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Inequality and Monetary Policy: THRANK model

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Pavel Vikharev
Anna Novak
Andrei Shulgin

Pavel Vikharev
Volga-Vyatka Main Branch of the Bank of Russia
Email: pavelvik99@gmail.com

Anna Novak
Volga-Vyatka Main Branch of the Bank of Russia
Email: ananova7@gmail.com

Andrei Shulgin
Volga-Vyatka Main Branch of the Bank of Russia
Email: andrei.shulgin@gmail.com

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

Abstract

The paper explores the mutual influence of inequality and monetary policy. The model introduces household heterogeneity in terms of access to the financial market and intertemporal preferences. The parameters are calibrated and estimated based on both Russia's microdata (including RLMS-HSE and HBS) and macro statistics. We have shown that the introduction of households with no access to the financial market has only a slight impact on the transmission of a monetary policy shock, while its secondary effects help amplify the action of most structural shocks. The behavior of wealthy hand-to-mouth households amplifies the response of macroeconomic variables to the monetary policy shock but has a slight impact on these variables' responses to most of the other structural shocks.

We have identified non-structural inequality shocks at the bottom and the top of the Lorenz curve. As a result, we have found that the mutual influence of inequality and monetary policy is limited. The interest rate immediate response to changes in the Gini consumption index equals 0.1 for inequality shocks and 10 for a monetary policy shock. We have demonstrated that the shocks at the top of the Lorenz curve cause a more persistent response from the economy, whereas the shock at the bottom of the Lorenz curve. On first approximation, only one integral inequality indicator can be used to study the role of inequality in a business cycle.

The relative consumption dynamics for specified household groups is not a conclusive indicator of either pro- or disinflationary policy, but it provides additional data to help identify structural shocks.

JEL: E21, E44, E52, E58.

Keywords: monetary policy, inequality, THRANK, inequality shock, hand-to-mouth, Russia, Lorenz curve, household heterogeneity, Wealthy HtM.

Contents

1. Introduction

Until recently, monetary policy had hardly been associated with inequality. Firstly, most inequality-related issues are viewed as long-term, whereas monetary policy is aligned with a business cycle. Secondly, monetary policy tools are inefficient in identifying, for example, a group of poor households. Thirdly, structural models that are basic for monetary policy are based on a representative agent's behavior and do not account for a household's heterogeneity. However, the agents' homogeneity assumption is currently seen as excessively rigid for most research purposes, including for the development of monetary policy (Campbell and Mankiw, 1989). The heterogeneity of the agents' access to financial markets was the first introduced in modelling (Gali et al. 2007; Colciago 2011). The behavior of a household that, for whatever reason, does not use the financial market is starkly different from that of a representative agent under the conventional approach. The second source of heterogeneity is the agents' intertemporal preferences (Cloyne et al. 2020; Eskelinen 2021). Households with a low subjective future discount rate will be amassing assets, while households with a higher subjective future discount rate will be building up debt to increase current consumption. The behavior of impatient households in the face of an imperfect capital market can significantly differ from that of a traditional representative agent.

While consistent with the conventional inflation-forecast targeting (IFT) approach to economic modelling, our paper suggests the existence of both above-mentioned sources of heterogeneity. Such an expanded theoretical toolset has helped scrutinize some relevant issues regarding the mutual impact of inequality and monetary policy that were previously viewed as either trivial or impossible.

First, we discuss the impact of inequality trends on the monetary transmission mechanism. We have demonstrated that the trend for an increasing share of households involved in the financial market (Abramov et al. 2020) reduces the fluctuations of macro variables in the economy and somewhat amplifies the variables' response to discretionary monetary policy. We have also shown that an increase in heavily indebted households intensifies the economy's response to a monetary policy shock. However, the response to most of the other structural shocks does not amplify. Both trends contribute to a more impactful monetary policy toolset. However, it cannot be argued that it must lead to an improved well-being of the economy, as society's potential losses from the bankruptcies of heavily indebted households amid crises cannot be accurately calculated. Thus, the developed model can be used as a 'laboratory' to analyze the impact of various structural changes on the monetary transmission mechanism.

Second, the heterogeneous response of various groups to a monetary policy instrument prompts the study of inequality within a business cycle. This view of inequality is relatively unconventional, which is supported by, eg, the lack of monthly inequality data. We have demonstrated that even if we do not adjust the goals of monetary authorities for inequality figures, inequality data can enhance the identification of structural shocks, thereby improving the quality of stabilization policy (Auclert 2019). To explain consumption inequality dynamics within a business cycle, we introduce several structural shocks into the model. These affects both the inequality indicators and aggregate variables. In order to estimate the effect of inequality shocks to the economy, we synthetically combine the structural shocks. The resulting non-structural inequality shocks are better interpreted, on the one hand, but on the other, they turn out to be similar to inequality shocks identified in a VAR framework used to analyze the relationships between inequality and monetary policy (Guerello 2018; Samarina, Nguyen 2019). This helps compare the results of the two approaches to analysing the mutual influence of inequality and monetary policy.

Introducing three groups of households into the model allows us to conclude which end of the Lorenz curve produces inequality shocks and what the implications for the economy will be. We have shown that the inequality shocks at the top of the Lorenz curve (associated with a group of wealthier households in possession of assets) make for a more persistent response from the economic variables. The shocks at the bottom of the Lorenz curve (associated with a group of poorer households not engaged in the financial market) have a more material effect on the output. However, in general, regardless of the end of the Lorenz curve that produces the inequality shock, the interest rate shows moderate growth in response to a positive shock of aggregate inequality. As non-structural inequality shocks arise, the sensitivity of the interest rate, according to the consumption Gini index, has proved to be quite low and shown almost no correlation with the end of the Lorenz curve that has produced the shocks. The response of the inequality indicators to a monetary policy shock exhibits no such homogeneity. We have demonstrated that the interest rate's positive shock leads to a stronger decrease in a household's consumption in the middle of the Lorenz curve, resulting in the inequality at both ends of the Lorenz curve moving in different directions. Furthermore, a decrease in the consumption of wealthier households is lower than with poorer households, which moderately raises the integral consumption inequality indicator. The interest rate's sensitivity to a monetary policy shock on the Gini index is quite low too.

In our paper, we have replicated many of the findings of Eskelinen (2021) regarding the economy's response to a monetary policy shock and its determinants, namely, a share of households with limited access to the financial market and the intensity of borrowing restrictions. The consumption behaviours of the three groups in response to a monetary policy shock have retained its properties. We have found that the most prominent drop in consumption in response to interest rate growth is for the group of heavily indebted households, whereas certain combinations of parameters may lead to non-hand-to-mouth households increasing consumption due to financial asset income effects. However, compared to Eskelinen (2021), we are expanding the list of structural shocks, providing more opportunities to analyze the income behaviors of various groups. Unlike the monetary policy shock, most structural shocks lead to a short-term unidirectional change in the inequality indicators at both ends of the Lorenz curve. In the medium term, a response to structural shocks is shaped by the financial market dynamics, with the savings redistribution channel and the portfolio composition channel coming to the fore. In this case, the key is whether a household is a saver or a borrower as well as the direction of the rate's change in response to a structural shock. As a result, in 12 to 16 months, the cyclical components of inequality will be opposite at the two ends of the Lorenz curve. Thus, on the first approximation, one can ignore the dimensionality (or, in general, multidimensionality, if there are more than three groups of households) of the consumption inequality indicators. Both empirical and theoretical models that include a single integral consumption inequality indicator can be valid.

We have demonstrated that the groups' relative consumption indicators reflecting consumption inequality show a multidimensional response to most structural shocks and can be instrumental in their identification (Auclert 2019). At the same time, relative consumption indicators per se cannot be conclusively interpreted as either a pro- or anti-inflationary signal.

The rest of the paper is organized as follows. Section 2 offers a review of literature on the mutual influence of inequality and monetary policy. Section 3 presents a structural model with three types of households (representative agents). Section 4 parametrizes the model in question based on the Russians-sourced data. Section 5 examines the sensitivity of the shock transmission mechanism to household groups as well as the interaction of inequality and monetary policy within a business cycle. The Conclusion summarizes the key findings.

2. Literature Review

Until recently, the interrelation between economic inequality and monetary policy has not been in a focus of economic literature. On the one hand, a popular notion was that income and wealth inequalities have a weak contribution to the dynamics of aggregated variables (Krusell and Smith 1998). On the other hand, the redistributional effects associated with the conduction of monetary policy were considered as temporary and immaterial. This has to do with the fact that in the long term, the monetary policy is neutral for economic inequality, which, due to its non-monetary nature, is shaped by structural factors, such as technological progress, globalization, demographic trends and institutional changes in the labour market (Calciago et al. 2019; Auclert 2019; Bernanke 2015). Within a business cycle, however, this neutrality is violated, as evidenced by empirical researches (BIS 2021; Ampudia et al. 2018; Gautier et al. 2020; Samarina and Nguyen 2019). Besides, it was found that once household heterogeneity is included in the model properly, it can help better identify structural shocks and the overall effect of the monetary policy shock and therefore better describes the expected dynamics of macroeconomic variables (Auclert 2019). Significantly, agent heterogeneity is examined not only in terms of economic features, including income, consumption and wealth, but also in terms of more general ones, such as intertemporal preferences, access to the financial market, educational background and qualifications, employment status and income composition (BIS 2021; Ampudia et al. 2018; Colciago et al. 2019). Another important source of household heterogeneity is the structure of their assets (by risk, liquidity etc.) and liabilities (by maturity, interest rate type etc.).

2.1 Role of inequality in shaping the monetary policy transmission mechanism

The most common type of New Keynesian DSGE models, the Representative Agent New Keynesian ('RANK'), does not account for household heterogeneity (Clarida et al. 2000). Households are assumed to be identical and to have unlimited access to the financial market, which helps them use the adjustments of saving or borrowed funds to smooth consumption regardless of transitory income changes. Such households are referred to as non-hand-to-mouth ('Non-HtM'). However, a lot of studies fail to support the transitory smooth consumption theory (Deaton 1987; Campbell and Mankiw 1989). The reasons cited include limited access to the capital market, inability to lend and borrow at the same rate, liquidity constraints (Zeldes 1989) and agents' "myopia" (Runkle 1991). This leads to including so called rule-of-thumb, or hand-to-mouth, households ('HtM') in the models, whose consumption is insensitive to real interest rate changes while being strongly affected by actual income fluctuations, making it more procyclical.

Models that involve a constant share of both non-hand-to-mouth and hand-to-mouth households are referred to as Two-Agent New Keynesian models (TANK). They can account for heterogeneity between the groups of households, with groups' share in the population presumed to be constant and exogenous. TANK models have become widely used in fiscal policy analysis (Gali et al. 2007; Colciago 2011) since, with a large share of hand-to-mouth households, they can generate a positive response of aggregate consumption to fiscal stimuli, which matches empirical findings and differs from the RANK model forecasts.

However, economic inequality is more comprehensively covered by the recent Heterogeneous Agent New Keynesian models (HANK) (Kaplan et al. 2018). These models suggest an infinite number of households affected by idiosyncratic shocks from labor income and other types of income that allow for empirically realistic income and wealth distributions (Carroll et al. 2017; Hedlund et al. 2017). Their advantages over TANK models include considering for agent heterogeneity both between the groups and within that groups as well as possible endogenous changes in shares of various household groups in the population. Importantly, in HANK models, each household operates in an incomplete financial market and is forced into precautionary savings to mitigate potential costs incurred by materialized uninsurable risks (eg, the risk of losing a job).

Medium and large-sized HANK models typically account for another significant source of household heterogeneity: a varying structure of assets and liabilities. It includes two mechanisms. First, agents are classified as either borrowers or savers based on intertemporal preferences: borrowers have lower subjective discount rates than savers. Second, the agent-specific process of idiosyncratic shocks from labor incomes (by frequency and value) leads to the heterogeneous structure of assets and liabilities[1]. Because this heterogeneity is associated with variations in the marginal propensity to consume (MPC), HANK models with such a structure can cover four types of

[1] Frequent weak shocks lead households to hold liquid assets, while rare powerful shocks call for illiquid assets (Eskelinen 2021).

households (Kaplan et al. 2014).

The first group holds diverse liquid wealth. These are relatively wealthy Ricardian households (Non-HtM) that are also behave as savers in the economy. The second group owns few illiquid assets while having many liquid ones. Normally, it is not considered separately, as in terms of economic behavior, these households are close to Non-HtM households due to their ability to smooth consumption through liquid assets under any income shocks. These two sets have unlimited access to the financial market and liquid assets, rendering their MPC low.

The remaining two groups of households, on the contrary, are lacking in liquid assets to smooth consumption and therefore their MPC is high (those are associated with HtM households). The third group of households is characterized by owning sizable amounts of illiquid assets and little liquid wealth. This is accounted for by their intertemporal consumption choices, and not by the level of income that is similar to the incomes of the Non-HtM, hence they are referred to as Wealthy HtM. These are impatient agents preferring current consumption and acting as main debtors in the economy. The participation of such households in an incomplete financial market is hindered by the credit limit based on the amount of their illiquid assets (real estate) used as a deposit. As a result, the Wealthy HtM group spend all of their current incomes on consumption and purchasing illiquid assets. For this household type, borrowings serve as an instrument to increase current consumption compared to the lack of access to the financial market. Such households cannot fully smooth their consumption path in response to various shocks because of the credit limit. For this reason, their consumption proves to be sensitive to income shocks along with financial market shocks affecting the collateral amount. This leads to this household type's consumption being procyclical in response to shocks where the movement of actual consumption and of the financial market is unidirectional. The fourth group, which has little to no assets, is referred to as the Poor HtM. These households have no access to the financial market and their consumption is shaped by budget constraints rendering it more procyclical than that of the Non-HtM. This classification of households matches the one obtained empirically based on microeconomic data in Kaplan et al. (2014).

Such HANK models show that the heterogeneity of a household's position in the financial market helps identify both a direct and indirect effect that monetary policy shocks have on household consumption. The direct effect of a changed interest rate has to do with the intertemporal substitution effect, ie, a monetary policy shock affects an optimal consumption/saving path for households that maximize utility function. Meanwhile, the indirect effect stems from the changes in general equilibrium and therefore in disposable household income.

The direct effect primarily concerns Non-HtM households. Conversely, the HtM consumption is almost unresponsive to a changed interest rate while being significantly impacted by the secondary effects of a monetary policy shock, ie, income changes. Consequently, the indirect effect targets this type of households. Ampudia et al. (2018) and Kaplan et al. (2018) estimated that the indirect effect of a monetary policy shock accounts for at least 60% of the total effect.

The differences in aggregate variables' responses to a monetary policy shock between the HANK and RANK models are limited to their varying decomposition into direct and indirect effects. Factoring in HtM households amplifies the responses of aggregate variables to the shocks, hence the more pronounced composite effect of the monetary policy shock (Luetticke, 2021). The Wealthy HtM's behaviour is more procyclical because the effect of the interest rate shock on consumption amplifies, as the latter affects collateral constraints. The price of illiquid wealth is procyclical and therefore an expansionary shock provides this household type with an opportunity to further increase borrowings and hence consumption, while a contractionary shock spurs the opposite (Iacoviello 2005; Wong 2016; Luetticke, 2021). A steeper decline in aggregate consumption can explain why countries with high income inequality figures face deeper recessions (Kharroubi et al. 2021).

Although HANK models prove to be the most exhaustive in accounting for household heterogeneity, they are hard to solve and assess due to a lack of fixed methodology. However, some papers show that similar effects on aggregate variables can be identified using more conventional models. For example, Debortoli and Gali (2017) analysed the differences between the HANK, TANK and RANK model behaviours and concluded that consumption heterogeneity between the groups of households is essential to identify the effects of aggregate shocks, including monetary policy shocks, on aggregate variables that are similar to HANK behaviours. Another finding is that consumption inequality within the groups of households does not change considerably in response to shocks. Meanwhile, Bilbiie (2020) shows that endogenous fractions of household groups can be accounted for in small-scale HANK models and therefore a full-scale HANK (with varying asset portfolios and labour market imperfections) is only uniquely used to examine heterogeneity within the groups of households. Hence the conclusion that the TANK model or the small-scale HANK model can be considered a fair approximation of the full-size HANK to analyze the dynamics of aggregate variables in response to aggregate shocks (Debortoli, Gali 2017; Bilbiie 2020).

Nevertheless, the TANK model does not include Wealthy HtM households, whose behavior in HANK models is key to understanding the dynamics of aggregate variables. For this reason, some researchers extend TANK's heterogeneity between the groups of households by adding different structures of assets, liabilities and incomes as well as a different subjective discount rate (Cloyne et al. 2020; Eskelinen 2021). This helps identify additional household groups, eg, the Wealthy HtM group. Such models are referred to as K-Agent New Keynesian (KANK). They contribute to a more comprehensive picture of households' heterogeneity within the standard general equilibrium model framework. Using a contractionary monetary policy shock, Eskelinen (2021) shows that a THRANK (a KANK model with three representative agents) can reproduce monetary policy transmission channels of HANK models. Moreover, the overall effect of the interest rate shock on output and inflation in the THRANK is closer to that of the HANK than in a conventional TANK model. This is explained both by the introduction of the Wealthy HtM households with their sizable contribution to the dynamics of aggregate variables and by a reproduction of redistribution channels that change the income to consumption ratio between agents with different MPCs (Auclert 2019).

2.2 Monetary policy's impact on inequality

Potential redistribution channels of monetary policy impacting inequality are shown in Table 1. The first is the portfolio composition channel: a drop in aggregate incomes of Non-HtM households amplifies due to a decline in potential profits from selling cheaper financial assets. However, the declining incomes are offset by the savings redistribution channel reflecting the impact of higher interest rate deposit and loan payments of Wealthy HtM households. Notably, if the model has flexible nominal wages, the growing price markup leads to increasing business dividends in Non-HtM households, since the nominal price rigidity prevents their instant adjustment as opposed to the nominal wages, and producers receive higher profits for a certain period of time (Eskelinen 2021).

Horvath et al. (2021) show that a contractionary monetary policy shock leads to growing dividends due to increased equity risk premiums. It results in the redistribution of incomes from HtM to Non-HtM households owning the stock[2]. In some cases, opposite redistribution channels can end in a trade-off, and monetary policy changes will not significantly affect even the cyclical income inequality fluctuations, as evidenced by empirical studies (Dolado et al. 2018).

Through its direct and indirect effects, the contractionary monetary policy shock leads to reduced consumption by all types of households, albeit in different proportions. Consumption by Non-HtM households reduces to a lower extent, as it is affected primarily by the intertemporal substitution effect. However, due to unlimited access to the financial market and real rigidities, this group of households smooths the consumption path. As a result, the shock's effect on the Non-HtM's consumption is less pronounced than on the other types of households. HtM households can smooth their consumption due to restricted access to the financial market and therefore a decline in their actual incomes directly leads to less consumption. However, for the Wealthy HtM, the shock's effect amplifies in the wake of the changed collateral cost (wealth effect) and savings redistribution channel. An increased interest rate prompts a dip in prices for real estate used as collateral by Wealthy HtM households and hence a lower credit limit. Because this group of households is always at this limit, a decrease makes them repay the fraction of the old debt that exceeds the newly set limit due to current consumption constraints.

Some researchers identify this effect as a separate collateral monetary policy channel (Iacoviello 2005). Besides, it raises the cost of debt service, which has a further negative effect on this household group's consumption. Thus, consumption inequality shows overall growth in response to a contractionary monetary policy shock, albeit not in a uniform way. At the upper end of the Lorenz curve, the inequality increases while decreasing at the lower end due to a considerable drop in consumption by the central Wealthy HtM household group.

[2] In the event of an expansionary monetary policy shock, the qualify effect of these channels is the opposite.

Table 1

Monetary policy redistribution channels

Channel	Impact rationale
	Direct effect of monetary policy shock
Savings redistribution channel	Has to do with the number of households' net assets. Includes redistribution of interest rate payments between borrowers and savers. Its impact depends on the type of contract's real interest rate and duration (Garriga et al. 2017; Cloyne et al. 2020). Reflects changes in bank deposits' profitability.
Unexpected inflation channel	Has to do with nominal values: outstanding debt and its repayment. Unexpected inflation benefits the borrowers while hurting the savers (Iacoviello 2005). The impact of this channel depends on the type of real interest rate. Depreciates funds and bank deposits.
Interest rate exposure channel	Has to do with rare-sensitive assets and liabilities in a broad sense whose differential (accounting for different maturity periods) is typically referred to as unhedged risk exposure (Auclert 2019). A fall in the real interest rate triggers income redistribution from positive URE households (investments in short-term assets or bank deposits) to negative URE households (long-term bonds or adjustable-rate mortgage).
Portfolio composition channel	Has to do with differences in households' asset portfolios. A fall in interest rates leads to increased wealth inequality due to the rising price of financial assets that are primarily owned by wealthy households. This also increases their incomes from selling the capital that has gone up in price. The effect on wealth inequality can be offset by relatively even distribution of real estate in society.
	Indirect effect of monetary policy shock
Earnings heterogeneity channel	Has to do with differences in households' skills. Earnings of the high-skilled wealthy households depend on the wages, while earnings of the low-skilled poor households hinge upon on hours worked and the employment status (Heathcote et al. 2010; Amaral 2017). The effect on income inequality will depend on what the monetary policy affects the most and on the proportion in which the companies' demand for labour from households with different skills will change.
Income composition channel	Has to do with differences in income acquisition sources: low-income households are most reliant on transfers, middle-income households on labour income and the wealthy on capital and business income. A fall in interest rates leading to increased labour income and lower interest capital shrinks the distance between middle-income households and the wealthy while increasing the gap between them and low-income households.

Source: compiled by authors based on Colciago et al. (2019), Ampudia et al. (2018).

Empirical studies mostly focus on the income heterogeneity channel and total income composition channel. Overall, they prove that contractionary monetary policy shocks often lead to increased income inequality, both labour and total. These findings hold true for the US (Coibion et al. 2017; Aye et al. 2019), the UK (Mumtaz, Theophilopoulou 2017), the Euro area (Guerello 2018; Samarina, Nguyen 2019) and a panel of developed and emerging market countries (Furceri et al. 2018). Typically, such results are explained by the fact that the monetary policy shock and the ensuing fall in the employment rate and in wages affect low-income households most adversely. However, wealthier agents benefit from rising interest income and are less likely to lose their jobs due to the higher skills. As a result of increased income inequality, contractionary monetary policy shocks lead to an increase in consumption inequality as well (Ampudia et al. 2018; Coibion et al. 2017).

At the same time, some papers' findings point to the opposite results for the US and the UK (Cloyne et al. 2020) as well as Japan (Inui et al. 2017). Specifically, Inui et al. (2017) explain it by labour market rigidities that, under the expansionary monetary policy shock, lead to wage adjustments to the growing labour demand failing to affect different households in a uniform way, which in turns prompts a rise in earnings inequality. Besides, several papers show the monetary policy impact on inequality change within a business cycle.

Along the same lines the impact of unconventional monetary measures (above all, quantitative easing (QE)) on economic inequality is explored. The findings are not conclusive either, which has to do with the oppositely directed effects. For example, with the earnings heterogeneity channel, QE leads to lower income inequality and hence lower consumption through the stimulus to economic activity and employment (Bivens 2015; Guerello 2018; Casiraghi et al. 2018). On the other hand, with the portfolio composition channel, QE amplifies inequality through higher prices for financial assets selling which results in more income for predominantly wealthy households (Saiki, Frost 2014; Montecino, Epstein 2015; Mumtaz, Theophilopoulou 2017). As a result, the overall impact of unconventional monetary measures on income inequality and consumption inequality stems from input of the effects these channels have. In some cases, however, the redistributive effect is relatively weak (Bunn et al. 2018).

Wealth inequality is also sensitive to monetary policy surprises. It can be affected via the redistributive channels of the monetary policy shock direct effect. For instance, the unexpected inflation channel involves the interest rate's expansionary shock leading to the redistribution of economic benefits from savers to borrowers. Because savers are represented by predominantly wealthier households and borrowers by lower-income ones, the unexpected inflation channel prompts a decline in wealth inequality. This is supported by several empirical studies (Doepke, Schneider 2006; Meh et al. 2010; Adam, Zhu 2016; Sterk, Tenreyro 2018).

On the other hand, expansionary monetary policy, primarily through unconventional measures, leads to a rise in prices of financial assets, which can amplify wealth inequality via the portfolio composition channel. However, empirical studies show a mostly negligible contribution of conventional monetary policy shocks to a change in wealth inequality. The price increases for various assets (equity, bonds and housing) can have a different impact on wealth inequality based on their societal distribution (Adam, Tzamourani 2016; Bivens, 2015; Bunn et al. 2018; O'Farrell et al. 2016). Equity price and bond price increases amplify net wealth inequality, while housing price increases dampen it through more even distribution among households (Colciago et al. 2019). The savings redistribution channel also slightly compensates for a rise in wealth inequality through a lower stream of interest from poorer borrower households to wealthier saver households (Casiraghi et al. 2018; Inui et al. 2017). Thus, the overall effect of a monetary policy shock to wealth inequality largely depends on the household portfolio composition and households group distribution both in terms of the sign and the value. Nevertheless, some works show that QE leads to a more pronounced impact on wealth inequality (Domanski et al., 2016; Bank of England, 2012).

2.3 Monetary policy rules and inequality

Another way monetary policy affecting economic inequality focuses on the analysis of a systemic stabilisation policy as well as choosing an optimal monetary rule. The U-shaped household utility function in terms of consumption helps explain the impact of economic inequality on welfare. Growing inequality may lead to lower aggregate utility and therefore, in a household heterogeneity model, a benevolent central bank needs to account for it when conducting an optimal monetary policy. Moreover, at the disinflation stage, it faces a choice between the expedited lowering of inflation and the prevention of consumption inequality growth. This renders the central bank more tolerant of inflation, which changes its systemic behaviour. From the welfare standpoint, of more value is a higher interest rate response to the output gap (or cyclical unemployment) in the monetary policy rule (Tirelli, Ferrara 2019; Ferrara et al. 2020; Gornemann et al. 2021), that is, gradualism in disinflation. Some papers also show that increased welfare can be ensured under the augmented Taylor rule that, besides a deviation from target inflation and output gap, accounts for a consumption gap between wealthy and low-income households (Hansen et al. 2020). Nevertheless, this approach pertains more to the discussion of the optimal hybrid inflation targeting. However, Ascari et al. (2017) uses the TANK model to show that agent heterogeneity can be irrelevant when designing the optimal monetary policy in the case of nominal wage stickiness, as it dampens income procyclicality in HtM households.

In summary, introducing household heterogeneity into the structural models helps examine agents' behaviours that are different from those of a standard representative agent under the RANK model. Besides, income redistribution between groups of households with different MPCs and changes in size of these groups (economic inequality change) affect the responsivity of aggregate variables to structural shocks and therefore the value of the overall monetary policy shock effect. Using various redistributive transmission channel, the monetary policy impacts the cyclical fluctuations of income inequality, consumption inequality and net wealth inequality. Empirical studies often yield controversial results as to the profile of effects the monetary policy has on economic inequality and therefore the composite effect may be uncertain. Structural studies can overcome these limitations. Stylised facts support the finding that the contractionary monetary policy shock leads to increased income inequality and consumption inequality, while being capable of dampening wealth inequality. Typically, this impact is taken to be weak due to multidirectional effects of various redistributive monetary policy channels. It makes sense to introduce inequality into a monetary policy rule if monetary authorities are targeting a reduction in cyclical fluctuations of the real values, ie, income and unemployment.

3. Three-agent model

As a baseline, we use the DSGE model with three groups of households, similar to Eskelinen (2021), except we consider several differences. First, we model a small open export-oriented economy, which, among other things, adds foreign assets to the model and allows us to analyse the impact of foreign economies on the domestic one. Second, we plug in a more detailed fiscal block that helps measure the impact of the government's redistributive effects on economic inequality and hence the composite effect of the monetary policy shocks. Third, we add nominal wage stickiness for all groups of households along with the indexation of the previous inflation according to the CPI. Furthermore, the supply is better represented through the introduction of the three production sectors. The differences from Eskelinen (2021) that include the Bayesian estimation of the model seek to use this model design for the practical purposes of forecasting the small open export-oriented economy of Russia.

3.1 Model structure

The model identifies three groups of households. The households of the first group – Non-Htm households – smooth the consumption and are considered sole firm proprietors in the economy and therefore the profits that the companies across all sectors post for each period are evenly distributed among them as dividend payments. Besides, only Non-HtM households have access to the external capital market.

The households of the second group – Poor HtM households – have no access to the financial markets and consume their current income. Additionally, we identify the third group of households, Wealthy HtM households, that, like the first group, own illiquid assets (real estate) but differ from the Non-HtM group in their intertemporal preferences. The Non-HtM households have a higher subjective discount rate than the Wealthy HtM ones, which in the long term makes the Non-Htm households net savers that fund the higher consumption by the Wealthy HtM households through one-period bonds. As a result, the latter accrue debt whose maximum value is determined by the amount of their illiquid assets (real estate). The Wealthy HtM households are constantly at the borrowing limit and lose their ability to smooth consumption over time, which makes them similar to the Poor HtM households. As the price of illiquid assets increases, the Wealthy HtM households get an opportunity to add borrowings and amplify their current consumption. As the price of illiquid assets falls, they have to reduce their current consumption more, so that they can meet the borrowing limit condition. Since the price of illiquid assets is procyclical, consumption by the Wealthy HtM households becomes more procyclical than the behaviour of the Poor HtM households with no access to the financial markets. Fig. 1 illustrates the interaction of agents in different markets.

Households consume three types of goods produced by firms from the corresponding sector: non-tradable internationally (N sector), tradable domestic (H sector) and tradable imported (F sector) goods. Firms from the N and H sectors only use labour resources and observe a linear production function. The total factor productivity in both sectors follows the AR(1) process. Firms from the F sector use a unit of homogeneous imported goods to produce a unit of heterogeneous goods. Firms from all the three sectors produce heterogeneous goods in the context of the monopolistic competition market under the Calvo pricing model (Calvo 1983) and the Yun indexation model (Yun 1996). There is global competition between the three sectors: the elasticity of substitution between tradable and non-tradable goods is α, while the elasticity of substitution between domestic and foreign tradable goods is δ.

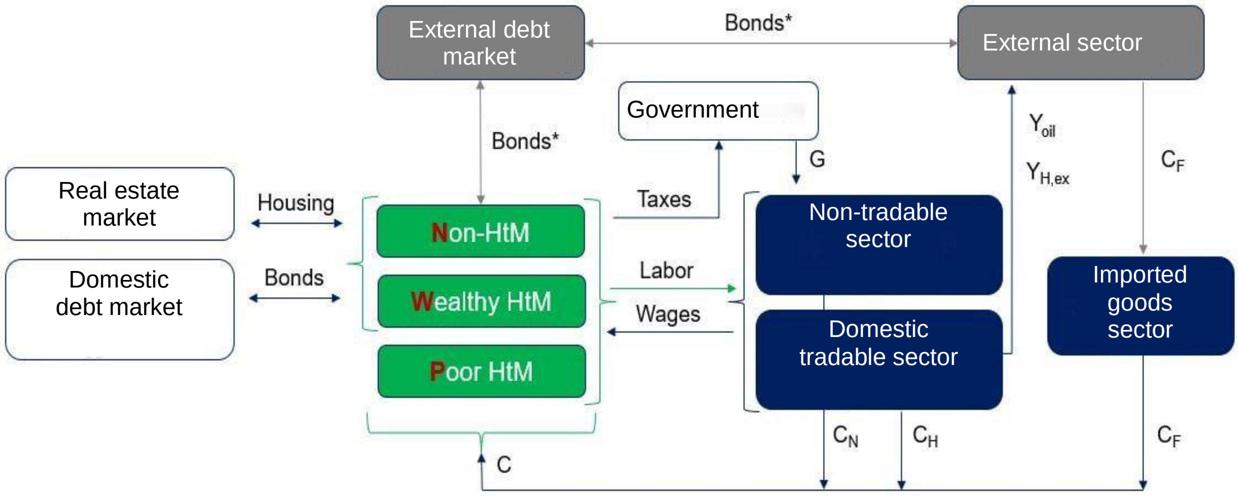

Fig. 1. A flowchart of interaction of agents in the main markets.

Source: compiled by the authors.

The goods produced in the N sector are consumed domestically, whereas the goods produced in the H sector can be both consumed domestically and exported (chiefly oil). The oil demand is completely elastic: domestic firms can sell any amount of it in the external market at an exogenous price following the AR(1) process.

Household offer labour services in the monopolistic competition market setting the wages under the Calvo–Yun model (Calvo 1983; Yun 1996) with inflation indexed on the CPI for the previous period. The three groups of households are competing in the market for labour demand from the N- and H-sector firms: elasticity of substitution μ.

Real estate is seen as illiquid assets owned by Non-Htm and Wealthy HtM households. That said, the classification of assets as liquid or illiquid is done similarly to what Eskelinen (2021) proposes. On the one hand, a change in housing level is subject to an adjustment cost, which makes this asset the last to be sold by households. On the other hand, the illiquidity of housing is ensured by its addition to the household utility function, which prompts the agents to adjust the level of liquid bonds first. Housing supply follows an exogenous AR(1) process, while housing demand is determined by the Non-HtM and Wealthy HtM households, taking into account the marginal utility of owning a housing unit, alternative homeownership costs (financial market rate) and a housing adjustment cost. For the Wealthy HtM households, housing play a collateral role for a loan and determines the borrowing limit. The difference between the intertemporal discount for the Non-HtM and Wealthy HtM households is assumed to be big enough for the cyclical housing price, income and consumption fluctuations to result in the borrowing limit for the Wealthy HtM households staying active. We establish several mechanisms for the direct income redistribution between the groups of households. First, the government redistributes funds from the Non-HtM households to the Poor HtM households through lump-sum transfers. Second, we assume that the firms' extra profit from elevated oil prices not only go to households owning these firms in the form of dividend payments but also are redistributed as transfers received by Wealthy HtM and Poor HtM households.

Foreign economies are accounted for by a new Keynesian model of a closed economy with homogeneous agents and a constant economy of scale. For the domestic economy, the foreign output dynamics determine the export demand, while the price dynamics create spillovers of global demand among countries due to international competition. The elasticities of substitution between the domestic and foreign tradable goods in the domestic (δ) and international (δ^*) markets may mismatch. For the domestic market, we assume the LCP (local currency pricing) principle that helps explain the moderate exchange-rate pass-through. The long-term exchange-rate pass-through of foreign prices to domestic ones is complete. For simplicity, we assume that H-sector producers do not discriminate against markets, setting the foreign price that corresponds to the domestic price (complete short-term exchange-rate pass-through).

The government exogenously creates demand for public goods that is modelled by the AR(1) process. The total amount of taxes is adjusted to the government needs and, at any point, the zero deficit budget condition is met. The taxes include payroll taxes (flat payroll tax system) and lump-sum taxes paid by the Non-HtM households (identical to a wealth tax).

As part of the inflation-forecast targeting, the Central Bank manages the interest rate under the Taylor rule based on the annual inflation forecast three quarters ahead and the current GDP long-term trend deviation. The Taylor rule includes inertia.

Foreign currency exchange rate is determined by the uncovered interest rate parity condition. The model's financial market is incomplete; a foreign risk premium is determined by the deviation of debt accrued by the Non-HtM households. The ad hoc function suggests that the higher the debt accrued, the higher the lending rate in the external market.

Appendix 1 contains all of the model's equations.

3.2 Steady state and model's parametrisation

To find the steady state, let us set several calibrating ratios, including the shares of the three groups of households and their consumption. The Bayesian estimation of the model's other parameters is conducted using quarterly macroeconomic data for 2014–2021.

3.2.1 Household structure evaluation for three groups

The model's parameters associated with the heterogeneity between groups of households were calibrated based on the RLMS-HSE[3] data on households for 2014–2021 and Rosstat data for 2014–2021.

Most studies group households by illiquid assets (housing) and liquid assets required for consumption redistribution. The Non-HtM involve households with a sizeable amount of liquid assets (typically over half of the current income), such as cash, accounts' balance, and overdrafts. The Wealthy HtM include households with illiquid assets (eg, housing) that may or do act as household loan collateral. The Poor HtM encompass households that have no illiquid assets or whose illiquid assets' cost is comparable to that of a loan amount (early mortgage payments) (Kaplan, Violante, Weidner 2014).

As opposed to a number of other countries, most Russian are homeowners. Part of the reason for that was free privatisation[4]. Another factor is Russia's relatively low labour mobility compared to European countries and the US, which causes households to purchase residential property, rather than rent it.

That is why, unlike foreign research papers, this paper, besides homeownership, takes into account qualitative housing characteristics as potential collateral: its market value and square footage per family member.

A household was classified as Non-HtM if, when asked, *'Imagine that all of your family members are left with no income sources. How long will your family maintain the material level you currently enjoy, that is, without cutting expenses or selling property, but using your savings?",* they replied *'several months'* or *'six months or longer'*. This means the household owns liquid savings that help smooth consumption over time. All other households were classified as hand-to-mouth, including the Wealthy HtM and Poor HtM types.

Foreign researchers tend to split hand-to-mouth households into Wealthy HtM and Poor HtM by ownership of pure illiquid assets (eg, housing). While the Wealthy HtM households hold them, the Poor HtM households almost do not. It is true for some Western countries where many families do not own residential property but live in rented homes. When it comes to Russia, this approach does not appear to be justified because most households own residential property. Introducing housing into the model is necessary above all to ensure procyclical lending, and not to reflect Russia's actual lending mechanism (collateral constraints serve as a financial accelerator in an imperfect market). That said, the practice of using housing as collateral for individual loans is not widespread in Russia, except mortgages.

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[3] Russian Longitudinal Monitoring Survey of HSE (RLMS HSE) conducted by the National Research University Higher School of Economics and Demoscope LLC featuring the Carolina Population Center at the University of North Carolina at Chapel Hill and the Institute of Sociology of the Federal Center of Theoretical and Applied Sociology of the Russian Academy of Sciences. (Relevant websites for RLMS-HSE: http://www.hse.ru/rlms, https://rlms-hse.cpc.unc.edu).

[4] The preferred strategy of Russian households is to buy property for ownership, which sets them apart from Western households (part of the reason is the immature long-term rental property market in Russia) (Kapelyushnikov 1990; Nureyev, Gulyayeva 2021).

A household is classified as Wealthy HtM if it owns housing and has a loan (this proves its access to the financial market) or quality assets that can be used as loan collateral. It must be pointed out that around 20% of households owning an apartment hesitated to tell its value or exact square footage. To avoid narrowing down the sample, additional data was used to identify the households' possession of other assets. A household as classified as Wealthy HtM if it meets at least two out of three criteria below:

– The apartment's square footage is in compliance with social norms established for residential property: 18 sq. m. for one resident, 21 sq. m. for two residents and 36 sq. m. for more residents.

– The cost of 1 sq. m. of residential property is above median[5].

– A household owns a different asset (second apartment, car, summer house, garage, motorcycle, tractor)[6].

The households whose assets fail to meet these criteria were classified as Poor HtM.

Table 2 shows the main characteristics of consumption by the three groups of households. The income share of both aggregate and current consumption by Non-HtM households is the lowest, which is consistent with their ability to smooth consumption over time. The consumption costs for Poor HtM households are the lowest, while the cost share of current consumption is the highest, which also confirms the assumptions on their behaviours.

Table 2

Key variables of heterogeneity between the groups of households for 2020

	Non-HtM	Wealthy HtM	Poor HtM
Number of households in a group, individuals	1133	1548	1745
Share of population	0.25	0.36	0.39
Income share of current consumption	0.35	0.41	0.44
Income share of aggregate consumption	0.73	0.81	0.78
Current consumption, RUR	8,897	8,271	7,609
Aggregate consumption, RUR	18,398	16,844	14,099

Source: authors' estimation based on RLMS-HSE data.

[5] The cost of 1 sq. m. in Russian regions varies significantly, so the initial stage involved calculating the ratio of the cost of 1 sq. m. for each household to the median cost of 1 sq. m. of residential property in the region as of the survey date (Rosstat data). Next, all households were ranked based on the resulting figure. The above-median cost of 1 sq. m. of residential property signified quality housing.

[6] The questionnaire does not contain data on the cost of the assets listed and therefore availability alone is taken into account.

The described procedure of classifying the households as one of the three types was utilised for each year, after which the shares for 2014–2020 were averaged out[7] (Table 3).

Table 3

Households classified as one of the three types, averaged for 2014–2020

	Non-HtM	Wealthy HtM	Poor HtM
Share of households	0.247	0.359	0.394

Source: authors' estimation based on the RLMS-HSE data.

Besides classifying the households, we needed to obtain the consumption dynamics for these groups of households. RLMS-HSE only contains yearly consumption figures, whereas Rosstat's HBS has quarterly consumption data by household type deciles. Since the databases only apply to Russia, let us split the RLMS-HSE households into deciles by income and identify the share of households from each decile that pertains to each of the three household groups in RLMS-HSE (Fig. 2). Note that the lower deciles mostly contain Poor HtM households, whereas higher deciles involve a higher share of Non-HtM households. On the one hand, it confirms the relevance of the premises and chosen criteria to group the households into groups. On the other hand, it points to only partial correlation with households' incomes and access to the financial market.

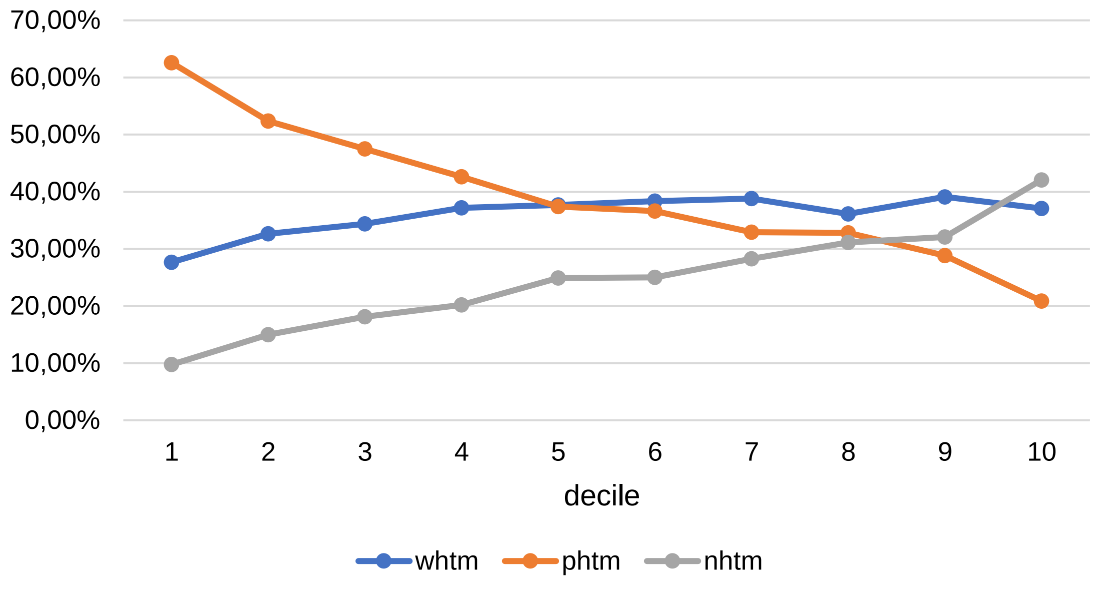

Fig. 2. Decile structure of three groups of households, averaged for 2014–2020

Source: authors' estimation based on the RLMS-HSE and HBS data.

The quarterly consumption by each group of households according to HBS is calculated as weighted mean consumption adjusted for the decile structure. Nominal consumption is converted to real consumption based on the COICOP and consumption

[7] When calculating the shares, observations were excluded where households' current consumption costs are twice the income or more (Khvostova et al. 2016).

structure for each decile according to HBS. Seasonal adjustment is done using X13-ARIMA SEATs.

3.3 Calibrating parameters to calculate the steady state

Table 4 shows the calibration of the parameters that are loosely identified on high-frequency data and are associated with the calculation of the steady state.

The consumption ratios for groups $\gamma_{Cn/w}$ and $\gamma_{Cw/p}$ are calculated based on mean real consumption by one household member for each of the three groups. The GDP share of government procurement spending γ_G is found as the mean value based on Rosstat's GDP data and the Federal Treasury data on the extended government's budget for 2014–2021. However, the spending does not include the costs associated with transfers ('social welfare' and 'family and childhood protection' rows). These transfers presumably stand for direct incentive payments to low-income and vulnerable demographics. The GDP $\gamma_{T_{0p}}$ share of these transfers is calculated based on similar data. It carries a negative sign, as the model accounts for it as lump-sum taxes for Poor HtM households. The ratio parameter for lump-sum taxes between Non-HtM and Wealthy HtM households $\gamma_{T_{0nw}}$ is chosen so that they are mostly paid by the former (similar to wealth tax; does not significantly affect consumption dynamics for the *Non-HtM* group).

Table 4

Calibrating constant values to calculate the steady state

Indicator	Calculation and value	Explanatory note
Share of groups' consumption	$\gamma_{Cn/w} \equiv \frac{\overline{C_n}}{\overline{C_w}} = 1{,}09$ $\gamma_{Cw/p} \equiv \frac{\overline{C_w}}{\overline{C_p}} = 1{,}19$	Authors' estimation
GDP share of government procurement spending	$\gamma_G \equiv \frac{\bar{G}}{\bar{Y}} = 0{,}32$	Authors' estimation
GDP transfer share	$\gamma_{T_{0p}} \equiv \frac{\overline{T_{0p}}}{\bar{Y}} = -0{,}033$	Authors' estimation
Ratio of lump-sum taxes between Non-HtM and Wealthy HtM households	$\gamma_{T_{0nw}} \equiv \frac{\overline{T_{0n}}}{\overline{T_{0w}}} \to +\infty$	The parameter is chosen so that lump-sum taxes are only paid by Non-HtM households
Ratio of external borrowing to export	$\gamma_{b^*} = 5{,}06$	Authors' estimation
Parameter of risk premium response to deviations of external borrowing from its steady state	$\nu = \gamma_\nu = 0{,}011$	Authors' estimation based on Novak, Shulgin (2020).

Source: compiled by the authors.

The ratio of external borrowing to median quarterly exportγ_{b^*} is calculated based on the Bank of Russia's External Sector's statistics for 2014–2021. Foreign borrowing is represented by a combination of private external public debt and the net International Investment Position (IIP), excluding foreign exchange reserves. The parameter of risk premium response to deviations of external borrowing from its steady stateγ_{ν} is calibrated to be 0.011. The value is calculated based on the similar value of the deviation from the steady ratio of foreign currency borrowing to the GDP in Shulgin (2017). It is adjusted for the GDP share of export (an average of 0.279 for 2014–2021) and for the ratio of external borrowing to median quarterly exportγ_{b^*}.

These ratios have yielded the analytical representation of the steady state (Appendix 1). The model is solved using the Dynare software platform (Adjemian et al. 2011). The rest of the parameters are evaluation using the Bayesian estimation or calibrated as well. As prior distributions, we use the results of both Russian and foreign studies but, if needed, they are adjusted to better match Russia's circumstances and yield more robust results and relevant impulse responses.

3.4 Bayesian estimation of model parameters

3.4.1 Data and detrending

To compute the model parameters, we use the Bayesian estimation approach that help combine the prior information with Russia's quarterly macroeconomic statistics for Q1 2014 – Q4 2021 (a total of 32 quarters) on the following observable variables:

- Key rate i_t, % (Bank of Russia) Quarterly rate (the annual rate is divided by 4).
- Oil price $P^*_{oil,t}$, \$/barrel (Russia's Ministry of Finance data) Average quarterly price of Urals oil is used.
- Foreign output y^*_t (IMF) The constant price GDP of the G20 countries is used, a seasonally adjusted baseline index (Q1 2010 = 1).
- International Price Program indexesP^*_t (US Bureau of Labor Statistics) US CPI as a seasonally adjustment baseline index (Q1 2010 = 1).
- Foreign exchange ratei^*_t, % (US Fed). The upper bound of the federal funds rate (the annual rate is divided by 4) is used and a mean quarterly value is calculated.
- y_t GDP in constant prices 2016 (Rosstat).
- Aggregate real wages $\frac{W_t}{P_t}$(Rosstat). A seasonally adjusted baseline index (Q1 2010 = 1) is used.
- Nominal dollar/ruble exchange rateS_t, RUR/\$ (Bank of Russia).
- Price indexP_t, % (Rosstat). CPI for all goods and services is used. The QoQ value is calculated by multiplying the three correspondent seasonally adjusted MoM inflation figures.
- Non-tradable goods price index$P_{N,t}$, % (Rosstat). CPI for services only is used. The

QoQ value is calculated by multiplying the three correspondent seasonally adjusted MoM inflation figures.

- Panels of relative consumption by Non-HtM and Wealthy HtM households as well as Wealthy HtM and Poor HtM households for 2014–2021 (Rosstat).

In all observed panels, the trend, the seasonal and the cyclical components were singled out. A detrending mechanism similar to that in Novak, Shulgin (2020) was used. The variables were broken down into three types: for type one, the trend component only had a constant measure (key rate, nominal oil price, foreign rate and foreign inflation, relative consumption behaviours by N/Wealthy HtM and W/Poor HtM households); for type two, there were a constant measure and a linear trend (Russia's GDP, foreign output, currency exchange rate, real wages); for type three (inflation according to CPI and for non-tradable goods), there was assumed to be a hyperbolical trend with an asymptote corresponding to a 4% annual target. For all the inflation panels, additional data on seasonal components was used[8]. Kinks in the trend are assumed for some of the panels. Appendix 3 shows the data and the trends identified.

3.4.2 Calibration

We set discount factors for Non-HtM households at: $\beta_n = 0.995$, which corresponds to the real interest rate of 2% per annum. For foreign households, this parameter is $\beta^* = 0.9975$ (1% per annum). For Wealthy HtM households, the discount factor is chosen at the level $\beta_w = 0.97$. The difference $\beta_n - \beta_w = 0.025$ must be big enough for the borrowing limit for Wealthy HtM households to be an equation for every period. For Poor HtM households, the discount factor $\beta_p = 0.98$ is irrelevant to the consumption path while affecting the choice of optimal wages amid the monopolistic competition.

The housing adjustment costs were set at $\phi = 0.01$, which is slightly lower than in Eskelinen (2021). This value makes housing somewhat more liquid and renders its volume dynamics more procyclical. The reciprocal of the elasticity of intertemporal substitution was set at $\sigma_c = 0.6$, which is consistent with a pronounced consumption response to the expected real interest rate (Shulgin, 2017). For the purposes of symmetry, let us assume that this variable in foreign economies is $\sigma^* = 0.6$. The relatively low σ_c also serves as a constraint to the income's effect on households' decisions relative to the optimal wages[9]. To this end, we set elasticities of substitution φ and φ^* at 20. This is higher than indicated in most studies and it aims to achieve more realistic income distribution of Non-HtM households between labour income and income from firm ownership by monopolistic competitors[10].

Parameter m, which defines the available credit amount as fractions from the household's illiquid asset prices, was set at $m = 0.6$. This is slightly lower than in similar

[8] For other variables, there is no seasonal component or it has been cleared of seasonality by Rosstat.

[9] Cantore, Freund (2021) solves the problem of a sluggish MPC response to the households' income, which is formed by the firms' profits, by identifying a set of "capitalist" households that do not participate in the labour market. Low σ_c partially solves the problem laid out by Cantore, Freund (2021) by dampening the optimal wage response to fluctuations in consumption.

[10] Lower the effect of profits on Non-HtM households' decision in the labour market.

studies (Eskelinen 2021; Iacoviello 2005), which points to a moderate relation between lending and the housing prices (Kolesnik et al. 2021).

The CPI share of non-tradable goods $\psi_N = 0.263$ matches the services' weight on Russia's CPI. Hence $\psi_T = 1 - \psi_N = 0.737$. To approximate the shares of domestic and foreign goods in the consumption of tradable goods, the import-to-GDP ratio was used that averaged at 20.7% for 2014–2021. Including the share of tradable goods in aggregate consumption, the preferences of imported and domestic goods amounted to $\psi_F = 0.281$ and $\psi_H = 0.719$.

The elasticity of labour substitution between the groups of households was $\mu = 1.5$. A relatively high extent of substitution is explained by the analysis results for the composition of the three groups that showed that the households are rather homogeneous in their position in the labour market.

The shares of global demand for domestic tradable goods are calculated as a ratio of the PPP-based exports of natural resources (fuel and energy complex) and all other goods and services to the global GDP (GDP PPP for G20 was used as a proxy) for 2014–2020. The share of natural resource exports is $\omega_{oil} = 0.0055$, while the share of other exports is $\omega = 0.0056$.

We assume lump-sum taxes paid, under this model, by Non-HtM households to include all form-related taxes: company taxes, aggregate income taxes, natural resource consumption taxes and taxes on foreign economic activity. Under the model, the GDP share of the remaining budget tax revenue of the extended government is associated with payroll taxes and averages $\tau = 0.2155$ for 2014–2021.

3.4.3 Prior distributions of parameters

To assess the utility function parameters for domestic and foreign households, we use prior distributions which are standard for the Bayesian approach in the context of general equilibrium models. The parameters are η and $\eta^* \sim\Gamma(1; 0{,}2)$, while consumer habits are ξ and $\xi^* \sim\mathrm{B}(0{,}4; 0{,}05)$. The prior distribution of the elasticity of substitution between tradable and non-tradable goods is $\alpha \sim\Gamma(1; 0{,}5)$. The parameters of the elasticity of substitution between domestic and imported tradable goods for the domestic and foreign economy are δ and $\delta^* \sim\Gamma(1{,}5; 0{,}75)$.

When assessing the parameters of nominal rigidity and wages, we use the following prior distributions: for prices in the domestic economy sectors θ_H, θ_N, $\theta_F \sim\mathrm{B}(0{,}75; 0{,}03)$ and for the foreign economy $\theta^* \sim\mathrm{B}(0{,}75; 0{,}03)$, as well as for the wages of different groups of households θ_{Wn}, θ_{Ww}, and $\theta_{Wp} \sim\mathrm{B}(0{,}75; 0{,}05)$. This mean value of prior distributions is consistent with price and wage adjustments averaging once a year and is supported by a number of empirical studies for the US and the Euro area (Alvarez, Hernando 2006; Blinder 1991; Fabiani et al. 2006). All indexation parameters exhibit beta distribution χ, χ^* and $\chi_w \sim\mathrm{B}(0{,}5; 0{,}1)$. The selected median value means partial indexation and is often used in other papers (Averina et al. 2018; Zubarev 2018; Sokolova 2014).

Under the monetary rule, coefficients of the interest rate response to expected inflation and output gap have the following prior distributions: $k_\pi \sim N(2; 0{,}2)$ and $k_y \sim N(0{,}05; 0{,}01)$ for the domestic economy, $k_\pi^* \sim N(1{,}5; 0{,}2)$ and $k_y^* \sim N(0{,}125; 0{,}2)$ for the foreign economy.

Due to the lack of data on structural shocks, in order to assess standard deviations, a non-informative heterogeneous prior distribution is used. Based on the idea of shock persistence, we set autoregressive coefficients for some of these, while for others, we conduct an assessment using a beta distribution as a prior one. Thus, we set the values for autoregressive coefficients of the key rate $\rho_i = 0.7$, real global oil price $\rho_{x^*} = 0.8$, government procurement spending $\rho_G = 0.7$, transfers $\rho_{T_p} = 0.8$, wages $\rho_w = 0.6$, housing supply $\rho_{h_s} = 0.6$ and housing demand $\rho_{h_d} = 0.6$. The following autoregressive coefficients are estimated: foreign interest rate persistence $\rho_i^* \sim \mathrm{B}(0{,}6; 0{,}1)$, total factor productivity shocks for the domestic and foreign economy ρ_A and $\rho_{A^*} \sim \mathrm{B}(0{,}8; 0{,}1)$ intertemporal choice shocks ρ_β and $\rho_{\beta^*} \sim \mathrm{B}(0{,}5; 0{,}1)$, risk premium $\rho_{rp} \sim \mathrm{B}(0{,}7; 0{,}05)$ and consumption shocks $\rho_c \sim \mathrm{B}(0{,}75; 0{,}1)$.

To assess the parameters setting the distribution of extra profit on oil exports between the three groups of households, we used relatively weak a beta prior distributions $\gamma_{oil,p} \sim B(0.2, 0.05)$ and $\gamma_{oil,w} \sim B(0.3, 0.05)$.

The coefficients of the external premium response to the debt accrued and real oil price have a normal prior distribution with overdispersion $\nu \sim N(0.05, 0.02)$ and $\xi_x \sim N(0.04, 0.02)$, signifying low certainty in the mean values of these coefficients.

3.4.4 Assessment results

When identifying the shocks that determine consumption by the groups of households, we used shock dispersion constraints. We assumed standard deviations of consumption shocks for all the three groups of households to be identical. This premise allowed us to compute the likelihood function and launch a MAP estimation of the function according to the model parameters. However, for all further model estimations, we used modes of multivariate posterior distribution parameters. Appendix 4 shows the results of the model's parametrisation (calibration and Bayesian estimation).

Especially noteworthy are relatively low estimations of $\theta \approx 0.6 \div 0.65$ Calvo pricing parameters for the domestic sectors: this result is standard for model estimations specific to Russia when the model's period includes the crisis of 2014–2015. The high odds of price adjustments (low nominal price stickiness) are consistent with a relatively high cost pass-through. For example, around 26% of the initial currency exchange rate hike passes to consumer prices over the five quarters following the shock. The indexed rate for domestic goods was estimated at a low $\chi = 0.23$. An important parameter that was assessed was utility $\sigma_h = 2.06$. We selected a high prior mean estimate for this parameter to obtain a moderate income swing for Wealthy HtM households, associated with financial market incomes. This fits our case where all the groups are homogeneously distributed by consumption deciles. The reciprocal of the Frisch substitution elasticity was estimated at $\eta = 0.84$, which leads to a pronounced labour market's response to shocks. All th estimated elasticities of goods substitution ($\alpha = 0.68$, $\delta^* = 1.30$) proved to be relatively low, which confirms low real price stickiness.

Overall, the analysed data panels contain a limited amount of information to properly identify structural parameters, which stresses the importance of calibration as well as the use of prior knowledge of the model parameters.

Appendix 5 shows the decomposition results for inflation, output, the interest rate, relative consumption by N/Wealthy HtM and W/Poor HtM households and the Gini index response to shocks (Figs. P5.1–P5.6). We broke down all structural shocks into several groups. Demand shocks are shocks of intertemporal choices $\varepsilon_{\beta,t}$ as well as of government expenditure $\varepsilon_{G,t}$. This category shall also include consumption preference shock $\varepsilon_{C,t}$, but since the Bayesian estimation of data did not cover this shock, its contribution to the decomposition is zero. Supply shocks are shocks of total factor productivity $\varepsilon_{A,t}$ and wage shock $\varepsilon_{W,t}$. External shocks include foreign interest rate shock $\varepsilon_{i^*,t}$, foreign productivity shock $\varepsilon_{A^*,t}$, shock of foreign intertemporal choices $\varepsilon_{\beta^*,t}$, oil price shock $\varepsilon_{x^*,t}$ and external premium (currency exchange) shock $\varepsilon_{rp,t}$. A policy shock is interest rate shock $\varepsilon_{i,t}$. Inequality shocks involve consumer preference shock for groups of households $\varepsilon_{C_n,t}$, $\varepsilon_{C_w,t}$ and $\varepsilon_{C_p,t}$ as well as observed and non-observed transfer shocks $\varepsilon_{T_p,t}$ and $\varepsilon_{T_{up},t}$. Shocks of Intertemporal choices for groups of households $\varepsilon_{\beta_n,t}$, $\varepsilon_{\beta_w,t}$ and $\varepsilon_{\beta_p,t}$ together with housing demand shocks $\varepsilon_{h_n,t}$, $\varepsilon_{h_w,t}$ and $\varepsilon_{h_p,t}$ should also be included in this group, but they were not used to interpret the dynamics of the observed variables.

The decomposition of the dynamics of variables into shocks is quite typical of New Keynesian models. Output is mostly shaped by domestic demand shocks and external shocks that primarily encompass oil price shocks. The dynamics of inflation and hence of the key rate are chiefly determined by supply shocks and external shocks that primarily encompass external premium (currency exchange rate) shocks.

Hereinafter we will show that analysing non-structural inequality shocks is more convenient because the structural shocks included in this group impact both consumption inequality variables and aggregate variables. The decomposition into shocks shows that the group of structural household consumption and transfer shocks impacts the output more significantly than the inflation and the interest rate. The decomposition of the inequality variables into shocks demonstrates that the aggregate structural shocks' contribution to the explanation of the inequality variables is larger than that of shocks from certain groups.

3.4.5 Robustness analysis

To analyse robustness, we estimated the model with non-informative priors for the parameters whose prior and posterior distributions proved to be the closest. In the alternative estimation scenario, we used heterogeneous prior distribution for interest rate response to the output gap for the domestic and foreign economy k_y and k_y^* as well as for the shares of extra profit on oil prices received by Wealthy HtM and Poor HtM households $\gamma_{oil,w}$ and $\gamma_{oil,p}$. Appendix 10 provides the estimation results. Clearly, the estimations of the shares considerably differ from the baseline estimation scenario:

$\gamma_{oil,w}(Alt) = 0.25$ against $\gamma_{oil,w}(Base) = 0.20$ and $\gamma_{oil,p}(Alt) = 0$ against $\gamma_{oil,p}(Base) = 0.29$. By contrast, the coefficients of the interest rate response to the output gap proved to be rather close to the baseline scenario: $k_y(Alt) = 0.0534$ against $k_y(Base) = 0.05$ and $k_y^*(Alt) = 0.19$ against $k_y^*(Base) = 0.20$.

The impulse response functions for the baseline and alternative scenarios are provided in Figs. P10.1 and P10.2. For most shocks (Fig. P10.2 shows the example of a monetary policy shock), the impulse response functions showed sluggish changes, which points to the robustness of the Bayesian estimation. The most salient deviations were observed in the functions of the impulse response to the oil price shock, as shares $\gamma_{oil,w}$ and $\gamma_{oil,p}$ have the most considerable effect on the variables' response to this shock. It can be asserted that these parameters help adjust the endogenous variable response to the oil price shock. The estimation of the remaining model parameters did not change significantly, which points to the big role of parameters $\gamma_{oil,w}$ and $\gamma_{oil,p}$, particularly in terms of the oil price shock's impact on the inequality variables.

For more information, we additionally computed the impulse response functions for the baseline estimation scenario with coefficients set to $\gamma_{oil,w} = 0$ and $\gamma_{oil,p} = 0$. The key findings in the robustness analysis is that the oil price shock with zero shares $\gamma_{oil,w} = 0$ and $\gamma_{oil,p} = 0$ amplifies consumption inequality, while in both estimation scenarios (baseline and alternative), the rise in oil price dampens inequality through the redistribution (both budgetary and non-budgetary) of funds obtained due to extra profit on elevated oil prices.

However, the relative consumption response for N/Wealthy HtM and W/Poor HtM households is sensitive to $\gamma_{oil,w}$ and $\gamma_{oil,p}$. To identify the contribution of the oil price to the dynamics of relative consumption, we suggest using prior data on more homogeneous distribution of shares $\gamma_{oil,w}$ and $\gamma_{oil,p}$ that is covered by the baseline estimation scenario.

3.4.6 Impulse response functions

Fig. 3 and Figs. P6.1–P6.6 (Appendix 6) show the responses of the key endogenous variables to the structural shocks. The response of the economy and of the consumption by the three groups of households to the monetary policy shock is qualitatively consistent with the results in Eskelinen (2021). The interest rate shock (Fig. 3) typically destimulates demand, which results in lower production volumes and lower inflation. Three quarters into the shock, the interest rate becomes negative as a consequence of stabilised lower inflation under the Taylor rule. The inflation's response to the interest rate is rather prominent, which is typical of a high cost pass-through. During the shock, consumption by all groups of households reduces. The primary effect is the reaction exhibited by Non-HtM households that reduce consumption in the current period responding to the interest rate hike. The Non-HtM's reduced consumption spurs secondary effects of the interest rate hike: lower production volumes and hence lower incomes and consumption by Wealthy HtM and Poor HtM households. The interest rate hike also leads to a further drop in consumption by Wealthy HtM households due to devalued illiquid assets and lower lending opportunities in the financial market. As a result, these households' consumption declines the most in response to the interest rate shock.

Since the Wealthy HtM comprises middle-income households, the inequality at both ends of the Lorenz curve moves in opposite directions. At the upper tail, the inequality rises (the Wealthy HtM households' consumption dampens more than that of Non-HtM households). At the lower end, the inequality declines, as the Poor HtM households' consumption decreases more moderately than that of the Wealthy HtM households. Aggregate consumption inequality posts insignificant steady change trending towards higher inequality because the Non-HtM households exhibit the lowest reduction in consumption at the time of the monetary restriction.

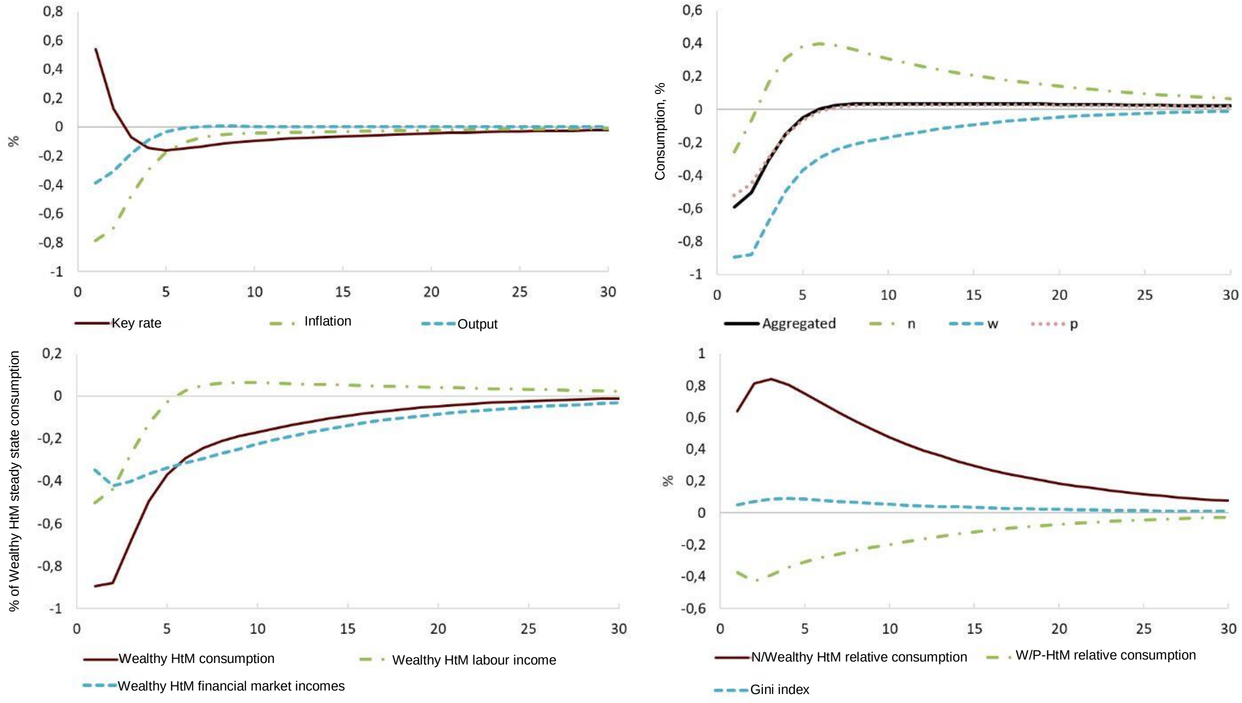

Fig. 3. IRF to one st.dev. monetary policy shock.

Note. Bottom right panel: N/Wealthy HtM relative consumption, W/Poor HtM relative consumption, Gini consumption index excluding differentiation within the groups.

Source: authors' calculations.

For other structural shocks (Figs. P6.1–P6.2, Appendix 6), consumption behaviours of different groups of households may significantly vary from the monetary policy shock picture. For example, for supply shocks, consumption by Non-HtM and Poor HtM households will move in opposite directions, as the labour incomes and the interest rate also post contradirectional changes. A similar picture is true of the external premium (currency exchange rate) shock and the shock of foreign intertemporal choices: a weaker currency prompts short-term growth in output, wages and Poor HtM consumption. For Non-HtM households, the interest rate hike designed to constrain the inflation leads to a fall in optimal consumption.

For the shock of intertemporal choices, all groups of households show a homogeneous response. However, Non-HtM households react more prominently than Poor HtM households, as the inflation and the interest rate are more affected by the shock than the output. Finally, the oil price shock cause changes in households' consumption that are qualitatively similar to the monetary policy shock. The Wealthy HtM households are the most responsive as their labour and financial incomes move in the same direction. For the rest of the shocks listed, the Wealthy HtM consumption response proves to be median for all the groups of households, while labour and financial incomes change in opposite directions, with the financial market as a stabiliser.

All the impulse responses exhibit a persistent component associated with the financial market's long-term adjustment. The adjustment reveal the effect of the savings and portfolio composition redistribution channels. Deviations in the consumption by Non-HtM and Wealthy HtM households from their steady states have the opposite signs: Non-HtM households own extra income assets, whereas Wealthy HtM households have outstanding debt and pay interest on it. This leads to the cyclical inequality components at both ends of the Lorenz curve, too, having the opposite signs in the long term.

4. Inequality and Monetary Policy

This section will discuss the three aspects of the interaction between [consumption] inequality and monetary policy. Subsection 1 will examine the evolution of the shock transmission mechanism against the varying shares of the three groups of households. This will offer insight into the way trends – above all, amid the heterogeneous access to the financial market – will change the shock transmission mechanism in the economy. Subsection 2 will investigate the dynamics of inequality variables at the upper tail and the lower end of the Lorenz curve and the inequality composite along with the dynamics of the interest rate. This will show us the type of information in the inequality-related panels and provide us with an idea of the information advantage of using these panels. Lastly, in Subsection 3, we will identify the non-structural inequality shocks. We will show that for Russia's business cycle, the contribution of inequality fluctuations at the lower end of the Lorenz curve is more significant than that of inequality fluctuations at the upper tail. Furthermore, we will demonstrate that two non-structural inequality shocks lead to a similar, moderate response from the monetary policy. It enables researchers to incorporate the inequality composite, such as the Gini index, into the models.

4.1 Financial market and shock transmission mechanism

Based on the estimated structural model, let us address the question of how change in inequality may affect the shock transmission mechanism. At this stage we will compare the behaviours of the key macroeconomic variables in various distribution scenarios for the aggregate demand between the groups of households in the model, bracketing the economy adjustments to a new long-term equilibrium. We will also shelve the endogenous response of the household income and consumption inequality arising within a business cycle. The main question that needs to be addressed is as follows. How can the change in the inequality steady states affect the response of inflation, output and the interest rate to monetary policy shocks as well as the other structural shocks?

In the model, inequality impacts the shock transmission mechanism, above all, due to the households unequal access to the financial market. Heretofore, we have not investigated the way households were classified into groups and how unequal access to the financial market correlates with the households' income distribution. The task suggests, and empirical data confirms that the three groups of households with different access to the financial market also vary in terms of median consumption and income; in other words, they may be associated with long-term income inequality.

However, there is no conclusive correlation between the rise in a specific household's income and its position in the financial market: the empirical section has shown a vast household income spread within each group. The lack of a conclusive correlation between income inequality and household heterogeneity in their interactions with the financial market makes us focus on the role unequal access to the financial market plays in determining the monetary policy transmission mechanism and other structural shocks.

Consumer behaviour in the three groups of households vary dramatically under different types of shocks. Thus, a change in shares of individuals pertaining to each group can significantly change shock transmission across the entire economy. In order to understand the change in economy responses to the shocks, we suggest conducting counterfactual experiments with the model. In the first pair of experiment, we will assume the share of individuals pertaining to Wealthy HtM households to be either large ($\gamma_w = 0.9$; '*All wealthy*' in the figures) or small ($\gamma_w = 0.1$; '*No wealthy*' in the figures). In the experiments, the proportions of the two other groups of households remain the same as in history parametrisation, ie, $\frac{\gamma_n}{\gamma_p} = \frac{0.25}{0.36}$. In the second pair of experiments, the same manipulations will be applied to the shares in Poor HtM households: the share of this group will be either large ($\gamma_p = 0.9$; '*All poor*' in the figures) or small ($\gamma_p = 0.1$; '*No poor*' in the figures). That said, we will preserve the proportions of the remaining groups: $\frac{\gamma_n}{\gamma_w} = \frac{0.25}{0.39}$. The first pair of experiments answers the question of how the Central Bank benefits from households being extensively involved in the financial market in terms of lending, which many researchers associate with the rising income in poor demographics, ie, with the dampening inequality in the low-income area of the Lorenz curve. The second pair helps clarify the scenario where the economy is hit with a crisis and most agents lose access to the financial market, ie, the cyclically dampening inequality in the high-income area of the Lorenz curve.

4.1.1 Role of indebted Wealthy HtM households

Fig. 4 shows the response of inflation, output and the interest rate to a monetary policy shock in the historical scenario as well as the two alternative 'All wealthy' and 'No wealthy' scenarios along with response properties for the model history parametrisation explaining the financial sector's role in the behaviours of the series for Wealthy HtM households.

The increased the Wealthy HtM share in the aggregate demand amplifies the response of inflation and output to the monetary policy shock. As is seen, the consumption response of Wealthy HtM and Non-HtM households groups the response's lower and upper bounds respectively, while consumption by Poor HtM households almost matches the aggregate consumption behaviour. This is not standard for structural shocks. Normally, it is Wealthy HtM households that set median behaviours in the economy, as it averages out the behaviour of both Poor HtM households consuming their labour income and Non-HtM households optimising their behaviour to match the dynamics of the interest rate. When the interest rate shock occurs, the behaviour of Poor HtM households becomes median, as their reduced consumption is only determined by a fall in their labour income. In other groups, a fall in labour income is accompanied in financial losses incurred by the high interest rate for the indebted Wealthy HtM households and gains of the Non-HtM savers, allowing this group of households to promptly advance to the increased consumption area.

The consumption response of Wealthy HtM households to the interest rate shock becomes the most acute among the three groups and, if the share of this group of households is large, the response of the entire economy to the monetary policy shock will be acute too. For the Central Bank, it proves beneficial, as it is capable of sending more powerful impulses to the economy via its discretionary policy.

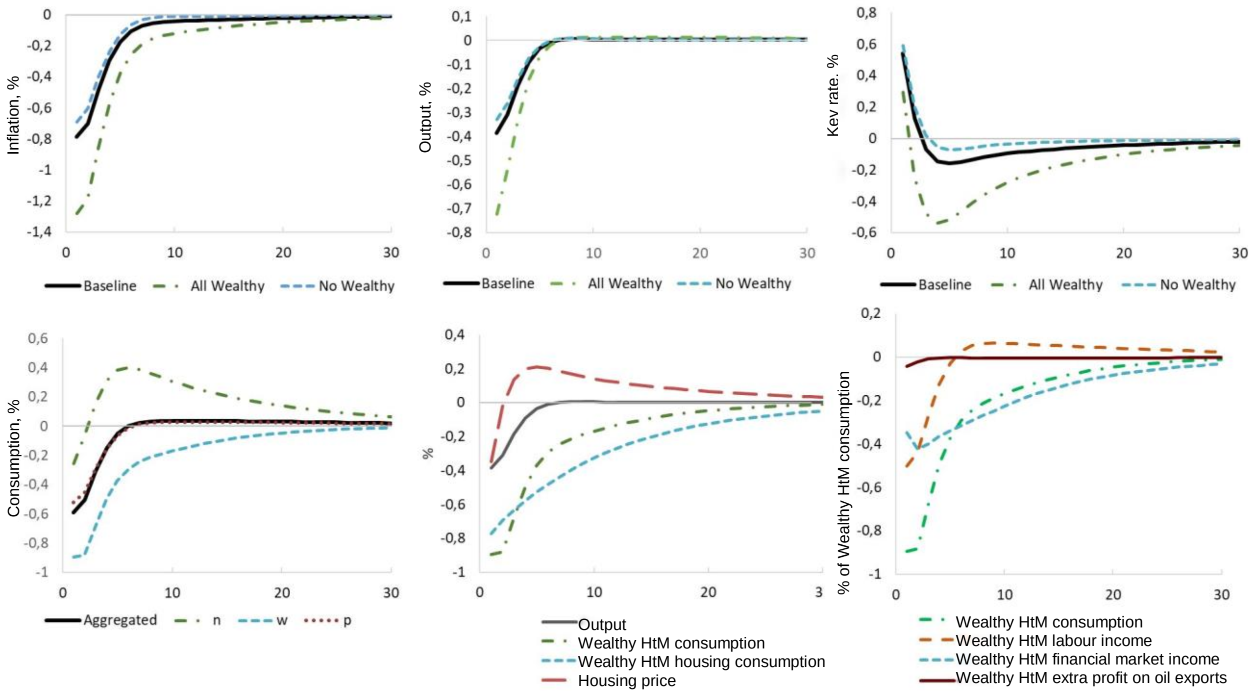

Fig. 4. Experiments with the share of Wealthy HtM. One-standard-deviation monetary policy shock.
Source: authors' calculations.

The combination of labour income that fell following the monetary policy shock and an increased interest rate that causes the Wealthy HtM households' atypical behaviour is not representative of other shocks. A more typical picture (Appendix 7) is the labour income and the interest rate moving in the same direction as other structural shocks arise. Financial incomes (that account for a change in the borrowing limit) of the indebted Wealthy HtM households offset the losses incurred by decreased labour income. This brings consumption by the Wealthy HtM households closest to aggregate consumption and, consequently, the rise in the share of such households does not amplify the economy's response to such shocks. Prominently, what stands out from the traditional picture is the oil price shock. A rise in the households' labour income that follows the increase in oil prices together with the partial redistribution of extra profit is accompanied by the price downturn caused by the strengthening national currency. Stabilisation monetary policy involves a reduced interest rate and additional growth in financial incomes of the indebted households, which renders the consumption response of Wealthy HtM households to this shock the most acute. This outlier does not change the general picture since the stabilisation fiscal policy is capable of smoothing the effects of the oil price shock for the economy.

Thus, for most structural shocks, the higher percentage of the indebted Wealthy HtM households does not amplify the response of inflation and output to these shocks. Moreover, due to a rare combination of a high interest rate and low labour incomes, the monetary policy shock prompts a pronounced response of the Wealthy HtM households to the discretionary policy. Overall, it benefits the Central Bank, as it makes the discretionary monetary policy a more powerful tool. However, should the Central Bank seek a scenario where a large share of households face a borrowing limit? The answer depends on the group from which households transition to the Wealthy HtM. If a household has not had access to the financial market, the transition from the Poor HtM to the Wealthy HtM provides the household with more opportunities to achieve a more beneficial consumption path. But we consider a possible transition of an Non-HtM household to the Wealthy HtM, society will not benefit from such a transition. A previously unconstrained household will face a scenario where it cannot achieve the first best consumption distribution over time. Discretionary policy interventions will not offset the long-term decline in the state of such a household caused by the financial market imperfection.

Finally, another applied question is as follows. What will occur if the borrowing limit for the Wealthy HtM is eased, ie, the model's m parameter, which determines the borrowing limit as a proportion of illiquid assets, rises? In this case, the Non-HtM and Wealthy HtM households become more polarised, whereas the aggregate variables' response to the monetary policy will be more significant (Fig. P9.1, Appendix 9). With eased constraints for households, a more pronounced discretionary monetary policy response appears to benefit the society. But in this case, the financial market will exhibit other imperfections (eg, a possibility of bankruptcy) that can be ignored with a more moderate m parameter.

Lowering the m parameter to zero makes the Wealthy HtM households' behaviour identical to that of the Poor HtM households, which is similar to the increased share of the latter in the total number of households.

4.1.2 Role of Poor HtM households with no access to the financial market

In the second pair of experiments, we change the share of Poor HtM households.

Fig. 5 shows the response of key variables to the monetary policy shock for the history parametrisation compared to the two counterfactual distribution scenarios: 'All poor' and 'No poor'. The monetary policy shock brings consumption of the Poor HtM households closer to aggregate consumption; therefore a change in the share of these households does not affect the monetary transmission mechanism. A large share of the Poor HtM households with no access to the financial market slightly dampens the negative response of inflation and output to the interest rate shock. It suggests that in the financial market, the aggregate sum of income contributions of all groups of households to consumption is generally negative for the economy. This is caused by the general investment position being negative for the economy and an interest rate hike creating a slight negative income effect.

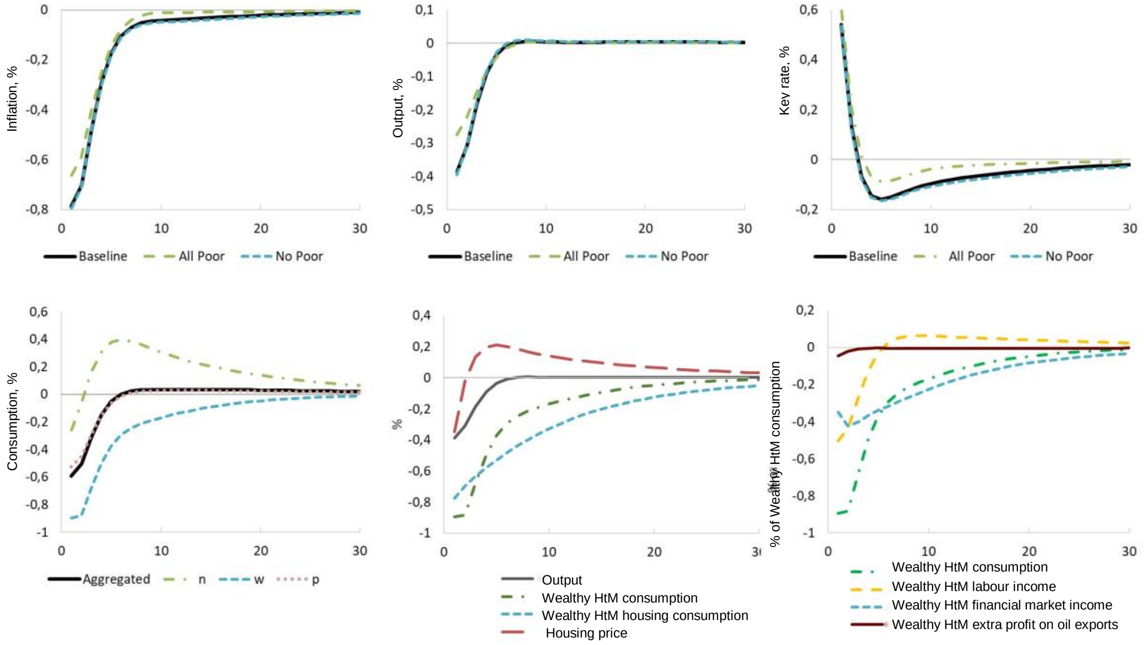

Fig. 5. Experiments with the share of Poor HtM. One-standard-deviation monetary policy shock/

Source: authors' calculations.

The role of the percentage of individuals pertaining to this group proves to be insignificant for the monetary policy shock, something that is not true of other shocks. As has been noted, for most shocks, the response of Non-HtM and Poor HtM households accounts for the two extreme lines with the response of Wealthy HtM households in between. Moreover, for many structural shocks, the consumption response of Poor HtM households is opposite in sign to that of Non-HtM households. For example, the wage shock (Fig. P8.7, Appendix 8) increases the income of Poor HtM households and hence their consumption. For the firms, this is a negative supply shock that drives inflation, increases the interest rate and decreases consumption by Non-HtM households. A similar picture applies to a total factor productivity shock, which is another supply shock. A rise in productivity lowers the need for resources and reduces labour income for all groups of households. While Non-HtM households increase consumption following a lower interest rate and growing financial incomes, Poor HtM households shrink their consumption. In summary, it can be asserted that supply shocks for Poor HtM households become de facto demand shocks, as they directly reduce this group's consumption. Another unusual response of Poor HtM concerns government expenditure (Fig. P8.2, Appendix 8). For

Non-HtM households, a rise in government expenditure crowds out private consumption by the acceleration of inflation and the interest rate hike. As for Poor HtM households, the crowding-out effect does not play a role, and the households with no access to the financial market amplifies the response of inflation and output to this shock by additionally spurring the consumption of this group of households as a result of rising wages.

For most structural shocks, a large share of Poor HtM households leads either to an amplified response of inflation and output or to a change in sign of the output response to the shocks. As has been observed, for some shocks, a share of Poor HtM households does not produce much of an effect (monetary policy shock, foreign productivity shock, oil price shock). Lastly, the sole exception is the intertemporal choice shock resulting in the response of inflation and output for the 'All poor' scenario being lower than for the history parametrisation. But this fact has an uncommon explanation. The intertemporal choice shock does not have a direct effect on the Poor HtM households that do not lead to intertemporal consumption smoothing.

Thus, an increased share of households with no access to the financial market (Poor HtM) or with a borrowing limit (Wealthy HtM) slightly dampens the response of inflation and output to the monetary policy shock, while amplifying fluctuations in the economy caused by the majority of other shocks. This should be taken into account when analysing a business cycle. For example, the m parameter can drop amid a crisis[11], while the Central Bank prioritises financial stability and cannot afford to ease its macroprudential policy interventions. If this is the case, the Central Bank needs a more accommodative discretionary policy.

Can we say infer the empowerment of the discretionary monetary policy that accompanies an increase in the share of Wealthy HtM households benefits the goals of the stabilisation monetary policy? On the one hand, we can since the economy's response to most structural shocks does not amplify and the reason to adopt discretionary interventions includes substandard fluctuations of economic activity. On the other hand, the undertaken analysis is not structural, as we do not control the agents' losses from indebted Wealthy HtM households losing solvency in crises. If we assume that the Central Bank exercises some measure of control over the *m* parameter[12], we can suggest trade-off between the power of the monetary policy and financial viability.

4.2 Inequality and monetary policy within the business cycle

Let us consider the fluctuations of variables that stand for consumption inequality and that arise in response to structural shocks. This analysis is useful from a positive standpoint as it highlights the instruments to be used in the empirical analysis of the mutual impact between inequality and monetary policy. The normative benefit conferred by the insights into inequality variable fluctuation within a business cycle is that, with limited data on the business cycle, having several observed panels tied to structural

[11] These properties are highlighted in several studies associated with the modelling of an imperfect financial market (such as Gertler, Karadi 2011).

[12] The Central Bank does not fully control the *m* parameter, as commercial banks are entitled to change their lending policy on their own to mitigate the losses incurred by bad loans.

shocks means a much more accurate prediction of inflation. In our paper, we investigate the key properties of impulse responses of the panels showing consumption inequality at the upper tail and lower end of the Lorenz curve as well as the aggregate inequality index. We focus on the consumption dynamics because in the long term, income inequality and consumption inequality smooth out, while in the business cycle, consumption inequality directly relates to the mechanism of shock transmission into inflation, output and other macrovariables.

Fig. 6 shows the dynamics of relative consumption by Non-HtM and Wealthy HtM as well as Wealthy HtM and Poor HtM households in response to various structural shocks. Highlighted in red are responses to the supply shocks, blue denotes the demand shocks, purple designates the external shocks and green marks the response to latent shocks of a specific group. A growth in relative consumption by Non-HtM and Wealthy HtM households (Fig. 6, left) means increased inequality at the upper tail of the Lorenz curve. A growth in relative consumption by Wealthy HtM and Poor HtM households (Fig. 6, right) means increased inequality at the lower end of the Lorenz curve. The shock values match the estimated standard deviations of each shock and give us an idea of the relative contribution each shock makes to the dynamics of households' relative consumption. Almost all the responses have a relatively slow converging part associated with the dynamics of asset incomes. A faster dampening fraction of the responses has to do with the dynamics of labour incomes as well as of the interest rate. Relative consumption responses to most shocks exhibit a moderate amplitude (up to +/- 1%). The exception is the TFP shock (solid red line) that causes more substantial fluctuations (up to 2.5% for the relative consumption by Wealthy HtM and Poor HtM households).

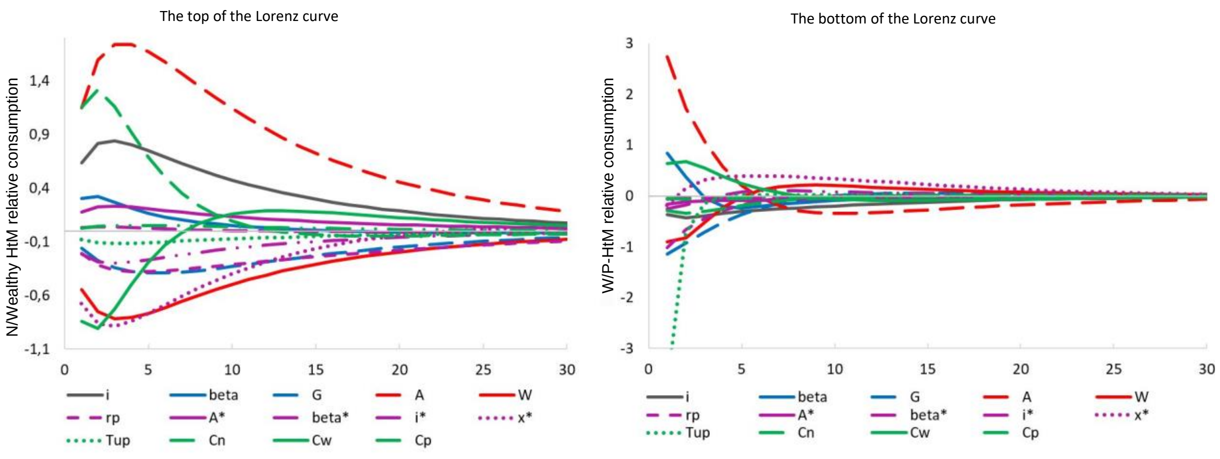

Fig. 6. The relative consumption response (as a percentage of its stationary values) to structural shocks for Non-HtM and Wealthy HtM (left) as well as Wealthy HtM and Poor HtM (right) households.

Source: authors' estimation.

The high amplitude of relative consumption responses (highlighted in green) to consumption shocks for the specific groups of households shows that these latent inequality shocks play a big role in the dynamics of relative consumption. The interest rate response to these shocks proves to be moderate; therefore, if other structural shocks cannot account for the observed dynamics of relative consumption and we need to use latent inequality shocks to explain it, the latter make no sizeable contribution to the interest rate dynamics. For example, the aggregate contribution of the latent consumption shocks to the interest rate dispersion was estimated at 0.5% for 2014–2021.

To identify the main properties behind the inequality dynamics in response to structural shocks, let us merge two graphs in Fig. 6. In Fig. 7, there is no time axis, while all impulse response functions (IRFs) are planar projections. Plotted to the left of the x-axis is the relative consumption by Non-HtM and Wealthy HtM households. The y-axis represents relative consumption by Wealthy HtM and Poor HtM households (as a deviation percentage of the steady state value). Plotted to the right of the x-axis is the interest rate response. The y-axis represents the response to the aggregate consumption inequality index: the model Gini consumption index.

Each projection of the impulse responses passes through the origin, as all the impulses dampen over time. For a better understanding of the graphs, Table 5 shows an instant response of all the analysed variables to structural shocks (first dot in the IRF projection in Fig. 7).

Most structural shocks create a unidirectional inequality change at the upper tail and the lower end of the Lorenz curve in the short term. This is due to the codirectional movement of the labour incomes and the interest rate. In response to demand shocks, such movement is due to the fact that, eg, a positive demand shock increases output and labour incomes while prompting a price hike and, with it, an interest rate hike under the Taylor rule. In response to supply shocks, this codirectional movement is due to the fact that, eg, a rise in wages or a reduction in productivity lead to increased household labour incomes[13], spurring both a price hike and a interest rate hike. A rise in labour incomes against the interest rate hike results in Non-HtM households reducing their consumption and Poor HtM households increasing it. Wealthy HtM households find themselves in the middle. This reduces inequality at both ends of the Lorenz curve. Over time, in four to eight quarters, most shocks have their cyclical inequality component at both ends of the Lorenz curve opposite in sign. This is explained by the fact that consumption components associated with the financial market are the slowest to dampen. As a result, in four to eight quarters, the highest consumption inequality is at the upper tail of the Lorenz curve, as the positions of Non-HtM and Wealty HtM households emerge to be exactly opposed. If a shock led to an interest rate hike, Non-HtM households are the long-term winners, while Wealthy HtM households are the losers, which amplifies the inequality at the upper tail of the Lorenz curve. Conversely, at the lower end, Poor HtM households with no access to the financial market will be better positioned than Wealthy HtM households. This slightly reduces the inequality at the lower end of the Lorenz curve.

[13] A short-term decline in productivity does not lead to a lower wage stickiness, but increases the demand for resources on the part of the firm, which boosts the demand for labour and households' labour incomes.

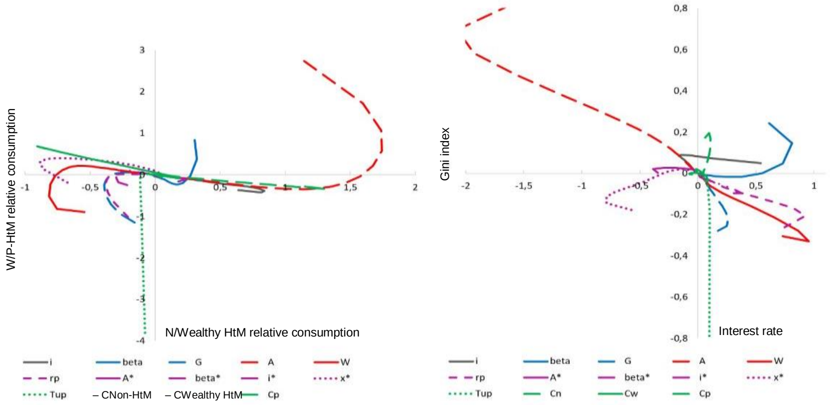

Fig. 7. Impulse response projection on structural shocks. On the left: relative consumption (as a percentage of their steady state values) by Non-HtM and Wealthy HtM households (x-axis) and Wealthy HtM and Poor HtM households (y-axis). On the right: interest rate (x-axis)and Gini consumption index (y-axis).

Source: authors' estimation.

If the shocks originated in the financial market, such as the monetary policy shock, the behaviour of indebted households changes most saliently, which creates the opposite dynamics at the ends of the Lorenz curve. In its configuration, the oil price shock resembles that of the financial market, as an oil price hike creates extra profit for the firms, which are instantly consumed by Wealthy HtM and Poor HtM households and partially saved by Non-HtM households. As a result, during the shock, the inequality at the upper tail goes down, whereas the inequality at the lower end remains around its steady state value. Over time, Wealthy HtM households benefit from the decreased interest rate (the Central Bank addresses the effects of the strong ruble), which leads to a moderate rise in inequality at the bottom of the Lorenz curve.

Thus, shocks directly affecting the financial market should lead to the opposite movement of the inequality at the top and the bottom of the Lorenz curve. For example, crisis events that cause an interest rate hike increase the inequality at the upper tail while reducing it at the bottom of the Lorenz curve, as they adversely affect the indebted Wealthy HtM households positioned in the middle of the curve.

The prevalence of the TFP shocks in the rationale behind the inflation and the interest rate leads to the likeliest combination in the aggregate cyclical dynamics of inequality and the interest rate (Fig. 7, graph on the right) being that with codirectional deviations from the steady state values. For example, the negative supply (TFP or wage) shock drives inflation, which calls for an increased interest rate while reducing the inequality at both ends of the Lorenz curve and hence the Gini consumption index.

A less likely combination is the codirectional deviation of the interest rate and the Gini index, which arises in response to demand, oil price and monetary policy shocks. Moreover, the supply shock is listed because we set this shock through a change in intertemporal choices, which have no direct effect on the Poor HtM households' behaviour (that optimise consumption over time). That is why, for example, a positive shock of intertemporal choices will lead to a more sluggish rise in consumption by Poor HtM households, as their behaviour can only be affected by the secondary effect through the rise in aggregate demand that causes a spike in labour incomes. The other demand shock, the government expenditure shock, exhibits more conventional behaviour.

Thus, the codirectional dynamics of the rate and the Gini index relative to its long-term levels along with the opposite changes in the inequality at the ends of the Lorenz curve signals the prevalence of shocks associated with the financial market. In our view, this finding is hard to implement, as the Central Bank typically deals with more evident signals pointing to the financial market problems. However, this finding conclusively points to the economically valid difference between the responses of consumption inequality variables to several key types of shocks at the two ends of the Lorenz curve. This testifies to the information advantage of using this consumption inequality data when identifying shocks that explain the national business cycle. However, this data is updated with a significant delay (about a quarter); therefore the extent of this advantage is debatable and subject to further research in the field.

4.3 Non-structural inequality shocks

In this paper, we have introduced several latent structural shocks designed to explain the observed dynamics of the relative consumption by the three groups of households: $\varepsilon_{C_n t}$, $\varepsilon_{C_w t}$, $\varepsilon_{C_p t}$ and $\varepsilon_{T_{up} t}$. Each structural shock impacts two observed variables of households' relative consumption and aggregate consumption. From the informational perspective, a more relevant task is that of identifying the economy's response to a combination of shocks that changes the relative consumption between a pair of groups in the current period, while not affecting the relative consumption of the other pair as well as aggregate consumption. This task has informational value as it addresses the marginal effect exercised over the monetary policy by the informational innovation in the relative consumption of a pair of groups against the unchanged aggregate consumption and relative consumption of the other pair.

To solve this task, we will determine a combination of weights for latent structural shocks such that, during the shock, the relative consumption of one pair of groups changes by 1%, while the relative consumption of the other pair and aggregate consumption remain constant. Based on the analysis of the impulse responses, we excluded the consumption shock ε_{C_p} for Poor HtM houseuholds, as the relative consumption response to this shock is rather sluggish. With three remaining latent shocks to set the responses of the three variables, let us write a Jacobian matrix of the form:

$$\Psi \equiv \frac{\partial z}{\partial \varepsilon}, \tag{1}$$

where $z \equiv [c_t \; rc_{n/wt} \; rc_{w/pt}]'$;$\varepsilon \equiv [\varepsilon_{C_n t} \; \varepsilon_{C_w t} \; \varepsilon_{T_u t}]'$.

If we exclude the impact of other structural shocks and the inertia to the dynamics of endogenous variables z, we can write:

$$\Delta z = \Psi \varepsilon \tag{2}$$

The geometric interpretation of this condition proves that matrix Ψ sets the transformation of structural shock vector ε into vector Δz. The task of identifying non-structural shocks affecting a single variable of vector Δz without affecting the remaining two variables is solved using the transition to a different set of basis vectors (non-structural shocks) u. Let us define the new set of basis vectors so that the matrix of transformation from $u$toΔz is the identity matrix.

$$\Delta z = \mathrm{E}_3 u, \tag{3}$$

where E_3 is identity matrix 3×3.

It follows from (2) and (3) that the transformation matrix from the old set of basis vectors to a new one matches Ψ:

$$u = \Psi \varepsilon \tag{4}$$

Each component in the new set of basis vectors has its interpretation according to its position in vector z: u_1 is a non-structural shock of aggregate consumption; u_2 is a non-structural shock of relative consumption by Non-HtM and Wealthy HtM; and u_3 is a non-structural shock of relative consumption by Wealthy HtM and Poor HtM.

To calculate the impulse response to the three non-structural shocks, we resolve the corresponding vector u into an old set of basis vectors:

$$\varepsilon_1 = \Psi^{-1}\begin{bmatrix}1\\0\\0\end{bmatrix} \qquad \varepsilon_2 = \Psi^{+-1}\begin{bmatrix}0\\1\\0\end{bmatrix} \qquad \varepsilon_3 = \Psi^{-1}\begin{bmatrix}0\\0\\1\end{bmatrix}, \tag{5}$$

where ε_j is the old set of basis vectors (structural shocks) that resolves the vector for the corresponding non-structural shock u_j.

Estimated inverse of the transformation matrix: $\Psi^{-1} = \begin{bmatrix}103.8 & 67.7 & 28.2\\140.6 & -25.3 & 40.7\\8.6 & -5.1 & -12.0\end{bmatrix}$.

The solution is provided in Figs. 7–8.

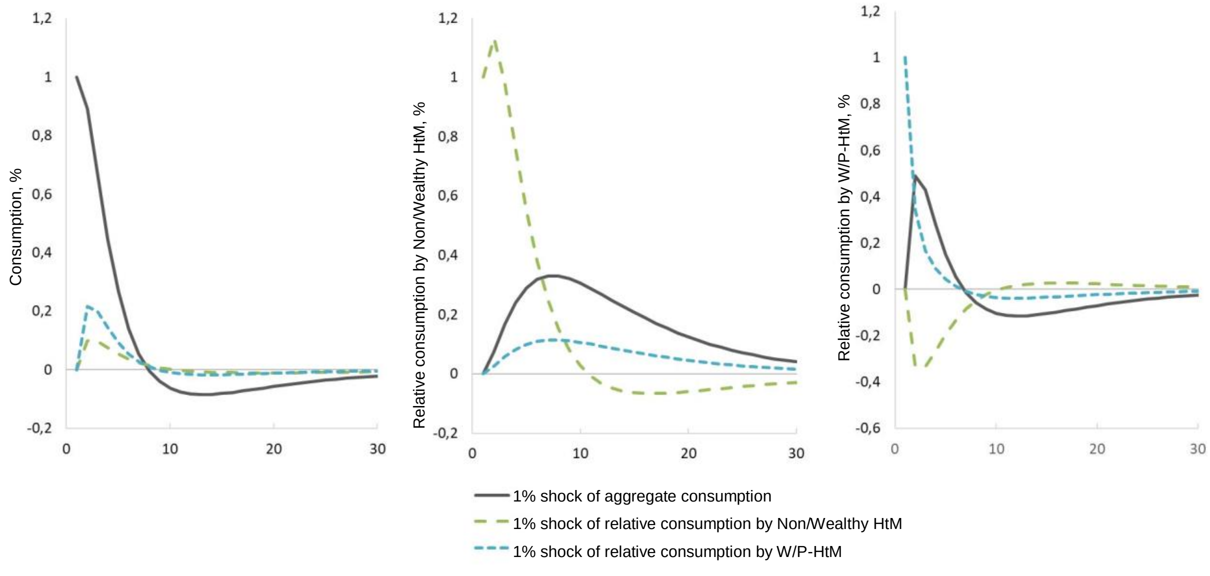

Fig. 8. Dynamics of variables of vector z in response to non-structural shocks u_j.

Source: authors' estimation.

Condition (5) stipulates that as the shocks emerge, each variable of vector z respond only to its own non-structural shock z and not respond to other non-structural shocks. This stipulation does not apply to further periods; therefore we can assert the impact of non-structural shocks on all endogenous variables. The non-structural shock of aggregate consumption leads to increased relative consumption variables in the medium term. The response to this shock is very similar to the reaction to the aggregate structural consumption shock as well as the intertemporal choice shock, except the latter produces an instant effect on inequality. The resulting simultaneous growth in labour income and the nominal interest rate (against the instant drop in the expected real interest rate) amplifies inequality at both ends of the Lorenz curve. The shocks of households' relative consumption lead to increased aggregate consumption in the medium term. This can be illustrated by the fact that the response of Non-HtM households is more persistent than that of Wealthy HtM households, which is in turn more persistent than the response of Poor HtM households. The positive non-structural shock of relative consumption by W/Poor HtM households reduces relative consumption by Non/Wealthy HtM households in the medium term, ie, has the opposite impact on the inequality at both ends of the Lorenz curve. The rise in relative consumption by W/Poor HtM households against the constant Non/Wealthy HtM consumption means that Poor HtM households loses in consumption relative to the two other groups, which can be mostly accounted for by shock transfer $\varepsilon_{T_{up}t}$. This shock redistributes the income from Non-HtM to Poor HtM households, and the relative consumption by Non/Wealthy HtM households decreases. On the contrary, the positive non-structural shock of relative consumption by Non/Wealthy HtM households amplifies the inequality at both ends of the Lorenz curve. This shock increases consumption by Non-HtM households relative to the two other groups. However, financial market income makes the reduction in consumption by Wealthy HtM households more moderate than that by Poor HtM households.

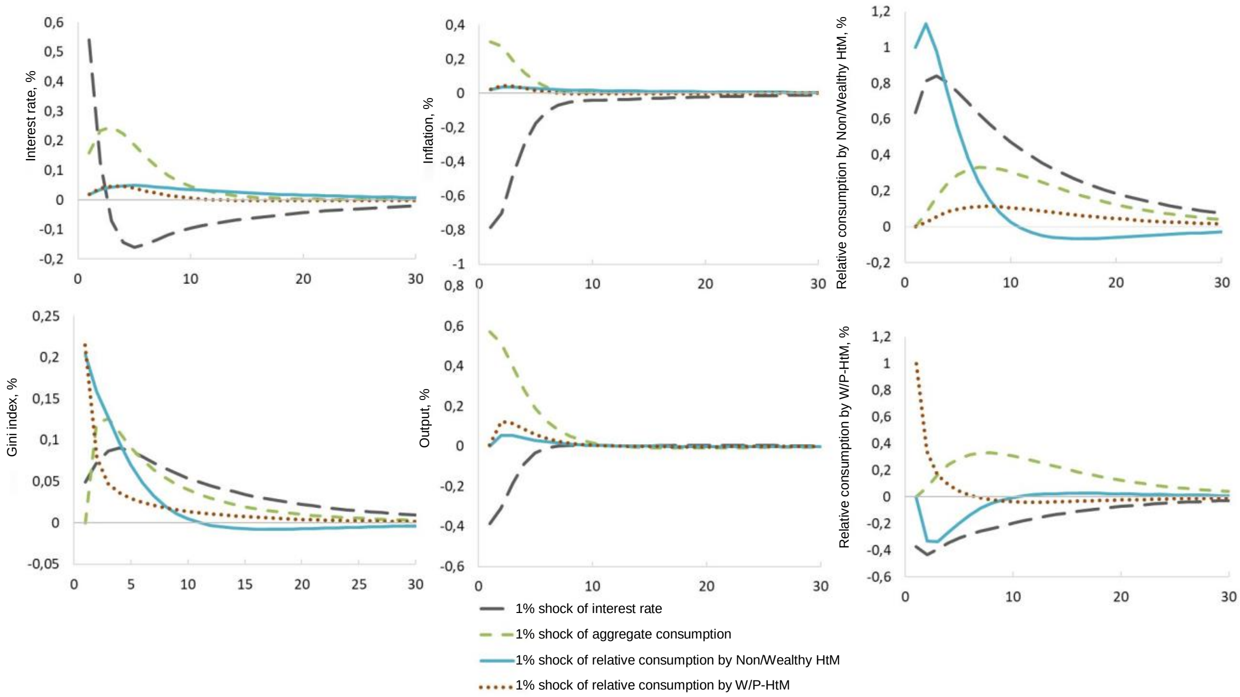

Fig. 9 The response of the interest rate, inflation, output, relative consumption by Non/Wealthy HtM and W/Poor HtM households and the Gini index to the three non-structural shocks causing a 1% growth in the corresponding variable of vector z.

Source: authors' calculations.

The two non-structural inequality shocks have a similar effect on the inflation, output and interest rate. Increased inequality at both ends of the Lorenz curve assigned to the latent household consumption shocks leads to a moderate growth in the output, the inflation and hence the interest rate. The response to the non-structural shock of relative consumption by Non/Wealthy HtM households is more persistent that that of relative consumption by W/Poor HtM households. The latter has a more substantial impact on the output. To be able to compare the responses of typical inequality shocks to other typical structural shocks, we need to calculate the covariance matrix for non-structural shocks $D(u)$:

$$D(u) = \Psi D(\varepsilon)\Psi', \tag{6}$$

where $D(\varepsilon)$ is the diagonal covariance matrix of structural shocks ε.

One-standard-deviation responses to non-structural shocks are shown in Fig. 10. Table 5 shows the economy's instant reaction to structural and non-structural shocks. Combined, Fig. 9 and Table 5 give you an idea of the role the inequality shocks play.

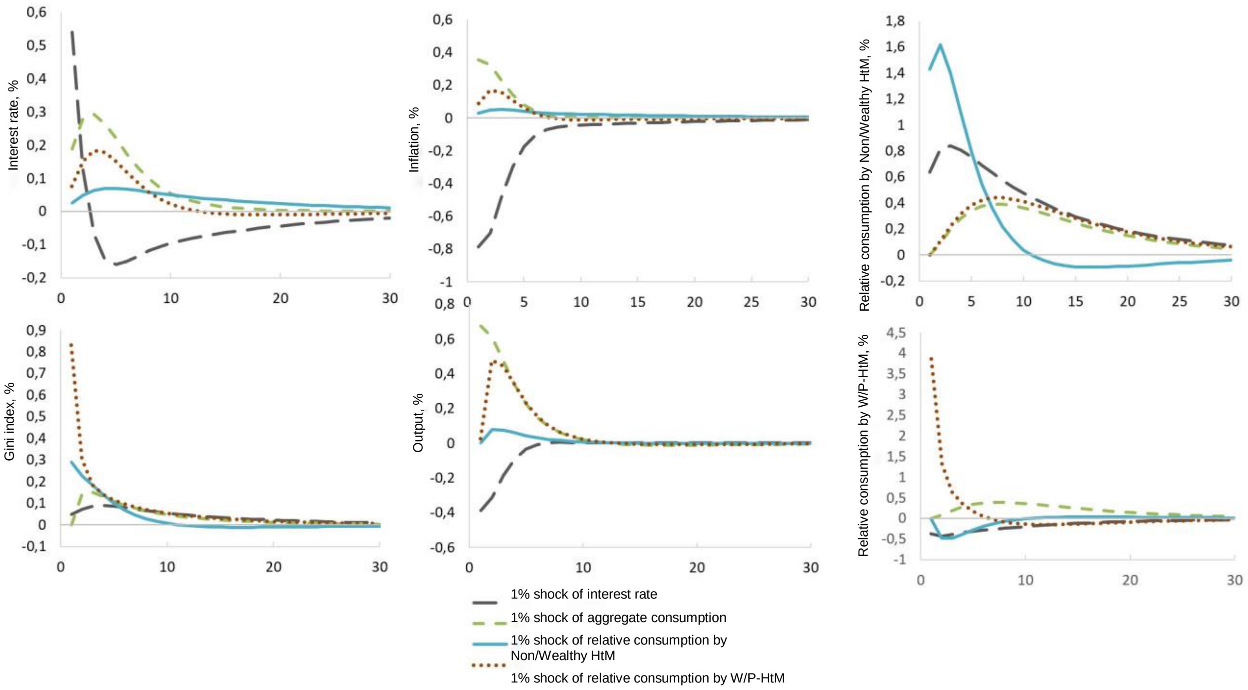

Fig. 10. The response of the interest rate, inflation, output, relative consumption by Non/Wealthy HtM and W/Poor HtM households and the Gini index to the three one-standard-deviation non-structural shocks.

Source: authors' calculations.

Table 5

Instant response of endogenous variable to structural (ε_t) and non-structural (u_t) one-standard-deviation shocks

Shock	Title	$\frac{4d\pi_t}{d\varepsilon_t}$	$\frac{dy_t}{d\varepsilon_t}$	$\frac{4di_t}{d\varepsilon_t}$	$\frac{drc_{n/wt}}{d\varepsilon_t}$	$\frac{drc_{w/pt}}{d\varepsilon_t}$	$\frac{dGini_t}{d\varepsilon_t}$	$\frac{4di_t}{dGini_t}$
ε_{it}	Monetary policy shock	-0.786	-0.386	0.540	0.638	-0.372	0.050	10.883
$\varepsilon_{T_{up}t}$	Structural household consumption shocks	0.237	0.594	0.098	-0.079	-3.802	-0.834	-0.117
ε_{C_nt}		0.105	0.166	0.061	1.152	-0.288	0.172	0.354
ε_{C_wt}		0.110	0.218	0.057	-0.842	0.632	-0.035	-1.636
ε_{C_pt}		-0.116	0.027	-0.050	0.029	-0.049	-0.005	10.659
$\varepsilon_{\beta t}$	Intertemporal preference shock	1.516	1.550	0.615	0.305	0.840	0.243	2.535
ε_{Gt}	Government expenditure shock	0.266	0.936	0.173	-0.158	-1.148	-0.279	-0.621
ε_{At}	TFP shock	-4.763	-0.050	-1.593	1.145	2.737	0.821	-1.940
ε_{Wt}	Wage shock	2.088	0.039	0.732	-0.545	-0.901	-0.305	-2.403
ε_{rpt}	Currency exchange rate shock	2.390	0.628	0.747	-0.210	-1.021	-0.262	-2.850
ε_{A^*t}	External shocks	-1.351	-0.066	-0.345	0.179	-0.160	0.002	-176.931
ε_{β^*t}		0.973	0.380	0.310	-0.214	-0.246	-0.096	-3.218
ε_{i^*t}		0.038	-0.022	0.008	0.032	-0.066	-0.008	-1.036
ε_{x^*t}		-1.605	0.075	-0.575	-0.676	-0.185	-0.177	3.247
u_{1t}	Non-structural aggregate consumption shock	0.357	0.677	0.189	0.000	0.000	0.000	Inf
u_{2t}	Non-structural inequality shocks	0.030	0.002	0.025	1.429	0.000	0.290	0.087
u_{3t}		0.089	0.026	0.075	0.000	3.865	0.831	0.090

Source: authors' calculations.

On the one hand, the instant response of the interest rate to inequality shocks proves to be more sluggish than for most structural shocks. On the other hand, these shocks have the ratio of the maximum interest rate response to the instant interest rate response to the shock that is the highest among all structural shocks. It signifies that the inequality shocks' contribution to the interest rate dynamics is higher in the long term than in the short term. The inequality shocks emerging at the lower end of the Lorenz curve substantially affect the output dynamics with a lag between one quarter and two years. The growth in relative consumption by W/Poor HtM households leads to a substantial positive output gap in the following quarter, and starting in the second quarter, the output response to this shock is practically identical to the response to the non-structural aggregate demand shock.

Table 5 shows that the monetary policy response to a change in the aggregate inequality index (Gini index) is barely dependent on the portion of the Lorenz curve containing the reason for the changed Gini index. The interest rate elasticity on the Gini consumption index for both non-structural inequality shocks is around 0.1. This very moderate effect amplifies in the long term and therefore the inequality shock factor may manifest itself in two to six quarters. For example, a reduction in inequality amid the crisis through the fiscal income redistribution in favour of Poor HtM households may prompt a lower interest rate during the economy's recovery growth following the crisis.

The data analysis of the households' relative consumption does not confer a substantial information advantage outside the short-term inflation forecasting caused by the identification of structural shocks. The analysis of the monetary policy response to the relative consumption data only applies to the part of the dynamics in relative consumption panels that is cleared of the effects of other structural shocks[14]. The practical use of the information on the panels characterising inequality may be derived by adding the premise of the heterogeneous access to the financial market to the structural model employed for the estimations.

5. Conclusion

The paper explores the practicality of using consumption inequality data when designing the monetary policy. To this end, we have expanded the standard New Keynesian model of a small open export-oriented economy by introducing three groups of agents with a different relation to the financial market. In this effort, we have expanded non-hand-to-mouth households with a group of households that have no access to the financial market and a group of households that place less value on future consumption and therefore extensively increase their borrowing. In an imperfect financial market, the latter fact also begins to limit their access to funds. The presence of the three groups of households with varying long-term income and consumption levels and with a unique response to structural shocks enables us to examine both the aggregate inequality index (referred to as the Gini consumption index throughout the paper) and the inequality at the upper tail and the lower end of the Lorenz curve. Such decomposition boosts the analysis as it provides additional information essential to decision-making. However, the assessment of shocks creating the inequality at both ends of the Lorenz curve makes us argue that the use of one aggregate inequality in theoretical and econometric models proves to be a legitimate strategy.

The paper parameterised the model using the Bayesian estimation approach based on the macroeconomic statistics provided by Rosstat and the Bank of Russia as well as the data available from the databases of household surveys: RLMS-HSE and HBS.

In this paper, we have replicated the results obtained by most researchers, which proves that, given the imperfect use of the financial market by the two groups of households, the economy's response to the monetary policy shock is supposed to be amplified by the secondary effects. Nevertheless, these two groups of households play a different role. On the one hand, the larger the share of agents with no access to the financial market, the more salient the response of aggregate variables to most structural shocks. However, the response to the monetary policy shock remains almost unchanged. On the other hand, the expanded share of agents with access to the financial market, albeit subject to the borrowing limit, makes virtually no change to the response to most structural shocks, while amplifying the response of the inflation and the output to the

[14] Under the econometric approach, there is evidence of leftover regression of the relative consumption of the sets of households on the key macroeconomic factors.

monetary policy shock. Thus, the households' expanded involvement in the financial market and a trend towards higher indebtedness of Russian households leads to a situation where the effectiveness of the Bank of Russia's discretionary interventions increases. The economy's amplified response to the discretionary monetary policy comes at a cost of reduced financial viability that manifests itself in, eg, the rising number of households' bad loans amid the crises.

We have incorporated into the model a number of structural shocks that can be used to explain the fluctuations of the observed inequality variables, specifically two panels of households' relative consumption characterising the inequality at both ends of the Lorenz curve. All structural shocks affect both the inequality variables and the aggregate indexes in the economy. To focus more on the evident inequality shocks, we have identified combinations of household consumption structural shocks such that, as they emerge, they have an effect on only one variable of the consumption ratio at the ends of the Lorenz curve and do not impact the second inequality variable and aggregate consumption. The instant response of the inflation and the interest rate to the two resulting non-structural inequality shocks proves to be heterogeneous. The interest rate sensitivity on the Gini consumption index, which does not take into account heterogeneity within the groups of households, is about 0.1 for both non-structural inequality shocks. The differences in responses were not very substantial. The shock at the upper part of the Lorenz curve leads to more persistent responses of all the variables, whereas the shock at the bottom of the Lorenz curve has more effect on the output.

The mutual impact of the interest rate and aggregate inequality was mildly positive. If the shock's source is the consumption of specific groups of households (non-structural inequality shocks), each 1% increment on the Gini index leads the interest rate to rise by 1%. If a monetary policy shock is the case, each 1% increment in the interest rate leads the Gini index to rise by 1% during the shock. Dynamically, the response curve develops a small hump, but it has no fundamental role overall, which suggests low correlation between monetary policy and inequality. This finding applies to a scenario where the Central Bank adopts the inflation-forecast targeting approach to the monetary policy, ie, does not add inequality variables to the policy rule. That being said, we have demonstrated that crucial differences in the dynamic properties of the consumption response for the three groups of households lead to the aggregated output's more pronounced reaction to non-structural inequality shocks. It may boost the position of the aggregate inequality index when discussing the stabilisation policy for the Central Bank whose mandate involves the stabilisation of real activity.

When designing the monetary policy, the key function of consumption equality appears to be the contribution of relative consumption data to the identification of structural shocks. However, the change in relative consumption per se is neither a pro- nor anti-inflationary signal, and should be considered together with the other variables characterising the business cycle.

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Appendix 1. Model

Households

Non-HtM households

Non-HtM are represented by a continuum of households with unlimited access to the financial market. Hereinafter, we will omit the index of each household within a group of agents (same for the firms of each sector) since within a group (sector), all agents are homogeneous, and formulas are true for each household (firm). They maximise the aggregate utility function:

$$U_{n,t} = E_t \sum_{s=0}^{\infty} \beta_n^s u_{\beta,t+s} \Lambda_{n,t+s}, \quad \text{(P1)}$$

where β_n denotes a subjective discount rate for Non-HtM households $u_{\beta,t}$ is an AR(1) process reflecting the effect of the intertemporal choice shock:

$$u_{\beta,t} = \left[u_{\beta,t-1}\right]^{\rho_\beta} e^{\varepsilon_{\beta,t}}, \quad \text{(P2)}$$

where ρ_β denotes an autoregressive coefficient for intertemporal choice shocks in the model and $\varepsilon_{\beta,t}$ is the intertemporal choice shock.

Instant utility function:

$$\Lambda_{n,t} = \frac{(C_{n,t}-\xi C_{n,t-1})^{1-\sigma_C}}{1-\sigma_C} u_{c_n,t} + \frac{h_{n,t}^{1-\sigma_h}}{1-\sigma_h} - \frac{L_{n,t}^{1+\eta}}{1+\eta}, \quad \text{(P3)}$$

where $C_{n,t}$ denotes consumption of Non-HtM households; $h_{n,t}$is housing stock; $L_{n,t}$ stands for hours of work; $\sigma_c$andσ_h are the reciprocals of the elasticity of intertemporal substitution and housing; $\eta$is the reciprocal of the Frisch elasticity of labour supply; $\xi$is the parameter of external consumption habits; $u_{c_n,t}$denotes the AR(1) process for consumption utility shocks for Non-HtM households.

The budget constraint for Non-HtM households is described by the equation:

$$P_{C,t}C_{n,t} + q_t P_{C,t}\left(h_{n,t} - h_{n,t-1}\right) + \frac{\phi}{2}\left(\frac{h_{n,t}-h_{n,t-1}}{h_{n,t-1}}\right)^2 q_t P_{C,t} h_{n,t-1} - P_{C,t}b_{n,t} - S_t P_{C,t}^* b_t^* = (1-\tau)W_{n,t}L_{n,t} - (1+i_{t-1})P_{C,t-1}b_{n,t-1} - (1+i_{t-1}^*)(1+rp_{t-1})S_t P_{C,t-1}^* b_{t-1}^* + Profit_t - P_{N,t}T_{0_n,t}, \quad \text{(P4)}$$

where $P_{C,t}$ and $P_{C,t}^*$are domestic and foreign consumer price levels; q_t denotes the real housing price; ϕ stands for housing adjustment costs; $b_{n,t}$ and b_{t-1}^* is the real bond debt ($b_{n,t}$< 0 and b_t^*< 0 signifies that the household is a saver in the domestic and foreign financial market respectively); i_t and i_t^* denote the domestic and foreign interest rate; S_t is the nominal reciprocal exchange rate; τ is a fixed income tax rate; $W_{n,t}$ is the median nominal wage; $P_{N,t}T_{0_n,t}$ is the nominal lump-sum tax in domestic non-tradable goods sector prices; and $Profit_t$ represents the firms' dividend payments:

$$Profit_t = (P_{F,t} - MC_{F,t}P_{C,t})Y_{F,t} + (P_{N,t} - MC_{N,t}P_{N,t})Y_{N,t} + (P_{H,t} - MC_{H,t}P_{H,t})(Y_{H,t} - Y_{oil,t}) + (1-\gamma_{oil,w} - \gamma_{oil,p})(S_t P_{oil,t}^* - P_{H,t})Y_{oil,t}, \quad \text{(P5)}$$

where $\gamma_{oil,w}$ and $\gamma_{oil,w}$ stand for the shares of the firms' profits on elevated oil price that are distributed between the Wealthy HtM and Poor HtM households, and $MC_{F,t}$, $MC_{N,t}$ and $MC_{H,t}$ are real marginal costs of the firms representing the corresponding sectors.

To maximise equation (P1) on condition (P4), the first-order conditions associated with consumption and housing are determined by the Euler equation and the intertemporal housing demand equation. The Euler equation for non-hand-to-mouth households is:

$$\beta_n E_t \left\{ \frac{\Lambda_{C_n,t+1} \cdot u_{\beta,t+1}}{\Lambda_{C_n,t} \cdot u_{\beta,t}} \frac{1+i_t}{1+\pi_{C,t+1}} \right\} = 1, \tag{P6}$$

where $\pi_{C,t}$ is the CPU inflation rate, and for any group of households $j \subset \{n, w, p\}$: $\Lambda_{C_{j},t} \equiv \frac{\partial \Lambda_{j,t}}{\partial C_{j,t}} = \left(C_{j,t} - \xi C_{j,t-1}\right)^{-\sigma_c} u_{c_j,t}$ is marginal consumption utility; and $u_{c_j,t}$ is the AR(1) process for the consumption shock for the *j* group:

$$u_{c_j,t} = \left[u_{c_j,t-1}\right]^{\rho_c} e^{\varepsilon_{c_j,t}}, \tag{P7}$$

where ρ_c is an autoregressive coefficient for consumption shocks and $\varepsilon_{c_j,t}$ are consumption utility shocks for the *j* group.

Intertemporal housing demand equation:

$$u_{\beta,t}\Lambda_{h_n,t} - u_{\beta,t}\Lambda_{C_n,t}\left\{q_t + \phi q_t \left[\frac{h_{n,t} - h_{n,t-1}}{h_{n,t-1}}\right]\right\} + \beta_n E_t \Lambda_{C_n,t+1} u_{\beta,t+1}\left\{q_{t+1} + \frac{\phi}{2} q_{t+1}\left[\frac{h_{n,t+1}^2 - h_{n,t}^2}{h_{n,t}^2}\right]\right\} = 0, \tag{P8}$$

where $\Lambda_{h_{j'},t} \equiv \frac{\partial \Lambda_{j',t}}{\partial h_{j',t}} = h_{j',t}{}^{-\sigma_h}$ $j' \subset \{n, w\}$ is the marginal housing utility.

Equations (P6) and (P8) determine the optimal consumption path and increased housing stock trajectory for Non-HtM households. Besides, it is the Euler equation that determines the steady state equilibrium interest rate for non-hand-to-mouth households.

Wealthy HtM households

They are represented by a continuum of households with limited access to the financial market. They too maximise utility, but their subjective discount rate is lower than that of Non-HtM households and therefore they are borrowers in the economy.

$$U_{w,t} = E_t \sum_{s=0}^{\infty} \beta_w^s \, u_{\beta,t+s} \Lambda_{w,t+s}, \tag{P9}$$

where $\beta_w < \beta_n$ to an extent where, under $\forall\, u_{\beta_w,t}$, the discount inequality of the two groups of households is still true.

Because the equilibrium interest rate is set according to a higher subjective discount rate of Non-HtM households, agents of the Wealthy HtM fail to reach the indifferent state between current and future consumption. As a result, they always seek to borrow extra money to increase consumption in the current period.

Instant utility function $\Lambda_{w,t}$:

$$\Lambda_{w,t} = \frac{(C_{w,t}-\xi C_{w,t-1})^{1-\sigma_c}}{1-\sigma_c} u_{c_{w},t} + \frac{h_{w,t}^{1-\sigma_h}}{1-\sigma_h} - \frac{L_{w,t}^{1+\eta}}{1+\eta}. \tag{P10}$$

Budget constraint for Wealthy HtM:

$$P_{C,t}C_{w,t} + q_t P_{C,t}\left(h_{w,t} - h_{w,t-1}\right) + \frac{\phi}{2}\cdot\left(\frac{h_{w,t} - h_{w,t-1}}{h_{w,t-1}}\right)^2 q_t P_{C,t} h_{w,t-1} +$$
$$+(1+i_{t-1})P_{C,t-1}b_{w,t-1} = (1-\tau)W_{w,t}L_{w,t} - P_{C,t}b_{w,t} + \gamma_{oil,w}(S_t P^*_{oil,t} - P_{H,t})Y_{oil,t}. \tag{P11}$$

This group of households has no access to the foreign capital market. Wealthy HtM households fund their consumption through labour income and borrowings ($b_{w,t}$), which, in an imperfect financial market, have a limit stemming from the household's housing price:

$$b_{w,t} = m q_t h_{w,t}, \tag{P12}$$

where *m* determines the maximum ratio of the total borrowings to the collateral cost $q_t h_{w,t}$.

To maximise (P9) on conditions (P11) and (P12), the first-order conditions for Wealthy HtM households are determined in a similar manner. The Euler equation is specialised to be of the form:

$$\beta_w E_t\left\{\Lambda_{C_w,t+1} u_{\beta,t+1} \frac{1+i_t}{1+\pi_{C,t+1}}\right\} + \lambda_{w,t}(1+i_t) = \Lambda_{C_w,t} u_{\beta,t}, \tag{P13}$$

where $\lambda_{w,t}$ is the parameter that balances out the marginal consumption utilities in the current and future period for Wealthy HtM households.

Intertemporal housing demand equation:

$$u_{\beta,t}\Lambda_{h_w,t} - u_{\beta,t}\Lambda_{C_w,t}\left\{q_t + \phi q_t\left[\frac{h_{w,t}-h_{w,t-1}}{h_{w,t-1}}\right]\right\} + \beta_w E_t \Lambda_{C_w,t+1} u_{\beta,t+1}\left\{q_{t+1} +\right.$$
$$\left.\frac{\phi}{2} q_{t+1}\left[\frac{h^2_{w,t+1}-h^2_{w,t}}{h^2_{w,t}}\right]\right\} + \lambda_{w,t} m E_t q_{t+1}(1+\pi_{C,t+1}) = 0. \tag{P14}$$

Poor HtM households

They are represented by a continuum of households that have no access whatsoever to the financial market. Besides, they do not own housing and therefore their aggregate and instant utility functions are of the form:

$$U_{p,t} = E_t \sum_{s=0}^{\infty} \beta_p^s\, u_{\beta,t+s} \Lambda_{p,t+s}, \tag{P15}$$

$$\Lambda_{p,t} = \frac{(C_{p,t}-\xi C_{p,t-1})^{1-\sigma_c}}{1-\sigma_c} u_{c_p,t} - \frac{L_{p,t}^{1+\eta}}{1+\eta}, \tag{P16}$$

where β_p is assumed to be the mean between β_n and β_w: this group of households is not as frugal as the Non-HtM, even though Poor HtM households do not seek to directly maximise consumption utility, consuming their entire current income instead:

$$P_{C,t}C_{p,t} = (1-\tau)W_{p,t}L_{p,t} - P_{N,t}T_{0_p,t} + \gamma_{oil,p}(S_t P^*_{oil,t} - P_{H,t})Y_{oil,t} \tag{P17}$$

where $T_{0_p,t}$ is a lump-sum transfer.

Households' consumption composition

Each group of households consumes both tradable $C_{T,t}$ and non-tradable $C_{N,t}$ goods. Their aggregate consumption is calculated using the CES technology, which suggests constant elasticity of substitution:

$$\left(C_{j,t}\right)^{\frac{\alpha-1}{\alpha}} = (1-\psi_T)^{\frac{1}{\alpha}}\left(C_{j,N,t}\right)^{\frac{\alpha-1}{\alpha}} + \psi_T{}^{\frac{1}{\alpha}}\left(C_{j,T,t}\right)^{\frac{\alpha-1}{\alpha}}, \quad j \subset \{n,w,p\} \qquad \text{(P18)}$$

where ψ_T is the share of tradable goods in a market basket; α denotes the elasticity of substitution between tradable and non-tradable goods; $C_{j,N,t}$ is the consumption index for domestic non-tradable goods (eg, to an extent, it can include services, construction and education); and $C_{j,T,t}$ is the consumption index for international tradable goods.

The first-order condition for the optimisation of the group's consumption between tradable and non-tradable goods:

$$C_{j,T,t} = \psi_T C_{j,t}\left(\frac{P_{T,t}}{P_{C,t}}\right)^{-\alpha}, \qquad j \subset \{n,w,p\} \qquad \text{(P19)}$$

$$C_{j,N,t} = (1-\psi_T)C_{j,t}\left(\frac{P_{N,t}}{P_{C,t}}\right)^{-\alpha}, \qquad j \subset \{n,w,p\} \qquad \text{(P20)}$$

where $P_{C,t}$ is the consumer price index:

$$\left(P_{C,t}\right)^{1-\alpha} = (1-\psi_T)\left(P_{N,t}\right)^{1-\alpha} + \psi_T\left(P_{T,t}\right)^{1-\alpha}. \qquad \text{(P21)}$$

Similarly, the CES technology is used to aggregate domestic and foreign tradable goods:

$$\left(C_{j,T,t}\right)^{\frac{\delta-1}{\delta}} = (1-\psi_H)^{\frac{1}{\delta}}\left(C_{j,F,t}\right)^{\frac{\delta-1}{\delta}} + \psi_H{}^{\frac{1}{\delta}}\left(C_{j,H,t}\right)^{\frac{\delta-1}{\delta}}, j \subset \{n,w,p\} \qquad \text{(P22)}$$

where ψ_H is the share of domestic tradable goods in a market basket; δ denotes the elasticity of substitution between domestic and foreign tradable goods; $C_{j,H,t}$ is the internal consumption index for domestic goods that are traded both domestically and abroad; and $C_{j,F,t}$ is the consumption index for foreign goods.

The first-order conditions for the optimisation of the group's consumption between domestic and foreign tradable goods:

$$C_{j,H,t} = \psi_H C_{j,T,t}\left(\frac{P_{H,t}}{P_{T,t}}\right)^{-\delta}, \qquad j \subset \{n,w,p\} \qquad \text{(P23)}$$

$$C_{j,F,t} = (1-\psi_H)C_{j,T,t}\left(\frac{P_{F,t}}{P_{T,t}}\right)^{-\delta}, \qquad j \subset \{n,w,p\} \qquad \text{(P24)}$$

where $P_{T,t}$ is the index of tradable goods:

$$\left(P_{T,t}\right)^{1-\delta} = \psi_H\left(P_{H,t}\right)^{1-\delta} + (1-\psi_H)\left(P_{F,t}\right)^{1-\delta}. \qquad \text{(P25)}$$

Importantly, $C_{j,H,t}$, $C_{j,N,t}$ and $C_{j,F,t}$ are aggregate consumption indexes for households from different groups and goods of various firms *i* from sectors $m \subset \{N, H, F\}$. The aggregate consumption by a household from the *j* set of goods from the *m* sector operated by a continuum of firms with the *i* index is written of the form:

$$C_{j,m,t} = \left[\int_0^1 C_{j,m,t}(i)^{\frac{\varphi-1}{\varphi}} di\right]^{\frac{\varphi}{\varphi-1}}, \qquad j \subset \{n, w, p\}, m \subset \{N, H, F\} \qquad \text{(P26)}$$

where φ is the elasticity of substitution between differentiated goods by various firms in the sector (this parameter is assumed to be equal across all sectors) and $C_{j,m,t}(i)$ is the consumption by a household from the *j* set of goods by the *i* firm from the *m* sector, ie, a specific household's demand for products by a specific firm. This household-specific demand function meets the first-order condition to optimise the household's consumption distribution in a specific sector between specific firms:

$$C_{j,m,t}(i) = \left(\frac{P_{m,t}(i)}{P_{m,t}}\right)^{-\varphi} C_{j,m,t}, \qquad j \subset \{n, w, p\}, m \subset \{N, H, F\} \qquad \text{(P27)}$$

where $P_{m,t}(i)$ is the product price set by the *i* firm from the *m* sector (as a result of profit maximisation) and $P_{m,t}$ is the sector's price index:

$$P_{m,t} = \left[\int_0^1 P_{m,t}(i)^{1-\varphi} di\right]^{\frac{1}{1-\varphi}}. \qquad m \subset \{N, H, F\} \qquad \text{(P28)}$$

The households' aggregate demand for the products of the specific *i* firm from the *m* sector is shaped by aggregating the demand of specific groups of households adjusted for their share in the population:

$$C_{m,t}(i) = \gamma_n C_{n,m,t}(i) + \gamma_w C_{w,m,t}(i) + \gamma_p C_{p,m,t}(i), \qquad m \subset \{N, H, F\} \qquad \text{(P29)}$$

where γ_n, γ_w, γ_p denotes the exogenous and fixed shares in the aggregate population of Non-HtM, Wealthy HtM and Poor HtM households respectively.

Households' labour supply amid monopolistic competition

Of all the industrial sectors $m \subset \{N, H, F\}$, only two $k \subset \{N, H\}$ use households' labour, ie, in the production of domestic tradable and non-tradable goods. In either of the two sectors, homogeneous firms have demand for labour of various households $j \subset \{n, w, p\}$, which is aggregated using the CES technology (the *i* form index is omitted):

$$L_{k,t}^{\frac{\mu-1}{\mu}} = \alpha_n^{\frac{1}{\mu}} L_{n,k,t}^{\frac{\mu-1}{\mu}} + \alpha_w^{\frac{1}{\mu}} L_{w,k,t}^{\frac{\mu-1}{\mu}} + \alpha_p^{\frac{1}{\mu}} L_{p,k,t}^{\frac{\mu-1}{\mu}}, \qquad k \subset \{N, H\} \qquad \text{(P30)}$$

where a_j is the share of a group of households in aggregate labour income in the economy and μ denotes the elasticity of substitution between the labour of various groups of households.

The first-order condition to mitigate the costs of the firm from the *k* sector for the use of labour of different groups of households allows us to obtain the function of the firm's demand for the labour of each group $L_{j,k,t}$:

$$L_{j,k,t} = \alpha_j \left[\frac{W_{j,k,t}}{W_{k,t}}\right]^{-\mu} L_{k,t}, \qquad j \subset \{n, w, p\}, k \subset \{N, H\} \qquad \text{(P31)}$$

where $W_{k,t}$ is the median nominal wage in the sector:

$$W_{k,t}{}^{1-\mu} = \alpha_n W_{n,k,t}{}^{1-\mu} + \alpha_w W_{w,k,t}{}^{1-\mu} + \alpha_p W_{p,k,t}{}^{1-\mu}, \qquad k \subset \{N,H\} \qquad \text{(P32)}$$

The labour of the specific *z* household of each group in each sector is aggregated using the following technology:

$$L_{j,k,t} = \left[\int_0^1 L_{j,k,t}(z)^{\frac{\mu-1}{\mu}} dz\right]^{\frac{\mu}{\mu-1}}. \qquad j \subset \{n,w,p\},\ k \subset \{N,H\} \qquad \text{(P33)}$$

The first-order condition to mitigate the costs of the firm from the *k* sector for the use of labour of households from a particular group j, if (P38) is met, allows us to obtain the function of the firm's demand for the labour of each group in each sector:

$$L_{j,k,t}(z) = \left[\frac{W_{j,k,t}(z)}{W_{j,k,t}}\right]^{-\mu} L_{j,k,t}, \qquad j \subset \{n,w,p\},\ k \subset \{N,H\} \qquad \text{(P34)}$$

where $W_{j,k,t}(z)$ is the nominal wage established by the *z* household from the *j* group in the *k* sector (as a result of utility maximisation) and $W_{j,k,t}$ is the median nominal wage of the *j* group of households in the *k* sector:

$$W_{j,k,t} = \left[\int_0^1 W_{j,k,t}(z)^{1-\varphi_L} dz\right]^{\frac{1}{1-\varphi_L}}, \qquad j \subset \{n,w,p\},\ k \subset \{N,H\} \qquad \text{(P35)}$$

where φ_L denotes the elasticity of substitution between the labour services offered by specific households.

This model suggests that each household is a monopolistic competitor in the labour market in each of the production sectors. Households from each of the *j* groups establish the optimal wage from the utility standpoint for each of the *k* sectors based on the Calvo pricing (Calvo 1983) and the Yun indexing (Yun 1996). The odds of households from the *j* group being signaled of a change in the nominal wage in the *k* sector to the optimal wage $W_{j,k,opt,t}$ for the current period are $(1-\theta_{Wj})$. Otherwise, the odds are θ_{Wj} for a household to index the previous wage for the inflation of the previous period: $(W_{j,k,t-1}(z) \cdot (1+\pi_{C,t-1})^{\chi_w})$, where $\chi_w \in (0,1)$ is the indexation rate. Hereinafter, the *z* index will be omitted, as households within the same group are considered identical. The aggregation across all households from the *j* group for the *k* sector yields the following dynamics equation for the aggregate nominal wage of a group of households in the sector:

$$W_{j,k,t}{}^{1-\varphi_L} = \theta_{Wj}\left[(1+\pi_{C,t-1})^{\chi_w} W_{j,k,t-1}\right]^{1-\varphi_L} + \left(1-\theta_{Wj}\right)\left[W_{j,k,opt,t}\right]^{1-\varphi_L}.$$

$$j \subset \{n,w,p\},\ k \subset \{N,H\} \qquad \text{(P36)}$$

Described in real terms, this equation can be rewritten of the form:

$$\left[\frac{W_{j,k,t}}{P_{C,t}}\right]^{1-\varphi_L} = \theta_{Wj}\left[\frac{(1+\pi_{C,t-1})^{\chi_w}}{(1+\pi_{C,t})}\frac{W_{j,k,t-1}}{P_{C,t-1}}\right]^{1-\varphi_L} + \left(1-\theta_{Wj}\right)\left[\frac{W_{j,k,opt,t}}{P_{C,t}}\right]^{1-\varphi_L}.$$

$$j \subset \{n,w,p\},\ k \subset \{N,H\} \qquad \text{(P37)}$$

The household's task is to select the nominal wage $W_{j,k,opt,t}$ such that it can maximise the discounted expected utility which would be obtained if this nominal wage remain the same for *s* periods when the household cannot readjust it:

$$max_{W_{j,k,opt,t}} \quad E_t \sum_{s=0}^{\infty} \left(\theta_{Wj}\beta_j\right)^s \Lambda_{j,t+s}(\bullet|_{W_{j,k,opt,t}}). \qquad j \subset \{n,w,p\} \qquad \text{(P38)}$$

The task is solved under the constraint which is the demand for the labour of a specific *z* household from the *j* group in the *k* sector, for which, in the context of the Yun indexing (Yun 1996), the equation changes to:

$$\text{s.t. } L_{j,k,t+s|_t}(z) = \left[\frac{W_{j,k,opt,t}\left(\frac{P_{C,t+s-1}}{P_{C,t-1}}\right)^{\chi_W}}{W_{j,k,t+s}}\right]^{-\varphi_L} L_{j,k,t+s}.$$

$$j \subset \{n,w,p\},\ k \subset \{N,H\} \qquad \text{(P39)}$$

The task is solved with the optimal real wage of the households from the *j* group in the *k* sector, which can be represented as a system of forward-looking recurrence equations:

$$\frac{W_{j,k,opt,t}}{P_{C,t}} = \frac{\varphi_L}{\varphi_L - 1}\frac{J_{W,j,k,t}}{N_{W,j,k,t}}\frac{1}{1-\tau}\, u_{Wt}, \qquad j \subset \{n,w,p\},\ k \subset \{N,H\} \qquad \text{(P40)}$$

where $u_{Wt}$is the AR(1) process reflecting the impact of the shocks of the wage monopoly markup (economy-wide aggregate shock and household-specific respectively):

$$u_{Wt} = \left[u_{W,t-1}\right]^{\rho_W} e^{\varepsilon_{W,t}}, \qquad \text{(P41)}$$

where ρ_w is the autoregressive coefficient of the wage shock and $\varepsilon_{w,t}$ is the shock of the wage monopoly markup.

The additional forward-looking variables:

$$J_{W,j,k,t} = u_{\beta,t} L_{j,k,t}\left[\frac{W_{j,k,t}}{P_{C,t}}\right]^{\varphi_L}\left(-\Lambda_{L_j,t}\right) + \theta_{Wj}\beta_j E_t\left\{\left[\frac{1+\pi_{C,t+1}}{\left(1+\pi_{C,t}\right)^{\chi_W}}\right]^{\varphi_L} J_{W,j,k,t+1}\right\},$$

$$j \subset \{n,w,p\},\ k \subset \{N,H\} \qquad \text{(P42)}$$

$$N_{W,j,k,t} = u_{\beta,t} L_{j,k,t}\left[\frac{W_{j,k,t}}{P_{C,t}}\right]^{\varphi_L} \Lambda_{C_j,t} + \theta_{Wj}\beta_j E_t\left\{\left[\frac{1+\pi_{C,t+1}}{\left(1+\pi_{C,t}\right)^{\chi_W}}\right]^{\varphi_L - 1} N_{W,j,k,t+1}\right\},$$

$$j \subset \{n,w,p\},\ k \subset \{N,H\} \qquad \text{(P43)}$$

where $\Lambda_{L_j,t} \equiv \frac{\partial \Lambda_{j,t}}{\partial L_{j,t}} = -{L_{j,t}}^{\eta}$ denotes the marginal utility of additional hours worked.

Equations (P37), (P40), (P42) and (P43) describe wage adjustments in the sectors $k \subset \{N,H\}$ for all groups of households $j \subset \{n,w,p\}$. That said, aggregate hours worked by households from each group:

$$L_{j,t} = L_{j,H,t} + L_{j,N,t}. \qquad j \subset \{n,w,p\} \qquad \text{(P44)}$$

Using expression (P44), we can calculate the median wage of households from each group to be a ratio of the aggregate labour income of this group to total hours worked:

$$W_{j,t} = \frac{W_{H,t}L_{j,H,t} + W_{N,t}L_{j,N,t}}{L_{j,t}}. \qquad j \subset \{n,w,p\} \qquad \text{(P45)}$$

Considering that the aggregate labour demand in each sector is calculated by equation (P30), we can make the economy-wide aggregation, obtaining the equilibrium condition in the aggregate labour market:

$$L_t = L_{H,t} + L_{N,t}. \quad \text{(P46)}$$

Therefore, the median household wage economy-wide is:

$$W_t = \frac{W_{H,t}L_{H,t}+W_{N,t}L_{N,t}}{L_t}. \quad \text{(P47)}$$

Producers

The model represents three sectors of producers $m \subset \{N, H, F\}$: domestic companies from the sectors of tradable and non-tradable goods use households' labour and produce differentiated goods, while the importers purchase homogeneous foreign goods and resell them in the domestic market as differentiated ones with a price markup. Amid the nominal price stickiness, all the firms use the model following the Calvo pricing (Calvo 1983) and the Yun indexing (Yun 1996).

Domestic producers of tradable (H) and non-tradable (N) goods

These markets $k \subset \{N, H\}$ have a continuum of producers (*i* index ∈ (0.1)) creating differentiated products in monopolistic competition (the aggregate prices in the sector are considered exogenous). They follow a linear production function that only includes households' labour:

$$Y_{k,t} = A_{k,t}L_{k,t}, \qquad k \subset \{N, H\} \quad \text{(P48)}$$

where $A_{k,t}$ is the exogenous AR(1) process characterising total factor productivity:

$$A_{k,t} = [A_{k,t-1}]^{\rho_A}[\overline{A_k}]^{1-\rho_A}e^{\varepsilon_{A,t}}, \qquad k \subset \{N, H\} \quad \text{(P49)}$$

where $\rho_A$is the autoregressive coefficient of the exogenous process; $\overline{A_k}$is the steady state of total factor productivity; and $\varepsilon_{A,t}$ is its structural shock.

The aggregate production volume of the k sector is calculated using the CES technology by output of specific firms *i*:

$$Y_{k,t} = \left[\int_0^1 Y_{k,t}(i)^{\frac{\varphi-1}{\varphi}} di\right]^{\frac{\varphi}{\varphi-1}}. \qquad k \subset \{N, H\} \quad \text{(P50)}$$

Importantly, the demand for products from sectors $Y_{k,t}$ is dissimilar: non-tradable goods are consumed by households and the government as part of public procurement, while domestic tradable goods are consumed by households and the external sector.

Therefore, the aggregate demand for products by a specific firm *i* can be defined as:

$$Y_{k,t}(i) = \left(\frac{P_{k,t}(i)}{P_{k,t}}\right)^{-\varphi} Y_{k,t}, \qquad k \subset \{N, H\} \quad \text{(P51)}$$

where $P_{k,t}$ is the particular value of index $P_{m,t}$, whose formula is provided above.

Producers face the nominal price stickiness under the Calvo pricing (Calvo 1983):

the odds are $1 - \theta_k$ (where θ_k denotes nominal price stickiness in the *k* sector) that a firm may establish an optimal price for its products in the current period, while the odds are θ_k that it will not have this opportunity, and the firm will have to index the inflation under the Yun indexing (Yun 1996) with the indexation rate χ. Aggregating all firms from the sector yields the dynamics equation of the sector-wide price index:

$$P_{k,t}{}^{1-\varphi} = \theta_k\left[(1+\pi_{C,t-1})^{\chi}P_{k,t-1}\right]^{1-\varphi} + (1-\theta_k)\left[P_{k,opt,t}\right]^{1-\varphi}.$$

$$k \subset \{N, H\} \qquad \text{(P52)}$$

We can also obtain the real price index dynamics for the k sector:

$$\left[\frac{P_{k,t}}{P_{C,t}}\right]^{1-\varphi} = \theta_k\left[\frac{(1+\pi_{C,t-1})^{\chi}}{(1+\pi_{C,t})}\frac{P_{k,t-1}}{P_{C,t-1}}\right]^{1-\varphi} + (1-\theta_k)\left[\frac{P_{k,opt,t}}{P_{C,t}}\right]^{1-\varphi}.$$

$$k \subset \{N, H\} \qquad \text{(P53)}$$

Similarly to households, firms solve the task of selecting the optimal price $P_{k,opt,t}$, which allows them to maximise the discounted expected profits that would be earned if the price $P_{k,opt,t}$ they had established remained the same for *s* periods. Calibrating the utility of stakeholders of the future profit flows to the present moment uses the discount factor for households from the *n* group, as this group owns all the firms economy-wide:

$$max_{P_{k,opt,t}}$$

$$E_t\sum_{s=0}^{\infty}(\theta_k\beta_n)^s\,\Lambda_{C_n,t+s}u_{\beta,t+s}\left[\left(\frac{P_{C,t+s-1}}{P_{C,t-1}}\right)^{\chi}\frac{P_{k,opt,t}}{P_{C,t+s}} - \frac{W_{k,t+s}}{P_{C,t+s}A_{k,t+s}}\right]Y_{k,t+s|_t}(i),$$

$$k \subset \{N, H\} \qquad \text{(P54)}$$

where $\frac{W_{k,t}}{P_{k,t}\cdot A_{k,t}} \equiv MC_{k,t}$ denotes the real marginal costs of a firm in the *k* sector, matching the median costs.

The task is solved under the constraint which is the aggregate demand for the products of a specific *i* firm from the *k* sector, for which, in the context of the Yun indexing (Yun 1996), the equation changes to:

$$\text{s.t. } Y_{k,t+s|_t}(i) = \left[\frac{P_{k,opt,t}\left(\frac{P_{C,t+s-1}}{P_{C,t-1}}\right)^{\chi}}{P_{k,t+s}}\right]^{-\varphi} Y_{k,t+s}. \qquad k \subset \{N, H\} \qquad \text{(P55)}$$

The task is solved with the real optimal price by a producer from the *k* sector, which can be represented as a system of forward-looking equations:

$$\frac{P_{k,opt,t}}{P_{C,t}} = \frac{\varphi}{\varphi-1}\frac{J_{k,t}}{N_{k,t}}, \qquad k \subset \{N, H\} \qquad \text{(P56)}$$

where the additional forward-looking variables are:

$$J_{k,t} = \Lambda_{C_n,t}u_{\beta,t}Y_{k,t}\left[\frac{P_{k,t}}{P_{C,t}}\right]^{\varphi} MC_{k,t} + \theta_k\beta_n E_t\left\{\left[\frac{1+\pi_{C,t+1}}{(1+\pi_{C,t})^{\chi}}\right]^{\varphi} J_{k,t+1}\right\},$$

$$k \subset \{N, H\} \qquad \text{(P57)}$$

$$N_{k,t} = \Lambda_{C_n,t} u_{\beta,t} Y_{k,t} \left[\frac{P_{k,t}}{P_{C,t}}\right]^{\varphi} + \theta_k \beta_n E_t \left\{ \left[\frac{1+\pi_{C,t+1}}{(1+\pi_{C,t})^{\chi}}\right]^{\varphi-1} N_{k,t+1} \right\}.$$

$$k \subset \{N, H\} \qquad \text{(P58)}$$

The steady state real price by a producer in the *k* sector exceeds the real marginal costs by the amount of the monopoly markup:

$$\frac{\overline{P_k}}{\overline{P_C}} = \frac{\overline{P_{k,opt}}}{\overline{P_C}} = \frac{\varphi}{\varphi-1} \overline{MC_k}. \qquad k \subset \{N, H\} \qquad \text{(P59)}$$

Importers

The F market has a continuum of firms (*i* index ∊ (0.1)) purchasing homogeneous goods abroad at a wholesale price $P^*_{who,t} \equiv MC^*_t P^*_t$ (where MC^*_t and P^*_t denote the real marginal costs of foreign firms and the foreign price index respectively) and then, without extra costs, transform them into differentiated products to further sell them in the domestic market with the monopoly markup $P_{F,t}$.

The aggregate production volume of the import sector F is calculated using the CES technology by the output of specific importers *i*:

$$Y_{F,t} = \left[\int_0^1 Y_{F,t}(i)^{\frac{\varphi-1}{\varphi}} di\right]^{\frac{\varphi}{\varphi-1}}. \qquad \text{(P60)}$$

Importantly, it is assumed that the demand for imported products only comes from households. The aggregate demand for the imported products of the firm *i* can be defined as:

$$Y_{F,t}(i) = \left(\frac{P_{F,t}(i)}{P_{F,t}}\right)^{-\varphi} Y_{F,t}, \qquad \text{(P61)}$$

where $P_{F,t}$ is the particular value of index $P_{m,t}$, whose formula is provided above.

Similarly to other firms, the importers face the Calvo pricing (Calvo 1983) and the Yun indexing (Yun 1996). Aggregating all firms selling foreign goods yield the dynamics equation of the real price index in the sector:

$$\left[\frac{P_{F,t}}{P_{C,t}}\right]^{1-\varphi} = \theta_F \left[\frac{(1+\pi_{C,t-1})^{\chi}}{(1+\pi_{C,t})} \frac{P_{F,t-1}}{P_{C,t-1}}\right]^{1-\varphi} + (1-\theta_F)\left[\frac{P_{F,opt,t}}{P_{C,t}}\right]^{1-\varphi}. \qquad \text{(P62)}$$

Each importer firm's task is to select the optimal price $P_{F,opt,t}$, similarly to other domestic producers:

$$max_{P_{F,opt,t}}$$

$$E_t \sum_{s=0}^{\infty} (\theta_F \beta_n)^s \Lambda_{C_n,t+s} u_{\beta,t+s} \left[\left(\frac{P_{C,t+s-1}}{P_{C,t-1}}\right)^{\chi} \frac{P_{F,opt,t}}{P_{C,t+s}} - \frac{S_{t+s} P^*_{who,t+s}}{P_{C,t+s}}\right] Y_{F,t+s|_t}(i), \qquad \text{(P63)}$$

where $\frac{S_t P^*_{who,t}}{P_{c,t}} \equiv MC_{F,t}$ denotes the real marginal costs of the import firm: $P^*_{who,t} = MC_t{}^*$, ie, importers purchase homogenous goods abroad without markup.

The constraint is the aggregate demand for products by the specific *i* firm from sector, for which, under the Yun indexing (Yun 1996), the equation changes to:

$$\text{s.t. } Y_{F,t+s|_t}(i) = \left[\frac{P_{F,opt,t}\left(\frac{P_{C,t+s-1}}{P_{C,t-1}}\right)^{\chi}}{P_{F,t+s}}\right]^{-\varphi} Y_{F,t+s}. \tag{P64}$$

The task is solved with the real optimal price by an importer firm, which can be represented as a system of forward-looking equations:

$$\frac{P_{F,opt,t}}{P_{C,t}} = \frac{\varphi}{\varphi-1}\frac{J_{F,t}}{N_{F,t}}, \tag{P65}$$

where the additional forward-looking variables are:

$$J_{F,t} = \Lambda_{C_n,t} u_{\beta,t} Y_{F,t}\left[\frac{P_{F,t}}{P_{C,t}}\right]^{\varphi} MC_{F,t} + \theta_F \beta_n E_t\left\{\left[\frac{1+\pi_{C,t+1}}{(1+\pi_{C,t})^{\chi}}\right]^{\varphi} J_{F,t+1}\right\}, \tag{P66}$$

$$N_{F,t} = \Lambda_{C_n,t} u_{\beta,t} Y_{F,t}\left[\frac{P_{F,t}}{P_{C,t}}\right]^{\varphi} + \theta_F \beta_n E_t\left\{\left[\frac{1+\pi_{C,t+1}}{(1+\pi_{C,t})^{\chi}}\right]^{\varphi-1} N_{F,t+1}\right\}. \tag{P67}$$

The steady state real price for the importer's production exceeds the real marginal costs by the amount of the monopoly markup:

$$\frac{\overline{P_F}}{\overline{P_C}} = \frac{\overline{P_{F,opt}}}{\overline{P_C}} = \frac{\varphi}{\varphi-1}\overline{MC_F}. \tag{P68}$$

Therefore, the inflation of economy-wide producer prices are defined as the following ratios:

$$\pi_{m,t} = \frac{P_{m,t}-P_{m,t-1}}{P_{m,t-1}}, \qquad m \subset \{N, H, F\} \tag{P69}$$

$$\pi_{T,t} = \frac{P_{T,t}-P_{T,t-1}}{P_{T,t-1}}, \tag{P70}$$

$$\pi_{C,t} = \frac{P_{C,t}-P_{C,t-1}}{P_{C,t-1}}. \tag{P71}$$

Equations (P70) and (P71) in turn calculate the inflation in the tradable sector and consumer inflation.

Central Bank

The Central Bank uses inflation targeting as it changes the nominal interest rate based on the output gap as well as the current consumer inflation and its forecast for the following three quarters (thereby accounting for the expected inflation within a year). Systemic foreign exchange interventions are not conducted, while the national currency rate is flexible.

Monetary authorities set the key rate under the Taylor rule:

$$\frac{1+i_t}{1+\bar{\imath}} = \left[\frac{1+i_{t-1}}{1+\bar{\imath}}\right]^{\rho_i}\left[\left\{\frac{E_t[(1+\pi_{C,t})(1+\pi_{C,t+1})(1+\pi_{C,t+2})(1+\pi_{C,t+3})]}{(1+\overline{\pi_C})}\right\}^{k_\pi/4}\left\{\frac{Y_t}{\bar{Y}}\right\}^{k_y}\right]^{1-\rho_i} e^{\varepsilon_{i,t}}, \tag{P72}$$

where ρ_i is the persistence of the key rate's dynamics; k_π denotes the coefficient of the key rate response to the expected annual inflation; k_y is the coefficient of the monetary rule response to the output gap; $\varepsilon_{i,t}$ is the monetary shock (the discretionary component of the monetary policy); and $\bar{\imath}$, $\overline{\pi_C}$ and $\bar{Y}$ are the steady state interest rate, consumer inflation and output.

Accounting for the key rate's persistence smoothes its dynamics and demonstrates the Central Bank's commitment to its previous obligations (Woodford 2001).

Government

The government adheres to the balanced budget concept in terms of real values:

$$T_t = G_t, \tag{P73}$$

where T_t denotes the real aggregate tax incomes and G_t are the real government procurement that completely pertains to the sector of non-tradable domestic goods and follows the exogenous AR(1) process:

$$G_t = [G_{t-1}]^{\rho_G}[\bar{G}]^{1-\rho_G}e^{\varepsilon_{G,t}}, \tag{P74}$$

where ρ_G is the autoregressive coefficient for government expenditure (affecting the persistence of government expenditure shocks); $\bar{G}$ stands for the steady state government expenditure; and $\varepsilon_{G,t}$ is the fiscal shock (discretionary component).

The government's systemic policy cannot be modelled in a detailed way, as in, eg, Dib (2008). Nevertheless, due to the failure of Ricardian equivalence in some groups of households, the fiscal policy cannot be viewed as neutral: lump-sum taxes affect the current earnings of Wealthy HtM and Poor HtM households and hence the aggregate variables. The aggregate tax revenue consists of two parts: the flat wage tax $T_{L,t}$(this part of the tax revenue is of a procyclical nature) and the lump-sum taxesT_{0_t}:

$$T_t = T_{L,t} + T_{0_t}, \tag{P75}$$

where $T_{L,t}$ denotes aggregate labour taxes:

$$T_{L,t} = \gamma_n T_{L_{n,t}} + \gamma_w T_{L_{w,t}} + \gamma_p T_{L_{p,t}}, \tag{P76}$$

where $T_{L_{j,t}}$ denotes the labour tax for households of each *j* type:

$$T_{L_{j,t}} = \frac{\tau \cdot W_{j,t} L_{j,t}}{P_{N,t}}. \qquad j \subset \{n, w, p\} \tag{P77}$$

Lump-sum payments T_{0_t} consist of taxes ($T_{0_{j,t}} > 0$) that come from Non-HtM households:

$$T_{0_t} = \gamma_n T_{0_{n,t}} + \gamma_w T_{0_{w,t}} + \gamma_p T_{0_{p,t}}, \tag{P78}$$

$$T_{0_{n,t}} = T_{0_{w,t}} \gamma_{T_{0_{nw}}}, \tag{P79}$$

where $\gamma_{T_{0_{nw}}}$ is the parameter that determines the lump-sum tax distribution between Non-HtM and Wealthy HtM households (it is assumed to be large for lump-sum taxes to be mostly paid by Non-HtM households).

We assume that for Non-HtM households, these lump-sum taxes can, on the one hand, be interpreted as a wealth tax (including on their firms' profits), but on the other hand, it is the only group of households whose consumption does not depend on the current income. Adjustment $T_{0_{n,t}}$ helps balance the state budget, while avoiding the distortion of the dynamics of aggregate variables. For Poor HtM households, lump-sum taxes are negative $T_{0_{p,t}} < 0$, ie, they receive exogenous lump-sum transfers from the government:

$$T_{0_{p,t}} = \left[T_{0_{p,t-1}}\right]^{\rho_{T_p}} \left[\overline{T_{0_p}}\right]^{1-\rho_{T_p}} e^{\varepsilon_{T_{p,t}}}, \qquad \text{(P80)}$$

where ρ_{T_p} is the autoregressive coefficient for transfers of Poor HtM households and $\overline{T_{0_p}}$ are steady state transfers constituting share $\gamma_{T_{0_p}} < 0$ in the steady state GDP.

External sector

The condition of uncovered interest rate parity defines the floating exchange rate dynamics as:

$$1 + i_t = (1 + i_t^*)(1 + rp_t)\frac{E_t S_{t+1}}{S_t}, \qquad \text{(P81)}$$

where rp_t is the risk premium described by the ad hoc function (incomplete financial market):

$$1 + rp_t = (1 + \overline{rp})u_{rp} + \nu\left[\frac{b_t^* - \overline{b^*}}{\overline{b^*}}\right] - \xi_x\left[\frac{x_t^* - \overline{x^*}}{\overline{x^*}}\right], \qquad \text{(P82)}$$

where ν is the premium risk response to a the external debt deviation from the steady state; ξ_x is the parameter that helps set the foreign currency rate response to the real oil price deviation from the steady state; and u_{rp} is the AR(1) process reflecting the effect of the risk premium shock:

$$u_{rp,t} = \left[u_{rp,t-1}\right]^{\rho_{rp}} e^{\varepsilon_{rp,t}}, \qquad \text{(P83)}$$

where ρ_{rp} is the autoregressive coefficient of external premium risk shock and $\varepsilon_{rp,t}$ is the structural risk premium shock.

Due to this function, the higher the current external debt, the higher the cost of foreign borrowing, which rules out a Ponzi scheme scenario in this market.

The external sector (foreign economy) is described by the New Keynesian model as a closed private economy with homogeneous agents, flexible nominal wages and a constant economy of scale.

Foreign households are assumed to be non-hand-to-mouth and therefore their consumption C_t^* is defined by the Euler equation as:

$$\beta^* E_t\left\{\frac{\Lambda_{c.t+1}^* \cdot u_{\beta^*,t+1}}{\Lambda_{c.t}^* \cdot u_{\beta^*,t}} \frac{1 + i_t^*}{1 + \pi_{C,t+1}^*}\right\} = 1, \qquad \text{(P84)}$$

where $\Lambda_{c.t}^* \equiv \frac{\partial \Lambda_t^*}{\partial C_t^*} = (C_t^* - \xi^* C_{t-1}^*)^{-\sigma^*}$ is the foreign marginal utility of consumption (ξ^* denotes foreign consumption habits and σ^* is the reciprocal of foreign elasticity of intertemporal consumption substitution); $\pi^*_{C,t+1} \equiv \frac{P^*_{C,t+1} - P^*_{C,t}}{P^*_{C,t}}$ is foreign CPI inflation; and $u_{\beta^*,t}$ is the AR(1) process reflecting the effect of the shock of foreign intertemporal choices:

$$u_{\beta^*,t} = \left[u_{\beta^*,t-1}\right]^{\rho_{\beta^*}} e^{\varepsilon_{\beta^*,t}}, \tag{P85}$$

where ρ_{β^*} is the autoregressive coefficient of foreign intertemporal choice shocks and $\varepsilon_{\beta^*,t}$ denotes the structural shock of foreign intertemporal choices.

Because the economy is closed and fair, the aggregate consumption of foreign households is consistent with the aggregate outputY^*_t:

$$C^*_t = Y^*_t. \tag{P86}$$

Foreign producers following the Calvo pricing (Calvo 1983) and the Yun indexing (Yun 1996). The foreign price index dynamics is:

$$P^{*\,1-\varphi}_t = \theta^*\left[(1+\pi^*_{C,t-1})^{\chi^*} P^*_{t-1}\right]^{1-\varphi^*} + (1-\theta^*)\left[P^*_{opt,t}\right]^{1-\varphi^*}, \tag{P87}$$

where θ^* is the foreign nominal price stickiness; χ^* is the foreign indexation rate; and φ^* is the foreign elasticity of differentiated product substitution.

External sector producers maximise discounted profits by selecting the real optimal price $\frac{P^*_{opt,t}}{P^*_t}$, which can be represented as a system of forward-looking recurrence equations:

$$\frac{P^*_{opt,t}}{P^*_t} = \frac{\varphi^*}{\varphi^*-1}\frac{J^*_t}{N^*_t}, \tag{P88}$$

where the additional forward-looking variables are:

$$J^*_t = \Lambda^*_{c.t} u_{\beta^*,t} Y^*_t MC^*_t + \theta^*\beta^* E_t\left\{\left[\frac{1+\pi^*_{C,t+1}}{(1+\pi^*_{C,t})^{\chi^*}}\right]^{\varphi^*} J^*_{t+1}\right\}, \tag{P89}$$

$$N^*_t = \Lambda^*_{c.t} u_{\beta^*,t} Y^*_t + \theta^*\beta^* E_t\left\{\left[\frac{1+\pi^*_{C,t+1}}{(1+\pi^*_{C,t})^{\chi^*}}\right]^{\varphi^*-1} N^*_{t+1}\right\}, \tag{P90}$$

where MC^*_t denotes the real marginal costs of foreign firms:

$$MC^*_t = Y^{*\,\sigma^*+\eta^*}_t \frac{1}{A^{*\,1-\eta^*}_t}, \tag{P91}$$

where η^* is the reciprocal of the Frisch foreign labour supply elasticity and A^*_t is the exogenous AR(1) process characterising the foreign total factor productivity:

$$A^*_t = [A^*_{t-1}]^{\rho_{A^*}}[\overline{A^*}]^{1-\rho_{A^*}} e^{\varepsilon_{A^*,t}}, \tag{P92}$$

where ρ_{A^*} is the autoregressive coefficient of the exogenous process; $\overline{A_k}$ is the steady state of foreign total factor productivity; and $\varepsilon_{A^*,t}$ is its structural shock.

The steady state real price by foreign sector producers exceeds their real marginal costs by the amount of the monopoly markup:

$$\frac{\overline{P^*_{opt}}}{\overline{P^*}} = \frac{\varphi^*}{\varphi^*-1}\overline{MC^*}. \qquad \text{(P93)}$$

Foreign monetary authorities also set the key rate under the Taylor rule, responding to the current inflation and the output gap:

$$\frac{1+i_t^*}{1+\overline{i^*}} = \left[\frac{1+i_{t-1}^*}{1+\overline{i^*}}\right]^{\rho_i^*}\left[\left\{\frac{1+\pi_{C,t}^*}{(1+\overline{\pi_C^*})}\right\}^{k_\pi^*}\left\{\frac{Y_t^*}{\overline{Y^*}}\right\}^{k_y^*}\right]^{1-\rho_i^*} e^{\varepsilon_{i^*,t}}, \qquad \text{(P94)}$$

where ρ_i^* is the persistence of the foreign key rate dynamics; k_π^* is the coefficient of the foreign key rate response to the inflation's current deviations from the target; k_y^* is the coefficient of the foreign Central Bank's monetary rule response to the output gap; $\varepsilon_{i^*,t}$ denotes the external shock of the monetary policy; and $\overline{i^*}$, $\overline{\pi_C^*}$ and $\overline{Y^*}$ are the steady state foreign key rate, consumer inflation and output.

Aggregate and general equilibrium

In equilibrium all households and firms within the group of agents and the sector respectively make identical decisions and have equal characteristics; therefore aggregate variables are the weighted mean accounting for shares γ_j of groups of households $j \subset \{n, w, p\}$ in the population.

The aggregate consumption of the sectors' $m \subset \{N, H, F\}$products by households is:

$$C_{m,t} = \gamma_n C_{n,m,t} + \gamma_w C_{w,m,t} + \gamma_p C_{p,m,t}. \qquad m \subset \{N, H, F\} \qquad \text{(P95)}$$

The aggregate consumption of tradable goods by households is:

$$C_{T,t} = \gamma_n C_{n,T,t} + \gamma_w C_{w,T,t} + \gamma_p C_{p,T,t}. \qquad \text{(P96)}$$

The aggregated consumption by domestic households economy-wide is:

$$C_t = \gamma_n C_{n,t} + \gamma_w C_{w,t} + \gamma_p C_{p,t}. \qquad \text{(P97)}$$

Aggregating the housing demand across all Non-HtM and Wealthy HtM households helps define the equilibrium condition for the real estate market as:

$$h_t = \gamma_n h_{n,t} + \gamma_w h_{w,t} + \gamma_p h_{p,t}, \qquad \text{(P98)}$$

where h_t is the housing demand following the exogenous AR(1) process:

$$h_t = [h_{t-1}]^{\rho_{h_s}}\left[\bar{h}\right]^{1-\rho_{h_s}} e^{\varepsilon_{h_s,t}}, \qquad \text{(P99)}$$

where ρ_{h_s} is the autoregressive coefficient of the housing demand; $\bar{h}$ is the steady state demand; and $\varepsilon_{h_s,t}$ is the housing demand shock.

Equilibrium in the non-tradable goods market is described by the condition of supply by firms from this sector and demand from households and the government being equal:

$$Y_{N,t} = C_{N,t} + G_t. \qquad \text{(P100)}$$

Described similarly is equilibrium in the tradable goods market accounting for the fact that firms from this sector work to meet both the domestic demand from households and the external demand for natural resources and tradable goods:

$$Y_{H,t} = C_{H,t} + Y_{oil,t} + Y_{H_{ex},t}, \tag{P101}$$

where $Y_{oil,t}$ is the export of natural resources (external demand for them) and $Y_{H_{ex},t}$ denotes the export of other domestic tradable goods.

In the model, the export of natural resources, or the external demand for them, depends on the external market environment (external sector output):

$$Y_{oil,t} = \omega_{oil} Y_t^*, \tag{P102}$$

where ω_{oil} is the share of global demand Y_t^* for domestic natural resources.

It is assumed that domestic producers of tradable goods do not discriminate against the export markets and set the unified price $P_{H,t}$; therefore the export of their products (external demand) is:

$$Y_{H_{ex},t} = \omega Y_t^* \left[\frac{P_{H,t}}{S_t \cdot P_t^*}\right]^{-\delta^*}, \tag{P103}$$

where ω is the share of global demand Y_t^* for domestic tradable goods and δ^* stands for the elasticity of substitution between domestic and imported tradable goods in the foreign economy.

Because imported goods are only consumed by households, the equilibrium in the import sector is:

$$Y_{F,t} = C_{F,t}. \tag{P104}$$

Therefore the gross domestic product (hereinafter 'GDP') calculated based on expenditure in terms of real values is:

$$Y_t = C_{H,t} + C_{N,t} + G_t + Y_{H_{ex},t} + Y_{oil,t}. \tag{P105}$$

At the same time, the nominal GDP calculated based on expenditure is:

$$P_{H,t}C_{H,t} + P_{N,t}(C_{N,t} + G_t) + P_{H,t}Y_{H_{ex},t} + S_t P_{oil,t}^* Y_{oil,t} = P_{defl,t} Y_t, \tag{P106}$$

where $P_{defl,t}$is the GDP deflator and$P_{oil,t}^*$ is the nominal global oil price defined by the equation of the real oil price as:

$$x_t^* = \frac{P_{oil,t}^*}{P_t^*}, \tag{P107}$$

where x_t^* is the real global oil price following the exogenous AR(1) process:

$$x_t^* = [x_{t-1}^*]^{\rho_{x^*}} [\overline{x^*}]^{1-\rho_{x^*}} e^{\varepsilon_{x^*,t}}, \tag{P108}$$

where ρ_{x^*} is the autoregressive coefficient of the real global oil price; $\overline{x^*}$ is its steady state; and $\varepsilon_{x^*,t}$ is the structural shock of the real global oil price.

The balance sheet equation reflects the equilibrium in the external debt market in real terms (relative toP_t^*):

$$x_t^* Y_{oil,t} + \frac{P_{H,t}}{S_t \cdot P_t^*} Y_{H_{ex},t} - \frac{P_{who,t}^*}{P_t^*} C_{F,t} - \frac{(1+i_{t-1}^*)(1+rp_{t-1})}{1+\pi_{C,t}^*} b_{t-1}^* + b_t^* = 0. \tag{P109}$$

At the same time, the equilibrium in the domestic financial market suggests:

$$b_{n,t} + b_{w,t} = 0. \tag{P110}$$

The analysis of the redistributive effects of the monetary policy requires defining the aggregate real current income for each of the group of households (excluding wealth income). The income of Non-HtM households is:

$$I_{n,t}P_{C,t} = (1-\tau)W_{n,t}L_{n,t} + mq_{t-1}P_{C,t-1}h_{n,t-1}i_{t-1}\frac{\gamma_w}{\gamma_n} - T_{0_{n,t}}P_{N,t} - S_{t-1}P^*_{C,t-1}b^*_{t-1}\left[\frac{S_t}{S_{t-1}}(1+i^*_{t-1})(1+rp_{t-1}) - 1\right]\frac{1}{\gamma_n} + Profit_t\frac{1}{\gamma_n}, \tag{P117}$$

where $Profit_t\frac{1}{\gamma_n}$ denotes the nominal dividend payments for a single Non-HtM household.

The income of Wealthy HtM households is:

$$I_{w,t}P_{C,t} = (1-\tau)W_{w,t}L_{w,t} - mq_{t-1}P_{C,t-1}h_{w,t-1}i_{t-1} - T_{0_{w,t}}P_{N,t}, \tag{P111}$$

where $mq_{t-1}P_{C,t-1}h_{w,t-1}$ denotes the debt of Wealthy HtM households in the previous period, consistent with their borrowing limit.

The income of Poor HtM households is:

$$I_{p.t}P_{C,t} = (1-\tau)W_{p,t}L_{p,t} - T_{0_{p,t}}P_{N,t}. \tag{P112}$$

Therefore the aggregate real current income is:

$$I_t = \gamma_n I_{n.t} + \gamma_w I_{w.t} + \gamma_p I_{p.t}. \tag{P113}$$

Assuming that the current income and consumption of Non-HtM households are higher than those of Wealthy HtM households that in turn exceed the figures of Poor HtM households, we can estimate the aggregate real current income and consumption inequalities at:

$$Gini\ Income_t = 1 - \gamma_n - (1+\gamma_w)\frac{I_{p,t}\gamma_p}{I_t} - (1-\gamma_p)\frac{I_{w,t}\gamma_w}{I_t}, \tag{P114}$$

$$Gini\ Cons_t = 1 - \gamma_n - (1+\gamma_w)\frac{C_{p,t}\gamma_p}{C_t} - (1-\gamma_p)\frac{C_{w,t}\gamma_w}{C_t}. \tag{P115}$$

Steady state

Suppose, in the long-term equilibrium, the prices across all economy sectors are fixed, optimal, balance out and therefore are consistent with the price index for tradable and consumer goods as well as with the GDP deflator:

$$\overline{P_N} = \overline{P_H} = \overline{P_F} = \overline{P_{N,opt}} = \overline{P_{H,opt}} = \overline{P_{F,opt}} = \overline{P_T} = \overline{P_C} = \overline{P_{defl}}, \tag{P116}$$

$$\overline{\pi_N} = \overline{\pi_H} = \overline{\pi_F} = \overline{\pi_T} = \overline{\pi_C} = \overline{\pi^*} = 0. \tag{P117}$$

Suppose further, cross-country prices balance out; we will set the nominal anchor for the domestic and foreign economies to:

$$\overline{P_C} = \bar{S} = 1, \tag{P118}$$

$$\overline{SP^*} = \overline{SP^*_{opt}} = \overline{P_C} = 1. \quad \text{(P119)}$$

Let us calculate of the real oil price matches this anchor; then:

$$\overline{x^*} = \overline{P^*_{oil}} = \overline{P^*} = 1. \quad \text{(P120)}$$

Considering the pricing mechanism, the real marginal costs are:

$$\overline{MC_N} = \overline{MC_H} = \frac{\varphi-1}{\varphi}, \quad \text{(P121)}$$

$$\overline{MC^*} = \frac{\varphi^*-1}{\varphi^*} = \overline{P^*_{who}} = \overline{MC_F}. \quad \text{(P122)}$$

Therefore, $\overline{P_F} = \overline{P_C} = \bar{S} \cdot \overline{P^*} = 1$ requires $\overline{MC^*} = \overline{MC_F}$ and, consequently, to ensure the equality of price indexes between the countries, ratio $\varphi^* = \varphi$ must be observed.

Assume that the scale of the domestic economy is defined through the export; let the latter equal 1:

$$\overline{Y_{oil}} + \overline{Y_{H_{ex}}} = 1. \quad \text{(P123)}$$

Then:

$$\overline{Y^*} = \frac{1}{\omega_{oil}+\omega}, \quad \text{(P124)}$$

$$\overline{Y_{oil}} = \frac{\omega_{oil}}{\omega_{oil}+\omega}, \quad \text{(P125)}$$

$$\overline{Y_{H_{ex}}} = \frac{\omega}{\omega_{oil}+\omega}. \quad \text{(P126)}$$

From the balance sheet equation:

$$\overline{C_F} = \left[1 - \overline{b^*}(\overline{\iota^*} + \overline{rp} + \overline{\iota^*}\overline{rp})\right]\frac{\varphi^*}{\varphi^*-1}, \quad \text{(P127)}$$

where $\overline{\iota^*} = \frac{1-\beta^*}{\beta^*}$, according to the Euler equation for foreign households, and considering the similar equation for Non-HtM households $\bar{\iota} = \frac{1-\beta_n}{\beta_n}$, $\overline{rp}$can be expressed through the uncovered interest rate parity equation:

$$\overline{rp} = \frac{\beta^*}{\beta_n} - 1. \quad \text{(P128)}$$

We set external debt $\overline{b^*}$as shareγ_{b^*} of the export:

$$\overline{b^*} = \gamma_{b^*} \cdot 1. \quad \text{(P129)}$$

Using the ratio of aggregate consumptions yields:

$$\overline{C_H} = \frac{\psi_H}{1-\psi_H}\overline{C_F}, \quad \text{(P130)}$$

$$\overline{C_T} = \frac{1}{1-\psi_H}\overline{C_F}, \quad \text{(P131)}$$

$$\overline{C_N} = \frac{1-\psi_T}{\psi_T}\frac{1}{1-\psi_H}\overline{C_F}, \quad \text{(P132)}$$

$$\bar{C} = \frac{1}{\psi_T}\frac{1}{1-\psi_H}\overline{C_F}. \quad \text{(P133)}$$

We set government procurement as share $\gamma_G$of the GDP:

$$\bar{G} = \gamma_G \bar{Y}. \tag{P134}$$

The output across the sectors is:

$$\overline{Y_N} = \overline{C_N} + \bar{G}, \tag{P135}$$

$$\overline{Y_H} = \overline{C_H} + 1, \tag{P136}$$

$$\overline{Y_F} = \overline{C_F}, \tag{P137}$$

Aggregate output

$$\bar{Y} = \frac{1}{1-\gamma_G}\left[\overline{C_F}\frac{1}{1-\psi_H}\left(\frac{1-\psi_T}{\psi_T} + \psi_H\right) + 1\right]. \tag{P138}$$

Let us calibrate the ratios of consumption by the groups of households to a fixed level:

$$\frac{\overline{C_n}}{\overline{C_w}} = \gamma_{C_{n/w}}, \tag{P139}$$

$$\frac{\overline{C_w}}{\overline{C_p}} = \gamma_{C_{w/p}}. \tag{P140}$$

Then, considering aggregating condition$\bar{C} = \gamma_n\overline{C_n} + \gamma_w\overline{C_w} + \gamma_p\overline{C_p}$, we can express the consumptions of the groups of households through these ratios:

$$\overline{C_p} = \bar{C}\frac{1}{\gamma_n \cdot \gamma_{C_{n/w}}\gamma_{C_{w/p}} + \gamma_w\gamma_{C_{w/p}} + \gamma_p}, \tag{P141}$$

$$\overline{C_w} = \overline{C_p}\gamma_{C_{w/p}}, \tag{P142}$$

$$\overline{C_n} = \overline{C_w}\gamma_{C_{n/w}}. \tag{P143}$$

Knowing the aggregate consumptions of the groups of households, these can be disaggregated:

$$\overline{C_{J,T}} = \bar{C_J}\psi_T, \quad j \subset \{n, w, p\} \tag{P144}$$

$$\overline{C_{J,N}} = \bar{C_J}(1-\psi_T), \quad j \subset \{n, w, p\} \tag{P145}$$

$$\overline{C_{J,H}} = \overline{C_{J,T}}\psi_H, \quad j \subset \{n, w, p\} \tag{P146}$$

$$\overline{C_{J,F}} = \overline{C_{J,T}}(1-\psi_H). \quad j \subset \{n, w, p\} \tag{P147}$$

The first-order conditions to maximise the housing stock utility of Non-HtM and Wealthy HtM households therefore equal:

$$\overline{\Lambda_{h_n}} - \overline{\Lambda_{C_n}}(\bar{q} - \beta_n\bar{q}) = 0, \tag{P148}$$

$$\overline{\Lambda_{h_w}} - \overline{\Lambda_{C_w}}(\bar{q} - \beta_w\bar{q}) + \overline{\lambda_w}m\bar{q} = 0, \tag{P149}$$

where$\overline{\lambda_w} = (\beta_n - \beta_w)\overline{\Lambda_{C_w}}$, according to the Euler equation for Wealthy HtM households, while$\overline{\Lambda_{C_J}}$ and $\overline{\Lambda_{h_{J'}}}$are defined respectively as:

$$\overline{\Lambda_{C_J}} = \left[(1-\xi)\bar{C_J}\right]^{-\sigma_c}, \quad j \subset \{n, w, p\} \tag{P150}$$

$$\overline{\Lambda_{h_{J'}}} = \left(\overline{h_{J'}}\right)^{-\sigma_h}. \quad j' \subset \{n, w\} \tag{P151}$$

For aggregate housing, let us assume $\bar{h} = \gamma_n \overline{h_n} + \gamma_w \overline{h_w} + \gamma_P \overline{h_p} = 1$. Then, considering that $\overline{h_p} = 0$, the equilibrium in the housing market is achieved at:

$$\overline{h_n} = \left[\gamma_n + \gamma_w \left(\frac{\overline{C_w}}{\overline{C_n}}\right)^{\frac{\sigma_c}{\sigma_h}} \left(\frac{1-\beta_n}{1-\beta_w-m(\beta_n-\beta_w)}\right)^{\frac{1}{\sigma_h}}\right]^{-1}, \tag{P152}$$

$$\overline{h_w} = \left[\gamma_w + \gamma_n \left(\frac{\overline{C_n}}{\overline{C_w}}\right)^{\frac{\sigma_c}{\sigma_h}} \left(\frac{1-\beta_w-m(\beta_n-\beta_w)}{1-\beta_w}\right)^{\frac{1}{\sigma_h}}\right]^{-1}, \tag{P153}$$

$$\bar{q} = \left(\overline{h_n}\right)^{-\sigma_h}[(1-\xi)\overline{C_n}]^{-\sigma_c}\frac{1}{1-\beta_n}. \tag{P154}$$

Assume that steady state wages of a group of households in each sector are optimal and equalised; however, wages vary among the groups of households:

$$\overline{W_{J,N}} = \overline{W_{J,H}} = \overline{W_{J,k,opt}} = \overline{W_J}, \qquad j \subset \{n,w,p\},\ k \subset \{N,H\} \tag{P155}$$

where:

$$\overline{W_{J,k,opt}} = \frac{\varphi_L}{\varphi_L - 1}\frac{1}{1-\tau}\frac{\overline{\Lambda_{L_J}}}{\overline{\Lambda_{C_J}}}, \qquad j \subset \{n,w,p\},\ k \subset \{N,H\} \tag{P156}$$

where $\overline{\Lambda_{L_J}} = -\left(\overline{L_J}\right)^{\eta}$ for $j \subset \{n,w,p\}$.

Because households' wages are equalised within the group, median sector-wide wages are equalised, too:

$$\overline{W_N} = \overline{W_H} = \overline{W}, \tag{P157}$$

where $\overline{W}$ denotes the median economy-wide wages, while sector-wide wages are:

$$\overline{W_k}^{1-\mu} = \alpha_n \overline{W_n}^{1-\mu} + \alpha_w \overline{W_w}^{1-\mu} + \alpha_p \overline{W_p}^{1-\mu}. \qquad k \subset \{N,H\} \tag{P158}$$

This also necessitates equality in the steady state cross-sector total factor productivity. Considering that $\overline{MC_N} = \overline{MC_H}$ and $\overline{W_N} = \overline{W_H}$, it follows from the sector-wide marginal cost equation that:

$$\overline{A_N} = \overline{A_H} = \frac{\overline{W_k}}{\overline{MC_k}}. \qquad k \subset \{N,H\} \tag{P159}$$

A balanced state budget requires:

$$\gamma_G \overline{Y} = \overline{T_0} + \overline{T_L}, \tag{P160}$$

where $\overline{T_L}$ denotes the steady state aggregate labour taxes:

$$\overline{T_L} = \gamma_n \overline{T_{L_n}} + \gamma_w \overline{T_{L_w}} + \gamma_p \overline{T_{L_p}}, \tag{P161}$$

where $\overline{T_{L_J}}$ for $j \subset \{n,w,p\}$:

$$\overline{T_{L_J}} = \tau \overline{W_J}\,\overline{L_J}, \qquad j \subset \{n,w,p\} \tag{P162}$$

where households' labour income $\overline{W_J} \cdot \overline{L_J}$ can be expressed through their budget constraint, considering that amid a lack of investment $\overline{I_J} = \overline{C_J}$ for steady state $j \subset \{n,w,p\}$:

$$\overline{W_p L_p} = \frac{\overline{C_p}}{1-\tau} + \frac{\overline{T_{0p}}}{1-\tau}, \tag{P163}$$

where $\overline{T_{0_p}} = \gamma_{T_{0_p}} \cdot \bar{Y}$ denotes steady state transfers, constituting $\gamma_{T_{0_p}}$ of the steady state GDP.

$$\overline{W_w L_w} = \frac{\overline{C_w}}{1-\tau} + m\frac{\bar{q}\cdot\overline{h_w}\cdot\bar{\iota}}{1-\tau} + \frac{\overline{T_{0_w}}}{1-\tau}, \qquad \text{(P164)}$$

$$\overline{W_n L_n} = \frac{1}{1-\tau}\left[\overline{C_n} - m\bar{q}\overline{h_w}\bar{\iota}\frac{\gamma_w}{\gamma_n} + \overline{T_{0_n}} + \frac{\gamma_{b^*}}{\gamma_n}(\overline{\iota^*} + \overline{rp} + \overline{\iota^*}\overline{rp}) - \frac{\overline{Profit}}{\gamma_n}\right], \qquad \text{(P165)}$$

where $\overline{Profit} = \frac{\overline{Y_N}+\overline{Y_H}+\overline{Y_F}}{\varphi}$.

Then, using steady state labour income, the condition of a balanced state budget can express steady state lump-sum taxes:

$$\overline{T_0} = (1-\tau)\gamma_G\bar{Y} - \tau\left[\bar{C} - \overline{Profit} + \gamma_{b^*}(\overline{\iota^*} + \overline{rp} + \overline{\iota^*}\overline{rp})\right]. \qquad \text{(P166)}$$

At the same time, from the aggregating condition $\overline{T_0}$ for households:

$$\overline{T_0} - \gamma_p\overline{T_{0_p}} = (\gamma_n\gamma_{T_{0_{nw}}} + \gamma_w)\overline{T_{0_w}}, \qquad \text{(P167)}$$

where $\overline{T_{0_p}} = \gamma_{T_{0_p}}\bar{Y}$ and $\gamma_{T_{0_p}} < 0$.

Therefore steady state lump-sum taxes for Non-HtM and Wealthy HtM households are:

$$\overline{T_{0_w}} = \frac{\overline{T_0} - \gamma_p\overline{T_{0_p}}}{\gamma_n\gamma_{T_{0_{nw}}} + \gamma_w}, \qquad \text{(P168)}$$

$$\overline{T_{0_n}} = \frac{1}{\gamma_n}\left[\overline{T_0} - \gamma_w\overline{T_{0_w}} - \gamma_p\overline{T_{0_p}}\right]. \qquad \text{(P169)}$$

Knowing the steady state labour income for the groups of households and their median wages, hours worked can be expressed:

$$\overline{L_n} = \left(\frac{\varphi_L - 1}{\varphi_L}\frac{\left[\overline{C_n} - m\bar{q}\overline{h_w}\bar{\iota}\frac{\gamma_w}{\gamma_n} + \overline{T_{0_n}} + \frac{\gamma_{b^*}}{\gamma_n}(\overline{\iota^*} + \overline{rp} + \overline{\iota^*}\overline{rp}) - \frac{\overline{Profit}}{\gamma_n}\right]}{[(1-\xi)\overline{C_n}]^{\sigma_C}}\right)^{\frac{1}{1+\eta}}, \qquad \text{(P170)}$$

$$\overline{L_w} = \left(\frac{\varphi_L - 1}{\varphi_L}\frac{\left[\overline{C_w} + m\bar{q}\overline{h_w}\bar{\iota} + \overline{T_{0_w}}\right]}{[(1-\xi)\overline{C_w}]^{\sigma_C}}\right)^{\frac{1}{1+\eta}}, \qquad \text{(P171)}$$

$$\overline{L_p} = \left(\frac{\varphi_L - 1}{\varphi_L}\frac{\left[\overline{C_p} + \overline{T_{0_p}}\right]}{\left[(1-\xi)\overline{C_p}\right]^{\sigma_C}}\right)^{\frac{1}{1+\eta}}. \qquad \text{(P172)}$$

On the other hand, they can be expressed through the aggregate demand of firms from *k* sectors for the labour of each of *j* groups:

$$\overline{L_J} = \overline{L_{J,N}} + \overline{L_{J,H}} = \frac{\alpha_j}{\gamma_j}\left[\frac{\overline{W_J}}{\overline{W}}\right]^{-\mu}\bar{L}, \qquad j \subset \{n,w,p\} \qquad \text{(P173)}$$

where $\bar{L} = \overline{L_N} + \overline{L_H}$ denotes the economy-wide aggregate hours worked and $\overline{L_{J,k}}$ is the steady state demand for the labour of households of the *j* group in the *k* sector:

$$\overline{L_{J,k}} = \frac{\alpha_j}{\gamma_j}\left[\frac{\overline{W_J}}{\overline{W}}\right]^{-\mu}\overline{L_k}, \qquad j \subset \{n,w,p\},\ k \subset \{N,H\} \qquad \text{(P174)}$$

where α_j, when calculating the steady state, are considered quasi-variables and are estimated from the ratios of aggregate demands for the labour of different groups of households as well as condition $\alpha_n + \alpha_w + \alpha_p = 1$:

$$\alpha_p = \frac{\gamma_p \overline{L_p}(\overline{W_p})^{\mu}}{\gamma_p \overline{L_p}(\overline{W_p})^{\mu} + \gamma_w \overline{L_w}(\overline{W_w})^{\mu} + \gamma_n \overline{L_n}(\overline{W_n})^{\mu}}, \quad \text{(P175)}$$

$$\alpha_w = \frac{\gamma_w \overline{L_w}(\overline{W_w})^{\mu}}{\gamma_p \overline{L_p}(\overline{W_p})^{\mu} + \gamma_w \overline{L_w}(\overline{W_w})^{\mu} + \gamma_n \overline{L_n}(\overline{W_n})^{\mu}}, \quad \text{(P176)}$$

$$\alpha_n = 1 - \alpha_p - \alpha_w. \quad \text{(P177)}$$

At the same time, considering the equality of wages and total factor productivity between the *k* production sectors, according to the production function:

$$\overline{L_N} = \bar{L}\frac{\overline{Y_N}}{\overline{Y_N} + \overline{Y_H}}, \quad \text{(P178)}$$

$$\overline{L_H} = \bar{L}\frac{\overline{Y_H}}{\overline{Y_N} + \overline{Y_H}}. \quad \text{(P179)}$$

Having identified aggregate hours in worked across the sectors, the production function can be used to express the steady state total factor productivity:

$$\overline{A_k} = \frac{\overline{Y_k}}{\overline{L_k}}. \qquad k \subset \{N, H\} \quad \text{(P180)}$$

For the foreign economy:

$$\overline{A^*} = \left[\frac{(\overline{Y^*})^{\sigma^* + \eta^*}}{\overline{MC^*}}\right]^{\frac{1}{1-\eta^*}}, \quad \text{(P181)}$$

$$\overline{Y^*} = \overline{C^*}. \quad \text{(P182)}$$

Combining the equations of aggregate labour income and demand for the labour of a group of households:

$$\bar{W} = \overline{W_p}\left[\frac{1}{\alpha_p}\frac{\gamma_p \overline{L_p} \cdot \overline{W_p}}{\gamma_p \overline{L_p W_p} + \gamma_w \overline{L_w} \cdot \overline{W_w} + \gamma_n \overline{L_n W_n}}\right]^{\frac{1}{\mu-1}}, \quad \text{(P183)}$$

$$\bar{L} = \frac{\gamma_p \overline{L_p W_p} + \gamma_w \overline{L_w W_w} + \gamma_n \overline{L_n W_n}}{\bar{W}}. \quad \text{(P184)}$$

Additional variable for the Calvo pricing (Calvo 1983):

$$\overline{J_m} = \frac{1}{1 - \beta_n \theta_m}\left[\overline{\Lambda_{C_n} Y_m MC_m}\right], \qquad m \subset \{N, H, F\} \quad \text{(P185)}$$

$$\overline{N_m} = \frac{1}{1 - \beta_n \theta_m}\left[\overline{\Lambda_{C_n} Y_m}\right]. \qquad m \subset \{N, H, F\} \quad \text{(P186)}$$

Similarly, for the foreign economy:

$$\overline{J^*} = \frac{1}{1 - \beta^* \theta^*}\left[\overline{\Lambda_C^* Y^* MC^*}\right], \quad \text{(P187)}$$

$$\overline{N^*} = \frac{1}{1 - \beta^* \theta^*}\left[\overline{\Lambda_C^* Y^*}\right], \quad \text{(P188)}$$

where $\overline{\Lambda_C^*}$ is the marginal consumption utility for the foreign economy:

$$\overline{\Lambda_C^*} = \left[(1 - \xi^*)\overline{C^*}\right]^{-\sigma^*}. \quad \text{(P189)}$$

Additional variables for the Calvo pricing (Calvo 1983) when establishing the wages:

$$\overline{J_{W,J,k}} = \frac{1}{1-\beta_j\theta_{Wj}}\left[-\overline{L_{J,k}}\left(\overline{W_J}\right)^{\varphi_L}\overline{\Lambda_{L_J}}\right], \quad j \subset \{n,w,p\},\, k \subset \{N,H\} \qquad \text{(P190)}$$

$$\overline{N_{W,J,k}} = \frac{1}{1-\beta_j\theta_{Wj}}\left[\overline{L_{J,k}}\left(\overline{W_J}\right)^{\varphi_L}\overline{\Lambda_{C_J}}\right], \quad j \subset \{n,w,p\},\, k \subset \{N,H\} \qquad \text{(P191)}$$

Economic inequality aggregates:

$$\overline{G\imath n\imath\ Income} = 1 - \gamma_n - (1+\gamma_w)\frac{\overline{I_p}\gamma_p}{\bar{I}} - (1-\gamma_p)\frac{\overline{I_w}\gamma_w}{\bar{I}}, \qquad \text{(P192)}$$

where the steady state real current wages $\overline{I_J} = \overline{C_J}$ and the aggregate wages:

$$\bar{I} = \gamma_n\overline{I_n} + \gamma_w\overline{I_w} + \gamma_p\overline{I_p}. \qquad \text{(P193)}$$

$$\overline{G\imath n\imath\ Cons} = 1 - \gamma_n - (1+\gamma_w)\frac{\overline{C_p}\gamma_p}{\bar{C}} - (1-\gamma_p)\frac{\overline{C_w}\gamma_w}{\bar{C}}. \qquad \text{(P194)}$$

The risk premium response to the external debt deviation ν acts as a quasi-variable calibrated to be $= \gamma_\nu$.

In all AR(1) processes reflecting the effects of the structural shocks, steady state $\overline{u_\beta}$, $\overline{u_{c_J}}$, $\overline{u_{Wt}}$, $\overline{u_{rp,t}}$ and $\overline{u_{\beta^*,t}}$ for $j \subset \{n,w,p\}$ and $j' \subset \{n,w\}$ are considered equal to 1.

Appendix 2. Households' consumption estimation

Once the households are classified into groups, we need to calculate the consumption ratio of these groups. As the nominal consumption c_t^{nom} of the *i* household, the sum of expenditures on goods consumption and services of current and long-term use is employed:

$$c_i^{nom} = \left(c_i^{month} + c_i^{quater}/3\right)/n_i, \quad \text{(P195)}$$

where c_i^{month} denotes the 30-day sum of consumption expenditures; c_i^{quater} is the three-month sum of consumption expenditures; and n_i is the number of members in the *i* household.

Current consumption is defined as the sum of expenditures on short-term-use products and services, averaged for one member of a household. Importantly, there are several approaches to identifying short-term-use products (Jacobs and Wang 2004; Grishchenko and Rossi 2012; Khvostova et al. 2016).

In this paper, consumption is summarised based on such items as foodstuffs, alcoholic beverages, tobacco products, utilities, clothing, public transport, fuel, personal care products, entertainment, education, telecom and healthcare. RLMS-HSE involves questions regarding consumption over the past week (foodstuffs, alcoholic beverages etc.) or month (miscellaneous services, fuel etc.). Assuming that consumption does not change over the month, weekly consumption is adjusted for monthly consumption. Some questions (clothing expenses) refer to quarterly consumption, which is also adjusted for monthly consumption. For some observations, the households' current consumption turns out to exceed their income. That said, the household income was inferred based on answers to the question *f14: '*Could you please tell us your entire family's money income over the past 30 days? Make sure to include all money payments all of your family members have received: wages, pensions, any other payments, including in foreign currency, but please convert those into rubles*.' Part of the reason behind this phenomenon is that households take out loans or that individuals tend to deliberately report lower numbers when it comes to income and higher numbers when it comes to consumption (Lukiyanova, Oshchepkov 2012; Murashov, Ratnikova 2016). For this reason, most of these observations are counted in the sample; observations where the consumption exceeds the income more than twice are excluded.

The consumption of durable goods includes recreational supplies, smartphones, domestic appliances, construction materials, medical and travel services along with other positions detailed further.

Non-durable goods

	Expenditures	RLMS-HSE code	Period
Eating			
1	About how much money did all members of your family spend on eating at home and out of door in the last 30 days?	*e4	Last 30 days
Goods and Services			
2	Services of tailor shops, workshops, and private individuals	*e9*b	Last 30 days
3	For washing materials (e.g., soap, laundry detergent)	*e13.32b	Last 30 days
4	For personal hygiene (e.g., shampoo, toothpaste, toilet paper, sanitary napkins, diapers, etc.).	*e13.33b	Last 30 days
5	For cosmetics and perfume	*e13.34b	Last 30 days
6	Fuel for running vehicles, motors, generators	*e8.1b	Last 30 days
7	Firewood, coal, peat, kerosene	*e8.2b	Last 30 days
8	Bottled gas	*e8.3b	Last 30 days
9	Apartment including rent and utilities	*e11b	Last 30 days
10	Other services	e13.1b e13.21b e13.3*b e13.4b e13.6b e13.9b e13.11b e13.12b e13.13b	Last 30 days
Clothing and shoes			
11	Spending on buying clothing and shoes for adults	*e6.1b	Last 3 months
12	Spending on buying clothing and shoes for children	*e6.2 b	Last 3 months

Source: RLMS-HSE.

Durable goods

	Expenditures	RLMS-HSE code	Period
1	Cultural goods: television, tape recorder, video, musical instruments, computer gadgets, camera etc.	*e7.1.0b	Last 3 months
2	Cell phone	*e7.1.1b	Last 3 months
3	Household items: furniture, rugs, etc.	*e7.2b	Last 3 months
4	Household appliances: refrigerator, washer, vacuum, sewing machine, iron, food processor, etc.	*e7.3b	Last 3 months
5	Building materials, maintenance materials	*e7.7b	Last 3 months
6	Books, textbooks, training aids, office supplies	*e7.9b	Last 3 months
7	Sporting equipment: bicycle, scooter, skates	*e7.10b	Last 3 months
8	For treatment or examination in inpatient hospitals, military hospitals, or clinics, not including medicine	*e13.22b *e13.23b *e13.24b	Last 3 months
9	For sanitaria, vacation homes, children’s camps, tourist travel, etc., excluding transportation	*e13.2b	Last 3 months

Source: RLMS-HSE.

Appendix 3. Detrending

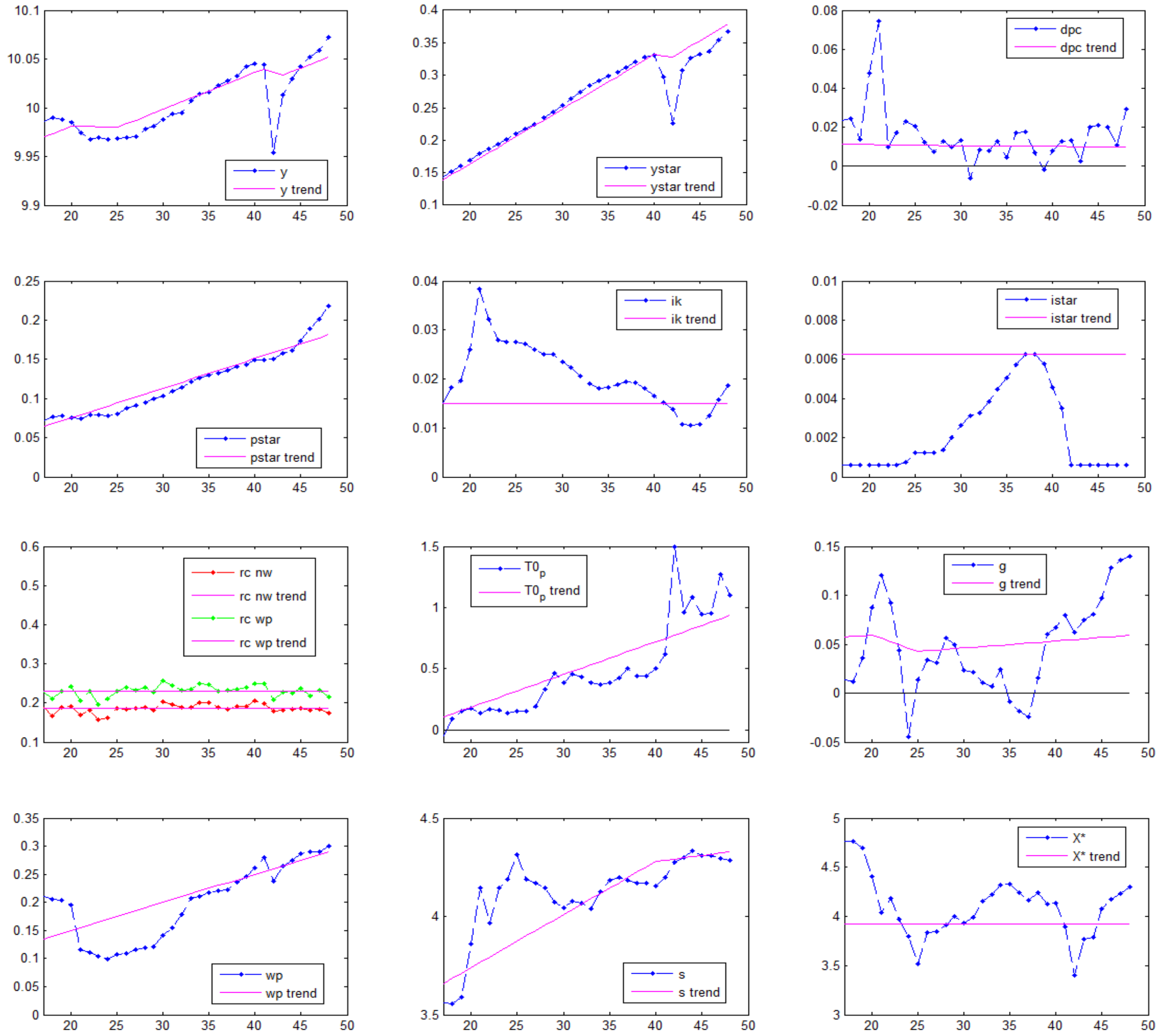

Fig A3.1. Trends in data. Blue lines are data. Purple lines are trends in the data (trend).

Note. По горизонтальной оси: начальная точка:17 = 1кв. 2014; конечная точка 48 = 4кв 2021.
First row: y — [log] RF GDP; ystar - [log] foreign GDP; dpc - CPI inflation.
Second row: pstar - [log] foreign price index; ik — key rate; istar - foreign interest rate.
Third row: rc nw - relative consumption of groups n/w; rc wp - relative consumption of groups w/p; $T0_p$ — [log] government transfers to group p; g - [log] government spending.
Fourth row: wp - [log] real wage; s - [log] nominal dollar exchange rate; X^* - [log] real oil price.

Appendix 4. Bayesian estimation results

	Calibration	Prior			Posterior		Parameter
		Type	Avg.	Std. Dev	Mode	Std. Dev	
γ_n	0.25	–	–	–	–	–	Share of household groups in the population
γ_w	0.39	–	–	–	–	–	
γ_p	0.36	–	–	–	–	–	
β_n	0.995	–	–	–	–	–	Subjective discount factor
β_w	0.97	–	–	–	–	–	
β_p	0.98	–	–	–	–	–	
β^*	0.9975	–	–	–	–	–	
σ_c	0.6	–	–	–	–	–	Parameter reciprocal of the elasticity of intertemporal substitution of consumption
σ_c^*	0.6	–	–	–	–	–	
σ_h	–	gamma	3	0.5	2.0643	0.3636	Parameter reciprocal of the elasticity of intertemporal substitution of holding property
η	–	gamma	1.1	0.2	0.8427	0.1557	Parameter reciprocal of the Frisch elasticity of labor supply
η^*	0.2	–	–	–	–	–	
ξ	–	beta	0.4	0.05	0.4222	0.0490	External consumption habits
ξ^*	–	beta	0.4	0.05	0.3782	0.0473	
ϕ	0.01	–	–	–	–	–	Real estate adjustment costs
α	–	gamma	0.7	0.2	0.6786	0.2008	Elasticity of substitution between tradable and non-tradable goods
ψ_T	0.737	–	–	–	–	–	The share of tradable goods in the consumer basket
δ	1.1	–	–	–	–	–	Elasticity of substitution between domestic and imported tradable goods
δ^*	–	gamma	2	0.75	1.2971	0.2930	
ψ_H	0.719	–	–	–	–	–	The share of domestic tradable goods in the consumer basket

	Calibration	Prior			Posterior		Parameter
		Type	Avg.	Std. Dev	Mode	Std. Dev	
θ_{Wn}	0.6	–	–	–	–	–	
θ_{Ww}	0.6	–	–	–	–	–	Wage rigidity
θ_{Wp}	0.6	–	–	–	–	–	
χ_w	0.5	–	–	–	–	–	Average indexation of wages for the previous CPI inflation
μ	1.5	–	–	–	–	–	Elasticity of substitution of differentiated labor by different groups of households
φ_L	6	–	–	–	–	–	Intragroup elasticity of substitution of differentiated households' labor
θ_H	–	beta	0.65	0.03	0.5909	0.0237	Nominal price rigidity parameter (percentage of firms that cannot optimize the price in the current period)
θ_N	–	beta	0.65	0.03	0.6268	0.0251	
θ_F	–	beta	0.65	0.03	0.5843	0.0426	
θ^*	–	beta	0.75	0.05	0.7739	0.0287	
χ	–	beta	0.5	0.1	0.2261	0.0570	Degree of price indexation of firms for previous CPI inflation
χ^*	0.5	–	–	–	–	–	
φ	20	–	–	–	–	–	Elasticity of substitution between differentiated products of different firms
φ^*	20	–	–	–	–	–	
ω_{oil}	0.0055	–	–	–	–	–	Share of global demand for domestic natural resources
ω	0.0056	–	–	–	–	–	Share of global demand for domestic tradable goods
τ	0.2155	–	–	–	–	–	Labor income tax rate
m	0.6	–	–	–	–	–	The maximum ratio of borrowing to real estate collateral

	Calibration	Prior			Posterior		Parameter
		Type	Avg.	Std. Dev	Mode	Std. Dev	
k_π	–	normal	2	0.2	1.8562	0.1516	Parameter of reaction to the deviation of expected inflation from the target level in the monetary rule
k_π^*	–	normal	1.5	0.2	1.1169	0.1957	
k_y	–	normal	0.05	0.01	0.0509	0.0099	Output gap response parameter in the monetary rule
k_y^*	–	normal	0.2	0.2	0.1987	0.0190	
$\gamma_{Cn/w}$	1.19	–	–	–	–	–	Consumption ratios of household groups
$\gamma_{Cw/p}$	1.23	–	–	–	–	–	
γ_G	0.32	–	–	–	–	–	Share of spending on public spending in GDP
$\gamma_{T_{0p}}$	-0.033	–	–	–	–	–	Share of transfers in GDP
$\gamma_{T_{0nw}}$	+∞	–	–	–	–	–	Ratio of lump-sum taxes between n and w h/h
γ_{b^*}	5.06	–	–	–	–	–	Ratio of external borrowings to exports
ν	–	normal	0.05	0.02	0.0460	0.0155	Parameter of risk premium reaction to deviation of external borrowings from their stationary level
ξ_x	–	normal	0.04	0.02	0.0288	0.0117	Parameter of the reaction of the risk premium to deviation of the real oil price from its stationary level
$\gamma_{oil,p}$	–	beta	0.2	0.05	0.2045	0.0462	Share of excess profits from oil production going to group p
$\gamma_{oil,w}$	–	beta	0.3	0.05	0.2887	0.0497	The share of excess profits from oil production that goes to group w
ρ_i	0.7	–	–	–	–	–	Persistence coefficient of the key rate dynamics
ρ_{i^*}	0.6	–	–	–	–	–	
ρ_A	–	beta	0.5	0.1	0.7153	0.0737	Autoregression coefficient of total factor productivity
ρ_{A^*}	0.5	–	–	–	–	–	
ρ_{h_s}	0.6	–	–	–	–	–	Real estate supply autoregression coefficient

	Calibration	Prior Type	Prior Avg.	Prior Std. Dev	Posterior Mode	Posterior Std. Dev	Parameter
ρ_{x^*}	0.8	–	–	–	–	–	Autoregression coefficient of the world oil price
ρ_G	–	beta	0.7	0.1	0.7700	0.0748	Government spending autoregression coefficient
ρ_{T_p}	–	beta	0.5	0.1	0.1893	0.0544	Autoregression coefficient of transfers
ρ_β	–	beta	0.5	0.1	0.3885	0.1013	Autoregression coefficient of intertemporal preference shocks
ρ_{β^*}	0.5	–	–	–	–	–	
ρ_{h_d}	0.6	–	–	–	–	–	Autoregression coefficient of real estate demand shocks
ρ_w	–	beta	0.5	0.1	0.4453	0.1105	Autoregression coefficient of wage shocks
ρ_{rp}	–	beta	0.5	0.1	0.5181	0.0844	Autoregression coefficient of external risk premium shocks
ρ_c	0.75	–	–	–	–	–	Autoregression coefficient of consumption shocks
σ_{ε_i}	–	uniform			0.0022	0.0004	Standard deviation of key rate shocks
$\sigma_{\varepsilon_{i^*}}$	–	uniform			0.0028	0.0005	Standard deviation of foreign rate shocks
σ_{ε_A}	–	uniform			0.0319	0.0053	Standard deviation of total factor productivity shocks
$\sigma_{\varepsilon_{A^*}}$	–	uniform			0.0509	0.0188	
$\sigma_{\varepsilon_{x^*}}$	–	uniform			0.1750	0.0226	Standard deviation of real oil price shocks
σ_{ε_G}	–	uniform			0.0287	0.0037	Standard deviation of public expenditure shocks
$\sigma_{\varepsilon_{T_p}}$	–	uniform			0.2479	0.0365	Standard deviation of transfer shocks
$\sigma_{\varepsilon_{Tu_p}}$	–	uniform			0.5514	0.0686	Standard deviation of latent transfer shocks
$\sigma_{\varepsilon_\beta}$	–	uniform			0.0390	0.0074	Standard deviation of intertemporal preference shocks
$\sigma_{\varepsilon_{\beta^*}}$	–	uniform			0.0240	0.0036	

	Calibration	Prior			Posterior		Parameter
		Type	Avg.	Std. Dev	Mode	Std. Dev	
σ_{ε_w}	–	uniform			0.0365	0.0056	Standard deviation of wage shocks
$\sigma_{\varepsilon_{rp}}$	–	uniform			0.0246	0.0055	Standard deviation of risk premium shocks
$\sigma_{\varepsilon_{c_{nwp}}}$	–	gamma	0.02	0.01	0.0121	0.0021	Standard deviation of consumption shocks of household groups

Source: author's calculations.

Appendix 5. Decomposition of endogenous variables to shocks

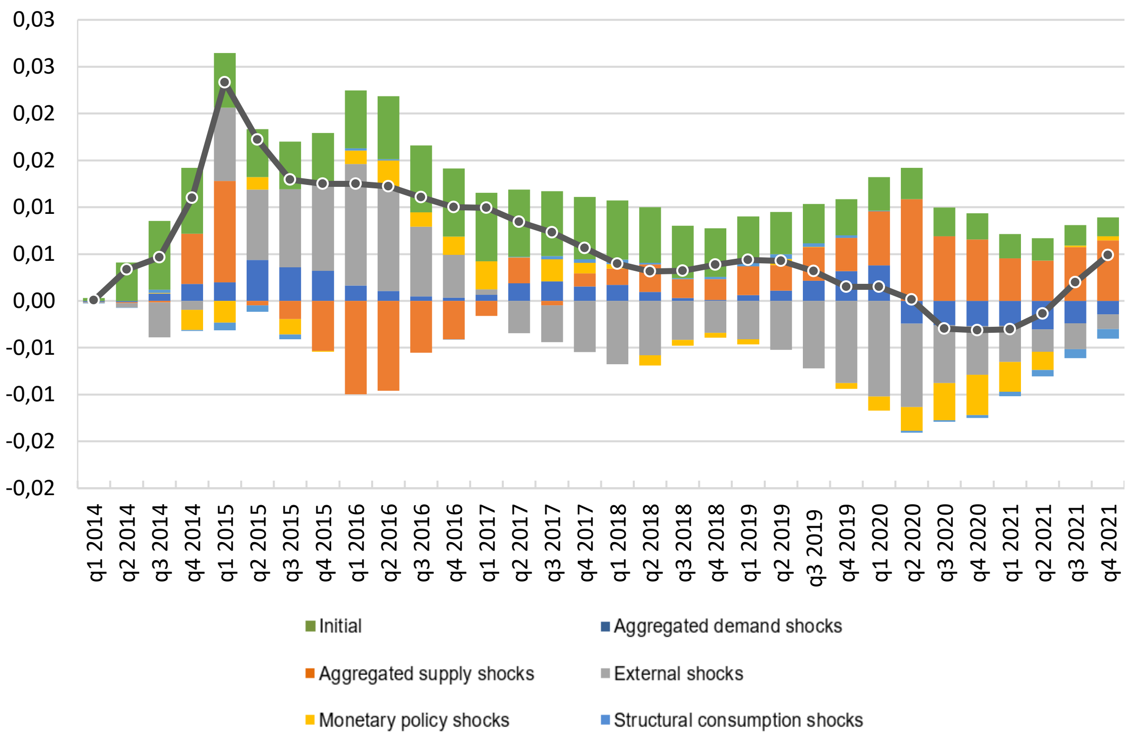

Fig. A5.1. Shock decomposition of key rate.

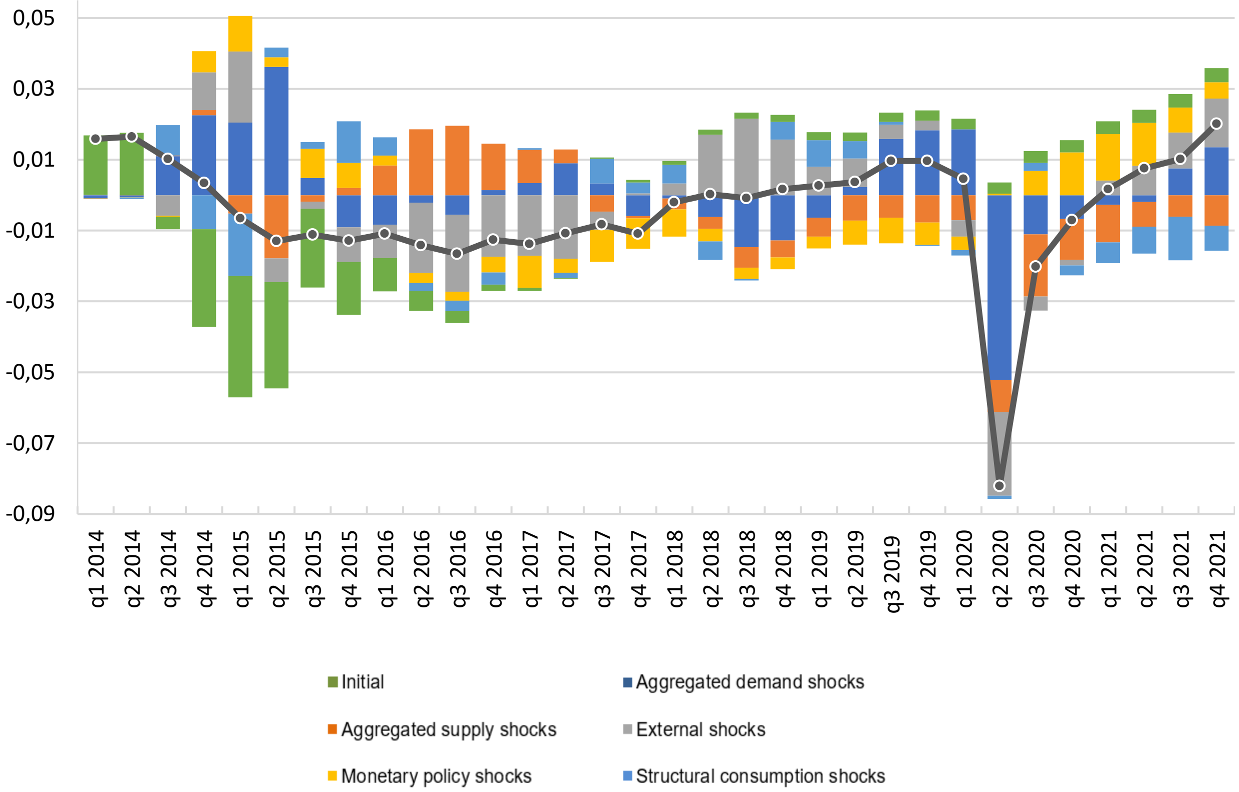

Fig. A5.2. Shock decomposition of GDP.

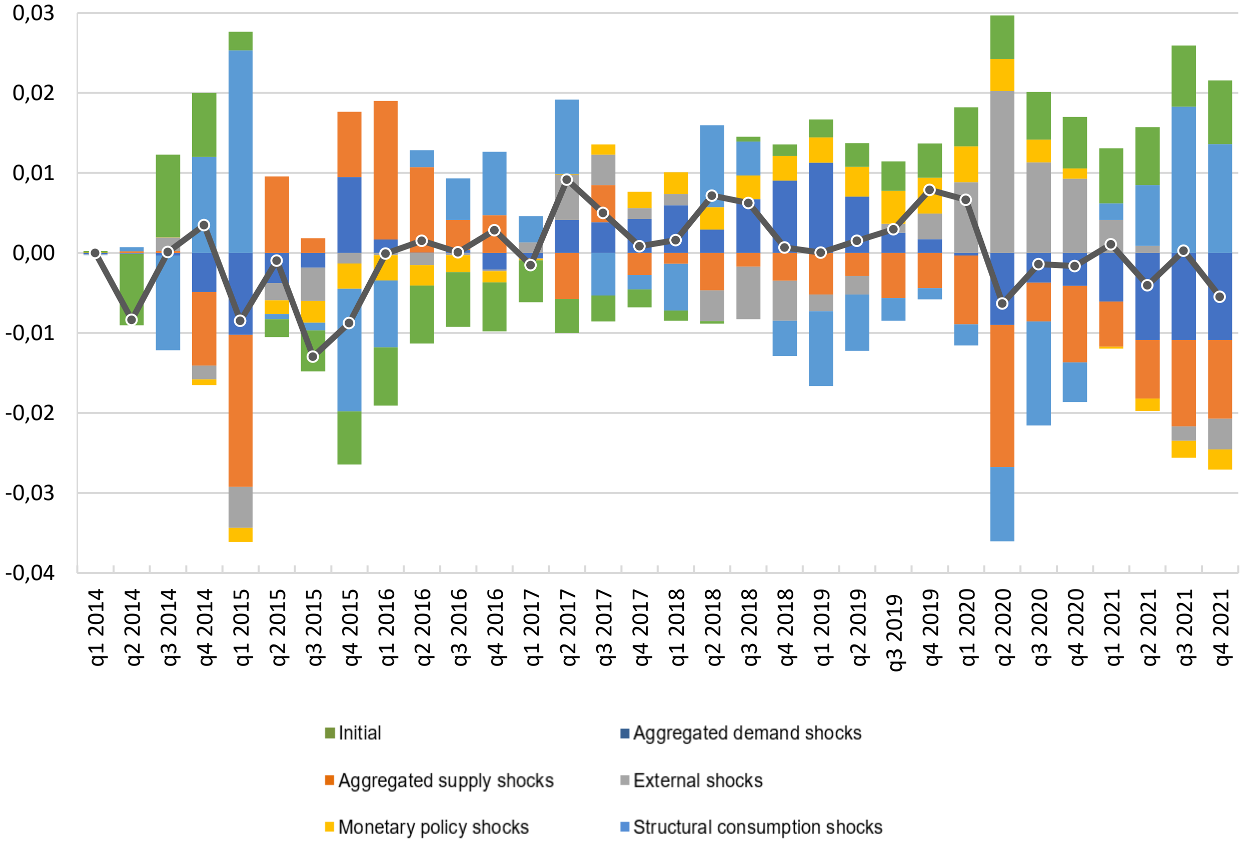

Fig. A5.3. Shock decomposition of Gini consumption index without intra-group differentiation.

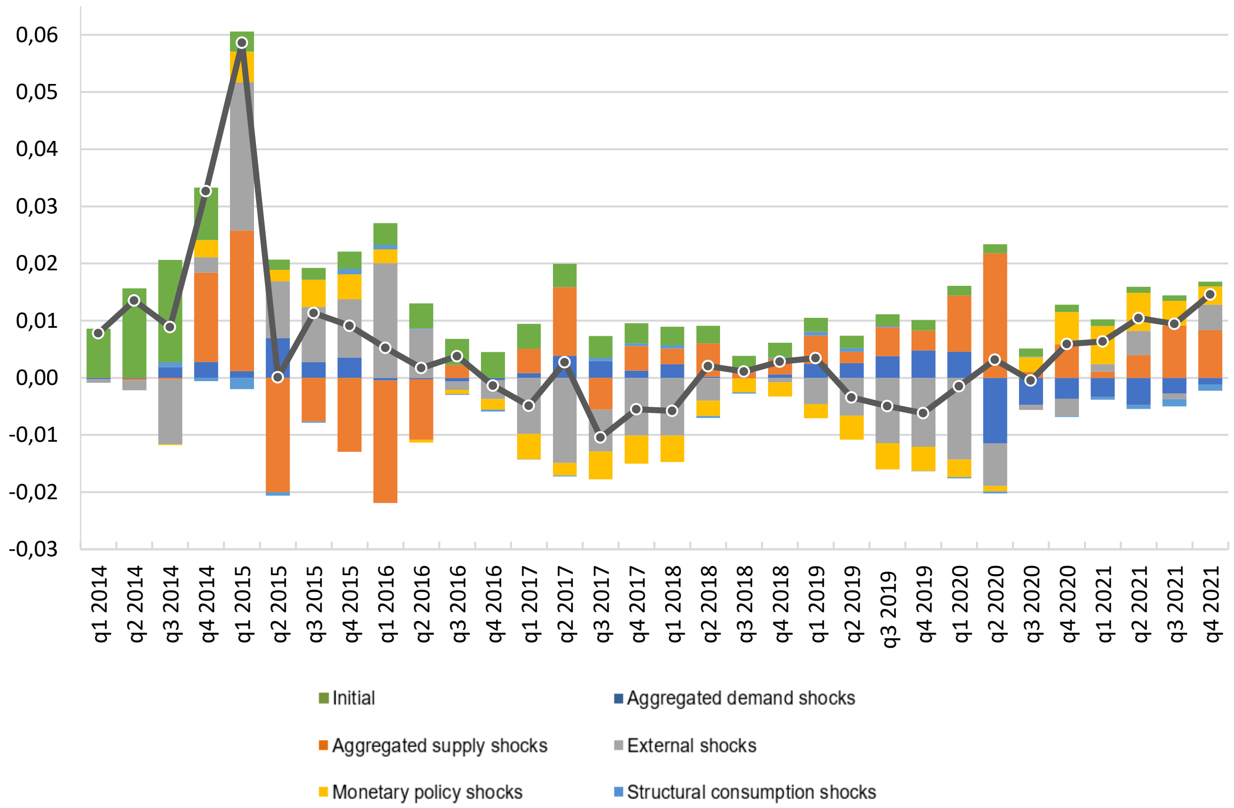

Fig. A5.4. Shock decomposition of inflation.

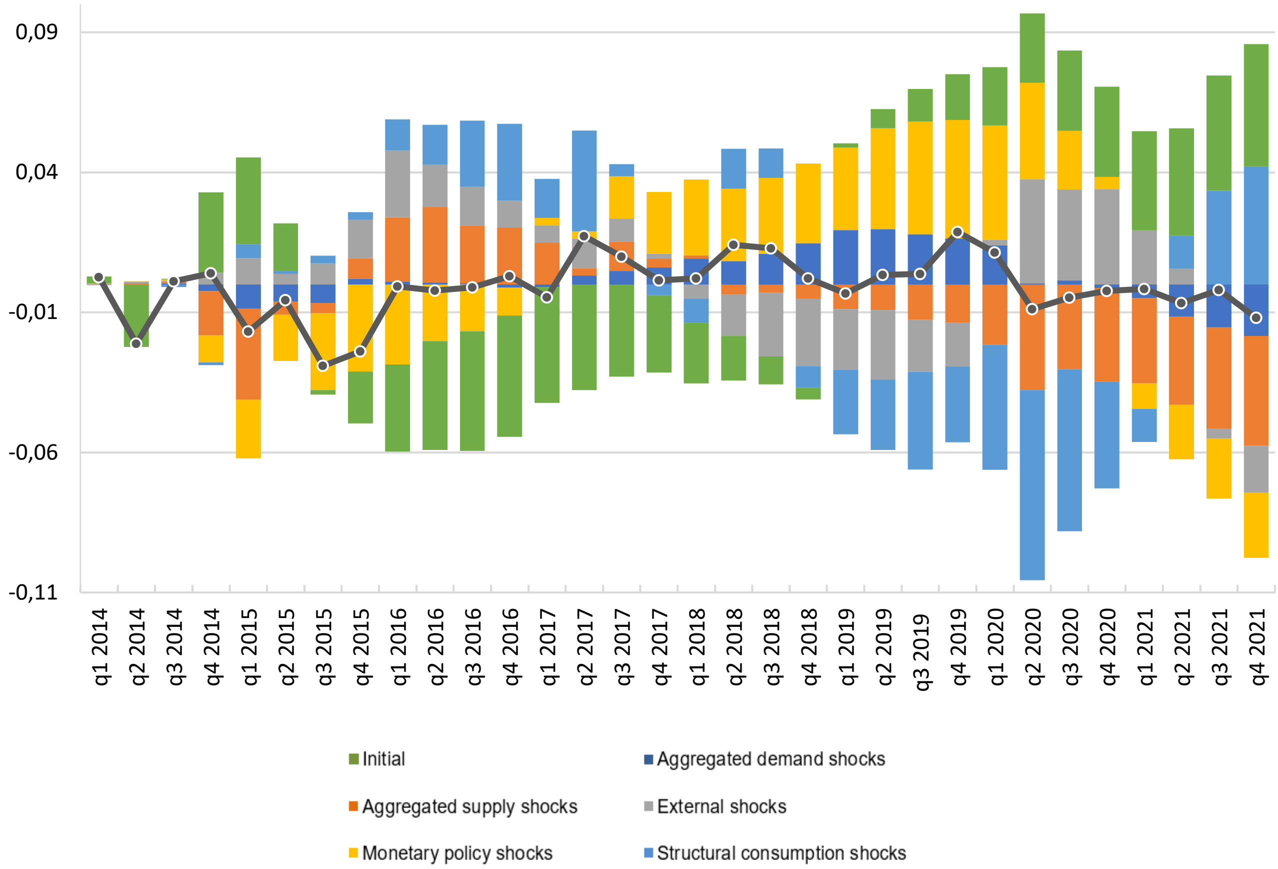

Fig. A5.5. Shock decomposition of relative *n/w* consumption.

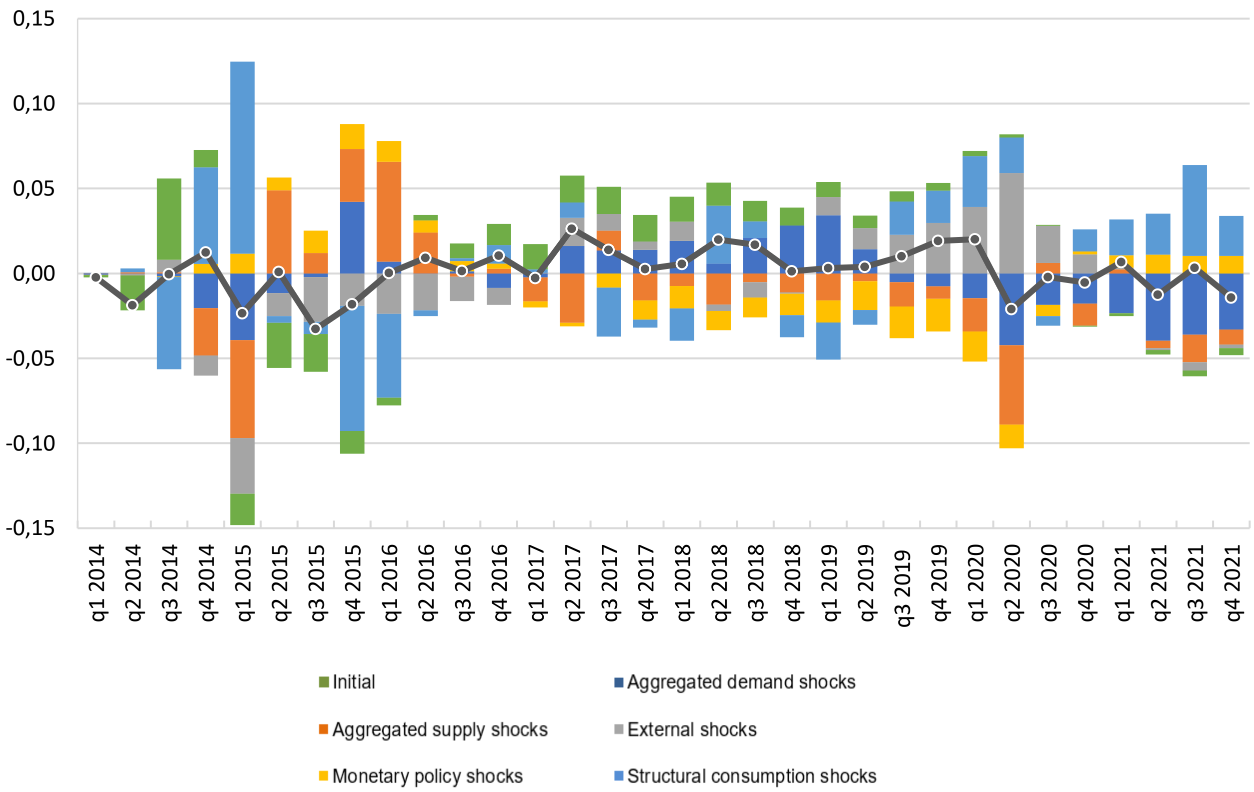

Fig. A 5.6. Shock decomposition of relative *w/p* consumption.

Appendix 6. Impulse response functions

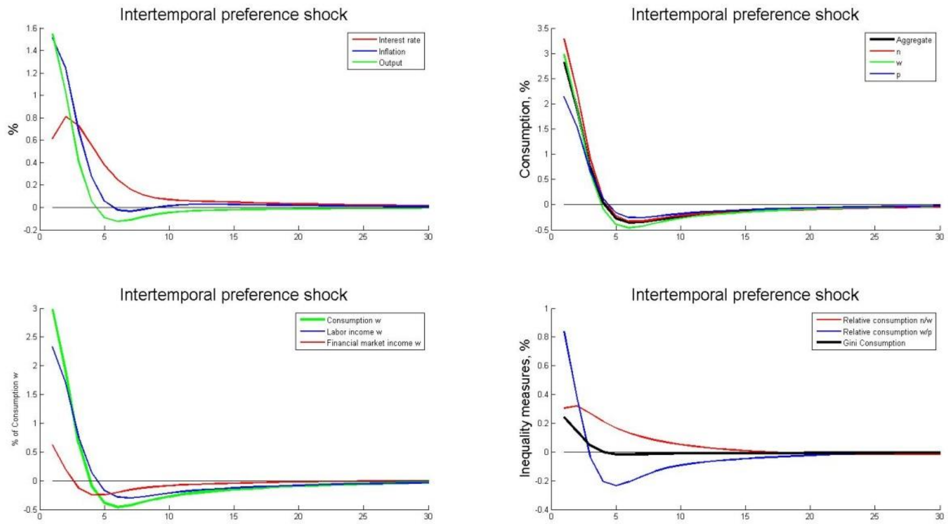

Figure A6.1. IRF to an intertemporal preference shock of one standard deviation.
Note:
Top row. Left: key rate (Interest rate), CPI inflation, Output; right: aggregated consumption (Aggregate), household groups n, w and p;
Bottom row. Left: household consumption group w (Consumption w), labor income (Labor income w) and income from the financial market (Financial market income w) as a percentage of the stationary level of group w household consumption; right: relative consumption of groups n/w, relative consumption of groups w/p, Gini consumption index without intra-group differentiation.

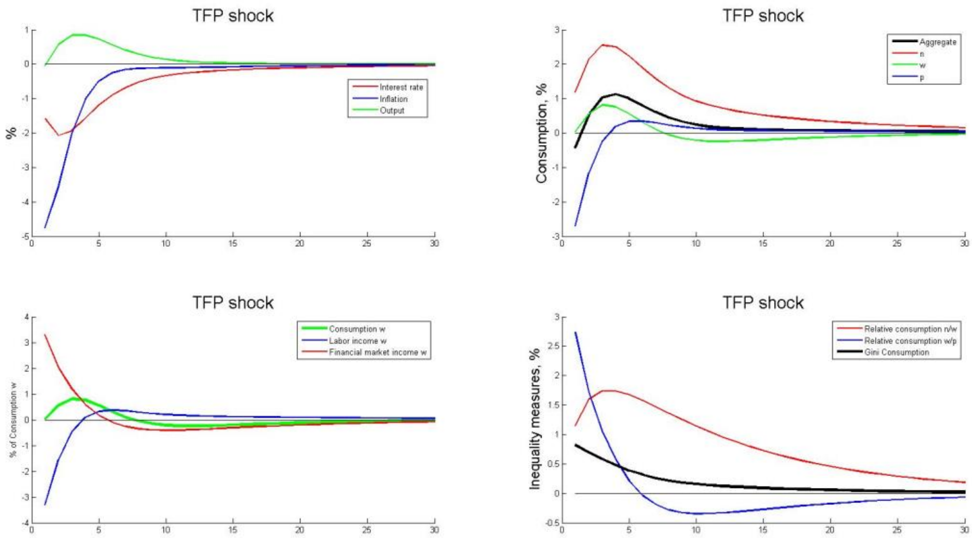

Figure A6.2. IRF to a total factor productivity shock of one standard deviation.
Note:
Top row. Left: key rate (Interest rate), CPI inflation, Output; right: aggregated consumption (Aggregate), household groups n, w and p;
Bottom row. Left: household consumption group w (Consumption w), labor income (Labor income w) and income from the financial market (Financial market income w) as a percentage of the stationary level of group w household consumption; Right: relative consumption of groups n/w, relative consumption of groups w/p, Gini consumption index without intra-group differentiation.

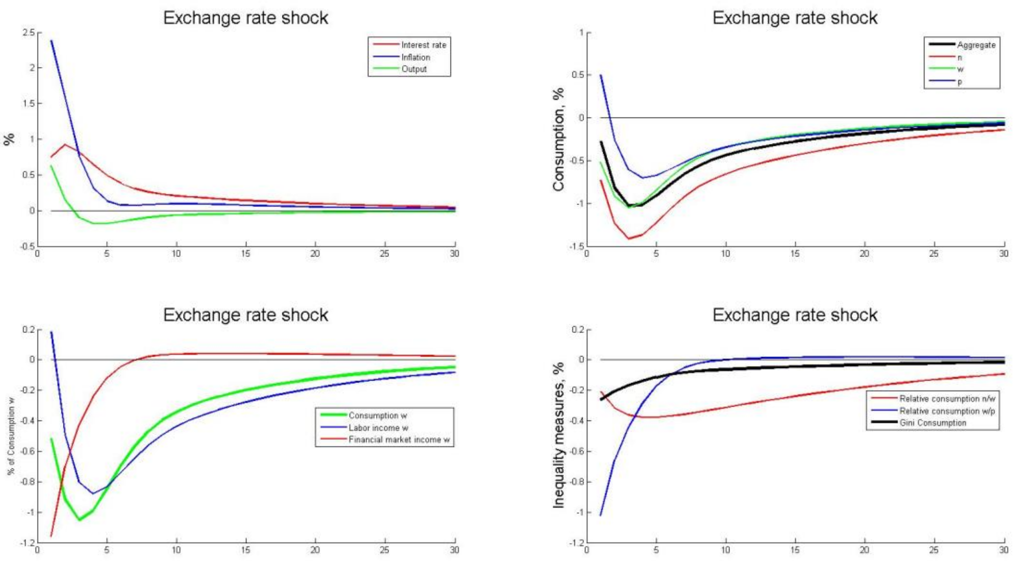

Figure A6.3. IRF to an external premium (exchange rate) shock of one standard deviation.

Note:
Top row. Left: key rate (Interest rate), CPI inflation, Output; right: aggregated consumption (Aggregate), household groups n, w and p;
Bottom row. Left: household consumption group w (Consumption w), labor income (Labor income w) and income from the financial market (Financial market income w) as a percentage of the stationary level of group w household consumption; Right: relative consumption of groups n/w, relative consumption of groups w/p, Gini consumption index without intra-group differentiation.

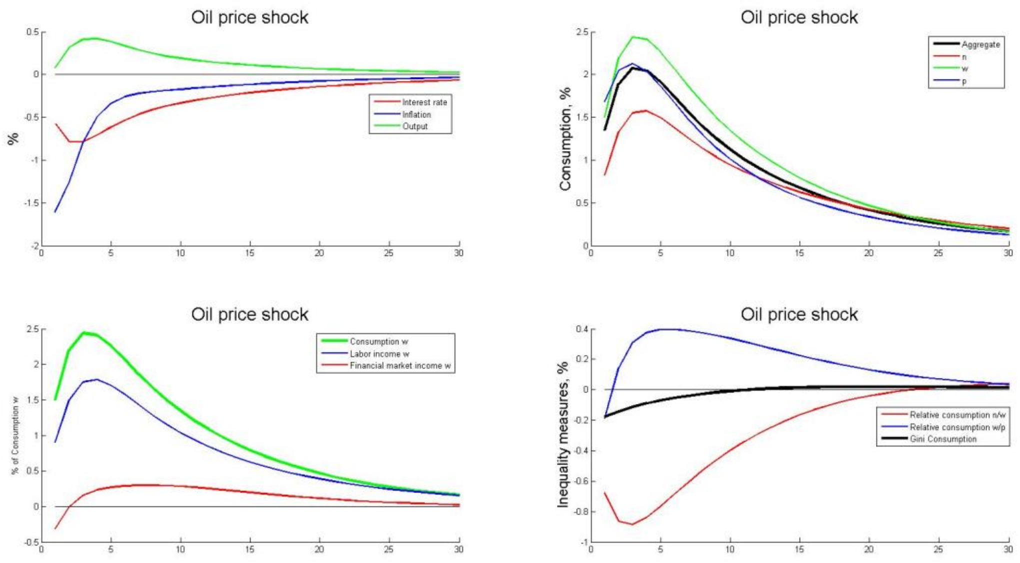

Figure A6.4. IRF to an oil price shock of one standard deviation.

Note:
Top row. Left: key rate (Interest rate), CPI inflation, Output; right: aggregated consumption (Aggregate), household groups n, w and p;
Bottom row. Left: household consumption group w (Consumption w), labor income (Labor income w) and income from the financial market (Financial market income w) as a percentage of the stationary level of group w household consumption; Right: relative consumption of groups n/w, relative consumption of groups w/p, Gini consumption index without intra-group differentiation.

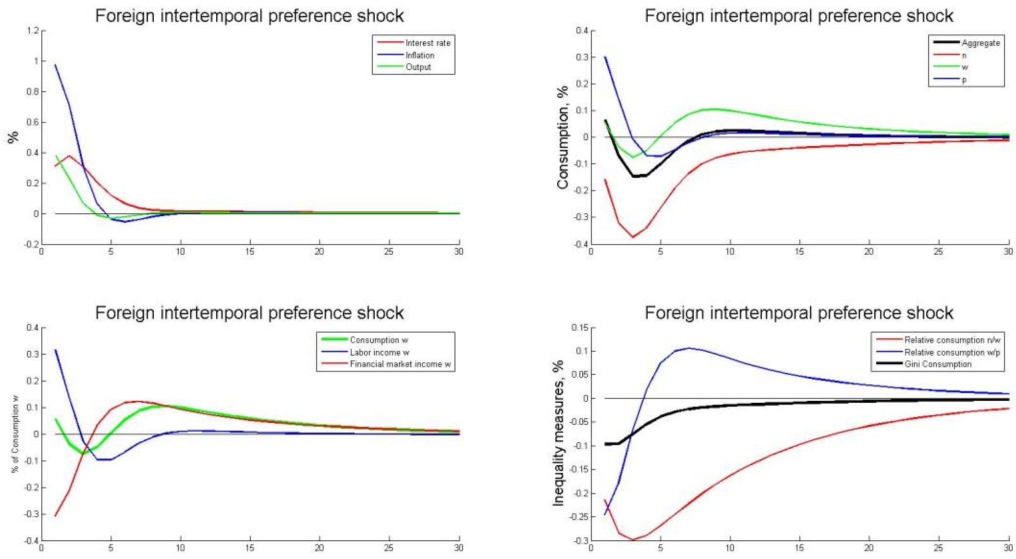

Figure A6.5. IRF to a foreign intertemporal preferences shock of one standard deviation.

Note:

Top row. Left: key rate (Interest rate), CPI inflation, Output; right: aggregated consumption (Aggregate), household groups n, w and p;

Bottom row. Left: household consumption group w (Consumption w), labor income (Labor income w) and income from the financial market (Financial market income w) as a percentage of the stationary level of group w household consumption; Right: relative consumption of groups n/w, relative consumption of groups w/p, Gini consumption index without intra-group differentiation.

Appendix 7. Experiments with the share of group w

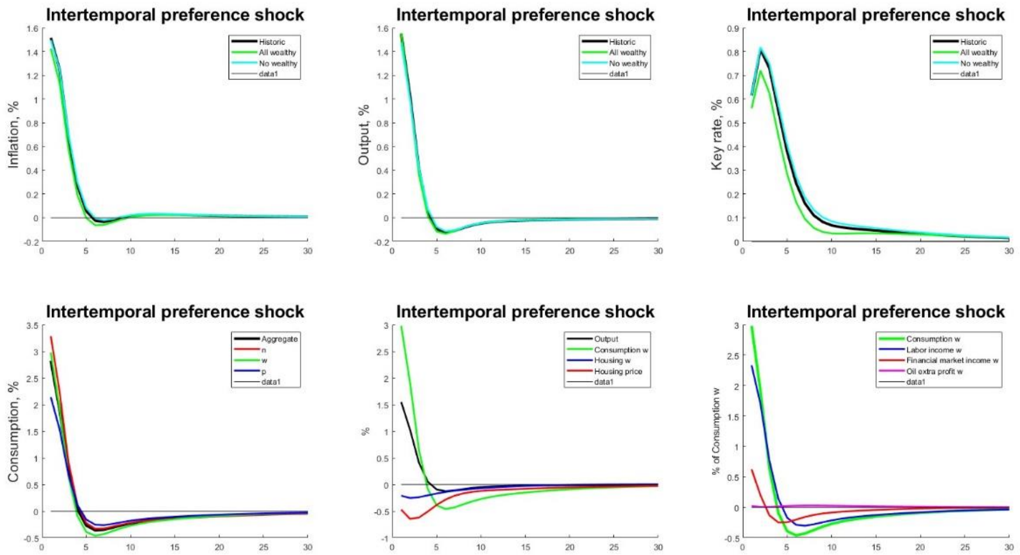

Figure A7.1. Experiments with the share of group w. An intertemporal preferences shock of one standard deviation.

Note: Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All wealthy, No wealthy.

Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

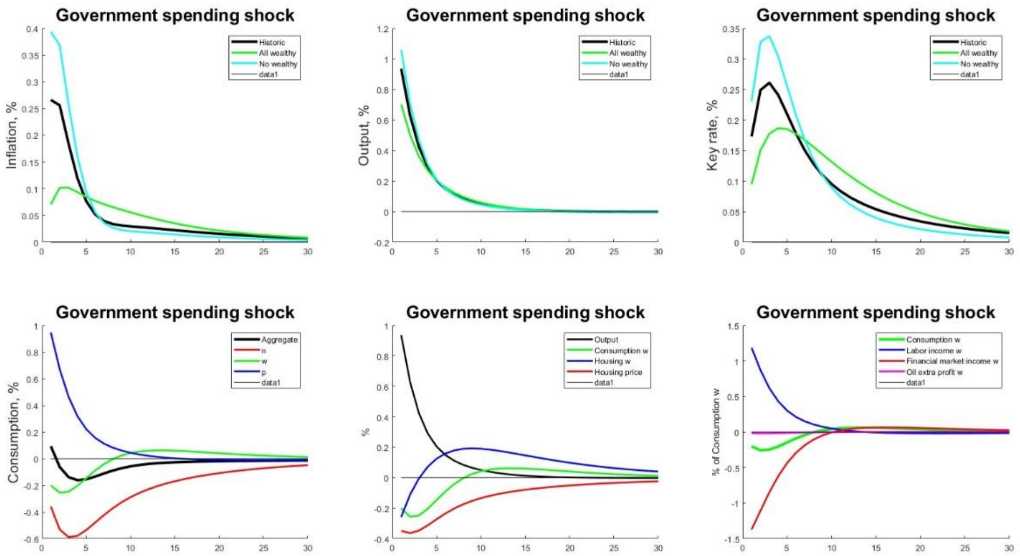

Figure A7.2. Experiments with the share of group w. A government spending shock of one standard deviation.

Note: Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All wealthy, No wealthy.

Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

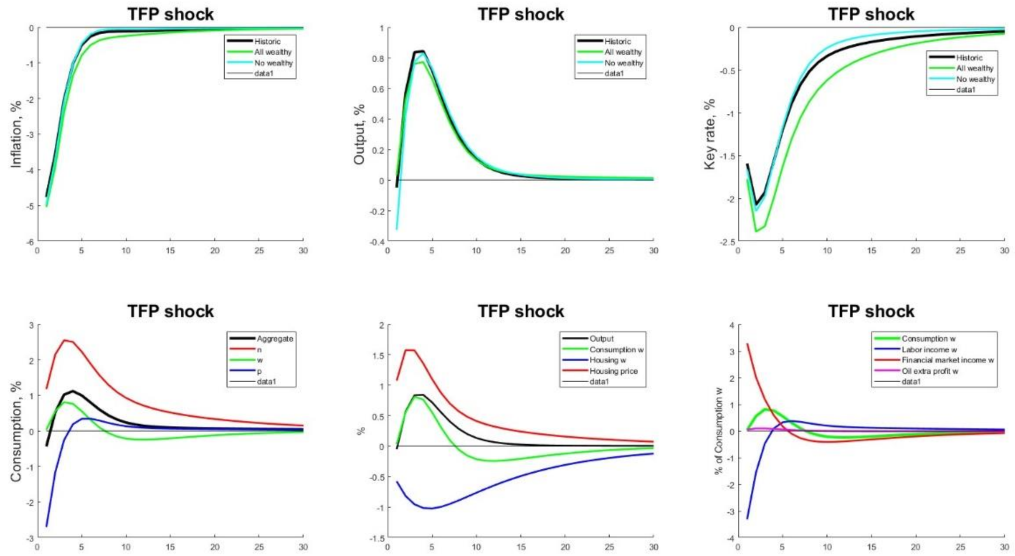

Figure A7.3. Experiments with the share of group w. A technological shock of one standard deviation.

Note:

Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All wealthy, No wealthy.

Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

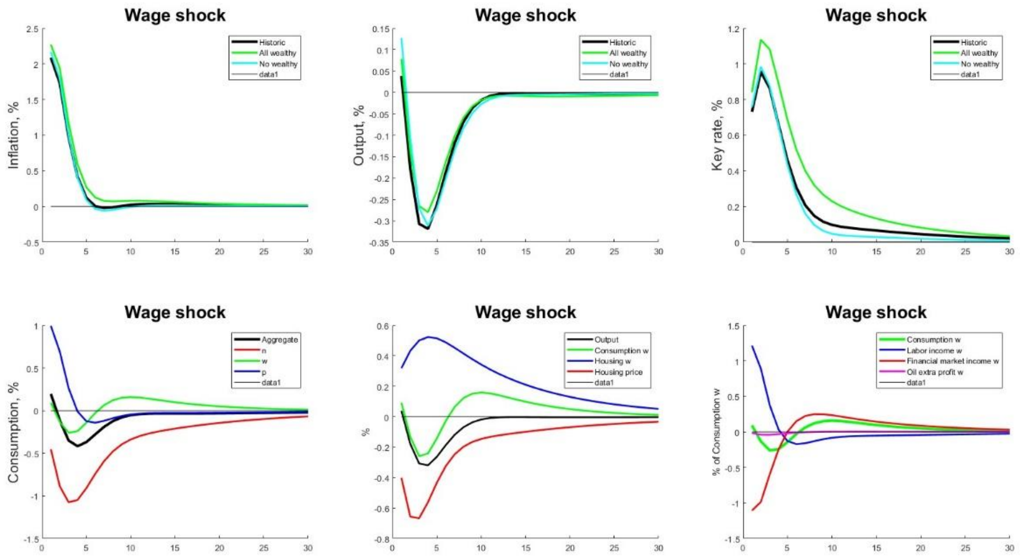

Figure 7.4. Experiments with the share of group w. A salary shock of one standard deviation.

Note:

Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All wealthy, No wealthy.

Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

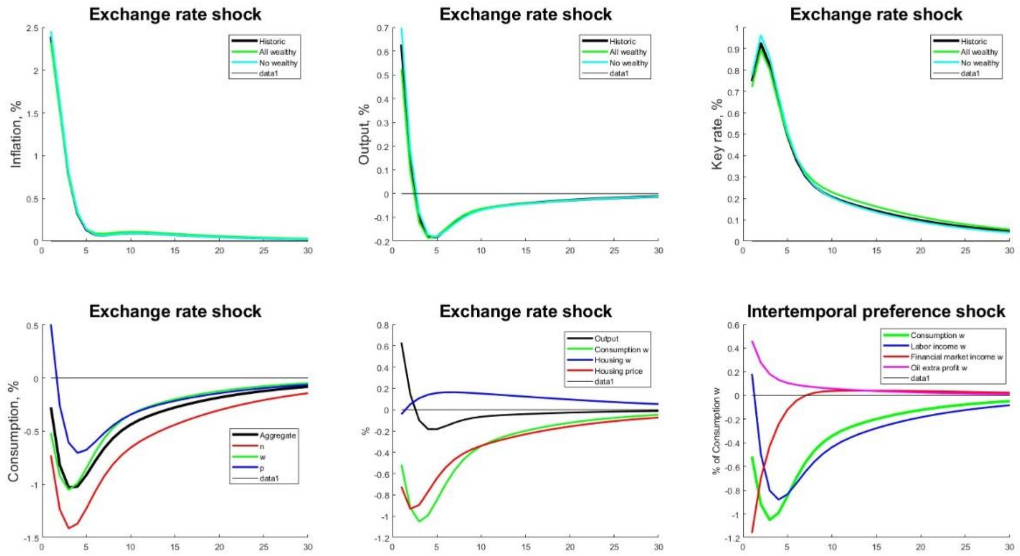

Figure A7.5. Experiments with the share of group w. An exchange rate shock of one standard deviation.
Note:
Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All wealthy, No wealthy.
Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

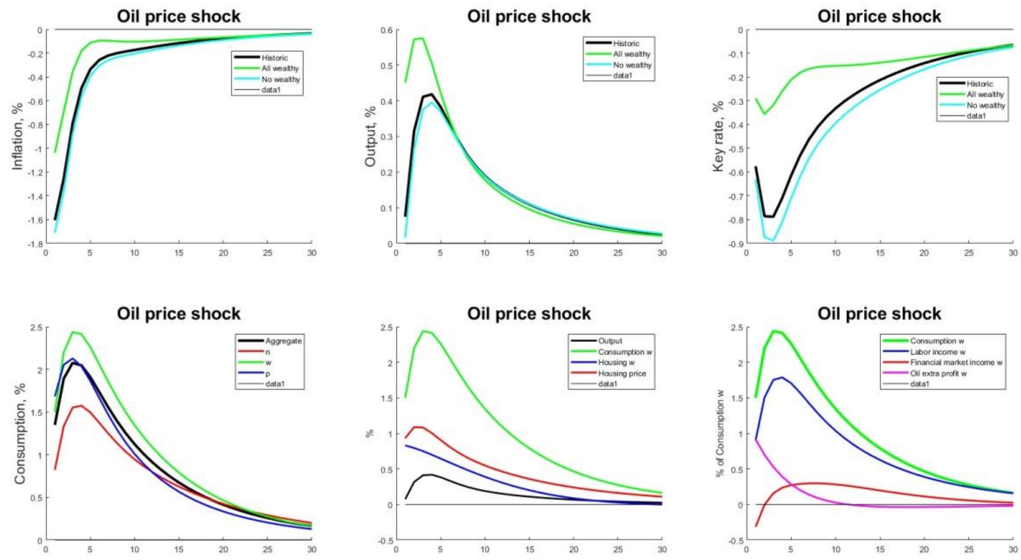

Figure A7.6. Experiments with the share of group w. An oil price shock of one standard deviation.

Note:
Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All wealthy, No wealthy.
Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

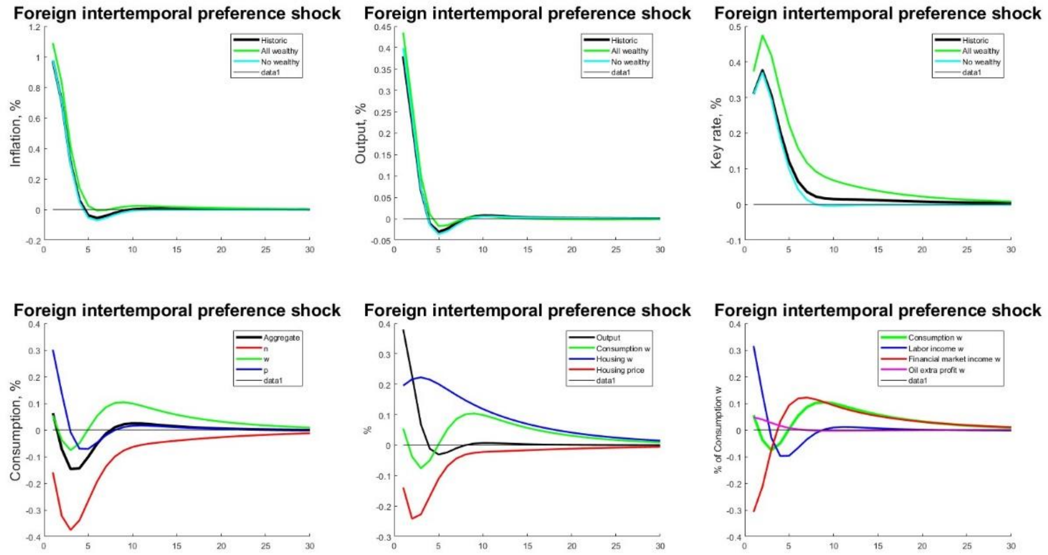

Figure A7.7. Experiments with the share of group w. A foreign intertemporal preferences shock of one standard deviation.
Note:
Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All wealthy, No wealthy.
Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

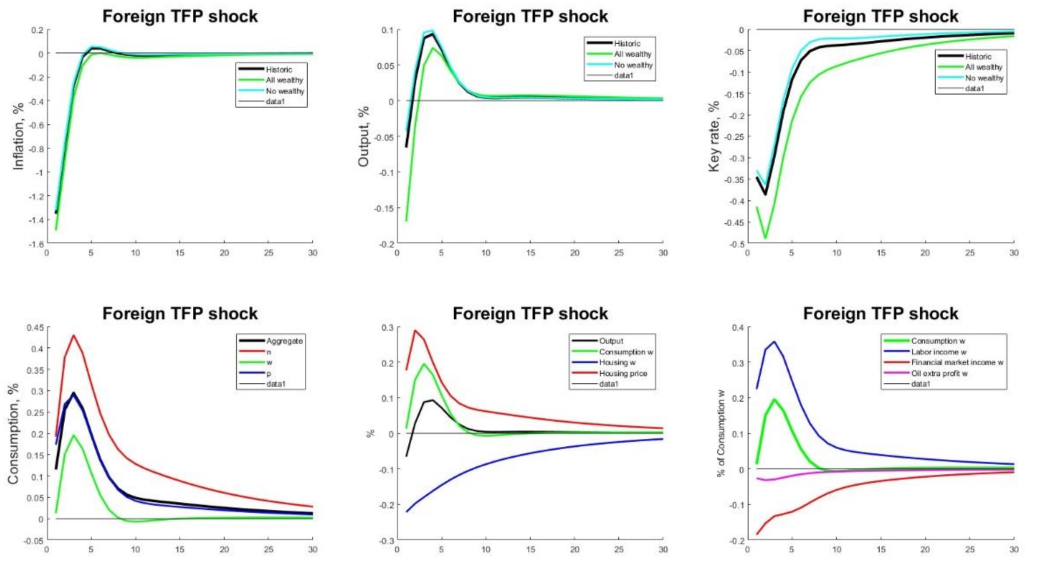

Figure A7.8. Experiments with the share of group w. A foreign productivity shock of one standard deviation.
Note:
Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All wealthy, No wealthy.
Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

Appendix 8. Experiments with the share of group p

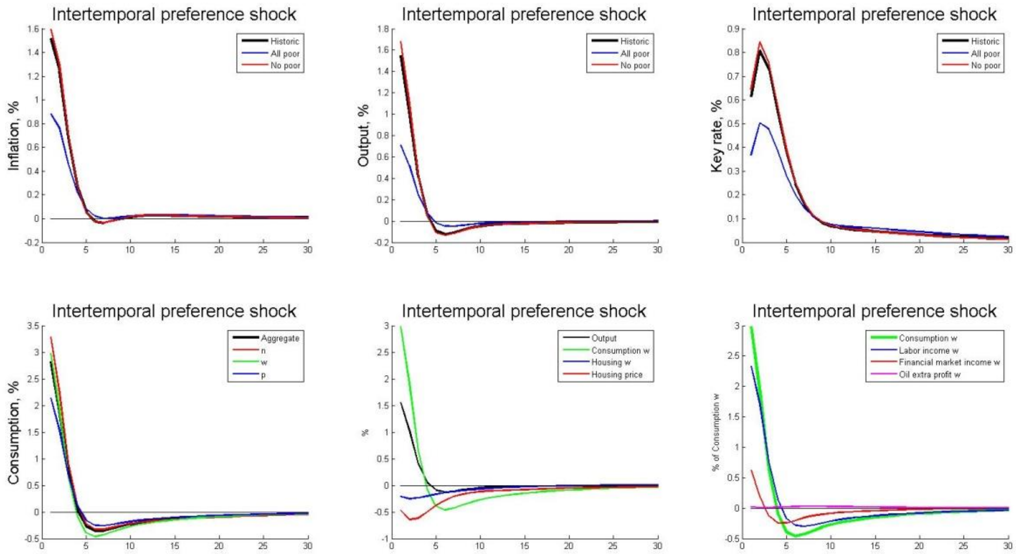

Figure A8.1. Experiments with the share of group p. An intertemporal preferences shock of one standard deviation.

Note:
Top row: the reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All poor, No poor.
Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

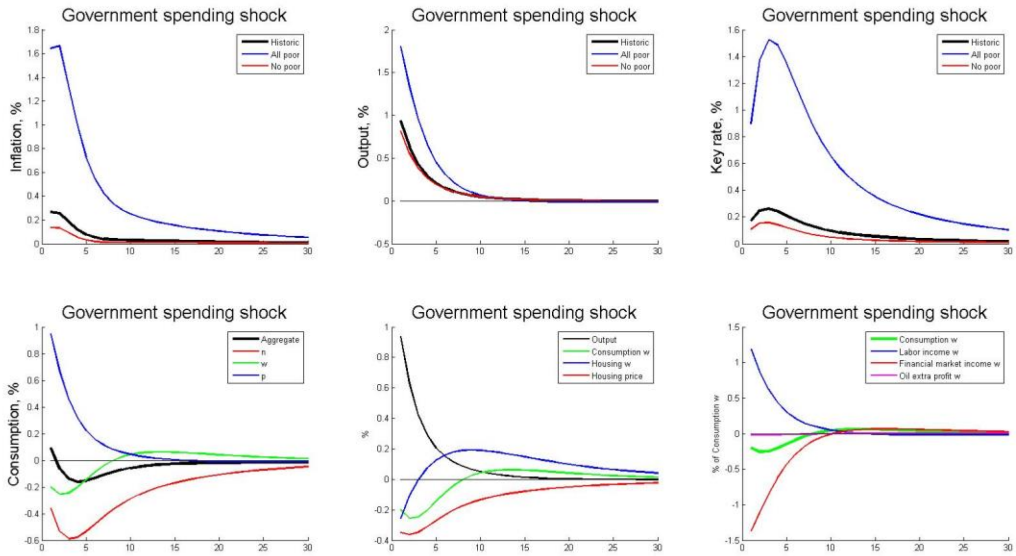

Figure A8.2. Experiments with the share of group p. A government spending shock of one standard deviation.

Note:
Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All poor, No poor.
Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

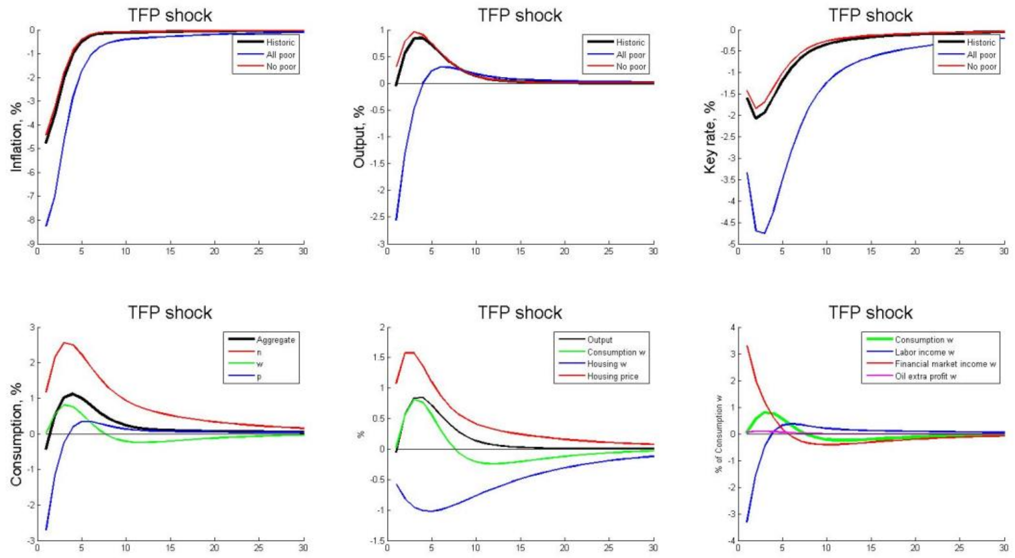

Figure A8.6. Experiments with the share of group p. A technological shock of one standard deviation.

Note:

Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All poor, No poor.

Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

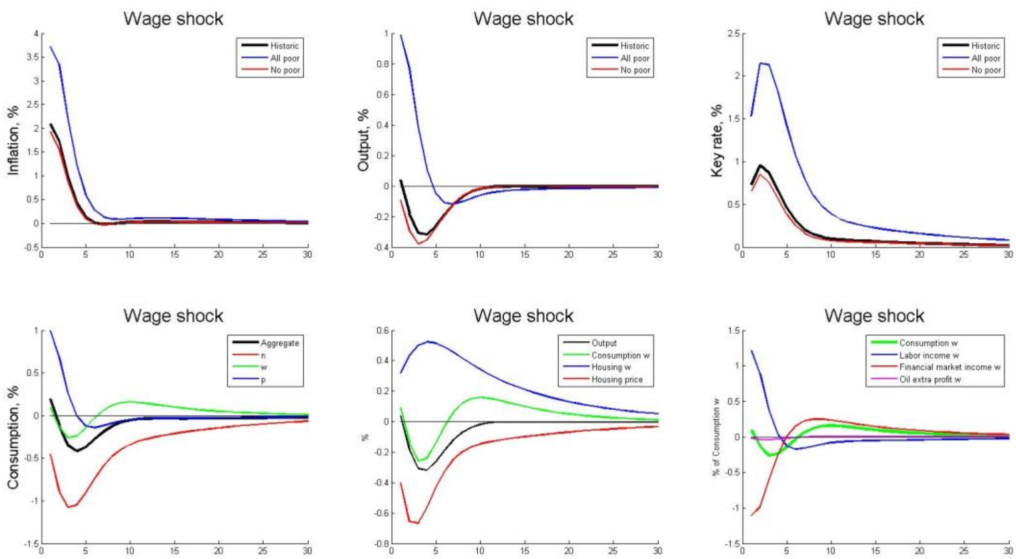

Figure A7.4. Experiments with the share of group p. A salary shock of one standard deviation.

Note:

Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All wealthy, No wealthy.

Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

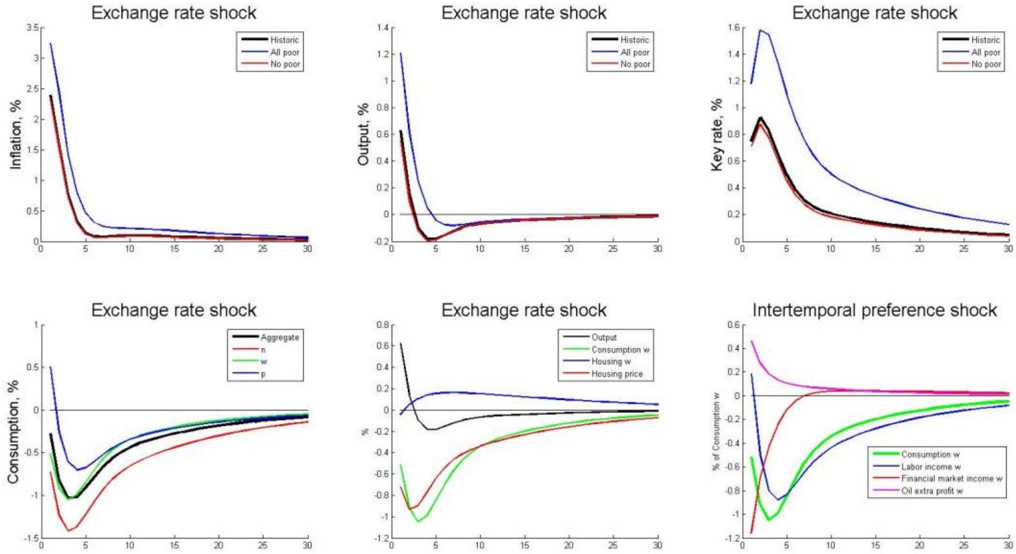

Figure A8.8. Experiments with the share of group p. An exchange rate shock of one standard deviation.

Note:
Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All poor, No poor.
Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

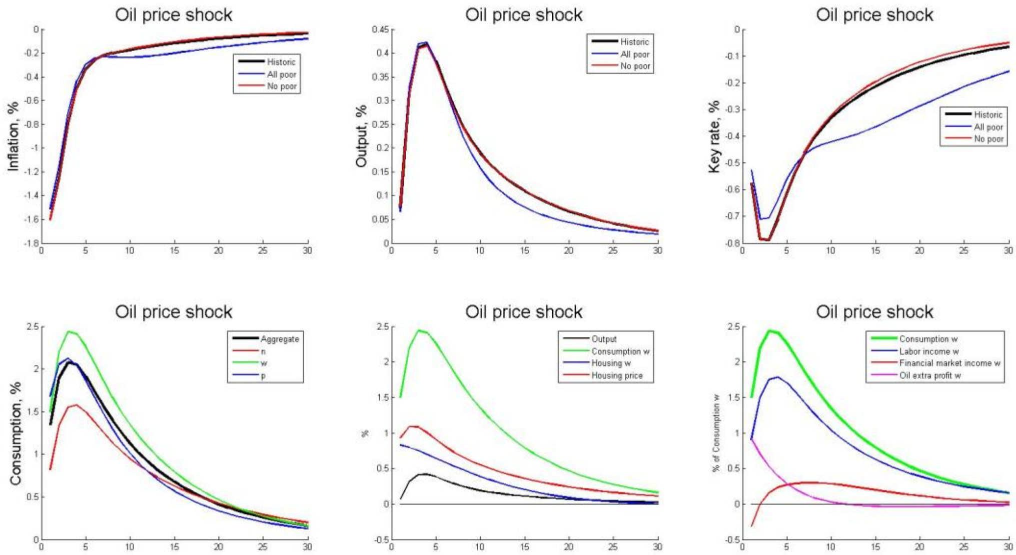

Figure A8.9. Experiments with the share of group p. An oil price shock of one standard deviation.

Note:
Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All poor, No poor.
Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

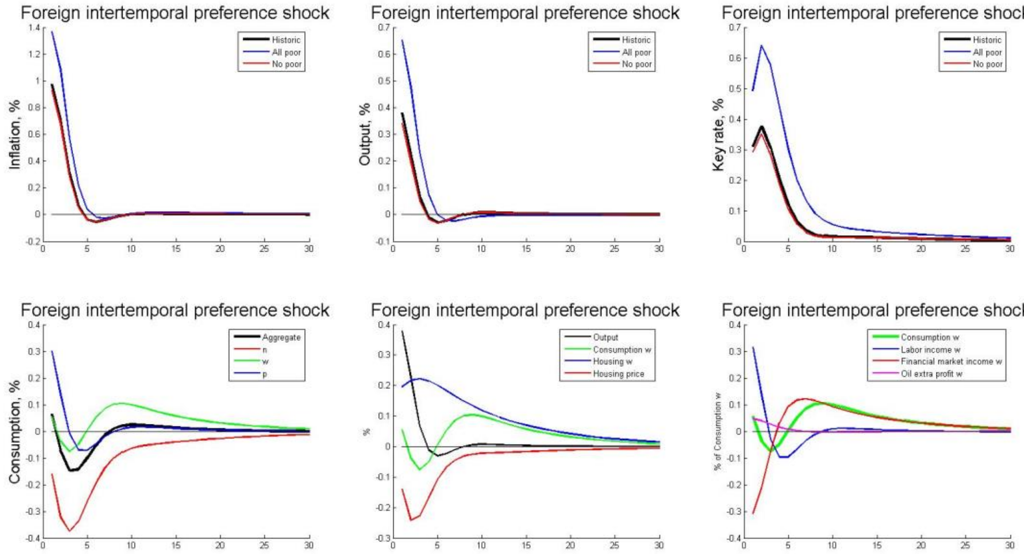

Figure A8.10. Experiments with the share of group p. A foreign intertemporal preferences shock of one standard deviation.

Note:

Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All poor, No poor.

Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

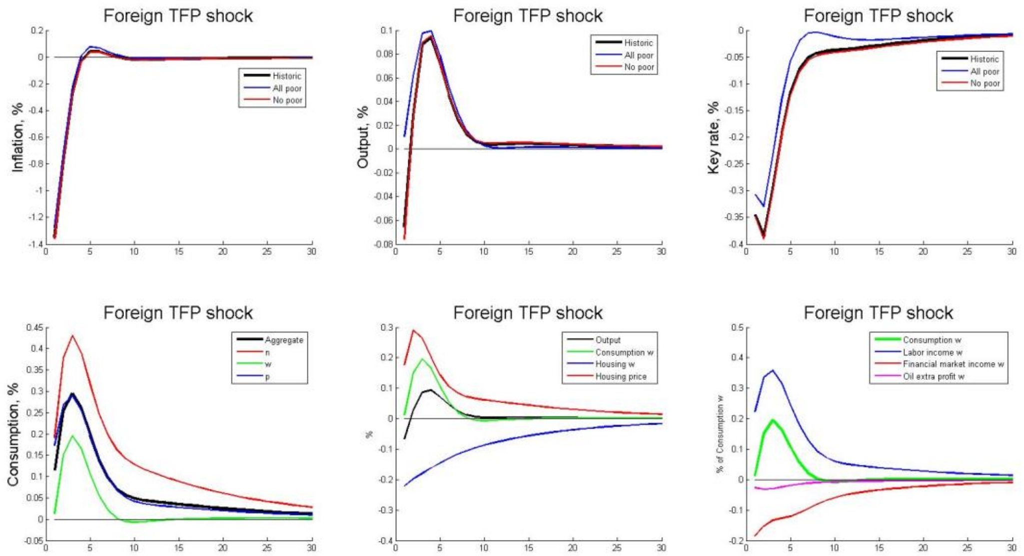

Figure A8.11. Experiments with the share of group p. A foreign productivity shock of one standard deviation.
Note:

Top row: reaction of inflation, output, key rate for cases of historical parameterization (Historical), as well as two experiments: All wealthy, No wealthy.

Bottom row (for historical parameters): reaction of aggregated consumption (Aggregate) and household groups n, w and p; reaction of output (Output), consumption of real estate services (Housing) of group w, real estate prices (Housing price); contribution of labor (Labor income) and financial (Financial market income) income, share of excess profit from oil exports (Oil extra profit) as a percentage of group w household consumption.

Appendix 9. Experiment with the parameter *m*

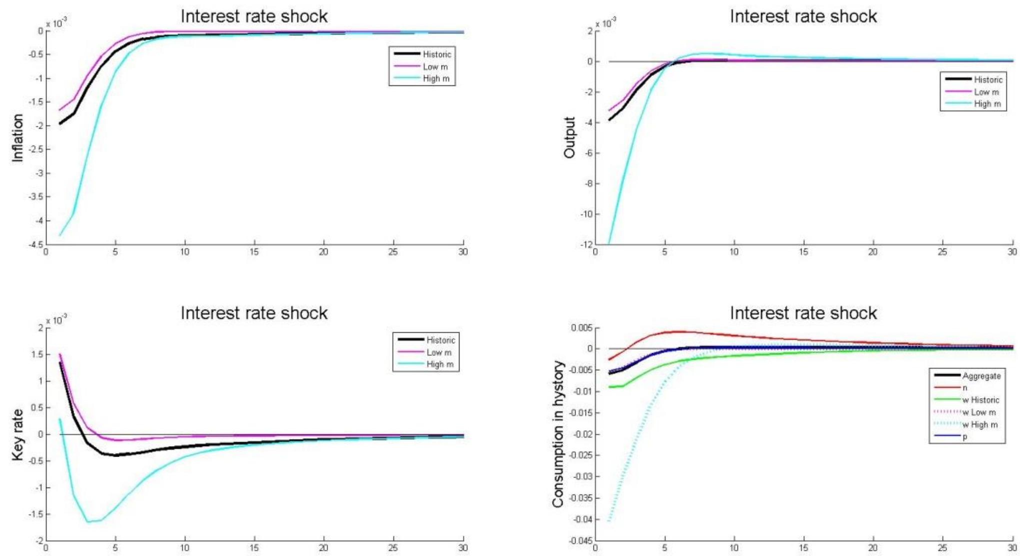

Figure A9.1. Experiments with the parameter m, which sets the limits of lending to the household group w. Interest rate shock (monetary policy) of one standard deviation.

Note:

Top row: reaction of Inflation and output.

Bottom row. Left: reaction of the key rate for cases of historical parameterization (Historical), as well as two experiments: Low m (m=0.1), High m (m=0.9); right: the reaction of aggregated consumption (Aggregate) and three groups (n, p, w historic) for historical parameterization, as well as group w for three cases (Historic, Low m, High m.).

Appendix 10. An alternative version of the Bayesian model estimation

Table A10. Analysis of robustness of Bayesian estimation

	Basic					Alternative				
	Prior			Posterior		Prior			Posterior	
	Type	Avg.	Std. Dev	Mode	Std. Dev	Type	Avg.	Std. Dev	Mode	Std. Dev
σ_h	G*	3	0.5	2.0643	0.3636	G	3	0.5	2.0634	0.3589
η	G	1.1	0.2	0.8427	0.1557	G	1.1	0.2	0.8414	0.1556
η^*	G	0.5	0.25	0.2465	0.1438	G	0.5	0.25	0.2458	0.1430
ξ	B	0.4	0.05	0.4222	0.0490	B	0.4	0.05	0.4165	0.0485
ξ^*	B	0.4	0.05	0.3782	0.0473	B	0.4	0.05	0.3790	0.0474
α	G	0.7	0.2	0.6786	0.2008	G	0.7	0.2	0.6777	0.2010
δ^*	G	2	0.75	1.2971	0.2930	G	2	0.75	1.2605	0.2901
θ_H	B	0.65	0.03	0.5909	0.0237	B	0.65	0.03	0.5902	0.0238
θ_N	B	0.65	0.03	0.6268	0.0251	B	0.65	0.03	0.6268	0.0251
θ_F	B	0.65	0.03	0.5843	0.0426	B	0.65	0.03	0.5831	0.0428
θ^*	B	0.75	0.05	0.7739	0.0287	B	0.75	0.05	0.7734	0.0288
χ	B	0.5	0.1	0.2261	0.0570	B	0.5	0.1	0.2263	0.0574
k_π	N	2	0.2	1.8562	0.1516	N	2	0.2	1.8834	0.1516
k_π^*	N	1.5	0.2	1.1169	0.1957	N	1.5	0.2	1.1113	0.1990
k_y	N	0.05	0.01	0.0509	0.0099	U			0.0534	0.0270
k_y^*	N	0.2	0.2	0.1987	0.0190	U			0.1909	0.0505
ν	N	0.05	0.02	0.0460	0.0155	N	0.05	0.02	0.0465	0.0154
ξ_x	N	0.04	0.02	0.0288	0.0117	N	0.04	0.02	0.0278	0.0118
$\gamma_{oil,p}$	B	0.2	0.05	0.2045	0.0462	U			0.2489	0.0944
$\gamma_{oil,w}$	B	0.3	0.05	0.2887	0.0497	U			0	-
ρ_A	B	0.5	0.1	0.7153	0.0737	B	0.5	0.1	0.7201	0.0742
ρ_G	B	0.7	0.1	0.7700	0.0748	B	0.7	0.1	0.7703	0.0749
ρ_{T_p}	B	0.5	0.1	0.1893	0.0544	B	0.5	0.1	0.1909	0.0541
ρ_β	B	0.5	0.1	0.3885	0.1013	B	0.5	0.1	0.3890	0.0998
ρ_w	B	0.5	0.1	0.4453	0.1105	B	0.5	0.1	0.4520	0.1079
ρ_{rp}	B	0.5	0.1	0.5181	0.0844	B	0.5	0.1	0.5232	0.0852
σ_{ε_i}	U			0.0022	0.0004	U			0.0022	0.0004
$\sigma_{\varepsilon_{i^*}}$	U			0.0028	0.0005	U			0.0028	0.0005
σ_{ε_A}	U			0.0319	0.0053	U			0.0319	0.0053
$\sigma_{\varepsilon_{A^*}}$	U			0.0509	0.0188	U			0.0507	0.0187
$\sigma_{\varepsilon_{x^*}}$	U			0.1750	0.0226	U			0.1750	0.0226
σ_{ε_G}	U			0.0287	0.0037	U			0.0287	0.0037
$\sigma_{\varepsilon_{T_p}}$	U			0.2479	0.0365	U			0.2459	0.0363

	Basic					Alternative				
		Prior		Posterior			Prior		Posterior	
	Type	Avg.	Std. Dev	Mode	Std. Dev	Type	Avg.	Std. Dev	Mode	Std. Dev
$\sigma_{\varepsilon_{Tu_p}}$	U			0.5514	0.0686	U			0.5508	0.0688
$\sigma_{\varepsilon_{\beta}}$	U			0.0390	0.0074	U			0.0384	0.0072
$\sigma_{\varepsilon_{\beta^*}}$	U			0.0240	0.0036	U			0.0239	0.0037
$\sigma_{\varepsilon_{w}}$	U			0.0365	0.0056	U			0.0365	0.0056
$\sigma_{\varepsilon_{rp}}$	U			0.0246	0.0055	U			0.0242	0.0055
$\sigma_{\varepsilon_{c_{nwp}}}$	G	0.02	0.01	0.0121	0.0021	G	0.02	0.01	0.0117	0.0020

Note: * U – uniform distribution; B – beta distribution; G – gamma distribution.
Source: authors' calculations.

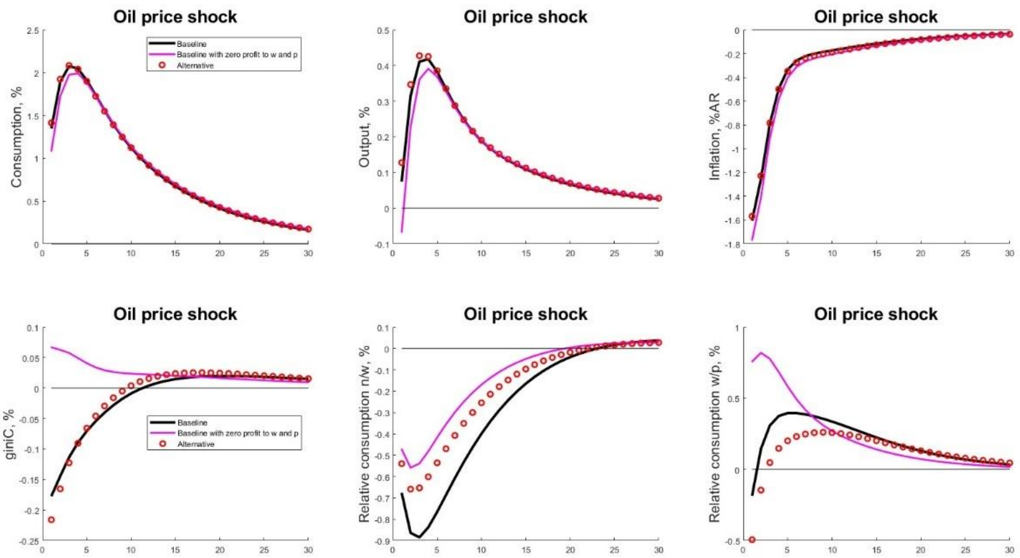

Figure A10.1. IRF to a shock of the real oil price of one standard deviation for basic (‘Baseline’) and alternative (‘Alternative’) scenario of the model estimation.
Note: ‘Baseline with zero profit to w and p’ is the basic variant with zeroed shares $\gamma_{oil,w} = 0$ and $\gamma_{oil,p} = 0$.

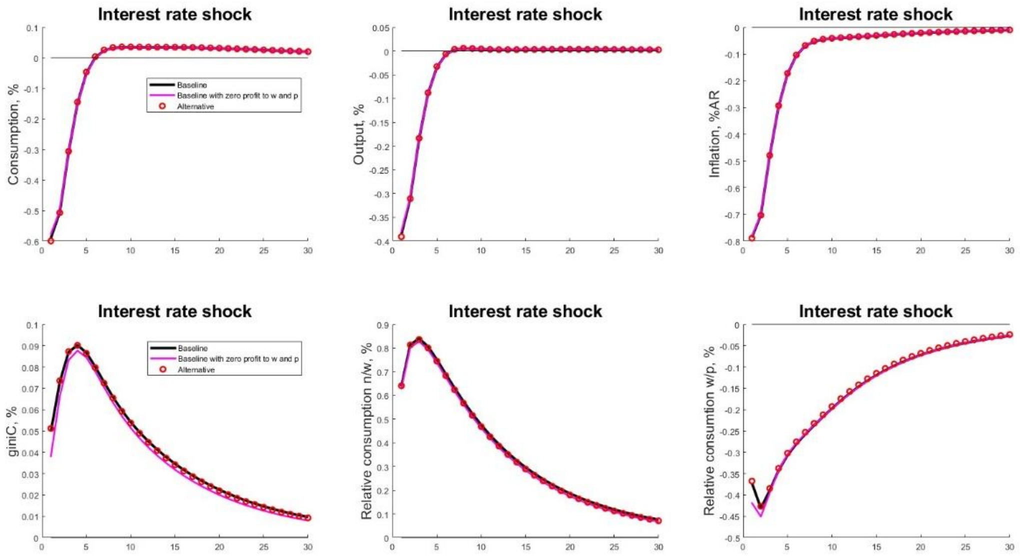

Figure A10.2. IRF to a monetary policy shock of one standard deviation for the basic ('Baseline') and alternative ('Alternative') scenario of the model evaluation.
Note: 'Baseline with zero profit to w and p' is the basic version with zeroed shares $\gamma_{oil,w} = 0$ and $\gamma_{oil,p} = 0$.