget deficits,[2] which may persist. To finance the increased expenditures, the Ministry used a wide range of measures in 2022–2023. Additional measures are expected to be implemented in the future. In particular, the volume of federal government bonds (OFZs) rose by ₽4.5 trillion from January 2022 over two years,[3] leading to only a slight increase in the debt-to-GDP ratio from 11.4% to 11.6% by early 2024, due to a rapidly growing GDP deflator. Between 2024 and 2026, an increase in the OFZ volume of ₽2.6–3.5 trillion per year is forecast, reaching ₽29 trillion by the end of 2026.[4]

[2] Ministry of Finance expects Russia's budget deficit to be within ₽1.5 trillion in 2024. Interfax, 11 April 2024.
[3] OFZ statistics. Bank of Russia.
[4] Financial Stability Review. Bank of Russia, 2023.

Taxes are also being selectively increased: a one-time tax on excess profits was introduced in 2023, import duties on goods from unfriendly countries are rising, and adjustments to the tax scale may follow soon.[5] Additionally, the mineral extraction tax for Gazprom was raised, signifying a higher tax burden in the oil and gas sector. The largest budget inflows came from the National Wealth Fund (NWF) and the 2022–2023 fiscal rule amendment, which mandated oil and gas revenues of ₽8 trillion per year in 2022–2023, with future taxes calculated based on a $60 per barrel oil price starting in 2024, a higher level than before 2022. The revision of the fiscal rule is aimed at establishing a sustainable level of budget spending from oil and gas revenues. The breadth and variety of the Ministry of Finance's measures may suggest an intention to finance increased spending from multiple sources without overburdening individual areas.

These measures motivate us to consider several options for financing the increase in government spending in this study: through domestic borrowing, through tax hikes on production or oil and gas revenues, and through external financing via the NWF or external debt markets. The effects of various financing options for growth in expenditure are assessed based on public welfare and accumulated long-term changes in government consumption.

In studies on the long-term effects of fiscal policy, researchers emphasise the interdependence of tax, monetary, and fiscal policies (*Sargent and Wallace,* 1984; *Leeper,* 1991; *Davig and Leeper,* 2011), particularly the relationship between inflation and public debt. For example, the fiscal theory of the price level (*Sargent and Wallace,* 1984; *Cochrane,* 2022) suggests that a price level is determined by the future aggregate budget deficit (*Cochrane,* 2022), while *Angeletos et al.* (2023) assert that fiscal authorities, under certain economic assumptions, can safely increase the level of debt, which is partially reduced by inflation and partially offset by higher tax revenues. However, we set aside the issue of inflation’s impact on accumulated debt, assuming a single-period borrowing instrument and a zero initial level of public debt. Additionally, unlike studies suggesting that government spending directly affects consumer utility or boosts economic productivity (e.g. *Sims and Wolff,* 2018), our paper assumes that the increase in government spending is important in its own right, without secondary benefits in the model. This approach is justified by the observation that the current rise in government spending is part of state policy, though it is still necessary to compare the effectiveness of various financing options for increased spending.

The academic literature on deep habits explores government spending shocks, though the results obtained are only loosely applicable to the questions addressed in this study. In *Ravn et al.* (2006), which focuses on the countercyclicality of producer markups due to deep habits, habits actually lead to procyclical household output and consumption responses to a government spending shock. *Ravn et al.* (2012) use a general equilibrium model with deep habits and lump-sum taxes to reproduce the result of a VAR model showing that higher spending increases

[5] Government drafts changes to personal income tax scale and profit tax rate. Vedomosti, 5 March 2024.

output and consumption and weakens the domestic currency. However, they note that a news shock related to future government spending does not lead to an increase in consumption or wages. *Aloui* (2013) adds overlapping generations to the model used by *Ravn et al.* (2006), further weakening Ricardian equivalence, and observes that a positive government spending shock results in higher interest rates, a decline in consumption and employment, and only a short-term increase in output if prices are rigid in the economy. *Cantore et al.* (2012) examine the influence of fiscal rule form on how a government spending shock impacts consumption: with optimal fiscal policy or an optimised Taylor rule, the fiscal multiplier of public spending is greater than one, and the economy expands in response to a government spending shock. Conversely, the economy contracts if monetary authorities respond aggressively to the output gap. *Aloui* (2024) notes that, with deep habits, the government spending multiplier decreases at lower interest rates, although it remains above one.

The paper is structured as follows. Section 2 provides a brief description of the model (Subsection 2.1) along with its detailed mathematical formulation. Terms-of-trade shocks and government spending shocks are discussed in Section 0, where the deep habits mechanism is also examined within the model for an export-oriented economy. Section 4 presents variable responses and efficiency indicators given various financing options for increased government spending, while Section 5 offers concluding remarks.

The academic novelty of this study lies in employing a new description of deep habits for an export-oriented economy where imports represent a significant component of consumer demand. Unlike previous studies (*Aloui*, 2013; *Aloui*, 2024; *Cantore et al.,* 2012; *Ravn et al.,* 2006; *Ravn et al.,* 2012), this paper distinguishes between temporary and long-lasting government spending shocks, as well as various financing options for increased public spending, which, as shown, determine whether an accumulation or crowding-out effect occurs.

2. Model description

2.1. General model description

The model used reflects the fact that various agents – households, the government, and investors in production capital – possess deep consumption habits. Deep habits link the volume of current consumption of an individual good not only to the price of that good but also to its consumption in the previous period. The demand functions for goods are known to the producers, who operate in a monopolistically competitive market. Producers charge a markup, generating profits that are transferred to the owners – households.

The model includes a micro-level heterogeneity of goods and their producers, which disappears in the macro description of the model due to the assumption of symmetric equilibrium.

Households, in addition to choosing a basket of goods, rent out their labour to producers, accumulate and rent out production capital, lend funds to each other, and decide how much to invest in foreign assets. They also receive a share of revenue from commodity sales.[6]

The remaining portion of revenue from commodity sales is received by the government as a tax. This tax, together with production tax, finances government consumption. The government may also borrow on the domestic market or draw funds from the NWF held in foreign currencies, should this be one of the options considered for financing increased government spending. Monetary policy is inflation targeting.

The model includes a number of technical agents, such as capital goods producers and an employment agency, whose involvement leads to imperfections in the labour and investment markets. Other imperfections in the model include the costs of investing in foreign assets, price rigidity, and deep habits.

The dynamics of the variables in the model result from two types of shocks: terms-of-trade and government spending shocks.

2.2. Deep habits: demand for individual product categories by various agents

In the model economy, firms $i \in [0;1]$ produce differentiated domestic goods. Agents in the model – households, the government, and new capital producers – choose the volume of purchase $d_{i,t}^{j}$ of good y produced by firm i, where j is the buyer's index. Domestic goods $d_{i,t}^{j}$ are combined by consumers with the volume of imported goods $imp_{i,t}^{j}$ in accordance with the following technology:

$$c_{i,t}^{j} = \frac{1}{\omega^{\omega}\left(1-\omega\right)^{1-\omega}} \left(d_{i,t}^{j}\right)^{\omega} \left(imp_{i,t}^{j}\right)^{1-\omega} \tag{1}$$

where $c_{i,t}^{j}$ denotes the volume of final differentiated goods. All agents consuming goods $c_{i,t}^{j}$ measure their consumption in terms of a habit-adjusted aggregate consumption level x_t^j:

[6] In this model economy, households act not only as 'consumers' but also as 'owners', earning profits from various types of production, including a portion of export revenues. In equilibrium models, the role of owners is often assigned to Ricardian households, while non-Ricardian households own no assets, adding a realistic element to the model. Initially, our study included a division between Ricardian and non-Ricardian households, but this did not bring any significant results to the model. Consequently, households are treated uniformly and each receives a share of export revenues.

$$x_t^j = \left(\sum_i \left(c_{i,t}^j - \varphi^j \, c_{i,t-1}^j \right)^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{2}$$

For households, the value given by expression (2) is an argument of the utility function, while for other agents, it serves as an aggregate measure to be minimised, reflecting the objective function. At the product group segmentation level, each agent solves a cost-minimisation problem:

$$\sum_i P_{i,t}^d d_{i,t}^j + S_t P_t^{imp} imp_{i,t}^j \to \min \tag{3}$$

given (1) and (2). In expression (3), $P_{i,t}^d$ is the price of firm i's domestic good, $S_t P_t^{imp}$ is the price of the imported product, and S_t is the nominal exchange rate. The price P_t^{imp} depends neither on the good j with which imports are used nor on time: $\boldsymbol{P}_t^{imp} = \boldsymbol{P}^{imp}$.

This cost-minimisation approach mirrors the logic of demand determination for individual product groups as outlined in *Ravn et al.* (2006). Typically, in the literature on deep habits and two-economy interactions (*Ravn et al.*, 2012; *Punnoose and Lenno*, 2019), habits formation is modelled separately for imported and domestic goods, with habit-adjusted aggregate consumption x_t^j defined as a CES function of both. This implies that, depending on the CES parameter, imported and domestic goods can serve as partial substitutes. In contrast, this study assumes the rigid aggregation of imported and domestic goods, as given by (1), meaning that the goods are complements and that habits are formed with respect to their aggregate.

The solution to the cost-minimisation problem determines the demand functions for domestic and imported goods:

$$d_{i,t}^j = \omega \left(\frac{S_t P_t^{imp}}{P_{i,t}^d} \right)^{1-\omega} \left[x_t^j \left(\frac{\left(P_{i,t}^d \right)^{\omega} \left(S_t P_t^{imp} \right)^{1-\omega}}{P_t} \right)^{-\varepsilon} + \varphi^j \, c_{i,t-1}^j \right] \tag{4}$$

$$imp_{i,t}^j = (1-\omega) \left(\frac{P_{i,t}^d}{S_t P_t^{imp}} \right)^{\omega} \left[x_t^j \left(\frac{\left(P_{i,t}^d \right)^{\omega} \left(S_t P_t^{imp} \right)^{1-\omega}}{P_t} \right)^{-\varepsilon} + \varphi^j \, c_{i,t-1}^j \right] \tag{5}$$

where

$$P_t = \left(\sum_i \left(\rho_{i,t} \right)^{1-\varepsilon} \right)^{\frac{1}{1-\varepsilon}} \tag{6}$$

$$\rho_{i,t} = \left(P_{i,t}^d \right)^{\omega} \left(S_t P_t^{imp} \right)^{1-\omega} \tag{7}$$

The demand for domestic and imported goods (4) and (5) is a function of domestic prices $P_{i,t}^d$, exchange rate S_t, consumption lags $c_{i,t-1}^j$, and habit-adjusted aggregate consumption x_t^j. It follows from equations (1), (4) and (5) that

$$c_{i,t}^j = x_t^j \left(\frac{\left(P_{i,t}^d \right)^{\omega} \left(S_t P_t^{imp} \right)^{1-\omega}}{P_t} \right)^{-\varepsilon} + \varphi^j \, c_{i,t-1}^j$$

The demand for the combination $c_{i,t}^j$ of imported and domestic goods is determined by the ratio of the combined price $\rho_{i,t} = \left(P_{i,t}^d \right)^{\omega} \left(S_t P_t^{imp} \right)^{1-\omega}$ to the overall price level P_t, as in *Ravn et al.* (2006), *Ravn et al*. (2012), and *Punnoose and Lenno* (2019).

Additionally, cost minimisation implies that:

$$\sum_i P_{i,t}^d d_{i,t}^j + S_t P_t^{imp} imp_{i,t}^j = P_t \; x_t^j + \varphi^j \sum_i \rho_{i,t} c_{i,t-1}^j \tag{8}$$

As indicated by equation (8), the variety in aggregate-level product group selection maximises habit-adjusted aggregate consumption x_t^j, evaluated at price P_t (6). Due to the assumption of a uniform import-domestic aggregation function (1), all agents face the same price P_t at x_t^j. Price P_t is used as the normalisation price in the model, and its growth rate $\pi_t = P_t / P_{t-1}$ represents inflation. Regarding the lag term $\varphi^j \sum_i \rho_{i,t}^j c_{i,t-1}^j$ in (8), it is assumed that non-producing agents do not perform optimisation on the variables within this term.

In a symmetric equilibrium among producers $i \in [0;1]$, the prices of all producers are equal: $P_{i,t}^d = P_t^d$. It follows that in a symmetric equilibrium

$$P_t = \left(P_t^d\right)^{\omega} \left(S_t P_t^{imp}\right)^{1-\omega} \tag{9}$$

the nominal price of the final product is determined by the domestic product price and the imported product price (via the exchange rate). In terms of relative prices $\tilde{P}_t^d = P_t^d / P_t$, $RER_t = S_t P_t^{imp} / P_t$ (relative domestic price and real exchange rate), the following holds:

$$1 = \left(\tilde{P}_t^d\right)^{\omega} \left(RER_t\right)^{1-\omega}$$

2.3. Households

Similar to *Greenwood et al.* (1988) and *Aloui* (2013), households are assumed to maximise utility

$$E_{t_0} \sum_{t=t_0}^{+\infty} \beta^{t-t_0} \ln\left(X_t^r - \chi \frac{\left(L_t^r\right)^{1+1/\sigma}}{1+1/\sigma} \right) \tag{10}$$

where E_{t_0} is the expectation operator, X_t^r is habit-adjusted aggregate consumption as defined in (2), L_t^r is labour supplied by households to the employment agency at a nominal price W_t, and

$$A_t^r = X_t^r - \chi \frac{\left(L_t^r\right)^{1+1/\sigma}}{1+1/\sigma}$$

is adjusted consumption.

Households can invest funds $D_t^{r,f}$ in foreign bonds at a fixed interest rate R^f, incurring real costs $\Psi_t^D = \frac{1}{2} d_s \left(D_t^{r,f} S_t / P_t Y_t\right)^2 Y_t S_t \frac{P^{imp}}{P_t}$ paid abroad for adjusting investment levels.

They can also borrow funds $D_t^{r,d}$ domestically at an interest rate R_t, which is set by the regulator (e.g. *Smets and Wouters,* 2003). Generally, borrowing takes place between households, resulting in zero net savings. However, if the government borrows domestically, savings are equal to the government's debt.

Households also accumulate production capital $K_{i,t}$ for each firm $i \in [0;1]$. The amount $K_{i,t-1}$ of capital is rented out to firms at a nominal rate $R_{i,t}^k$. The production capital

depreciates at rate δ and increases through the purchase of new capital $DK_{i,t}$ from capital producers at price $Q_{i,t}$:

$$K_{i,t} = (1-\delta) K_{i,t-1} + DK_{i,t}. \tag{11}$$

The nominal household budget constraint is as follows:

$$\begin{aligned} &-P_t X_t^r - \varphi^r \sum_i \rho_{i,t} c_{i,t-1}^r + W_t L_t^r - D_t^{r,d} + R_t D_{t-1}^{r,d} - S_t D_t^{r,f} + S_t R^f D_{t-1}^{r,f} - P_t \Psi_t^D + \\ &+ \sum_i \left(R_{i,t}^k K_{i,t-1} - Q_{i,t} DK_{i,t} \right) + \Pi_t^Y + \Pi_t^L + \Pi_t^K + (1-\tau^{oil}) S_t P_t^{oil} O = 0. \end{aligned} \tag{12}$$

Here, the first two terms represent the costs of purchasing goods (as per Subsection 2.2); $\Pi_t^Y, \Pi_t^L, \Pi_t^K$ are the profits of goods producers, the employment agency and capital producers, respectively; P_t^{oil} is the price of exported commodities; O is a constant export volume; and τ^{oil} is the government tax on revenue from commodity sales.

Households aim to maximise utility (10) subject to constraints (11) and (12). Denoting the Lagrange multipliers under constraint (12) by $\beta^t \frac{\Lambda_t}{P_t}$ and excluding $DK_{i,t}$ via (11), we obtain that the first-order conditions with respect to habit-adjusted consumption X_t^r, labour L_t^r, savings $D_t^{r,d}$, investment in foreign bonds $D_t^{r,f}$, and capital stock $K_{i,t}$ are as follows:

$$\Lambda_t = 1/A_t^r,$$

$$\chi \left(L_t^r \right)^{1/\sigma} = W_t / P_t \tag{13}$$

$$\Lambda_t = \beta E_t \Lambda_{t+1} \frac{R_t}{\pi_{t+1}} \tag{14}$$

$$S_t = \beta R^f E_t \frac{\Lambda_{t+1}}{\Lambda_t} \frac{S_{t+1}}{\pi_{t+1}} - d_s \frac{S_t^2 D_t^{r,f}}{P_t^2 Y_t} \frac{S_t P^{imp}}{P_t} \tag{15}$$

$$\Lambda_t Q_{i,t}/P_t = \beta E_t \Lambda_{t+1}\left(R^k_{i,t+1}/P_{t+1} + (1-\delta)Q_{i,t+1}/P_{t+1}\right) \quad (16)$$

where $\pi_t = P_t/P_{t-1}$. Note that condition (13) follows from the choice of the utility function in form (10). Condition (13) means that all households supply the same amount of labour regardless of their current wealth or other factors. The standard Euler relation (14) suggests that the real rate in the economy on average equals the reciprocal of the time preference coefficient, linking the marginal propensity to consume with the real interest rate. Equations (14) and (15) together yield the parity condition between domestic interest and foreign rates, R_t and R^f, adjusted for exchange rate growth and foreign bond transaction costs. Equation (16) links the real return on capital $R^k_{i,t+1}/P_{t+1}$ with the depreciation rate δ, the time preference coefficient, and the dynamics of real prices $Q_{i,t}/P_t$ of new capital.

Producers factor in household demand functions for domestic goods.

2.4. Capital producers and employment agency

In the model, two types of agents, the employment agency and capital producers, introduce certain market imperfections in line with New Keynesian theory.

The employment agency purchases labour L_t from households at a nominal wage rate W_t, differentiates it into components $L_t(k)$, and sells it to an intermediary at differentiated prices $W^r_t(k)$. In turn, the intermediary aggregates the labour according to the Dixit-Stiglitz technology. The agency is aware of the labour demand from the intermediary: $L_t(k) = \left(\frac{W^r_t(k)}{W^r_t}\right)^{-\xi} L_t$, where L_t is the aggregated labour and W^r_t is the aggregate wage. When setting a price $W^r_t(k)$, the agency incurs quadratic costs $\frac{k^w}{2}\left(\frac{W^r_t(k)}{W^r_{t-1}(k)} - 1\right)^2 W^r_t L_t$ in line with Rotemberg's approach (*Rotemberg*, 1982). The nominal profit of the agency is given by:

$$\Pi^L_t = W^r_t(k) L_t(k) - W_t L_t(k) - \frac{k^w}{2}\left(\frac{W^r_t(k)}{W^r_{t-1}(k)} - 1\right)^2 W^r_t L_t \quad (17)$$

The agency aims to maximise the present value of profit $E_{t_0}\sum_{t=t_0}^{+\infty}\beta^{t-t_0}\Lambda_t\frac{\Pi_t^L}{P_t}$, which is transferred to the owners – households. Maximising the present value of profit while taking into account (17) and the labour demand function, along with the assumption of symmetric equilibrium ($W_t^r(k)=W_t^r$), results in:

$$1-\xi+\xi\frac{W_t^r}{W_t}-k^w\left(\frac{W_t^r}{W_{t-1}^r}-1\right)\frac{W_t^r}{W_{t-1}^r}+k^w\beta E_t\frac{\Lambda_{t+1}}{\Lambda_t}\left(\frac{W_{t+1}^r}{W_t^r}-1\right)\left(\frac{W_{t+1}^r}{W_t^r}\right)^2\frac{L_{t+1}}{L_t}=0 \tag{18}$$

It follows from equation (18) that when $k^w=0$, meaning the cost of adjusting the price is zero, the intermediary's role is simply to create a markup $1/\xi$ on the cost of labour W_t due to monopoly power. If $k^w>0$, then the higher this parameter, the less actively the labour price W_t^r adjusts to economic changes, thus becoming rigid.

In relation to each producer $i\in[0;1]$, the capital producer buys domestic and imported goods to assemble investments $Inv_{i,t}$ in accordance with technology (1). The capital producer minimises cost function (3) without forming habits ($\varphi=0$ in (2)). Investments $Inv_{i,t}$ are purchased at price $\rho_{i,t}=\left(P_{i,t}^d\right)^{\omega}\left(S_tP_t^{imp}\right)^{1-\omega}$ (see (7)) and sold in volume $DK_{i,t}$ to household owners at price $Q_{i,t}$. The amount of purchased investment $Inv_{i,t}$ and new capital sold $DK_{i,t}$ are connected by a relationship that accounts for costs incurred in adjusting the level of investment:

$$DK_{i,t}=Inv_{i,t}-\frac{k^{inv}}{2}\left(\frac{Inv_{i,t}}{Inv_{i,t-1}}-1\right)^2Inv_t$$

where Inv_t represents the overall level of investment. The producer seeks to maximise the expected present value of profit $E_{t_0}\sum_{t=t_0}^{+\infty}\beta^{t-t_0}\Lambda_t\frac{\Pi_t^K}{P_t}$, where

$$\Pi_t^K=Q_{i,t}DK_{i,t}-\rho_{i,t}Inv_{i,t}.$$

The result of maximising the present value of profit is as follows:

$$\frac{Q_{i,t}}{P_t}-\frac{\rho_{i,t}}{P_t}-k^{inv}\frac{Q_{i,t}}{P_t}\left(\frac{Inv_{i,t}}{Inv_{i,t-1}}-1\right)\frac{Inv_{i,t}}{Inv_{i,t-1}}+k^{inv}\beta E_t\frac{Q_{i,t+1}}{P_{t+1}}\frac{\Lambda_{t+1}}{\Lambda_t}\left(\frac{Inv_{i,t+1}}{Inv_{i,t}}-1\right)\left(\frac{Inv_{i,t+1}}{Inv_{i,t}}\right)^2=0 \quad (19)$$

When there are no adjustment costs ($k^{inv}=0$), in a symmetric equilibrium consistent with (9), equation (19) implies that the relative price of capital remains constant: $Q_{i,t}/P_t=1$. The higher the adjustment costs k^{inv} , the less responsive investment is to economic changes.

2.5. Goods producers

Each goods producer $i\in[0;1]$ rents labour $L_{i,t}$ at nominal wage W_t^r and capital $K_{i,t-1}$ at rate $R_{i,t}^K$ to produce output $Y_{i,t}$:

$$Y_{i,t}=a^i\left(K_{i,t-1}\right)^{\alpha}\left(L_{i,t}\right)^{1-\alpha} \quad (20)$$

Product $Y_{i,t}$ is sold at price $P_{i,t}^d$, and the revenue is taxed by the government at rate $\tau^y P_{i,t}^d Y_{i,t}$. Producers know the demand function for their goods, allowing them to set individual prices $P_{i,t}^d$. When changing the price of a good, the producer incurs costs $\frac{k^p}{2}\left(\frac{P_{i,t}^d}{P_{i,t-1}^d}-1\right)^2 P_t^d Y_t$, where P_t^d , Y_t are the aggregate price and the output of domestic goods, respectively. Producer profit is given by:

$$\Pi_t^Y=\left(1-\tau^y\right)P_{i,t}^d Y_{i,t}-R_{i,t}^K K_{i,t-1}-W_t^r L_{i,t}-\frac{k^p}{2}\left(\frac{P_{i,t}^d}{P_{i,t-1}^d}-1\right)^2 P_t^d Y_t \quad (21)$$

The producer seeks to maximise the expected present value of profit $E_{t_0}\sum_{t=t_0}^{+\infty}\beta^{t-t_0}\Lambda_t\frac{\Pi_t^Y}{P_t}$, acting in the interests of the owners. In doing so, the producer considers not only the production constraint (20), but also aggregate demand and the demand functions (4) related to households $d_{i,t}^r$, capital producers $d_{i,t}^{inv}$, and the government $d_{i,t}^g$:

$$Y_{i,t} = d^{r}_{i,t} + d^{inv}_{i,t} + d^{g}_{i,t}$$

$$d^{r}_{i,t} = \omega\left(\frac{S_t P^{imp}_t}{P^{d}_{i,t}}\right)^{1-\omega}\left[x^{r}_t\left(\frac{\left(P^{d}_{i,t}\right)^{\omega}\left(S_t P^{imp}_t\right)^{1-\omega}}{P_t}\right)^{-\varepsilon} + \varphi^{r}\, c^{r}_{i,t-1}\right] \tag{22}$$

$$d^{inv}_{i,t} = \omega\left(\frac{S_t P^{imp}_t}{P^{d}_{i,t}}\right)^{1-\omega} x^{inv}_t\left(\frac{\left(P^{d}_{i,t}\right)^{\omega}\left(S_t P^{imp}_t\right)^{1-\omega}}{P_t}\right)^{-\varepsilon} \tag{23}$$

$$d^{g}_{i,t} = \omega\left(\frac{S_t P^{imp}_t}{P^{d}_{i,t}}\right)^{1-\omega}\left[x^{g}_t\left(\frac{\left(P^{d}_{i,t}\right)^{\omega}\left(S_t P^{imp}_t\right)^{1-\omega}}{P_t}\right)^{-\varepsilon} + \varphi^{g}\, c^{g}_{i,t-1}\right] \tag{24}$$

Denoting Lagrange multipliers for constraints (20)–(24) by $\beta^t \Lambda^{Y}_t$, $\beta^t \mathrm{M}^{r}_t$, $\beta^t \mathrm{M}^{inv}_t$, and $\beta^t \mathrm{M}^{g}_t$, we derive optimum conditions for capital, labour, price $P^{d}_{i,t}$, and the components of demand $d^{r}_{i,t}$, $d^{inv}_{i,t}$, and $d^{g}_{i,t}$:

$$\frac{R^{K}_{i,t}}{P_t} K_{i,t-1} = \alpha \frac{\Lambda^{Y}_t}{\Lambda_t} Y_{i,t} \tag{25}$$

$$\frac{W^{r}_t}{P_t} L_{i,t} = (1-\alpha)\frac{\Lambda^{Y}_t}{\Lambda_t} Y_{i,t} \tag{26}$$

$$\begin{aligned}
&\left(1-\tau^{y}\right)\frac{Y_{i,t}}{P_t}\Lambda_t - k^{p}\Lambda_t\left(\frac{P^{d}_{i,t}}{P^{d}_{i,t-1}}-1\right)\frac{P^{d}_t Y_t}{P^{d}_{i,t-1}P_t} + k^{p}\beta\, E_t\Lambda_{t+1}\left(\frac{P^{d}_{i,t+1}}{P^{d}_{i,t}}-1\right)\frac{P^{d}_{i,t+1}}{\left(P^{d}_{i,t}\right)^{2}}\frac{P^{d}_{t+1}Y_{t+1}}{P_{t+1}} + \\
&-\omega(1-\omega)\left(\frac{S_t P^{imp}_t}{P^{d}_{i,t}}\right)^{1-\omega}\frac{1}{P^{d}_{i,t}}\left(\mathrm{M}^{r}_t\, c^{r}_{i,t} + \mathrm{M}^{inv}_t\, c^{inv}_{i,t} + \mathrm{M}^{g}_t\, c^{g}_{i,t}\right) - \\
&-\varepsilon\,\omega^{2}\left(\frac{S_t P^{imp}_t}{P^{d}_{i,t}}\right)^{1-\omega}\frac{1}{P^{d}_{i,t}}\left(\mathrm{M}^{r}_t\, x^{r}_t + \mathrm{M}^{inv}_t\, x^{inv}_t + \mathrm{M}^{g}_t\, x^{g}_t\right) = 0
\end{aligned} \tag{27}$$

$$\left(1-\tau^{y}\right)\frac{P_{i,t}^{d}}{P_{t}}\Lambda_{t}-\Lambda_{t}^{Y}-\mathrm{M}_{t}^{r}+\beta E_{t}\mathrm{M}_{t+1}^{r}\omega\left(\frac{S_{t+1}P_{t+1}^{imp}}{P_{i,t+1}^{d}}\right)^{1-\omega}\varphi^{r}\omega\frac{c_{i,t+1}^{r}}{d_{i,t+1}^{r}}=0 \tag{28}$$

$$\left(1-\tau^{y}\right)\frac{P_{i,t}^{d}}{P_{t}}\Lambda_{t}-\Lambda_{t}^{Y}-\mathrm{M}_{t}^{inv}=0 \tag{29}$$

$$\left(1-\tau^{y}\right)\frac{P_{i,t}^{d}}{P_{t}}\Lambda_{t}-\Lambda_{t}^{Y}-\mathrm{M}_{t}^{g}+\beta E_{t}\mathrm{M}_{t+1}^{g}\omega\left(\frac{S_{t+1}P_{t+1}^{imp}}{P_{i,t+1}^{d}}\right)^{1-\omega}\varphi^{g}\omega\frac{c_{i,t+1}^{g}}{d_{i,t+1}^{g}}=0 \tag{30}$$

It follows from expressions (27)–(30) that the multiplier Λ_{t}^{Y} is proportional to the value of $\left(1-\tau^{y}\right)\frac{P_{i,t}^{d}}{P_{t}}\Lambda_{t}$. Given this, expressions (25) and (26) indicate that a certain portion of revenue $\left(1-\tau^{y}\right)P_{i,t}^{d}Y_{i,t}$, reduced by profits, is spent on production factors (labour and capital), while the cost of these factors maintains a standard ratio $\alpha/(1-\alpha)$. Relations (28)–(30) determine the shadow values M_{t}^{r}, M_{t}^{inv} and M_{t}^{g} of demand functions (22)–(24). When habits are not formed by agents, as in the case of capital producers, shadow values are static and do not depend explicitly on future consumption. However, for households and the government, where deep habits are formed, an additional unit of demand for a particular good today also drives future demand. Expression (27) determines the price dynamics of the good and, through (21) and other relations, the firm's profit margin. A positive profit margin is driven by the firm's monopoly power, which can be broken down into two components. The first component, as described in the deep habits literature (*Ravn et al.*, 2006; *Aloui*, 2013), arises from the firm's awareness of the demand dependence on price, stemming from the aggregation of product groups into aggregate x_{t}^{j} (equation (2)), as reflected in the final group of terms in expression (27). The second component arises from the firm's awareness that demand for its output is linked to the aggregation of domestic and imported goods (equation (1)) as shown in the second-to-last group of terms in (27).

2.6. Symmetry of equilibrium

In line with studies on deep habits, we assume symmetry of equilibrium in the model across all producers $i\in[0;1]$. Symmetry implies identical tasks for producers and identical initial conditions. Under this assumption, all indices i in the expressions can be omitted. Specifically, it

follows that $P_{i,t}^d = P_t^d$, $\rho_{i,t} = \rho_t = P_t = \left(P_t^d\right)^{\omega}\left(S_t P_t^{imp}\right)^{1-\omega}$, $\frac{\left(P_{i,t}^d\right)^{\omega}\left(S_t P_t^{imp}\right)^{1-\omega}}{P_t} = 1$, and demand functions (22)–(24) can be simplified to facilitate model computation.

In what follows, analytical expressions for equilibrium conditions and the description of fiscal policy are provided under the assumption of a symmetric equilibrium. Nonetheless, as previously discussed, the fiscal authorities aim to minimise costs (1)–(3) in relation to groups of goods.

2.7. Monetary and fiscal policies

We assume that monetary policy is aimed at targeting inflation. When setting the nominal interest rate, the central bank follows the Taylor rule:

$$R_t = R^{ss} + \rho\left(\pi_t - \pi^{ss}\right) \tag{31}$$

where R^{ss}, π^{ss} are the long-term values of the interest rate and inflation, and the value of π_t represents inflation.

Fiscal policy is described by several relationships. First, there is the fiscal authority's budget constraint:

$$P_t^G G_t = \tau_t^y P_t^d Y_t + \tau_t^{oil} S_t P_t^{oil} O + B_t^d - R_{t-1} B_{t-1}^d + S_t B_t^f - S_t r^f B_{t-1}^f \tag{32}$$

where τ_t^y is the tax on domestic production, τ_t^{oil} is the tax on oil and gas revenues, B_t^d are domestic market loans, and B_t^f is the flow of borrowed funds from the foreign market. This flow can be interpreted as external debt obligations or transactions involving foreign assets of the NWF, the dynamics of which are not described in this paper.

According to expression (32), nominal government consumption is funded by taxes, domestic debt market transactions, and foreign transactions.

There are several options for financing increased government spending: through higher taxes τ_t^y and τ_t^{oil}, increased domestic borrowing B_t^d, or external financing B_t^f. These options, along with the accompanying macroeconomic processes, are central to this study.

Under each financing option, budget expenditure growth may persist. However, it is assumed that the fiscal authorities aim to stabilise public debt, returning it to the level preceding the shock.

All the options for financing expenditure growth are based on a persistent government spending shock, described by the following process:

$$s_t = \rho^s s_{t-1} + \varepsilon_t^s \tag{33}$$

where ε_t^s is a zero mean random variable equally distributed across periods.

1. An increase in government spending is financed by an increase in domestic government borrowing B_t^d :

$$B_t^d = \rho^d P_t B_{ss}^d + \left(1-\rho^d\right)\frac{R_{t-1}}{R^{ss}} B_{t-1}^d + s_t \tag{34}$$

With a positive government spending shock s_t, borrowing B_t^d increases, leading, according to equation (32), to an increase in government consumption. The presence of parameter ρ^d in equation (34) is due to the need for the real debt level B_t^d / P_t to be asymptotically returned to its original value B_{ss}^d.

Tax rates τ_t^y and τ_t^{oil} are assumed to be constant, and external financing B_t^f is zero.

2. An increase in government spending is financed by raising the production (sales) tax, so the interest rate changes as follows:

$$\tau_t^y = \tau_{ss}^y + \frac{s_t}{Y_t P_t^d / P_t} \tag{35}$$

3. An increase in government spending is financed by raising the tax on oil and gas revenues:

$$\tau_t^{oil} = \tau_{ss}^{oil} + \frac{s_t}{S_t P_t^{oil} O / P_t} \tag{36}$$

In expressions (35) and (36), τ_{ss}^y and τ_{ss}^{oil} represent the long-term values of tax rates.

4. An increase in government spending is achieved through external financing B_t^f :

$$B_t^f = \rho^f B_{ss}^f + \left(1-\rho^f\right) B_{t-1}^f + s_t / S_t \tag{37}$$

Equation (37) is similar to (34), with the only difference being that prices and the interest rate for the external economy are considered constant.

2.8. Equilibrium conditions

The equilibrium conditions for the currency, labour, and domestic debt markets are as follows:

$$P^{imp}\left(Imp_t^r + Imp_t^{inv} + Imp_t^g\right) - P_t^{oil}\,O + D_t^{r,f} - R^f D_{t-1}^{r,f} + \Psi_t^D\,P_t/S_t - \\ -B_t^f + R^f B_{t-1}^f = 0 \tag{38}$$

$$L_t^r = L_t \tag{39}$$

$$\sum_r D_t^{r,f} = B^d \tag{40}$$

The first term in relation (38) includes the demand for imports from households, capital producers, and the government, while $\Psi_t^D\,P_t/S_t$ reflects nominal expenditures in foreign currency related to changes in the level of investments in foreign bonds $D_t^{r,f}$. The equilibrium condition in the debt market (40) is based on the equality between household savings and domestic government debt.

It is also assumed that the terms of trade follow an AR(1) process with the mean P_{ss}^{oil}:

$$P_t^{oil} = P_{ss}^{oil} + \rho^{oil}\left(P_{t-1}^{oil} - P_{ss}^{oil}\right) + \varepsilon_t^{oil} \tag{41}$$

2.9. Model calibration

The following parameters and model relationships were chosen during calibration (

Table 1). In line with the practice in dynamic stochastic equilibrium models (*Bernanke et al.,* 1999*; Kiyotaki and Moore*, 1997*; Smets and Wouters,* 2003) the consumer's time preference rate was set to $\beta = 0,99$, corresponding to a real rate of return on assets of 4% per annum. The depreciation parameter was taken to be $\delta = 0,025$, corresponding to an annual depreciation rate of 10% (*Bernanke et al.*, 1999; *Smets and Wouters*, 2003). The parameter of the elasticity of demand for intermediary products in the domestic intermediate goods market was set to $\varepsilon = 7$. This value aligns with that in *Drobyshevsky and Polbin* (2015), but is slightly higher than in some international studies (e.g. 5 in *Christiano et al.* (2005)) and deep habits studies (e.g. 5 in *Ravn et al.* (2012) and 6 in *Punnoose and Lenno* (2019)). The parameter of the elasticity of demand for labour was taken as $\eta = 10$, with the Frisch elasticity of $\sigma = 0,3$ (*Andreyev and Polbin*, 2019). The elasticity parameter for the production function was set in accordance with *Bernanke et al.* (1999) and *Polbin* (2014): $\alpha = 0,35$. The rigidity parameters were chosen to align with those in studies of the Russian economy: $k^w = k^p = 10$, $d_s = 0,1$ (e.g. 0.05 in *Andreyev and Polbin* (2019)), $k^{inv} = 4$ (4 in *Polbin* (2014)). The Taylor rule parameter was taken as the standard value for non-inertial policy $\rho = 1,5$. The parameters defining habits were chosen similarly to *Ravn et al.* (2012): $\varphi^r = \varphi^g = 0,5$.

The structural parameters of the economy were calibrated as follows. The ratio of imports to GDP was set equal to 0.25 in line with Russian statistical data. Aggregate exports were set equal to imports in the long-term equilibrium, with investments in foreign bonds assumed to be zero. The tax τ^{oil} on revenue from commodity sales was set at 50%, close to the tax burden on the oil and gas sector in Russia, while the production tax was set at 10%, yielding a government consumption level equal to 20% of GDP.

The autocorrelation parameter ρ^s for the government spending shock process (33) was taken as 0.95 to model the duration of increased government spending. For exported goods, the parameter ρ^{oil} was set to 0.8, close to the terms-of-trade figure for Russia. Finally, the parameter ρ^d in equation (34) was set to 0.05, which supports the return of credit levels in real terms to their initial level and aligns with a slow pace of debt repayment by the government.

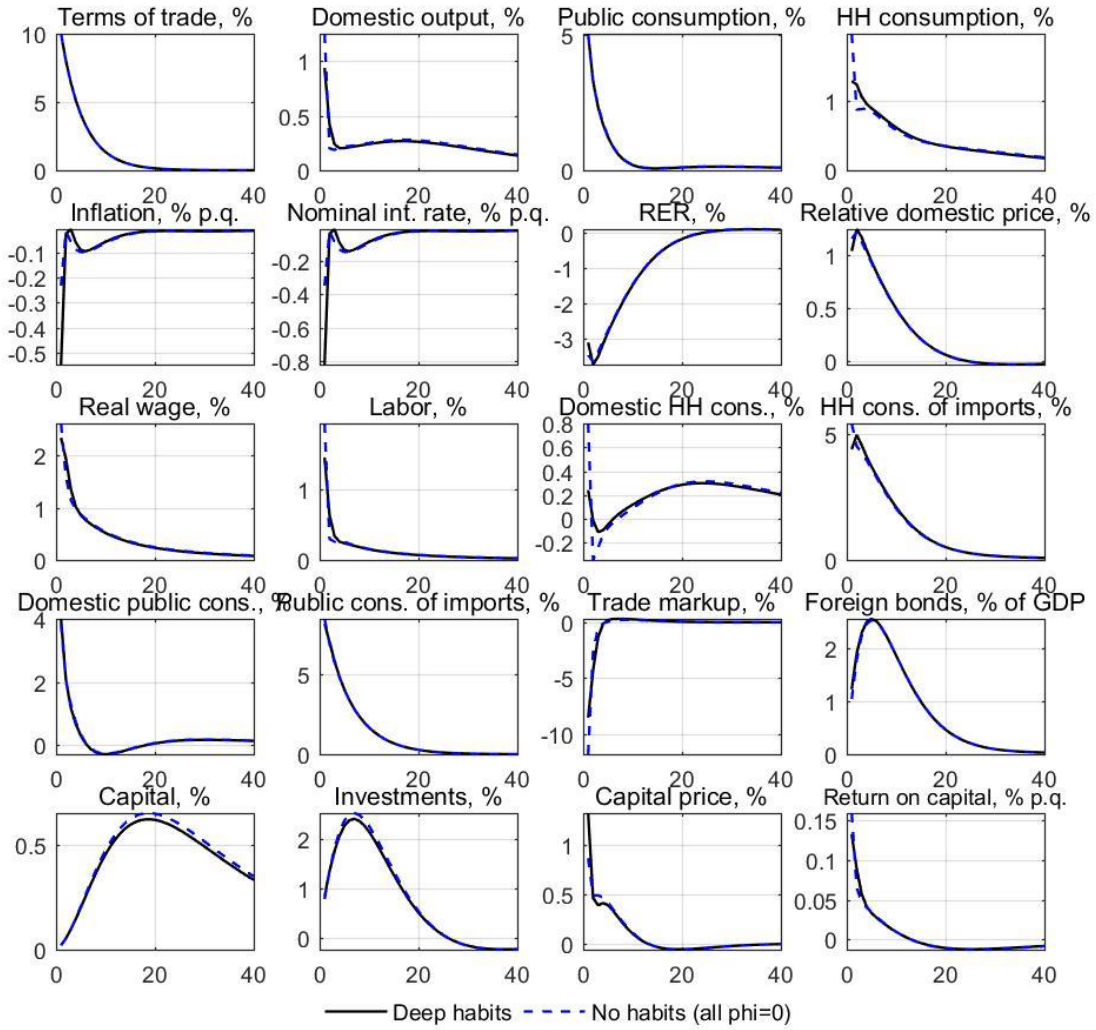
Table 1. Model parameters

Parameter	Value	Description	Studies with similar parameters (parameter values are given in brackets)
β	0.99	Time preference	Bernanke et al., 1999; Kiyotaki and Moore, 1997; Smets and Wouters, 2003
δ	0.025	Depreciation rate	Bernanke et al., 1999; Smets and Wouters, 2003
ε	7	Elasticity of demand for intermediary products	Drobyshevsky and Polbin, 2015 (7); Christiano et al., 2005 (5); Ravn et al., 2012 (5); Punnoose and Lenno, 2019 (6)
η	10	Elasticity of demand for labour	
σ	0.3	Frisch elasticity of labour supply	Andreyev and Polbin, 2019
α	0.35	Capital elasticity	Bernanke et al., 1999; Polbin, 2014
k^w, k^p	10	Rigidity of wages and domestic prices	
d_s	0.1	Cost parameter for changing investments in foreign bonds	Andreyev and Polbin, 2019 (0.05)
k^{inv}	4	Cost parameter for changing investments	Polbin, 2014
φ^r, φ^g	0.5	Level of deep habits	Ravn et al., 2012
τ^{oil}	0.5	Tax burden in the oil and gas sector	
ρ^s	0.95	Autocorrelation of government spending shocks	
ρ^{oil}	0.8	Autocorrelation of terms of trade	
ρ^d	0.05	Stationarity parameter for the fiscal rule	

3. Shocks to terms of trade and government consumption: impact of deep habits

Below (Figure 1), we examine the effects of two shocks: a terms-of-trade shock (41) and a government consumption shock (33), financed through domestic debt (34). The impact of these shocks is analysed to verify the accuracy of the mechanisms in place and to identify specific characteristics associated with deep habits in the economy.

Figure 1. Impulse response of model variables to positive 10% terms-of-trade shock with and without deep habits ($\varphi^g = \varphi^r = 0$). '%' indicates that the variables are shown as a percentage deviation from the steady state, '% of GDP' indicates that they are shown as a percentage deviation from the model's quarterly long-term GDP, and '% p.q.' indicates that they are shown as a quarterly percentage rate

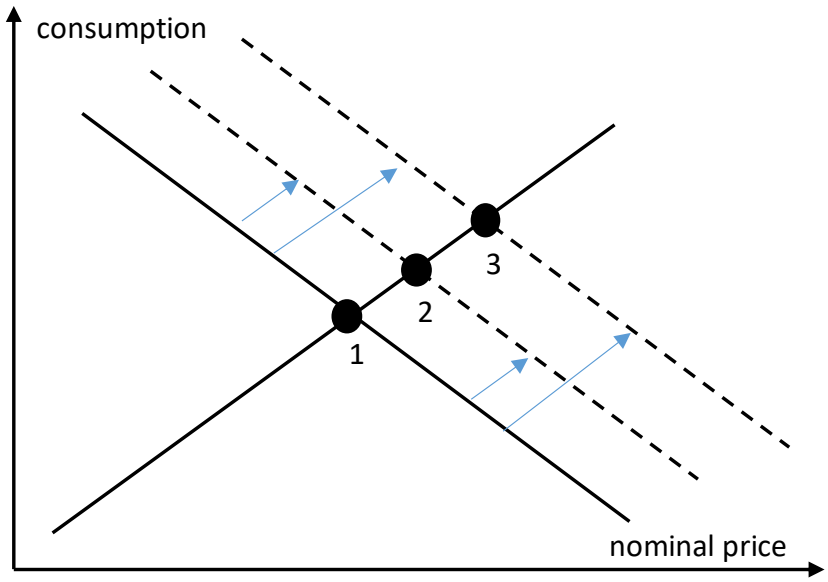


A positive terms-of-trade shock typically produces an income effect and an exchange rate effect, as observed in a number of studies on the Russian economy (*Kreptsev and Seleznev*,

2018; *Polbin*, 2014; *Andreyev and Polbin*, 2022). The income effect leads to an increase in additional revenues for the government budget and households, which in turn drives up demand, resulting in higher output, consumption, production factors and their prices, and domestic prices. The exchange rate effect causes a drop in external prices, the changes in which are represented solely by the exchange rate in our model, to outweigh the rise in domestic prices. As a result, inflation slows down (declines relative to the trend) and the interest rate is reduced.

The case of deep habits, compared to the opposite case, leads to a smaller increase in domestic output and consumption, and a stronger decline in inflation, which is explained by slower growth in nominal prices. This means that the domestic demand curve shifts less to the right and upward (Figure 2), which is due to habits dampening the initial impact of the terms-of-trade shock.

Figure 2. Movement of household demand curve with and without habits under positive terms-of-trade shock.[7] **1** denotes the initial equilibrium position, **2** denotes the equilibrium position after the shock with habits, and **3** denotes the equilibrium position after the shock without habits



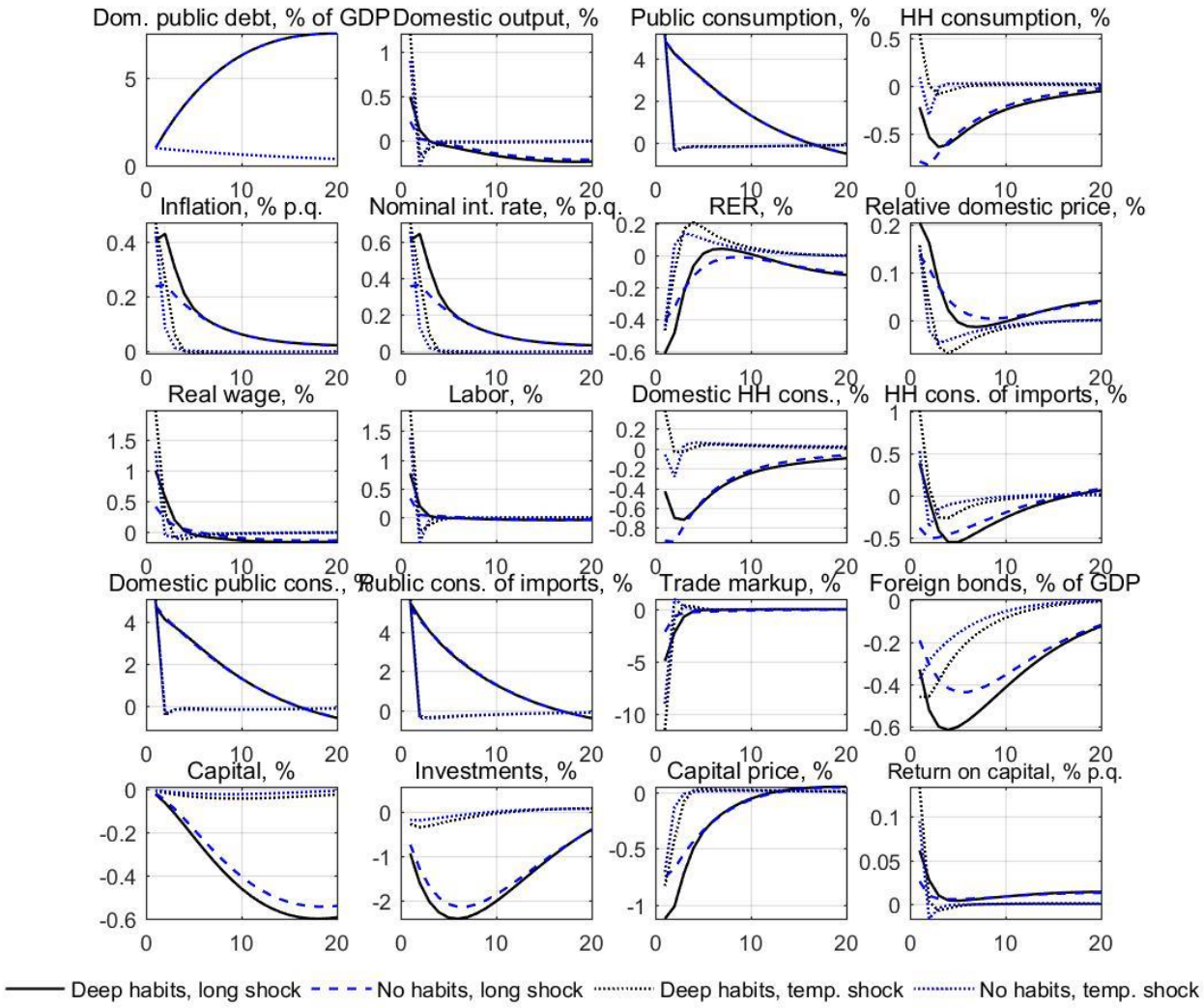
The ‘constraining’ influence of deep habits is similarly noted in (*Punnoose and Lenno*, 2019), where accounting for habits in the consumption of imported goods in a two-country model economy leads to the exchange rate having less impact on import prices and, as a result, requiring lower values of the price rigidity parameter.

Next, let us consider (Figure 3) the government spending shock financed by domestic loans, analysing not only the presence or absence of habits but also the duration of the shock: the shock

[7] For simplicity, the diagram does not take into account the appreciation of the domestic currency under a positive terms-of-trade shock. Therefore, without accounting for currency strengthening, prices rise relative to the initial equilibrium. The summing of the price movement effect with the currency appreciation effect leads to a reduction in prices, as shown in Figure 2.

can be persistent, indicating a prolonged increase in borrowing, or temporary ($\rho^s = 0{,}95$ or $\rho^s = 0$ in equation (33)).

Figure 3. Response of model variables to positive government expenditure shock ε_t^s equal to 1% of GDP, distinguishing between cases of a long-lasting ($\rho^s = 0{,}95$) and temporary ($\rho^s = 0$) spending shock on the economy, and also distinguishing between cases with and without deep habits ($\varphi^g = \varphi^r = 0$). '%' indicates that the variables are shown as a percentage deviation from the steady state, '% of GDP' indicates that they are shown as a percentage deviation from the model's quarterly long-term GDP, and '% p. q.' indicates that they are shown as a quarterly percentage rate



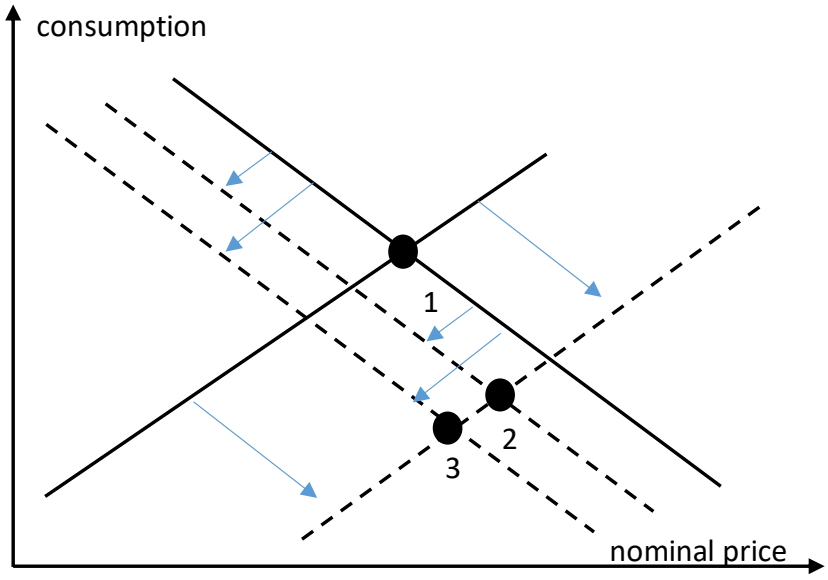
A prolonged increase in government spending leads to a temporary (over 18 quarters) rise in government consumption, after which it remains below its long-term level for an extended period. The reasons for the long-term reduction in government consumption are, first, the need to repay

the borrowed funds along with interest, and second, the negative impact of increased government spending on the economy in both the medium and long term: domestic output and household consumption decrease. The increase in domestic demand due to government consumption leads to a rise in nominal prices for domestic goods, resulting in higher inflation and interest rates. The rise in interest rates, coupled with the increase in government borrowing (and the decrease in household disposable income), explains why households respond to the government spending shock by reducing consumption (crowding-out effect).

The presence of habits, compared to the case of their absence, results in a larger increase in output, a smaller decrease in household consumption, and a higher rise in inflation, which is explained by a larger increase in the price of domestic goods.

At the level of supply and demand functions, a government spending shock to households causes the supply curve to shift towards higher prices. Simultaneously, the demand curve shifts leftwards and downwards, reflecting an increase in household savings. As a result, prices rise, and consumption falls. However, the presence of consumer habits slows the shift of the demand curve in the short term, leading to a higher price increase and a smaller drop in consumption (Figure 4).

Figure 4. Movement of household demand curve with and without habits under positive terms-of-trade shock. **1** denotes the initial equilibrium position, **2** denotes the equilibrium position after the shock with habits, and **3** denotes the equilibrium position after the shock without habits



The crowding-out effect, where household consumption is displaced by government consumption, observed here, is also noted in *Aloui* (2013), where a spending shock led only to a temporary increase in output. However, the accumulation effect is more frequently discussed in

Western literature (*Ravn et al.*, 2006; *Ravn et al.*, 2012), although it remains unclear whether government consumption shocks are considered long-lasting or temporary.

As can be seen from 4, in our model, a temporary spending shock leads to the accumulation effect – both in terms of output and consumption. The difference in the impact of long-lasting and temporary spending shocks is explained by the dynamics of household disposable income. If the government spending shock is temporary, the production sector responds with a sharp, short-term increase in labour demand, leading to higher household income and consumption, which temporarily stimulates output growth. In the case of a long-lasting government spending shock, the production sector responds by adjusting capital expenditures (the explanation of this effect is provided in the next section), while labour income grows only slightly. If, at the same time, household disposable income decreases (due to higher taxes or the purchase of government bonds), consumer demand and thus output drop, neutralising the stimulating effect of government demand.

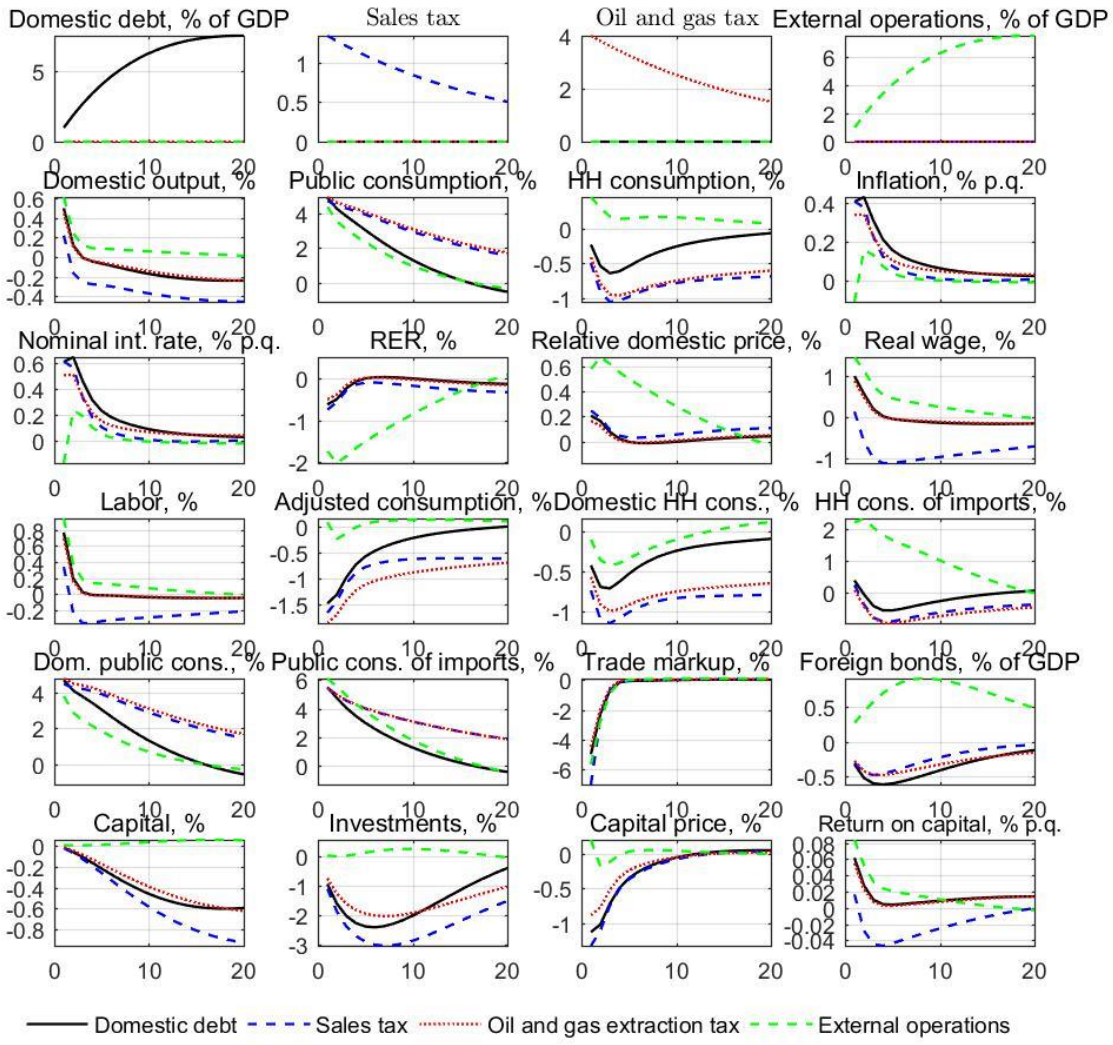
The domestic literature based on DSGE and VAR models (*Vlasov and Deryugina*, 2018; *Votinov and Stankevich*, 2017; *Votinov and Yelkina*, 2018) states that production reacts positively to a government consumption shock. However, the duration of the positive output response and the types of shocks considered (or, more specifically, identified) as temporary or long-lasting are not explained in these papers.

4. Scenarios of government spending growth

Next, we compare the results of a positive government spending shock under different financing options (Figure 5). The effect of the shock is similar in all cases, except for the use of external financing: in the medium term, an increase in government consumption is observed, which, after 14 or more quarters, is followed by a decline in government consumption below its long-term level. Domestic production shows a temporary rise (temporary accumulation effect), after which it falls below its long-term level (crowding-out effect), while household consumption always remains below its long-term level (crowding-out effect). Domestic prices, inflation, and the interest rate increase after the shock but quickly return to their long-term levels.

Among the options for financing the growth in government spending, the use of external financing stands out in the form of attracting foreign assets from the national fund or borrowing on the external debt market. In this case, the inflow of external funds in the medium term leads to a stronger appreciation of the domestic currency. This makes imports cheaper as a factor of production, giving the economy an additional production boost. The response of domestic output, consumption, and investment remains positive, while inflation shows less volatility owing to the stronger appreciation of the domestic currency.

Figure 5. Response of model variables to positive government spending shock ε_t^s equal to 1% of GDP for various government expenditure financing options. '%' indicates that the variables are shown as a percentage deviation from the steady state, '% of GDP' indicates that they are shown as a percentage deviation from the model's quarterly long-term GDP, and '% p. q.' indicates that they are shown as a quarterly percentage rate



The specific features of the scenario with external financing of budgetary expenditures helps explain why the crowding-out effect on household consumption is observed in other options. The external financing scenario does not directly affect household incomes. In contrast, the options involving higher taxes and financing through the domestic debt market lead to a decline in disposable household income net of investments in debt instruments: due to taxes (in the case of an increase in the oil and gas income tax), due to a reduction in the payment for production factors (in the case of production taxes), or due to the direct borrowing of funds. The deep habit

mechanism is sensitive to a decline in household income. Its effect smooths out the impact of income decline over the entire period, so consumption does not increase even in the short term.

Changes in household disposable income also form the basis for several other effects, such as the reduction in production capital in scenarios not associated with external financing. When disposable incomes decrease, households seek to smooth consumption dynamics and resort to three methods: (1) the long-term reduction of investments in foreign financial instruments, (2) a short-term increase in labour supply, and (3) a reduction in investments (since the model assumes the household is the owner of production capital). The reduction in investments to smooth consumption is the reason for the fall in production capital. Meanwhile, the government does not make decisions regarding investments in the model. In this regard, a relevant question is who will drive demand in the economy: households or the government, financed by household savings.

It should be noted that these results have a scope of applicability for the option of financing public debt through internal borrowing. The results are applicable if the growth in government spending is accompanied by an increase in household savings. In reality, there is an alternative mechanism by which the rise in public debt is financed without household participation. This mechanism involves the issuance of government bonds, which are bought by banks using funds borrowed from the central bank and secured by previous issues of government bonds. In this case, due to the greater stability of household disposable income, domestic demand and investment levels may not decrease. This means that with this type of financing, internal borrowing could become as attractive as external financing. However, the structural model reproducing the financing mechanism through internal borrowing without household involvement requires a description of the demand for money and the money creation process in the economy. Modelling these mechanisms will be the subject of future research.

Next, let us compare the following intertemporal indicators under various financing options for government spending growth: (1) changes in public welfare, (2) present value of government consumption, and (3) the amount of government consumption over a two-year period.

The present value of government consumption is calculated using the following formula:

$$NPVG_t = G_t + \sum_{\tau=1}^{+\infty} \frac{G_{t+\tau}}{\prod_{k=0}^{\tau-1} R_{t+k} / \pi_{t+k+1}}$$

i.e. real government consumption is discounted based on the real interest rate. Government consumption over a two-year period is calculated using a similar formula, taking into account consumption over eight quarters:

$$NPVG_t = G_t + \sum_{\tau=1}^{7} \frac{G_{t+\tau}}{\prod_{k=0}^{\tau-1} R_{t+k} / \pi_{t+k+1}}$$

The values of indicators are given in Table 2.

Table 2. Public welfare and present value of government consumption following a positive government spending shock ε_t^s equal to 1% of GDP for the deep-habit case

	Unit	Domestic borrowing	Production tax	Oil and gas extraction tax	External financing
Changes in public welfare	In terms of consumption equivalence (% of consumption)	-0.005	-0.239	-0.260	-0.004
Changes in the present value of government consumption	In % of long-term quarterly GDP	-30.1	-13.0	-15.1	1.5
Changes in government consumption over 8 quarters	In % of long-term quarterly GDP	4.0	5.2	5.6	4.2

All financing options for government spending growth provide an increase in government consumption, accounting for 4% to 5.6% of quarterly GDP during the first eight quarters. This means that all the considered options are effective, and fiscal authorities, pursuing their short-term goals, can achieve them by choosing any financing option.

However, in terms of aggregated indicators over a long-term horizon, the options differ significantly. All options, except for the scenario involving external financing, lead to the present value of government consumption being 13–30% lower than quarterly GDP, compared to the same value without the government spending shock in long-term equilibrium. This means that, although the increase in government spending during the first few quarters leads to a rise in government consumption, after 20 to 30 quarters, government consumption falls below the long-term level. In most options, the present value of the reduction in government consumption over the long term is higher than the rise in government consumption in the short term. Only the external financing option shows an approximate equality of gain in the short term and loss in the long term.

Regarding the change in welfare, strategies involving loans are less detrimental, with the reduction in welfare being close to zero. On the contrary, options with increased taxes lead to a more substantial decrease in welfare (by 0.25% in our calculations).

An economy free of deep habits does not change the *ranking* of financing options for increased government spending (Table 33). A meaningful difference is that in the absence of deep habits, tax-based financing options for spending become less negative in relation to the present value of government consumption.

Table 3. Public welfare and the present value of government expenditures following a positive government spending shock ε_t^s equal to 1% of GDP in the absence of deep habits

	Unit	Domestic borrowing	Production tax	Oil and gas extraction tax	External financing
Changes in public welfare	In terms of consumption equivalence (% of consumption)	-0.004	-0.243	-0.229	-0.001
Changes in the present value of government spending	In % of long-term quarterly GDP	-22.2	-5.0	-4.8	-0.1
Changes in government spending over 8 quarters	In % of long-term quarterly GDP	4.5	5.7	6.1	4.5

5. Conclusion

According to the theoretical description of deep habits, when such habits are in place, each unit of additional demand generates future additional demand for the consumed product. One might expect this mechanism to exhibit a multiplier effect on demand in the calculations. However, our model shows no such effect. Instead, we find that in response to terms-of-trade or government expenditure shocks, deep habits dampen households' reactions, resulting in less pronounced shifts in the demand curve. In an exporting economy, deep habits lead to lower volatility in output and consumption, but higher volatility in inflation.

Additionally, we find that a long-lasting positive shock in government expenditure, when financed by sources that reduce household funds (all the options considered except for external

financing), shows a crowding-out effect on household output and consumption. The crowding-out effect on household consumption may be explained by a combination of two factors: a decrease in household disposable income as a result of increased savings or taxes, and the existence of deep habits coupled with rational expectations, which smooths household consumption and makes consumption negative over the entire time horizon.

The same long-lasting government expenditure shock, when financed through external sources, leads to an accumulation effect instead of a crowding-out effect, attributed not only to the preservation of household income but also to the appreciation of the domestic currency.

With a temporary government spending shock, the accumulation effect on consumption and output occurs. This is explained by the fact that, in response to a temporary shock, the production sector reacts with a short-term surge in labour demand, leading to an increase in household demand and income, thereby stimulating output growth in the short term (in contrast to a long-lasting government spending shock, where the production sector responds with increases in capital expenditure, but household labour incomes grow only slightly).

In other words, a temporary government spending shock is procyclical, whereas a long-lasting shock can be either procyclical or countercyclical depending on its influence on household incomes.

A comparison of the options for financing growth in government consumption indicates that its short- and medium-term increases can be achieved through any of the scenarios considered. However, in almost all the scenarios, a medium-term increase in government consumption occurs at the cost of reduced long-term consumption, as the government is assumed to eventually return debt levels to their original state. Tax-based financing options for growth in government spending reduce public welfare in the long term, whereas debt-based options have minimal impact. The most attractive financing option for minimising long-term losses is external financing through foreign assets of the national welfare fund or external borrowing. The preference for external financing can be explained, first, by a stronger domestic currency during the period of increased government spending, which reduces the cost of imports as a production factor, and second, by the stability of household disposable incomes. Both factors help prevent household consumption and output from declining during periods of increased government consumption. Finally, the presence or absence of deep consumption habits affects the quantitative indicators of the options for financing government consumption growth but does not alter their ranking.

6. Bibliography

Andreyev M., Polbin A. (2019). Studying the financial accelerator effect in a two-sector DSGE model for an export-oriented economy. Journal of the New Economic Association, vol. 44(4), pp. 12–49.

Vlasov S., Deryugina E. (2018). Fiscal multipliers in Russia. Journal of the New Economic Association, vol. 38(2), pp. 104–119 (in Russian).

Votinov A., Elkina M. (2018). Estimation of fiscal stimulus efficiency in Russian economy: simple DSGE model with government sector. Financial Journal, vol. 45(5), pp 83–96 (in Russian).

Votinov A., Stankevich I. (2017). VAR approach to efficiency evaluation of fiscal economy encouragement measures. Financial Journal, vol. 40(6), pp. 64–74 (in Russian).

Drobyshevsky S., Polbin A. (2015). Decomposition of the structural shocks contribution to the Russian macroeconomic indicators based on the DSGE model. Ekonomicheskaya Politika, vol. 10(2), pp. 20–42 (in Russian).

Ivashchenko S. (2020). Long-term growth sources for sectors of Russian economy. Journal of the New Economic Association, vol. 48(4). pp 86–112 (in Russian).

Kreptsev D., Seleznev S. (2018). Forecasting for the Russian economy using small-scale DSGE models. Russian Journal of Money and Finance, vol. 77(2), pp. 51– 67 (in Russian).

Polbin A. (2014). Econometric estimation of a structural macroeconomic model for the Russian economy. Applied Econometrics, vol. 33(1), pp. 3–29 (in Russian).

Aloui R. (2013). Deep habits and the macroeconomic effects of government debt. macroeconomic dynamics, Cambridge University Press, vol. 17(8), pp. 1659–1686, December.

Aloui R. (2024). Habit formation and the government spending multiplier. Economic Modelling, Elsevier, vol. 132(C).

Angeletos G., Lian C., Wolf. C. (2023). Can Deficits Finance Themselves? NBER Working Papers 31185, National Bureau of Economic Research, Inc.

Andreyev M., Polbin A. (2022). Monetary policy for a resource-rich economy and the zero lower bound. Ekonomicheskaya Politika, vol. 17(3), pp. 44–73.

Bernanke B.S., Gertler M., Gilchrist S. (1999). The financial accelerator in a quantitative business cycle framework. In Handbook of macroeconomics, vol. 1. The Netherlands: North-Holland, pp. 1341–1393.

Cantore C., Levine P., Melina G., Yang B. (2012). A fiscal stimulus with deep habits and optimal monetary policy. Economics Letters, Elsevier, vol. 117(1), pp. 348–353.

Christiano L., Eichenbaum M., Evans C. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. Journal of Political Economy, vol. 113(1), pp. 1–45.

Cochrane J. (2022). A fiscal theory of monetary policy with partially repaid long-term debt. Review of Economic Dynamics, Elsevier for the Society for Economic Dynamics, vol. 45, pp. 1–21, July.

Davig T., Leeper E. (2011). Monetary-fiscal policy interactions and fiscal stimulus. European Economic Review, Elsevier, vol. 55(2), pp. 211–227, February.

Greenwood J., Hercowitz Z., Huffman G. (1988). Investment, capacity utilization and the real business cycle. American Economic Review vol. 78, 402–417.

Kiyotaki N., Moore, J. (1997). Credit cycles. Journal of political economy, vol. 105(2), pp. 211–248.

Leeper E. (1991). Equilibria under 'active' and 'passive' monetary and fiscal policies. Journal of Monetary Economics, Elsevier, vol. 27(1), pp. 129–147, February.

Martyanova E, Polbin A. (2023). General equilibrium model with the entrepreneurial sector for the Russian economy. Russian Journal of Economics, vol. 9(2), pp. 109–133.

Punnoose J., Lenno U. (2019). Deep habits and exchange rate pass-through. Journal of Economic Dynamics and Control, Elsevier, vol. 105(C), pp. 67–89.

Ravn M., Schmitt-Grohe S., Uribe M. (2006). Deep habits. Review of Economic Studies, vol. 73, pp. 195–218.

Ravn M., Schmitt-Grohe S., Uribe M. (2012). Consumption, government spending, and the real exchange rate. Journal of Monetary Economics, Elsevier, vol. 59(3), pp. 215–234.

Rotemberg J.J. (1982). Sticky prices in the United States. Journal of Political Economy, vol. 90(6), pp. 1187–1211.

Sargent T., Wallace N. (1984). Some unpleasant monetarist arithmetic. Palgrave Macmillan Books, in: Brian Griffiths & Geoffrey E. Wood (ed.), Monetarism in the United Kingdom, pp. 15–41, Palgrave Macmillan.

Sims E., Wolff J. (2018). The output and welfare effects of government spending shocks over the business cycle. International Economic Review, Department of Economics, University of Pennsylvania and Osaka University Institute of Social and Economic Research Association, vol. 59(3), pp. 1403–1435, August.

Smets F., Wouters R. (2003). An estimated dynamic stochastic general equilibrium model of the euro area. Journal of the European Economic Association, vol. 1(5), pp. 1123–1175.