Bank of Russia

Heterogeneous Inflation Expectations Across Economic Agents: Implications for Monetary Policy

WORKING PAPER SERIES

No. 152 / July 2025

Sergey Ivashchenko,
Andrey Sinyakov

Sergey Ivashchenko
Bank of Russia. Email: IvashchenkoSM@cbr.ru

Andrey Sinyakov
Bank of Russia. Email: SinyakovAA@cbr.ru

Authors thank Sergey Slobodyan, Ph.D., as well as unanimous referees and participants of the internal research seminar at the Bank of Russia for helpful comments and suggestions. All errors and omissions are ours.

Bank of Russia Working Paper Series is anonymously refereed by members of the Bank of Russia Research Advisory Board and external reviewers.

Cover image: Shutterstock.com

Address: 12 Neglinnaya street, Moscow, 107016
Tel.: +7 495 771-91-00, +7 495 621-64-65 (fax)
Website: www.cbr.ru

Abstract

It is well-documented in economic literature that inflation expectations exhibit significant heterogeneity across various economic agents, notably households, firms, and financial institutions. This paper investigates the relative importance of these agents' expectations in shaping inflation dynamics within a general equilibrium framework.

We introduce non-rational, non-systematic expectation shocks into an otherwise standard small open economy New-Keynesian model, calibrated and estimated using Russian data. This novel approach allows us to isolate exogenous variations in inflation expectations specific to each agent type and assess their distinct impacts on realized inflation.

Our results demonstrate that central banks must respond explicitly to non-rational, non-systematic expectation shocks originating from private agents. Importantly, we find that expectation shocks from financial institutions (banks) exert a larger influence on realized inflation than shocks originating from households or firms. This outcome remains robust across multiple variations in model structure and parameterization. In contrast, the inflationary effects of households' and firms' expectation shocks manifest in ways unpredictable to these agents themselves, highlighting an expectations-feedback gap.

The findings have important implications for monetary policy, particularly regarding communication strategies.

Key words: inflation expectations, heterogeneous agents, expectation shocks, monetary policy, financial institutions, New-Keynesian model, general equilibrium, diversity in inflation expectations

JEL codes: E31, E37, E52, D84

Authors used LLM to help us to describe the model equations and proof-read the text.

Contents

1. Introduction

Inflation expectations is the cornerstone of the inflation-targeting regime of monetary policy followed by most central banks, including the Bank of Russia, Adrian (2023). Anchoring of inflation expectations helps central banks in macroeconomic stabilization after supply/cost push shocks, Svensson (2010). Managing of inflation expectations has been widely discussed as an additional monetary policy tool to the setting a current level of policy interest rate, see for example, discussion in Coibion et al. (2020a).

From practical as well as theoretical point of view, there are three main group of agents that form price expectations (in general, for different price measures): households, firms and financial sector analysts (banks).

If we look at the level and dynamics of their expectations in Russia, we will discover that inflation expectations (in Russia) are highly diverse between different groups of agents[1]. Figure 1 below shows survey measure of inflation expectations by households, where we can observe a persistent upward bias to actual inflation. Figure 2 shows survey measure of price expectations by corporate sector with similar features, but less volatile in total comparing to households'. Figure 3 shows survey measure of consensus forecasts by professional analysts in the financial sector, which are well anchored at the Bank's of Russia inflation target of 4%.

Figure 1.

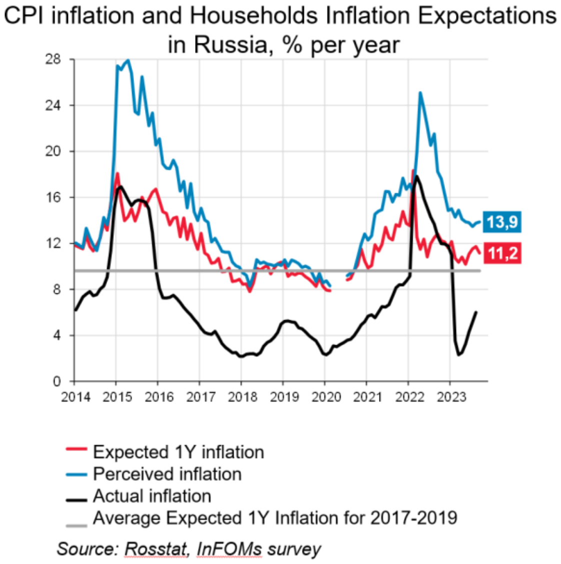
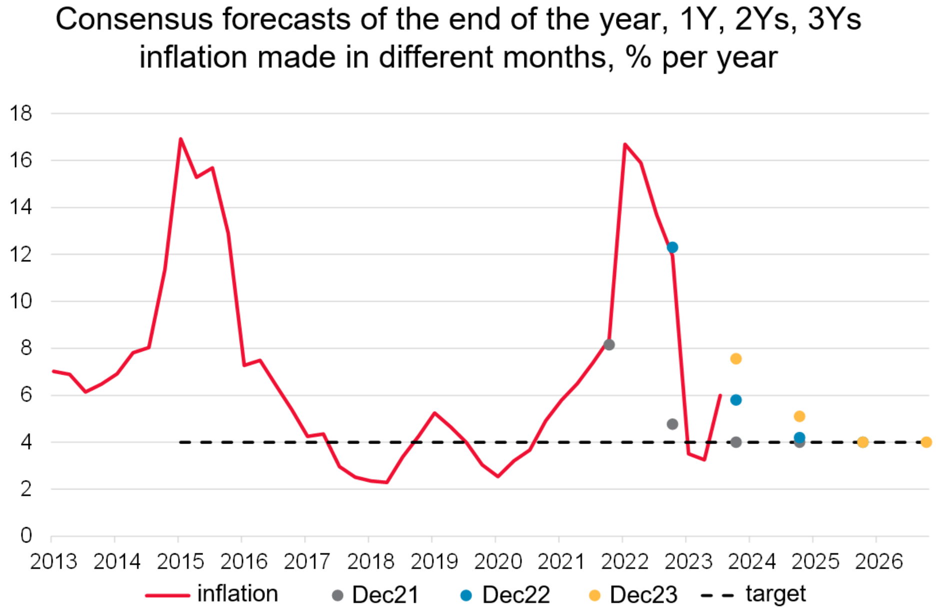


Figure 2.

[1] The picture will be the similar in other countries, see for example, Coibion et al. (2020a)

Figure 3.



Source: Bank of Russia, Rosstat

The questions arise as a result: How to explain observed features and diversity of different agent's inflation expectations (in Russia)? What does such diversity imply for the inflation dynamic (in Russia)?

There is an extensive literature on studying *heterogeneity* of inflation expectations, where heterogeneity defined as a variation of inflation expectations inside a group of agents. The *diversity* is a different concept of expectations variation among types of agents (where expectations may be homogeneous or heterogeneous inside the particular type's). The issue of diversity is relatively new in the literature. Loretta J. Mester (Federal Reserve Bank of Cleveland) at ECB Forum on Central Banking 2022 noted that *"…the inflation expectations of different groups of agents can behave differently from one another and the literature has not firmly established whose expectations are most important for inflation dynamics."* Cornand, C., & Hubert, P. (2022b) in their empirical study of inflation expectations diversity among five types of economic agents concluded: *"macroeconomic theory should account for heterogeneity within and across the different categories of economic agents".*

This paper tries to close the gap and addresses a question: What does a generally defined diversity of inflation expectations among agents' types mean for inflation?

The answer is non-trivial as, first, inflation expectations may play different role in agents' economic decisions. Second, economic decisions of a particular type of agents, for example, households, may influence other agents' decisions and appear to be more important in general equilibrium for the resulting actual inflation. Thus, households, especially "Ricardian", who undertake intertemporal optimization and use inflation expectations to make today's decisions, may have excess consumer demand that influences sellers' pricing decisions that result in inflation in general equilibrium. In general, other agents' decisions may alter some (budget) constraints that enter optimization task of given agents, which policy function is important for setting inflation dynamics in general equilibrium.

In this regard, we *expect* that banks' inflation expectations may appear of most importance. The reason is that banks do create and supply financing (money) to other agents, which is needed to realize desired demand for consumer or investment goods. And money creation is known to be a driver of inflation[2]. In theory and practice at an individual level, inflation expectations by households and corporates affect their demand for financing. For example, demand for housing/mortgages, Schwab (1982); consumer credit/car loans, Lieb&Schuffels (2022); Bachmann (2021); corporate credit, Coibion et al. (2020b), Ropele et al. (2022). On the supply side, banks are creatures of financing. Banks use inflation expectations in practice for making macroeconomic forecasts of borrowers' nominal income dynamics. The nominal income growth is important variable for calculating indebtedness indicators (like debt-service-to-income, DSTI, or debt-to-income, DTI), that are often used by banks to set credit limits (limits of a portfolio growth). Thus, higher inflation expectations by banks may impact their credit limits and volumes of new loans issued to borrowers. There is empirical evidence that lenders' expectations about economic conditions, including inflation, impact their lending decisions, Ma et al. (2021). Thus, if there are constraints on the supply side of financing, transactions with money that fuel inflation, like consumption by households or investments and purchase of intermediate goods by firms, are harder to perform. Even very high demand for financing from households and firms (due to their high inflation expectations and preferences to spend) might not be met if banks have different view on the future course of the economy (including the inflation expectations). As a result, high inflation expectations may not transform into actual inflation if banks do not add "fuel" (money) to the "engine" (economic activity).

[2] "Inflation is always and everywhere a monetary phenomenon" by M. Friedman

In our paper, we theoretically (in a DSGE) compare role of households, firms and banks expectations in inflation dynamics with some implications for monetary policy communication.[3]

Our contribution is the following. First, this paper uses a novel theoretical framework to model *diverse* inflation expectations and identify an 'exogeneous' (orthogonal to other agents' expectations) variation in each type of agents' inflation expectations. The paper introduces a special form of non-rational expectations. This form suggests that agents construct rational plans in a non-real world (real only in their mind). After that, they act in the real world with expectations, formed in their imaginary world. Such expectations in contrast to adaptive learning create consistent expectations of multiple variables. Consistent expectations mean that they are agreed with the world in the agent's mind. It prevents possibility of strange combination of expectations such as expected growth of inflation with expected reduction in real interest rate (impossible due to monetary policy reaction function).

Second, such defined exogenous variation in inflation expectations is used to study the role of each agent's expectations in inflation dynamics in general equilibrium. In this regard, the paper investigates consequences of misunderstanding/ignoring of the central bank's signal on inflation and interest rates by different types of agents. Comparison of consequences for inflation helps to assess relative importance of communication with different agents. We find that among the agents' types, expectation shocks of banks have larger influence on reality than those of other agents (trajectory of key variables in their mind are closer to real ones).

The IRF decomposition highlights that all agents' expectation shocks trigger economy-wide adjustments, but the balance of effects differs by agent type. An expectation shock from banks ends up having the largest and clearest impact on actual inflation, with the resulting inflation path closer to what banks anticipated, whereas shocks from households or firms are largely diffused by the system's feedback loops. In practice, this means a central bank will see a bigger, more direct shift in inflation dynamics when banks revise their inflation outlook, while households' and firms' expectation swings tend to be absorbed by opposing reactions (so the actual inflation outcome often diverges from what those agents expected). Thus, household

[3] As mentioned by Reis, R. (2023) "…People may be wrong, misguided, or foolish in their expectations, but these are the same people who then choose how much to spend, work, and charge…." a central bank should respond to noisy upside risk in measured expected inflation, "unless it is very confident that the increase in the measure of expected inflation is purely noise that not even the respondents will act on..."

and firm expectation channels are more indirect and quickly counterbalanced, whereas banks' expectations feed through financial channels with more persistent general equilibrium effects on inflation.

We find that households and firms expectations shocks have influence on reality that is unpredictable for them (trajectory of key variables in their mind could be far from the real ones) – there appears to exist expectations-feedback gap for these agents[4].

The results could help in guiding the central banks communication. In particular, central banks are recommended to focus their communication efforts on agents, whose inflation expectations are most important for inflation dynamics in general equilibrium.

The paper is structured as follows. Section 2 provides a review of the relevant literature and explains our contribution to the literature. In Section 3, we describe a DSGE model that we use to analyse market equilibrium under different news shocks to inflation expectations of households, firms and financiers and introduce, first, a measure to compare the role of each types' expectations and, second, suggest an IRF's decomposition to evaluate the role of inflation expectations in the inflation dynamics. In Section 4, we describe the results. In Section 5, we analyse the robustness of the results to changes in the structure of the model as well as to changes in the parameters of the model, showing that the results remain valid over a wide range of parameters. The last section, the Conclusion, provides a summary of the main results and some suggestions on policy implications.

2. Relationship with the literature

First, our paper refers to the literature examining the diversity in inflation expectations of different types of agents, and in particular, the role of their expectations in inflation from the theoretical point of view.

The theoretical issue of *diversity* of inflation expectations among different types of agents is comparatively new one relative to the issue of inflation expectations *heterogeneity* (inside a particular type of agents, e.g. households).[5]

---

[4] See, Evans, G. W., and S. Honkapohja. (2001); Goy, G., Hommes, C., and Mavroeidis, S. (2023); Milani, F. (2007); Eusepi, S., and Preston, B. (2011).

[5] On the modelling and studying heterogeneity of inflation expectations see, Branch, W. A. (2004), Pfajfar, D., & Santoro, E. (2010), Madeira, C., & Zafar, B. (2015), Angeletos, G. M., Huo, Z., & Sastry, K. A. (2021), Doh et al (2024).

We have not found papers that would theoretically compare impact of different types of agents' expectations on inflation and other general equilibrium outcomes.

The empirical aspects of diversity are covered in the recent paper by Coibion et al (2020a). Authors empirically find diversity of inflation expectations and review recent empirical results on the pass-through of inflation expectations in decisions of firms and households. They conclude, that "*there is robust evidence on the causal effect of inflation expectations on the decisions of households and firms*". Regarding a relative role of a particular type of agents for inflation, they point that *"shaping inflation expectations of price-setters can have a direct effect on price changes, thus providing another channel to control inflation*." Other empirical studies of diverse inflation expectations include: Meyer, B., & Sheng, X. S. (2024), Link et al. (2021), Miyajima, M. K., & Yetman, J. (2019), Łyziak, T. (2013), Andrade, P., & Le Bihan, H. (2013), Mankiw et al (2003).

Second, technically, our paper follows literature that considers deviation from FIRE (Full Information Rational Expectations). There are multiple forms of introducing behavioural aspects in DSGE models, see Roos (2017). However, most of them deviate from rationality (optimal behaviour) not in expectations. Angeletos, G. M., Huo, Z., & Sastry, K. A. (2021) review different approaches to model imperfect inflation expectations and its heterogeneity. Adaptive learning is a common way to model deviations in expectation formation within DSGE models, Slobodyan and Wouters (2012). There are alternative mechanics such as sticky information, Chou et al. (2023). Mankiw and Reis (2002) introduce the sticky-information model of inflation expectations to theoretically explain *heterogeneity* in inflation expectations among economic agents. There are also heuristic approaches for expectation formation, Beqiraj et al. (2020). We add to the literature by considering a special form of incomplete information in the rational expectations framework: diverse information across different types of economic agents. Each type of economic agents receives different signals from the central bank to (or don't get a signal at all, when each type of agents cannot check whether other type of agents got the signal or not).

Third, we add to the literature that analyses information frictions among economic agents and between the private sector and the central bank and to corresponding literature that model expectations (as well as expectations of particular types of economic agents) under such conditions. For the recent empirical survey, see Cornand, C., & Hubert, P. (2022a), Binder, C. (2017), on firms' expectations: Ferrando, A., & Grazzini, C. F. (2023). Theoretical approaches are reviewed in Angeletos et al. (2021), Reis, R. (2022), Melosi, L. (2017)[6].

3. Model

3.1 non-technical background

To evaluate the role of a particular type of agent's inflation expectations on inflation in a general equilibrium someone needs to consider *an exogeneous* variation in this type's expectations. To isolate such variation in a given type of agent's expectations we introduce a deviation from FIRE on the part of agents in an otherwise standard New Keynesian model. The model closely follows Ivashchenko (2013) that is deep modification of Walque et al (2010), except for the fact that three types of agents form inflation expectations: households (labelled here and after as 'H'), firms (F), financiers (banks, B).[7] The model is the open economy model that consists of five agents: households, firms, financiers (banks), the government and the central bank.

Households each time decide how much to consume and save, how many hours to work, what share of their savings to keep in a form of cash (non-interest-bearing national money) or interest-bearing deposits at local banks. They have the standard budget constraint.

Firms act on monopolistically-competitive market and maximize the flow of dividends. They set prices optimally subject to Rotemberg price rigidities and choose on investments, labor demand, debt, share of defaults following several adjustment costs (in capital formation, labor demand and nominal wages, volume of debt to banks, and reputation costs linked to the share of defaulted debt). Firms' decisions are restricted by their flow of funds, by the production function, by the demand function on their products and by evolution of the productive capital – all are standard.

[6] In the Melosi, L. (2017) price-setters get a signal from the central bank in a form of current monetary policy decision, the current value of interest rate, which conveys information about the central bank's assessment of inflation and the output gap. The author evaluates macroeconomic effects of such signalling, but doesn't compare outcomes of sending a signal to other agents.

[7] The agents also form expectations of all other variables except for the control variables of their optimization problem.

Banks maximize their utility (profit) function subject to the budget constraint and the capital restriction (supervision set by the central bank). Banks use as given credit and deposit interest rates. Banks decide on the volume of the bank's capital, volume of loans to local corporates, volume of deposits from local households, volume of local and foreign debt issued by the government. In case of a loan default banks receive a restructured value of debt (compensation value from the borrower) which only partially covers the volume of the defaulted debt.

The government decides on the size of government spending and on taxes and as a result on the size of the government debt. The central bank follows inflation targeting and sets an interest rate according a Taylor rule. The central bank's policy and all the signals it sends to agents are fully credible by assumption.

This environment provides a rich general equilibrium setting to study how information frictions – introduced via differential signals received by agent types – propagate through the economy. By comparing outcomes under full information rational expectations to those when agents receive heterogeneous signals, the model isolates the impact of expectation errors on inflation and output.

Turning to the information content of the model, all three types know everything about the structure of the economy and expectation formation by other agents.

The deviation from full information is introduced along two lines (schemes) – Scheme A and Scheme B. They differ in what signal the central bank really sends to the economic agents. The signal affects their inflation expectations.

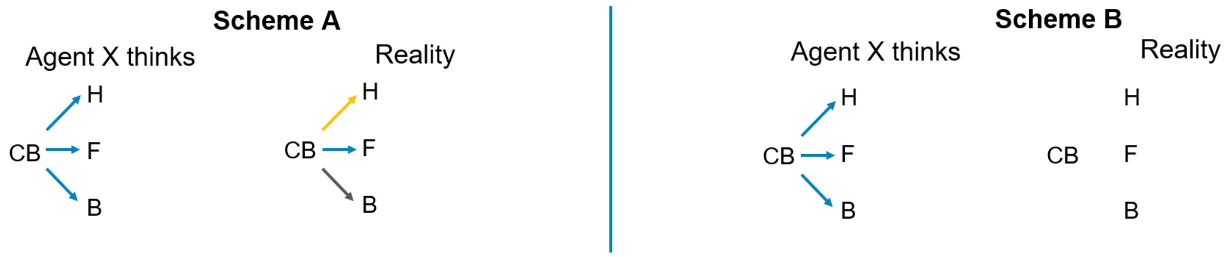
Scheme A: Each of the agents' types receives its own part of the central bank's signal on the future stance of monetary policy in period zero. Each type mistakenly believes that all other types receive the same signal as this type. Thus, there can observed an exogeneous deviation between what a given type expects and does and what the reality is. These three signals by the central banks may be interpreted as a three ways of its communication, which the central bank thinks are most suitable for the given type of agents.

Scheme B: each of types thinks that a news signal by the central bank on the future stance of monetary policy exists in period zero, i.e. each type creates its own signal in its mind. There is no any signals to any agents in reality.

The central bank knows everything in both schemes.

For example, for agents of type F (as well as any one type X of set {H,F,B}) we can draw the following illustration - Figure 4.

Figure 4.



Source: by authors

In scheme A (on the left), agents F think that all other agents receive the same signal on the future course of monetary policy as the agents F. However, other types of agents receive different signals from the central bank. As a result, the agents F think that agents H and B would behave in a manner they would not. The ignorance of two other parts of the news creates a deviation in the agents F inflation expectations from the full information rational inflation expectations.

In scheme B (on the right), the central bank does not send any signal to anyone at all. The news in this case is a pure imagination in the mind of the agents F. So, agents F make a mistake by incorrectly interpreting the imaginary signals received by others.

There are no other signals.

Table 1 contains description of the three news shocks (correspondingly one for each of three types) in both schemes.

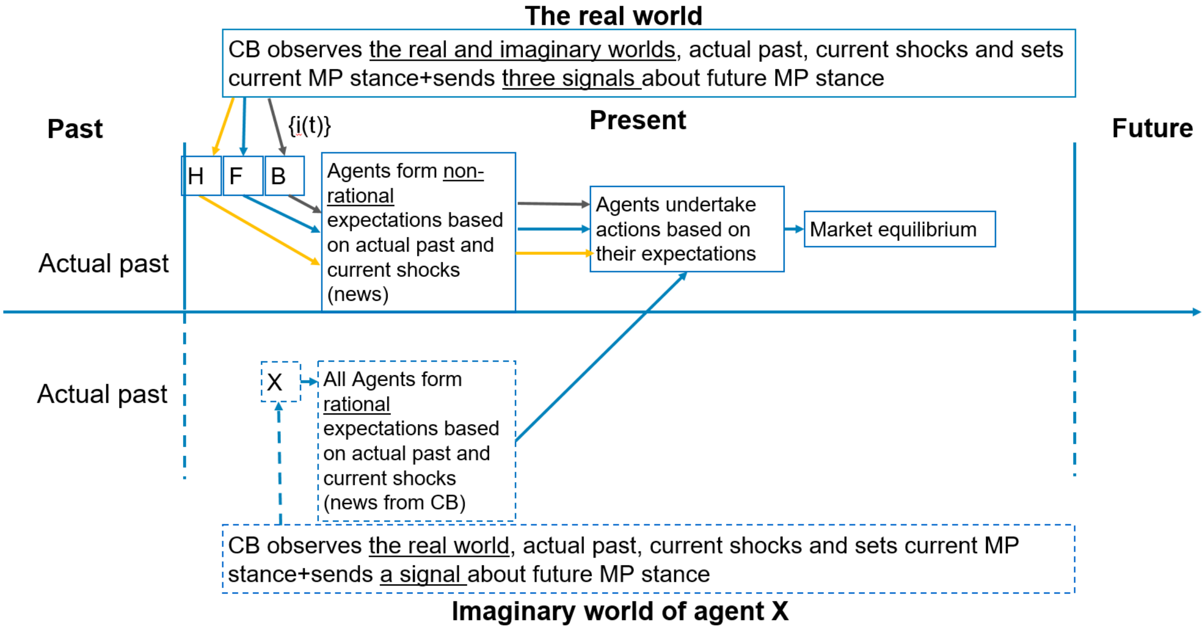
Table 1.

Scheme A			Scheme B		
Reality: what does the CB send?	Reality: who receives the signal?	What agents know about signals to other agents?	What does the CB send?	Who thinks that it get a signal?	What agents know about signals to other agents?
News shock №1	**H**	H thinks: "F and B get the signal №1 and there are no other signals"	Nothing	**H**	H thinks: "F and B get the same signal"
News shock №2	**F**	F thinks: "H and B get the signal №2 and there are no other signals"	Nothing	**F**	F thinks: "H and B get the same signal"
News shock №3	**B**	B thinks: "H and F get the signal №3 and there are no other signals"	Nothing	**B**	B thinks "H and F get the same signal"

Source: by authors

The model's timeline for an agent of type X, where X is one of the {H,F,B}, in case of the scheme A is drawn on Figure 5.[8]

Figure 5.



Source: by authors

The agent X (X is one of {H,F,B}) live in an imaginary world, where they think that all other agents receive the same signal from the central bank. Using expectations formed in such way, agents X undertake actions (set prices, decide on the volume of investments and borrowing) in the real world that result in some market outcome in the general equilibrium. Such shocks repeat every period.

The estimated DSGE model is linearized, so we can easily compare consequences of this news shock. In equations, current and expected values of variables are replaced with their values from the imaginary worlds of agents, but all lags are taken from the real past of the real world.

3.2 Economic agents and markets

[8] The timeline for the Scheme B is similar.

Main agents are forward-looking and optimize intertemporally. We first describe their objectives and constraints, then present the key equilibrium conditions (structural equations) that govern the dynamics.

All model variables are described in Appendix 1. Here we present a full version of the model – a NK small open economy model. A simpler version of closed economy the model without government sector and banks is described in Appendix 2.

3.2.1 Households

Households maximize the discounted sum of expected utilities from consumption and money while incurring disutility from labor and any penalties related to their default on bank loans – eq 1.:

$$U_t = E\left(\sum_{s=0}^{\infty} Z_{\beta,t+s-1}\left(\begin{array}{l}\frac{\left(C_{t+s}/(Z_{t+s})\right)^{1-\omega_c}}{(1-\omega_c)} - \frac{Z_{l,t+s}\left(L_{t+s}/Z_{trL,t}\right)^{1+\omega_l}}{(1+\omega_l)} + \\ +\frac{e^{\phi_{BDH}}\left(M_{H,t+s}/(P_{t+s}Z_{t+s})+\phi_{WBDH}B_{DH,t+s}/(P_{t+s}Z_{t+s})\right)^{1-\omega_m}}{(1-\omega_m)} \\ -e^{\phi_{MH}}\left(\frac{M_{H,t+s}}{P_{t+s}C_{t+s}} - Z_{MH,t+s}\right)^2 - e^{\phi_{DCH}}\left(d_{CH,t+s} - Z_{DCH,t+s}\right)^2\end{array}\right)\right) \rightarrow \max_{B,C,L,M} \quad (1)$$

Here:

$Z_{\beta,t+s-1}$ - is an exogenous process that modifies the households' discount factor over time. In other words, it affects how much weight households place on future utility relative to present utility.

$\frac{\left(C_{t+s}/(Z_{t+s})\right)^{1-\omega_c}}{(1-\omega_c)}$ - consumption's contribution to utility, adjusted by a preference parameter ω_c . Z_{t+s} (real variables trend, mainly produced by TFP) appears here so that the model can handle long-run growth by making consumption "stationary" in logs.

$\frac{Z_{l,t+s}\left(L_{t+s}/Z_{trL,t}\right)^{1+\omega_l}}{(1+\omega_l)}$ - the function that captures this disutility from labor. The exogenous factor $Z_{l,t+s}$ shifts the disutility.

$\frac{e^{\phi_{BDH}}\left(M_{H,t+s}/(P_{t+s}Z_{t+s})+\phi_{WBDH}B_{DH,t+s}/(P_{t+s}Z_{t+s})\right)^{1-\omega_m}}{(1-\omega_m)}$ - represents the utility contribution from real liquidity (cash plus deposits) held by the household.

$M_{H,t+s}/(P_{t+s}Z_{t+s})$ - is the real value of money (cash) the household holds. $P_{t+s}Z_{t+s}$ is a price index (inflation-adjusted by the trend) so that the ratio is in real (or "stationary") terms.

$\phi_{WBDH}B_{DH,t+s}/(P_{t+s}Z_{t+s})$ - is the real value of deposits, scaled by the weight ϕ_{WBDH} , which indicates how deposits compare to cash in providing liquidity or direct utility services.

$e^{\phi_{MH}}\left(\frac{M_{H,t+s}}{P_{t+s}C_{t+s}} - Z_{MH,t+s}\right)^2$ - is penalty or disutility when ratio of real money to consumption deviates from a desired level or target. $Z_{MH,t+s}$ - is an exogenous process (or a time-varying parameter) that indicates a target or desired ratio of money to consumption. The term included to ensure households hold an "optimal" level of real money balances relative to consumption. If they hold too little money, they pay a "convenience" or "transaction cost." If they hold too much, they pay an "opportunity cost." The penalty function enforces a trade-off: households decide how much real money to hold, balancing the direct utility (or convenience) of money against this penalty if they deviate from the target.

$e^{\phi_{DCH}}\left(d_{CH,t+s} - Z_{DCH,t+s}\right)^2$- is a disutility (or penalty) associated with the household default share $d_{CH,t+s}$. It represents the share of household defaults in t+s. Economically, it can be interpreted as the fraction of households who fail to meet their debt obligations or loans in that period. $Z_{DCH,t+s}$ – is an exogenous process that influences or shifts the "benchmark" or "target" default rate. When deciding on borrowing/saving, households factor in that higher defaults escalate this penalty. Consequently, the model's equilibrium can shift if policies, interest rates, or exogenous shocks make default more or less likely—and thus more or less costly.

The household's budget constraint means that the household's total uses of funds (consumption, net asset acquisitions, money holdings) must equal its total sources of funds (net labor income, old money, old assets, plus any government transfers), minus debt repayments and any default-related penalties – eq.2:

$$P_{C,t}C_t + M_{H,t} + B_{DH,t}/R_{DH,t} - B_{CH,t}/R_{CH,t} + X_{H,t}P_{S,t} = W_tL_t\left(1 - \tau_{L,t}\right) + M_{H,t-1} + B_{DH,t-1} + X_{H,t-1}\left(D_{total,t} + P_{S,t}\right) + T_{G,t} - B_{CH,t}\left(1 - d_{CH,t}\right) - d_{CH,t-1}B_{CH,t-2} * \left[Z_{dpayH,t} + \frac{M_{H,t-1}}{B_{CH,t-2}} \cdot \varphi_{dpayMH,t} + \frac{B_{DH,t-1}}{B_{CH,t-2}} \cdot \varphi_{dpayBH} + \frac{X_{H,t-1} \cdot P_{S,t-1}}{B_{CH,t-2}} \cdot * X_{H,t-1}^{\varphi_{dpayXH}}\right] \quad (2)$$

Where:
On the spendings site: $P_{C,t}C_t$ - Households' expenditure on consumption; $M_{H,t}$ - the new money holdings (cash) the household chooses to hold in period t. $B_{DH,t}/R_{DH,t} - B_{CH,t}/R_{CH,t}$ - The net position in deposits and loans, discounted by corresponding gross interest rates. $X_{H,t}P_{S,t}$ - Equity purchases.

On the resources' size: $W_tL_t(1-\tau_{L,t})$ - Labor income net of labor taxes; $M_{H,t-1}$ - previous period's money holdings become available for use this period; $B_{DH,t-1}$ - previous deposits become accessible in period t; $X_{H,t-1}(D_{total,t}+P_{S,t})$ - Dividends plus equity value from last period's holdings; $T_{G,t}$ - Government transfers (lump-sum or otherwise). $B_{CH,t}(1-d_{CH,t})$ is loan repayment on current debt. The factor $(1-d_{CH,t})$ indicates that if there is a default share$d_{CH,t}$, the household only repays the portion that is not in default. $d_{CH,t-1}B_{CH,t-2}$ [*] - penalty or partial payment from previous default decisions. If the household defaulted in t-1, it owes some payments or faces penalties in t.

Inside the brackets: $Z_{dpayH,t}$ - an exogenous factor shifting how much must be paid after a default. $\frac{M_{H,t-1}}{B_{CH,t-2}}\cdot\varphi_{dpayMH,t}$ - how money holdings from the prior period factor into the default penalty or repayment. $\frac{B_{DH,t-1}}{B_{CH,t-2}}\cdot\varphi_{dpayBH}$ - how deposits from the prior period factor in. $\frac{X_{H,t-1}\cdot P_{S,t-1}}{B_{CH,t-2}}\cdot * X_{H,t-1}^{\varphi_{dpayXH}}$ - how equity holdings influence the penalty (the model presumably has a function that uses last period's equity to determine partial repayment or penalty after default).

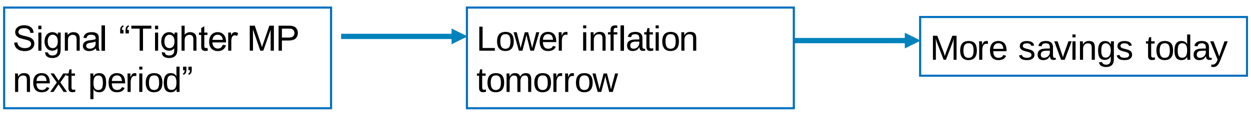
From the Euler's equation (eq. 3), as one of the first order conditions in the utility maximization problem, we can grasp the intuition of how a MP signal to households/firms affects their inflation expectations and spending/saving decisions.

$$-\lambda_{BH,t}e^{-r_{DH,t}}+\lambda_{BH,t+1}e^{z_{\beta,t}-p_{t+1}-z_{trY,t+1}}+other\quad elements=0 \qquad (3)$$

This equation is one of the first-order conditions (FOCs) from the household's utility maximization problem, specifically related to optimal deposits (or saving) decisions. Here: $\lambda_{BH,t}$ is the Lagrange multiplier (or "shadow price") on the household's budget constraint at time t. A negative sign appears because depositing money today costs you the opportunity to consume that money immediately. $\lambda_{BH,t+1}$ is the Lagrange multiplier on next period's budget constraint. $z_{\beta,t}$ affects the time preference (the household's discount factor), so $e^{z_{\beta,t}}$ scales how much future utility is valued relative to current. p_{t+1} is (log) inflation and $e^{-p_{t+1}}$ adjusts the *nominal* return to a *real* return. $z_{trY,t+1}$ is an exogenous trend (mainly TFP growth), which also factors into how returns or future income are evaluated in "effective" real terms.

A signal about "tighter monetary policy next period" means lower inflation tomorrow. This translates into higher real interest rates today given nominal interest rates which results in more savings (less consumption) today. This is the way how an exogenous variation in households' inflation expectations influence their actions in the true world in the model – Figure 6.

Figure 6.



Source: by authors

3.2.2 Firms

A representative firm chooses *B, D, I, K, L, P, Y* (its credit-deposit position, dividends, investment, capital, labor, prices, output) to maximize the following net present value of its profits with rigidities (eq. 4):

$$E\left(\sum_{t=0}^{\infty}\left(\prod_{k=0}^{t-1} R_k\right)^{-1}\left(\begin{array}{l} D_{f,t}-e^{\phi_p}P_{F,t}Y_{F,t}\left(\frac{P_{f,t}}{P_{f,t-1}}-e^{\overline{p}}\right)^2-e^{\phi_{MF}}P_{F,t}Y_{F,t}\left(\frac{M_{f,t}}{W_tL_{f,t}}-Z_{MF,t}\right)^2 \\ -e^{\phi_{DCF}}P_{F,t}Y_{F,t}\left(d_{CF,t}-Z_{DCF,t}\right)^2-e^{\phi_{BCF}}P_{F,t}Y_{F,t}\left(\frac{B_{CF,t}}{K_{f,t}P_{I,t}}-Z_{BCF,t}\right)^2 \\ -e^{\phi_{BDF}}P_{F,t}Y_{F,t}\left(\frac{B_{DF,t}}{P_{F,t}Y_{F,t}}\phi_{WBDF}+\frac{M_{f,t}}{P_{F,t}Y_{F,t}}-Z_{BDF,t}\right)^2 \end{array}\right)\right) \rightarrow \max_{B,D,I,K,L,P,Y} \quad (4)$$

Where:

$\left(\prod_{k=0}^{t-1} R_k\right)^{-1}$ – discounting factor based on all gross interest rates from k=0 to k=t-1; $D_{f,t}$ -the firm's dividend or cash flow; $e^{\phi_p}P_{F,t}Y_{F,t}\left(\frac{P_{f,t}}{P_{f,t-1}}-e^{\overline{p}}\right)^2$ – is a price-adjustment cost, capturing the friction if the firm changes its price

$P_{f,t}$; $e^{\phi_{MF}} P_{F,t} Y_{F,t} \left(\frac{M_{f,t}}{W_t L_{f,t}} - Z_{MF,t} \right)^2$ - costs linked to money holdings by the firm; $e^{\phi_{DCF}} P_{F,t} Y_{F,t} \left(d_{CF,t} - Z_{DCF,t} \right)^2$ - costs tied to credit defaults $d_{CF,t}$; $e^{\phi_{BCF}} P_{F,t} Y_{F,t} \left(\frac{B_{CF,t}}{K_{f,t} P_{I,t}} - Z_{BCF,t} \right)^2$ - costs for borrowing or balance-sheet adjustments, as $B_{CF,t}$ is the outstanding volume of bank credit (or loans) to firms at time t; $e^{\phi_{BDF}} P_{F,t} Y_{F,t} \left(\frac{B_{DF,t}}{P_{F,t} Y_{F,t}} \phi_{WBDF} + \frac{M_{f,t}}{P_{F,t} Y_{F,t}} - Z_{BDF,t} \right)^2$ represents a cost to the firm stemming from how much deposits $B_{DF,t}$ and money $M_{f,t}$it holds, relative to a target or norm $Z_{BDF,t}$. Deviations from that norm incur a higher penalty, especially for large firms or large deviations.

The budget constraint is:

$$D_{f,t} + P_{I,t} I_{f,t} + W_t L_{f,t} + B_{DF,t}/R_{DF,t} - B_{CF,t}/R_{CF,t} + M_{f,t} = P_{f,t} Y_{f,t}\left(1 - \tau_{Y,t}\right) + B_{DF,t-1} + M_{f,t-1} + T_{W,t} - B_{CF,t-1}\left(1 - d_{CF,t}\right) - d_{CF,t-1} B_{CF,t-2} \left(Z_{dpayF,t} + \frac{K_{F,t-1} P_{I,t-1}}{B_{CF,t-1}} \phi_{dpayKF} + \frac{M_{F,t-1}}{B_{CF,t-1}} \phi_{dpayMF} + \frac{B_{DF,t-1}}{B_{CF,t-1}} \phi_{dpayBF} \right) \quad (5)$$

Where, on the usage of flows side: $D_{f,t}$ - Dividends Paid Out. The firm distributes part of its net profit or retained earnings to shareholders as dividends. This is a direct cash outflow; $P_{I,t} I_{f,t}$ - Investment Spending in nominal terms. $W_t L_{f,t}$ - Wage Bill; $B_{DF,t}/R_{DF,t}$ – new deposits discounted by the gross deposit rate $R_{DF,t}$; $B_{CF,t}/R_{CF,t}$ – new credits; $M_{f,t}$ - Money Holdings.

On the resources side: $P_{f,t} Y_{f,t}\left(1 - \tau_{Y,t}\right)$ - Sales Revenue (Net of Corporate Tax); $B_{DF,t-1}$ – last period (carry-over) firm deposits; $M_{f,t-1}$ – last period money holdings (cash); $T_{W,t}$ - transfers or Subsidies (from foreign part of firms). $B_{CF,t}\left(1 - d_{CF,t}\right)$ - Principal Repayment on Bank Credit (Non-Default Portion); $d_{CF,t-1} B_{CF,t-2} \left(Z_{dpayF,t} + \frac{K_{F,t-1} P_{I,t-1}}{B_{CF,t-1}} \phi_{dpayKF} + \frac{M_{F,t-1}}{B_{CF,t-1}} \phi_{dpayMF} + \frac{B_{DF,t-1}}{B_{CF,t-1}} \phi_{dpayBF} \right)$ - Defaulted Debt from Previous Period with related costs. $d_{CF,t-1}$ is the fraction (or rate) of “standard” bank credit that defaulted in period t-1; $B_{CF,t-2}$ is the amount of that standard bank credit issued two periods ago; $Z_{dpayF,t}$ – is a baseline or “lump-sum” factor that determines how much of the defaulted debt must be repaid or compensated this period; $\frac{K_{F,t-1} P_{I,t-1}}{B_{CF,t-1}}$ - how much capital collateral is available per unit of credit from the prior period; ϕ_{dpayKF} - is a parameter scaling the share of capital "pledged" or used to partially repay last period's defaulted debt; $\frac{M_{F,t-1}}{B_{CF,t-1}}$ - Similar logic, but using money (cash or deposits) $M_{F,t-1}$. If a firm holds more cash relative to its debt, it can cover more of its defaulted obligation. ϕ_{dpayMF} – share of the per-unit of debt money collateral used to repay the loan; $\frac{B_{DF,t-1}}{B_{CF,t-1}}\phi_{dpayBF}$ – similar to previous two terms, share of the deposit-collateral used to repay the loan. Summed up, these pieces define a repayment multiplier on the defaulted portion of the old loan. The firm (or bank) is effectively recovering or forcing partial repayment (even after default) by tapping into capital, liquidity, or deposits. Even though the firm defaulted last period, the model assumes there is some enforced repayment or penalty in the following period, scaled by available resources. This formulation captures financial frictions:

- Banks/creditors recoup a fraction of defaulted loans.
- The firm faces ongoing penalties and forced repayments (or "haircuts") tied to how much capital, money, or deposits it has.

The production function constraint is standarsd Cobb-Douglass production function:

$$Y_{f,t} = Z_{trY,t} Z_{Y,t} \left(K_{f,t-1}\right)^{\alpha_k} \left(L_{f,t}\right)^{1-\alpha_k} \tag{6}$$

Where: $K_{f,t-1}$ – firm's capital stock, $L_{f,t}$ - firm's labor demand; $Z_{trY,t}$ represents a trend component of technology or productivity. Can reflect long-run growth in the production process (e.g., from technical progress or other structural factors). $Z_{Y,t}$ - a cyclical or temporary productivity process. Fluctuates around the trend, capturing short-term variations in technology or efficiency.

Capital evolution is also standard:

$$K_{f,t} = (1-\delta)K_{f,t-1} + I_{f,t} \tag{7}$$

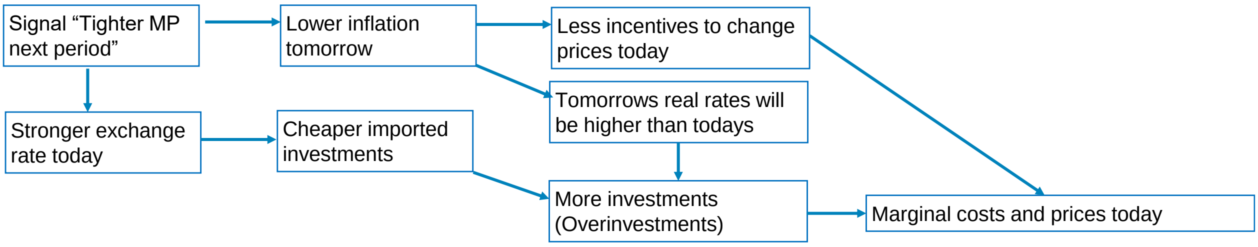
The demand on domestic goods $Y_{f,t}$ negatively depends on their relative price:

$$Y_{f,t} = \left(\frac{P_{f,t}}{P_{F,t}}\right)^{-z_{\theta,t}} Y_{D,t} \tag{8}$$

Where: $Y_{D,t}$ - total or aggregate demand in the relevant market/sector. The firm's demand depends on how its price $P_{f,t}$ compares to an aggregate or reference price $P_{F,t}$.

Figure 7 shows how a signal to firms about future course of monetary policy affect their inflation expectations and spending/investment decisions in the model.

Figure 7.



Source: by authors

There are two main channels on how an exogenous variation in the signal affects firms' actions and the macroeconomic outcome.

A. investment/output channel, which acts through *Expected Real Interest Rate* and *Relative Prices and Exchange Rate Effects*.

First, Expected Real Interest Rate. A credible signal of tighter monetary policy, for instance, implies higher future nominal rates. If firms also expect lower future inflation (due to central-bank credibility), real interest rates may rise. Higher real rates raise the firm's cost of capital—the discount factor in their investment decisions becomes larger, making future payoffs less valuable relative to present costs. Thus, the higher rates reduce preferences to make investments today relative to tomorrow.

Second, Relative Prices and Exchange Rate Effects. A signal of future domestic tightening often leads to an appreciation of the home currency in open-economy models. For firms reliant on imported intermediates or capital goods, an appreciated currency lowers their import costs. This can encourage some kinds of investment. On the other hand, a stronger currency can reduce the competitiveness of exports, affecting expected sales. The higher rates today change the relative price of domestic goods and as a result the demand for domestic goods relative to imported goods.

On balance, higher financing costs (from rising real rates) typically curb investment, while cheaper imported inputs (from an appreciated currency) can offset or partly counteract that. Whether firms invest more or less depends on which effect dominates in the model's calibration.

B. Price-Setting (Inflation) Channel.

If firms believe the central bank's signal that inflation will be restrained (due to tighter policy), they revise down their expected path of price growth.

In many New Keynesian models, firms set prices in a forward-looking way. Thus, expecting lower future inflation reduces the incentive to raise prices aggressively today—price adjustments become more moderate.

In additions, If the firm anticipates softer aggregate demand tomorrow (a typical result of higher real interest rates), it doesn't need to raise prices as much. Setting a higher price could reduce demand too much. This reinforces a lower inflation outcome in equilibrium.

To sum up:

- Monetary Policy Signal → Revises Inflation Expectations: A credible announcement of tighter policy reduces anticipated inflation; firms then plan for smaller price adjustments.

- Shifting Discount Rate and Exchange Rate → Alters Investment: Future real rates and currency appreciation/depreciation shape the firm's cost of capital and import costs, steering how much it spends today on investment projects or inventory.

- Overall Outcome: The interplay of lower expected inflation (less aggressive price-setting) and higher real interest rates (constraining capital spending) influences current decisions on output, investment, and pricing in ways that can dampen future inflation and moderate economic activity—just as monetary authorities intend when signaling a policy change.

3.2.3 Financiers (Banks)

A bank maximizes the net present value of its profits with rigidities:

The bank chooses loan volumes, dividends and capital holdings to maximize the discounted sum of its net returns (dividends) minus a series of frictional or penalty costs:

$$E\left(\sum_{t=0}^{\infty}(\prod_{k=0}^{t-1}R_k)^{-1}\left(D_{B,t}-e^{\phi_{KB}}P_tZ_t\left(\frac{B_{CF,t}}{K_{B,t}}+\frac{B_{CH,t}}{K_{B,t}}-Z_{KB,t}\right)^2-e^{\phi_{MB}}P_tZ_t\left(\frac{M_{B,t}}{B_{DH,t}}+\frac{M_{B,t}}{B_{DF,t}}\phi_{DFB}-Z_{MB,t}\right)^2\right)\right)\rightarrow \max_{D,B,K} \quad (9)$$

Where:

$(\prod_{k=0}^{t-1}R_k)^{-1}$ - is the discount factor. In each period, the bank obtains some net payoff (the terms in brackets in equation 9) which it then discounts and sums over all future periods. $D_{B,t}$ - Bank Dividends or Profit Flow. This is the baseline "benefit" in period t. The bank distributes or accrues it to its shareholders. $e^{\phi_{KB}}P_tZ_t\left(\frac{B_{CF,t}}{K_{B,t}}+\frac{B_{CH,t}}{K_{B,t}}-Z_{KB,t}\right)^2$ - A penalty term (the negative sign) capturing friction or cost from deviating loan portfolio (per one unit of capital) to corporates $B_{CF,t}$ and households $B_{CH,t}$ from a targeted level $Z_{KB,t}$. Essentially: "the more capital the bank must hold (or the more it lends to firms), the higher the cost," perhaps reflecting regulatory requirements or capital constraints. $e^{\phi_{MB}}P_tZ_t\left(\frac{M_{B,t}}{B_{DH,t}}+\frac{M_{B,t}}{B_{DF,t}}\phi_{DFB}-Z_{MB,t}\right)^2$ - A penalty term (the negative sign) capturing friction or cost from deviation liquidity holding $M_{B,t}$ by the bank relative to corporates' deposits $B_{DF,t}$ and households' deposits $B_{DH,t}$ from the targeted level $Z_{MB,t}$. The term captures liquidity constraint on the bank's side. Bank's liquidity cannot deviate significantly from the targeted level.
Bank's budget constraint is

$$D_{B,t}+M_{B,t}-B_{G,t}/R_{G,t}-B_{DH,t}/R_{DH,t}-B_{DF,t}/R_{DF,t}+B_{CH,t}/R_{CH,t}+B_{CF,t}/R_{CF,t}-FX_tB_{W,t}/R_{BW,t}=M_{B,t-1}-B_{G,t-1}-B_{DH,t-1}-B_{DF,t-1}-FX_tB_{W,t-1}+B_{CH,t-1}(1-d_{CH,t})+d_{CH,t-1}B_{CH,t-2}\cdot\left[Z_{dpayH,t}+\frac{M_{H,t-1}}{B_{CH,t-2}}\cdot\varphi_{dpayMH}+\frac{B_{DH,t-1}}{B_{CH,t-2}}\cdot\varphi_{dpayBH}+\frac{X_{H,t-1}\cdot P_{S,t-1}}{B_{CH,t-2}}\cdot\varphi_{dpayXH}X_{H,t-1}^{\varphi_{dpayXH}}\right]+B_{CF,t}(1-d_{CF,t})+d_{CF,t-1}B_{CF,t-2}\cdot\left[Z_{dpayF,t}\cdot\frac{K_{F,t-1}P_{I,t-1}}{B_{CF,t-1}}\cdot\varphi_{dpayKF}+\frac{M_{F,t-1}}{B_{CF,t-1}}\cdot\varphi_{dpayMF}+\frac{B_{DF,t-1}}{B_{CF,t-1}}\cdot\varphi_{dpayBF}\right] \quad (10)$$

Where, on the usage of bank's funds' side: $D_{B,t}$ - Dividends to Shareholders. A direct outflow of funds as the bank distributes net profit to owners. $M_{B,t}$ - Bank's Money Holdings. The bank decides how much new money (or liquid assets) to hold. Setting aside more liquidity is effectively a "use" of funds. $B_{G,t}/R_{G,t}$ – Government or Central bank deposits at the bank, divided by the government bonds gross return (policy interest rate); $B_{DH,t}/R_{DH,t}$ - the bank's liability to households (deposits), an increase in deposits is an inflow from the household's perspective but for the bank, it raises liabilities. $B_{DF,t}/R_{DF,t}$ - the bank's liability to firms (deposits); $B_{CH,t}/R_{CH,t}$ - credit to Households. A positive sign suggests the bank is issuing new loans; to households, receiving loan claims as an asset. The factor $1/R_{CH,t}$ reflects the present value or discount on these new loans. $B_{CF,t}/R_{CF,t}$ - Credit to Firms; $FX_tB_{W,t}/R_{BW,t}$ - Foreign Currency liabilities. $B_{W,t}$ is external debt or foreign-currency–denominated bonds; multiplied by the exchange rate FX_t. Negative sign indicates outflow if the bank invests or holds foreign instruments (or repays foreign liabilities).

On the source's side: holdings of money $M_{B,t-1}$, government bods $B_{G,t-1}$, household deposits $B_{DH,t-1}$,firm deposits $B_{DF,t-1}$, and foreign assets $FX_tB_{W,t-1}$ in the previous period. $B_{CH,t-1}\left(1-d_{CH,t}\right)$ - Repayment of Household Loans without default; $B_{CF,t}\left(1-d_{CF,t}\right)$ - Repayment of Corporate Loans without default.

$d_{CH,t-1}B_{CH,t-2}\cdot\left[Z_{dpayH,t}+\frac{M_{H,t-1}}{B_{CH,t-2}}\cdot\varphi_{dpayMH}+\frac{B_{DH,t-1}}{B_{CH,t-2}}\cdot\varphi_{dpayBH}+\frac{X_{H,t-1}\cdot P_{S,t-1}}{B_{CH,t-2}}\cdot\varphi_{dpayXH}X_{H,t-1}^{\varphi_{dpayXH}}\right]$ - partial Recovery of Previously Defaulted Household Loans. If some fraction $d_{CH,t-1}$ of household loans $B_{CH,t-2}$ defaulted in period t−1, the bank can still recoup a portion in period t. The bracket includes fixed recovery rate $Z_{dpayH,t}$ plus parameters that scale how the bank recovers from household money $M_{H,t-1}$, deposits $B_{DH,t-1}$ and equity stock $X_{H,t-1}\cdot P_{S,t-1}$.

$d_{CF,t-1}B_{CF,t-2}\cdot\left[Z_{dpayF,t}\cdot\frac{K_{F,t-1}P_{I,t-1}}{B_{CF,t-1}}\cdot\varphi_{dpayKF}+\frac{M_{F,t-1}}{B_{CF,t-1}}\cdot\varphi_{dpayMF}+\frac{B_{DF,t-1}}{B_{CF,t-1}}\cdot\varphi_{dpayBF}\right]$ - partial Recovery of Previously Defaulted Corporate Loans. If some fraction $d_{CF,t-1}$ of loans $B_{CF,t-2}$ defaulted in period t−1, the bank can still recoup a portion in period t. The bracket includes parameters that scale how the bank recovers from firm's capital (fixed part of recovered debt) $Z_{dpayF,t}\frac{K_{F,t-1}P_{I,t-1}}{B_{CF,t-1}}$, money $M_{F,t-1}$ and deposits $B_{DF,t-1}$.

Definition of the bank's capital:

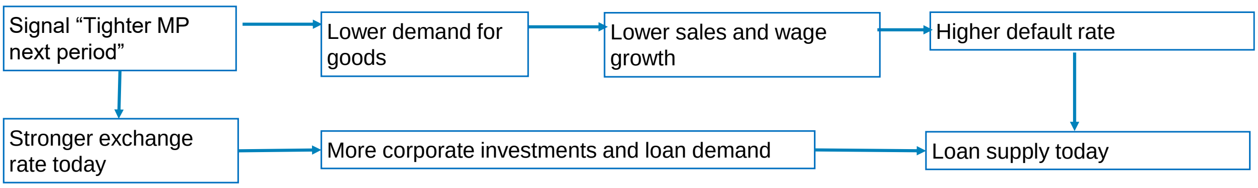
$$K_{B,t}=-B_{G,t}-B_{DH,t}-B_{DF,t}+B_{CH,t}+B_{CF,t}-B_{W,t}+M_{B,t}-\varphi_{BW}\left(B_{W,t}\right)^2 \qquad (11)$$

Where: $K_{B,t}$ represents bank capital or net worth in period t. Intuitively, it is the residual after the bank has accounted for all its various asset and liability positions. On the asset side of the bank are corporate $B_{CH,t}$ and household loans $B_{CF,t}$ and money holdings by the bank $M_{B,t}$. On the liability side of the bank's balance sheet are household deposits $B_{DH,t}$, firm's deposits $B_{DF,t}$ and government deposits $B_{G,t}$. $-\varphi_{BW}\left(B_{W,t}\right)^2$ is a quadratic penalty (or cost) associated with the bank's foreign-currency position $B_{W,t}$. It reduces bank capital to reflect, for example, risk exposure or regulatory friction—the bigger $B_{W,t}$ is, the more of a penalty is applied.

Having **positive** $K_{B,t}$ means that, after netting assets and liabilities (and subtracting any penalty terms), the bank still has a positive surplus (net worth).

A signal to banks affects their inflation expectations and loan supply decisions along the lines presented in Figure 8.

Figure 8.



Source: by authors

A signal about tighter monetary policy next period means, first of all, higher real rates that reduce expected household and corporate demand for new loans as well as higher share of defaults on existing loans, which implies more risky lending (with higher share of expected defaults). Thus, signal about tighter monetary policy (higher expected inflation) points to lower credit supply - this is how the bank lending channel of monetary policy works, See Disyatat (2011).

Second, tighter monetary policy next period means stronger exchange rate, this changes bank's preferences for making domestic loans against investing abroad and additionally reduces supply of lending by banks. Exchange rate appreciation also affects firm's preferences for investments and loan demand. Depending on the strength of different factors on the demand side of loans of the presented on Figure 8, a lower expected inflation may result in more loans today or in less loans today.

3.2.4 Government and central bank

Government budget constraint is equation where the left side represents government expenditures and obligations, including transfers, deposits at banks, and buying of new equity holdings. The right side reflects government revenues, including labor and corporate taxes, import taxes, oil tax revenues, debt repayments, and returns from previous assets.
This structure ensures that government financing is balanced each period, showing the interplay between taxes, debt, and returns from public assets in a dynamic and stochastic macroeconomic model.

$$e^{p_{g,t}+g_t} + \tau_{G,t} + b_{G,t}e^{-r_{G,t}} + x_{G,t}e^{p_{s,t}} = \tau_{L,t}e^{w_t+l_t} + \tau_{Y,t}e^{p_{F,t}+y_{F,t}} + \tau_{Y,t}e^{p_{im,t}+im_t} + \tau_{oil,t}(e^{ex_{oil,t}+p_{oil,t}+fx_t} - e^{p_{F,t}+ex_{oil,t}-z_{oils,t}}) + b_{G,t-1}e^{-z_t-p_t} + x_{G,t-1}\left(e^{p_{s,t}} + d_{total,t}\right) + (e^{m_t} - e^{m_{t-1}-z_t-p_t}) \quad (12)$$

Where: $e^{p_{g,t}+g_t}$ reflects government expenditures (consumption) adjusted for the price level $p_{g,t}$; $\tau_{G,t}$ - represents transfers paid by the government to households; $b_{G,t}e^{-r_{G,t}}$ – real government deposits at banks at time t, discounted by the interest rate; $x_{G,t}e^{p_{s,t}}$ – worth of equity holdings owned by the government, scaled by the price of the shares $p_{s,t}$. $\tau_{L,t}e^{w_t+l_t}$ - represents labor income taxes; $\tau_{Y,t}e^{p_{F,t}+y_{F,t}}$ - tax revenue from firms' income; $\tau_{Y,t}e^{p_{im,t}+im_t}$ - Tax revenue from imports, with $p_{im,t}$ being the import price level and im_t the volume of imports; $\tau_{oil,t}\left(e^{ex_{oil,t}+p_{oil,t}+fx_t} - e^{p_{F,t}+ex_{oil,t}-z_{oils,t}}\right)$ - taxes from oil exports adjusted for the exchange rate fx_t, oil price $p_{oil,t}$, and oil-export volume $ex_{oil,t}$; $b_{G,t-1}e^{-z_t-p_t}$ - Repayment of past government deposits, adjusted for real variables growth z_t and inflation; $x_{G,t-1}\left(e^{p_{s,t}} + d_{total,t}\right)$ - previous period's returns from equity holdings, including dividends $d_{total,t}$; $(e^{m_t} - e^{m_{t-1}-z_t-p_t})$ - change in money holdings of economy, adjusted for inflation and real variables trend-growth.

Government fiscal rule depends on the phase of economic cycle – eq. 13

$$g_{pol,t} = \gamma_{pol}\left(g_{pol,t-1}\right) + \left(1-\gamma_{pol}\right)\begin{pmatrix}\gamma_{poly}(y_t - \overline{y}) + \\ +\gamma_{polb}\left(b_{G,t}e^{-y_t} - \overline{b_G}e^{-\overline{y}}\right) + z_{pol,t}\end{pmatrix} \quad (13)$$

Where: $g_{pol,t}$ - represents the current policy stance of fiscal policy. $\gamma_{pol}\left(g_{pol,t-1}\right)$ Introduces persistence or inertia. The parameter γ_{pol} (where -

1<γ_{pol}<1) indicates how strongly current policy depends on last period's policy; y_t is the current level of output (GDP), while $\overline{y}$ is the steady-state or potential output. $b_{G,t}$ is the level of real government deposits (minus debt) at time t, while $\overline{b_G}$ is its steady-state level. The exponential terms normalize debt relative to output. This term ensures that if debt is too high relative to output, policy will adjust (e.g., tighter fiscal policy to stabilize debt levels); $z_{pol,t}$ - Captures random policy shocks or unexpected changes in policy behavior, which are not explained by output or debt deviations.

Government expenditures and transfers adjust to their policy-rule's defined levels:

$$g_t = \gamma_g(g_{t-1}) + (1-\gamma_g)\left(\gamma_{gpol}\left(g_{pol,t} - \overline{g_{pol}}\right) + z_{G,t}\right) \quad (14)$$

$$\tau_{trG,t} = \gamma_{tr}\left(\tau_{trG,t-1}\right) + (1-\gamma_{tr})\left(\gamma_{trpol}\left(g_{pol,t} - \overline{g_{pol}}\right) + z_{tr,t}\right) \quad (15)$$

Taxes on labor, import and output also adjust to the levels, prescribed by the fiscal rule:

$$\tau_{Y,t} = \gamma_{taxy}\left(\tau_{Y,t-1}\right) + \left(1-\gamma_{taxy}\right)\left(\gamma_{taxypol}\left(g_{pol,t} - \overline{g_{pol}}\right) + z_{taxy,t}\right) \quad (16)$$

$$\tau_{L,t} = \gamma_{taxl}\left(\tau_{L,t-1}\right) + (1-\gamma_{taxl})\left(\gamma_{taxlpol}\left(g_{pol,t} - \overline{g_{pol}}\right) + z_{taxl,t}\right) \quad (17)$$

Assets (privatization / nationalization) also follow the need of the policy rule:

$$x_{G,t} = \gamma_{xg}\left(x_{G,t-1}\right) + \left(1-\gamma_{xg}\right)\left(\gamma_{xgpol}\left(g_{pol,t} - \overline{g_{pol}}\right) + z_{xg,t}\right) \quad (18)$$

Taxes for oil have additional dependence on oil prices:

$$\tau_{oil,t} = \gamma_{taxoil}\left(\tau_{oil,t-1}\right) + (1-\gamma_{taxoil})\left(\gamma_{taxoilpol}\left(g_{pol,t} - \overline{g_{pol}}\right) + \gamma_{taxoilp}\left(p_{oil,t} - \overline{p_{oil}}\right) + z_{taxoil,t}\right) \quad (19)$$

Monetary policy rule is different in two schemes. In scheme A the central bank sends a compound news signal to the agents (each type of agents receives only one part of the compound signal) regarding future interest rate – eq. 20.

$$log(R_{G,t}) = r_{G,t} = \gamma_r(r_{G,t-1}) + (1-\gamma_r)\begin{pmatrix}\gamma_{rp}\left(log\left(\frac{P_{C,t}}{P_{C,t-1}}\right)-\overline{p}\right)+\gamma_{ry}(y_t-\overline{y})+ \\ +\gamma_{rfx}(fx_t-\overline{fx})+z_{R,t}+\sum_{i=1}^{3} z_{newsR,i,t-1}\end{pmatrix} \quad (20)$$

Where: $\gamma_r(r_{G,t-1})$ – the term, that captures some policy inertia; $\gamma_{rp}\left(log\left(\frac{P_{C,t}}{P_{C,t-1}}\right)-\overline{p}\right)$ – part of the rule, that prescribes for the central bank to react on a deviation of inflation $log\left(\frac{P_{C,t}}{P_{C,t-1}}\right)$ from the target $\overline{p}$; $\gamma_{ry}(y_t-\overline{y})$ – the term, that captures stabilization of the output gap; $\gamma_{rfx}(fx_t-\overline{fx})$ – the term, that captures stabilization of the exchange rate; $z_{R,t}$ – is a common to all agents monetary policy shock; the sum $\sum_{i=1}^{3} z_{newsR,i,t-1}$ captures the anticipated one period in advance (at t-1) component of the monetary policy decision in period t. At t-1 the central bank sends a compound signal to the three types of agents. Each type discovers only part of the signal at time t-1. Monetary policy shock at time t is agent specific. For example, for households, being agents №1 in notations above, the monetary policy shock at t is $\mathrm{z_{R,t}} + \mathrm{z_{newsR,2,t-1}} + +\mathrm{z_{newsR,3,t-1}}$. It means that there is only such monetary policy shock (received by everyone) in imaginary world of households.

In scheme, B the central bank does not send any signal to anyone– eq. 21. However, agents think that signal exist similar to scheme A.

$$log(R_{G,t}) = r_{G,t} = \gamma_r(r_{G,t-1}) + (1-\gamma_r)\begin{pmatrix}\gamma_{rp}E_t\left(log\left(\frac{P_{C,t+1}}{P_{C,t}}\right)-\overline{p}\right)+\gamma_{ry}(y_t-\overline{y})+ \\ +\gamma_{rfx}(fx_t-\overline{fx})+z_{R,t}\end{pmatrix} \quad (21)$$

3.2.5 Foreign sector

The balance of payments identity is:

$$e^{p_{ex,t}+ex_t} + e^{fx_t+p_{oil,t}+ex_{oil,t}} + \tau_{W,t} + (b_{W,t})e^{fx_t-r_{BW,t}} + x_{W,t}e^{p_{s,t}} = (b_{W,t-1})e^{fx_t-z_t-p_{w,t}} + x_{W,t-1}(d_{total,t}+e^{p_{s,t}}) + e^{p_{im,t}+im_t}(1-\tau_{Y,t}) \quad (22)$$

Where: $e^{p_{ex,t}+ex_t}$ – non-oil export revenues. $p_{ex,t}$ - is the price of general exports, and ex_t is the quantity of exports. The exponential ensures these terms are in nominal terms, representing total export earnings; $e^{fx_t+p_{oil,t}+ex_{oil,t}}$ – oil-export revenues; $\tau_{W,t}$ - represents transfers from foreign part of firms. $(b_{W,t})e^{fx_t-r_{BW,t}}$ - represents foreign currency bond issued by banks. $b_{W,t}$ is the current period's foreign bond issuance; fx_t exchange rate, and $r_{BW,t}$ is the interest rate on foreign bonds; $x_{W,t}e^{p_{s,t}}$ – worth of foreign equity holdings. $(b_{W,t-1})e^{fx_t-z_t-p_{w,t}}$ represents repayment of previous foreign bonds. $b_{W,t-1}$ is the bond issuance from the previous period; $x_{W,t-1}(d_{total,t}+e^{p_{s,t}})$ is returns from previous foreign equity investments, including share of total dividends; $e^{p_{im,t}+im_t}(1-\tau_{Y,t})$ is total import expenditures, net of import taxes.

Regarding the foreign economy, three New-Keynesian equations of the world economy follow. First, Foreign Interest Rate Dynamics (Taylor rule):

$$r_{w,t} = \gamma_{rfw}(r_{w,t-1}) + (1-\gamma_{rfw})(\gamma_{rfwPW}(p_{w,t}-\overline{p_w}) + \gamma_{rfwYW}(y_{w,t}-\overline{y_w}) + z_{rfw,t}) \quad (23)$$

Second, Foreign Price Dynamics (Phillips curve):

$$p_{w,t} = \gamma_{pw}(p_{w,t-1}) + \gamma_{pwe}E_t(p_{w,t+1}) + \gamma_{pwyw}(y_{w,t}-\overline{y_w}) + (1-\gamma_{pw}-\gamma_{pwe})z_{pw,t} \quad (24)$$

Third, Foreign Output Dynamics (IS-curve):

$$y_{w,t} = \gamma_{yw}(y_{w,t-1}) + \gamma_{ywe}E_t(y_{w,t+1}) + \gamma_{ywrp}(r_{w,t}-E_t(p_{w,t+1}) - \overline{r_w} + \overline{p_w}) + (1-\gamma_{yw} - \gamma_{ywe})z_{yw,t} \quad (25)$$

These three equations jointly define the behavior of the foreign economy in the model, specifically the interaction between interest rates, prices, and output. Thus, the foreign economy is:

- Forward-looking (as shown by expectations terms).
- Responsive to monetary policy, especially through real interest rates.
- Subject to shocks, which add realism to the model dynamics.

The following equations are complementary. Oil prices and demanded oil volumes follow an exogeneous processes:

$$p_{oil,t} = z_{poil,t} \quad (26)$$

$$ex_{oil,t} = z_{oil,t} \tag{27}$$

Foreign trade (import):

$$\left(1 - \tau_{Y,t}\right)e^{p_{IM,t}} = e^{fx_t + z_{PIM,t}} \tag{28}$$

The demand for import is composed of different domestic uses—consumption, investment, government spending, and exports of re-exported goods.

$$e^{im_t} = (1 - w_C)e^{c_t - (1-\theta_C)z_{Cs,t} - \theta_C\left(p_{im,t} - p_{C,t}\right)} + (1 - w_I)e^{i_{F,t} - (1-\theta_I)z_{Is,t} - \theta_I\left(p_{im,t} - p_{I,t}\right)} + (1 - w_G)e^{g_t - (1-\theta_G)z_{Gs,t} - \theta_G\left(p_{im,t} - p_{G,t}\right)} + (1 - w_{EX})e^{ex_t - (1-\theta_{ex})z_{EXs,t} - \theta_{EX}\left(p_{im,t} - p_{EX,t}\right)} \tag{29}$$

Each line of the right-hand side corresponds to one agent or sector purchasing imported goods, with its own parameters and relative-price effects. Here: e^{im_t} is the level of total import demand; $(1 - w_C)e^{c_t - (1-\theta_C)z_{Cs,t} - \theta_C\left(p_{im,t} - p_{C,t}\right)}$ - Consumption-Related Imports. $(1 - w_C)$ - is the share/fraction of consumption that is met by imports (or an import "intensity" parameter). $z_{Cs,t}$ - is an exogenous process of "efficiency" transformation of import and intermediate domestic goods to consumption. $\theta_C\left(p_{im,t} - p_{C,t}\right)$ captures how relative prices affect import demand. The same is for other components of import demand: (log) real investment demand by firms $i_{F,t}$; (log) government consumption level g_t; (log) volume of exports, or components used in producing export goods, ex_t.

Country risk-premium (interest rates spread) on the country's **foreign bonds** (or external debt) $r_{BW,t}$ relative to the global reference rate $r_{w,t}$.

$$\left(r_{BW,t} - r_{w,t}\right) = \gamma_{rwb}\left(r_{BW,t-1} - r_{w,t-1}\right) + (1 - \gamma_{rwb})\begin{pmatrix}\gamma_{rwb}\left(b_{WH,t} - \overline{b_{WH}}\right) + \\ +\gamma_{rwbdy}\left(b_{WH,t}e^{fx_t - y_{F,t}} - \overline{b_{WH}}e^{\overline{fx} - \overline{y}}\right) + z_{rwb,t}\end{pmatrix} \tag{30}$$

Where: $\gamma_{rwb}\left(r_{BW,t-1} - r_{w,t-1}\right)$ – term, capturing persistence of the spread; $b_{WH,t} - \overline{b_{WH}}$ – deviation of external debt from the steady state; $\gamma_{rwbdy}\left(b_{WH,t}e^{fx_t - y_{F,t}} - \overline{b_{WH}}e^{\overline{fx} - \overline{y}}\right)$ captures deviation of external debt in terms of domestic firms output from steady state; $z_{rwb,t}$ is a shock term

capturing unexplained fluctuations in the country's risk premium—e.g., sudden changes in market sentiment, political risk, or other exogenous events.
A positive spread indicates the country must pay a higher rate than the global benchmark.

Transfers from abroad:

$$\tau_{W,t} = z_{DW,t} \quad (31)$$

Foreign equity position:

$$x_{W,t} = z_{xw,t} \quad (32)$$

The non-oil exported goods price:

$$p_{exD,t} = fx_t + z_{PEX,t} \quad (33)$$

Where: $p_{exD,t}$ is *log* of the **"destination price"** (or a *competitive export price*) in foreign markets. It represents how expensive (or cheap) exported goods are to foreign buyers. This relationship states that **export prices** in the destination market fluctuate primarily with:
The **exchange rate** fx_t , which translates domestic costs into foreign-currency terms, and with A **shock or baseline** $z_{PEX,t}$ that might capture structural or policy changes in the export sector, external demand shifts, or other cost factors not directly linked to the exchange rate.

Demand on our non-oil exports (foreign desired import) depends on the exchange rate and foreign income:

$$ex_{D,t} = \left(\gamma_{exs}\left(fx_t - \overline{fx}\right) + \gamma_{exyw}\left(y_{W,t} - \overline{y_W}\right) + z_{ex,t}\right) \quad (34)$$

$$e^{ex_t} = (w_{EX})e^{ex_{D,t} - \theta_{EX}(p_{F,t} - p_{exD,t})} \quad (35)$$

In the DSGE framework, these equations help determine how foreign conditions impact the domestic economy, particularly through interest rate differentials, trade flows, and capital movement.

3.3 Data and estimation

The Model is estimated using posterior mode. The following 33 time series covering period from 2011q1 until 2022q4 are used (some series are shorter)[9]:

- different interest rates (**zzobs_r_G**, zzobs_rc_F_v1, zzobs_rc_H_v1, zzobs_rd_F_v1, zzobs_rd_H_v1)
- Deposits and credits as share of GDP (zzobs_b_G_PY, zzobs_b_W_PY_v1, zzobs_bc_F_PY_v1, zzobs_bc_H_PY_v1, zzobs_bd_F_PY_v1, zzobs_bd_H_PY_v1)
- Defaults rates (zzobs_dc_F, zzobs_dc_H)
- Share of GDP components (zzobs_ex_oil_PY, zzobs_PC_PY, zzobs_PEX_PY, zzobs_PG_PY, zzobs_PI_PY, zzobs_PIM_PY)
- Fiscal sector variables (zzobs_spend_PY, zzobs_tax_LWL_PY, zzobs_tax_oil_PY, zzobs_tax_PY)
- Growth rates of real and nominal exchange rate (zzobs_dNFX, zzobs_dRFX)
- Labor market statistics (zzobs_dL, zzobs_dW, zzobs_WL_PY)
- Inflation measures (**zzobs_dPC**, zzobs_dPI)
- Oil prices growth (zzobs_dp_oil)
- Real growth rates (zzobs_dI, **zzobs_dY**)

Appendix 2 contains time-series diagrams for each of the variables.

3.4 Criterion of inflation expectations importance

To evaluate relative importance of each agents' inflation expectations for the dynamics of the macroeconomic variables we use a variable-period related measure - eq. 36:

$$IMP(x,T,s) = \sqrt{\sum_{t=1}^{T} \left(\frac{\left(IRF(x_{real},t,s) - IRF(x_{min\,d},t,s)\right)}{abs\left(IRF(x_{real},t,s) + IRF(x_{min\,d},t,s)\right)/2 + c_0} \right)^2 /T} \qquad (36)$$

Where: $IRF(x_{real},t,s)$ - is the actual (real) impulse response of variable x at horizon t after a shock s (news shock of a particular agents); $IRF(x_{min\,d},t,s)$ - is the agent's perceived or "imagined" impulse response of

[9] The small-scale model from Robustness check section (Appendix 4) uses only three **bold series**

the same variable *x*; Denominator normalizes that difference, roughly by the average magnitude of the real and "mind" IRFs. A small constant c_0 (e.g., 0.01) is added so that the denominator stays safely away from zero and prevents division by a very small number.

Equation (36) defines a *normalized root-mean-square difference* between the model's actual (real) impulse response for some variable *x* and the impulse response that a given agent *s thinks* (or "has in mind") will occur. It is used in the paper to gauge how closely the agent's *s* perceived dynamics of a variable x align with that variable's *true* dynamics in the model.

If the $IMP(x,T,s)$ is small, it means that the true dynamics of the variable *x* is very close to the perceived by the agents *s*. It means that rational expectations dynamics of the variable *x* in their mind spillover into the true world. It follows, that expectations of agents *s* are important for the true world dynamics of the given variable.

If $IMP(x,T,s)$ is *large*, there is a big discrepancy between what the agent thinks will happen and what truly happens. This indicates that agent's expectations do *not* translate effectively into real-world dynamics for that variable.

The measure has the following characteristics:

- The larger difference – the larger measure.
- The different sign – much larger measure.
- If the IRF is near zero in mind and reality, then measure is near zero too.
- We use normilized IRF for elimination effect of the shock's standard deviation.
- C_0=0.01.

3.5 IRF decomposition

The IRFs are usually used for understanding of model dynamics. However, even when a model is not very complicated it may be hard to form intuition for IRF (why it has particular shape or even sign). We propose a technique for decomposition of the IRFs from the viewpoint of particular group of equations. The method aims to provide a clearer understanding of how agents' decisions are formed and what drives the IRFs.

Several academic papers have proposed similar methods for decomposing impulse response functions (IRFs) in dynamic stochastic general equilibrium (DSGE) models. Notable contributions include: Labus, M., & Labus, M. (2019), Wegner, E., Lieb, L., Smeekes, S., & Wilms, I. (2024), Guerron-Quintana, P., Inoue, A., & Kilian, L. (2017), Wróbel-Rotter, R. (2016).

Standard IRFs show how variables respond over time to a shock. But in large models, it's hard to tell:

- *Why* a variable reacts the way it does,
- *Which expectations or mechanisms* are driving the response,
- And *how important* each part of the system is in shaping that response.

This method breaks the IRF down into contributions from different sources, like:

- Lagged decisions,
- Current and future expectations,
- The shock itself, and
- Reactions from the rest of the economy.

Because the model is linearized (as we are working with first order approximation), it allows for additive decomposition using the model's structural equations. The steps are:

1. **Choose a subset of n equations and n variables** (e.g., all those controlled by a specific agent like households).
    - Call these variables x_t (their deviation from steady-state)
    - All other variables are y_t

Here variables controlled by one type of agents are those that enter the decision set of the agents, i.e. variables for which the agents form policy functions.

2. Rearrange the sub-system of equations of the DSGE as equation (37).

$$A_L x_{t-1} + A_0 x_t + A_F E_t x_{t+1} + B_L y_{t-1} + B_0 y_t + B_F E_t y_{t+1} + D\varepsilon_t = 0 \quad (37)$$

Here: x_t - vector of target variables or controlled variables (e.g., a subset like consumption, inflation, etc., often tied to a particular agent or decision maker); y_t - vector of other endogenous variables in the system (complementary to x_t); ε_t - vector of structural shocks (e.g., technology, preference, policy shocks). A_L , A_0 , A_F - Matrices capturing, correspondingly, the influence of past, current, and expected future values of x_t; B_L, B_0, B_F - matrices capturing the influence of past, current, and expected future values of y_t; D - matrix mapping shocks to current dynamics.

We can think of it as a dynamic equation that *balances out*:

Lagged history + **Current decisions** + **Future expectations** + **Interactions with other variables** + **Shock effects** = 0

3. Isolate contribution (past, current and expectations) by rewriting the equation 37 as equation 38

$$x_t = -(A_0)^{-1}(A_L x_{t-1} + A_F E_t x_{t+1} + B_L y_{t-1} + B_0 y_t + B_F E_t y_{t+1} + D\varepsilon_t) \quad (38)$$

It shows what is the transmission mechanics that force an agent to make decision in response to a particular shock. Some share of response at period t comes from previous period decisions x_{t-1}, some from previous period state of the economy y_{t-1}. Another part comes from expectations about future decisions and of the state of the economy ($E_t x_{t+1}$, $E_t y_{t+1}$). The last part comes from current shock ε_t and reaction of the rest economy y_t. If we choose full system than we would not be able to say what is the influence of reaction of the rest economy.

Additional useful feature of such approach is that we can evaluate sensitiveness of particular agent's decision to some particular variable or expectation. For example, how sensitive households decision to current interest rate is. How sensitive households decision to their inflation expectation is.

Let's illustrate this approach in single dimensional case. Euler equation (F.O.C related to bonds) of households in small-scale model is described by equation (39).

$$E_t \beta \lambda_{BH,min\,dH,t+1}\, exp(-p_{min\,dH,t+1} - z_{trY,t+1}) = \lambda_{BH,t}\, exp(-r_{H,t}) \quad (39)$$

It shows how a household's decision to save or consume – the value of the current period consumption (Lagrange multiplier of households $\lambda_{BH,t}$) is influenced by:

- Its expected inflation, $p_{min\,dH,t+1}$
- Expected TFP growth, $z_{trY,t+1}$
- Expected Lagrange multipliers (utility value of consumption in the future), $\lambda_{BH,min\,dH,t+1}$

- And current interest rates $r_{H,t}$

So, the total reaction of Lagrange multiplier $\lambda_{BH,t}$ in response of households expectation shock would consist of the reaction of its expectations and of the monetary policy reaction.

The difference between the real reaction of households' Lagrange multiplier and their reaction in imaginary world comes from difference in interest rates, as the reaction in the imaginary world is described as equation (40):

$$E_t\beta\lambda_{BH,min\,dH,t+1}\,exp\left(-p_{min\,dH,t+1}-z_{trY,t+1}\right)=\lambda_{BH,min\,dH,t}\,exp(-r_{H,min\,dH,t}) \quad (40)$$

That's key to the paper's method: agents optimize rationally within their imagined world, but those expectations may be non-rational relative to the true economy. The difference of equations (39) and (40) means the difference in consumption decisions due to difference in an interest rate perceived by agents in their imaginary world and an actual interest rate.

This (single equation) logic is working for the initial period of the shock. The future development would depend on households' decisions due to dependence between Lagrange multiplier, consumption, savings and other variables controlled by households. That is why it is better to make decomposition based on all equations-variables related to particular agent instead of single equation approach.

4. Results

First, we present results for a small-scale new-Keynesian model, similar to Clarida, Gali, Gertler (1999). Then we turn to the main, lager scale model, with banks.

4.1 Results for a small-scale model

We first consider a small-scale closed economy new-Keynesian model without banks (see Appendix 3 for the description of the model). The number of news shocks is equal to two (households' and firms'), not three, in this case.

Expectation shock importance measure (for Scheme B) is calculated in Table 2, the IRFs are presented in Appendix 4.

Table 2. Expectation shock importance for Scheme B in the small-scale model.

	5 periods		10 periods		15 periods		20 periods	
	er_R_newsH	er_R_newsF	er_R_newsH	er_R_newsF	er_R_newsH	er_R_newsF	er_R_newsH	er_R_newsF
a_H	0.47	**0.45**	0.33	**0.32**	0.27	**0.26**	0.23	**0.23**
c_H	**0.64**	1.17	**0.45**	0.83	**0.37**	0.68	**0.32**	0.59
d_F	**0.75**	1.20	**0.53**	0.84	**0.43**	0.69	**0.37**	0.60
l_H	**0.65**	1.23	**0.46**	0.87	**0.38**	0.71	**0.33**	0.61
limda_BF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
limda_BH	1.37	**1.22**	0.97	**0.86**	0.79	**0.70**	0.68	**0.61**
limda_DF	**0.74**	1.24	**0.52**	0.88	**0.42**	0.72	**0.37**	0.62
limda_PF	**0.72**	1.25	**0.51**	0.88	**0.42**	0.72	**0.36**	0.62
m_H	**1.26**	1.26	**0.89**	0.89	**0.73**	0.73	**0.63**	0.63
p	**0.67**	0.90	**0.47**	0.64	**0.39**	0.52	**0.33**	0.45
p_C	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
p_F	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
r_H	**1.19**	1.20	**0.84**	0.85	**0.69**	0.70	**0.59**	0.60
tr_H	0.40	**0.32**	0.28	**0.23**	0.23	**0.19**	0.20	**0.16**
w_H	**0.76**	1.25	**0.54**	0.88	**0.44**	0.72	**0.38**	0.62
y_D	**0.64**	1.17	**0.45**	0.83	**0.37**	0.68	**0.32**	0.59
y_F	**0.64**	1.17	**0.45**	0.83	**0.37**	0.68	**0.32**	0.59

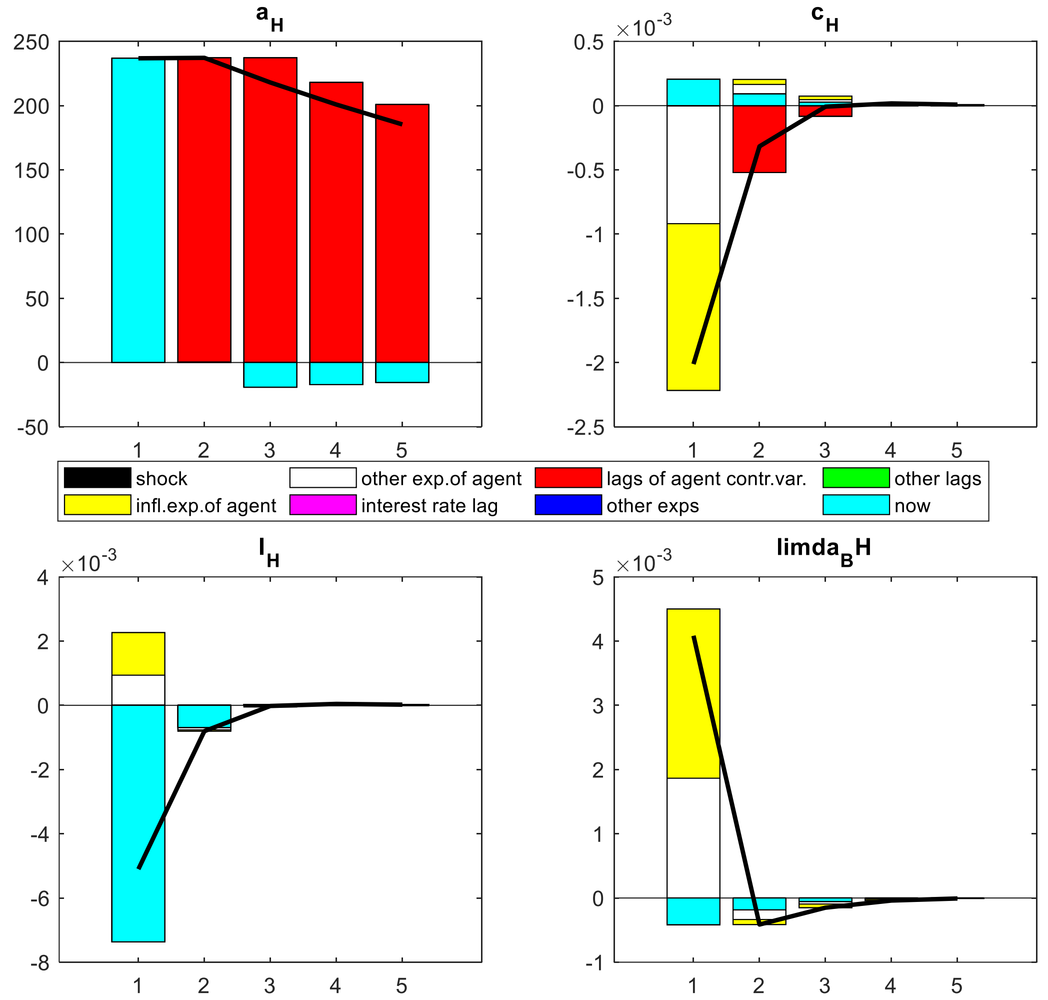
Note: The values in the cells contain the values of $IMP(x,T,s)$ for a given x (in a raw), T (in a column), s (in a sub column). Values in **bold** are the smallest values of $IMP(x,T,s)$ for a given T among different s.

As we can see, in the smaller model household expectations are the main driver of inflation dynamics in the real world.

To better understand the underlying drivers of this result, we consider IRF decomposition procedure.

We can distinguish effects of expectations and actions of other agents (firms, the government, and the central bank) if we look at the households' point of view - see Figure 9.

Figure 9. IRF decomposition to households' expectation shock from households' viewpoint.



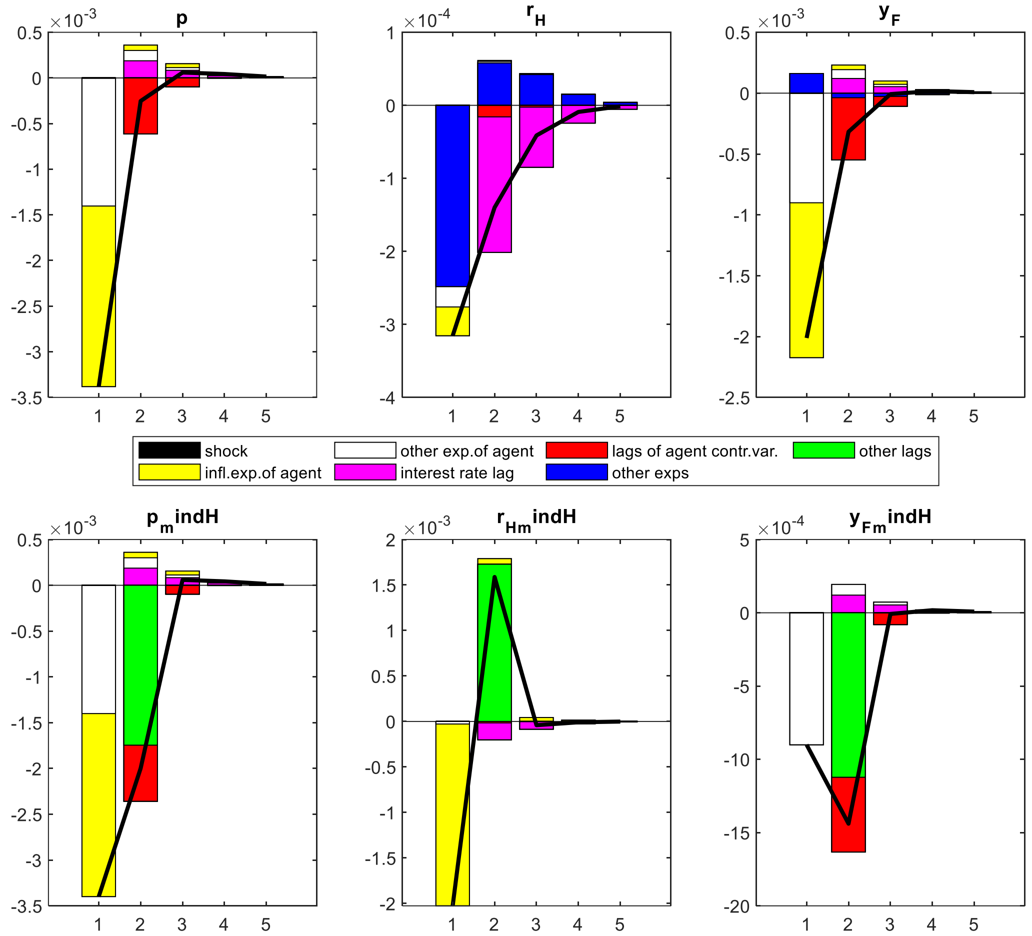
Note: The Figure shows four impulse responses of the households' decision set variables (a_H – asset demand, c_H – consumption, l_h – labor supply, lambda_BH – current shadow price of household's income) to a households' news shock (in Scheme B). Each IRF is decomposed into effects of: news-shock (black), households' inflation expectations (yellow), households' other expectations (white), lagged interest rate (purple), lagged other variables in households' decision set (red), others' expectations (blue), other variables' lags (green), current values of other model variables (cyan).

As the white and yellow bars show, changes of household consumption and Lagrange multiplier are driven initially by expectations. Inflation expectations (the yellow bars) explain a little bit more than a half of consumption reaction. Other half is explained by other expectations that are expectation of Lagrange multiplier. Monetary policy reaction (interest rate changes – purple bars) compensates households' consumption decisions partly.

At the same time, households' investment activity *a_H* (assets owned by households), and labor supply, *l_H*, are driven by other agents' reactions produced by households' expectation shock (cyan bars). These (cyan) reactions are result of households' impact on other agents. Nevertheless, the fact that wages react to a decreased demand *c_H* from households force them to decrease labor supply, *l_H*.

Then, we can look at the economy as a whole and decompose dynamics of inflation, the interest rate and GDP - see Figure 10. Unlike the households' view, this perspective includes how the rest of the economy responds to households' initial actions, showing interactions across sectors and agents. It reflects the cumulative responses of the entire economy, where households' initial expectation shocks influence other agents' decisions (firms' investment, central bank's interest rate setting, etc.) and these responses, in turn, feedback into households' decisions in subsequent period. The economy-wide view reveals the total general equilibrium effect of the households' expectation shock, which may significantly differ from households' initial perception. For example, the central bank's actual monetary policy response (interest rate change) can mitigate or amplify the initial shock, which households might not fully anticipate.

Figure 10. IRF decomposition to households' expectation shock from all economy viewpoint.



Note: The Figure shows six impulse responses of the economy variables to a households' news shock in the real and imaginary worlds (in Scheme B). The first row – are actual dynamics of the p – price level, r_H – interest rate, Y_f – firm's output after the shock. The second raw: the same three variables from the households' point of view. Each IRF is decomposed into effects of: news-shock (black), households' inflation expectations (yellow), households' other expectations (white), lagged interest rate (purple), lagged other variables in households' decision set (red), others' expectations (blue), other variables' lags (green).

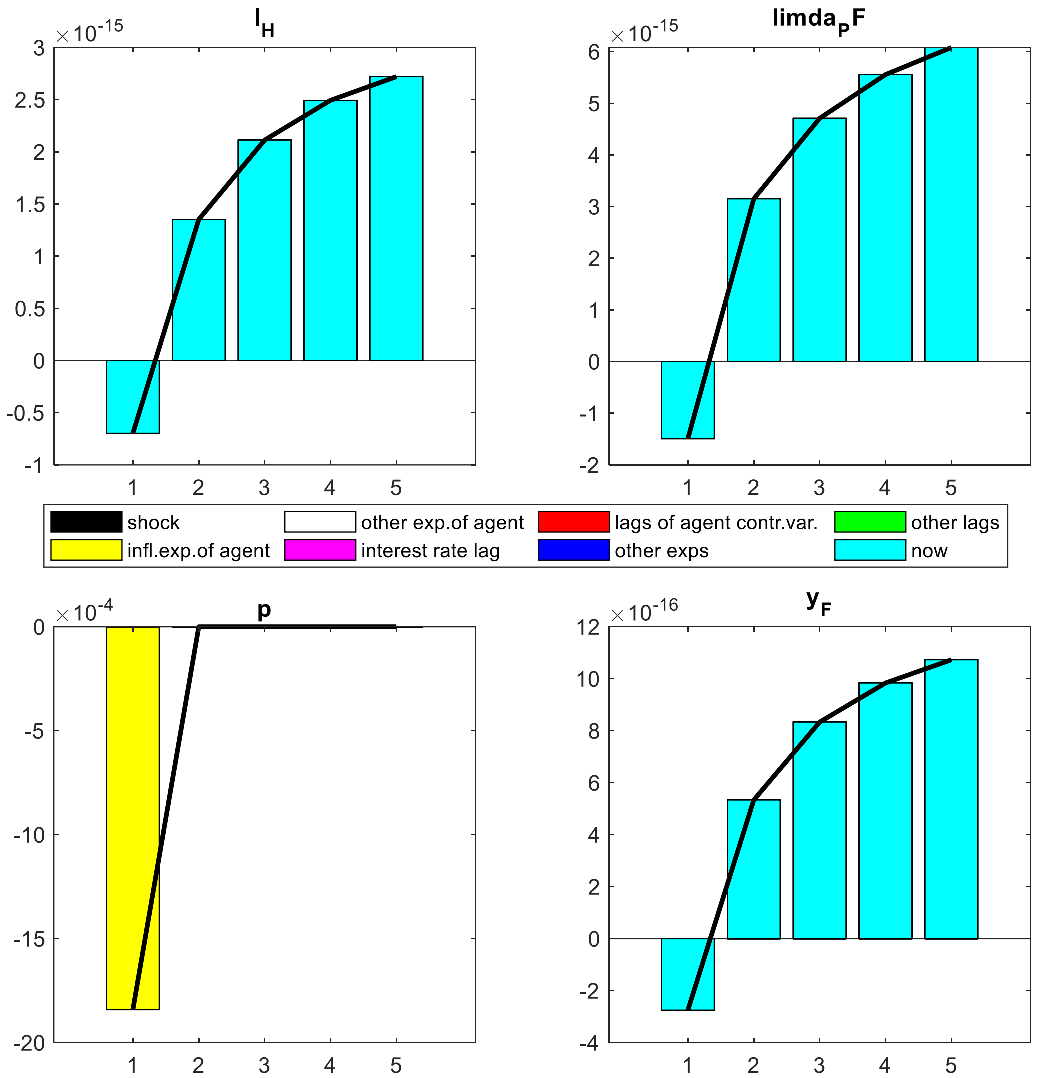
The economy wide view implies absence of current variable influence (comparing to the households' view on Figure 9). Output and consumption coincide in this model. The change of viewpoint leads to almost no change in the contribution of households' inflation expectation to the reaction of output (*y_F*), which is mostly driven by expectations. However, there is a large difference between sources of reaction of output to a news shock in households' mind and in reality (compare two rows in the third column in Figure 10). In households's mind it is mostly driven by lags of consumption and other variables as well as by other expectations. While in reality it is mostly driven by inflation expectations and, in the second period, by lags of consumption. Other variables' lags should have much more different effect in households' mind. But other agents' reaction on households' expectation shock is different from fantasy of households, thus creating a difference in output reaction in second period.

In other words, households' inflation expectations alter the general equilibrium by influencing aggregate demand, which moves inflation and interest rates, ultimately looping back to affect households' actual consumption path and employment. This feedback can make the realized inflation trajectory different from what households initially anticipated.

Important to note, that inflation in the economy is mostly driven by households' and other agents' inflation expectations.

Now we turn to firms' expectation shock. Formally firms control their own prices. But they are the same, so we use price level *p* as variable controlled by firms for decomposition purpose. **Figure 11** shows impulse responses of labor demand (*l_H*), prices (p), output (y_F) and shadow price of firm's profit (lambda_pF) from the viewpoint of firms. As can be seen from Figure 11, firms just react on current actions of the market. Only prices have some reaction on firms' expectation of inflation. Following lower expected inflation firms reduce their prices.

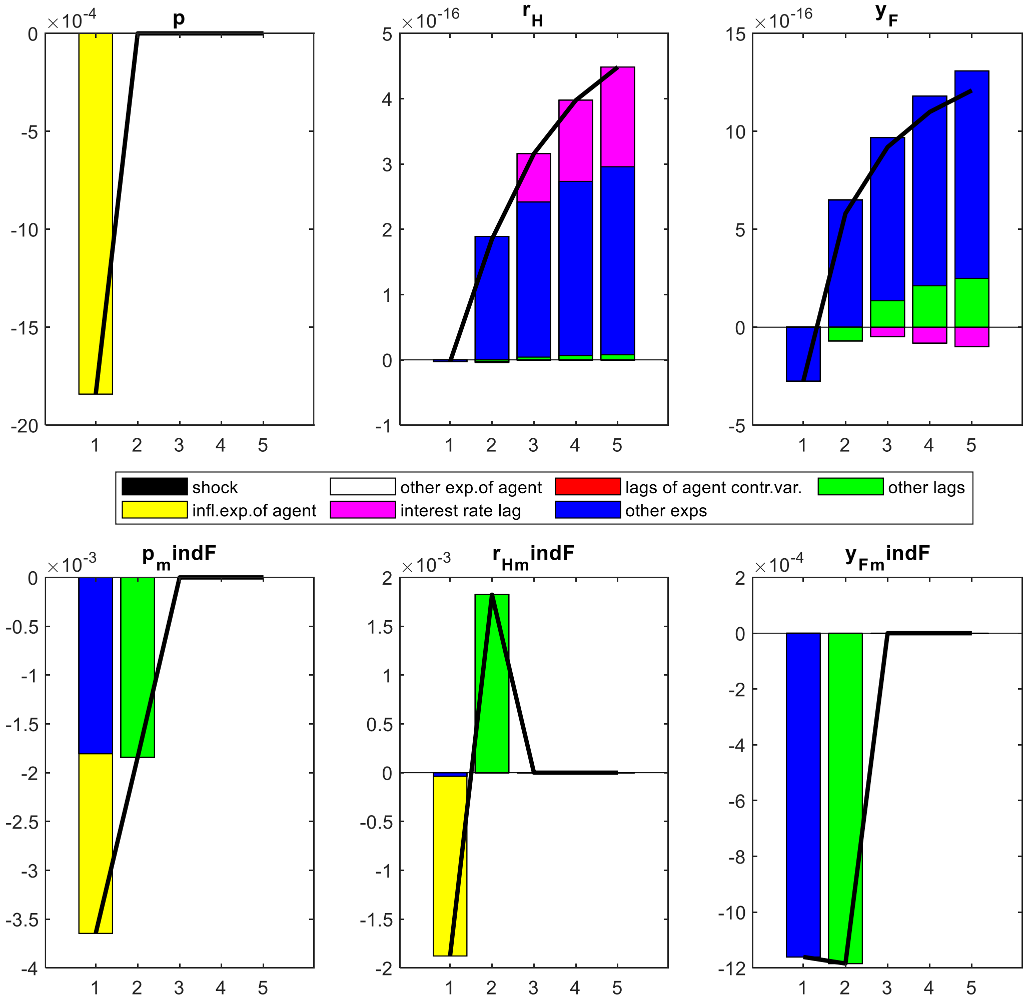
Figure 11. IRF decomposition to firms' expectation shock from firms' viewpoint



Note: The Figure shows four impulse responses of the firms' decision set variables (L_H – firm labor demand, p – firm prices, y_F – firm's output, lambda_pF – current shadow price of firm's profit) to a firms' news shock (in Scheme B). Each IRF is decomposed into effects of: news-shock (black), firms' inflation expectations (yellow), firms' other expectations (white), lagged interest rate (purple), lagged other variables in firms' decision set (red), others' expectations (blue), other variables' lags (green), current values of other model variables (cyan).

However, if we look at whole economy perspective – the picture would change, see Figure 12.

Figure 12. IRF decomposition to firms' expectation shock from the economy viewpoint



Note: The Figure shows six impulse responses of the economy variables to a firms' news shock (in Scheme B). The first row – are actual dynamics of the p – price level, r_H – interest rate, Y_f – firm's output after the shock. The second raw: the same three variables from the firms' point of view. Each IRF is decomposed into effects of: news-shock (black), firms' inflation expectations (yellow), firms' other expectations (white), lagged interest rate (purple), lagged other variables in firms' decision set (red), others' expectations (blue), other variables' lags (green), current values of other model variables (cyan).

Firms expect that the reaction of other economy would have similar effect on inflation as firms think. A change in firms' inflation expectations directly shifts their pricing, which immediately influences the price level (inflation) that households experience. The firms think that due to tighter monetary policy next period all others' inflation expectations should be lower (thus contributing to lower prices in the economy – blue bars on the left-low picture). And as a result of higher real interest rates the output should be lower. However, it does not happen. If such a firm's expectation change is not shared by other agents, its broader impact can be muted. The model shows that when only firms receive a disinflationary news shock (expecting lower inflation), they lower their prices, but other agents (households and the central bank) do not necessarily adjust their expectations or behavior in tandem. Absence of the economy wide changes in expected inflation leads to absence of central bank reaction on firms' expectation shock.

When households change their consumption based on expected inflation, firms feel the impact through shifting demand. For example, if households cut spending due to lower inflation expectations (higher real rates), firms face weaker sales and may respond by lowering production or cutting wages, which in turn forces households to adjust (e.g. reducing labor supply as their wages fall). In general equilibrium, a firm-driven expectation change might lead to a one-off price level adjustment (e.g. a modest dip in inflation if prices were cut) but no sustained inflation spiral unless it influences household behavior or elicits a policy response. By contrast, a household-driven expectation change (especially if widespread) directly alters demand and can induce persistent changes in inflation and policy rates. Thus, one key difference is that household expectation shocks tend to propagate through the economy via demand and trigger broader adjustments, whereas firm expectation shocks have a more direct but contained effect – powerful if reinforced by others, but limited if they occur in isolation.

Thus, the firms' news shock is less important in this economy for the inflation dynamics than that of households'. Household expectation shifts often lead to broader, more persistent changes in inflation (via the demand channel), albeit with outcomes that even households couldn't predict perfectly, while firm expectation shifts lead to immediate price-level changes (via the supply channel) that can either be quickly neutralized or amplified depending on the response of other agents.

4.2 Results for a large-scale model

4.2.1 Measuring importance of agents' inflation expectations

We start with the Scheme A. The Expectation importance measure (equation 36) for Scheme A is calculated in Table 3, while the IRFs for its calculations are presented in Appendix 5.

Raws of the Table 3 show a variable *x* - for which the response to a news shock is calculated. Columns represent the lengh of the IRF's horizon – T=5, T=10, T=15 and T=20 in equation 36. Sub columns with three news shocks (s1, s2, s3) – represent a particular type of agents' news shock.

Table 3. The measure of importance of agents' inflation expectations in Scheme A.

	5 periods			10 periods			15 periods			20 periods		
	er_R_new s1	er_R_new s2	er_R_new s3	er_R_new s1	er_R_new s2	er_R_new s3	er_R_new s1	er_R_new s2	er_R_new s3	er_R_new s1	er_R_new s2	er_R_new s3
asset_house	0.983	1.019	**0.000**	0.695	0.721	**0.000**	0.567	0.588	**0.000**	0.491	0.510	**0.000**
b_G	0.489	0.266	**0.164**	0.346	0.188	**0.116**	0.282	0.154	**0.095**	0.245	0.133	**0.082**
b_W	0.968	1.056	**0.021**	0.684	0.747	**0.015**	0.559	0.610	**0.012**	0.484	0.528	**0.011**
bc_F	**0.383**	0.854	0.721	**0.271**	0.604	0.510	**0.221**	0.493	0.416	**0.192**	0.427	0.360
bc_H	0.975	0.994	**0.002**	0.690	0.703	**0.002**	0.563	0.574	**0.001**	0.488	0.497	**0.001**
bd_F	0.394	**0.030**	0.146	0.279	**0.021**	0.103	0.228	**0.017**	0.084	0.197	**0.015**	0.073
bd_H	0.381	**0.028**	0.147	0.269	**0.020**	0.104	0.220	**0.016**	0.085	0.190	**0.014**	0.074
c	0.060	0.128	**0.036**	0.042	0.091	**0.025**	0.034	0.074	**0.021**	0.030	0.064	**0.018**
fx	0.609	0.371	**0.057**	0.431	0.262	**0.041**	0.352	0.214	**0.033**	0.305	0.186	**0.029**
i_F	0.884	0.128	**0.111**	0.625	0.090	**0.078**	0.511	0.074	**0.064**	0.442	0.064	**0.055**
k_B	0.970	1.060	**0.019**	0.686	0.750	**0.013**	0.560	0.612	**0.011**	0.485	0.530	**0.009**
k_F	0.383	0.051	**0.051**	0.271	0.036	**0.036**	0.221	0.030	**0.029**	0.192	0.026	**0.025**
l	0.019	0.036	**0.008**	0.013	0.026	**0.006**	0.011	0.021	**0.005**	0.010	0.018	**0.004**
p	0.351	0.335	**0.003**	0.248	0.237	**0.002**	0.203	0.193	**0.002**	0.176	0.167	**0.001**
r_BW	0.936	1.020	**0.021**	0.662	0.721	**0.015**	0.540	0.589	**0.012**	0.468	0.510	**0.010**
r_G	0.289	**0.026**	0.094	0.204	**0.018**	0.067	0.167	**0.015**	0.054	0.144	**0.013**	0.047
rc_F	0.294	**0.021**	0.061	0.208	**0.015**	0.043	0.169	**0.012**	0.035	0.147	**0.011**	0.030
rc_H	1.171	1.146	**0.019**	0.828	0.810	**0.013**	0.676	0.662	**0.011**	0.586	0.573	**0.009**
rd_F	0.092	**0.008**	0.056	0.065	**0.006**	0.039	0.053	**0.005**	0.032	0.046	**0.004**	0.028
rd_H	0.107	**0.009**	0.067	0.076	**0.006**	0.047	0.062	**0.005**	0.039	0.054	**0.005**	0.033
w	**0.003**	0.016	0.011	**0.002**	0.012	0.008	**0.002**	0.009	0.006	**0.002**	0.008	0.005
x_H	0.305	0.302	**0.006**	0.216	0.213	**0.004**	0.176	0.174	**0.004**	0.153	0.151	**0.003**
y_D	0.011	0.021	**0.005**	0.008	0.015	**0.003**	0.006	0.012	**0.003**	0.005	0.010	**0.002**

Note: The values in the cells contain the values of $IMP(x,T,s)$ for a given x (in a raw), T (in a column), s (in a sub column). Values in **bold** are the smallest values of $IMP(x,T,s)$ for a given T among different s.

From table 3 we can infer, that third news shock (to the banks) leads to most powerful spillovers of the agents' expectations (banks' in this case) into inflation at all horizons.

Expectation shock importance measure for Scheme B is calculated in Table 4, the IRFs for Scheme B are presented in Appendix 6.

Table 4. The measure of importance of agents’ inflation expectations in Scheme B.

	5 periods			10 periods			15 periods			20 periods		
	er_R_new s1	er_R_new s2	er_R_new s3	er_R_new s1	er_R_new s2	er_R_new s3	er_R_new s1	er_R_new s2	er_R_new s3	er_R_new s1	er_R_new s2	er_R_new s3
asset_house	1.26	1.67	**0.81**	0.89	1.18	**0.57**	0.73	0.96	**0.47**	0.63	0.84	0.40
b_G	0.98	1.39	**0.14**	0.69	0.98	**0.10**	0.57	0.80	**0.08**	0.49	0.69	0.07
b_W	1.27	1.80	**0.87**	0.90	1.27	**0.61**	0.73	1.04	**0.50**	0.64	0.90	0.43
bc_F	**0.86**	1.17	1.00	**0.61**	0.83	0.71	**0.50**	0.68	0.58	**0.43**	0.59	0.50
bc_H	1.26	1.68	**0.77**	0.89	1.19	**0.55**	0.73	0.97	**0.45**	0.63	0.84	0.39
bd_F	1.16	0.81	**0.43**	0.82	0.57	**0.30**	0.67	0.47	**0.25**	0.58	0.40	0.21
bd_H	1.15	0.86	**0.43**	0.82	0.61	**0.31**	0.67	0.50	**0.25**	0.58	0.43	0.22
c	0.22	0.41	**0.19**	0.15	0.29	**0.13**	0.12	0.23	**0.11**	0.11	0.20	0.10
fx	1.15	**0.91**	2.61	0.81	**0.64**	1.85	0.66	**0.52**	1.51	0.58	**0.45**	1.31
i_F	4.14	3.01	**0.85**	2.92	2.13	**0.60**	2.39	1.74	**0.49**	2.07	1.51	0.43
k_B	1.26	1.82	**0.78**	0.89	1.28	**0.55**	0.73	1.05	**0.45**	0.63	0.91	0.39
k_F	0.85	1.03	**0.49**	0.60	0.73	**0.35**	0.49	0.60	**0.28**	0.43	0.52	0.25
l	0.06	0.10	**0.05**	0.04	0.07	**0.03**	0.03	0.06	**0.03**	0.03	0.05	0.02
p	0.75	1.61	**0.23**	0.53	1.14	**0.17**	0.43	0.93	**0.14**	0.37	0.81	0.12
r_BW	**1.24**	1.56	3.51	**0.88**	1.10	2.48	**0.72**	0.90	2.03	**0.62**	0.78	1.76
r_G	0.48	**0.10**	0.20	0.34	**0.07**	0.14	0.28	**0.06**	0.11	0.24	**0.05**	0.10
rc_F	0.48	**0.04**	0.07	0.34	**0.03**	0.05	0.27	**0.02**	0.04	0.24	**0.02**	0.04
rc_H	1.23	1.61	**0.71**	0.87	1.14	**0.50**	0.71	0.93	**0.41**	0.61	0.80	0.35
rd_F	0.25	**0.05**	0.14	0.18	**0.03**	0.10	0.15	**0.03**	0.08	0.13	**0.02**	0.07
rd_H	0.28	**0.07**	0.17	0.20	**0.05**	0.12	0.16	**0.04**	0.10	0.14	**0.03**	0.09
w	**0.02**	0.05	0.04	**0.01**	0.04	0.03	**0.01**	0.03	0.02	**0.01**	0.02	0.02
x_H	0.67	0.92	**0.29**	0.47	0.65	**0.21**	0.39	0.53	**0.17**	0.33	0.46	0.15
y_D	0.03	0.06	**0.02**	0.02	0.04	**0.02**	0.02	0.03	**0.01**	0.02	0.03	0.01

Note: The values in the cells contain the values of $IMP(x,T,s)$ for a given x (in a raw), T (in a column), s (in a sub column). Values in **bold** are the smallest values of $IMP(x,T,s)$ for a given T among different s.

In scheme B, banks’ news shock is also most important driver of inflation (at least at not very long horizons, like T=20).

4.2.2 Variance decomposition

It should be noted that estimated values of expectations shocks’ standard deviations are quite different. It is near zero (close to prior mode) for expectation shocks of households and firms (4.61e-4 for both). Usual monetary policy shock has the same variance. However, it is large for banks (4.72). The model has not any observable variables that allow clear distinguishing between these shocks. Such variances of shocks produce domination in variance decomposition of banks expectations shock – Table 5. That is why our main focus is mechanics of how expectation shocks transmit through the economy (through impulse response functions, IRFs), rather than solely relying on variance decomposition and their relative importance.

Table 5. Variance decomposition

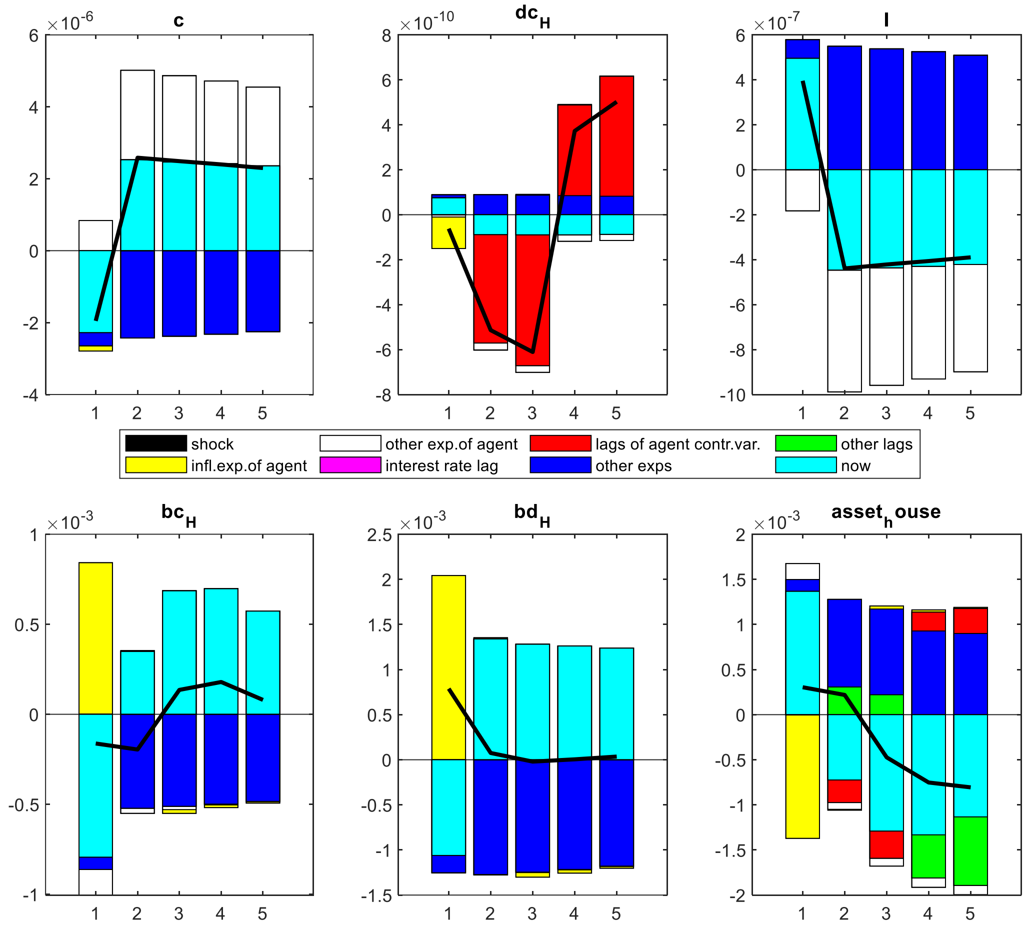
		MP+ household &banks expect	'er_R_news3'	Households related	Firms related	Banks related	World	Fiscal
unconditional	p	2.64E-07	2.23E+01	6.46E-03	7.73E+01	6.55E-04	1.98E-01	1.22E-01
	r_G	7.80E-07	7.61E+01	6.74E-03	2.36E+01	1.40E-03	2.75E-02	2.43E-01
	y	1.78E-07	3.79E+00	9.17E-02	9.50E+01	3.86E-05	9.40E-01	1.43E-01
	fx	1.52E-06	3.14E+01	4.53E-02	6.79E+01	4.17E-04	4.75E-01	1.38E-01
1-period	p	4.75E-10	7.65E-02	1.25E-04	9.17E-01	6.18E-06	5.22E-03	1.30E-03
	r_G	8.26E-09	8.87E-01	5.79E-05	1.10E-01	1.71E-05	2.76E-05	2.89E-03
	y	8.39E-09	3.63E-03	4.03E-04	9.85E-01	1.45E-07	6.84E-04	9.95E-03
	fx	4.22E-08	2.87E-01	4.65E-05	7.11E-01	6.05E-06	7.55E-05	2.16E-03
4-periods	p	2.63E-09	2.24E-01	6.02E-05	7.73E-01	6.51E-06	1.97E-03	1.21E-03
	r_G	7.93E-09	7.77E-01	5.00E-05	2.20E-01	1.44E-05	6.38E-05	2.48E-03
	y	3.69E-09	1.80E-02	6.51E-04	9.77E-01	1.71E-07	3.40E-04	3.90E-03
	fx	2.42E-08	4.89E-01	1.05E-04	5.09E-01	6.40E-06	5.65E-05	1.81E-03

Note: “unconditional variance decomposition" assesses the overall contribution of each type of shock to the long-run fluctuations of the variables in the second raw, without conditioning on specific time horizons or states of the economy. The columns display the proportion of the forecast error variance of the variables (p,r_G, etc.) that is attributed to expectation shocks from different economic agents: households, firms, and banks as well as to variation in other variables (world, fiscal).

4.2.3 Intuition for IRF: sensitiveness and decomposition

The analysis in the previous sections says nothing about the drivers behind the particular agents’ (e.g. banks’) expectations importance for inflation dynamics. That is why, here we describe results of the IRF decomposition, described in section 3.5. In this section we look at the decomposition plots for the main (the large scale) model (version B). Figures 13-14 shows decomposition of the household’s variables and the economy wide variables (in general equilibrium) to an expectation shock by households.

Figure 13. IRF decomposition to households' expectation shock from households' viewpoint.

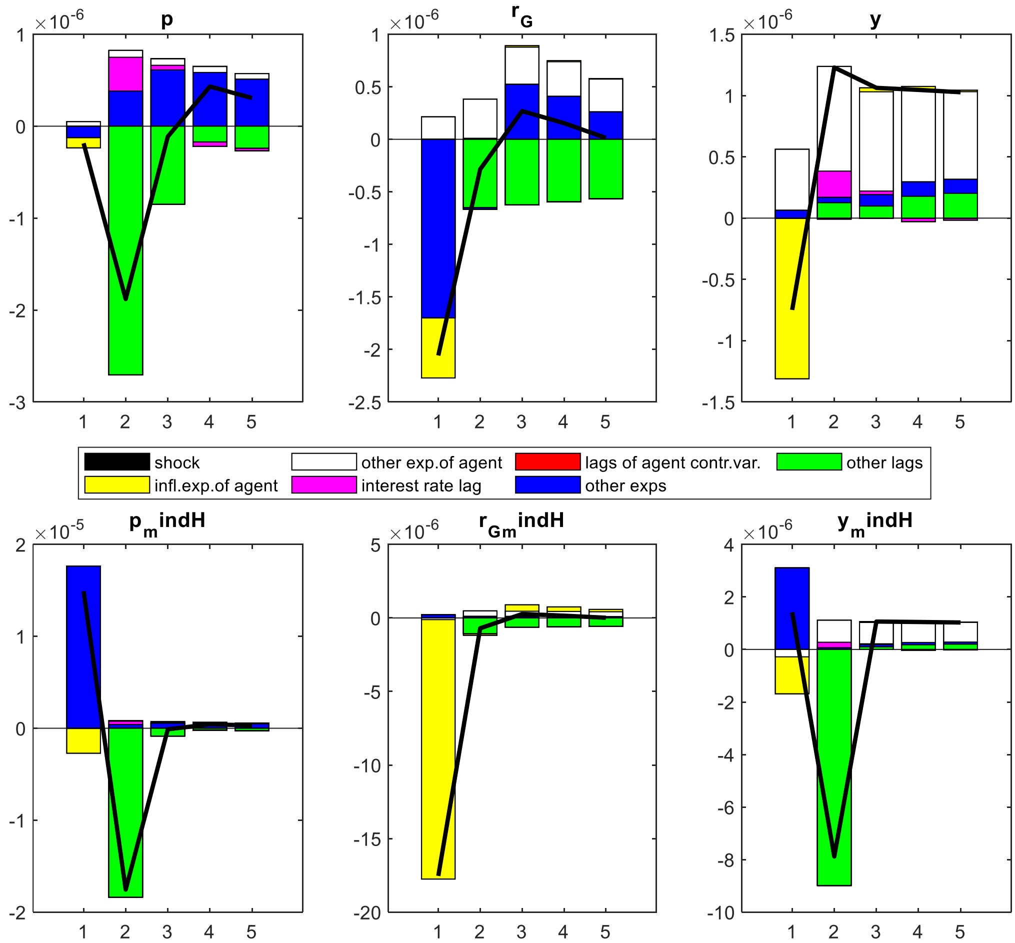


Note: The Figure shows six impulse responses of the households' decision set variables (c – consumption, dc_H – household's credit default rate, l – labor supply, bc_H – household loans, bd_H – household deposits, asset_H – asset demand) to a households' news shock (in Scheme B). Each IRF is decomposed into effects of: news-shock (black), households' inflation expectations (yellow), households' other expectations (white), lagged interest rate (purple), lagged other variables in households' decision set (red), others' expectations (blue), other variables' lags (green), current values of other model variables (cyan).

From Figure 13, we can see that responses of consumption and of labor supply are driven by the reaction of the rest of the economy (about 1/3) and expectations. Expected Lagrange multiplier and inflation expectations are important for deposit-credit dynamic at the first period only. After the first period other expectations and the rest of economy variables drive credit and deposit dynamics.

Current decisions of households are influenced by other economy reaction on its actions (produced by the expectation shock). Inflation expectation impacts households' assets only at the start. After that it is driven by other expectations and reactions of other economy. The important case is the default rate that is only driven by lags of households' decisions instead of their expectations.

Figure 14. IRF decomposition to households' expectation shock from the economy viewpoint.



Note: The Figure shows six impulse responses of the economy variables to a households' news shock (in Scheme B). The first row – are actual dynamics of the p – price level, r_G – interest rate, Y – GDP after the shock. The second raw: the same three variables from the households' point of view. Each IRF is decomposed into effects of: news-shock (black), households' inflation expectations (yellow), households' other expectations (white), lagged interest rate (purple), lagged other variables in households' decision set (red), others' expectations (blue), other variables' lags (green).

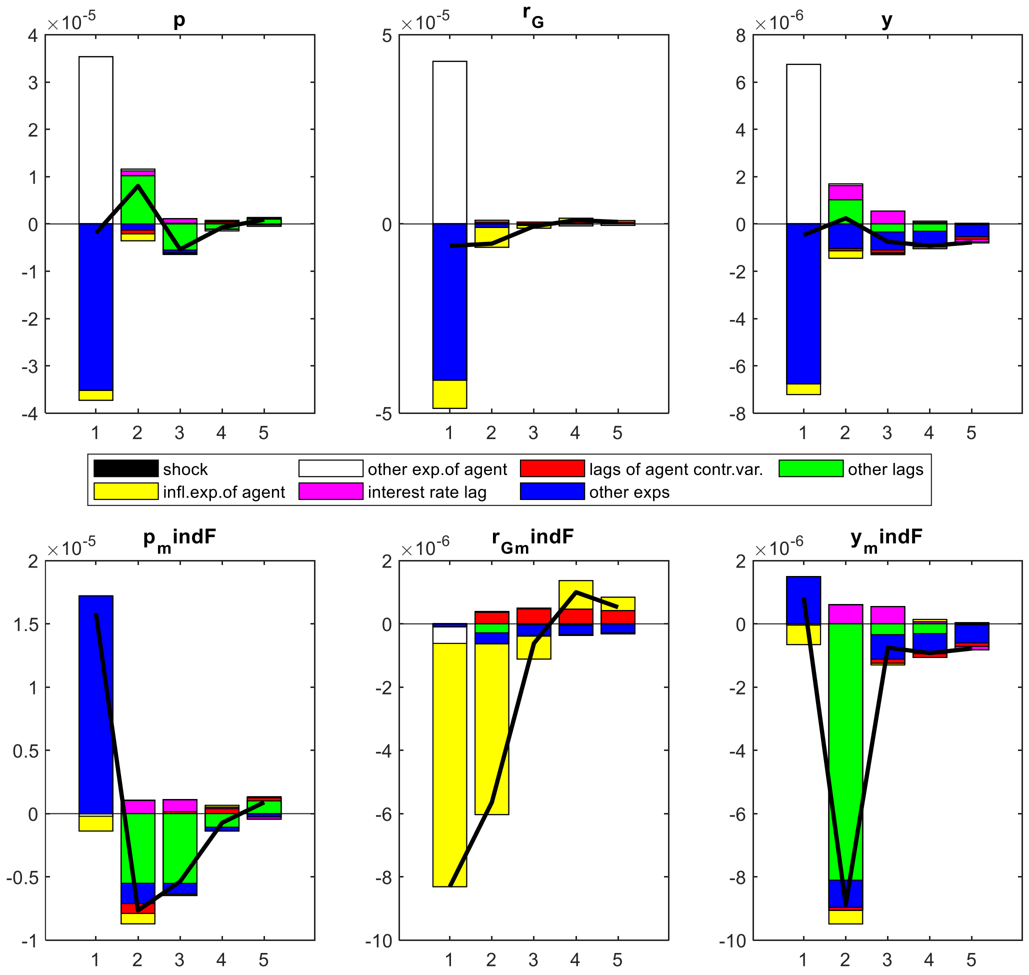
We can see from Figure 14 a large difference in impact of inflation expectations on the interest rate. Imaginary world suggests huge influence while real world demonstrate several times smaller influence.

Other expectations' impact is quite different in the real and imaginary worlds. The expectation shock leads to change of households' actions initially. However, the larger share of its effect is related to changes of expectations across the economy. Such actions move economy from steady-state and it needs time for back-convergence. It creates expected convergence trajectory that affects decisions in each period. It also moves variables (that are not controlled by households) from steady-state that also have large influence while lags of households' decisions itself have very small influence on the three key variables.

Inflation dynamics in great part results from other expectations and lagged values, not from the households' expectations.

The expectation shock of firms is explained on Figures 15-17.

Figure 15. IRF decomposition to firms' expectation shock from the economy viewpoint

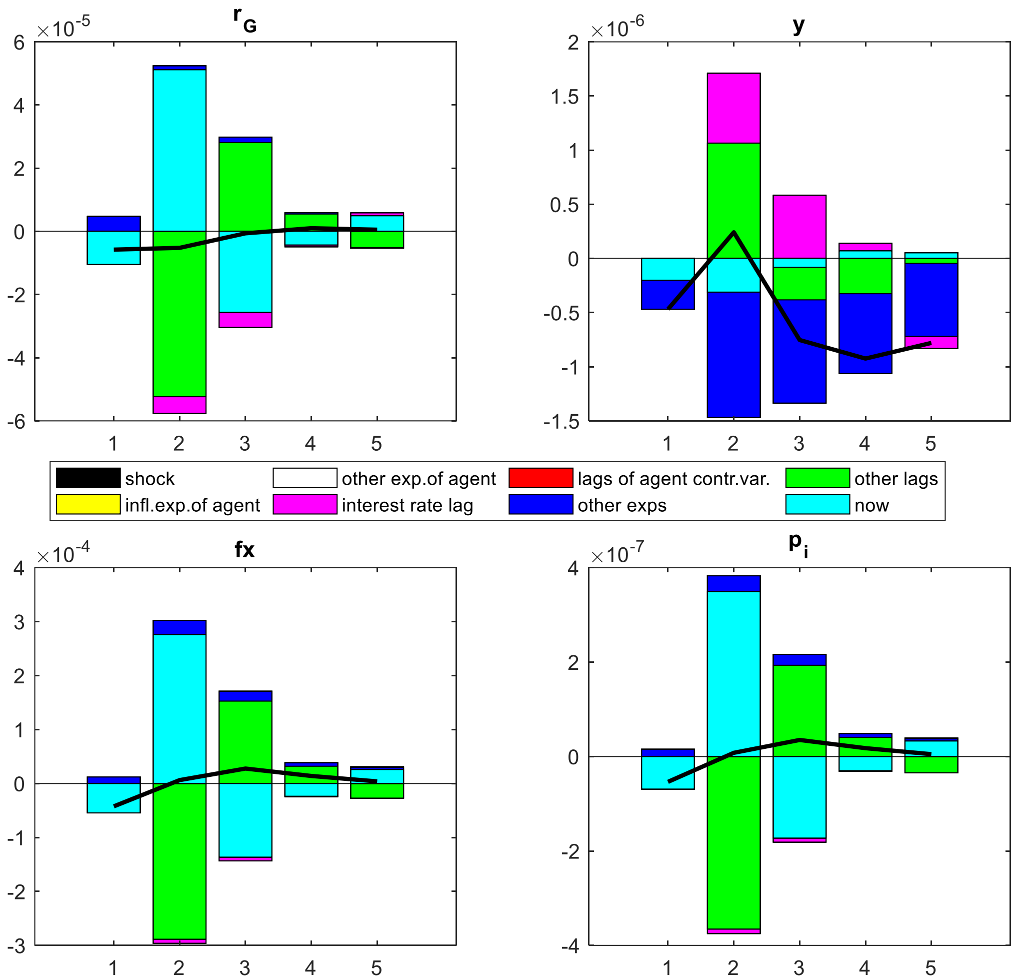


Note: The Figure shows six impulse responses of the economy variables to a firms' news shock (in Scheme B). The first row – are actual dynamics of the p – price level, r_G – interest rate, Y – GDP after the shock. The second raw: the same three variables from the firms' point of view. Each IRF is decomposed into effects of: news-shock (black), firms' inflation expectations (yellow), firms' other expectations (white), lagged interest rate (purple), lagged other variables in firms' decision set (red), others' expectations (blue), other variables' lags (green).

Figure 15 shows that similar to the household case, inflation expectations of firms play minor role in the inflation response. Firms' expectations have large impact on interest rates in imaginary world but small in the real one. Other expectations of firms play a crucial role for real world in the initial period. It includes Lagrange multipliers (including marginal costs and capital related ones). However, the impacts of these expectations of firms are compensated by other expectation. Lags of firms' decisions have not significant influence on key variables.

If we look at economy without firms (all equations and variables except related to firms) than picture would be different, Figure 16.

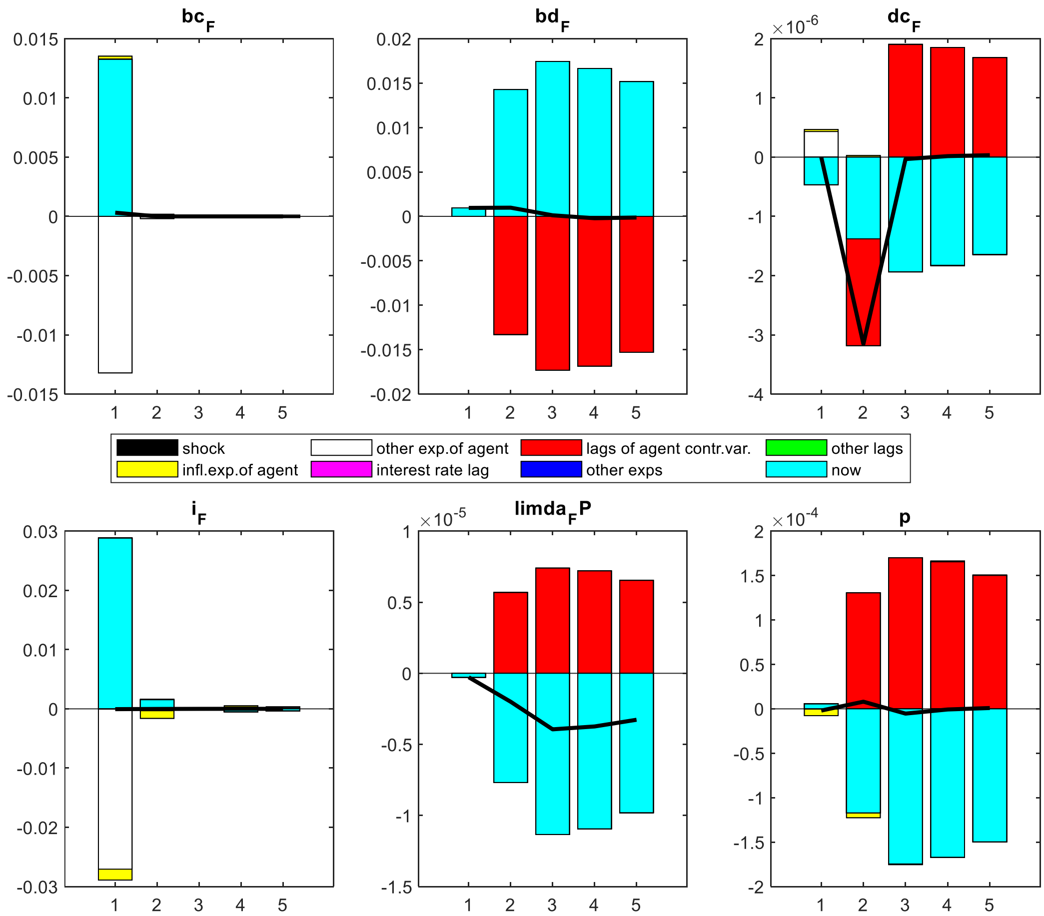
Figure 16. IRF decomposition to firms' expectation shock from the economy excluding firms' viewpoint



Note: The Figure shows four impulse responses of the economy variables except variables related to firms' decision set to a firms' news shock (in Scheme B). Each IRF is decomposed into effects of: news-shock (black), firms' inflation expectations (yellow), firms' other expectations (white), lagged interest rate (purple), lagged other variables in firms' decision set (red), others' expectations (blue), other variables' lags (green), current values of other model variables (cyan).

The firms control inflation due to the balance equation. The large impact of firms expectations on the interest rate and GDP disappear. The current decisions of firms are exogenous for this viewpoint. Firms' decisions are compensated by other variables lags.

Figure 17. IRF decomposition to firms' expectation shock from a firm's viewpoint



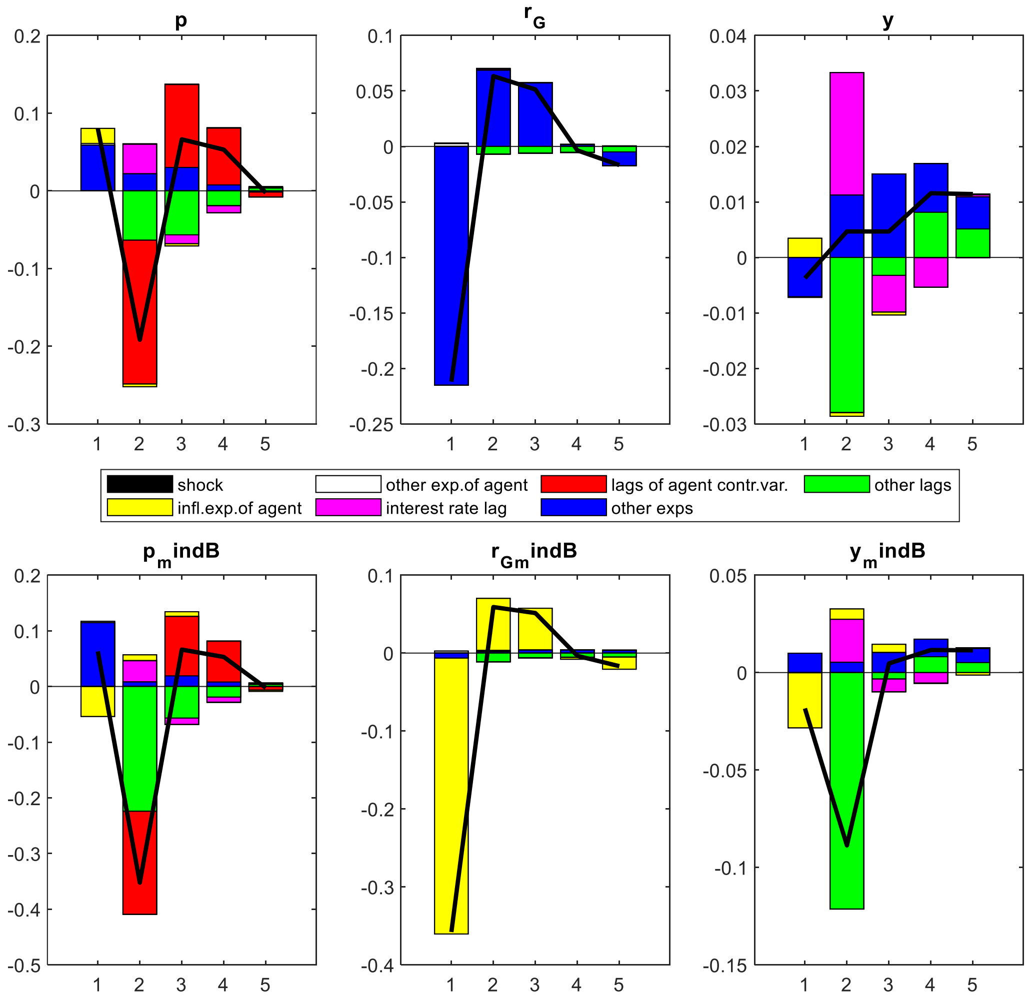
Note: The Figure shows five impulse responses of the variables from a firm's decision set to a firms' news shock (in Scheme B): bc_F – credit demand by a firm, bd_F – firm's deposits, dc_F- firm's default, i_F – firm's investments, lambdaF_P – Shadow price of firm's profit, p – firm's price. Each IRF is decomposed into effects of: news-shock (black), firms' inflation expectations (yellow), firms' other expectations (white), lagged interest rate (purple), lagged other variables in firms' decision set (red), others' expectations (blue), other variables' lags (green), current values of other model variables (cyan).

According to the Figure 17, firms think that their plans (expectations of variables controlled by firms) about loan demand and investments face contra-force from the rest of the economy. Inflation in eyes of a firm is a product of competing forces: the firm's lagged decisions and the current decisions of the rest economy.

These Figures illustrate the importance of a viewpoint selection (which effects are counted as endogenous or exogenous).

The last set of decompositions relates to banks' expectations shock (Figures 18-20).

Figure 18. IRF decomposition to banks' expectation shock from all economy viewpoint

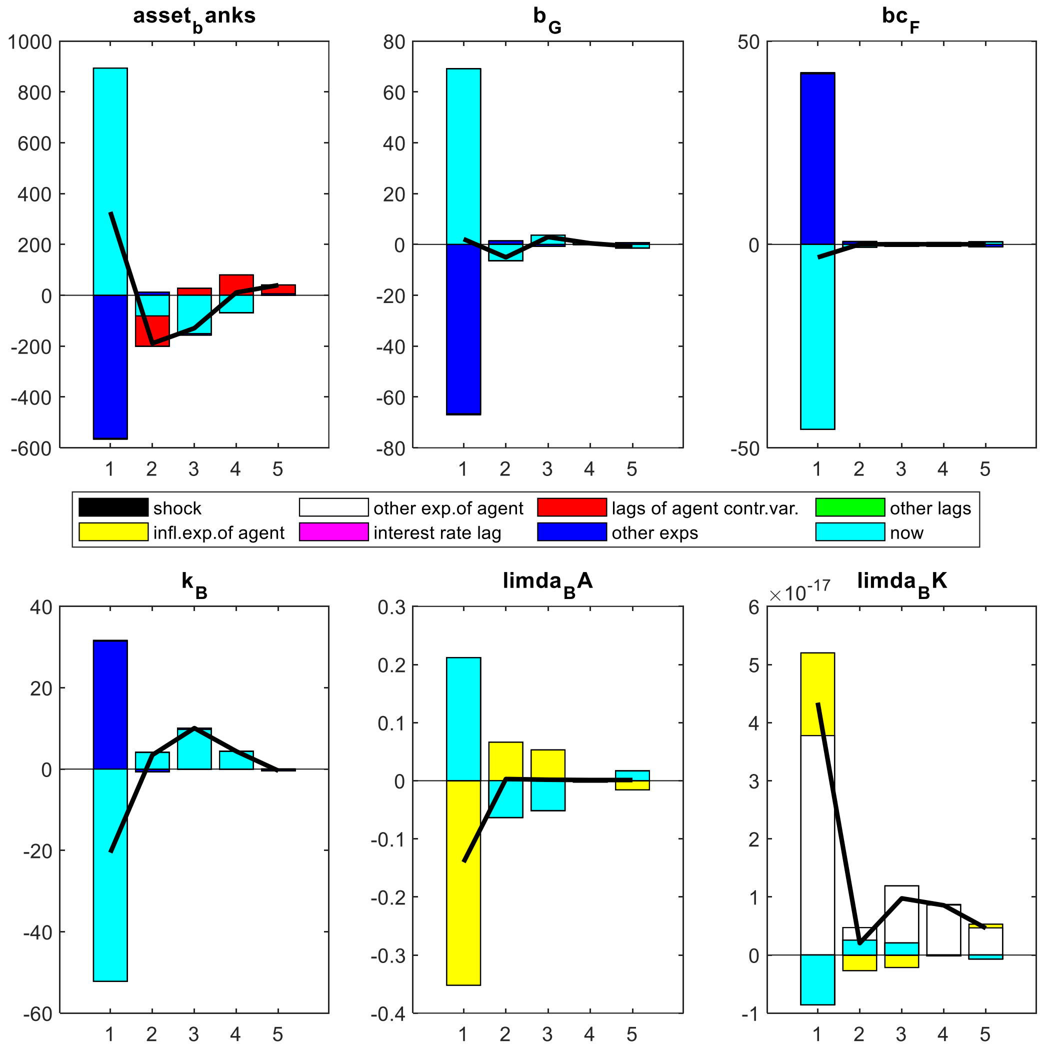


Note: The Figure shows six impulse responses of the economy variables to a banks' news shock (in Scheme B). The first row – are actual dynamics of the p – price level, r_G – interest rate, Y – GDP after the shock. The second raw: the same three variables from the banks' point of view. Each IRF is decomposed into effects of: news-shock (black), banks' inflation expectations (yellow), banks' other expectations (white), lagged interest rate (purple), lagged other variables in banks' decision set (red), others' expectations (blue), other variables' lags (green).

Figure 18 shows that banks decisions' lags have influence on inflation dynamics in contrast to firms and household cases. At the same time their expectations have not large *direct influence* on the three key variables, though the direct impact of their inflation expectations is larger comparing to that of other's agents.

Figure 19 shows the decomposition of a bank's decision set variables from the bank's viewpoint.

Figure 19. IRF decomposition to banks' expectation shock from a bank's viewpoint

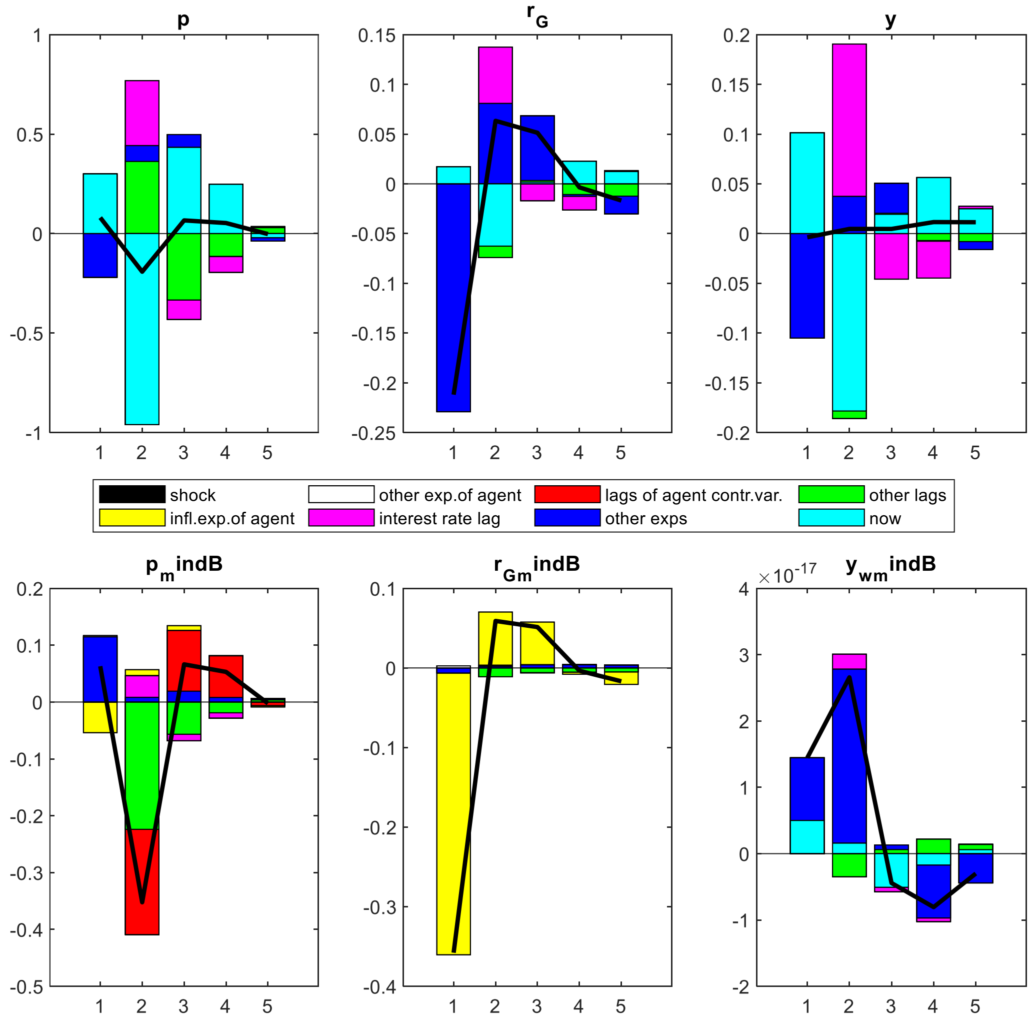


Note: The Figure shows six impulse responses of the variables from a bank's decision set to a banks' news shock (in Scheme B): asset_banks – bank's assets, b_G – passives from government/central bank, bc_F- loan supply to firms, k_B – bank's capital, lambdaB_A – Shadow price of bank's assets, lambda_K – shadow price of bank's capital. Each IRF is decomposed into effects of: news-shock (black), banks' inflation expectations (yellow), banks' other expectations (white), lagged interest rate (purple), lagged other variables in banks' decision set (red), others' expectations (blue), other variables' lags (green), current values of other model variables (cyan)

Viewpoint of banks reveal importance of inverse matrix A_0 existence in formula (38). If we look on equations related to banks and variables controlled by banks than A_0 would not be a full rank matrix. It can be understood why. Dividends, government bonds and foreign currency bonds appear only in the bank’s budget restriction and the capital definition. There is some nonlinearity of foreign currency debts. However, its effect is almost eliminated with first order approximation (Lagrange multiplayer related to capital restriction has zero steady-state). It means that banks indifferent between usage of government or foreign debts. They are risk-neutral in this sense. Thus, It makes impossible to see the viewpoint of banks. However, it is possible to make substitution that leads to full rank of matrix A_0. Instead of foreign currency bonds we use the exchange rate.

The view of economy excluding banks differs from all the economy view, see Figure 20.

Figure 20. IRF decomposition to banks' expectation shock from all economy ex banks viewpoint



Note: The Figure shows six impulse responses of the economy variables excluding banks variables to a banks' news shock (in Scheme B). The first row – are actual dynamics of the p – price level, r_G – interest rate, Y – GDP after the shock. The second raw: the same three variables from the banks' point of view. Each IRF is decomposed into effects of: news-shock (black), banks' inflation expectations (yellow), banks' other expectations (white), lagged interest rate (purple), lagged other variables in banks' decision set (red), others' expectations (blue), other variables' lags (green), current values of other model variables (cyan).

Comparing to the whole economy view (Figure 18), lags of banks decisions became much less important for inflation dynamics. It is substituted by current decisions of banks. Government controlled interest rate became much more important for inflation dynamics if we think that all banks' actions are exogenous. The influence of other lags changes as well (sometimes even sign of the effect).

To sum up, in general equilibrium, the initial demand push from households is quickly offset by firms' and banks' adjustments, so the direct contribution of household expectations to sustained inflation dynamics is minimal.

In the full general equilibrium, the actual inflation response to a firm expectation shock is muted – firms' own inflation expectations account for only a minor portion of the inflation movement. Other factors (like firms' expectations of costs/profits and the central bank's or other agents' responses) play a larger role initially, and even those firm-specific effects get compensated by the reactions of others in the economy. In other words, when firms expect higher inflation and act on it, the rest of the economy pushes back: the inflation outcome emerges from competing forces – the firm's price changes versus the counteracting responses of households, banks, and policy – largely canceling out the firm's direct influence. As a result, like households, firms' inflation expectations have only a limited direct effect on realized inflation under general equilibrium conditions.

Banks influence inflation through credit supply and interest-rate channels. When banks expect higher inflation, they may adjust lending, interest margins, and asset holdings, which affects money supply and demand conditions. A key difference is that banks' past decisions (lags) have a persistent impact on inflation dynamics, unlike the negligible lagged influence of household or firm decisions. For instance, if banks previously expanded credit, inflation can remain elevated for some time, and this inertia shows up strongly in the IRF decomposition.

In general equilibrium, the financial sector's expectation shocks propagate through interest rates and credit conditions, giving banks a relatively stronger and more sustained influence on inflation. If banks' actions are hypothetically held fixed (treating their lending/portfolio decisions as exogenous), the gap is filled by the central bank's policy – the policy interest rate would need to play a much bigger role to steer inflation. This finding underlines that, in the full model, banks' endogenous responses are an important transmission mechanism for inflation: their expectations shape credit and liquidity conditions in a way that materially affects the inflation path.

5. Robustness check and alternatives

As the robustness check, we change parameters to analyze the variation in the results[10]. Table 6 contains the results of the experiment when we change the parameters responsible for reliance of each type agents on their expectations. We increase and decrease role of households, and increase role of firms.

Table 6. Expectation shock importance (5 periods) for Scheme B: alternative parametrization

	Estimated			Households unimportant			Households important			Firms important		
	er_R_new s1	er_R_new s2	er_R_new s3	er_R_new s1	er_R_new s2	er_R_new s3	er_R_new s1	er_R_new s2	er_R_new s3	er_R_new s1	er_R_new s2	er_R_new s3
'asset_house'	1.258	1.670	**0.808**	1.299	2.147	**1.039**	1.268	1.689	**0.790**	**1.089**	9.950	15.567
'b_G'	0.979	1.388	**0.137**	0.721	1.274	**0.085**	1.168	15.551	**0.257**	**1.009**	6.489	8.887
'b_W'	1.271	1.795	**0.868**	1.298	2.163	**1.215**	1.284	1.661	**0.765**	**0.946**	2.742	14.005
'bc_F'	**0.864**	1.170	1.002	3.195	1.845	**0.249**	**1.045**	1.219	1.066	**0.728**	1.004	0.844
'bc_H'	1.265	1.683	**0.773**	1.255	2.157	**1.036**	1.278	1.642	**0.639**	**1.112**	16.175	8.014
'bd_F'	1.161	0.807	**0.426**	**0.990**	9.951	1.995	2.165	5.013	**0.817**	1.100	**0.874**	2.674
'bd_H'	1.153	0.860	**0.435**	**0.992**	9.608	1.949	1.871	3.215	**0.997**	1.093	**0.884**	2.944
'c'	0.215	0.407	**0.190**	1.061	1.016	**0.464**	**0.207**	0.385	1.170	0.125	0.360	**0.103**
'fx'	1.151	**0.906**	2.612	1.301	1.176	**1.135**	1.151	**0.922**	2.691	1.076	**0.641**	3.175
'i_F'	4.137	3.013	**0.853**	1.872	1.921	**0.769**	3.365	**2.066**	15.048	**1.026**	2.637	1.315
'l'	0.061	0.101	**0.047**	1.297	1.025	**0.923**	**0.032**	0.055	0.191	0.032	0.084	**0.024**
'p'	0.747	1.613	**0.234**	1.481	1.103	**0.459**	0.549	0.828	**0.329**	**0.386**	0.523	0.394
'r_BW'	**1.239**	1.560	3.511	**1.227**	1.859	2.601	**1.239**	1.465	2.639	**0.806**	1.278	3.335
'r_G'	0.482	**0.099**	0.197	1.422	0.260	**0.195**	0.360	**0.085**	0.358	0.525	**0.201**	0.465
'rc_F'	0.476	**0.038**	0.073	0.990	0.423	**0.226**	0.355	**0.064**	0.112	0.521	**0.141**	0.493
'rc_H'	1.228	1.607	**0.707**	1.265	2.112	**0.972**	1.237	1.571	**0.625**	**0.958**	3.538	3.438
'rd_F'	0.254	**0.047**	0.141	0.590	0.121	**0.120**	0.265	**0.029**	0.211	0.249	**0.064**	0.230
'rd_H'	0.277	**0.067**	0.174	0.664	0.135	**0.128**	0.299	**0.035**	0.184	0.253	**0.028**	0.296
'w'	**0.021**	0.050	0.039	0.433	0.558	**0.160**	0.021	**0.018**	0.059	**0.004**	0.017	0.012
'y_D'	0.031	0.057	**0.023**	1.030	0.916	**0.403**	**0.017**	0.031	0.105	0.021	0.058	**0.016**

Note: Households unimportant: ***omega_C= omega_L= omega_MB=2;*** *bc_H_SS=-0.85(est.1.15); fi_DCH= fi_MB=10*
Households important: ***omega_C=5; omega_L= omega_MB=45;*** *w_SS=-13 (est -4.4); m_H_SS=2.1 (est. 1.09);*
Firms important: ***fi_P=-0.5(est. -7.85); alfa_K=0.3(est. 0.439)****; SIG=0.04(est. 0.05); fi_MF=4; fi_BCF=10; nu0_BCF=0.71(est, 0.67); fi_BDF=6;*

The results show that banks' expectations keep playing important role in inflation dynamics, except for the case (on the margin) when firms' expectations become more rigid.
The results of the similar experiment in the smaller model are provided in the Table 7.

[10] Important: parameters changes often leads to break of BK conditions (unique non explosive solution).

Table 7. Expectation shock importance (5 periods). Small-scale model.

	Estimated		**fi_PF=15**		omega_C=omega_L= =omega_M=15 h=0.95		omega_C=1.2 omega_L=omega_M=1.01 h=0.0	
	er_R_newsH	er_R_newsF	er_R_newsH	er_R_newsF	er_R_newsH	er_R_newsF	er_R_newsH	er_R_newsF
a_H	0.470	**0.455**	**0.959**	1.265	0.578	**0.479**	**0.441**	0.456
c_H	**0.637**	1.172	**0.601**	1.172	**0.413**	0.722	**0.922**	1.191
d_F	**0.747**	1.195	**0.679**	1.195	**0.670**	1.213	**0.915**	1.181
l_H	**0.654**	1.227	**0.621**	1.227	**0.494**	0.975	**0.955**	1.235
limda_BF	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
limda_BH	1.365	**1.217**	**0.931**	1.217	11.511	**1.208**	**0.944**	1.221
limda_DF	**0.735**	1.244	**0.680**	1.244	**0.675**	1.245	**0.960**	1.242
limda_PF	**0.724**	1.247	**0.673**	1.247	**0.672**	1.245	**0.963**	1.246
m_H	**1.260**	1.264	**0.923**	1.239	2.016	**1.257**	**1.261**	1.264
p	**0.667**	0.899	1.19E-04	**1.18E-04**	**0.480**	0.892	**0.895**	0.898
p_C	0.000	**0.000**	0.000	**0.000**	0.000	**0.000**	0.000	**0.000**
p_F	0.000	**0.000**	0.000	**0.000**	0.000	**0.000**	0.000	**0.000**
r_H	**1.187**	1.204	**0.877**	0.887	1.830	**1.198**	**1.184**	1.204
tr_H	0.403	**0.323**	**0.991**	1.264	0.500	**0.345**	0.367	**0.325**
w_H	**0.761**	1.246	**0.696**	1.246	**0.681**	1.247	**0.962**	1.244
y_D	**0.637**	1.172	**0.601**	1.172	**0.413**	0.722	**0.922**	1.191
y_F	**0.637**	1.172	**0.601**	1.172	**0.413**	0.722	**0.922**	1.191

We find that many parameters have limited effect on expectation shock importance (due to fast decrease of marginal effect of parameter change).

Intuitively, higher rigidity of agents leads to higher importance of expectation shocks. It happens due to higher importance of expectations on current actions. Higher flexibility of agents leads to lower importance of expectation shocks.

Influence of steady-state changes is less obvious.

Steady-state of different variables are deeply nonlinear connected. It is also connected to some other parameters.

6. Conclusion

Our analysis demonstrates that a central bank must respond not only to changes in expectations that are justified by fundamentals, but also to non-rational, non-systematic expectation shocks arising from economic agents. Even seemingly unwarranted shifts in expectations can spill over into agents' decisions and thus propagate into actual inflation dynamics. Ignoring these expectation shocks would omit an important driver of short-run inflation fluctuations.

Moreover, we find notable heterogeneity across agent types in how their expectation shocks influence inflation. Expectation shocks originating from banks (financial intermediaries) exert the strongest and most predictable impact on realized inflation. Banks' internal forecasts of key macroeconomic variables tend to align more closely with actual outcomes, so when banks' expectations shift, their subsequent actions translate into inflation movements in a relatively systematic way. In contrast, expectation shocks from households and firms lead to economic responses that are largely unanticipated by those agents. The trajectories of inflation and output that households or firms have in mind often deviate significantly from the realized dynamics, in part because general equilibrium feedback effects counteract their initial expectations. When households or firms change spending and pricing based on incorrect beliefs, the broader economy adjusts (through price and income changes or policy reactions) in ways that offset what those agents originally expected, making the ultimate inflation outcome a surprise to them.

Our model's impulse response function (IRF) decomposition further illuminates these mechanisms. The results indicate that banks' lagged actions and expectation-driven decisions induce persistent effects on inflation. In other words, a shock to banks' expectations has a long-lived influence, as it not only moves prices immediately but also continues to shape inflation in subsequent periods through banks' ongoing adjustments. By contrast, households and firms affect inflation primarily through transient demand and price-setting channels. Their expectation shocks trigger short-lived changes—household consumption surges or firms' one-off price adjustments—that cause only temporary deviations in inflation. These differences underscore that financial-sector expectations are a key source of persistence in inflation, whereas non-financial agents' expectations mainly create brief inflationary or disinflationary impulses.

Collectively, these findings yield several policy implications for monetary authorities.

First, central banks should utilize expectations surveys and related measures to detect when agents' beliefs deviate from the rational benchmark. Timely identification of such expectation errors can help policymakers understand the sources of the deviations—be it misinformation, sentiment, or other frictions—and respond proactively to prevent unwarranted expectations from destabilizing inflation.

Second, communication efforts should focus especially on the financial sector. Aligning banks' expectations with the central bank's objectives is crucial because expectation misalignment in the banking sector has the most direct and potent effect on inflation outcomes. Clear guidance and credible policy signals aimed at financial institutions can thus quickly reinforce overall inflation stability.

Finally, policymakers must also closely monitor the expectations of households and firms. Even though these expectations are often less grounded in fundamentals and their effects on inflation are less predictable, they can still induce significant shifts in aggregate demand and price-setting behavior. Misguided expectations among consumers or businesses—such as an unfounded fear of high inflation—may lead to meaningful (if unexpected) changes in spending, wage demands, or price adjustments. A careful analysis of these channels is therefore necessary.

In sum, by accounting for the diverse expectation shocks across banks, firms, and households, central banks can better anchor inflation expectations and enhance the effectiveness of monetary policy in maintaining price stability.

REFERENCES

Adrian, Tobias, The Role of Inflation Expectations in Monetary Policy (2023), IBF / Deutsche Bundesbank Symposium, Remarks by Tobias Adrian, May 15, 2023

Andrade, P., & Le Bihan, H. (2013). Inattentive professional forecasters. Journal of Monetary Economics, 60(8), 967-982.

Angeletos, G. M., Huo, Z., & Sastry, K. A. (2021). Imperfect macroeconomic expectations: Evidence and theory. NBER Macroeconomics Annual, 35(1), 1-86.

Bachmann, Rüdiger, Tim O. Berg, and Eric R. Sims. 2015. "Inflation Expectations and Readiness to Spend: Cross-Sectional Evidence." American Economic Journal: Economic Policy, 7 (1): 1-35.

Beqiraj, Elton, Giovanni Di Bartolomeo , Marco Di Pietro and Carolina Serpieri (2020) Bounded rationality and heterogeneous expectations: Euler versus anticipated-utility approach // Journal of Economics, 2020, vol. 130, issue 3, No 2, 249-273

Binder, C. C. (2017). "Fed Speak on Main Street: Central Bank Communication and Household Expectations." Journal of Macroeconomics, 52, 238-251.

Branch, W. A. (2004). The theory of rationally heterogeneous expectations: evidence from survey data on inflation expectations. The Economic Journal, 114(497), 592-621.

Chou, Jenyu, Joshy Easaw and A. Patrick Minford (2023) Does inattentiveness matter for DSGE modeling? An empirical investigation // Economic Modelling, 2023, vol. 118, issue C

Cieslak, Anna, Semyon Malamud, and Andreas Schrimpf, “Optimal Transport of Information,” 2021. Working paper

Clarida, R., Gali, J., & Gertler, M. (1999). The science of monetary policy: a new Keynesian perspective. Journal of economic literature, 37(4), 1661-1707.

Coibion, O., Gorodnichenko, Y., & Ropele, T. (2020b). Inflation expectations and firm decisions: New causal evidence. The Quarterly Journal of Economics, 135(1), 165-219.

Coibion, O., Gorodnichenko, Y., Kumar, S., & Pedemonte, M. (2020a). Inflation expectations as a policy tool?. Journal of International Economics, 124, 103297.

Cornand, C., & Hubert, P. (2022a). Information frictions across various types of inflation expectations. European Economic Review, 146, 104175.

Cornand, C., & Hubert, P. (2022b). What lessons can we learn from the heterogeneity in inflation expectations among economic agents?

Disyatat, Piti (2011). The Bank Lending Channel Revisited. Journal of Money, Credit and Banking, 43(4), 711–734..

Doh, Taeyoung, JiHyung Lee, and Woong Yong Park. 2024. “Heterogeneity in Household Inflation Expectations: Policy Implications.” Federal Reserve Bank of Kansas City, Research Working Paper no. 24-06, July.

Dräger, L., & Nghiem, G. (2021). Are consumers spending decisions in line with a euler equation?. Review of Economics and Statistics, 103(3), 580-596.

Ferrando, A., & Grazzini, C. F. (2023). Monetary policy shocks and firms' bank loan expectations (No. 2838). ECB working paper.

Guerron-Quintana, P., Inoue, A., & Kilian, L. (2017). Impulse response matching estimators for DSGE models. Journal of Econometrics, 196(1), 144-155.

Ivashchenko (2013) Dynamic stochastic general equilibrium model with banks and endogenous defaults of firms. // Journal of the New Economic Association, 2013, vol. 19, issue 3, pages 27-50

Labus, M., & Labus, M. (2019). Monetary transmission channels in DSGE models: Decomposition of impulse response functions approach. Computational Economics, 53, 27-50.

Lieb, L., & Schuffels, J. (2022). Inflation expectations and consumer spending: the role of household balance sheets. Empirical Economics, 63(5), 2479-2512.

Link, S., Peichl, A., Roth, C., Wohlfart, J., 2021. Information Frictions Among Firms and Households. CESifo Working Paper, No. 8969
Loleyt, A., & Gurov, I. (2010). The Process of Inflation Expectations Formation. *Bank of Russia*.
Łyziak, T. (2013). Formation of inflation expectations by different economic agents: the case of Poland. Eastern European Economics, 51(6), 5-33.

Ma, Y., Paligorova, T., & Peydro, J. L. (2021). Expectations and bank lending. University of Chicago, Unpublished Working Paper.

Madeira, C., & Zafar, B. (2015). Heterogeneous inflation expectations and learning. Journal of Money, credit and Banking, 47(5), 867-896.

Mankiw, N. G., Reis, R., & Wolfers, J. (2003). "Disagreement about Inflation Expectations." NBER Macroeconomics Annual, 18 (1), 209-248.

Melosi, L. (2017). Signalling effects of monetary policy. *The Review of Economic Studies*, *84*(2), 853-884.

Mester, L. J. (2022, June). The role of inflation expectations in monetary policymaking: A practitioners perspective. In European Central Bank Forum on Central Banking: Challenges for Monetary Policy in a Rapidly Changing World, Sintra, Portugal.

Meyer, B., & Sheng, X. S. (2024). Unit cost expectations and uncertainty: Firms' perspectives on inflation.

Miyajima, K., & Yetman, J. (2019). Assessing inflation expectations anchoring for heterogeneous agents: analysts, businesses and trade unions. Applied Economics, 51(41), 4499-4515.

Pfajfar, D., & Santoro, E. (2010). Heterogeneity, learning and information stickiness in inflation expectations. Journal of Economic Behavior & Organization, 75(3), 426-444.

Reis, R. (2022). Losing the inflation anchor. Brookings Papers on Economic Activity, 2021(2), 307-379.

Reis, R. (2023). Expected Inflation in the Euro Area: Measurement and Policy Responses. Centre for Economic Policy Research.

Rondinelli, C., & Zizza, R. (2020). Spend today or spend tomorrow? The role of inflation expectations in consumer behaviour. The Role of Inflation

Expectations in Consumer Behaviour (April 27, 2020). Bank of Italy Temi di Discussione (Working Paper) No, 1276.

Roos, Michael (2017) Behavioral and complexity macroeconomics // European Journal of Economics and Economic Policies: Intervention, Vol. 14 No. 2, 2017, pp. 186–199.

Ropele, T., Gorodnichenko, Y., & Coibion, O. (2022). Inflation Expectations and Corporate Borrowing Decisions: New Causal Evidence (No. w30537). National Bureau of Economic Research.

Schwab, R. M. (1982). Inflation expectations and the demand for housing. The American Economic Review, 72(1), 143-153.

Slobodyan, Sergey and Raf Wouters (2012) Learning in a Medium-Scale DSGE Model with Expectations Based on Small Forecasting Models// American Economic Journal: Macroeconomics, 2012, vol. 4, issue 2, 65-101

Svensson, L. E. (2010). Inflation targeting. In Handbook of monetary economics (Vol. 3, pp. 1237-1302). Elsevier.

Walque G. de, Pierrard O., Rouabah A. (2010). Financial (in)stability, Supervision and Liquidity Injections: a Dynamic General Equilibrium Approach // Economic Journal. Vol. 120. No. 549. P. 1234–1261.

Wegner, E., Lieb, L., Smeekes, S., & Wilms, I. (2024). Transmission Channel Analysis in Dynamic Models. arXiv preprint arXiv:2405.18987.

Wróbel-Rotter, R. (2016). Impulse Response Functions in the Dynamic Stochastic General Equilibrium Vector Autoregression Model. Central European Journal of Economic Modelling and Econometrics, 93-114.

Evans, G. W., and S. Honkapohja. 2001. Learning and Expectations in Macroeconomics. Princeton, NJ: Princeton University Press.

Goy, G., Hommes, C., and Mavroeidis, S. 2023. "Behavioral Learning Equilibria in New Keynesian Models." Quantitative Economics, 14(3): 1083–1122. https://doi.org/10.3982/QE1533

Milani, F. 2007. "Expectations, Learning and the Changing Relationship Between Inflation and Output." Southern Economic Journal, 74(2): 367–385.

Eusepi, S., and Preston, B. 2011. "Expectations, Learning, and Business Cycle Fluctuations." American Economic Review, 101(6): 2844–2872. https://doi.org/10.1257/aer.101.6.2844

APPENDIX 1

Table A1. Variables and their description

Variable	Description	Stationary Transformation	Name in Code
C_t	Consumption of households	$C_t = \exp(c_t)\, Z_t$	c
$M_{H,t}$	Money (cash) of households	$M_{H,t} = \exp(c_t)\, Z_t P_t$	m_H
$P_{C,t}$	Price of consumption basket	$\log\left(\frac{P_{C,t}}{P_t}\right) = p_{c,t}$	p_c
P_t	Price of consumption basket -> inflation	$\log\left(\frac{P_t}{P_{t-1}}\right) = p_t$	p
$R_{DH,t}$	Interest rate for households deposits	$\log(R_{DH,t}) = r_{DH,t}$	rd_H
$R_{CH,t}$	Interest rate for households credits	$\log(R_{CH,t}) = r_{CH,t}$	rc_H
$X_{H,t}$	Share of equity of firms owned by households	$X_{H,t} = x_{H,t}$	x_H
$B_{DH,t}$	Amount of households deposits	$\log\left(\frac{B_{DH,t}}{Z_t P_t}\right) = b_{DH,t}$	bd_H
$B_{CH,t}$	Amount of households credits	$\log\left(\frac{B_{CH,t}}{Z_t P_t}\right) = b_{CH,t}$	bc_H
$P_{S,t}$	Price of domestic equity	$\log\left(\frac{P_{S,t}}{P_t Z_t}\right) = p_{S,t}$	p_s
W_t	Wage	$\log\left(\frac{W_t Z_{trL,t}}{P_t Z_t}\right) = w_t$	w
L_t	Labor supply	$\log\left(\frac{L_t}{Z_{trL,t}}\right) = l_t$	l
$D_{total,t}$	Total dividends of domestic firms	$\log\left(\frac{D_{total,t}}{P_t Z_t}\right) = d_{total,t}$	d_Total
$\tau_{L,t}$	Labor-wage tax	—	tax_L
$T_{G,t}$	Transfer from government	$\log\left(\frac{T_{G,t}}{P_t Z_t}\right) = \tau_{G,t}$	tr_G
$d_{CH,t}$	Share of households	—	dc_H

	defaults		
$Z_{l,t}$	Exogenous process with influence on labor disutility	$\log(Z_{l,t}) = z_{l,t}$	z_L
$Z_{MH,t}$	Exogenous process with influence on money demand	—	z_MH
$Z_{DCH,t}$	Exogenous process with influence on disutility of defaults	—	z_DCH
$Z_{dpayH,t}$	Exogenous process with influence on average payments after default	—	z_dpayH
Z_t	Real variables trend	—	z_ztemp_growth
$Z_{trY,t}$	Exogenous process of TFP growth	$\log\left(\frac{Z_{trY,t}}{Z_{trY,t-1}}\right) = z_{trY,t}$	z_trY
$Z_{trI,t}$	Exogenous process of capital construction efficiency growth	$\log\left(\frac{Z_{trI,t}}{Z_{trI,t-1}}\right) = z_{trI,t}$	z_trI
$Z_{trL,t}$	Exogenous process of labor growth	$\log\left(\frac{Z_{trL,t}}{Z_{trL,t-1}}\right) = z_{trL,t}$	z_trL
$\lambda_{BH,t}$	Lagrange multiplier for households budget	—	limda_HB
$Z_{\beta,t}$	Exogenous process of households discounting	—	z_bbb
$D_{f,t}$	Dividends of firms	$\log\left(\frac{D_{f,t}}{P_t Z_t}\right) = d_{F,t}$	d_F
$P_{I,t}$	Price for investment goods basket	$\log\left(\frac{P_{I,t} Z_{trI,t}}{Z_t}\right) = p_{I,t}$	p_i

$I_{f,t}$	Investments of firms	$\log\left(\frac{I_{f,t}}{Z_t}\right) = i_{F,t}$	i_F
$K_{B,t}$	Capital of bank	$\log\left(\frac{K_{B,t}}{P_t Z_t}\right) = k_{B,t}$	k_B
$B_{W,t}$	Foreign currency bonds issued by banks	$\frac{B_{W,t}}{Z_t P_{W,t}} = b_{W,t}$	b_W
FX_t	Exchange rates	$fx_t = \log\left(\frac{FX_t P_{W,t}}{P_t}\right)$	fx
$B_{G,t}$	Passives from government/central bank	$\frac{B_{G,t}}{Z_t P_t} = b_{G,t}$	b_G
RG_t	Interest rate for government debts		r_G
MB_t	Money(cash) of banks		m_B
ZKB_t	Exogenous process of desired credit to capital ratio		z_KB
ZMB_t	Exogenous process of desired money to deposits ratio		z_MB
$gpol_t$	“regime” of fiscal policy		g_policy
G_t	Government consumption		g
xG_t	Share(amount of equity) of firms owned by government		x_G
τoil_t	Taxes for oil		tax_oil
ex_t	Nonoil export		Ex
pex_t	Price level for exporting goods basket		p_ex
$poil_t$	Oil price in foreign currency		p_ex_oil
	Export of oil		ex_oil

$exoil_t$			
xW_t	Share (amount of equity) of firms owned by foreign sector		x_W
rw_t	Foreign interest rate		rf_w
pw_t	Foreign inflation		p_w
yw_t	Foreign output		y_w
im_t	Import		im
pim_t	Price of import (in domestic currency, after tax)		p_im
$pexD_t$	Competitive price for export		ex_D
exD_t	Demand for export		p_exD

APPENDIX 2

A small-scale model (a closed economy model)

Households

Target (utility) function:

$$U_t = E\left(\sum_{s=0}^{\infty}\beta^s\left(\frac{\left(C_{t+s}-hC_{h,t+s-1}\right)^{1-\omega_C}}{(1-\omega_C)}+\frac{\mu_M(M_{t+s})^{1-\omega_M}}{(1-\omega_M)}-\frac{\mu_L(L_{t+s})^{1+\omega_l}}{(1+\omega_l)}\right)\right)=\left(\left(\frac{\left(C_t-hC_{h,t-1}\right)^{1-\omega_C}}{(1-\omega_C)}+\frac{\mu_M(M_{t+s})^{1-\omega_M}}{(1-\omega_M)}-\frac{\mu_L(L_t)^{1+\omega_l}}{(1+\omega_l)}\right)\right)+$$

$$+E_t\beta U_{t+1}\rightarrow \max_{C,L,M}$$

Where:

$\frac{\left(C_{t+s}-hC_{h,t+s-1}\right)^{1-\omega_C}}{(1-\omega_C)}$ - consumption's contribution to utility, adjusted by a preference parameter ω_c and a habit in consumption $hC_{h,t+s-1}$.

$\frac{\mu_L(L_{t+s})^{1+\omega_l}}{(1+\omega_l)}$ - the function that captures this disutility from labor.

$\frac{\mu_M(M_{t+s})^{1-\omega_M}}{(1-\omega_M)}$ - represents the utility contribution from real liquidity (cash) held by the household.

Budget constraint:

$$P_tC_t + M_t + B_t/R_t = (1-\tau)W_tL_t + M_{t-1} + B_{t-1} + T_t$$

Where: P_tC_t - Households' expenditure on consumption; M_t - the new money holdings (cash) the household chooses to hold in period t. $B_t/R_{,t}$ - The net change in household assets, discounted by corresponding gross interest rates; $W_tL_t(1-\tau_t)$ - Labor income net of labor taxes; M_{t-1} - previous period's money holdings become available for use this period; B_{t-1} – previous period assets or liabilities (debt) become accessible in period t; $T_{G,t}$ - Government transfers (lump-sum or otherwise).

Firms

Target function:

$$E\left(\sum_{t=0}^{\infty}\left(\overset{k=0}{\underset{t-1}{\Pi}} R_k\right)^{-1}\left(D_{f,t} - e^{\phi_p} P_{F,t} Y_{D,t}\left(\frac{P_{f,t}}{P_{f,t-1}} - e^{\overline{p}}\right)^2\right)\right) \to \max_{D,L,Y}$$

Where: $D_{f,t}$ – firm's dividends, $e^{\phi_p} P_{F,t} Y_{D,t}\left(\frac{P_{f,t}}{P_{f,t-1}} - e^{\overline{p}}\right)^2$ – firm's quadratic costs for a price adjustment; $P_{f,t}$ - price of the firm's product.

Budget constraint:

$$D_{f,t} + W_t L_{f,t} = P_{f,t} Y_{f,t}$$

Where: $W_t L_{f,t}$ – labor costs for a firm, $P_{f,t} Y_{f,t}$ – firm's revenue.
Production function contains two productivity parameters (trends) $Z_{trY,t}$ and $Z_{Y,t}$, and the only factor of production – labor:

$$Y_{f,t} = Z_{trY,t} Z_{Y,t} \left(L_{f,t}\right)^{1-\alpha_k}$$

Demand function depends on relative price of the firm's output $P_{f,t}$ to other firms' prices $P_{F,t}$:

$$Y_{f,t} = \left(\frac{P_{f,t}}{P_{F,t}}\right)^{-z_{\theta,t}} Y_{D,t}$$

Government

Budget:

$$B_{t-1} + T_t = D_t + M_t - M_{t-1} - B_t/R_t + \tau(W_t L_t)$$

Fiscal policy:

$$T_t/\left(P_t Z_{trY,t}\right) = \gamma_{tr} T_{t-1}/\left(P_{t-1} Z_{trY,t-1}\right) + (1-\gamma_{tr})\left(\gamma_{try}\left(y_{D,t} - \overline{y_D}\right) + z_{tr,t}\right)$$

Monetary policy:

$$r_{H,t} = \gamma_r r_{H,t-1} + (1-\gamma_r)\left(\gamma_{rp} E_t(p_{t+1} - \overline{p}) + \gamma_{ry}\left(y_{D,t} - \overline{y_D}\right) + z_{r,t}\right)$$

Balances:

$$Y_{f,t} = C_t$$
$$L_{f,t} = L_t$$

APPENDIX 3

Time-series diagrams for each observed variables

Figure A2.1 Time-series plot

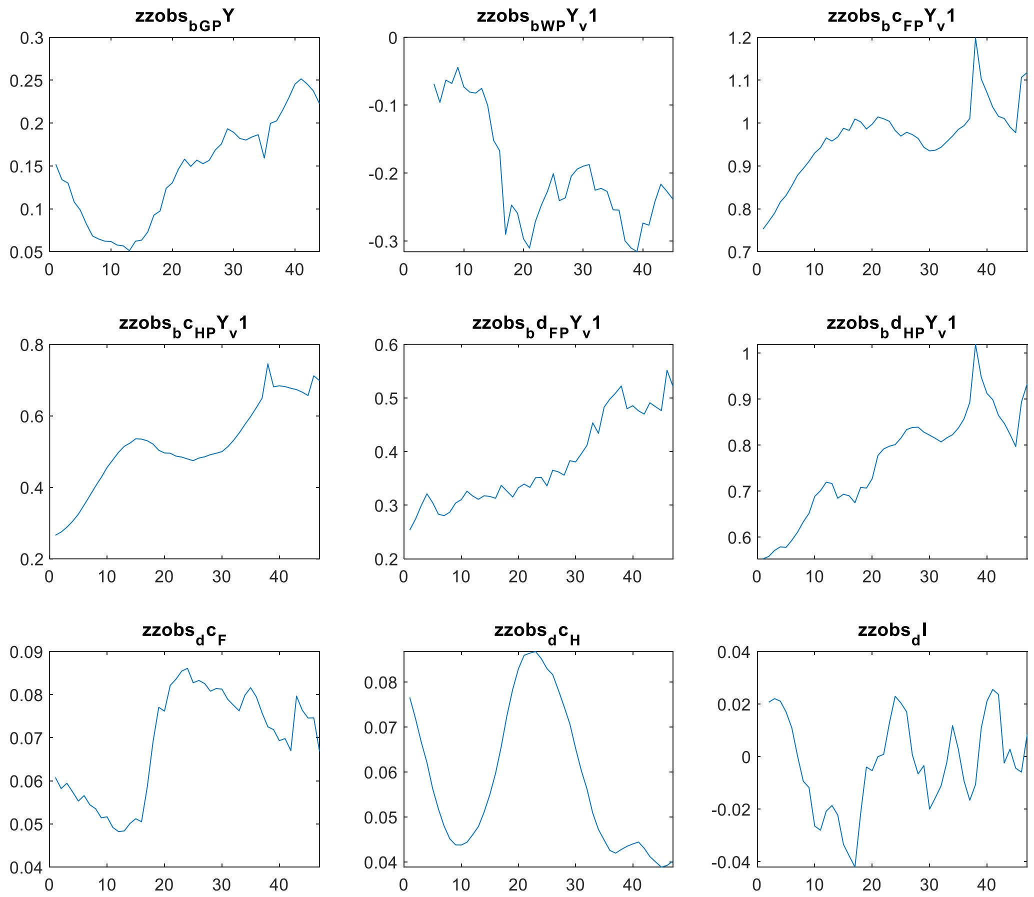


Figure A2.2 Time-series plot

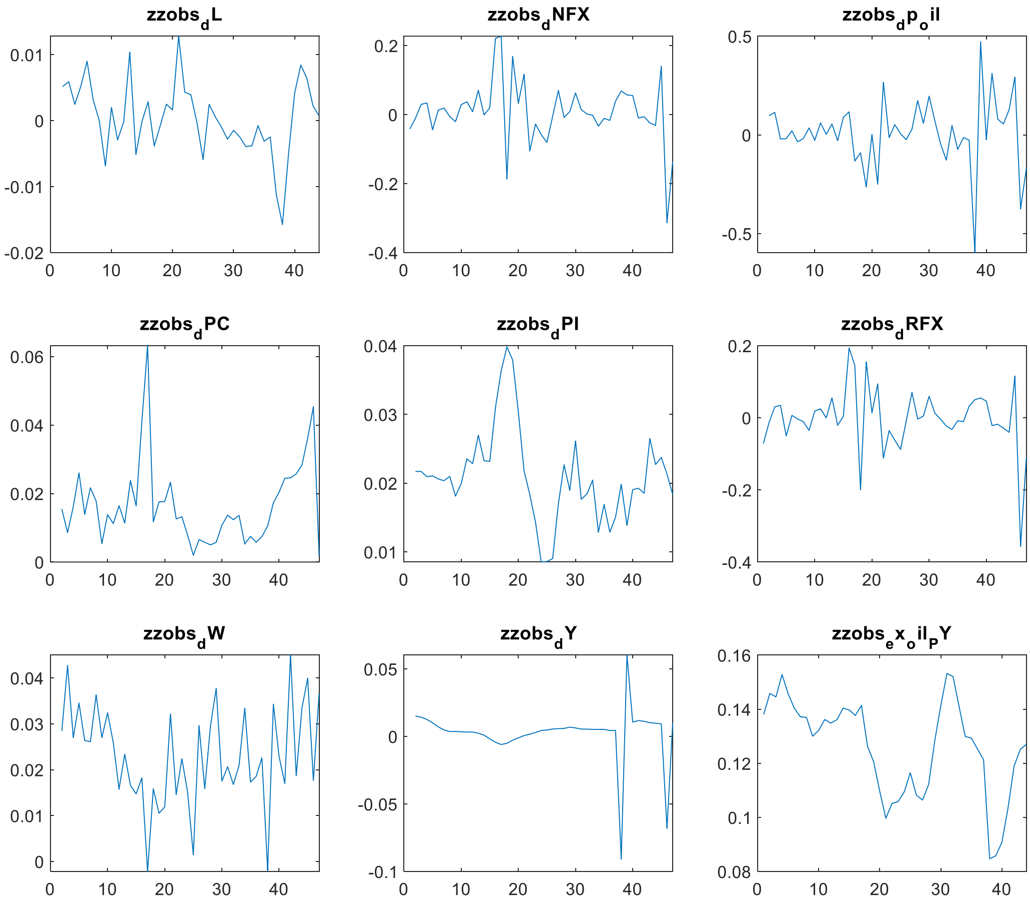


Figure A2.3 Time-series plot

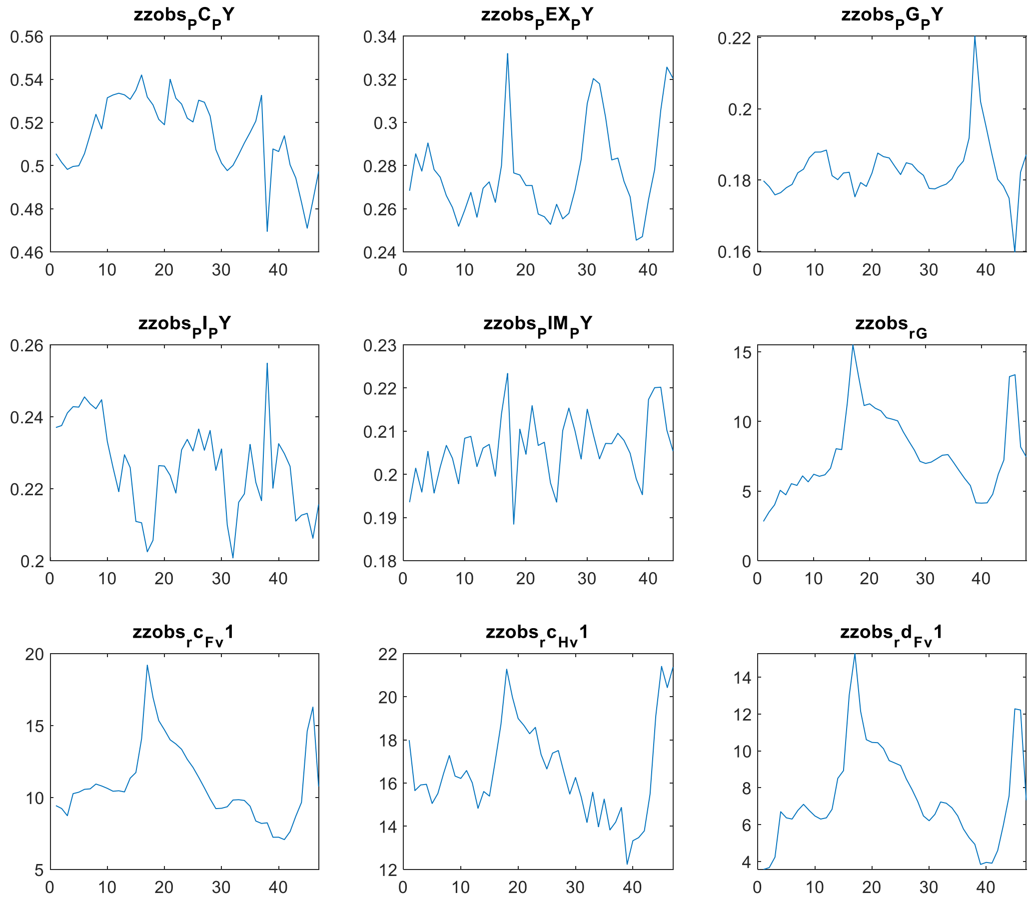
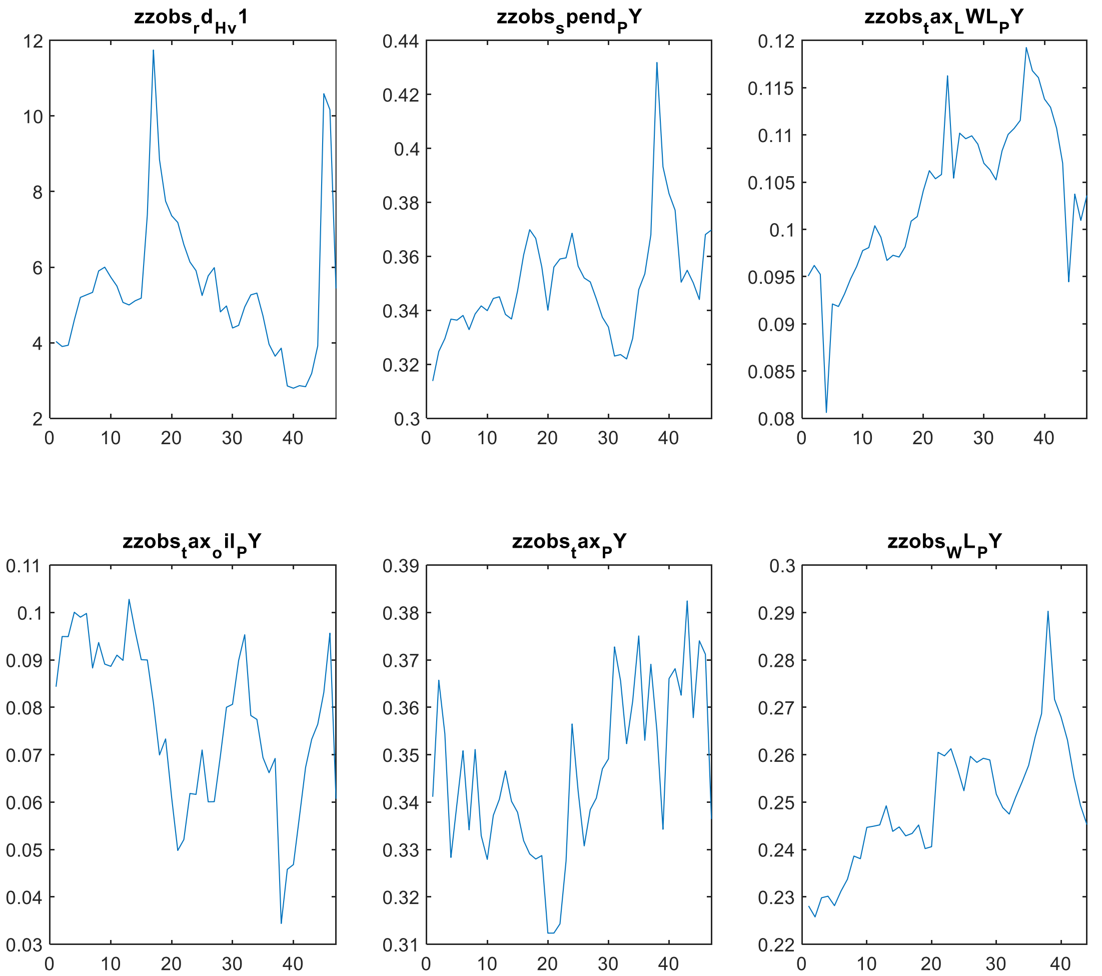


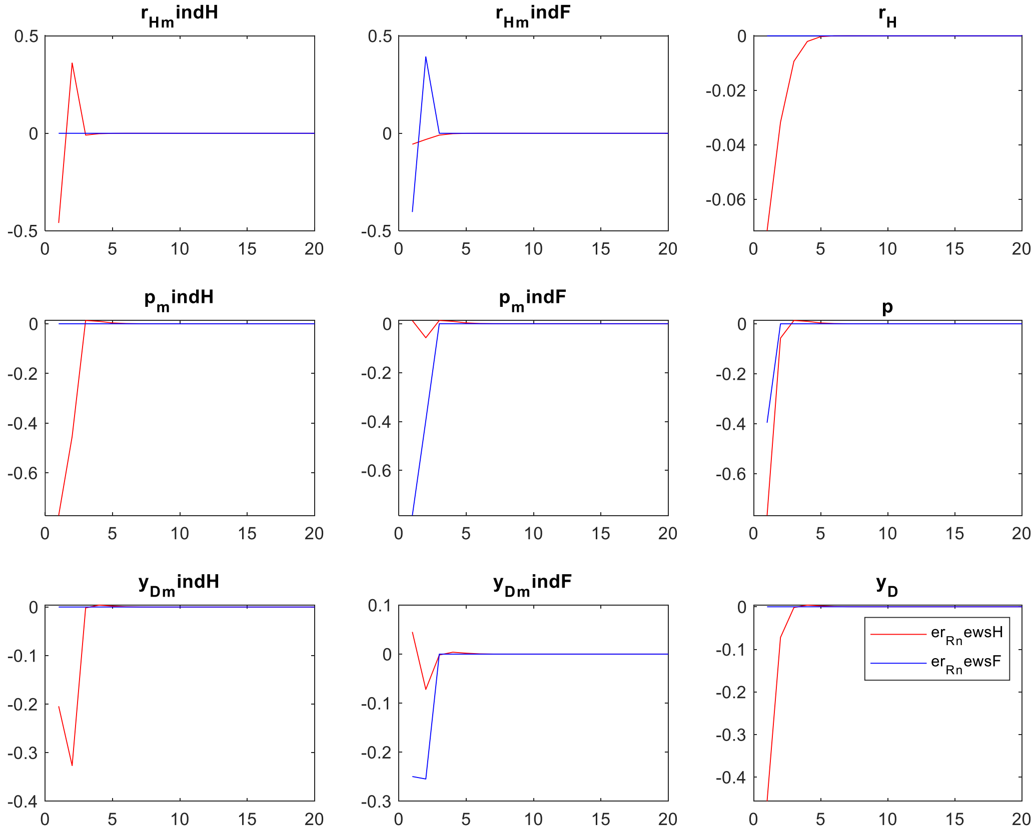
Figure A2.4 Time-series plot



APPENDIX 4

IRFs in Scheme B in the small-scale model

Figure A4.1 IRFs in Scheme B in the small-scale model



Note: Each column represents an impulse response of the raw variable in the mind of the corresponding agents (first column – households, second column – firms, third – banks) and in the reality to one of the three news shocks

APPENDIX 5

IRFs in Scheme A

Each column represents an impulse response of the raw variable in the mind of the corresponding agents (first column – in the mind of households, second column – of firms, third – of banks) and in the reality to one of the three news shocks (three lines: red – news shock to households, s1; blue – to firms; green – to banks)

Figure A5.1 IRFs in Scheme A

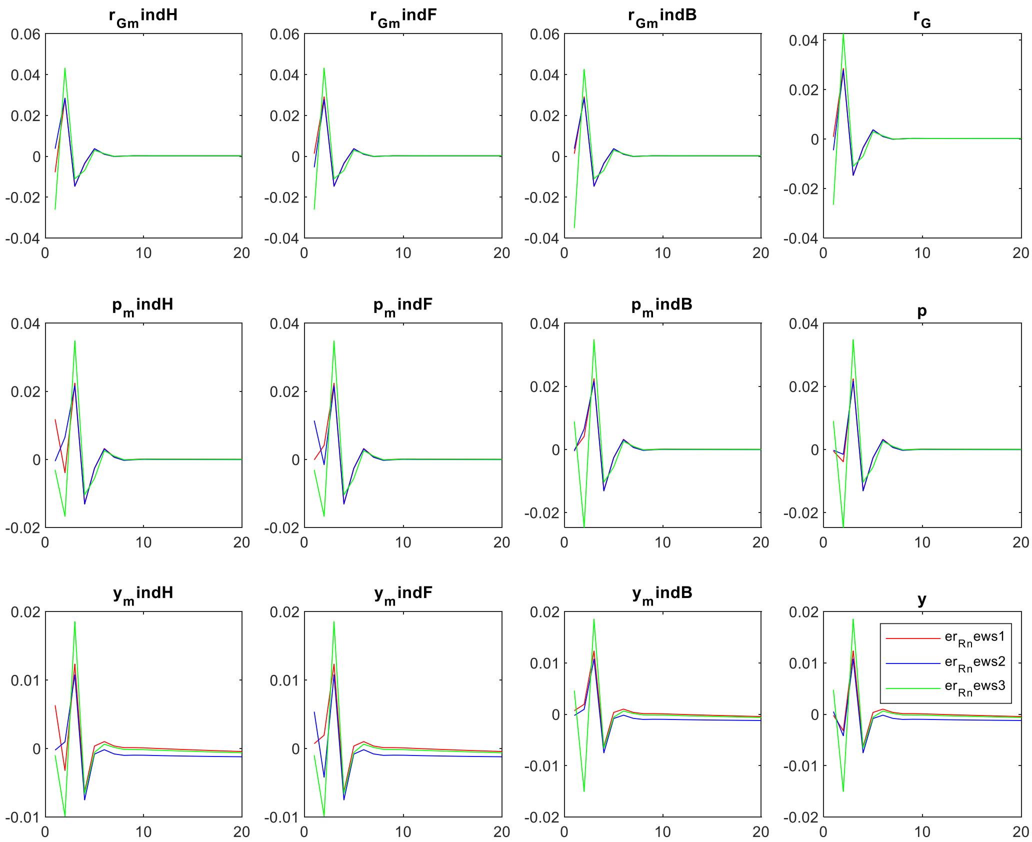


Figure A5.2 IRFs in Scheme A

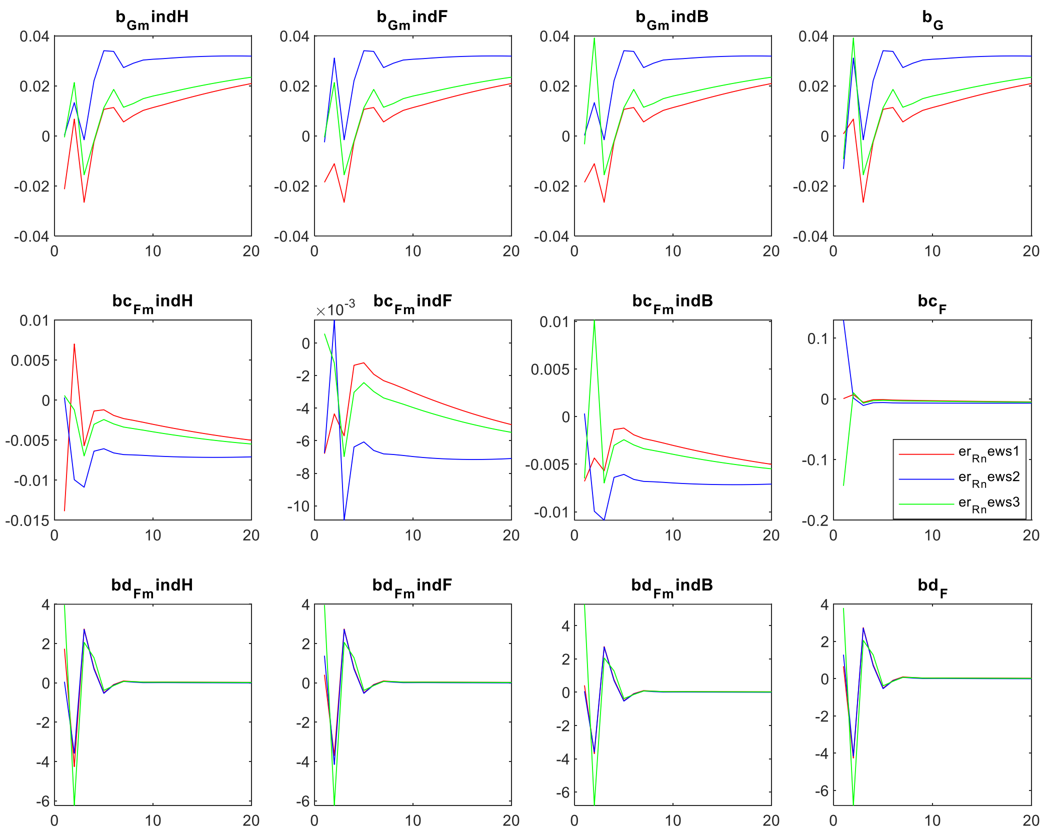
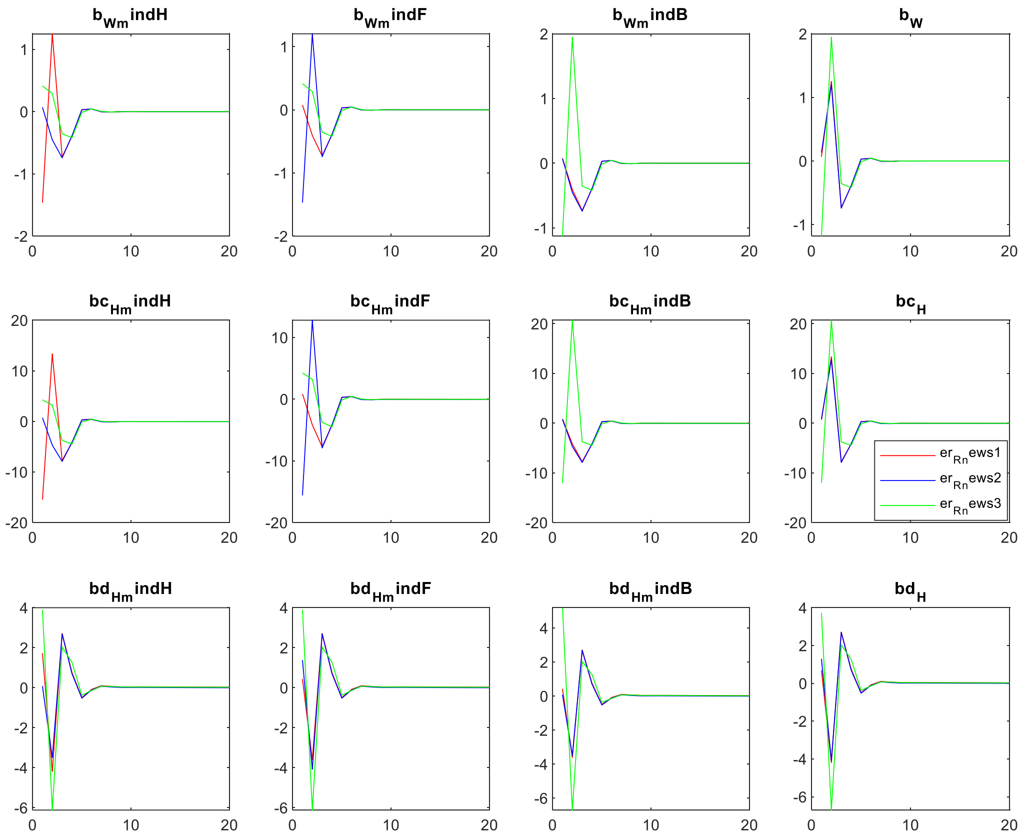


Figure A5.3 IRFs in Scheme A



APPENDIX 6

IRFs in Scheme B

Each column represents an impulse response of the raw variable in the mind of the corresponding agents (first column – households, second column – firms, third – banks) and in the reality to one of the three news shocks (appearing in this scheme only in the mind of the corresponding agents).

Figure A6.1 IRFs in Scheme B

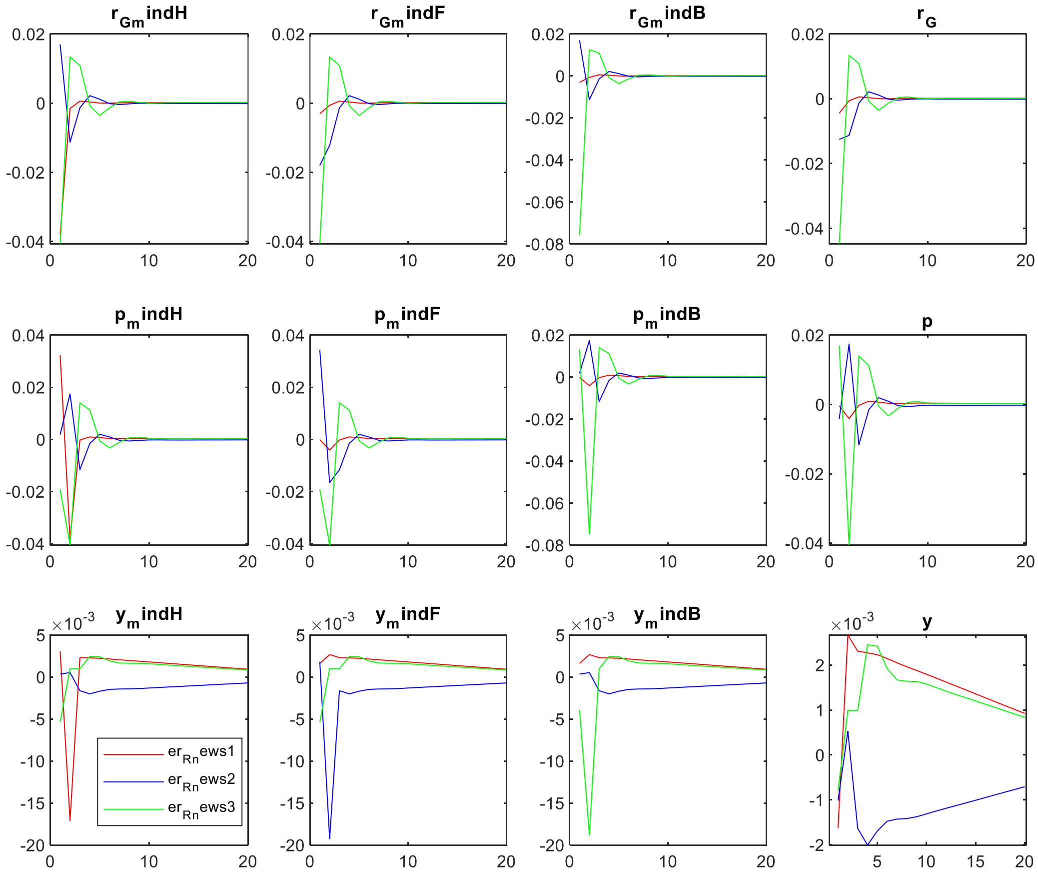


Figure A6.2 IRFs in Scheme B

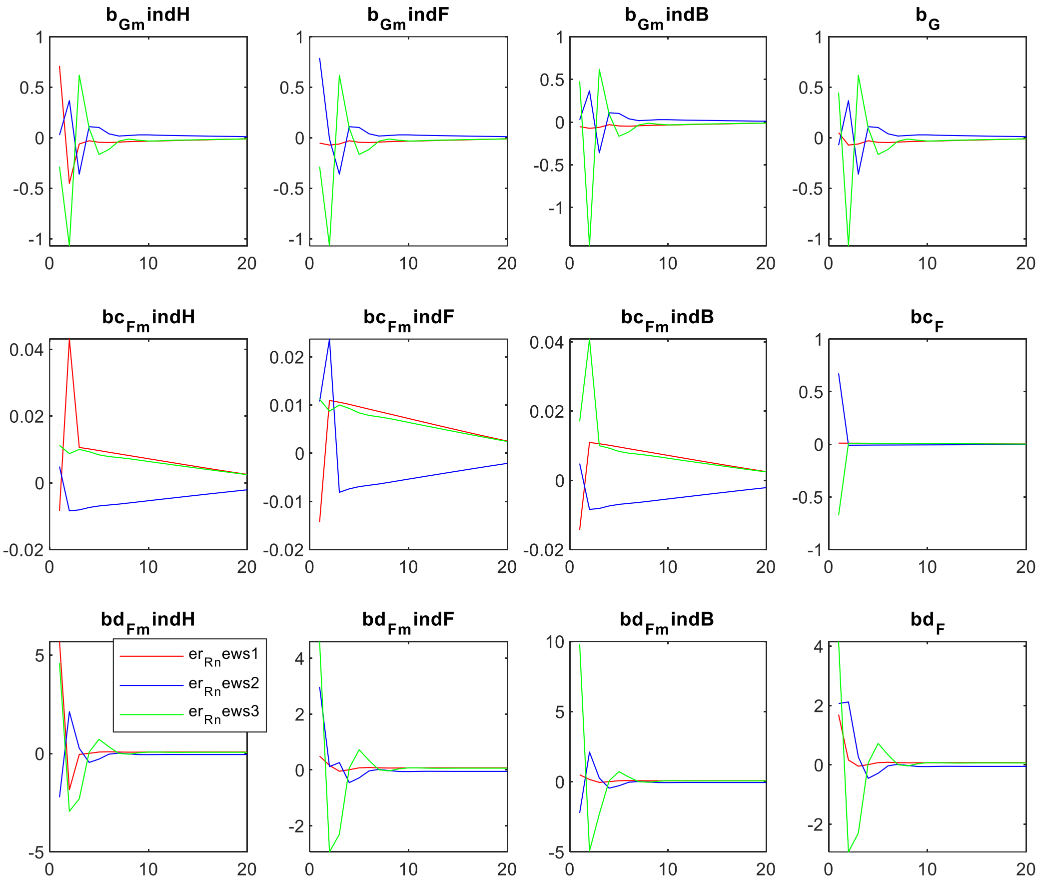


Figure A6.3 IRFs in Scheme B