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Non-Linear Response of Monetary Policy to Autonomous Demand Shocks

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Abstract

Standard macroeconomic models are typically either inherently linear or linearized during the solution process. Consequently, inflation in these models exhibits a linear relationship with other macroeconomic variables. However, empirically, inflation may accelerate non-linearly as the magnitude of autonomous demand shocks increases. In such scenarios, monetary policy (MP) must respond more aggressively to effectively contain inflation—more forcefully than prescribed by linear approximations.

The objective of this paper is to identify the characteristics of the economic system under which non-linear inflation growth (NLIG) may occur.

This study employs a dynamic stochastic general equilibrium (DSGE) model. Unlike common approaches in the literature for modeling non-linear inflation, such as menu cost or inattention models, this paper proposes alternative mechanisms for the emergence of these dynamics. Specifically, we augment relatively standard DSGE models with inequality constraints that become binding during large shocks, shifting the economy into a regime of heightened inflation sensitivity.

Keywords: non-linearity, dynamic models, rational expectations, demand shocks, monetary policy, Phillips curve, inflationary pressure, occasionally binding constraints, fake shocks.

JEL Codes: D58, E47, E62, E63

1. Introduction

Inflation dynamics exhibit asymmetry: inflation can surge sharply and escalate, while disinflation tends to be sluggish. Linear models are ill-equipped to adequately capture non-linearities, which can lead to forecast errors and distort monetary policy decisions. Analyzing the non-linear effects of shocks on inflation and the policy rate enables central banks to calibrate monetary policy in a timely manner, thereby preventing both excessive tightening and an inadequate response to demand shocks.

This paper seeks to answer the following question: which features of the economic system (the break-even constraint for firms, the financing mechanisms of demand expansion, the influence of subjective expectations, and subsidized lending to firms) can trigger non-linear, i.e., accelerated, increases in inflation and the policy rate in response to positive autonomous demand shocks[1]. Crucially, this study does not attempt to empirically establish the presence or absence of non-linear inflation dynamics in Russia.

Over the past three years, rising inflation in Russia has coincided with an expansion in government spending[2] and a surge in domestic demand. Given that, under current conditions, the expansion of government consumption is the primary driver of inflation dynamics, this paper focuses on analysing this specific type of shock[3] as the dominant component of autonomous demand.

This paper investigates non-linear inflation growth (NLIG) using a DSGE model.

To precisely characterize the target scenarios of non-linear inflation growth (NLIG) in response to autonomous demand shocks, it is useful to recall that inflation targeting is typically implemented via a Taylor-type policy rule, which in its simplest form takes the form:

$$r_t - r_{ss} = \rho^{\pi}\left(\pi_t - \pi_{ss}\right)^{4} \tag{1}$$

where r_t, r_{ss} – current and natural (steady-state) nominal interest rates, respectively, and π_t, π_{ss} – current and target inflation rates.

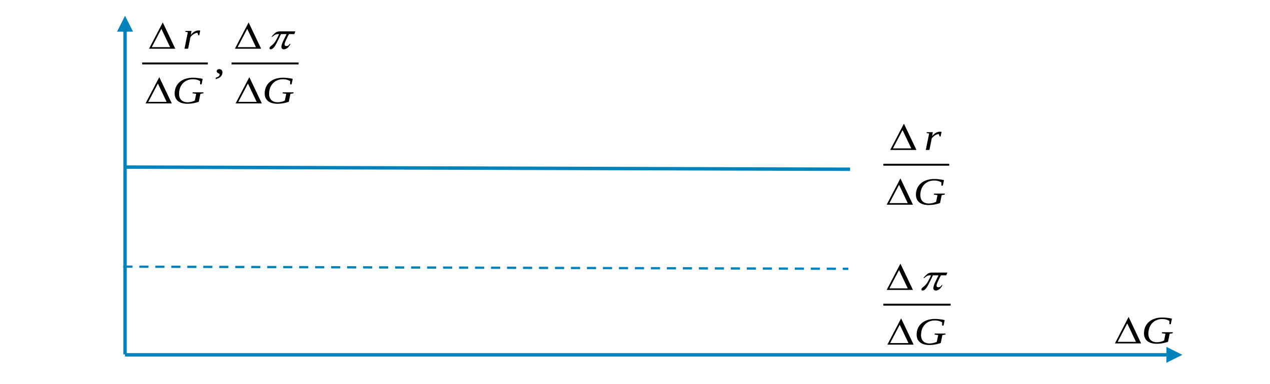
By definition, the relationships between endogenous variables in linearized models are strictly linear. Consequently, metrics such as the ratio of the change in inflation $\Delta\pi$ to the magnitude of the demand shock ΔG remain constant and are invariant to the shock's magnitude ΔG (Fig. 1A). Thus, NLIG cannot emerge endogenously within a strictly linear framework.

[1] An autonomous demand shock is a sudden change in one or more components of autonomous demand – the portion of aggregate demand that is exogenous to the current level of income.
[2] Since our study employs a simplified government budget constraint where fiscal outlays are proportional to government consumption, the terms 'government spending shock' and 'government consumption shock' should be considered synonymous throughout this text.
[3] Another important shock for the Russian economy, though currently less relevant, is the terms-of-trade shock, which has been analyzed in a number of studies (*Polbin, 2014; Andreev, Polbin, 2019*).
[4] Hereafter, the subscript SS denotes the value of the corresponding variables in steady state.

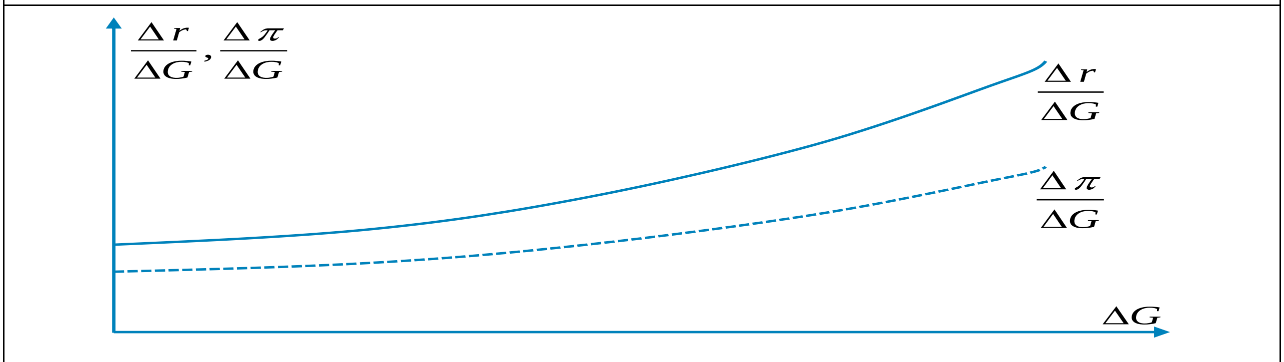
Therefore, we **define** a **non-linear growth of inflation and the policy rate** to demand shocks as a scenario where the ratio of inflation to the shock's magnitude **increases** as the shock itself becomes larger. If the central bank adheres to the standard Taylor rule (1), the adjustment in the policy rate remains strictly proportional to the increase in inflation (Fig. 1B). Under NLIG, inflation stabilization policies face additional challenges, in that the policy rate must be raised at a super-linear rate relative to the magnitude of the demand shock.

Figure 1. The relationship between the policy rate, inflation and autonomous demand shocks, which characterizes the situation of 'non-linear response of inflation and the policy rate to demand shocks

A. Absence of non-linear response of inflation and the policy rate to a demand shock



B. Non-linear response of inflation and the policy rate to demand shock



This study examines four features of an economic system in which NLIG is present. Since these features are studied using a dynamic model, we will sometimes refer to them as scenario features or simply scenarios.

The first feature analysed is the zero-profit constraint for firms (subsection 5.1). This leads to a kink in the standard mechanism of cost pass-through: when there are large shocks to autonomous demand, costs rise so much that firms lose profits, reaching zero profits, and begin to set prices based on the zero-profit constraint. At this moment of transition to a new pricing mechanism, inflation temporarily accelerates, indicating the NLIG effect.

The second scenario (subsection 5.2) is the financing of the autonomous demand shock exclusively through commercial banks purchasing long-term government bonds with fixed coupon rates. The model imposes significantly stricter requirements on the capital of the banking sector and the accounting treatment of these bonds on bank balance sheets than in reality. An unexpected autonomous demand shock increases inflation, erodes the value of banks' bond holdings, and depletes bank capital. The consequence is an increase in banks' yield demands on new government bond issues (an increase in the discount) against the backdrop of reduced bank capital and the need to expand the balance sheet. In the event of major shocks to autonomous demand, this situation leads to explosive growth in bond market indicators and banking sector instability. The central bank faces a trade-off: allow instability in the bond market or sacrifice price stability, which could lead to NLIG.

The third feature is the influence of subjective expectations on economic agents (subsection 5.3). This scenario demonstrates how macroeconomic indicators, including inflation and the policy rate, can surge due to a coordinated shift in agents' expectations about future events (including erroneous expectations not anchored in real economic fundamentals, i.e. fake shocks). This scenario illustrates a fundamental feature of the economic system: the economy's sensitivity to agents' expectations, which permits virtually any dynamic path in the absence of observable shocks, including NLIG.

Unlike the first three scenarios, the fourth scenario (subsection 5.4) is not formally supported by model simulations. This scenario highlights the potential for accelerating inflation if there is a sudden acceleration in monetary aggregate growth. Such an acceleration would occur if the source of financing for additional government consumption shifts from drawdowns of foreign assets held by the National Wealth Fund to domestic debt issuance.

Section 6 further examines a theoretical situation in which the central bank’s impact on corporate lending conditions is reduced, yet NLIG does not materialize. Specifically, it compares economic states that differ in terms of firms' stock of subsidized loans. The higher the stock of subsidized loans held by firms, the less a change in the policy rate translates into the average rate at which firms service their aggregate debt. This means that as subsidized lending grows, it becomes more difficult for the central bank to cool down corporate activity within the model. However, the NLIG effect does not emerge: the central bank’s monetary impulse is absorbed by the dynamics of firms' internal variables, but not passed through to prices. It should be noted that in this situation, the absence of NLIG is established specifically for corporate subsidized lending, while the question of NLIG emergence against the backdrop of subsidized consumer and mortgage lending is not addressed in this study.[5]

These findings are further discussed in Section 7.

[5] The literature has extensively covered the pro-inflationary effects of government subsidized lending to households. The key mechanism is that such lending boosts aggregate demand without a corresponding immediate increase in supply (see, for example, *Curdia, Woodford*, 2011; *Garriga, Kydland, Sustek*, 2017), thereby fueling inflation. However, no studies have documented a non-linear inflationary response to subsidized lending to households.

2. Related literature

In recent decades, researchers have increasingly turned to nonlinear models to explain the dynamics of inflation in response to macroeconomic shocks, emphasizing that the inflation response is not always proportional to the magnitude of the external shock. For a long time, the primary focus of research in this field was the decline in monetary policy effectiveness at the zero lower bound (and, consequently, the threshold acceleration of inflation when the economy hits the constraint). However, the literature on inflation nonlinearities has expanded in recent years. Both empirical data and theoretical models are being studied.

Aslanidis et al. (2024) use data for several countries and a threshold autoregressive model to show that inflation is more persistent when it lies below the central bank's target. *Yusifzada et al.* (2025) propose a Markov-switching model with thresholds for high and low inflation, where shocks exert different impact coefficients depending on their magnitude. The authors argue that shifts in inflation regimes have high predictive power for the BRICS countries and Turkey. Using energy market data, *Bobeica et al.* (2025) develop a hybrid VAR framework combined with a nonlinear structural model, demonstrating that the economy responds weakly to small shocks and disproportionately strongly to large shocks.

Theoretical studies on the disproportionate inflation response often seek to distinguish between time-dependent pricing and state-dependent pricing, aiming to identify and exploit the latter. The distinction between these concepts dates back at least to *Dotsey, King, and Wolman* (1999), *Mankiw and Reis* (2002), and *Golosov and Lucas* (2007). *Golosov and Lucas* (2007) employ the concept of 'menu costs', where changing the price of a firm's output incurs a fixed cost μ. A firm adjusts its price only when the gain in profit from the price change exceeds this cost μ. The implications of introducing such an assumption into a dynamic general equilibrium model are far-reaching. Firms suppress frequent price adjustments, revising prices only when the deviation of the current price from the optimal level becomes sufficiently large. Price adjustments lag behind shocks, making prices sticky. Money neutrality breaks down in the short run, and changes in the money supply affect real macroeconomic variables. The response of inflation is disproportionate to the magnitude of shocks. The change in inflation can be decomposed into the product of the fraction of firms adjusting prices and the average size of the price adjustment. This leads to a comparison between two approaches: Calvo pricing and menu cost pricing. Calvo pricing takes place at fixed intervals, thereby implementing time-dependent pricing. Menu cost pricing, by contrast, depends on the state of the economy, thus implementing state-dependent pricing. The latter is distinguished by the introduction of an additional margin: the frequency of price adjustments or the variability in the fraction of firms changing prices (in discrete-time models).

Recent empirical research decomposes inflation into the product of the frequency of price changes and the average size of a price adjustment (*Dedola et al.,* 2024). Using microdata for the euro area and the United States, the authors establish that the probability (and therefore the frequency) of a price change for a specific product in a store depends on the percentage by which the price of the same product has been raised in neighboring stores, and the magnitude of the change is directly proportional to the change made by neighbors. The authors conclude that because inflation is proportional to the product of the frequency and average size of price changes, the effect of the frequency of price changes begins to take effect in the event of large shocks, making the macroeconomic response of inflation nonlinear with respect to the shock. They also conclude that the Calvo model, which emphasizes the time-dependent nature of price changes, underestimates the effect of the price change frequency and inflation dynamics in the event of major shocks. Microdata evidence also reveals asymmetry in the magnitude and probability of price changes depending on whether prices are rising or falling.

Karadi et al. (2024) analyze optimal monetary policy in a Ramsey problem framework based on the model developed by *Golosov and Lucas* (2007). In the event of a large cost shock, monetary policy has a limited contractionary effect on GDP. Therefore, the optimal policy should respond aggressively to a large cost shock, actively counteracting the increase in the frequency of price changes. In contrast, in response to an aggregate TFP shock, the policy implications are identical to those of the Calvo pricing model. Another group of researchers, in a series of papers (*Blanco et al.*, 2024a, 2024b, 2024c), develops a dynamic inflation accelerator model capable of reproducing endogenous changes in the fraction of firms changing prices (*Blanco et al.*, 2024a) and, consequently, the nonlinear response of inflation. Using data for the United States and the United Kingdom, they investigate the possibility of a menu cost model reproducing historical dynamics. *Blanco et al.* (2024b) highlight a key trade-off: the model can reproduce either the change in the fraction of firms changing prices or the distribution of price changes in microdata, but not both effects simultaneously (i.e., depending on the calibration, the model is either equivalent to the classical one or cannot reproduce microdata). *Blanco et al.* (2024c) introduce several modifications (including multiple goods) into the model, allowing for an extremely nonlinear Phillips curve.

Several studies have introduced the concept of ‘attention’, which in its technical implementation closely overlaps with menu costs. *Bracha and Tang* (2022) use a theoretical model to demonstrate that in high-inflation environments, households pay more attention to prices, react more quickly to changes, and update information more frequently than in low-inflation environments. The authors find that under high inflation, agents reduce information costs, leading to more flexible prices and increased shock transmission, as well as an elevated risk of rising inflation expectations. *Korenok et al.* (2023), using data from 37 countries, confirm that attention to inflation (measured as the volume of internet search queries on the topic) increases when inflation exceeds a certain threshold. *Pfauti* (2023) uses a threshold econometric model to estimate the attention threshold for inflation at 3.9% for the United States and shows that the attention parameter (which affects the speed of inflation adjustment) nearly doubles once the threshold is crossed. Finally, survey analysis by *Weber et al.* (2025) establishes that households update their expectations more rapidly and by larger magnitudes when inflation is high, whereas during disinflation, they update them less frequently and by smaller margins.

Notably, this study employs a different approach from menu cost models. We employ a standard equilibrium model with occasionally binding constraints (and solve it using the algorithm of *Guerrieri and Iacoviello* (2015); see subsection 4.1), which implies a temporary switch of the economy under the impact of shocks to an alternative regime characterized by higher inflation (see subsections 5.1 and 5.2). Thus, this paper captures inflation nonlinearity structurally through the institutional constraints of individual agents, rather than by postulating a specific menu cost structure or the exogenous probability of price adjustments.

Demand shocks over which NLIG can be studied are widely discussed in the macroeconomic literature: monetary shocks, fiscal shocks, consumer preference shocks, production cost shocks, investment efficiency shocks, and external demand shocks. For two reasons, our study focuses on scenarios with an autonomous demand shock in the form of a government consumption shock. The first is the relevance of government consumption shocks for the contemporary Russian economy: inflation and the policy rate surged against the backdrop of such shocks in 2023–2024. The second reason is the premise that a government consumption shock is the most sizable among those listed and is capable of triggering a nonlinear inflation response (the terms-of-trade shock is excluded due to its fundamentally different transmission mechanism to economic activity).

Analyzing nonlinear inflation growth in response to government consumption shocks, and the central bank's need to raise the policy rate disproportionately, relates this study to the literature on fiscal dominance. This literature concerns the interaction between fiscal and monetary policies, a well-explored yet actively studied area of macroeconomics. Fiscal dominance describes a state of the economy in which a country’s public debt and/or budget deficit is so high that monetary policy ceases to be an effective tool for controlling inflation.

The seminal work on fiscal dominance is *Sargent and Wallace* (1984). The authors consider a situation in which the monetary authority abandons the goal of inflation control in favor of financial stability. Consequently, the term ‘fiscal dominance’ has acquired a negative connotation in the literature, often being perceived as the complete inability of the monetary authority to control inflation. However, more recent studies examining the interaction between monetary and fiscal policies and building on earlier work on fiscal dominance do not require the central bank to abandon its primary objective; rather, they often focus on the complications arising from active fiscal policy.

More precisely, *Sargent and Wallace* (1984) examined monetary base targeting against the backdrop of a dominant (active) fiscal policy that sets budget deficits independently. When the fiscal authority reaches a certain level of debt, the central bank is forced to increase the monetary base to meet the fiscal authority's plans, which leads to inflation. Even if the central bank follows a Taylor-type rule to target inflation instead of regulating the monetary base, the question of active or passive monetary policy still arises against the backdrop of active fiscal policy (*Leeper*, 1991; *Davig and Leeper*, 2011), which corresponds to the trade-off between fiscal sustainability and inflation control. In addition to choosing from the binary set between active and passive monetary policy, there are also mixed policy strategies (*Bianchi et al.*, 2023), where the central bank pursues an active policy in response to certain types of fiscal shocks, while allowing for periodic monetary financing of deficits in response to other shocks. *Camous and Matveev* (2023) provide a theoretical justification that the central bank can achieve welfare gains and improve economic performance if fiscal policy indicators are explicitly incorporated into its rule. A departure from the traditional Taylor rule is also discussed by *Avakyan and Kuznetsova* (2024). One of the central bank's policy measures that improves the state's consolidated financial position may be quantitative easing and the redistribution of profits in favor of the state (*Adrian et al.*, 2024).

The degree of tension between fiscal and monetary policy can be assessed using the fiscal-monetary gap indicator, which is based on the real interest rate required to stabilize the level of public debt (r-star) (*Bolhuis et al.*, 2024). In the post-pandemic period, global fiscal-monetary gap indicators are at a historical high.

The relationship between active fiscal policy and inflation gave rise to the fiscal price theory (*Sargent, Wallace,* 1984; *Cochrane,* 2022). This theory postulates a relationship between the present value of budget deficits and the price level. The postulates of the theory, which form the basis of non-structural models, are that deficits determine prices exclusively and that prices adjust to budget deficits, and not the other way around (*Cochrane*, 2024). The model with overlapping generations in *Angeletos et al.* (2023) demonstrated that prices do not fully adjust to increased debt but rise, partially depreciating the debt. Under certain conditions, the remaining, impaired part of the debt is financed by an increase in the tax base, which allows the state not to raise tax rates and, in general, to painlessly increase the level of debt in the economy.

The relationship between active fiscal policy and inflation gave rise to the Fiscal Theory of the Price Level (*Sargent and Wallace*, 1984; *Cochrane*, 2022), which postulates a relationship between the present value of budget deficits and the price level. The core postulates of the theory, which form the basis of non-structural specifications, are that the price level is determined exclusively by fiscal deficits and that prices adjust to budget deficits, and not the other way around (*Cochrane*, 2024). Using an overlapping generations model, *Angeletos et al.* (2023) show that prices do not fully adjust to increased debt but rise, partially eroding the debt. Under certain conditions, the remaining, non-eroded portion of the debt is financed by an increase in the tax base, which allows the state to avoid raising tax rates and, in general, to sustainably increase the level of debt in the economy.

The model considered in this article is calibrated to Russian data; thus, public debt is domestic and its holders are banks. It should be noted that private investors hold more public debt than the banking sector in the global economy (*Fang et al.*, 2023). However, the banking sector is less sensitive to yield changes. *Gonzalez-Aguado* (2022) notes that domestic debt, compared to external debt, reduces the economy's dependence on global interest rate fluctuations. Debt holders demand higher returns when unexpected fiscal shocks occur, and the trade-off between offering higher returns and combating inflation is a matter of wealth redistribution between debt holders and taxpayers (*Gomez-Cram et al.*, 2024). The issue of wealth distribution between the state and debt holders also arises in this paper. If fixed-coupon government bonds are used to finance debt, instability may arise in the bond market (subsection 5.2). When considering fixed-coupon government bonds, debt holders (banks) lose the present value of nominal payments at the time of the shock due to rising inflation. This situation differs from that described by *Abadi, Brunnermeier, and Koby* (2023). *Abadi, Brunnermeier, and Koby* (2023) show that banks benefit from the revaluation of public debt against the backdrop of falling interest rates and suffer from the contraction of the deposit base due to interest rates close to zero. If the second effect significantly prevails, a situation of the 'reversal interest rate' may arise when banks' profits decline, capital adequacy constraints become binding, and further rate cuts do not lead to an increase in lending. The situation considered in this paper is different in that the growth in government consumption is accompanied by an increase in inflation and rates, rather than a fall in rates. Furthermore, the prospect of achieving near-zero interest rates in the Russian economy is unlikely (*Andreyev, Polbin*, 2022).

In the scenario of attenuated monetary policy transmission (section 6), no NLIG emerges when entrepreneurs are granted subsidized loans. A similar result (only with regard to oil price shocks) is obtained by *Pak* (2024): subsidizing production does not increase the sensitivity of inflation to shocks. This study does not consider the impact of subsidized consumer and mortgage lending. At the same time, *Pak and Pekarsky* (2022) show that an increase in the level of state support for consumer lending forces the regulator to raise interest rates further during the cooling phase of the economy against the backdrop of an oil price shock, thereby effectively attenuating monetary policy transmission.

The government spending shock considered in this paper has been extensively studied in the existing literature (*Andreev and Polbin,* 2018). In the neoclassical model (*Baxter and King,* 1993), a temporary increase in government spending leads to an increase in output and a decline in investment and household consumption, whereas a persistent increase in government spending leads to an increase in investment and a decline in household consumption. Neo-Keynesian models (*Polbin*, 2024; *Andreev*, 2025) calibrated for an export-oriented economy, such as Russia's, show fundamentally different purely temporary and persistent shocks to government spending. A purely temporary shock leads to an accumulation effect in consumption and output, while a persistent shock leads only to a short-term increase in output and a decline in consumption (*Andreev*, 2025), and the government spending multiplier may have fairly low values (*Polbin*, 2024). Estimates of the impact of government spending shocks on Russian data give a positive multiplier value (*Vlasov and Deryugina,* 2018), without standard methodological separation of shocks into purely temporary and persistent. In this paper we analyze persistent government spending shocks. The government spending shock in our paper differs from the standard one in that funds are spent not only on government consumption but also on supporting entrepreneurs who own productive capital. A persistent shock in this scenario leads to sustained consumption and output growth.

The potential for NLIG is demonstrated in scenarios 5.1–5.4.

3. The theoretical framework

3.1. Baseline environment

We employ a dynamic stochastic general equilibrium (DSGE) model as our analytical framework. The model characterizes a small open economy.

Households follow a standard formulation (see, for example, *Andreev and Polbin*, 2019). They supply labor to firms, accumulate savings in the form of bank deposits and foreign bonds, allocate funds to consumption, and receive dividends from the bank and profits from various sectors and intermediaries.

The model features two types of producers. Intermediate goods producers (firms) use labor and productive capital as inputs. A final good producer combines the domestic intermediate good with imports. The resulting final good is allocated to household consumption, government consumption, and investment.

The government collects taxes on exports and domestic production, issues debt on the domestic market, and provides subsidized loans to entrepreneurs. The raised funds are spent on government consumption. Tax policy remains unchanged throughout the model.

By assumption, exported goods do not require factor inputs. Since the model does not consider export shocks, real export volumes remain constant. Fifty percent of nominal export revenue accrues to the government, and the remaining share accrues to households.

Equilibrium in the foreign exchange market (i.e., the balance of payments) is achieved through the adjustment of the nominal exchange rate, which balances export revenues, domestic import demand by producers, and household demand for foreign financial assets.

The goal of monetary policy is to stabilize inflation around its target. Inflation targeting is implemented via a Taylor rule:

$$r_t - r_{ss} = \rho^r \left(r_{t-1} - r_{ss}\right) + \left(1 - \rho^r\right) \rho^\pi \left(\pi_t - \pi_{ss}\right) \quad (2).$$

Monetary policy is assumed to be highly inertial ($\rho^r = 0{,}9$), consistent with estimates based on Russian data (*Andreev and Polbin*, 2022).

Several frictions are introduced in a standard fashion within the New Keynesian approach: nominal domestic price rigidity, nominal wage rigidity, foreign bonds adjustment costs, and investment adjustment costs.

The model incorporates three key features that distinguish it from standard models.

The first feature is the presence of entrepreneurs modeled in the spirit of *Bernanke et al.* (1999). Unlike their setup, we assume that entrepreneurs borrow funds not only from the bank but also from the government, which provides funds at a fixed subsidized rate. The availability of subsidized financing for entrepreneurs is one of the channels through which we investigate NLIG.

The second feature is the issuance of long-term government bonds. The duration of these bonds is a structural parameter of the model. Allowing for a bond duration exceeding one period (quarter) enables us to capture the effect of a decline in the real value of outstanding debt driven by unexpected inflation stemming from active fiscal policy.

The third feature is the inclusion of a banking sector modeled in the spirit of *Gerali et al.* (2010). The banking sector is the sole holder of public debt. Inflationary processes arising in the wake of an autonomous demand shock affect the profitability of the banking sector through the market value of its debt holdings.

3.2. Entrepreneurs and financial frictions

Our formulation of the entrepreneurial sector extends the standard financial accelerator model (*Bernanke et al.,* 1999; *Andreev and Polbin,* 2019). Entrepreneurs own physical capital K_t and finance it using their own net worth (Cap_t) and borrowed funds. Unlike the setup in *Bernanke et al.* (1999), we assume that borrowed funds are provided not only by commercial banks ($Loan_t^B$), but also by the government ($Loan_t^G$). Consequently, the funding constraint of the entrepreneurs takes the following form:

$$q_t \, K_t = Loan_t^B + Loan_t^G + Cap_t \, ,$$

where q_t is the current price of a unit of physical capital.

The bank extends one-period loans to entrepreneurs at an interest rate of R_t^B , while the government provides loans at a fixed subsidized rate of R^G . The government rate is subsidized, which is implemented in the model by assuming the bank lending rate in the steady state R_{ss}^B exceeds the rate on government loans:

$$R_{ss}^{B} > R^{G} \qquad (3).$$

We assume that the bank and the government jointly finance the entrepreneur, meaning the entrepreneur faces a volume-weighted average interest rate:

$$R_t^{eff} = \frac{R_t^G \, Loan_t^G + R_t^B \, Loan_t^B}{\left(Loan_t^G + Loan_t^B\right)} \qquad (4).$$

At the same time, the lending consortium of the bank and the government requires entrepreneurs to guarantee a risk-free return at rate R_t^{eff} which is captured by the following condition (*Bernanke et al.*, 1999; *Andreev and Polbin*, 2019):

$$R_t^{eff}\left(Loan_t^G + Loan_t^B\right) = (1-\mu)\int_{\omega_{min}}^{\bar{\omega}_{t+1}} \omega f(\omega)\, d\omega \left(Rk_{t+1}\, q_{t+1}\, K_t\right) + \left(1 - F(\bar{\omega}_{t+1})\right)\bar{\omega}_{t+1}\left(Rk_{t+1}\, q_{t+1}\, K_t\right) \;.$$

This condition[6] means that, ex ante, the bank and the government expect to receive, on average across all entrepreneurs, the amount $R_t^{eff}\left(Loan_t^G + Loan_t^B\right)$ in the next period for providing funds $Loan_t^G + Loan_t^B$ in the current period. The expected repayment is funded, first, by those 'defaulting' entrepreneurs whose idiosyncratic return ω proves to be too low: $\omega \le \bar{\omega}_{t+1}$. Such entrepreneurs default, and their assets $\omega Rk_{t+1}\, q_{t+1}\, K_t$ are fully liquidated by the bank, incurring a deadweight loss of a fraction of the assets μ. Second, the repayment received by creditors comes from 'solvent' entrepreneurs ($\omega > \bar{\omega}_{t+1}$), who pay a share $\bar{\omega}_{t+1}$ of the real value of their assets $Rk_{t+1}\, q_{t+1}\, K_t$ towards the loan.

Since government lending is subsidized (3), (4)), it follows that $R_{ss}^B \ge R_{ss}^{eff} > R^G$.

Subsidized lending implies that, on average, the effective interest rate R_t^{eff} faced by the entrepreneur is lower than the bank rate R_t^B that the entrepreneur would have paid if there had been no subsidized lending. Therefore, if the government actively extends credit to entrepreneurs during a period of rising inflation and interest rates, it will thereby offset monetary policy tightening:

[6] Following standard notation in *Bernanke et al.* (1999), the following symbols are used. μ denotes the fraction of the entrepreneur's assets that the bank, acting as the new temporary owner, loses in the event of bankruptcy. ω presents a random variable capturing the entrepreneur's idiosyncratic risk, with a mean of one and a cumulative distribution function F. The critical threshold $\bar{\omega}_{t+1}$, which separates bankruptcy and non-bankruptcy states, is endogenous and is determined from the aforementioned condition.

the central bank will seek to tighten monetary policy, transmitted through the bank lending rate R_t^B, while entrepreneurs will in fact face a milder increase in the effective rate R_t^{eff}.

3.3. Fiscal policy and long-term sovereign debt

The government can issue long-term bonds. To model the duration of a bond, we employ the following structure. At any given time t, the Russian Ministry of Finance issues securities with a total notional amount[7] A_t. This notional amount A_t entitles the holder to receive the following amounts in subsequent periods: ΔA_t in period $t+1$, $\Delta(1-\Delta)A_t$ in period $t+2$, $\Delta(1-\Delta)^2 A_t$ in period $t+3$, and so on. The relative market price of a unit of notional amount is denoted by Q_t[8]; accordingly, $Q_t A_t$ is the book value of outstanding bonds. Banks are the buyers of bonds in the model; therefore, the price of a bond Q_t is determined by discounting future cash flows at the bank's yield to maturity.

The bond considered here formally never matures. However, the duration of the bond – the payment-weighted average maturity – is finite for $0<\Delta\leq 1$. If $\Delta=1$, we have the standard one-period bond used in equilibrium models, which has a duration of 1 period. As Δ approaches 0, the duration increases. For example, at $\Delta=0{,}025$, the duration is approximately 40 periods.

The Russian Ministry of Finance may change the notional amount A_t, thereby changing the debt amount $Q_t A_t$, depending on its policy. However, the government cannot change the parameter Δ, i.e., the duration of the bond, within the framework of a given model experiment.

The Ministry collects a production tax τ^y from domestic production $P_t^d Y_t^d$, an export tax from exports $S_t P^{TOT} Exp$ valued at the nominal exchange rate S_t, issues single-period loans to entrepreneurs $Loan_t^G$, earning a return R^g, and purchases the final good G_t at a price P_t on the domestic market. The funding gap is covered by transactions with government bonds. Then, in nominal terms, the budget constraint of the Russian Ministry of Finance takes the following form:

$$P_t G_t = \tau^{oil} S_t P^{TOT} Exp + \tau^y P_t^d Y_t^d + Q_t\left(A_t - (1-\Delta)A_{t-1}\right) - \Delta A_{t-1} - Loan_t^g + R^g Loan_{t-1}^g \qquad (5).$$

In this expression, the term ΔA_{t-1} reflects the debt service payments on the bonds A_{t-1} in circulation at the end of period $t-1$. The term $A_t - (1-\Delta)A_{t-1}$ reflects the change in the notional

[7] Here, the 'notional amount' should not be interpreted as the face value paid by the issuer at maturity.
[8] This variable is dimensionless; it is best understood as one minus the bond discount.

amount during period t. Accordingly, the term $Q_t\left(A_t-(1-\Delta)A_{t-1}\right)$ represents the funds received from the bank. In particular, if the Russian Ministry of Finance did not issue or prepay bonds during period t, then this term is zero, i.e.:

$A_t=(1-\Delta)A_{t-1}$ – the natural amortization of the notional amount in the absence of new issuance and early redemption.

Currently, Russia and some commodity-exporting countries use stabilizing fiscal rules, which have been described in a number of works. The fiscal rule is not included in the above model because its effect is based on a terms-of-trade shock, which the author does not consider.

3.4. The banking sector and capital requirements

The banking sector in our model is a highly simplified version of the framework in *Gerali et al.* (2010), augmented with government bonds on the balance sheet. The bank's assets consist of loans to entrepreneurs, $Loan_t^B$, and government bond holdings, $Q_t\,A_t$. The bank's liabilities consist of its equity capital, Ω_t, and household deposits, D_t:

$$Loan_t^B+Q_t\,A_t=D_t+\Omega_t \qquad (6).$$

The bank's budget constraint is given by:

$$\begin{aligned}&D_t-R_{t-1}D_{t-1}-Loan_t^B+R_{t-1}^B\,Loan_{t-1}^B-Q_t\left(A_t-(1-\Delta)A_{t-1}\right)+\Delta\,A_{t-1}-\\&\quad-\frac{k^B}{2}\left(\frac{\Omega_t}{Loan_t^B+Q_tA_t}-\nu\right)^2\Omega_t-Div_t=0\end{aligned}$$

Here, R_t is the policy rate, which also serves as the deposit rate; ν is the target capital adequacy ratio, deviations from which incur costs for the bank; and Div_t denotes dividends to households. The second-to-last quadratic term, following *Gerali et al.* (2010), reflects the bank's aversion to deviating from the capital adequacy target: deviation is possible, but it entails costs that affect the choice variables.

The bank's objective is to maximize the expected (E_{t_0}) present value of dividends:

$$E_{t_0}\sum_{t_0}^{+\infty}\frac{Div_t}{P_t\prod_{t_0}^{t-1}r_\tau} \tag{7}$$

Following *Gerali et al.* (2010), to rule out recurrent capital injections by owners when the bank cannot generate positive dividends, we assume an exogenous dividend program. More precisely, we assume that dividends are fixed: $Div_t = Div_{ss}$. This constraint is imposed independently of the dividend maximization problem (7).

Several important relationships follow from the first-order conditions of the bank's problem.

First, the following relationship holds approximately:

$$R_t^B = E_t\frac{(1-\Delta)Q_{t+1}+\Delta}{Q_t} \tag{8}$$

This implies that the expected yields on the two competing bank assets – loans and bonds – are equalized. The return on bonds comprises the capital gain from the preserved notional $(1-\Delta)$ and the coupon payment Δ, scaled by the current price Q_t.

The second relationship takes the following approximate form:

$$R_t^B = R_t - k^B\left(\frac{\Omega_t}{Loan_t^B + Q_t A_t} - \nu\right)\nu^2 \tag{9}$$

A similar condition appears in *Gerali et al.* (2010). As lending $Loan_t^B$ increases, the lending rate R_t^B also increases. Economically, this means that by increasing lending, the bank is willing to accept a lower capital adequacy ratio, but only if the return on lending exceeds the policy rate R_t (i.e., its funding cost) by a sufficient spread. Since loans and bonds are competing investment opportunities for the bank, the same principle applies to its bond portfolio: the bank is willing to deviate from its target capital by increasing its holdings of government bonds on its balance sheet, but only if compensated by a higher yield on those government bonds.

3.5. Intermediate goods producers and price setting

A description of firms is provided because the scenario 'Factor shortages and the zero-profit constraint' (subsection 5.1) is based on modeling of firms.

Firms form a continuum and are indexed by j. Firms purchase labor L_t^j from households at a nominal wage W_t and lease capital K_{t-1}^j at a rental rate R_t^k from entrepreneurs. Labor and capital are aggregated into an intermediate good Y_t^d according to the technology:

$$Y_t^{d,j} = a\left(K_{t-1}^j\right)^{\alpha}\left(L_t^j\right)^{1-\alpha} \quad (10).$$

It is assumed that firms operate in a monopolistically competitive market. Firms know the demand $Y_t^{d,j}$ for their own good:

$$Y_t^{d,j} = Y_t^d\left(\frac{P_t^{d,j}}{P_t^d}\right)^{-\varepsilon} , \quad (11),$$

where Y_t^d – aggregate output of the intermediate good, P_t^d – aggregate price index, $P_t^{d,j}$ – the individual price of the good set by the firm. When setting the price $P_t^{d,j}$, the firm incurs price adjustment costs of $\frac{p^{rig}}{2}\left(\frac{P_t^{d,j}}{P_{t-1}^{d,j}}-1\right)^2 P_t^d\,Y_t^d$ according to the Rotemberg pricing approach (*Rotemberg,* 1982). The firm's profit is determined by the expression:

$$\Pi_t^{d,j} = P_t^{d,j}Y_t^{d,j}\left(1-\tau^y\right) - W_t\,L_t^j - R_t^k\,K_{t-1}^j - \frac{p^{rig}}{2}\left(\frac{P_t^{d,j}}{P_{t-1}^{d,j}}-1\right)^2 P_t^d\,Y_t^d \quad (12),$$

where τ^y is the tax rate.

The firm maximizes the discounted profit:

$$E_{t_0}\sum_{t=t_0}^{+\infty}\beta^{t-t_0}\,\Lambda_t\,\frac{\Pi_t^{d,j}}{P_t} \quad (13),$$

where E_{t_0} is the mathematical expectation operator conditional on information up to period t_0.

As a result of optimizing the objective function (13) (subject to constraints (10)–(12)) with respect to price $P_t^{d,j}$ under the assumption of a symmetric equilibrium (the index j is omitted), the following expression is obtained:

$$Mc_t - \frac{\varepsilon - 1}{\varepsilon} - \frac{p^{rig}}{1-\tau^y}\left(\frac{P_t^d}{P_{t-1}^d} - 1\right)\frac{P_t^d}{P_{t-1}^d} + E_t \frac{p^{rig}}{1-\tau^y}\left(\frac{P_{t+1}^d}{P_t^d} - 1\right)\left(\frac{P_{t+1}^d}{P_t^d}\right)^2 \frac{\Lambda_{t+1}}{\Lambda_t}\frac{Y_{t+1}^d}{Y_t^d} = 0 \qquad (14).$$

In this expression, Mc_t is the Lagrange multiplier for constraint (10) and can be interpreted as the marginal cost of the firm. In the steady-state equilibrium (i.e. in the absence of shocks, when all variables are constant), marginal cost is given by $Mc_t = \frac{\varepsilon - 1}{\varepsilon}$. In this case, if we neglect the second-order terms $\frac{p^{rig}}{2}\left(\frac{P_t^{d,j}}{P_{t-1}^{d,j}} - 1\right)^2 P_t^d Y_t^d$, profit is given by:

$$\Pi_t^{d,j} = P_t^{d,j} Y_t^{d,j}\left(1-\tau^y\right)\left(1 - Mc_t\right) \qquad .$$

This means that, on average, firms set a mark-up of $\frac{1}{\varepsilon}$ owing to their monopoly power. Due to the existence of a positive mark-up, firms' profits $\Pi_t^{d,j}$ will remain positive in the case of small shocks. However, in the case of large shocks leading to a decline in profits, firms' profits may turn out to be negative.

Standard equilibrium models ignore the fact that firms' profits sometimes become negative. In such a situation, the owner of the firm (the household) incurs a loss, or, equivalently, injects funds into the firm. We will follow this principle throughout, except in subsection 5.1.

In the scenario of subsection 5.1, we will assume that profit cannot be negative:

$$\Pi_t^{d,j} \geq 0 \qquad . \qquad (15).$$

This inequality makes the model non-linear. In this study, we solve the model with this inequality using the piecewise linear approximation algorithm of the Occbin toolkit (*Guerrieri, Iacoviello*, 2015).

If it turns out that profit is zero, $\Pi_t^{d,j} = 0$, the firm stops setting prices $P_t^{d,j}$ based on price optimization. Instead, the firm sets the price $P_t^{d,j}$ to ensure zero profit and prevent it from becoming negative $\Pi_t^{d,j} = 0$.

Thus, the standard condition (14) for DSGE models, known as the New Keynesian Phillips curve, is satisfied under the condition $\Pi_t^{d,j} > 0$ in subsection 5.1. This expression determines domestic price dynamics and significantly affects inflation. If $\Pi_t^{d,j}=0$, prices are implicitly determined by this expression, and condition (14) does not have to be satisfied. Consequently, when firms face the possibility of incurring losses, the pricing mechanism changes.

4. Modeling non-linear dynamics and fiscal shocks

4.1. Capturing non-linearities: occasionally binding constraints

As noted above (Fig. 1), searching for NLIG in a linear world and in linear models is pointless. Below we explain the types of non-linearity studied in this paper.

The DSGE models we use are generally written in the form:

$$E_t\bar{F}\left(\bar{y}_{t+1},\bar{y}_t,\bar{y}_{t-1},\bar{\varepsilon}_t\right)=0,$$

where $\bar{\varepsilon}_t$ denotes current period shocks, E_t – the conditional expectation operator, $\bar{F}$ – a vector-valued function describing the model, and $\bar{y}_t$ – the vector of endogenous variables. Solving the DSGE model means finding the mapping from past states and current shocks to the current state vector: $\bar{y}_t=g\left(\bar{y}_{t-1},\bar{\varepsilon}_t\right)$. Since a closed-form solution is generally unavailable, in the vast majority of cases a linear approximation to the solution is constructed:

$$\bar{y}_t=A\bar{y}_{t-1}+B\bar{\varepsilon}_t \tag{16}$$

Since linear models are unsuitable for detecting NLIG, it is necessary to go beyond linear models. This is achieved in two ways. The first method, used in subsections 5.1 and 5.2, is to impose an inequality constraint (*Guerrieri, Iacoviello*, 2015). Subsection 5.1 introduces the non-negativity constraint on profits; subsection 5.2 introduces the bank capital adequacy constraint. In both cases, in the steady-state equilibrium, the constraints are satisfied with slack, i.e. profits are strictly positive and the capital adequacy ratio exceeds the minimum threshold. These constraints do not bind under small shocks, and the model remains linear. However, under significant shocks, the constraints may become binding for some time and hold with equality. This constitutes the non-linearity.

The second method constructs a sequence of linear approximations (16) indexed by structural parameters. This approach is used in Section 6. The approximation (16) depends on the structural parameters $\bar{p}$ of the model and the steady-state values $\bar{y}_{ss}$ around which the model is linearized:

$$\bar{y}_t = A(\bar{y}_{ss}, \bar{p})\bar{y}_{t-1} + B(\bar{y}_{ss}, \bar{p})\bar{\varepsilon}_t \quad (17).$$

Section 6 examines a sequence of subsidized lending levels to entrepreneurs. For each level, a linear approximation (17) is computed and the coefficient of proportionality between the government spending shock and inflation is measured. If the coefficient of proportionality increases with the level of subsidized lending, this indicates the presence of NLIG.

4.2. Specification of the government consumption shock

The fiscal shock is modeled as follows. We assume that the fiscal authority issues debt on the domestic market in accordance with the following equations:

$$Q_t A_t / P_t = Q_{ss} A_{ss} / P_{ss} + \rho^{QA} \left(Q_{t-1} A_{t-1} / P_{t-1} - Q_{ss} A_{ss} / P_{ss} \right) + s_t \quad (18);$$

$$s_t = \rho^s s_{t-1} + \varepsilon_t \quad (19);$$

where $Q_t A_t$ – the current nominal public debt (subsection 3.3), P_t – the price level in the economy, $\rho^{QA} = 0{,}95$, $\rho^s = 0{,}9$, s_t – a variable characterizing the fiscal shock with a zero steady-state value, ε_t – independent and identically distributed (i.i.d.) random variables with zero mean.

Given equations (18), (19) and the selected coefficient values ρ^{QA}, ρ^s, we simulate the following scenario. The fiscal authority accumulates real public debt over several periods ($\rho^s = 0{,}9$), gradually reducing the net issuance of new real debt. At the same time, the government deleverages slowly ($\rho^{QA} = 0{,}95$), gradually returning to the steady-state debt level. Note that the average duration of the bonds, specified by the parameter Δ, is set independently of the parameters of equations (18), (19).

It is assumed that 50%[9] of the proceeds from the bond issuance are allocated to lending to entrepreneurs, and the other 50% are spent on government consumption. This allocation is formalized by the equation:

$$Loan_t^g / P_t = Loan_{ss}^g / P_{ss} + 0.5 \left(Q_t A_t / P_t - Q_{ss} A_{ss} / P_{ss} \right).$$

[9] The 50/50 distribution is probably not empirically accurate. According to informal expert estimates, the share of new funds raised through bonds and used to finance government aid programs for enterprises does not exceed 10%. However, the goal of this part of the model is not to obtain accurate quantitative estimates but to demonstrate the effect of NLIG. The NLIG effect is absent in Section 6, where this distribution matters; thus, the exact proportions are irrelevant. The chosen proportions are convenient for visualizing the absence of effects.

On the one hand, the assumption regarding lending to entrepreneurs constitutes the core of the scenario presented in Section 6. On the other hand, it yields more realistic model dynamics. Namely, empirical estimates show (for example, *Vlasov and Deryugina*, 2018) that a positive fiscal shock increases output. However, in a standard simulation of a persistent fiscal shock, equilibrium models show that the output response is positive for only a few periods, after which it may turn negative, falling below the steady-state level (*Polbin,* 2024; *Andreev,* 2025). Incorporating lending to entrepreneurs allows us to reconcile the theory with the empirical evidence: in this model, output remains positive in response to a persistent shock.

5. Scenarios of non-linear inflation growth

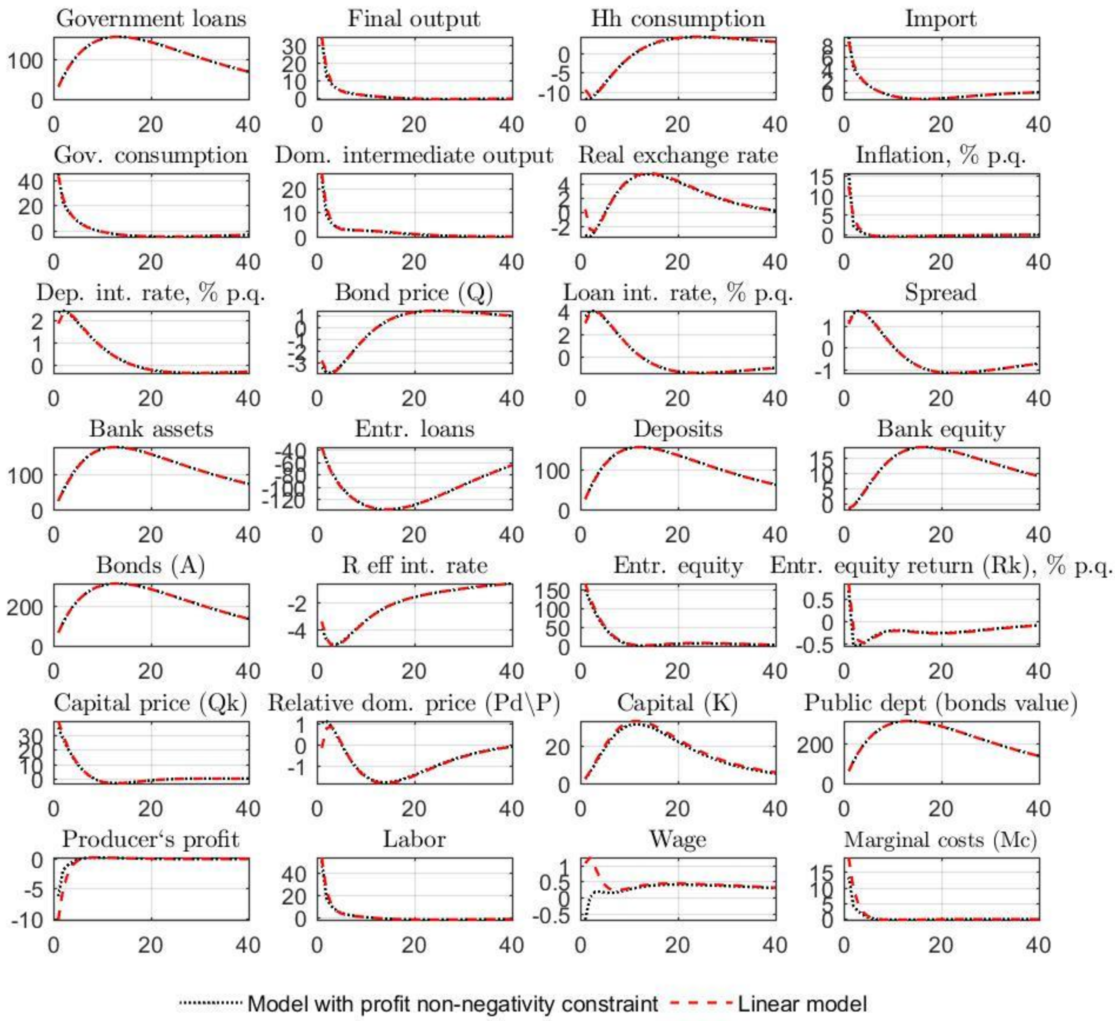
5.1. Factor shortages and the zero-profit constraint

With standard[10] parameters for the Russian economy (*Drobyshevsky and Polbin,* 2015; *Andreyev and Polbin*, 2022), a very large[11] shock to government consumption has the following effect. First, let us consider the model in the absence of any constraints on firm's profits (constraint (15), i.e. the linear model (red curves in Figure 2)).

A positive shock to autonomous demand in the form of growth in government consumption causes an increase in the demand for productive capital and labor, which leads to an increase in the cost of labor and a temporary increase in the rental rate of capital. The result is an increase in the firm's marginal costs and a temporary decrease in its profit. The firm's profit declines so sharply under the impact of a large shock that it becomes negative[12]. At the model level, this implies that the owner of the firm – the household – covers the firm's loss out of its own funds.

Figure 2. Impulse response functions of model variables to the government consumption shock. The case of a linear model and the case of a model with a non-negativity constraint on the firm's profit. "% p.q." means percentage per quarter; other indicators are presented as % deviation relative to steady-state quarterly GDP.

[10] It should be noted that this model not only maintains parameter continuity but also qualitatively replicates the functioning of economic mechanisms consistent with other DSGE models: the direction of variable responses to shocks and the magnitude of these responses.
[11] In Figure 2, the cumulative public debt reaches 150% of quarterly GDP after three years of continuous debt accumulation. The text also discusses the situation in which such a shock would have a smaller, more realistic scale while preserving the NLIG effect.
[12] In Figure 2, the zero value of the firm's profit corresponds to the -6.3 mark on the vertical axis, panel 'Producer's profit'. All figures show absolute deviations from the steady-state equilibrium. Since the firm's profit is positive in the steady-state equilibrium, it must decline (to the -6.3 mark in the figure) for profits to reach zero.



This situation is the norm in general equilibrium models because marginal effects, such as changes in inflation, interest rates and output, are usually the primary focus. The profitability of firms is not typically the focus of attention, especially since it plays no role in standard models for welfare analysis. In this study, we model frictions that may arise in the real world. Therefore, idealistic simplifications in the model, such as the arbitrary sign of profits, can be critical.

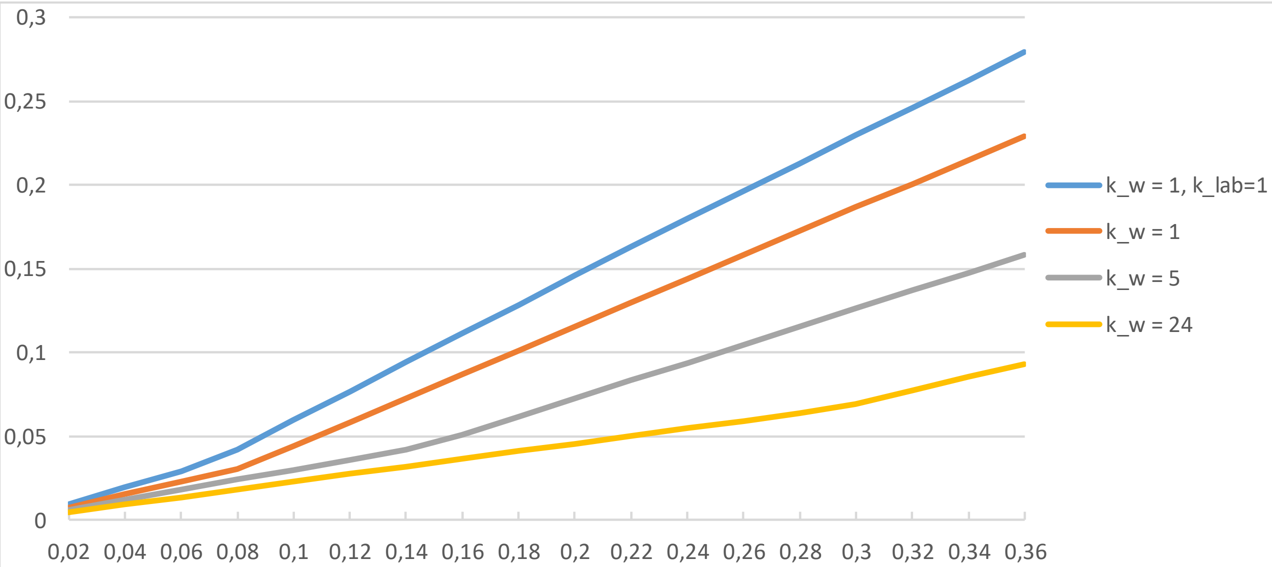
If we assume that a firm’s profit cannot be negative, and that when it reaches zero, the firm ceases to optimize prices (subsection 3.5, constraint (15)), this case is represented by the black curve (Fig. 2). In this case, profits do not fall below zero in the first period. The firm sets prices so that profits are at least zero. This means that prices are higher[13] than in the linear model without the non-negativity constraint on profits (15). The increase in the price of the domestic intermediate good allows the firm, among other things, to mitigate the growth of marginal costs.

[13] See panel ‘Inflation’.

Thus, the assumption of non-negativity of profits is equivalent to a shift in the pricing mechanism in the domestic market under very large autonomous demand shocks, whereby inflation begins to accelerate. In essence, this is an additional occasionally binding pricing mechanism characterized by full cost pass-through.

The aforementioned autonomous demand shock is unrealistically large. However, the parameters for the calculations were selected from estimates for the Russian economy prior to 2022. After 2022, against the backdrop of sanctions imposed on Russia by unfriendly nations, conditions in the factor markets changed. For example, the labor force shortage has become more acute since 2022. At the model level, this situation can be described as follows. If previously the household or the labor agency representing it on the labor market bore wage adjustment costs of the form $\frac{w^{rig}}{2}\left(\frac{W_t^{d,i}}{W_{t-1}^{d,i}}-1\right)^2 W_t\ L_t$ ($W_t^{d,i}$ – individual labor supply by a single household, $w^{rig}=47$ as according to (*Polbin,* 2014)), now they incur similar costs but with a lower value of the wage rigidity parameter w^{rig}. Its lower value w^{rig} indicates that nominal wages now rise more sharply in response to a positive shock of the same magnitude. This means that firms' costs grow more strongly, and firm profits hit the zero-profit constraint at a lower government spending shock (Fig. 3).

Figure 3. Peak inflation as a function of the government spending shock magnitude (horizontal axis) for different values of the wage rigidity parameter w^{rig}



If the labor rigidity parameter is calibrated and fixed, the peak inflation response curve steepens at least once[14] as government spending shocks increase. An increase in the slope means

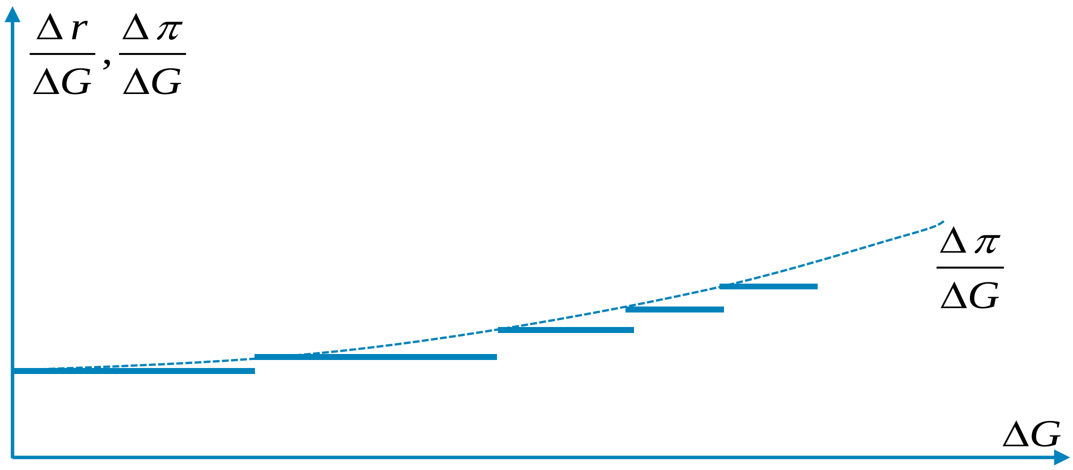
[14] In the figure, the blue curve illustrates a scenario where, alongside the wage rigidity mechanism, we also have a labor rigidity mechanism included. This means that when the demand for labor shifts, the firm incurs the costs

that the economy begins to employ a new pricing mechanism that corresponds to the zero-profit constraint with a shock of this magnitude and above, and inflation accelerates more sharply after this point. Notably, the tightening of labor market conditions corresponds to a decrease in the wage rigidity w^{rig} parameter, and we observe that inflation acceleration can occur with increasingly smaller shocks.

It is also possible to imagine an even more realistic situation where the economy consists of several heterogeneous sectors and not a multitude of identical segments. For each sector, the magnitude of the critical shock for the transition to a new pricing mechanism will be different, if only because the sectors' marginal costs are different. For such an economy, we will see the relationship shown in Figure 4.

When the shock is small, none of the sectors encounter the non-negativity profit constraint; the economy operates linearly, and the ratio of inflation to the shock magnitude is constant. As the shock intensifies, sectors start to face the constraint sequentially, activating a new pricing mechanism, and the inflation-to-shock ratio increases in discrete steps. Moreover, if the number of periods during which firms experience constraints grows alongside the shock's magnitude, these steps can subdivide (leading to a more pronounced increase in inflation). Since the Taylor rule (2) remains unchanged in these calculations and discussions, the policy rate is proportional to inflation; thus, qualitatively, the rate exhibits a dependence similar to that shown in Figure 4. This implies the presence of NLIG (see section 1, Fig. 1B).

Figure 4. Qualitative dependence of the inflation-to-shock ratio on the magnitude of the government spending shock in a multi-sector economy



$\frac{k^{lab}}{2}\left(\frac{L_t^{d,j}}{L_{t-1}^{d,j}}-1\right)^2 W_t \; L_t$. This mechanism captures the fact that labor can still become more rigid (and wages more flexible) even if the parameter w^{rig} falls to zero. If that happens, the increase in the parameter k^{lab} will indicate increasingly tighter conditions in the labour market. In this context, introducing the parameter $k^{lab}=1$ causes the blue curve to steepen twice. The curve's slope increases again when the firm is forced to remain at the zero profit constraint for two periods instead of one.

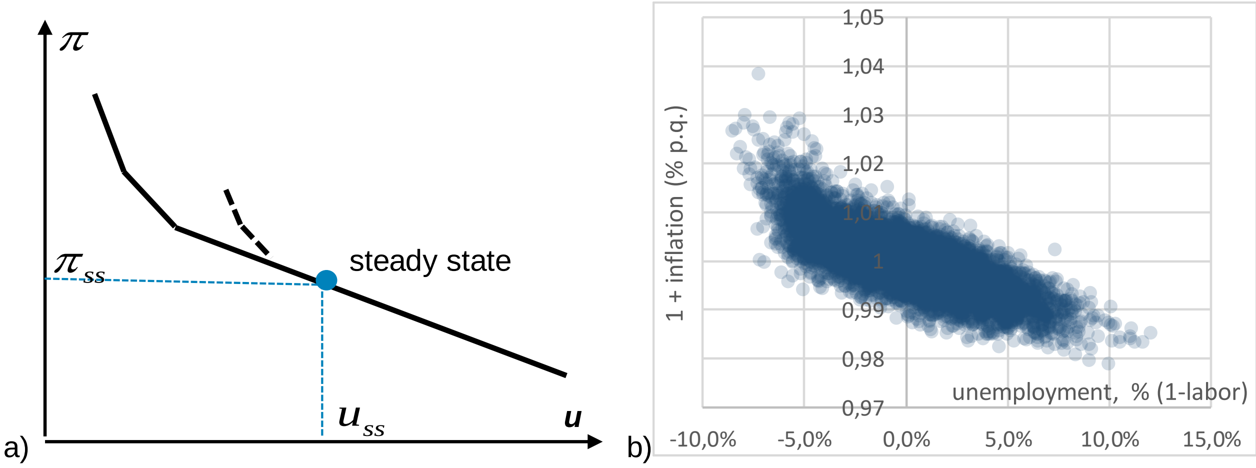
Note that in Russia in 2023–2024, the situation was consistent with NLIG[15]. Why then were there no signs of NLIG before 2023? It seems that before 2022, tightness in the factor markets was not as acute as it became subsequently. Before 2022, the economy was operating in a linear regime, barely moving beyond the first step (Fig. 4). However, after 2022, the tightening of conditions caused non-linear effects to manifest even with relatively small shocks (Fig. 3). In addition, the magnitude of the shocks themselves increased.

The labor market mechanism chosen here is merely the simplest example to illustrate the principle. NLIG can emerge due to supply constraints not just within the labor market. The standard production function (10) captures how output relies on capital and labor, but it overlooks the impact of maintenance. In some Russian enterprises, maintenance may depend on imported components that are currently hard to obtain, and the domestic economy is unable to substitute these imports due to deep-rooted structural issues. In this case, maintenance actually becomes an additional production factor. When bottlenecks in maintenance arise, they can impact inflation just like tightness in the labor market, which again leads to NLIG. Likewise, other mechanisms that drive up costs, especially when the ability to mitigate their rise is narrowing, will contribute to accelerating inflation. For instance, recent statistics indicate a rise in the share of profits directed to investment. Investment activity in recent years likely reflects several factors, including the need to substitute imported capital goods that have become inaccessible due to sanctions. The rising costs of investment play a crucial role in the pricing mechanism outlined in this scenario.

To conclude this scenario, it is important to highlight that the joint dynamics of labor and inflation are captured by a non-linear classical Phillips curve (Fig. 5). A positive shock to government spending results in a shift to the left from the steady-state equilibrium point. The factor shortage situation differs from the standard scenario (as shown by the dashed part of the curve in the figure) in that non-linearity emerges close to the equilibrium position (especially with small, realistic shocks).

[15] The estimation of the equation $r_t = a + \rho\pi_t + \varepsilon_t$ (where r_t is the policy rate and π_t is inflation) using the least squares method on monthly data yields a coefficient of $\rho = 1{,}95$ when estimated for the period from 2014 to 2022 and $\rho = 2{,}24$ when estimated for the period from 2014 to 2024. This indicates a non-linear tightening of monetary policy since 2023, which is a sign of NLIG.

Figure 5. (a) Qualitative shape of the classical Phillips curve in the scenario of a factor shortage and (b) model-based simulations (10 000 draws)



5.2. Long-term sovereign debt and bank capital erosion

Unanticipated shocks that drive up inflation lead to a decline in the market value of fixed-coupon bonds. This occurs because unexpected inflation erodes the real value of future nominal payments. When the banking sector holds these fixed-coupon bonds on its balance sheet, unanticipated autonomous demand shocks can erode bank income and equity capital, ultimately leading to a contraction in credit supply. Monetary policy typically faces no headwinds when credit supply contracts during an economic expansion. However, there is also an income effect on bank capital: the expansion of bond-financed public debt increases bank income through higher coupon payments. This income boost can augment bank equity and credit supply. Consequently, further expansion of credit supply can complicate the conduct of restrictive monetary policy. If the positive effect of rising bank capital significantly outweighs the negative effect of capital erosion, the NLIG effect may emerge.

This scenario examines the effect of an unanticipated autonomous demand shock under the assumption that the government finances consumption growth by issuing bonds with an average maturity of approximately ten years ($\Delta = 0{,}025$). The scenario also relies on several other assumptions, the realism of which is discussed in Section 7.

Given that unanticipated autonomous demand shocks cause bank capital to decline in the model, we introduce an additional constraint:

$$E\Omega_{t+1} \geq \Omega_{min} \tag{20}$$

– the expected value of bank capital cannot fall below a minimum threshold.

In the steady-state equilibrium, the parameters are calibrated such that the lower bound on bank capital (20) is satisfied with slack: $E\Omega_{ss} > \Omega_{min}$. Consequently, under small shocks, capital deviations are minimal, and constraint (20) is non-binding for banks. However, under large shocks, constraint (20) may temporarily become binding:

$$E\Omega_{t+1} = \Omega_{min} \quad .$$

Furthermore, instead of equation (18) for the dynamics of public debt, we employ the following condition:

$$G_t = G_{ss} - 0.1\left(Q_t A_t / P_t - Q_{ss} A_{ss} / P_{ss}\right) + s_t \quad (21).$$

Replacing (18) with (21) is motivated by the fact that under the debt dynamics equation (18), public finances become unstable when the debt is financed with long-term bonds. Equation (21) ensures the stability of public finances within a certain range of model parameters. Equation (21) implies that the policy goal is a certain path of real government consumption G_t, driven by a shock s_t. The term $-0.1\left(Q_t A_t / P_t - Q_{ss} A_{ss} / P_{ss}\right)$ implies that the government is willing to deviate to some extent from its target path of government consumption G_t to ensure public debt stability

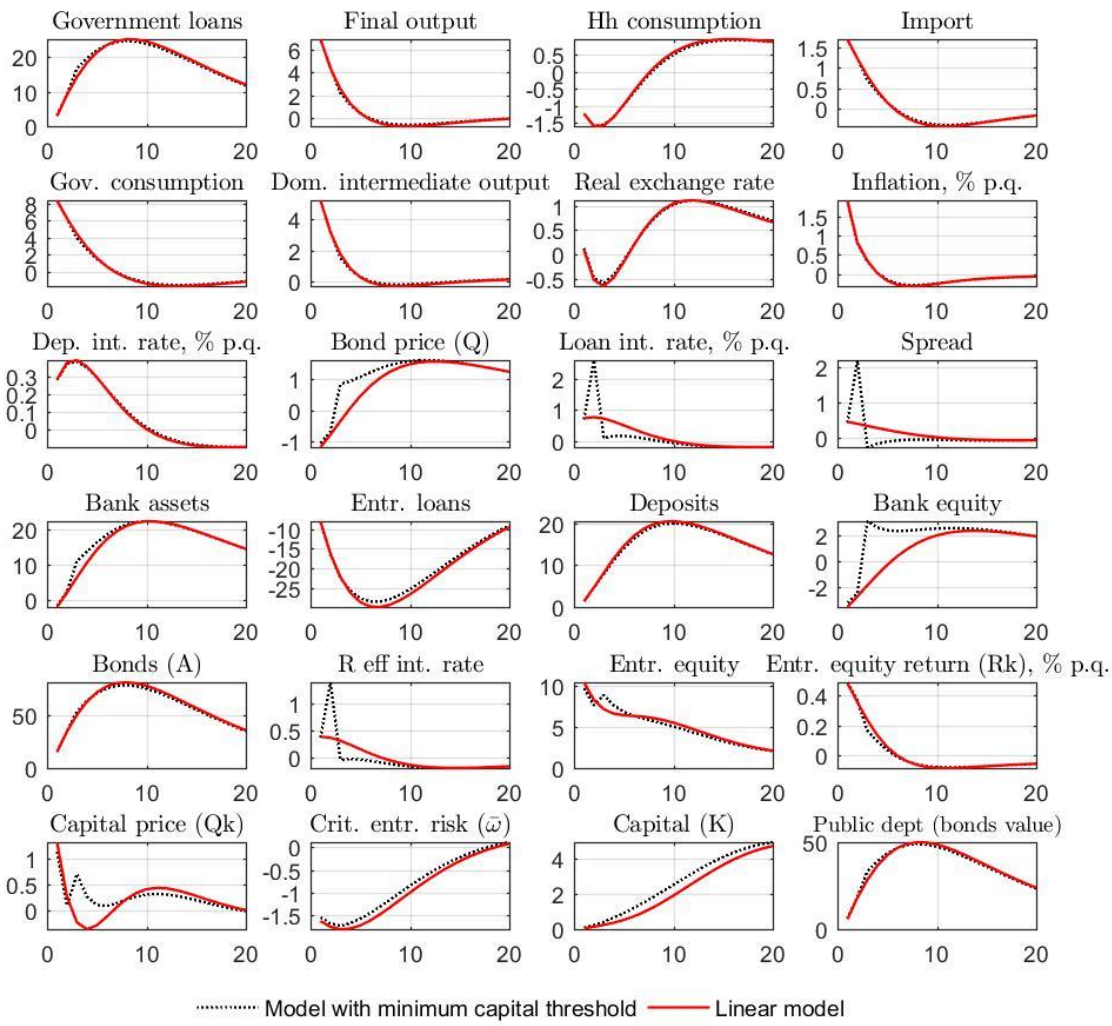
Next, we analyze the effect of the government consumption shock (Fig. 6) under two scenarios: one where the minimum capital constraint (20) is not imposed (linear model, red curve) and another where the constraint (20) is imposed (non-linear model, black curve).

The expansion of public debt and government consumption leads to an increase in aggregate output and an unanticipated rise in inflation. Inflation erodes the market value of long-term government bonds held by banks. Consequently, bank capital falls below its steady-state level for several periods. It then recovers and even exceeds its steady-state level due to coupon income. Thus, the effects of the autonomous demand shock on bank capital in the model exhibit a temporal separation: first, bank capital declines due to the revaluation of assets, and then it increases due to coupon income.

In the absence of minimum capital requirements (20), banks tend to keep their capital below the long-term target for a long time, which also leads to a drop in the availability of loans for entrepreneurs. As a result, under such conditions, monetary policy will not face any major challenges.

In the absence of the minimum capital constraint (20), bank capital remains below its steady-state level for an extended period, and credit supply to entrepreneurs contracts. Consequently, under such conditions, monetary policy faces no significant headwinds.

Figure 6. Impulse response functions of model variables to a shock to government consumption when financing public debt with long-term government bonds. For cases with and without constraints on minimum expected bank capital. "% p.q." means percentage per quarter; other indicators are presented as % deviation relative to steady-state quarterly GDP.



If the minimum capital constraint (20) is imposed, the requirement for capital $E\Omega_2$ in the subsequent period implies an additional demand for balance sheet components in that period ($\Omega_2 = Loan_2^B + Q_2 A_2 - D_2$ – equation (6)). This effectively increases the required return on the bank's asset portfolio—namely, loans and bonds[16]. The required return on bank loans increases. The yield on bond holdings also rises sharply; however, due to the pricing equation linking the

[16] From the perspective of optimal control theory, constraint (20) introduces a Lagrange multiplier (shadow price) into equation (9). The required return on assets increases because the cost of deposits is set by the central bank according to the Taylor rule.

current bond price Q_t to its future value Q_{t+1} (equation (8)), the market value of a unit of bond debt A_t/P_t jumps. This sharp appreciation in the value of outstanding debt artificially inflates bank capital. Since the government seeks to expand its real consumption according to a pre-announced path (21), the surge in bond prices has two effects: 1) the government is forced to accumulate public debt to a greater extent than in the linear case, and 2) government consumption contracts slightly relative to the linear case. The additional fiscal shortfall and the larger debt issuance relative to the linear case lead to an increase in bank income and capital through coupon payments on government bonds. Effectively, the government transfers part of its wealth to the banking sector through the bond market due to the monopsonistic structure of the buyer base – exclusively banks.

How does the magnitude of a government consumption shock impact the economy when the minimum expected bank capital constraint is binding? Figure 7 illustrates the impulse responses for varying magnitudes of the government consumption shock (ε_t = 8%, 9%, 10% and 11% of quarterly GDP).

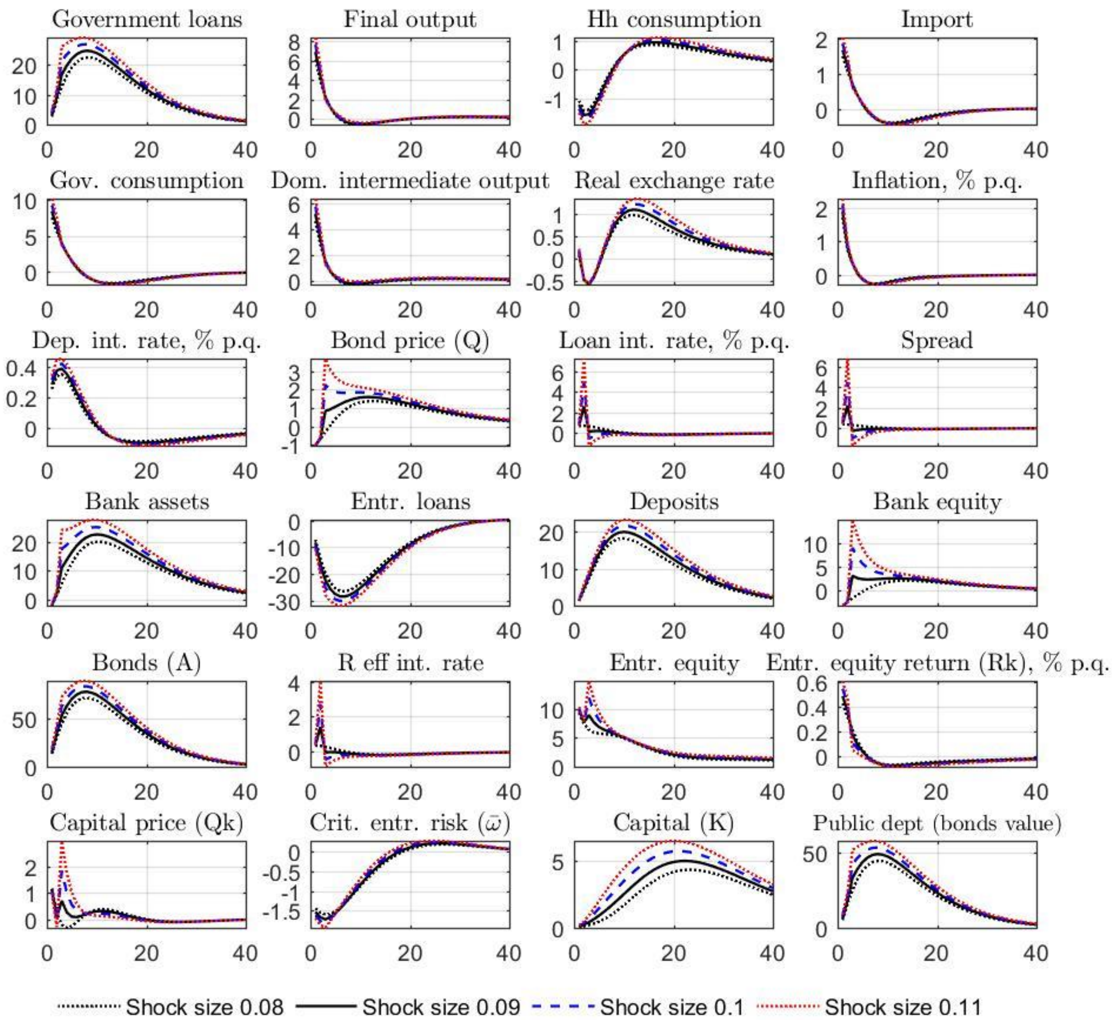
As the government consumption shock grows, inflation rises and the market value of bonds on banks' balance sheets depreciates more severely. This renders the minimum expected bank capital constraint (20) increasingly binding for banks, while the required return on assets escalates more dramatically. The market value of bonds also surges, resulting in a larger transfer of wealth from the government to banks via the bond market, which in turn exacerbates public debt growth. However, the impact of this rapid debt accumulation on real government consumption dissipates over a few periods: consumption follows an almost identical trajectory, regardless of the shock's magnitude.

Thus, increasing the shock magnitude has a negligible impact on real government consumption, but it induces significant instability in bond market dynamics. Inflation does not accelerate disproportionately with a larger shock, indicating that NLIG does not materialize.

The volatility in the bond market, along with the disproportionate rise in debt relative to the increase in public spending, might prompt the authorities to deviate from their standard policy frameworks. For instance, they could relax the capital constraint (20) if maintaining the stability of the banking sector and the bond market becomes a priority, or they might abandon their inflation-targeting strategy if public debt sustainability takes precedence. In the latter case, this would precipitate a NLIG episode.

Furthermore, if the shock is increased beyond a certain threshold, it becomes impossible to find a solution to the model. The absence of a solution may imply that the optimization problem of one of the economic agents (e.g., bank insolvency or the government's inability to satisfy its intertemporal budget constraint) is infeasible due to explosive trajectories. This situation can be interpreted as a model breakdown. However, we refrain from overstating the results due to the stringent assumptions imposed by the model, which can be relaxed (see section 7).

Figure 7. Impulse response functions of model variables to the government consumption shock. Case of financing public debt with bonds with an average maturity of ten years. For varying magnitudes of the government consumption shock (ε_t = 8, 9, 10, and 11% of quarterly GDP). "% p.q." means percentage per quarter; other indicators are presented as % deviation relative to steady-state quarterly GDP.



5.3. Unfounded coordinated beliefs (fake news)

The following scenario is based on a fundamental property of the economic system. This property is often referred to as 'self-fulfilling prophecies', which captures how the beliefs of economic agents are realized. More formally, the economic system is theoretically underdetermined, meaning there are not enough economic mechanisms in place to determine certain macroeconomic variables (like prices and interest rates). In the absence of these mechanisms, theorists usually assume that economic agents coordinate on a specific value that will emerge from a range of possibilities for an underdetermined variable. This phenomenon is known as sunspot equilibria (*Cass, Shell*, 1983). In pioneering studies, the terminal prices of assets and goods were the variables that remained underdetermined. The consensus on these terminal prices (based on coordinated beliefs) fixes the equilibrium, thereby determining the trajectories of prices, quantities, and interest rates in the economy. It turns out that price indeterminacy can be either nominal or real. Nominal indeterminacy refers to how selecting a specific value of the variable based on coordinated beliefs can influence nominal indicators, but it does not impact real indicators: the actual quantities of goods that provide utility. Real indeterminacy means that the choice of value also has an effect on real indicators. It should be noted that nominal indeterminacy is characteristic of idealized models without frictions, whereas the New Keynesian DSGE model with multiple frictions used here implies real indeterminacy in the model. A technique introduced by *Portier* (2004) using unrealized news shocks allows one to select certain equilibria from a set of sunspot equilibria within DSGE models.

We further demonstrate that agents' beliefs regarding a future increase in government consumption can drive real economic variables such as output and consumption, which in turn trigger inflation and prompt a response from the central bank. Crucially, the government consumption shock itself may never materialize.

Regarding the central question of this paper on the presence of NLIG, this implies the following. Agents in the economy may hold beliefs such as ‘a significant increase in government spending always leads to surging inflation,’ or ‘once the government accumulates debt, it will erode its real value through inflation.’ These beliefs generate additional inflation expectations among agents. Agents make decisions based on their subjective inflation forecasts, which exceed the inflation objectively warranted by observable autonomous demand shocks. Consequently, inflation materializes exactly as agents collectively anticipate. Since these beliefs can be self-reinforcing, they can fuel a spiral of inflation expectations, which can be interpreted as NLIG[17].

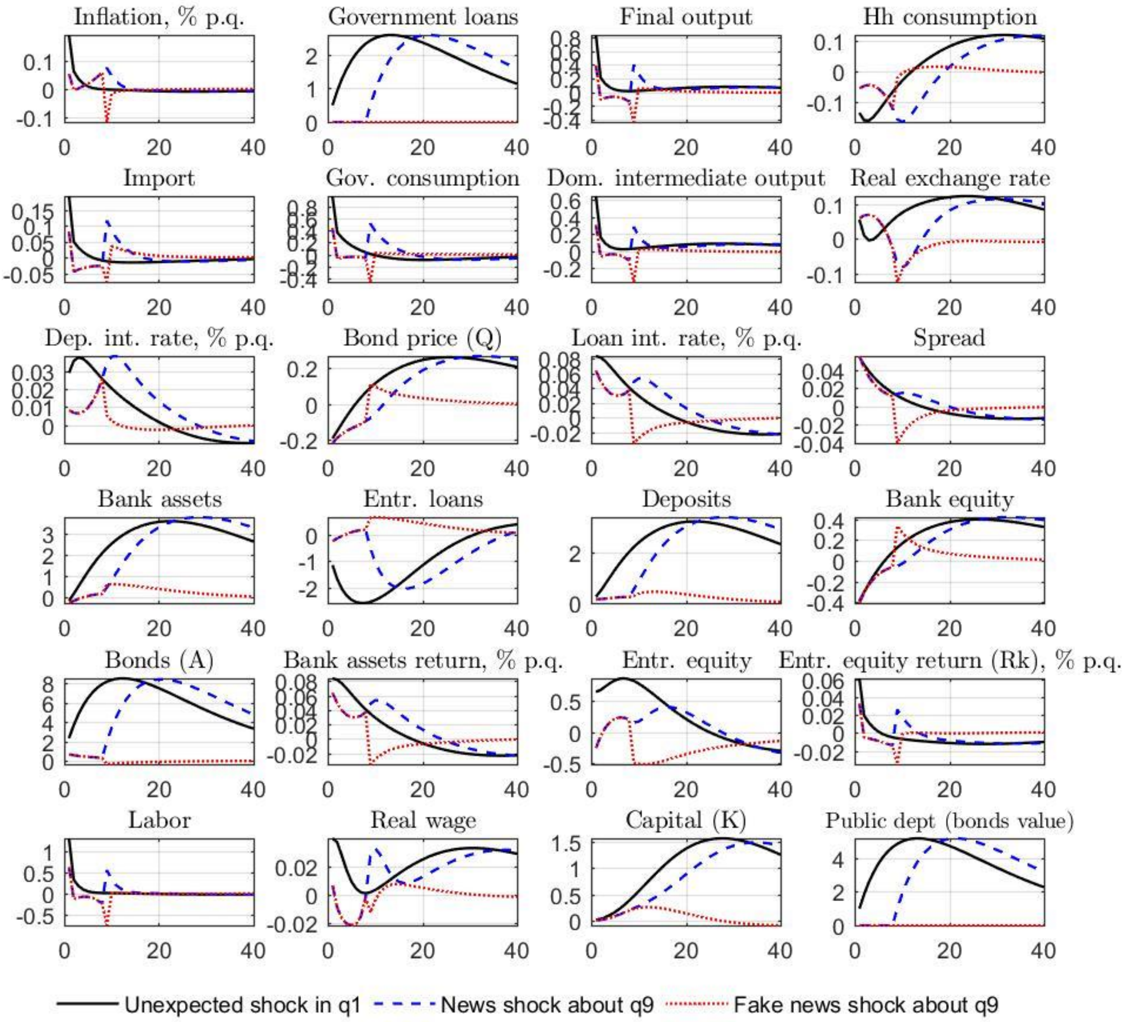
Figure 8 presents three trajectories. The first trajectory is the economy’s reaction to an unanticipated shock that occurs in the first period. This shock was previously considered in previous scenarios. The second trajectory is a news shock. Agents learn that government consumption will increase eight quarters ahead, and this shock is indeed realized[18]. The third trajectory is an unrealized news shock. In this case, agents also learn that government consumption will increase eight quarters ahead, but when the time arrives, this shock fails to materialize[19] (fake news).

[17] For example, agents’ beliefs may be structured identically to the definition of NLIG: agents believe that the greater the shock to government consumption, the more than proportionally inflation will grow in response to the shock.

[18] The realized news shock is modeled $s_t = \rho^s s_{t-1} + \varepsilon_{t-8}$ instead of equation (19).

[19] The unrealized news shock is modeled by equations $s_t = \rho^s s_{t-1} + \varepsilon_{t-8} - \varepsilon_t^{anti}$ and $\varepsilon_1 = \zeta,\ \varepsilon_9^{anti} = -\zeta$. At the beginning of the ninth quarter, when agents expect the news shock ε_1 to take effect, a neutralizing shock ε_9^{anti} occurs.

Figure 8. Impulse response functions of model variables to the government consumption shock. For the cases of an unanticipated shock, a realized news shock, and an unrealized news shock



In the presence of a news shock, regardless of whether it ultimately materializes, the dynamic response is typically concentrated around two key points (*Andreev and Polbin*, 2023). The first occurs in the initial period, when forward-looking agents learn about the future shock and begin to adjust their current plans based on their foresight of future changes. The second occurs when the shock is scheduled to materialize. In the case of a realized shock, agents react to the actual change in the economic environment; if it is unrealized, they unwind their plans.

The core idea behind this illustration is that in the case of an unrealized news shock, no fundamental changes in the economic environment actually occur. Nevertheless, inflation rises at the moment the 'news' breaks and on the eve of the expected realization of the shock. While it is possible that once the shock fails to materialize, the price level reverts to its previous state, it is equally possible that at that exact moment, new 'news' and unfounded coordinated expectations emerge, further fueling the spiral of inflation expectations. In both cases, the resulting rise in inflation driven by agents' unfounded beliefs, which exceeds the fundamental contribution of the government consumption shock, constitutes NLIG.

5.4. Monetary base dynamics under alternative financing regimes

In Russia, the level of domestic government bond debt relative to GDP has remained largely unchanged over the 2022–2025 period. This may indicate that the main source of funding for the expansion in government consumption was the drawdown of National Welfare Fund (NWF) resources. As shown by *Andreev* (2025), the use of NWF resources held abroad is the optimal way to finance the growth in government consumption. This is because this method of financing does not reduce households' disposable income, resulting in negligible or no adverse effects: inflation does not rise, and household consumption does not decline.

The use of NWF resources also offers an additional advantage in light of the NLIG question: it is neutral with respect to the monetary base. The increase in liquidity due to the growth in expenditures by the Russian Ministry of Finance is offset by a withdrawal of funds as economic agents purchase foreign currency from the NWF. In contrast, financing the growth of government consumption through government bonds purchased by Russian banks using Bank of Russia credit is not neutral with respect to the monetary base. Consequently, the monetary base expands.

The NLIG scenario in this case unfolds as follows. The Russian Ministry of Finance manages the NWF balance NWF_t, which is initially positive: $NWF_t > 0$. A series of large-scale shocks to government consumption depletes the fund, and the Ministry hits the non-negativity constraint on the fund's resources:

$$NWF_t \geq 0.$$

At this point, the Russian Ministry of Finance shifts to domestic government bonds as its main financing instrument, causing the monetary base to expand. In classical equilibrium models that do not explicitly model the monetary base, only a moderate adverse effect (*Andreev*, 2025) is observed from the switch in the financing mechanism.

How does the economy respond in models that explicitly describe household demand for the monetary base? There are two main approaches to modeling demand for the monetary base: the cash-in-advance constraint and money in the household's utility function. Regardless of the specific approach, an increase in the monetary base is expected to accelerate inflation in the economy.

Thus, once the NWF reserves are exhausted, inflation should accelerate. This constitutes NLIG. The scenario points to possible future risks if government consumption continues to expand at an accelerated pace.

6. Attenuated monetary policy transmission and the absence of non-linearity

This scenario examines the effect of subsidized lending to the production sector on inflation and on the interest rate faced by production sector. In the model presented here, an entrepreneur who owns physical capital and uses market loans from a bank $Loan_t^B$ and subsidized loans from the government $Loan_t^G$ to finance their activities faces these interest rates (see subsection 3.2). Mortgage and consumer lending are not considered in this scenario.

Equation (4) for the effective interest rate R_t^{eff} faced by the entrepreneur can be rewritten as follows:

$$R_t^{eff} = R_t^G \frac{Loan_t^G}{\left(Loan_t^G + Loan_t^B\right)} + R_t^B \frac{Loan_t^B}{\left(Loan_t^G + Loan_t^B\right)} \quad (22).$$

The higher the share of loans $\frac{Loan_t^G}{\left(Loan_t^G + Loan_t^B\right)}$ allocated to subsidized lending, the more the effective rate R_t^{eff} resembles the (constant) subsidized rate R_t^G and the less it resembles the market loan rate R_t^B, whose dynamics are heavily influenced by the policy rate R_t (through the operational mechanics of the banking sector, reflected in equation (9) of the model). Thus, the higher the share of subsidized lending, the less an increase in the policy rate R_t leads to an increase in the effective rate R_t^{eff}. It can be expected that subsidized lending will attenuate the cooling of the economy during the tightening phase. Let us verify whether this is indeed the case.

To do this, consider a sequence of steady states where the relative share of subsidized lending $\frac{Loan_{ss}^G}{\left(Loan_{ss}^G + Loan_{ss}^B\right)}$ increases. As noted above (subsection 4.1), since linear approximations of the model are considered at different steady states, the sensitivity of inflation and the interest rate to a shock in government consumption may increase with the level of subsidized lending. This would imply the presence of NLIG.

Table shows the values of variables in steady-state equilibrium depending on the volume of subsidized lending $Loan_{ss}^{G}$. With the growth of government subsidized lending, as assumed in the general scenario (see subsection 4.2), public debt grows, since it is assumed that the lending program is financed through public debt. The balance sheet of the bank purchasing public debt expands. However, bank loans are not growing and even decline slightly as the competing instrument – government lending – expands. The share of subsidized lending $\frac{Loan_{ss}^{G}}{\left(Loan_{ss}^{G}+Loan_{ss}^{B}\right)}$ in the market increases. The entrepreneurs' equity capital slightly decreases, as improved credit conditions allow entrepreneurs to hold less capital. And, as hypothesized, the steady-state value of the effective rate faced by the entrepreneur decreases with the growth of subsidized lending.

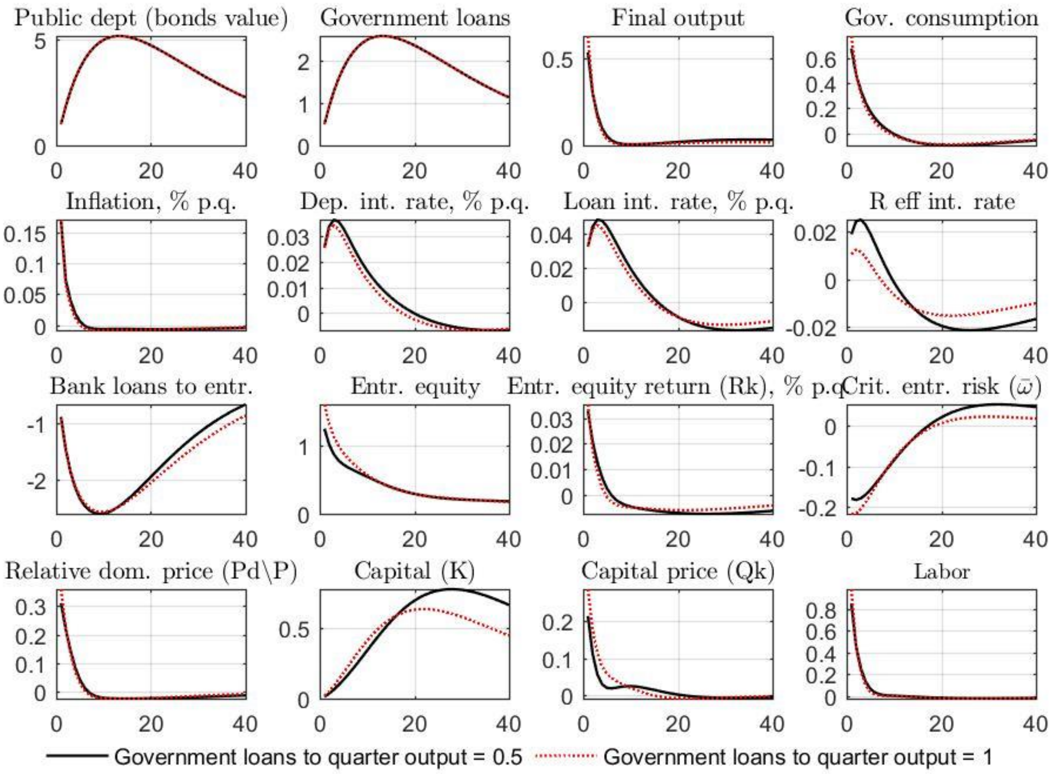
Table 1. Structural parameters of the model economy depending on the steady-state value of subsidized government lending $Loan_{ss}^{G}$. In relation to the steady-state quarterly output $P_{ss}Y_{ss}$

Public debt (balance sheet value of bonds) $Q_{ss}A_{ss}/\left(P_{ss}Y_{ss}\right)$	1.0	1.2	1.4	1.6	1.8	2.0
Subsidized government lending $Loan_{ss}^{G}/\left(P_{ss}Y_{ss}\right)$	0.5	0.6	0.7	0.8	0.9	1.0
Bank loans to entrepreneurs $Loan_{ss}^{B}/\left(P_{ss}Y_{ss}\right)$	1.29	1.27	1.25	1.23	1.21	1.19
Entrepreneurs' equity $Cap_{ss}/\left(P_{ss}Y_{ss}\right)$	2.22	2.20	2.18	2.15	2.13	2.11
Bank assets $\left(Loan_{ss}^{B}+Q_{ss}A_{ss}\right)/\left(P_{ss}Y_{ss}\right)$	2.29	2.47	2.65	2.83	3.01	3.19
Real effective interest rate for entrepreneurs R_{ss}^{eff}, % per annum	4.7	4.43	4.20	4.01	3.84	3.69

The research question now is as follows: is it true that the increase in inflation $\pi_t-\pi_{ss}$ in response to a government spending shock of a given magnitude increases as the steady-state volume of subsidized lending $Loan_{ss}^{G}$ expands? The answer turns out to be no. Impulse response functions that answer this question are provided in Figure 9 [20].

[20] In this case, it is assumed that the government uses short-term bonds ($\Delta=1$) with a maturity of one quarter to finance its active fiscal policy. Considering longer-term bonds introduces additional effects into the dynamics. These effects are

Figure 9. Impulse response functions of model variables to the government consumption shock. For cases of different levels of subsidized government lending to entrepreneurs



If the level of government support for entrepreneurs is high, then, as equation (22) suggests, the effective interest rate for entrepreneurs R_t^{eff} increases less in response to a shock (Figure 9, 'R eff int. rate'[21]). In other words, the high level of government support for entrepreneurs has indeed led to a reduction in the impact of monetary policy on credit conditions for entrepreneurs. However, as can be seen, the inflation response has not changed. And what impact did the increase in government support have? The operating conditions for entrepreneurs have changed – they have become more favorable. First, equity capital responds more strongly, as credit conditions have generally improved. Second, the threshold of individual risk ($\bar{\omega}_t$, Figure 9, 'Crit. entr. risk'[22]), below which an entrepreneur defaults, has decreased. This means that entrepreneurs are less likely to default, and the bank incurs the same expected loss on the liquidation of assets of defaulting entrepreneurs.

the subject of analysis in the scenario of subsection 5.2. The maturity of the bonds does not affect the main result of the current subsection.

[21] Effective rate for entrepreneurs.

[22] Critical risk of entrepreneurs.

Thus, as a result of the growth in the level of subsidized lending to entrepreneurs, the impact of monetary policy on the rate at which entrepreneurs service their aggregate debt has decreased. This led to improved conditions for entrepreneurs, but did not change the inflation response. This means that the NLIG effect is not observed in this case. Further discussion of the reasons for this result is provided in Section 7.

7. Discussion

1. NLIG was not detected in all of the scenarios considered. It was not found in the scenario of attenuated monetary policy transmission (section 6). Also, in the scenario of long-term sovereign debt and bank capital erosion (see subsection 5.2), NLIG arises only as a possibility if the central bank prioritizes debt market stability over returning inflation to target. Both of these cases share two features. First, in both, the key sectors of the scenarios (the entrepreneurial and banking sectors) were described in substantial detail. Second, in both cases, the price-setting mechanism was located not in these sectors, but in the production sector. As a result, the autonomous demand shock affected each of the key sectors – the entrepreneurial and banking sectors – and there was an active response in these sectors. However, the key sectors continued to influence the price-setting sector – the production sector – in the same, virtually unchanged manner. Logically, NLIG was not detected. But it was found in the scenario of a shortage of factors of production (subsection 5.1), which is directly related to the determination of price dynamics.

2. It is worth mentioning the reason why the production sector does not include a credit component, even though in reality production and corporate lending are inextricably linked. If the production sector included a credit component, autonomous demand shocks would have a stronger impact on the price-setting mechanism and, quite possibly, in the scenarios of attenuated monetary policy transmission (section 6) and in the scenario of long-term sovereign debt and bank capital erosion (subsection 5.2), we would observe NLIG. The main reason for this shortcoming appears to be the limited state of development of general equilibrium models and macroeconomic modeling. At present, there is no generally accepted unified mathematical model of the firm that describes many aspects of a modern firm simultaneously. Instead, a separate agent is responsible for each individual aspect of a real firm's activities. Credit frictions and borrowing activities, as is often done in DSGE models, are assigned to the 'entrepreneur' agent described in accordance with the approach of *Bernanke et al.* (1999).

3. Although the scenario of financial sector instability (see subsection 5.2) showed that the modeled bond market becomes increasingly unstable as the autonomous demand shock grows, and the equilibrium (solution) even ceases to exist as the shock increases, this should not raise concerns about the Russian bond market and banking sector. This scenario is precisely the type of case where the model's assumptions warrant careful discussion. The assumptions were as follows:

1) all debt securities are fixed-coupon government bonds; 2) all government bonds are revalued on banks' balance sheets each period in line with their current market value; 3) the central bank strictly monitors compliance with capital adequacy requirements. All three assumptions are critical for the obtained result. In the real economy, these assumptions are relaxed. 1) Not all debt securities issued by the Russian Ministry of Finance are fixed-coupon government bonds. In the second and third quarters of 2024, Russian banks showed increased demand for floating-coupon government bonds, while the issuance of fixed-coupon government bonds was met with weak demand. 2) As of 1 September 2024, only 10.6% of government bonds on banks' balance sheets were subject to strict mark-to-market accounting, 35% were held at amortized cost[23], and the remaining 54% had a flexible valuation framework. 3) Central banks may ease requirements for the valuation of securities on banks' balance sheets during periods of crisis.[24] If these assumptions are relaxed, in the event of an autonomous demand shock, unanticipated inflation will erode bank capital to a lesser extent, and the easing of requirements for revaluation and bank capital adequacy will mitigate the upward pressure on required bond yields.

4. The presented scenario of the impact of agents' unfounded coordinated beliefs on inflation (subsection 5.3) (expectation-driven fluctuations) allows for many interpretations of how NLIG can be generated, and also touches on many related topics. The scenario describes how, in addition to realized autonomous demand shocks, agents may incorporate analogous but purely imaginary future shocks, which are already accelerating inflation today. For example, agents may believe that with increasingly severe autonomous demand shocks, the central bank will be less active in returning inflation to its target, allowing public debt to depreciate. Mathematically, this can be expressed by the fact that agents expect a negative shock to the inflation response coefficient ρ^{π} in the Taylor rule (1). As in the baseline shock scenario (subsection 5.3), the decline in the response coefficient ρ^{π} may not materialize, but agents' beliefs alone will drive up inflation today.

Such scenarios, which describe how agents form unfounded coordinated beliefs, have a drawback: they are difficult to evaluate empirically. The impact of agents' expectational errors is difficult to assess objectively using data, as agents can deviate from rationality in countless ways. If one type of agent error is selected for assessment, the question arises: why are alternative types of errors not selected and assessed? Pure rational expectations models have the advantage of providing the only equilibrium in which agents do not make mistakes. All other equilibria are secondary in nature, as they form an infinite manifold above the single distinguished equilibrium: the most rational behaviour of agents. Nevertheless, the assessment of news shocks (which may or may not occur in reality) is carried out using equilibrium models. For example, *Beaudry and Portier* (2006) estimated that a news shock to productivity explains 50% of the volatility in the US business

[23] 'Bonds valued at amortised cost' in terms of the Banking Sector Review.
[24] For example, Vedomosti, 18 December 2014, 'Central Bank Eases Regulations for Banks'.

cycle. *Gomes et al.* (2017) conclude that news shocks make a significant contribution to explaining the historical dynamics of macroeconomic variables, while *Schmitt-Grohe and Uribe* (2012) estimate that up to half of the contribution to the dynamics of output, consumption and investment is attributable to news shocks. News shocks are closely related to the literature on verbal intervention and sentiment regarding inflation: the beliefs of agents subject to cognitive and emotional constraints. Empirical studies confirm the impact of sentiment on economic dynamics (*Gric et al.*, 2022) and even help improve forecasts (*Ashwin et al.*, 2024).

5. In the scenario of factor shortages, NLIG was identified: an increase in the autonomous demand shock leads to accelerated price growth. In response to the autonomous demand shock, employment increases, meaning unemployment falls. This implies that as unemployment decreases, inflation accelerates. In terms of the classical Phillips curve, this implies a non-linear Phillips curve: at lower unemployment rates, the curve is steeper (Fig. 4).

The importance of the nonlinear Phillips curve for the central bank lies in the fact that its nonlinearity indicates the presence of NLIG: with a nonlinear curve, the central bank's stabilization challenges increase non-linearly with the magnitude of the shock.

The Phillips curve is one of the cornerstones of modern economic theory and the neo-Keynesian models actively used by central banks. The nonlinearity of the curve has been studied in a number of papers. The non-linear form of the Phillips curve was documented in an empirical study based on US labour market data (*Simon et al.*, 2024). *Boehm and Pandalai-Nayar* (2022) explain the downward convexity of the Phillips curve through the convexity of firms' supply functions, which is empirically confirmed by estimates based on data from the electricity market. The convexity of the Phillips curve is also documented in the works of *Bec et al.* (2002), *Cristini and Ferri* (2021), and *Kumar and Orrenius* (2016). *Dotsey et al.* (1999) introduced the non-linearity of the Phillips curve into a theoretical DSGE model with state-dependent pricing. In this framework, price changes are costly for firms. Firms change prices only if the benefits of the change outweigh the costs, resulting in more frequent price changes during large shocks, which leads to the non-linearity of the Phillips curve. The non-linearity of the curve can also arise by assuming multiple equilibria in a model with regime switching (*Gomes et al.,* 2007).

6. What is ***not*** NLIG? Situations that are described by a linear model. As noted earlier, if the model or the real world is linear, the regulator can adhere to the same policy rule, and the size of the shocks does not matter. In particular, NLIG does not apply to a situation similar to the scenario on the 'monetary base dynamics under alternative financing regimes' (subsection 5.4), in which only government bonds are ***initially*** used to finance the growth in government consumption. With this financing method, monetary aggregates can grow rapidly, but the impact of the shock is linear. This is simply a shock to which inflation is very sensitive, which stands out against other shocks to which inflation is less sensitive. The general conditions under which the Russian economy has been operating since 2022 are not related to NLIG. For example, sanctions that lead to higher import

prices and shift the economy to a new, less efficient equilibrium (*Lymar et al.*, 2022) [25] have no effect on the linearity or non-linearity of the economy. These are just the general conditions for the functioning of the economy.

At the same time, it is important to remember that significant inflation growth, in accordance with the aforementioned literature on 'menu costs' and 'inattention' (section 2), can lead to nonlinear inflation growth.

8. Conclusion

This paper examined the economic conditions under which the constructed equilibrium model exhibited a non-linear response of inflation (NLIG) and the policy rate to autonomous demand shocks. These are situations in which demand shocks (i.e., government consumption shocks) lead to disproportionately accelerated inflation in response to a linear increase in the shock's magnitude, which in turn triggers a non-linear increase in the central bank's policy rate.

In contrast to the "menu costs" and "inattention" approaches typically used in studies of non-linear inflation responses, this paper detailed alternative drivers of NLIG, conceptualized as institutional constraints on economic agents. Four distinct scenarios for the emergence of NLIG were analyzed.

The first scenario examined concerns the zero-profit constraint for firms and the presence of factor shortages. Under large autonomous demand shocks accompanied by rising costs, when firm profits approach zero, firms set prices to prevent losses. The paper demonstrates that this alternative pricing mechanism is activated conditionally during large-scale shocks, accelerating inflation and generating NLIG. The presence of NLIG in this case implies the non-linearity of the classical Phillips curve. Furthermore, we show that tighter conditions in labor and capital markets cause NLIG to emerge under realistically calibrated autonomous demand shocks.

The second scenario involves the financing of an autonomous demand shock exclusively through *long-term* fixed-coupon government bonds. Banks that hold sovereign debt are constrained both by a minimum expected capital requirement and by a spread formation rule in the spirit of *Gerali et al.* (2010). The rise in inflation resulting from an unexpected autonomous demand shock erodes the market value of bond holdings, depleting bank capital. This, in turn, increases banks' yield demands on new public debt issues. Consequently, a larger government consumption shock leads to a disproportionate, sharp deterioration in bond market dynamics and a wealth transfer from the state to the banking sector. Within the model, this is interpreted as a crisis that could lead to NLIG if the central bank prioritizes bond market stability over price stability. The scenario highlights

[25] The study does not consider structural shifts in economic parameters that could move the economy to a more efficient equilibrium. The study examines an additional constraint on the space for economic choice – imports – which naturally narrows economic opportunities and leads to a less efficient equilibrium.

the importance of the central bank's commitment to price stability. It is noted that the assumptions underlying this scenario are excessively stringent and significantly relaxed in reality.

The third scenario considered was the influence of subjective expectations on economic agents. It is shown that coordinated expectations of a future government consumption shock drive up current inflation, regardless of whether the shock ultimately materializes. This phenomenon can generate NLIG in various ways: agents may form beliefs that inflation rises non-linearly in response to a shock, or that during large shocks, the regulator will relax its commitment to the inflation target.

The fourth scenario, unlike the first three, is not formally supported by model simulations; however, it highlights that a change in the financing mechanism for public consumption expansion could lead to NLIG. Inflation may accelerate if, first, the financing of public consumption shifts from the use of National Welfare Fund foreign currency reserves to domestic debt issuance, which expands the monetary base, and second, if an acceleration in monetary aggregate growth translates into higher inflation.

The paper additionally examines a theoretical scenario in which the central bank's transmission mechanism to corporate lending conditions is attenuated, yet NLIG does not materialize. It is shown that the larger the stock of subsidized loans held by firms, the less a change in the policy rate translates into the average rate at which firms service their aggregate debt. This means that as subsidized lending grows, it becomes more difficult for the central bank to cool down corporate activity within the model. However, NLIG does not emerge. The absence of NLIG within the model is explained by the central bank's monetary impulse being absorbed by the internal dynamics of firms and the distance of these firms from the pricing mechanism. Outside the model, the absence of NLIG is attributed to the limitations of current modeling frameworks in integrating purely productive activities with credit-related activities within a single agent. The impact of subsidized consumer and mortgage lending on the conduct of monetary policy under this scenario was not examined.

Overall, the results reveal institutional mechanisms – ranging from firms' pricing constraints to bond market dynamics and agents' subjective expectations – that can trigger a non-linear response of inflation and the policy rate to demand shocks. The results highlight the importance for the central bank to comprehensively assess the transmission channels of autonomous demand shocks, monetary policy transmission, and the institutional features of the economic system to enhance policy effectiveness.

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