On the Distributional Effects of Conventional Monetary Policy and Forward Guidance

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Abstract

This paper compares the distributional effects of conventional monetary policy and forward guidance. First, adopting a structural VAR model, we empirically estimate the impact of the two policies on aggregate macroeconomic variables and consumption inequality in the U.S. We find similar responses at the aggregate level. In contrast, consumption inequality is countercyclical after a monetary policy shock but responds procyclically to forward guidance. This mainly originates from the diverse reaction of households at the bottom and the top of the consumption distribution under the two monetary regimes. Second, we evaluate whether a New Keynesian model with household heterogeneity can explain the observed different inequality responses. We document as the main channel of our results the government response through a fiscal transfer scheme that reacts to changes in the debt burden and in cyclical variations. The difference in timing and magnitude of the fiscal response makes consumption of constrained agents decrease relatively more under conventional monetary policy but less under forward guidance.

JEL Classification: D31, E21, E22, E52, E58, E62
Keywords: Household Heterogeneity, Forward Guidance, Inequality, Monetary Policy, Hand-to-Mouth, Automatic Stabilizers, Exogenous Instruments

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1 Introduction

Economic agents are heterogeneously exposed to the activities of central banks. Moreover, different monetary policy tools are likely to influence the economy through different channels. Therefore, in recent years, academic researchers and policymakers have increasingly focused on studying the diverse channels through which monetary policy can impact households and firms beyond the standard aggregate macroeconomic effects. This has become of utmost importance in the post-Covid-19 period when inflation rates worldwide reached historically high levels. To tackle the current surge in prices, monetary authorities need to decide about the optimal set of policies to implement and this debate cannot abstract from also considering the second-order effects that particular policy tools might have.

In this paper, we study empirically and theoretically the distributional effects of conventional monetary policy and forward guidance on consumption inequality. We document that the two policies have opposite effects on the cross-sectional distribution of consumption: a contractionary conventional policy shock leads to an increase in consumption inequality whereas forward guidance decreases it. We then evaluate the potential driving forces of this result through the lens of a two-agent New Keynesian (TANK) model. We find that a transfer system in which the fiscal response follows changes in the government's debt burden and the business cycle is able to replicate the empirical findings. Finally, we show that the result persists when considering a fully-fledged two-agent version of the benchmark heterogeneous-agent New Keynesian (HANK) model.

Our first contribution is to empirically evaluate the diverse macroeconomic and distributional implications of conventional monetary policy and forward guidance. We exploit U.S. household-level survey data from the Consumer Expenditure Survey (CEX) to compute a measure of consumption inequality defined as the cross-sectional standard deviation in real consumption across households. We include this measure into a vector autoregressive (VAR) model, using latent factors extracted by Swanson (2021) from high-frequency monetary policy surprises in asset prices to disentangle the effects of the two policies. On the one hand, the aggregate macroeconomic variables respond similarly and significantly to both shocks. On the other hand, we show that consumption inequality is countercyclical after a conventional monetary policy shock, but responds procyclically to forward guidance.

We then identify which household group(s) drive the opposite responses of consumption inequality. Households at the left tail of the consumption distribution disproportionately reduce their spending in response to a contractionary shock, leading to an increase in inequality. Conversely, following a forward guidance shock, households at the top of the distribution are the ones who decrease their consumption the most, thus reducing inequality.

The second main contribution of the paper appears in terms of a theoretical framework. We build an analytical TANK model as in Bilbiie (2008, 2020) to derive a closed-form solution for consumption inequality as a function of the underlying structural parameters. The key ingredients of the model are a redistribution of profits between the two household types as well as a lump-sum transfer scheme that adjusts in response to changes in the government's budget and cyclical variations. Following a contemporaneous rise in the nominal interest rate, the government's debt burden increases immediately and triggers an instant fiscal adjustment which affects the consumption response of households. In comparison, the government only partially adjusts transfers after a forward guidance shock as the actual rate hike and thus the higher interest payments on outstanding debt lie in the future. The difference in fiscal adjustments between the two policies is responsible for the increase in inequality under conventional monetary policy and the decrease under forward guidance. Finally, we confirm that the same mechanisms are present and able to replicate the cyclical behavior of inequality in more complex heterogeneous-agent setups like the HANK model developed by Kaplan, Moll, and Violante (2018).

Central banks around the world have responded to the recent increase in the inflation rate by rising their interest rates considerably and with different mixtures of policy tools. At the same time, governments have announced new fiscal transfers to compensate households for the increase in energy costs. Our paper sheds new light on the interaction between monetary and fiscal policies. The aggregate impact of conventional monetary policy and forward guidance on the economy is quantitatively similar but the two policies can have opposite effects on consumption dispersion. The timing and the magnitude of the fiscal adjustment to the central bank's decisions are of pivotal importance to reduce the negative second-order effects and to avoid an increase in inequality.

Related literature. This paper contributes to two strands of the literature. First, the results complement the large body of empirical evidence on the distributional effects of monetary policy. Using the same survey data as we do, Coibion, Gorodnichenko, Kueng, and Silvia (2017) show that consumption and income inequality in the U.S. have a countercyclical response to contractionary monetary shocks. This result has been confirmed for the United Kingdom (Mumtaz & Theophilopoulou, 2017), for the Euro Area (Samarina & Nguyen, 2019), and for a panel of 32 advanced and emerging economies (Furceri, Loungani, & Zdzienicka, 2018). Colciago, Samarina, and de Haan (2019) provide a comprehensive summary of the empirical findings regarding the relationship between monetary policy and inequality.

The empirical evidence on the distributional consequences of unconventional policies is more limited and sometimes conflicting in its conclusions. Bielecki, Brzoza-Brzezina, and Kolasa (2022) show that in the Euro Area both traditional monetary policy and forward guidance redistribute welfare from older to younger generations, thus reducing inequality. Guerello (2018) documents that standard expansionary monetary measures have a small contractionary effect on income inequality whereas quantitative easing increases income dispersion. However, if households' asset portfolio consists mainly of bank deposits, both policies lead to lower inequality. Similarly, Tsiaras (2021) uses a proxy VAR to show that quantitative easing shocks diminish inequality but that this result crucially depends on the share of asset markets participation and on how flexible wages are. Finally, Lenza and Slacalek (2021) find that quantitative easing reduces the income distribution since many households with lower incomes become employed and that standard monetary policies have a negligible effect on wealth inequality.

We extend this literature by evaluating the aggregate and distributional responses to standard monetary policy in comparison to forward guidance for the case of the U.S. Combining a structural VAR (SVAR) model with high-frequency identification techniques, we document that both policies have comparable effects on macroeconomic variables but opposite effects on consumption inequality.

This paper also contributes to the growing literature on the transmission of monetary policy shocks in heterogeneous-agent models. The improvements in computational techniques of the past years have led to an increase in the complexity of heterogeneous-agent models by including more and more dimensions to the household and firm parts of the economy. This allowed for the assessment of the impact of monetary policy beyond the simple aggregate effects and toward its distributional effects. Prominent examples of the propagation of conventional and unconventional monetary policy once interacted with different household characteristics include, among others, McKay and Reis (2016), McKay, Nakamura, and Steinsson (2016), Farhi and Werning (2019), Wong (2021), Bilbiie (2018), Hagedorn, Luo, Manovskii, and Mitman (2019), Ferrante and Paustian (2019), and Auclert, Rognlie, and Straub (2020).

A key role in explaining the amplification or mitigation of the effects of monetary policy has been found to be the fiscal response in terms of transfers and profits redistribution. As shown for the two-agent models in Bilbiie (2008, 2018, 2020), the extent to which fiscal redistribution results in a procyclical or countercyclical response of inequality is critical for several features of the models like the determinacy properties of interest-rate rules, the forward guidance puzzle, the size of the fiscal multipliers, liquidity traps, and optimal monetary policy. For example, if the individual income of households at the lower end of the income distribution reacts more than one-to-one to changes in aggregate income and those households consume all of this additional income, general equilibrium effects can amplify the impact of both monetary policy and forward guidance. Related to this, Gerke, Giesen, and Scheer (2020) find in an estimated TANK model that a sufficient degree of countercyclical transfers decreases the power of forward guidance compared to a standard representative-agent model.

The importance of the fiscal response is also well-known in fully-fledged heterogeneous-agent models. The seminal paper on which we build part of our theoretical framework is Kaplan et al. (2018) who introduce uninsurable income shocks into a two-asset model and find, among others, that the fiscal response after a monetary shock crucially shapes its aggregate macroeconomic effects. Kaplan, Moll, and Violante (2016) extend the results to forward guidance shocks. Moreover, different fiscal responses significantly affect the sensitivity of income and consumption to monetary shocks as emphasized by Evans (2022). The author shows that different profit distribution schemes heterogeneously affect households along the wealth distribution. A mix of a bonus-based scheme (profits distributed in proportion to labor productivity) and a dividend-based scheme (profits distributed in proportion to illiquid asset holdings) is necessary to bring the distributional response to monetary shocks closer to the empirical evidence.

We contribute to the theoretical literature on heterogeneous-agent models by studying how the interaction between monetary and fiscal policy influences the inequality response to conventional monetary policy and forward guidance shocks. We propose a fiscal distribution scheme as a function of government debt and aggregate output as a way to stabilize the consumption response of financially constrained households during a recession. We show that the government's response under the two monetary policies differs in terms of timing and size and that this results in responses of consumption inequality of different signs.

Outline. The remainder of the paper is organized as follows. Section 2 describes the data we use for the empirical analysis and section 3 the empirical specification we adopt to evaluate the effects of the policy shocks on consumption inequality. Section 4 reports the main results of the empirical analysis. In section 5, we present the theoretical model and the resulting impulse responses. Section 6 discusses some policy implications of our findings. Finally, section 7 concludes.

2 Data and identification

This section presents the aggregate and household-level data used for the empirical analysis. We also discuss how we disentangle the effects of monetary policy and identify the structural shocks of interest.

2.1 Macroeconomic and financial variables

Our empirical analysis focuses on the U.S. economy. The main macroeconomic and financial variables for the baseline model are the real Gross Domestic Product (GDP), the GDP price deflator, the Excess Bond Premium (EBP) from Gilchrist and Zakrajsek (2012), the Federal Funds Rate (FFR), and the 2-year constant-maturity Treasury yield. In the robustness checks, we will use a few alternative variables: industrial production to measure real activity, the Consumer Price Index (CPI) as a price variable, and the 1-year constant-maturity Treasury yield as short-term rate. All these data series are taken from the FRED database operated by the Federal Reserve Bank of St. Louis, except for the EBP data which are taken from the website of the Federal Reserve System.

2.2 Consumption inequality

We compute the measures of consumption inequality from the Consumer Expenditure Survey (CEX). The CEX, provided by the Bureau of Labor Statistics (BLS) since 1980, is the most comprehensive and granular data source on household consumption in the U.S. and is used for constructing weights of the U.S. CPI. The survey consists of two separate modules: the Interview Survey and the Diary Survey. The first one provides information on up to 95% of a typical household's consumption expenditures whereas the second one covers only expenditures on small items from stores. Therefore, in our analysis, we only use data from the Interview Survey.[1]

The CEX is a monthly rotating panel where households are interviewed once per quarter, for at most five consecutive quarters (although the first interview is not publicly available). In each interview, the respondents report their expenditures relative to the three months prior to the interview. In line with the literature, we aggregate monthly expenditures into quarterly expenditures to reduce sampling errors.

To compute the measures of consumption inequality, we closely follow Coibion et al. (2017)[2]. Household consumption is defined as the sum of non-durables, services, and expenditures on durable goods. All nominal variables are deflated using the CPI for all urban consumers from FRED (CPI-U) and survey sample weights are consistently applied. Real consumption is winsorized at the bottom and top one percent to reduce the influence of outliers and the series are seasonally adjusted.

[1] See Bee, Meyer, and Sullivan (2013) for an assessment of the quality of the consumer dataset and its limitations.

[2] We refer the reader to the Appendix of Coibion et al. (2017) for a detailed description of the cleaning procedure performed on the data.

The baseline measure of inequality we compute is the cross-sectional standard deviation of real consumption across households. As a robustness check, we will use instead the Gini coefficient of the cross-sectional distribution of household-level real consumption. The advantage of the standard deviation relative to this alternative measure is that it is less sensitive to the behavior of extreme values at the tails of the distribution.

We decided to focus in this paper on consumption inequality rather than income or wealth inequality for several reasons. First, the data quality is higher for expenditures. In fact, the CEX is specifically designed to collect information on household spending over time. Although the BLS provides some measures of income and wealth, they are mainly imputed from expenditure and demographic data. Moreover, the consumption distribution is a good proxy for income and wealth distributions as well. Second, consumption is connected to the households' well-being since it directly enters their utility functions. In fact, it is the primary reason to earn income and build up wealth in the first place and fluctuates generally less than those two, allowing an assumingly more stable assessment of differences across households. Third, Coibion et al. (2017) already show that contractionary monetary shocks have a negligible effect on income inequality but that consumption responds strongly.

2.3 Monetary policy shocks

To identify the structural shocks of interest for our purposes, we draw on the concept of high-frequency identification. The goal is to monitor changes in market-based measures at dates with a policy event (so-called monetary policy surprises) to isolate the *unexpected* variation in monetary policy. One can then estimate unobserved factors that together explain the variations in the market-based measure around the policy events. Eventually, the idea is to use these exogenous monetary policy surprises or factors to instrument changes in interest rates.

We rely on different measures of U.S. monetary policy surprises and factors. In our baseline specification, we use the factors proposed by Swanson (2021) who extends the high-frequency approach of Gürkaynak, Sack, and Swanson (2005). The author collects the changes in specific asset prices in a 30-minute window around each Federal Open Market Committee (FOMC) announcement between 1991 and 2019 and computes the first three principal components of those responses, which together describe the vast majority of market movements. Among all possible rotations of these principal components, he considers the one in which the first factor can be thought of as corresponding to changes in the Federal Funds Rate (or FFR), the second to changes in forward guidance, and the third to changes in large-scale asset purchases (LSAPs).[3] Those represent the three elements of monetary policy that had the largest systematic impact on asset prices. Drawing on this, Swanson (2021) decomposes the changes in asset prices around FOMC announcements into a Federal Funds Rate (or FFR) factor, a Forward Guidance (or FG) factor, and a LSAP factor, which each measures surprises at very short maturities, medium-term maturities, and long maturities, respectively.[4] In particular, the FG factor captures the revision in market expectations about the future path of policy rates that are orthogonal to the current policy surprise.

For our analysis, we use the first two factors (FFR and FG) as measures of the structural monetary shocks. The series are available at a daily frequency and we sum up the data points within each quarter to convert them to quarterly frequency.[5]

As a robustness check, we use the original two factors computed by Gürkaynak et al. (2005), which we extend to 2019. On top of that, we also clean the factors of Gürkaynak et al. (2005) and Swanson (2021) from the superior-information component of the Federal Reserve by regressing the surprises on Greenbook forecasts and revisions, as proposed by Miranda-Agrippino and Ricco (2021). Those results are reported in Appendix A.

3 Econometric approach

We adopt a standard VAR specification with p lags:

$$y_t = B_0 + B_1 y_{t-1} + \ldots + B_p y_{t-p} + u_t \ , \tag{1}$$

where y_t is the vector of variables of dimension $n \times 1$, u_t the vector of reduced-form innovations with covariance matrix $\mathrm{Var}(u_t) = \Sigma_u$, B_0 is the vector of constant terms, and $B_1, ..., B_p$ are $n \times n$ coefficient matrices.

The VAR model can be written in its structural form by multiplying each side of the reduced form by A_0:

$$A_0 y_t = C_0 + C_1 y_{t-1} + \ldots + C_p y_{t-p} + \varepsilon_t, \quad \varepsilon_t \sim \mathcal{N}(0, \Sigma) \ , \tag{2}$$

[3] Swanson (2021) imposes three restrictions to identify the respective factors. First, changes in forward guidance have no impact on the current FFR. Second, neither do changes in LSAPs. Finally, LSAPs had only a minor impact in the time preceding the zero lower bound period.

[4] The factor capturing surprise changes in the FFR is sometimes termed Target factor. Likewise, the factor capturing changes in forward guidance is called Path factor elsewhere. See, for instance, the seminal work by Gürkaynak et al. (2005).

[5] Adopting the alternative approach from Gertler and Karadi (2015), who cumulate the surprises on any FOMC meeting days during the last 93 days and then take the quarterly averages, barely change the results.

where $C_0 = A_0 B_0$ and $C_j = A_0 B_j$ for $j = 1, \ldots, p$. The reduced-form residuals are a function of the structural shocks $u_t = A_0^{-1} \varepsilon_t$. Therefore, it is possible to write the reduced-form variance-covariance matrix as $\mathbb{E}(u_t u_t') = \Sigma_u = A_0^{-1} A_0^{-1'}$.

The conventional monetary and forward guidance shocks are identified by performing a Cholesky factorization of the reduced-form variance-covariance matrix Σ_u. As in Coibion (2012), Cloyne and Hürtgen (2016) and Lennard (2018), the FFR and the forward guidance factor are integrated directly into the vector autoregressive model and ordered first.[6] By ordering the factor of interest first, we allow all the other variables in the system to contemporaneously respond to the shock[7].

The remaining variables included in the baseline model specification are: (i) Real GDP; (ii) GDP price deflator; (iii) Excess Bond Premium; (iv) Federal Funds Rate; (v) 2-year Treasury yield; and (vi) consumption inequality measure. The Excess Bond Premium, the FFR, and the Treasury yield enter the model in percentage points (ppt.), while the other variables are in log levels, transformed by multiplying their log value by 100. The data are at quarterly frequency for the period 1991-Q3 to 2019-Q2. We include three lags ($p = 3$) for each independent variable as indicated by the corrected Akaike information criterion (AICc).[8] Standard errors are computed using a residual-based moving block bootstrap following Jentsch and Lunsford (2019) with block size set to 16.

4 Empirical results

This section reports the impulse responses resulting from the baseline SVAR model to both a conventional monetary policy and a forward guidance shock. We present the results for macroeconomic and financial variables, consumption inequality, and for differences along the consumption distribution. Our findings are robust to different sets of variables, including other factors and inequality measures, or alternative VAR settings. See Appendix A for more details.

[6]The small sample size and the relatively low frequency of the aggregate data hamper the use of the factors as direct instruments. For instance, the first stage of a proxy VAR with the factors used as external instruments for changes in interest rates results in low F-statistics, in particular for the forward guidance factor, suggesting that the factors are weak instruments. This result is confirmed for alternative factors like the ones discussed in Appendix A.

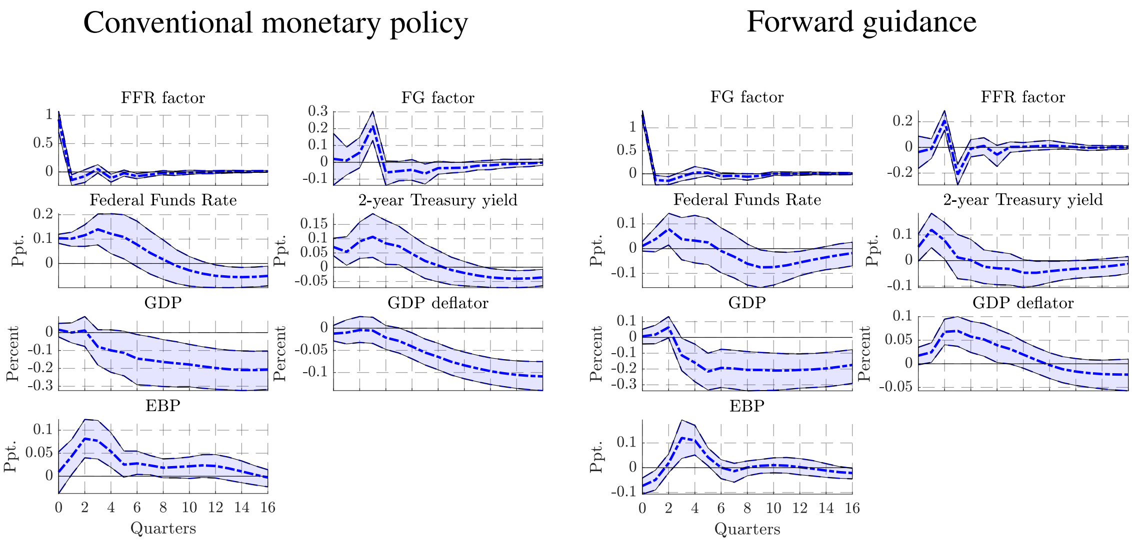
[7]Our results are insensitive to a different ordering of the variables in the VAR. The same holds for including one factor at the time because the two factors are orthogonal to each other.

[8]When facing small samples like ours, the AICc performs better than the more common AIC. However, the impulse responses are much the same when using four lags ($p = 4$), which is a common choice in VARs for monetary analysis with quarterly data.

4.1 Aggregate responses

We start by analyzing how the macroeconomic and financial variables react to conventional monetary policy and forward guidance shocks. The impulse responses to a one-standard-deviation increase in the respective factor are reported in Figure 1. The blue dashed lines are the point estimates and the shaded areas are the 68 percent confidence bands based on 10,000 residual-based moving block bootstrap replications.

Figure 1: Macroeconomic responses to monetary policy shocks



Notes: This figure depicts the impulse responses of macroeconomic variables to a one-standard-deviation increase in the target factor (left panel) and the path factor (right panel) from Swanson (2021), respectively. Impulse responses are from a SVAR model computed at quarterly frequency using aggregate-level data for the period 1991Q3-2019Q2. Shaded areas represent the 68% confidence interval.

Following a contractionary monetary policy shock, the Federal Funds Rate increases as expected whereas the impact on the 2-year Treasury yield is more muted. GDP and inflation start to decrease persistently around a year after the shock while the EBP signalizes tighter financial conditions.

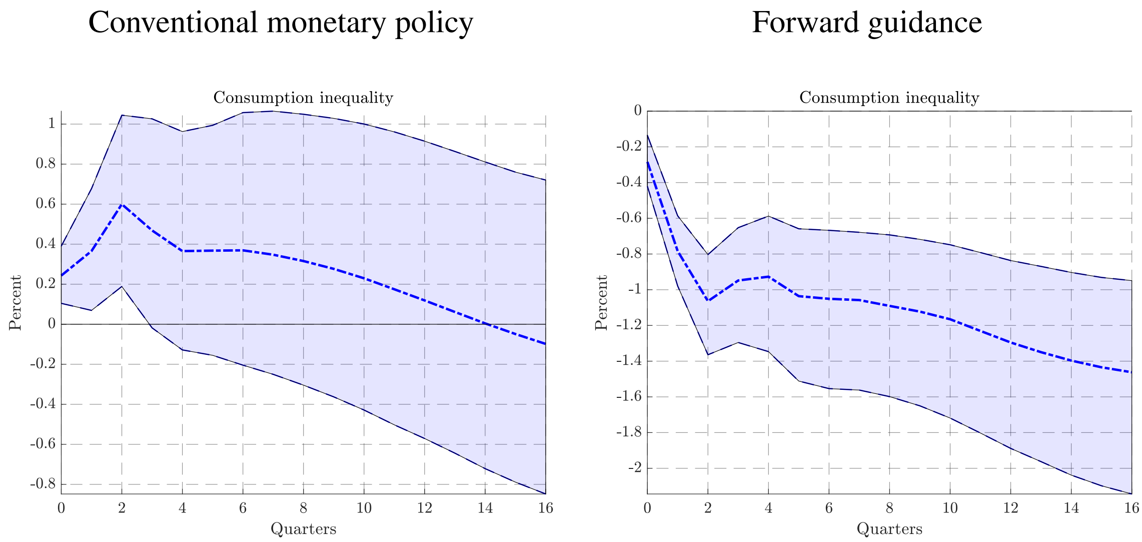
A positive forward guidance shock causes an increase in the Treasury yield, but the Federal Funds rate does not respond by much as could have been expected given the construction of the factors. The shock also leads to a sizable decrease in GDP and an increase in the EBP a few quarters after the shock. However, prices show a positive response for several quarters (price puzzle). The same result is found by Lakdawala (2019) and, as we show in Appendix A.5, once we control for central bank private information, the response of inflation becomes negative without affecting the sign of the consumption inequality response.

As discussed in Andrade and Ferroni (2021), the sign of the price response to a contractionary forward guidance shock depends on how the shock is perceived. If markets see the announcements as Delphic (news on future macroeconomic conditions), prices will increase, whereas if markets see them as Odyssean (news about the future stance of monetary policy), prices will decrease. Once we clean the shocks from the Delphic component we obtain the expected response that inflation decreases after a contractionary forward guidance shock.

4.2 Consumption inequality responses

We now focus on the cumulative response of our measure of inequality, namely the log of the cross-sectional standard deviation of real consumption. The impulse responses to a conventional monetary policy and a forward guidance shock are reported in Figure 2.

Figure 2: Consumption inequality responses to monetary policy shocks

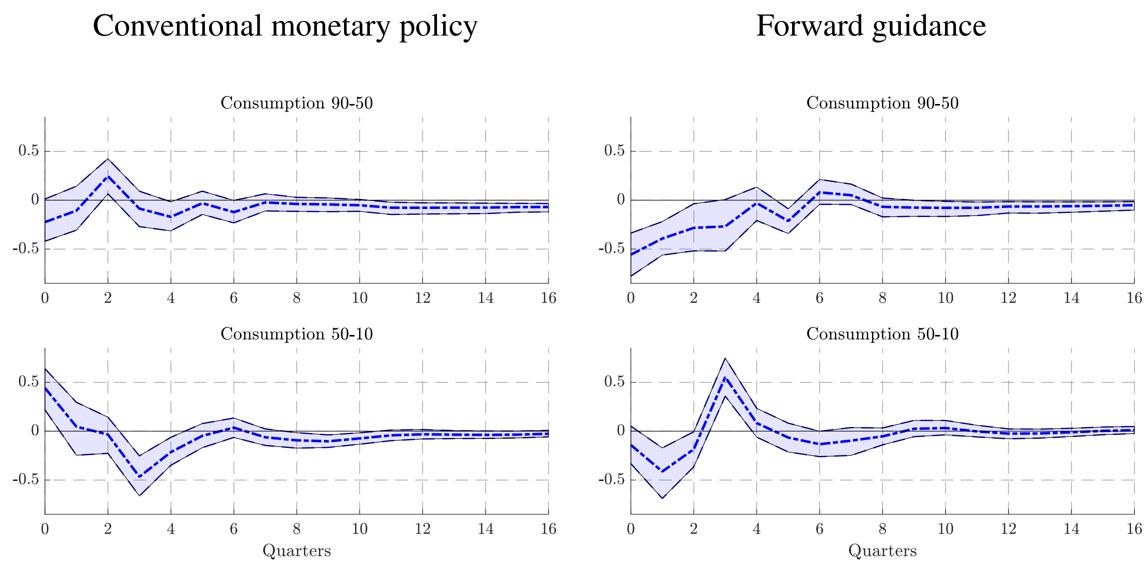


Notes: This figure depicts the cumulated impulse responses of consumption inequality to a one-standard-deviation increase in the target factor (left panel) and the path factor (right panel) from Swanson (2021), respectively. Consumption inequality is measured by the cross-sectional standard deviation of household-level real consumption. Impulse responses are from a SVAR model computed at quarterly frequency using aggregate-level and inequality data for the period 1991Q3-2019Q2. Shaded areas represent the 68% confidence interval.

The two shocks have opposite effects on inequality. A contractionary monetary shock results in an increase in consumption inequality, implying a countercyclical behavior with respect to the output response. This result is in line with the ones in Coibion et al. (2017), Furceri et al. (2018), Mumtaz and Theophilopoulou (2017), or Samarina and Nguyen (2019). In contrast, a forward guidance shock causes a sizable decrease in consumption inequality and hence a procyclical response. The latter is thereby much stronger in magnitude compared to the response to a conventional shock.

To shed further light on which households are driving this result, we replace our inequality measure in the SVAR with two variables: the difference between log consumption at the 90th and 50th percentiles of the household consumption distribution (the right tail minus the median) and the difference between log consumption at the 50th and 10th percentile (the median minus the left tail). The impulse responses are reported in Figure 3.

Figure 3: Consumption responses to monetary policy shocks by percentiles



Notes: This figure depicts impulse responses to a one-standard-deviation increase in the target factor (left panel) and the path factor (right panel) from Swanson (2021), respectively. The dependent variable in the panels of the top row is the difference in log consumption between the 90th and the 50th percentiles of the household consumption distribution. In the panels of the bottom row, it is the difference in log consumption between the 50th and the 10th percentiles. Impulse responses are from a SVAR computed at quarterly frequency using aggregate-level and inequality data for the period 1991Q3-2019Q2. Shaded areas represent the 68% confidence interval.

The top left panel shows that, in response to a contractionary shock, the households at the top 10% of the distribution reduce their consumption slightly more than those at the median such that the difference is negative, but not significantly. As expected, the households at the bottom 10% of the distribution remarkably decrease their consumption so that the distance to the median households further increases. This insight might be explained by the fact that a large share of these households are usually close to or even at their borrowing constraint and so their consumption is very sensitive to current interest rate changes. Overall, the considerable decrease in consumption of the left tail leads to a rise in inequality.

The right panel tells a different story. In response to a forward guidance shock, the consumption of households at the bottom 10% of the distribution reacts similarly to the consumption of the median households – at least in the first few periods after the shock. However, the consumption of the right tail substantially decreases and so the difference to the 50th percentile goes down as well. This implies that the cross-sectional standard deviation of real consumption significantly decreases after a forward guidance shock.

To sum up, the empirical analysis allows us to draw three main conclusions regarding the overall effects of conventional monetary policy and forward guidance. First of all, the macroeconomic variables show *similar* responses to the two monetary policies. Second, consumption inequality is *countercyclical* under conventional monetary policy but *procyclical* under forward guidance. Its response to the latter is thereby much stronger. Third, the opposite sign of the inequality responses emerges from the different sensitivity to the shocks at the two tails of the consumption distribution: inequality increases after a contractionary conventional shock because the consumption of households at the *bottom* of the consumption distribution decreases relatively more than for the rest of the distribution. Under forward guidance, however, households at the *top* of the distribution decrease their consumption disproportionately and so inequality goes down.

5 Theoretical framework

In this section, we investigate which channel of a standard heterogeneous-agent model is able to replicate the three main conclusions from the empirical analysis above, in particular the diverse cyclical responses of consumption inequality. We propose a particular fiscal policy mix comprising two elements: a redistribution of profits between households and a lump-sum transfer scheme that adjusts in response to changes in the government's budget and cyclical variations.

We start with a simple model framework to derive analytical closed-form solutions for the response of inequality and to explain our proposed channel in a transparent way. The model combines a standard two-agent household side as in Bilbiie (2008, 2020) with fiscal policy following Kaplan et al. (2018). We then evaluate whether the results still hold in a more complex setup such as a fully-fledged two-agent version of the benchmark HANK model from Kaplan et al. (2018). This framework comprises well-known channels of the HANK literature but is still tractable enough to examine the underlying transmission mechanisms.

5.1 Simple analytical two-agent model

The model economy includes four types of agents: households, firms, a government, and a monetary authority. Households are divided into constrained agents living hand-to-mouth and unconstrained savers. Firms are modeled in a standard New Keynesian fashion, with a nominal rigidity that implies sticky prices. The government makes lump-sum transfers financed by short-term debt and conducts redistributive policies by taxing firms' profits. Finally, the central bank controls the real interest rate and sets an exogenous time path for it. Appendix B provides more details regarding the model derivation and its equilibrium conditions.

Households. The unit mass of households is divided into two types: a share λ are hand-to-mouth households (H), while the remaining share $1-\lambda$ are savers (S). All households share the same period utility function over consumption C and labor L. For $j = \{H, S\}$,

$$U\left(C_t^j, L_t\right) = \frac{\left(C_t^j\right)^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} - \varphi^j \frac{L_t^{1+\nu}}{1+\nu} \; ,$$

with discount factor $\beta \in (0,1)$ and where σ is the elasticity of intertemporal substitution, $\frac{1}{\nu}$ denotes the Frisch elasticity of labor supply, and $\varphi^j > 0$ indicates how strong each agent values leisure relative to consumption. We assume that both household types supply the same amount of hours worked.[9]

Savers. Unconstrained households hold all assets in the economy. They can save in risk-free real bonds issued by the government and get uniform labor income, transfers, and dividends from profits made by monopolistic firms they own. Each saver solves the following problem:

$$\max_{C_t^S, L_t, B_{t+1}^S} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \, U\left(C_t^S, L_t\right) \qquad \text{subject to}$$

$$C_t^S + B_{t+1}^S = (1+r_{t-1})B_t^S + W_t L_t + \Gamma_t^S + T_t^S \; ,$$

where B_{t+1}^S are a saver's end-of-period-t holdings of liquid one-period government bonds issued in t, W_t is the real wage, Γ_t^S are dividends from firms' profits net of taxes (specified below), T_t^S are real lump-sum government transfers, and r_t is the real interest rate on bonds, where $1 + r_t = \frac{1+i_t}{1+\pi_{t+1}}$ with net inflation rate $\pi_t = \frac{P_t}{P_{t-1}} - 1$.

[9]One way to achieve equal hours worked across household types is to assume a centralized labor market. For example, Bilbiie, Känzig, and Surico (2022) impose that a union consolidates labor inputs by households and sets the wage on their behalf.

The optimality conditions for this problem result in the following Euler equation for bonds and labor supply conditions:

$$1 = \beta\,\mathbb{E}_t\left[\left(\frac{C^S_{t+1}}{C^S_t}\right)^{-\frac{1}{\sigma}}(1+r_t)\right] \ ,$$
$$W_t = \varphi^S\,(L_t)^\nu\,\left(C^S_t\right)^{\frac{1}{\sigma}} \ .$$

Hand-to-mouth households. Constrained households have no access to asset markets and simply consume their labor income and transfers from the government. Their budget constraint reads

$$C^H_t = W_t L_t + \Gamma^H_t + T^H_t \ .$$

Redistributed dividend income Γ^H_t and lump-sum transfers T^H_t will together play a key role in our proposed mechanism as explained below. They substantially govern the direction of the inequality response to a monetary policy or a forward guidance shock.

The labor supply choice of hand-to-mouth agents is characterized by

$$W_t = \varphi^H\,(L_t)^\nu\,\left(C^H_t\right)^{\frac{1}{\sigma}} \ .$$

Firms. The supply side of the economy is standard and features monopolistically competitive producers that provide intermediate goods to perfectly competitive final goods firms.

Final goods producers. A representative firm in the final goods sector aggregates differentiated intermediate inputs j to a final good according to the CES production function $Y_t = \left(\int_0^1 Y_t(j)^{\frac{\epsilon-1}{\epsilon}}\,di\right)^{\frac{\epsilon}{\epsilon-1}}$ with elasticity of substitution across goods ϵ. Profit maximization yields the demand for each input, $Y_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\epsilon} Y_t$, where $P_t(j)$ is the price of intermediate good j and $P_t^{1-\epsilon} = \int_0^1 P_t(j)^{1-\epsilon}\,dj$ the aggregate price index.

Intermediate goods producers. There is a continuum of monopolistically competitive firms, each of which produces a variety j of the intermediate good using labor N as input. Their production function reads $Y_t(j) = N_t(j)$ and cost minimization implies real marginal cost $MC_t = W_t$. Each producer faces quadratic price adjustment costs as in Rotemberg (1982) of the form $\Theta_t = \frac{\theta}{2}\left(\frac{P_t(j)}{P_{t-1}(j)} - 1\right)^2 Y_t$. Real profits of firm j are then given by

$$D_t(j) = \left(1+\tau^S\right)\frac{P_t(j)}{P_t}\,Y_t(j) - W_t\,N_t(j) - \Theta_t - T^F_t \ ,$$

where $P_t(j)$ is the price set by firm j and P_t denotes the aggregate price level. Following Bilbiie (2020), we assume that the government pays a subsidy on sales, financed by a lump-sum tax on firms such that $T_t^F = \tau^S\, Y_t(j)$. With this, total profits over all firms are

$$D_t = \left(1 - MC_t - \frac{\theta}{2}\pi_t^2\right)\, Y_t \ .$$

An intermediate goods producer sets its price $P_t(j)$ to maximize the discounted stream of expected profits subject to the demand for its good. Appendix B.1 shows the solution to this pricing problem which yields the following New Keynesian Phillips curve:

$$\pi_t(1+\pi_t) = \mathbb{E}_t\left[\frac{\Lambda_{t+k}}{\Lambda_t}\,\theta\pi_{t+1}(1+\pi_{t+1})\,\frac{Y_{t+1}}{Y_t}\right] + \frac{1}{\theta}\left[\epsilon MC_t - (1+\tau^S)(\epsilon - 1)\right] \ .$$

Government. The government issues one-period real bonds, only held by savers, to finance the repayment of existing debt and transfers to households. Its budget constraint is given by

$$B_{t+1} = (1 + r_{t-1})B_t + T_t \ ,$$

where B_{t+1} are new bonds issued at time t, such that $B > 0$ denotes debt, with real interest rate r_t, and T_t are lump-sum transfers. We assume that bonds are in positive net supply in equilibrium.

The key instrument of fiscal policy is a tax and transfer system comprising two elements. First, the government levies taxes on the profits of monopolistic firms owned by savers and redistributes the revenues as a transfer to hand-to-mouth agents. This policy is balanced in every period such that the following conditions hold:

$$\begin{aligned}\Gamma_t^H &= \frac{\tau^D}{\lambda}D_t \\ \Gamma_t^S &= \frac{1-\tau^D}{1-\lambda}D_t \ ,\end{aligned}$$

where τ^D is the proportional tax on profits that governs the magnitude of the redistribution. If $\tau^D > \lambda$, hand-to-mouth agents receive a disproportionate share of the profits and are therefore more exposed to changes in them.

Second, there is a lump-sum transfer scheme in place where total transfers are given by

$$T_t = \lambda T_t^H + (1-\lambda)T_t^S \ .$$

The exact functional form of individual transfers will be specified in section 5.3. For now, we should think of them as functions that depend, for instance, on interest rates, the level of debt, or the business cycle.

For this simple model, we assume that the government adjusts lump-sum transfers to maintain a constant level of debt over time. In other words, $B_t = B$ for all t, such that

$$-(r_{t-1} - r)B = \lambda \left(T_t^H - T^H\right) + (1-\lambda)\left(T_t^S - T^S\right) \ ,$$

where variables without time indices denote steady-state values. If the economy starts from a steady state, an expansionary monetary policy shock that moves the real rate below its long-run value r will imply lower interest payments on outstanding debt and allow for higher transfers to households.

Monetary authority. Following McKay et al. (2016) and Kaplan et al. (2016), we assume that the central bank controls the real interest rate. It implements monetary policy by setting and committing to a path for the interest rate, $\{r_k\}_{k\geq 0}$, that is perfectly credible and foreseen by agents.

Once the central bank changes the real interest rate at some arbitrary point in time $\mathcal{T} > 0$, monetary policy will be governed by an exogenous rule. Prior to $\mathcal{T}$, the real rate remains fixed at its steady-state value r. Formally, for $\mathcal{T} \geq 0$:

$$r_t = \begin{cases} r, & t < \mathcal{T} \\ r + \rho^{t-\mathcal{T}}\varepsilon_{\mathcal{T}}, & t \geq \mathcal{T} \end{cases}$$

with policy shock $\varepsilon_{\mathcal{T}} = r_{\mathcal{T}} - r$ and persistence ρ.[10] Therefore, we have $\mathcal{T} = 0$ under conventional monetary policy shock and $\mathcal{T} > 0$ under forward guidance shock, respectively. Moreover, the Fisher equation holds:

$$1 + r_t = \frac{1 + i_t}{1 + \pi_{t+1}} \ .$$

Aggregation and market clearing. Aggregate consumption and labor market clearing are given by $C_t = \lambda C_t^H + (1-\lambda)C_t^S$ and $N_t = L_t$, respectively. Goods clearing requires $Y_t = C_t + \frac{\theta}{2}\pi_t^2\, Y_t$ and the bond market clears if $B_{t+1} = (1-\lambda)B_{t+1}^S$.

5.2 Cyclical inequality through redistribution between households

We now study the key equilibrium conditions of our TANK model, log-linearized around a steady state without inequality ($C^H = C^S = C$), zero steady-state dividends ($\Gamma^S = \Gamma^H = 0$),

[10] An alternative setup would be to assume that the nominal interest rate is set according to a standard Taylor rule. In that case, there exists a sequence of anticipated shocks to the policy rule that implies the same path for the real rate that we set exogenously above.

and zero transfers to hand-to-mouth agents ($T^H = 0$). In general, small letters denote the log deviation of a variable from its non-stochastic steady state. See Appendices B.2 and B.3 for more details on the steady state and a summary of the log-linearized equilibrium conditions, respectively. In what follows, we build on previous work done by Bilbiie, Monacelli, and Perotti (2020) and extend it for our purposes.

First, it is possible to write individual consumption of households as a function of aggregate income and transfers to constrained households:

$$c_t^H = \chi c_t + t_t^H \tag{3}$$

$$c_t^S = \frac{1-\lambda\chi}{1-\lambda} c_t - \frac{\lambda}{1-\lambda} t_t^H \ , \tag{4}$$

where

$$\chi \equiv 1 + (\sigma + \nu) \left(1 - \frac{\tau^D}{\lambda}\right) \ ,$$

which captures the elasticity of hand-to-mouth agents' income to total income.[11] This parameter, discussed in detail by Bilbiie (2020), expresses the *profit redistribution* from savers to hand-to-mouth households (as long as $\tau^D > 0$). If $\chi > 1$, the individual income of constrained households responds more than proportionally to changes in aggregate income. This is the case if and only if $\tau^D < \lambda$, meaning that constrained agents receive a proportion of profits that is lower than their share in the population.

The appearance of t_t^H captures the fact that transfers to households immediately react to changes in the fiscal debt burden (through the government's budget constraint) and have a direct impact on individual spending levels. Even more important, (3) and (4) imply that those transfers are another source of redistribution: if $t_t^H > 0$, savers pay for the additional income of hand-to-mouth agents.

Second, aggregate demand is characterized by the (forwarded) aggregate consumption Euler equation:

$$c_t = \frac{\lambda}{1-\lambda\chi} t_t^H - \sigma \frac{1-\lambda}{1-\lambda\chi} \sum_{k=0}^{\infty} \mathbb{E}_t r_{t+k} \ . \tag{5}$$

This expression nests the standard Euler equation of a representative-agent model if $t_t^H = 0$ (zero response of transfers or no transfers) and $\chi = 1$ (hand-to-mouth agents' income moves one-to-one with total income).

[11]The elasticity expression slightly differs from the one in Bilbiie (2020) who defined $\chi = 1 + \nu \left(1 - \frac{\tau^D}{\lambda}\right)$. This difference is due to our assumption of uniformly allocated hours worked, while he assumes that each household type provides a separate labor supply.

Third, consumption inequality can be written as follows:

$$\Phi_t \equiv c_t^S - c_t^H = -\frac{1}{1-\lambda\chi}\, t_t^H - \sigma \frac{1-\chi}{1-\lambda\chi} \sum_{k=0}^{\infty} \mathbb{E}_t r_{t+k} \; . \tag{6}$$

The first part of the equation arises from the fact that transfers to households immediately react to changes in the government's interest payments on outstanding debt. The second part captures the common channel of intertemporal substitution, brought about by the Euler equation of savers. Overall, changes in either the contemporaneous or future real rates will have a direct effect on inequality.

Suppose now that the monetary authority announces at time 0 that it will change the real interest rate either today or at some future time $\mathcal{T}$. The contemporaneous response of inequality to this policy, for $\mathcal{T} \geq 0$, is

$$\frac{\partial\, \Phi_0}{\partial\, r_{\mathcal{T}}} = -\frac{1}{1-\lambda\chi} \frac{\partial\, t_0^H}{\partial\, r_{\mathcal{T}}} + \sigma \frac{\chi - 1}{1-\lambda\chi} \frac{1}{1-\rho} \; . \tag{7}$$

As becomes obvious from this expression, after a real interest rate change today or in the future, the transfer function t^H will determine the response of inequality endogenously, together with χ that determines it in the absence of such transfers.[12]

Relating these two elements to each other, we can derive a formal expression that defines the cyclical behavior of inequality.

Proposition 1 (Cyclicality of inequality for arbitrary transfer)**.** *In a simple TANK model with an arbitrary transfer t^H between the two agents that modulates inequality, there is countercyclical consumption inequality in response to a one-time change in the real interest rate at time $\mathcal{T}$ if*

$$\frac{\partial\, t_0^H}{\partial\, r_{\mathcal{T}}} < \sigma(\chi - 1)\, \frac{1}{1-\rho} \; . \tag{8}$$

In contrast, consumption inequality is procyclical with an opposite sign.

Proof. Assuming that $\lambda\chi < 1$, the proposition follows from (7). ■

In the case studied in this paper, the arbitrary transfer mentioned in the proposition and the associated redistribution occur through the government, in the form of lump-sum transfers. However, it needs to be stressed that this mechanism is only one out of a broader class of redistribution schemes that might work in this context. In fact, any mechanism in which the

[12]Throughout the paper, we assume that $\lambda < 1/\chi$ like, among others, Bilbiie (2020) did. If that condition does not hold, Bilbiie (2008) demonstrates how the slope of the IS curve might flip such that an expansionary monetary policy negatively affects aggregate consumption through the intertemporal substitution channel.

size and the timing of the government's intervention differ between the two monetary policy regimes can generate similar income effects and achieve the desired cyclicality of inequality.

5.3 Inequality and the impact of monetary shocks

To determine analytically the responses of inequality to an interest rate change, we specify now a transfer function. As a result of Proposition 1, in order to achieve countercyclical consumption inequality on impact of a real interest rate change today (i.e., $\mathcal{T} = 0$), it has to hold that $\frac{\partial t_0^H}{\partial r_{\mathcal{T}}} < \sigma(\chi - 1)\,\frac{1}{1-\rho}$. Conversely, for inequality to respond procyclically after a forward guidance shock (i.e., $\mathcal{T} > 0$), we require $\frac{\partial t_0^H}{\partial r_{\mathcal{T}}} > \sigma(\chi - 1)\,\frac{1}{1-\rho}$.

We assume in our baseline specification that the transfer function for hand-to-mouth agents comprises both a debt element and a cyclical component:

$$t_t^H = -\phi_1 r_t B_Y - \phi_2 y_t \ , \tag{9}$$

where $\phi_1 > 0$ and $\phi_2 > 0$. The motivation for this function and parameter value choice is twofold. First, the transfer scheme in our model is closely interlinked with fiscal debt. A look at the government's budget constraint unveils the channel: a rise in the real interest rate increases today's debt burden $r_t B_Y$ and triggers an instant fiscal adjustment in the form of fewer lump-sum transfers. Hence, $\phi_1 > 0$. If the rate change happens in the future instead, the government does not immediately adjust its transfers because the higher interest payments on outstanding debt are in the future. This story mirrors the considerations in Kaplan et al. (2016).

Second, following a shock to the real rate, it seems natural to assume that the government will adjust transfer payments to stabilize income and consumption of hand-to-mouth agents over time. It does so to offset the fluctuations in output y_t so that transfers act here as an automatic stabilizer and $\phi_2 > 0$.[13] This setup is similar to the countercyclical transfer scheme proposed by Gerke et al. (2020).

Combined with the aggregate consumption Euler equation (5), the transfer rule (9) can be rewritten as

$$t_t^H = -\phi_1 \frac{1-\lambda\chi}{\Upsilon}\, r_t B_Y + \phi_2 \frac{\sigma(1-\lambda)}{\Upsilon} \sum_{k=0}^{\infty} \mathbb{E}_t r_{t+k} \ ,$$

where

$$\Upsilon \equiv 1 - \lambda\chi + \phi_2\lambda \ .$$

[13] See, among others, McKay and Reis (2016) for an example of a theoretical model that studies the implications of automatic fiscal stabilizers for the business cycle.

Plugged into the equation for consumption inequality (6), we get

$$\Phi_t = \frac{\phi_1}{\Upsilon} r_t B_Y - \sigma \left[\frac{1-\chi}{1-\lambda\chi} + \phi_2 \frac{1-\lambda}{(1-\lambda\chi)\Upsilon} \right] \sum_{k=0}^{\infty} \mathbb{E}_t r_{t+k} \ .$$

We are now interested in how much inequality changes if the central bank announces a one-time change in the real interest rate that is going to happen either today at $\mathcal{T} = 0$ (conventional monetary policy shock) or $\mathcal{T} > 0$ periods from now (forward guidance shock). As described in the model outline, the central bank implements such monetary policy by setting a perfectly credible path for the real interest rate: it keeps the real rate at its steady-state value prior to $\mathcal{T}$ (i.e., $r_t = 0$ in log-linear terms) and follows an exogenously given rule with some persistence ρ after that (i.e., $r_t = \rho^{t-\mathcal{T}} \varepsilon_{\mathcal{T}}$).

Evaluating the last equation above at time 0, the response of inequality *on impact* of a conventional monetary policy and a forward guidance shock is

$$\frac{\partial \Phi_0}{\partial r_{\mathcal{T}}} = \begin{cases} \frac{\phi_1}{\Upsilon} B_Y + \sigma \left[\frac{\chi-1}{1-\lambda\chi} - \phi_2 \frac{1-\lambda}{(1-\lambda\chi)\Upsilon} \right] \frac{1}{1-\rho}, & \mathcal{T} = 0 \\ \sigma \left[\frac{\chi-1}{1-\lambda\chi} - \phi_2 \frac{1-\lambda}{(1-\lambda\chi)\Upsilon} \right] \frac{1}{1-\rho}, & \mathcal{T} > 0 \end{cases}$$

We can notice a few points. First, if bonds are in zero net supply ($B_Y = 0$) or transfers to constrained agents are not directly linked to debt ($\phi_1 = 0$), inequality will respond by exactly the same amount regardless of when the policy shock happens. This stresses not only the importance of the debt burden and any fiscal adjustment for the response of households, but also for the role of income sensitivity.

Second, given conventional values for σ, λ, and ρ, the sign and magnitude of the inequality response is determined by the three key parameters χ, ϕ_1, and ϕ_2. Drawing on Proposition 1, we can determine in which cases our proposed transfer function will be able to replicate the cyclical behavior of inequality found in the data. The following proposition summarizes the necessary condition, which is derived in Appendix B.5.

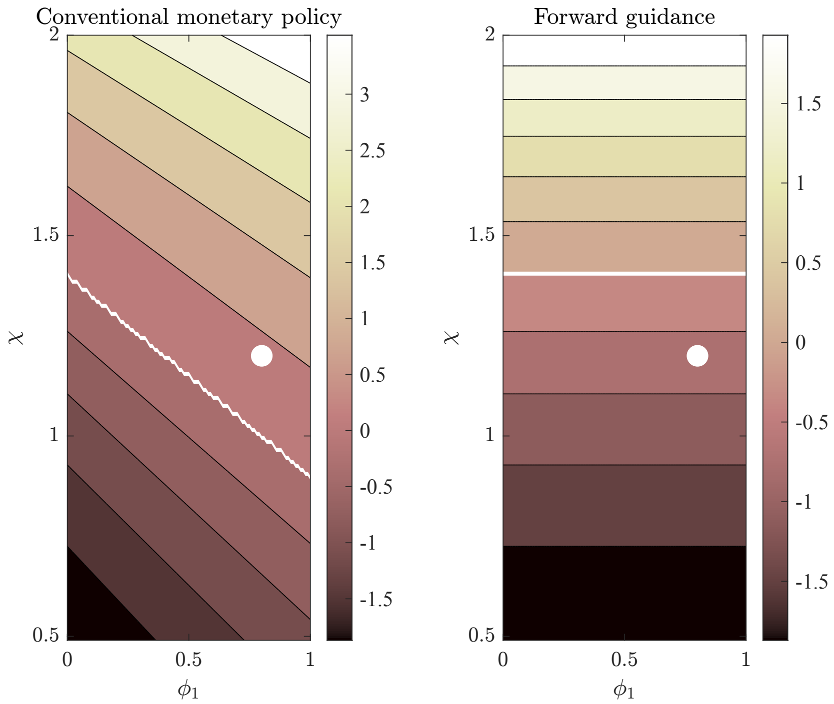
Proposition 2 (Opposed cyclicality of inequality for particular transfer)**.** *Given a transfer function of the form $t_t^H = -\phi_1 r_t B_Y - \phi_2 y_t$, the consumption inequality response on impact of a shock is countercyclical for conventional monetary policy and, at the same time, procyclical for forward guidance, if the following condition holds:*

$$-\phi_1 \frac{(1-\rho)}{\sigma} B_Y + \phi_2 < \chi - 1 < \phi_2 \ .$$

Proof. See Appendix B.5. ■

Figure 4 depicts graphically how the three parameters influence the cyclicality of income. The heat map reports the contemporaneous responses of consumption inequality for different combinations of χ and ϕ_1 to a conventional monetary policy shock (left panel) and a forward guidance shock (right panel). Positive and negative responses are separated by the white line. ϕ_2 is kept fixed at 0.4 and the white dots mark the parameter values that we use as a baseline to compute the dynamic responses in the analytical TANK model ($\phi_1 = 0.8$, $\chi = 1.2$).

Figure 4: Sensitivity of the inequality response to redistribution and transfers



Notes: These heat maps show the response of inequality on impact of a conventional monetary policy and a forward guidance shock, respectively, for different combinations of χ (the elasticity of the constrained household's income to aggregate income) and ϕ_1 (the coefficient on debt burden in the constrained agent's transfer function). The bars next to each plot label the colors, where values above (below) zero refer to a positive (negative) inequality response. The white line indicates the threshold with zero inequality response. The white dots mark the parameter values implied by the baseline calibration (see Table 2).

As recognizable from equation (3), the higher the value of χ the stronger the elasticity of hand-to-mouth agents' income to total income. In line with Bilbiie (2020), this implies that consumption inequality reacts more positively under both contractionary conventional monetary policy and forward guidance.

Similarly, the responsiveness of consumption inequality is increasing in ϕ_1 under conventional monetary policy. This is due to the fact that the amount of transfers the constrained agents receive is proportional to the debt burden. Under forward guidance, the interest rate hike happens only in the future so that there is no contemporaneous increase in the debt burden. Therefore, the value of ϕ_1 plays no role in this case.

Looking at the sign of the responses, we can notice that the higher the value of ϕ_1 under conventional monetary policy the lower χ can be to still achieve a positive response of inequality. Comparable empirical evidence from Auclert (2019) and Patterson (2022) suggests a value of $\chi > 1$, which implies $\tau^D < \lambda$ in our model. In that case, constrained agents get a proportion of profits that is numerically below their share in the population. However, their individual income reacts disproportionately more to changes in aggregate income, which ensures that consumption inequality responds countercyclically. Conversely, assuming $\chi < 1$ would require an extremely high ϕ_1, far above one for an otherwise standard calibration. Constrained agents would get a relatively high share of profits compared to savers. To ensure that the two individual incomes do not diverge too much, transfers would therefore need to be more sensitive to changes in debt. Finally, note that if hand-to-mouth agents are too sensitive to changes in aggregate income (i.e., χ is very large), then inequality is countercyclical under both monetary policy regimes regardless of the value of ϕ_1.[14]

In the next step, we can study the *dynamic* response of inequality after a one-time unexpected monetary shock with some exogenous persistence. Assume that the central bank either rises the real rate today by 25 basis points (i.e., $\varepsilon_0 = 0.0025$) or promises an increase of the same size in two years from now (i.e., $\varepsilon_8 = 0.0025$). Figure 5 shows the main impulse responses to these shocks under a standard set of parameter values. More details on the calibration and the remaining impulse responses can be found in Appendices B.6 and B.7, respectively.

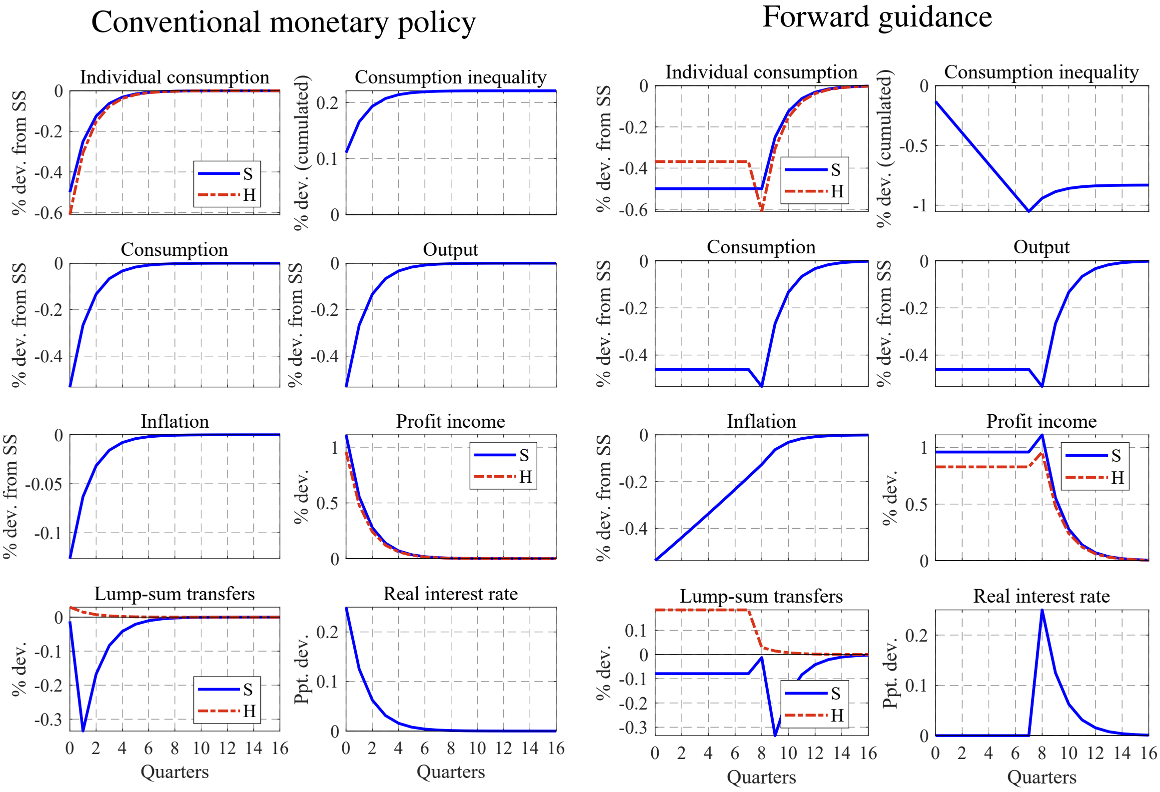
Both monetary regimes lead to a comparable decrease in aggregate consumption and output on impact of each shock. In contrast, inflation shows a stronger decline after forward guidance. This comes from the permanently lower marginal costs in the periods up to the real rate change, which affects prices through the forward-looking nature of the Phillips curve.

The amount of profits redistributed is such that the individual consumption responses are similar. On top of that, due to the automatic stabilizer component of the transfer rule (9), the government partially offsets the decrease in consumption experienced by the hand-to-mouth agents by increasing the amount of resources transferred to them and letting the savers pay more for the recession.

However, only the contemporaneous increase in the real interest rate (left panel of Figure 5) leads to a higher debt burden on impact. Under forward guidance (right panel of Figure 5), the interest rate change happens in the future and so does the adjustment in transfers owed to the component related to changes in the debt burden. What remains is only the cyclical part of

[14] Appendix B.7 contains an alternative heat map in which the weight on the cyclical component in the transfer rule (9) is set higher. That setup implies then a relatively higher value for χ to replicate the empirical results on the cyclicality of income.

Figure 5: Impulse responses to monetary policy shocks: Analytical TANK model



Notes: This figure depicts selected impulse responses for the analytical TANK model to a 25-basis-points increase in the contemporaneous real interest rate (left panel) or in the real rate eight quarters in the future (right panel). Responses of profit income and transfers are in deviations from their steady-state levels, relative to steady-state output. Plots with two lines show the results for savers (S) and hand-to-mouth agents (H).

lump-sum transfers which leads to a stronger reaction of the latter.[15] Once the announced real rate change actually occurs, hand-to-mouth agents will cut back their consumption slightly more because of the suspended transfers from the government. The difference in magnitude and timing of the fiscal response is such that the consumption of hand-to-mouth agents decreases relatively more than the one of savers under conventional monetary policy, but proportionally less under forward guidance. Eventually, this leads to a consumption inequality increase for the former and a decrease for the latter.

Overall, the key elements for the model to achieve the cyclicality of inequality observed in the data are the redistribution of profits and the timing and magnitude of the fiscal adjustment. The consumption of hand-to-mouth agents is always more sensitive to any type of monetary

[15] Note that the relatively small response of transfers to constrained agents after conventional monetary policy arises from the relatively higher weight on the debt burden in the transfer function ($\phi_1 = 0.8$) compared to the weight on output ($\phi_2 = 0.4$), which overall leads to a downward pressure on these transfers. This situation hinges on the choice of the calibration values. The key point is that the presence of the cyclical component avoids that hand-to-mouth agents have negative transfers (i.e., pay taxes) during a recession.

shock. However, everything else equal, the profit redistribution scheme and the presence of countercyclical profits make the consumption responses of the two household types close enough such that the fiscal response determines the sign of the inequality response.

5.4 Fully-fledged two-asset TANK model with investment

The analytical TANK model has shown that a combination of profit and lump-sum transfer redistribution is able to replicate the cyclicality of consumption inequality found in the data. To evaluate whether this finding still holds in a more complex setup, we implement our mechanism now into a widely used framework of the heterogeneous-agent literature: the model by Kaplan et al. (2018). We focus on the two-agent version of their benchmark HANK model to make it more comparable to our analytical model. Such a framework comprises the well-known channels of standard HANK models but is still tractable enough to examine the underlying transmission mechanisms. In fact, the model presented in section 5.1 can be seen as a simplified two-agent version of the fully-fledged HANK model in Kaplan et al. (2018). See Appendix C for a full description of the model and further explanations about the differences between our setup here and Kaplan et al. (2018). Furthermore, the appendix outlines the calibration values and comprises additional impulse responses not shown hereafter.

5.4.1 Model outline

The two major features that are added to the analytical TANK model are a multiple-asset structure and investment. Unconstrained households can save in two types of assets with different degrees of liquidity. There is a liquid asset with a low return, similar to the one-period government bond of the simple model.[16] In addition, there is a high-return illiquid asset. Deposits into or withdrawals from an agent's illiquid account are subject to a transaction cost. Yet each saver can invest their illiquid savings either into capital or into equity shares. Capital is used by monopolistically competitive producers, together with labor provided by individual households, to manufacture intermediate goods.[17] Shares figure as a claim to a fraction of intermediate firms' profits. That part is reinvested directly into the illiquid account, while the remaining fraction of profits is paid lump-sum to the savers' liquid account.

Finally, the two main instruments of fiscal policy are modeled as before. Savers pay taxes on monopolistic firms' total profits and the revenue is redistributed as a transfer to

[16]Besides short-term government bonds, liquid assets are understood as also comprising deposits in financial institutions and corporate bonds. On the other hand, the illiquid asset class captures elements like housing, consumer durables, and equity.

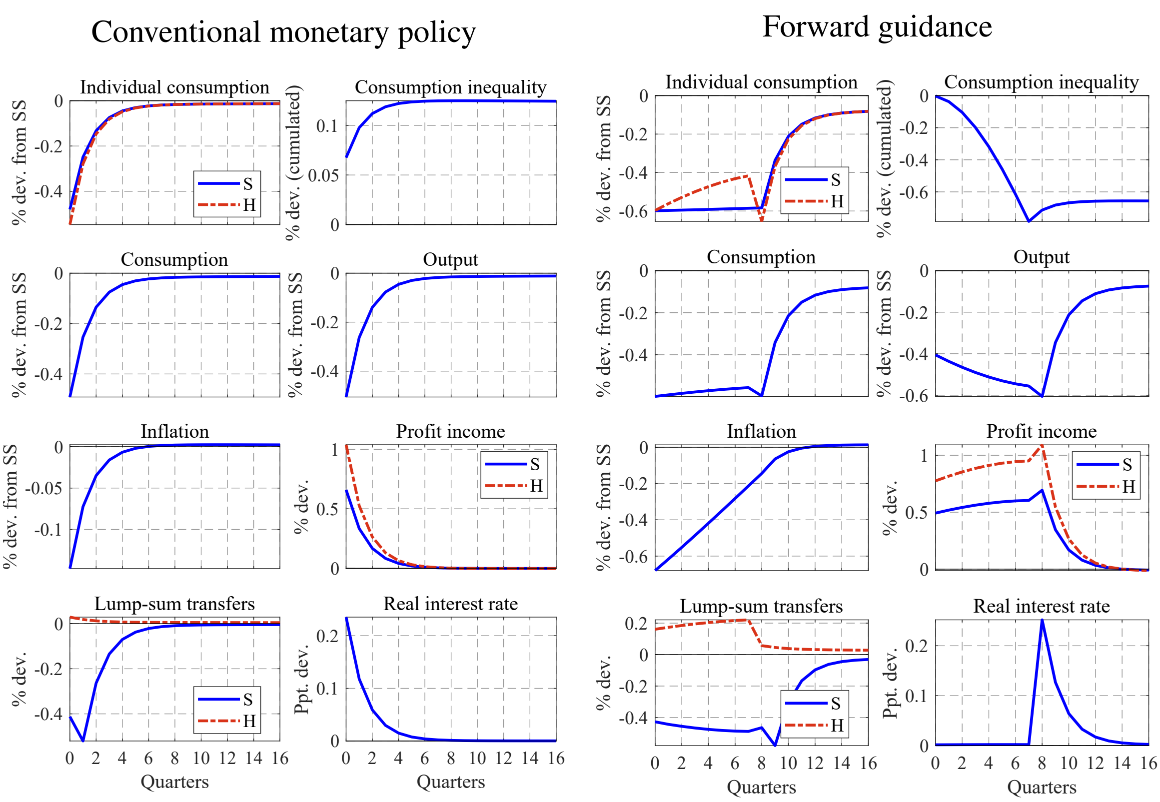
[17]The distinct labor earnings of each household type are now taxed by the government at a proportional rate.

hand-to-mouth agents. Second, the government runs a transfer scheme in which transfers to constrained agents depend on the amount of interest payments on outstanding debt and also contains an automatic stabilizer part.

5.4.2 Impulse responses for the extended model

Equivalent to the simple TANK model, suppose now a 25 basis points increase in the real interest rate, either today or eight quarters from now. Figure 6 shows the main impulse responses to these two shocks. Both the positive monetary policy and the forward guidance shock decrease consumption, output, and inflation on impact, where the latter sees again a stronger drop after forward guidance due to persistently lower marginal costs. The drop in consumption for the hand-to-mouth agents is partially offset by profit redistribution and the fiscal adjustment through transfers.

Figure 6: Impulse responses to monetary policy shocks: Fully-fledged TANK model



Notes: This figure depicts selected impulse responses for the extended TANK model to a 25-basis-points increase in the contemporaneous real interest rate (left panel) or in the real rate eight quarters in the future (right panel). Responses of profit income and transfers are in deviations from their steady-state levels, relative to steady-state output. Plots with two lines show the results for savers (S) and hand-to-mouth agents (H).

As before, the government's response varies between the two policy regimes. After a contemporaneous change in the real rate, both components of the transfer function – i.e., the automatic stabilizer and the debt burden parts – react to the shock. However, only the first component is affected by a positive forward guidance shock, leaving us with countercyclical lump-sum transfers that are higher for hand-to-mouth agents.

The difference in timing and magnitude of the fiscal response leads to the heterogeneous responses of inequality under conventional monetary policy and forward guidance. The consumption of hand-to-mouth agents decreases relatively more under the former and proportionally less under the latter. Therefore, consumption inequality is countercyclical in the first case and procyclical in the second case, in line with the empirical evidence we provide.

Overall, the findings from the fully-fledged two-asset TANK model are consistent with those of the analytical TANK model, not only in terms of the sign and shape of the macroeconomic and consumption inequality responses, but largely also in magnitudes. It seems that the additional model elements (illiquid asset and investment) has only a negligible impact in this respect. Yet this might clearly change with a different calibration of the main model parameters.

6 Policy implications

In this section, we discuss some policy implications that can be drawn from our empirical and theoretical findings. First of all, our results call for better coordination between monetary and fiscal entities. The activities of central banks and governments are deeply intertwined and they clearly need to act independently of each other. However, more coordination might be beneficial to limit any negative second-order effects arising from changes in interest rates, such as an increase in consumption inequality.

Second, our empirical evidence suggests that the governments might not be fully able to understand the macroeconomic consequences of some monetary policy so their (fiscal) response might not be appropriate. In the specific case we study, in response to a forward guidance announcement, the government does not adjust the debt component of the transfers like under conventional monetary policy because the interest rate hike happens in the future. Therefore, the contemporaneous effects this policy might have due to changes in expectations and indirect channels are underestimated. It follows that the central bank should better communicate the expected aggregate impacts of its policies such that they can be internalized in the government's decision-making process.

Third, the governments should design their transfer schemes in a way that they are able to more flexibly and optimally adapt to different monetary regimes and policy tools. Rather than strongly focusing on the debt burden, more importance should be given to the ongoing macroeconomic conditions, while the target should be the support of an adequate expenditure level of households at the bottom of the consumption, income, or wealth distributions. In the theoretical framework we propose, this corresponds to an increase in ϕ_2 (the transfer rule weight on the business cycle) relative to ϕ_1 (the weight on the debt burden).

These policy recommendations can be applied to the high-inflation environment we are currently experiencing. To reduce the increase in price growth, central banks have started to tighten their monetary policy by increasing their interest rates. This will lead to a severe contraction in the aggregate economy. Our results suggest that to some extent the government's response determines whether inequality will increase. The fiscal authority can prevent this by implementing sizable transfer schemes in favor of the most financially constrained households instead of, for instance, adjusting tax rates regressively.

7 Conclusion

The interaction between monetary policy and household heterogeneity is at the core of the modern macroeconomic research agenda. Both from a theoretical and empirical perspective, it has been shown that heterogeneity in terms of, for instance, asset market participation or homeownership affects the way shocks propagate to the economy. At the same time, monetary shocks heterogeneously impact the economic agents' decisions. However, there is still limited empirical evidence regarding the distributional effects that the various monetary policies might have.

This paper estimates the macroeconomic and distributional impact of conventional monetary policy and forward guidance. We compute a measure of consumption inequality from household-level expenditure data and include it in a SVAR model. The two monetary policies are identified using the factors extracted by Swanson (2021) from high-frequency surprises in assets prices. We find that the aggregate effects for both policies are similar in magnitude and shape. However, consumption inequality is countercyclical under conventional monetary policy and procyclical under forward guidance.

We offer an explanation for this empirical finding within a standard New Keynesian model with heterogeneous households. The key element is the fiscal response in the form of lump-sum transfers that depend on the government's debt burden and the business cycle. The timing of the interest rate change matters for the government's debt burden and thus results in fiscal adjustments differing in timing and magnitude for the two monetary policies. This ultimately results in opposite responses of consumption inequality to conventional monetary policy and forward guidance.

Our findings suggest that, from an aggregate point of view, an interest rate policy or announcements about the future stance of monetary policy have similar effects. However, it is critical that the monetary authority coordinates with the fiscal side of the economy to avoid potential adverse side effects. The extent of the fiscal response to the central bank's activity determines whether inequality increases or not.

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A Robustness checks for the empirical analysis

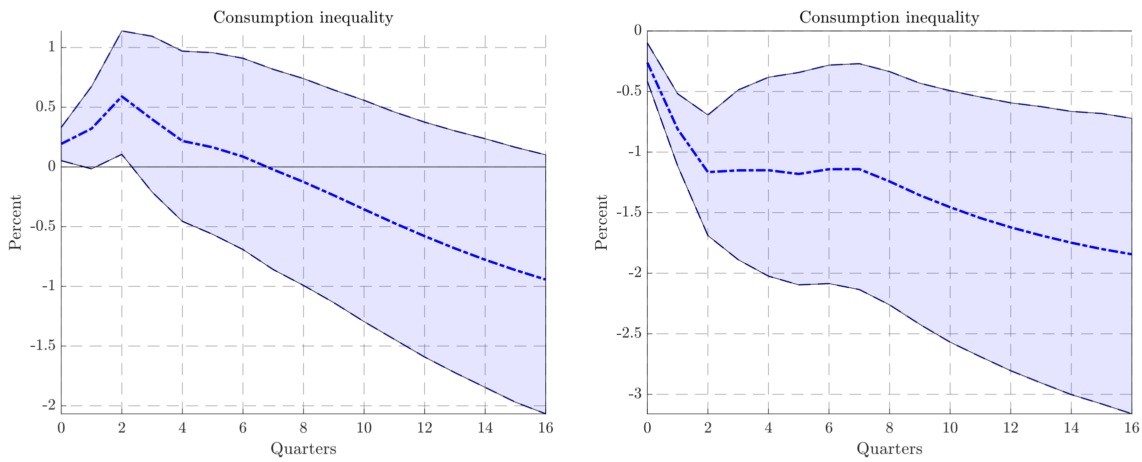
In order to strengthen the validity of our findings in section 4, we present here some sensitivity analysis in the form of alternative empirical model specifications. First, we use the Gini coefficient of real consumption as an alternative measure of consumption inequality. Second, we use the same empirical model as Bundick and Smith (2020) to study the effects of forward guidance shocks. Third, we adopt a series of alternative measures of conventional monetary policy and forward guidance shocks: the factors from Swanson (2021) cleaned by using the procedures proposed by Miranda-Agrippino and Ricco (2021), the raw and cleaned factors from Gürkaynak et al. (2005) and the cleaned path factor from Lakdawala (2019).

A.1 Alternative inequality measures

We start by showing that the choice of the measure of consumption inequality plays no role in our results. In the main analysis, we measure inequality with the cross-sectional standard deviation of real consumption across households. Alternatively, we can compute the Gini coefficient of the cross-sectional distribution of household-level real consumption.

Figure 7: Consumption inequality responses to monetary policy shocks: Gini

Conventional monetary policy | Forward guidance



Notes: This figure depicts the cumulated impulse responses of consumption inequality to a one-standard-deviation increase in the target factor (left panel) and the path factor (right panel) from Swanson (2021), respectively. Consumption inequality is measured by the Gini coefficient of the cross-sectional distribution of household-level real consumption. Impulse responses are from a SVAR model computed at quarterly frequency using aggregate-level and inequality data for the period 1991Q3-2019Q2. Shaded areas represent the 68% confidence intervals.

Figure 7 shows that the sign of each consumption inequality response is unaffected: contractionary monetary shocks increase inequality whereas forward guidance shocks decrease it.[18]

A.2 SVAR specification from Bundick and Smith (2020)

We compare our findings from the SVAR model with a similar specification used in the literature. Bundick and Smith (2020) evaluate the effect of a forward guidance shock on the economy in a structural VAR with a recursive identification scheme. The variables included in the VAR are the real GDP, a proxy for real equipment investment, capacity utilization, the GDP deflator, the cumulative sum of the path factor, and the 2-year Treasury yield. The authors assume that macroeconomic conditions adjust slowly to changes in expected policy rates but financial markets may respond immediately. They order therefore the forward guidance shock measure after real activity and the price level but before the 2-year Treasury yield. Finally, Bundick and Smith (2020) use the pre-zero lower bound period as a pre-sample to form the priors for the VAR parameters during the zero lower bound period (although uninformative priors lead to similar results).

We compute the impulse responses to path factor shock from the same VAR specification, with the same controls and the same measure of forward guidance. The only differences are that the VAR is computed at quarterly frequency and that we add our baseline measure of consumption inequality.

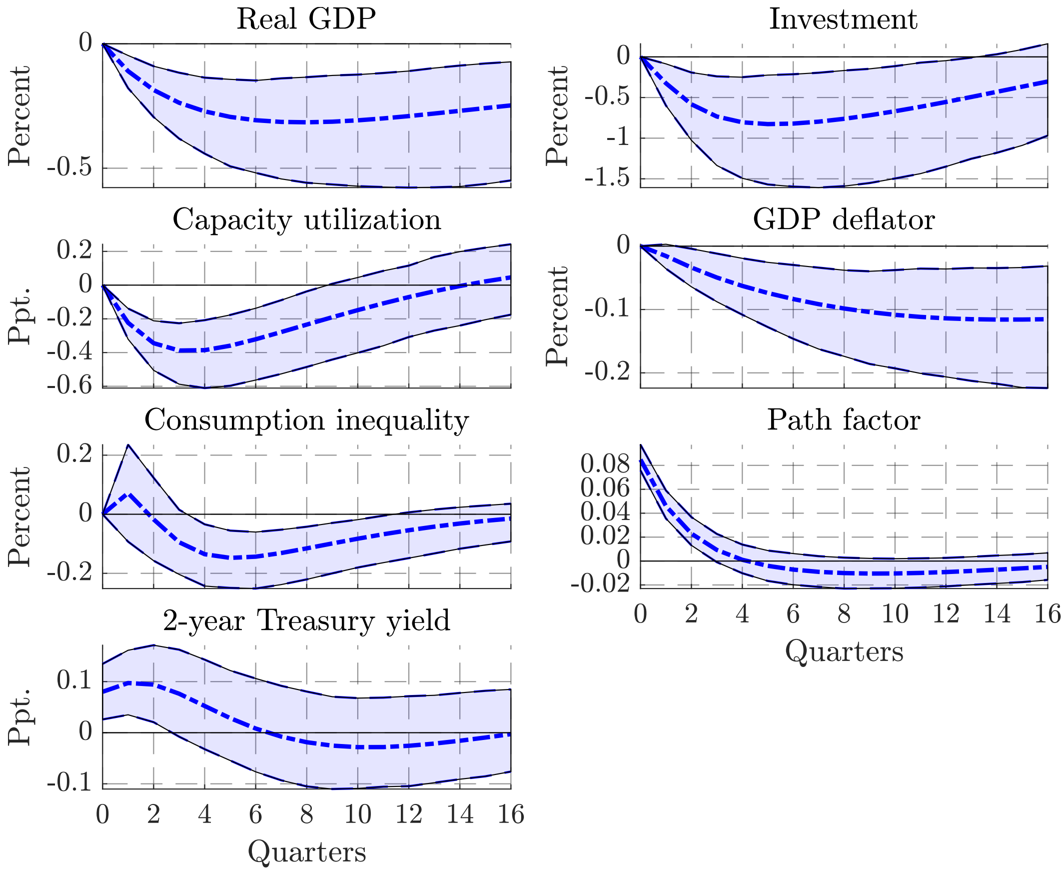
The results are reported in Figure 8. The responses of the macroeconomic variables are similar to those obtained by Bundick and Smith (2020). An increase in the path factor leads to a decrease in output, investment, capital utilization, and the price level. In line with the results from our baseline analysis, consumption inequality significantly decreases in response to forward guidance.

A.3 Swanson (2021): Cleaned FFR factor

Central banks and market participants have different information about the state of the economy. Due to this asymmetry, market participants try to infer the potential superior information that the policymakers might have through its policy actions (e.g., a change in policy rate). Therefore, as shown by Miranda-Agrippino and Ricco (2021), raw monetary policy surprises tend to include both the true policy shock as well as an information component

[18] The impulse responses of the macroeconomic variables are basically unaffected by the choice of the inequality measure. So for ease of exposition, we only show the inequality responses.

Figure 8: Impulse responses to a forward guidance shock: Bundick and Smith (2020) approach

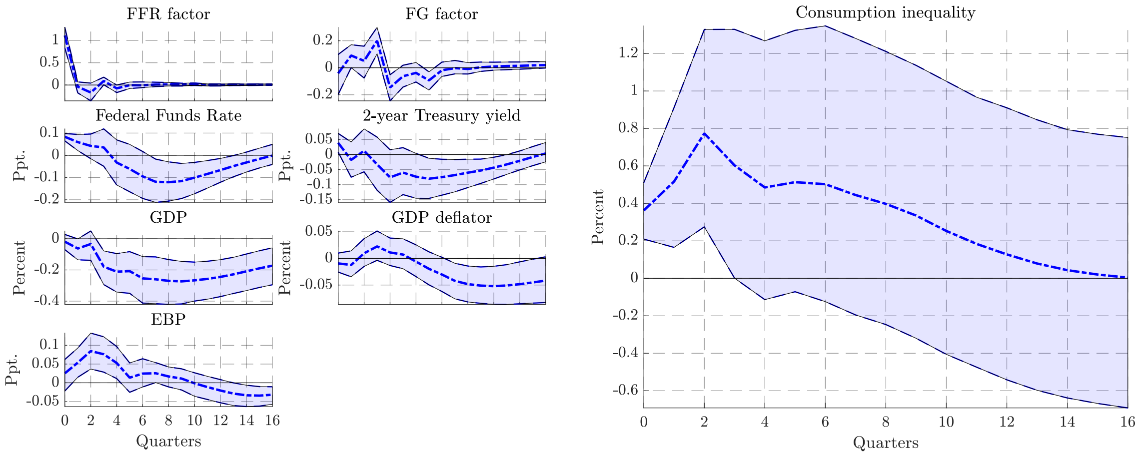


Notes: This figure depicts the impulse responses to a one-standard-deviation increase in the path factor from Bundick and Smith (2020). Consumption inequality is measured by the cross-sectional standard deviation of household-level real consumption. Impulse responses are computed at quarterly frequency using aggregate-level and inequality data for the period 1994Q1-2015Q4. Shaded areas represent the 90% confidence interval.

about fundamentals of the economy. This signaling effect of monetary policy can give rise to empirical puzzles.

To correct for the presence of information friction in our target factor, we adopt the approach proposed by Miranda-Agrippino and Ricco (2021) and Degasperi and Ricco (2021). In particular, we isolate the pure monetary shocks which are orthogonal to both the central bank's economic projections and to past market surprises by regressing the target factor from Swanson (2021) on the Greenbook forecasts and forecast revisions for real output growth, inflation (measured as the GDP deflator), and the unemployment rate. The residuals of the regression are the exogenous and unpredictable component of the monetary surprises since we control for the central bank's private information and hence for the central bank information channel. Since the Greenbook forecasts are published after a five-year lag, the most recent data series stops in 2016Q4.

Figure 9: Impulse responses to the cleaned target factor from Swanson (2021)



Notes: This figure depicts the impulse responses of macroeconomic variables (left panel) and the cumulated impulse response of consumption inequality (right panel) to a one-standard-deviation increase in the cleaned target factor from Swanson (2021). Consumption inequality is measured by the cross-sectional standard deviation of household-level real consumption. Impulse responses are from a SVAR model computed at quarterly frequency using aggregate-level and inequality data for the period 1992Q3-2016Q4. Shaded areas represent the 68% confidence interval.

Figure 9 reports the responses of the aggregate variables and consumption inequality to the cleaned target factor. Using the cleaned measure in the SVAR does not change the fact that the response of inequality is countercyclical under conventional monetary policy. Apart from that, results are much in line with the baseline results, except for the 2-year Treasury yield which turns negative almost on impact of the shock.

A.4 Gürkaynak et al. (2005): Raw and cleaned factors

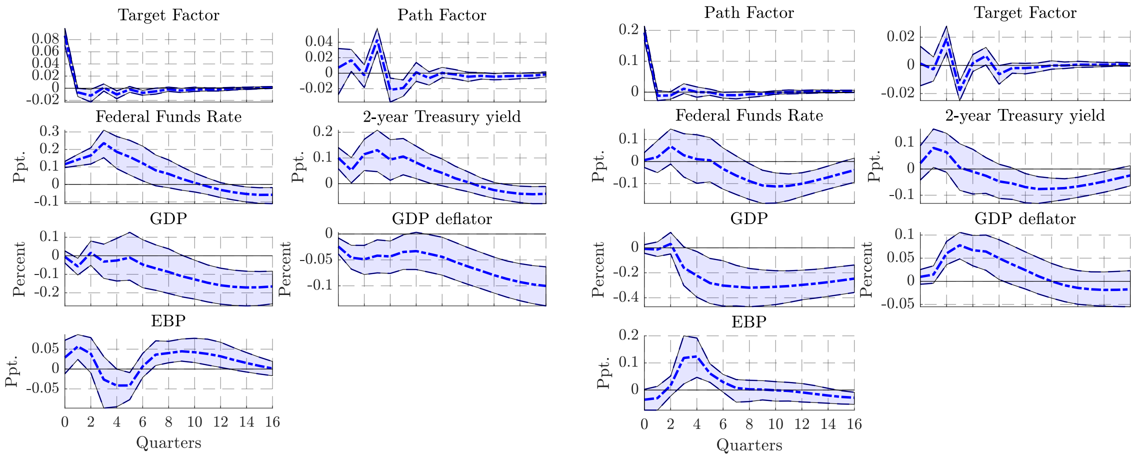
As an alternative measure of conventional monetary policy and forward guidance, we use the two factors (target and path) computed by Gürkaynak et al. (2005), which we extend to 2019.

Figure 10 reports the impulse responses to the two policy shocks. Similarly to the baseline specification with the Swanson (2021) factors, following a contractionary shock GDP and inflation decrease whereas EBP increases although the responses are less statistically significant. After a forward guidance shock, GDP decreases but inflation shows a price puzzle similar to the baseline model.

The corresponding consumption inequality responses are shown in Figure 11. The results are consistent with the main results presented in Section 4. An increase in the target factor rises inequality whereas an increase in the path factor decreases it.

Figure 10: Macroeconomic responses to the Gürkaynak et al. (2005) factors

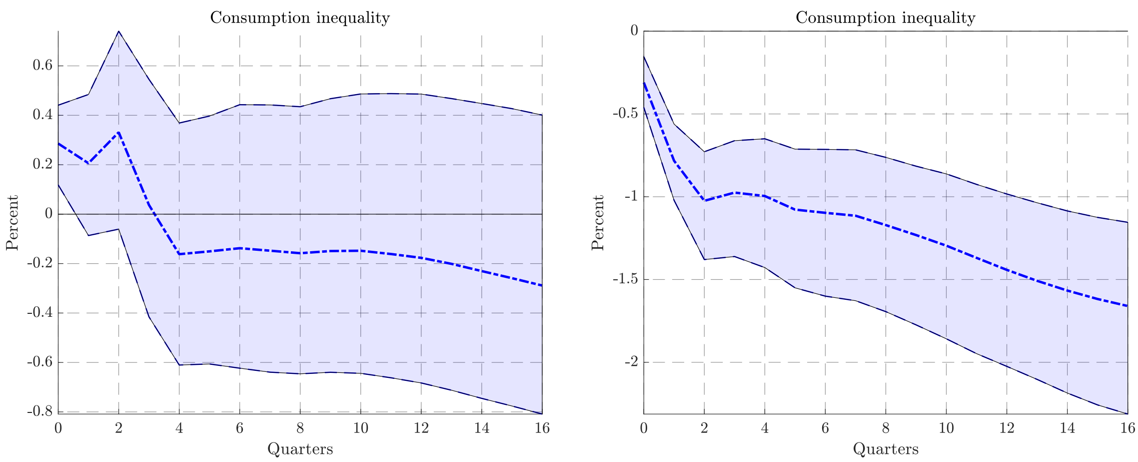
Conventional monetary policy | Forward guidance



Notes: This figure depicts the impulse responses of macroeconomic variables to a one-standard-deviation increase in the target factor (left panel) and the path factor (right panel) from Gürkaynak et al. (2005), respectively. Consumption inequality is measured by the cross-sectional standard deviation of household-level real consumption. Impulse responses are from a SVAR model computed at quarterly frequency using aggregate-level and inequality data for the period 1991Q1-2016Q4. Shaded areas represent the 68% confidence interval.

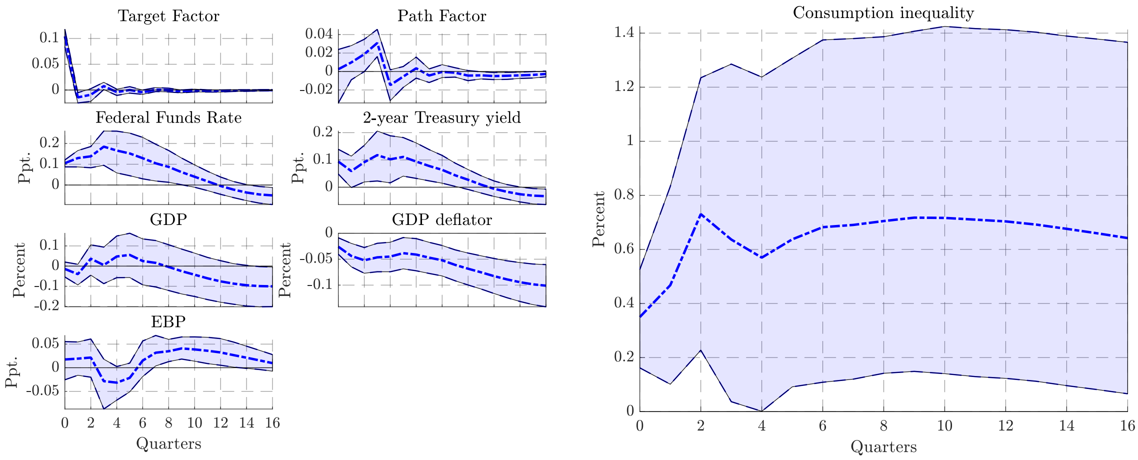
Figure 11: Consumption inequality responses to the Gürkaynak et al. (2005) factors

Conventional monetary policy | Forward guidance



Notes: This figure depicts the cumulated impulse responses of consumption inequality to a one-standard-deviation increase in the target factor (left panel) and the path factor (right panel) from Gürkaynak et al. (2005), respectively. Consumption inequality is measured by the cross-sectional standard deviation of household-level real consumption. Impulse responses are from a SVAR model computed at quarterly frequency using aggregate-level and inequality data for the period 1991Q1-2016Q4. Shaded areas represent the 68% confidence interval.

Figure 12: Impulse responses to the cleaned target factor from Gürkaynak et al. (2005)



Notes: This figure depicts the impulse responses of macroeconomic variables (left panel) and the cumulated impulse response of consumption inequality (right panel) to a one-standard-deviation increase in the cleaned target factor from Gürkaynak et al. (2005). Consumption inequality is measured by the cross-sectional standard deviation of household-level real consumption. Impulse responses are from a SVAR model computed at quarterly frequency using aggregate-level and inequality data for the period 1991Q1-2016Q4. Shaded areas represent the 68% confidence interval.

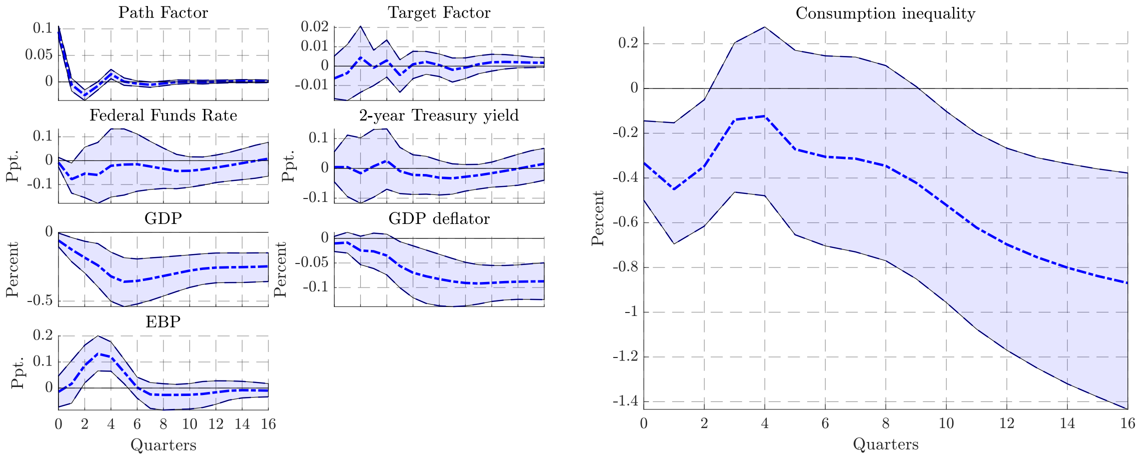
To remove the information component, we adopt the cleaning approach proposed by Miranda-Agrippino and Ricco (2021) on the target factor computed by Gürkaynak et al. (2005) as well. The responses are reported in Figure 12. Our main findings hold also under this alternative specification.

A.5 Lakdawala (2019): Cleaned path factor

Lakdawala (2019) proposes a different approach to remove from the factors any component that is capturing the release of private information by the Federal Reserve. The author uses the residuals from a regression where the factors are the dependent variable and controls for the Federal Reserve as well as the market information sets are included. In particular, the Greenbook dataset is used to capture the Federal Reserve's forecasts and the consensus forecasts from the Blue Chip survey is used as an indicator of the market's expectations. The main idea is that the difference between the Greenbook forecasts and the Blue Chip forecasts can be considered as a measure of Federal Reserve private information. The cleaned measures are available from 1991Q1 to 2011Q4.

The responses from the SVAR with the cleaned path factor from Lakdawala (2019) as exogenous variables are reported in Figure 13. Once the information component is removed from the factor, both GDP and inflation decrease after a contractionary forward guidance shock.

Figure 13: Impulse responses to the cleaned path factor from Lakdawala (2019)



Notes: This figure depicts the impulse responses of macroeconomic variables (left panel) and the cumulated impulse response of consumption inequality (right panel) to a one-standard-deviation increase in the cleaned path factor from Lakdawala (2019). Consumption inequality is measured by the cross-sectional standard deviation of household-level real consumption. Impulse responses are from a SVAR model computed at quarterly frequency using aggregate-level and inequality data for the period 1991Q1-2011Q4. Shaded areas represent the 68% confidence interval.

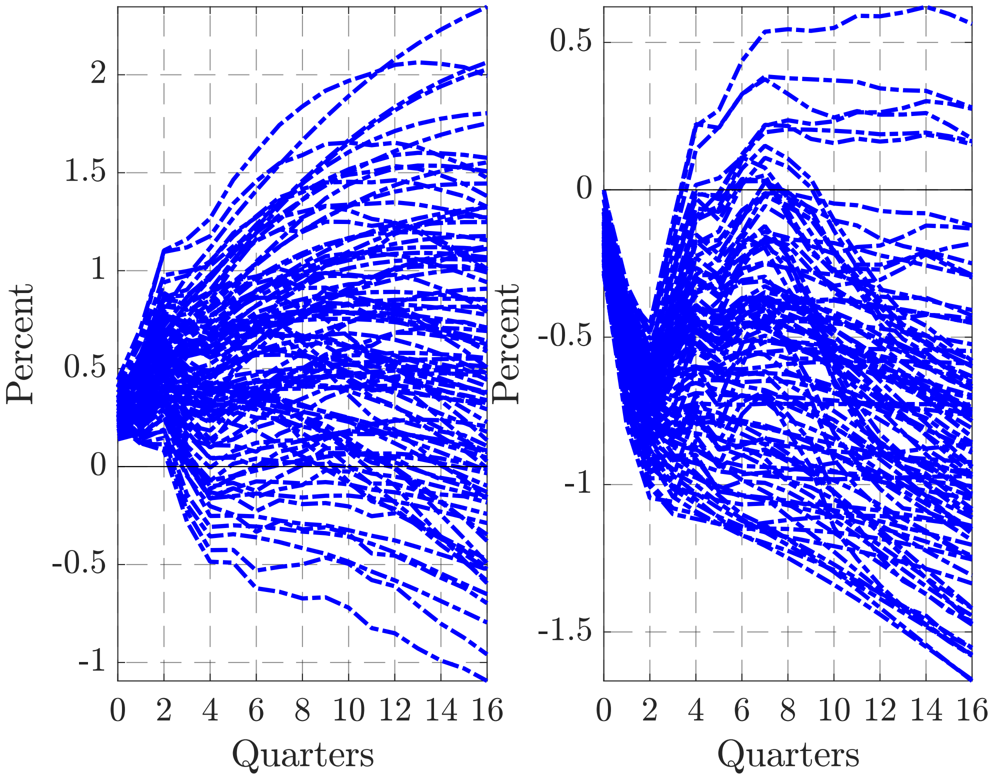
On top of that, the shock results in procyclical consumption inequality, again confirming our baseline results.

A.6 Additional robustness checks

As a final sensitivity analysis, we evaluate if alternative specifications in terms of variables used in the VAR or the selected lag length do significantly affect our main result. We compute the consumption inequality responses to conventional monetary policy and forward guidance shocks for all the possible combinations of the Swanson (2021) and the Gürkaynak et al. (2005) factors with either GDP or industrial production as real activity variable, either GDP deflator or CPI as price variable, either the Federal Funds Rate or the 1-year Treasury yields short-term interest rate variable, either including EBP in the VAR or not, and lag lengths from 2 to 4 lags. The nearly 100 impulse responses are reported in Figure 14.

The combination of variables and lags chosen clearly influence the shape and magnitude of the inequality responses to the two monetary policies. However, the majority of simulations point to countercyclical (procyclical) inequality after monetary policy (forward guidance). Even more relevant appears that conventional monetary policy always leads to a contemporaneous increase in inequality whereas forward guidance always decreases it. This

Figure 14: Consumption inequality responses for various parameter and variable combinations



Notes: This figure depicts the cumulated impulse responses of consumption inequality to a one-standard-deviation increase in the target factor (left panel) and the path factor (right panel) from Swanson (2021), respectively. Consumption inequality is measured by the cross-sectional standard deviation of household-level real consumption. The impulse responses arise from various SVAR models computed for all the possible combinations of the Swanson (2021) and the Gürkaynak et al. (2005) factors with either GDP or industrial production, either GDP deflator or CPI, either the federal funds rate or the 1-year Treasury yield , either including EBP in the VAR or not, and lag lengths from 2 to 4 lags.

finding implies that irrespective of the chosen specification, the main finding in terms of the cyclicality of inequality still holds.

B Analytical TANK model: Derivations

This appendix provides details on the derivations of the simple two-agent model presented in section 5.1 and derives its key analytical expressions. Furthermore, it contains a summary of selected parameter values and additional impulse responses.

B.1 Problem of the intermediate goods producers

The price-setting problem of each intermediate goods producer looks as follows:

$$\max_{\{P_{t+k}(j)\}_{k=0}^{\infty}} \mathbb{E}_t \sum_{k=0}^{\infty} \Lambda_{t,t+k} \left\{ \left[(1+\tau^S) \frac{P_{t+k}(j)}{P_{t+k}} - MC_{t+k} \right] Y_{t+k}(j) - \Theta_{t+k}(j) - T^F_{t+k} \right\}$$

$$\text{subject to} \quad Y_{t+k}(j) = \left(\frac{P_{t+k}(j)}{P_{t+k}} \right)^{-\epsilon} Y_{t+k}$$

$$\Theta_{t+k}(j) = \frac{\theta}{2} \left(\frac{P_{t+k}(j)}{P_{t+k-1}(j)} - 1 \right)^2 Y_{t+k} \ ,$$

where $\Lambda_{t,t+k} = (\beta^S)^k \left(\frac{U^S_{c,t+k}}{U^S_{c,t}} \right)$ is the stochastic discount factor for payoffs in period $t+k$. The optimality condition of this problem is

$$\mathbb{E}_t \Bigg\{ \Lambda_{t,t} \Bigg[\left(1+\tau^S\right) (1-\epsilon)\, P_t(j)^{-\epsilon}\, P_t^{\epsilon-1}\, Y_t + MC_t\, \epsilon\, P_t(j)^{-\epsilon-1}\, P_t^{\epsilon}\, Y_t$$

$$- \theta \left(\frac{P_t(j)}{P_{t-1}(j)} - 1 \right) \frac{Y_t}{P_{t-1}(j)} \Bigg] + \Lambda_{t,t+1}\, \theta \left(\frac{P_{t+1}(j)}{P_t(j)} - 1 \right) \frac{P_{t+1}(j)}{P_t(j)^2}\, Y_{t+1} \Bigg\} = 0 \ .$$

Note that in steady state, if adjustment costs are zero ($\theta = 0$), the last expression reduces to $MC = (1+\tau^S)\frac{\epsilon-1}{\epsilon}$, so that the optimal subsidy τ^S that induces marginal cost pricing in steady state ($MC = 1$) turns out to be $(\epsilon - 1)^{-1}$.

Since all firms are identical and face the same demand, they will all make the same decisions and set the same price such that $P_t(j) = P_t$ and $Y_t(j) = Y_t = N_t$. Rewriting the last expression then leads to the Phillips curve:

$$(1+\tau^S)(1-\epsilon) + \epsilon MC_t - \theta(1+\pi_t)\pi_t + \mathbb{E}_t \left[\frac{\Lambda_{t+k}}{\Lambda_t}\, \theta(1+\pi_{t+1})\pi_{t+1} \frac{Y_{t+1}}{Y_t} \right] = 0 \ .$$

B.2 Steady state

We consider a steady state with net inflation rate $\pi = 0$, where we normalize output to one by setting $N = 1$ and thus $Y = C = 1$. The Euler equation yields the steady-state real interest rate $r = \beta^{-1} - 1$, which in turn equals the discount rate. We assume that the subsidy on firms' sales is set to its optimal value ($\tau^S = (\epsilon - 1)^{-1}$), which induces marginal cost pricing ($MC = W = 1$) and leads to zero profits ($D = 0$) and thus zero dividend income for households ($\Gamma^S = \Gamma^H = 0$) in steady state. Given a calibrated value for the debt-to-GDP ratio $B_Y \equiv B/Y$, we have $B_Y^S = B_Y/(1-\lambda)$ and, through the government budget constraint, $T_y = -rB_y$. Furthermore, we assume that hand-to-mouth agents only consume their labor income in steady state, so that $T^H = 0$ and that steady-state consumption is the same across household types ($C^H = C^S = C$). This also pins down transfers to savers through $T_Y^S = T_Y/(1-\lambda)$. Finally, the weights on hours worked in the utility function are given by $\varphi^j = W\,(L)^{-\nu}(C^j)^{-1}$ for $j = \{H, S\}$.

B.3 Log-linearized model

The simple TANK model is approximated around the non-stochastic steady state just described before. Table 1 contains the log-linearized equilibrium conditions, where we have already imposed our assumption that debt is constant over time. Small letters denote the log deviation of a variable from its deterministic steady state. Exceptions are profits, transfers, and debt, each of whose deviation from steady state is considered relative to total income $\left(x_t^j = \frac{X_t^j - X^j}{Y} \text{ for } j = \{H, S\}\right)$, and interest and inflation rates which are expressed in absolute deviations from steady state. Finally, we denote steady-state debt as a fraction of aggregate steady-state income by $B_Y \equiv B/Y$.

Table 1: Model overview of the analytical TANK model

Euler equation, S	$c_t^S = \mathbb{E}_t c_{t+1}^S - \sigma r_t$
Budget constraint, S	$c_t^S = \frac{1}{1-\lambda} r_{t-1} B_Y + w_t + l_t + \frac{1-\tau^D}{1-\lambda} d_t + t_t^S$
Budget constraint, H	$c_t^H = w_t + l_t + \frac{\tau^D}{\lambda} d_t + t_t^H$
Labor supply	$\nu l_t = w_t - \sigma c_t$
Real marginal cost	$mc_t = w_t$
Phillips curve	$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \frac{\epsilon}{\theta}\, mc_t$
Production function	$y_t = n_t$
Real profits	$d_t = -mc_t$
Government constraint	$-r_{t-1} B_Y = \lambda t_t^H + (1-\lambda) t_t^S$
Aggregate consumption	$c_t = \lambda c_t^H + (1-\lambda) c_t^S$
Labor market clearing	$n_t = l_t$
Resource constraint	$y_t = c_t$
Fisher equation	$r_t = i_t - \mathbb{E}_t \pi_{t+1}$
Monetary policy	$r_t = \rho^{t-\mathcal{T}} \varepsilon_{\mathcal{T}}\,,\;\; t \geq \mathcal{T}$

Notes: This table summarizes the log-linearized equilibrium conditions for the analytical TANK model. The government's lump-sum transfers to individual households, t_t^h and t_t^S, are specified in the main text.

B.4 Reduced-form model equations for consumption and inequality

This section derives reduced-form expressions for the log-linearized analytical model, namely for individual and aggregate consumption and for inequality. The derivations in the first part resemble the ones in Bilbiie et al. (2020). We develop them further in the main part of the paper and determine the conditions required for any arbitrary transfer function to replicate the cyclical behavior of inequality found in the empirical analysis.

Drawing on Table 1, the expression for labor supply can be rewritten as $w_t = (\sigma+\nu)c_t$. We can use this together with the condition for profits in the budget constraint of hand-to-mouth agents to get

$$c_t^H = \chi c_t + t_t^H \ ,$$

where $\chi = 1 + (\sigma+\nu)\left(1 - \frac{\tau^D}{\lambda}\right)$. Replacing c_t^H in the equation for aggregate consumption by the last expression leads to

$$c_t^S = \frac{1-\lambda\chi}{1-\lambda} c_t - \frac{\lambda}{1-\lambda} t_t^H \ .$$

By using the above equations, consumption inequality can be written as

$$\Phi_t \equiv c_t^S - c_t^H = \frac{1-\chi}{1-\lambda} c_t - \frac{1}{1-\lambda} t_t^H \ .$$

If we iterate forward the Euler equation and assume $\lim_{i\to\infty} \mathbb{E}_t c_{t+i}^S = 0$, we get $c_t^S = -\sigma \sum_{k=0}^{\infty} \mathbb{E}_t r_{t+k}$. Replacing the saver's consumption with the previous expression and solving for aggregate consumption results in the aggregate Euler equation:

$$c_t = -\sigma \frac{1-\lambda}{1-\lambda\chi} \sum_{k=0}^{\infty} \mathbb{E}_t r_{t+k} + \frac{\lambda}{1-\lambda\chi} t_t^H \ . \tag{B.1}$$

Finally, the stream of real interest rates can be rewritten as $\sum_{k=0}^{\infty} \mathbb{E}_t r_{t+k} = \sum_{k=0}^{\infty} \mathbb{E}_t \rho^{t+k-\mathcal{T}} \varepsilon_{\mathcal{T}} = 1/(1-\rho)\, \varepsilon_{\mathcal{T}}$, for $t \geq \mathcal{T}$. Combining the previous equations then leads to the expression for consumption inequality (6).

B.5 Proof of Proposition 2

Combining the proposed transfer function for constrained households, $t_t^H = -\phi_1 r_t B_Y - \phi_2 y_t$, with the aggregate Euler equation (B.1) yields

$$t_t^H = -\phi_1 \frac{1-\lambda\chi}{1-\lambda\chi+\phi_2\lambda} r_t B_Y + \phi_2 \frac{\sigma(1-\lambda)}{1-\lambda\chi+\phi_2\lambda} \sum_{k=0}^{\infty} \mathbb{E}_t r_{t+k} \ .$$

Let $\mathcal{T} \geq 0$ denote the period of the real interest rate change. According to Proposition 1, to achieve countercyclical consumption inequality on impact of a conventional monetary policy shock ($\mathcal{T} = 0$) and, at the same time, for inequality to respond procyclically to forward guidance ($\mathcal{T} > 0$), the transfer function above must fulfill the following conditions simultaneously:

$$\frac{\partial t_0^H}{\partial r_{\mathcal{T}}} \begin{cases} < \sigma(\chi - 1)\,\frac{1}{1-\rho}, & \text{if } \mathcal{T} = 0 \\ > \sigma(\chi - 1)\,\frac{1}{1-\rho}, & \text{if } \mathcal{T} > 0 \end{cases}$$

For the first condition to hold, we require

$$-\phi_1 \frac{(1-\lambda\chi)}{1-\lambda\chi+\phi_2\lambda} B_Y + \phi_2 \frac{\sigma(1-\lambda)}{1-\lambda\chi+\phi_2\lambda}\frac{1}{1-\rho} < \sigma(\chi-1)\,\frac{1}{1-\rho}\ .$$

We assume again that $\lambda < 1/\chi$ and further that $\phi_2 > 0$ as argued in section 5.3, which together imply $1 - \lambda\chi + \phi_2\lambda > 0$. Simplifying the last equation then leads to

$$-\phi_1(1-\rho)B_Y + \phi_2\sigma < \sigma(\chi - 1)\ . \tag{B.2}$$

On the other hand, for the second condition above to be fulfilled, it has to hold that

$$\phi_2 \frac{\sigma(1-\lambda)}{1-\lambda\chi+\phi_2\lambda}\frac{1}{1-\rho} > \sigma(\chi-1)\,\frac{1}{1-\rho}\ .$$

which simplifies to

$$\phi_2 > \chi - 1\ . \tag{B.3}$$

Combining (B.2) with (B.3) concludes the proof.

B.6 Calibration for the analytical TANK model

Table 2 summarizes the parameterization for the simple TANK model. Most parameter values are either based on convention or taken from Kaplan et al. (2018), except for the demand elasticity ϵ which is chosen to match a price markup of 20%. The transfer rule coefficients and the tax rate on profits are jointly determined within the range of possibilities that fulfill Proposition 2. In particular, $\tau^D = 0.27$ is in line with the model-implied computations in Bilbiie (2020). Moreover, $\tau^D < \lambda$ implies that $\chi > 1$, which is in line with the comparable empirical results from Auclert (2019) and Patterson (2022).

Table 2: Parameter values for the simple TANK model

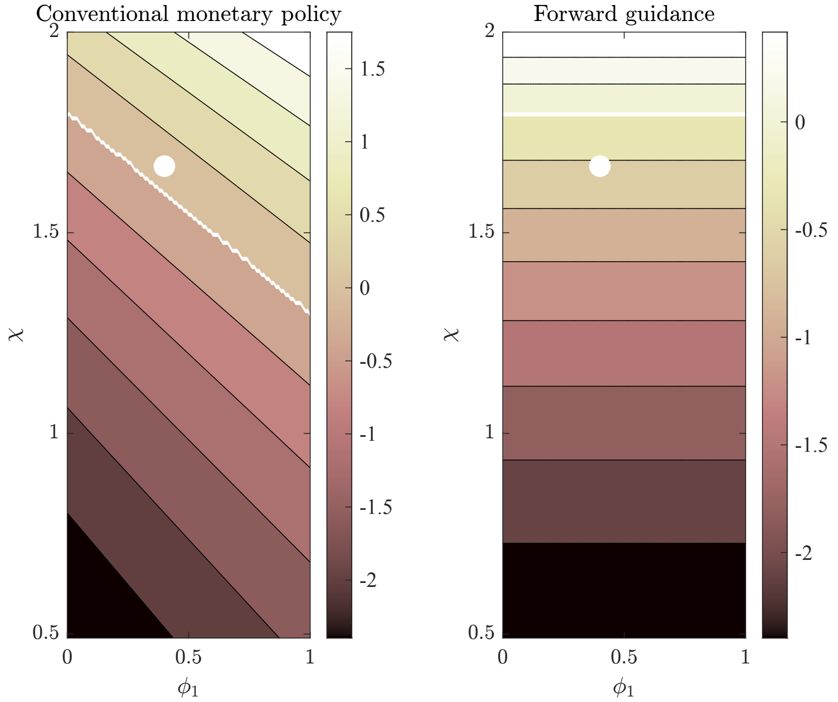
Parameter	Description	Value	Source / Target
λ	Share of hand-to-mouth	0.3	Kaplan et al. (2018)
β	Discount factor	1.0125^{-1}	Kaplan et al. (2018). Annual steady-state interest rate of 5%
σ	Intertemporal elasticity of substitution	1	Conventional
$1/\nu$	Frisch elasticity of labor supply	1	Conventional
ϵ	Elasticity of substitution between goods	6	Price markup of 20%
θ	Rotemberg price adjustment cost	100	Kaplan et al. (2018)
τ^D	Tax rate on profits	0.27	Own choice based on empirical evidence
ϕ_1	Transfer rule coefficient on debt	0.8	Own choice based on empirical evidence
ϕ_2	Transfer rule coefficient on output	0.4	Own choice based on empirical evidence
$\lvert B\rvert/(4Y)$	Steady-state debt to annualized GDP	0.23	Kaplan et al. (2018)
ρ	Persistence of policy shock	0.5	Kaplan et al. (2018)
$\varepsilon_{\mathcal{T}}$	Shock impact	0.0025	Annualized change of 1%

B.7 Additional figures for the analytical TANK model

Figure 15 shows an alternative specification which adds to the remarks in section 5.3. The baseline parameterization for the tax rate on profits and the transfer rule coefficients has been replaced by $\tau^D = 0.2$, $\phi_1 = 0.4$, and $\phi_2 = 0.8$, such that there is a higher weight on the cyclical component in the transfer function and a lower weight on the debt burden. Compared to Figure 4 this setup implies a lower τ^D and therefore a higher elasticity of constrained agents' income to total income. Namely, $\chi = 1.67$.

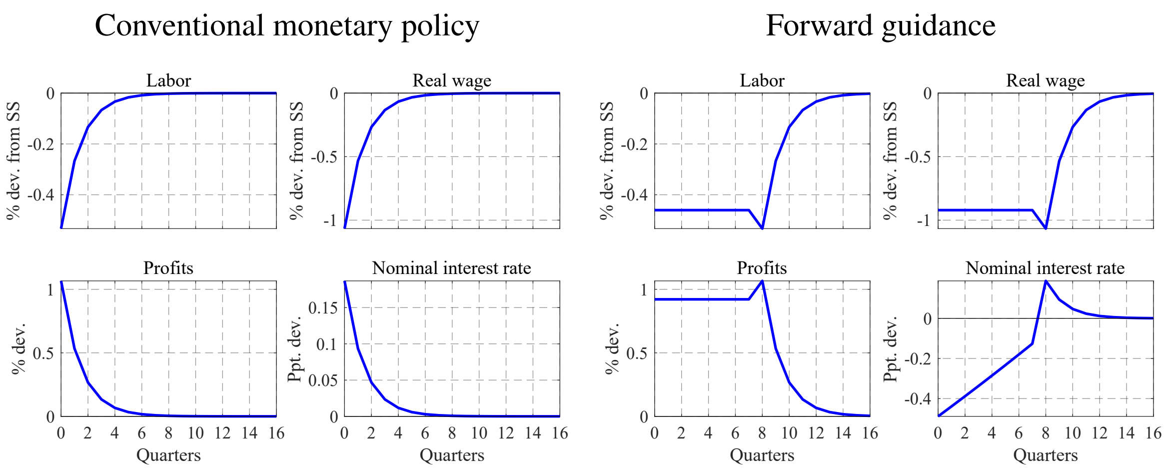
Figure 16 complements the set of impulse responses for the simple TANK model, with the main graphs located in Figure 5. Note that the response for debt is not shown because it is assumed to be constant and remains at its steady-state level over the full horizon.

Figure 15: Sensitivity of the inequality response to redistribution and transfers: Alternative calibration



Notes: These heat maps show the response of inequality on impact of a conventional monetary policy and a forward guidance shock, respectively, for different combinations of χ (the elasticity of the constrained household's income to aggregate income) and ϕ_1 (the coefficient on debt burden in the constrained agent's transfer function). The bars next to each plot label the colors, where values above (below) zero refer to a positive (negative) inequality response. The white line indicates the threshold with zero inequality response. The white dots mark the parameter values implied by an alternative calibration with $\tau^D = 0.2$, $\phi_1 = 0.4$, and $\phi_2 = 0.8$.

Figure 16: Additional impulse responses: Analytical TANK model



Notes: This figure depicts the remaining impulse responses for the analytical TANK model to a 25-basis-points increase in the contemporaneous real interest rate (left panel) or in the real rate eight quarters in the future (right panel). It complements the results in Figure 5. The response of profits is in deviations from their steady-state level, relative to steady-state output.

C Fully-fledged TANK model: Derivations

This appendix provides details on the derivations of the two-asset TANK model presented in section 5.4. It also contains a summary of our parameterization and additional impulse responses.

C.1 Model

This section outlines the model structure of the extended TANK model. It builds for the most part on the two-agent version of the heterogeneous-agent model by Kaplan et al. (2018). The main differences or novelties with respect to their model are: i) a tax and transfer system applied by the government that redistributes income between households (through either profit taxation or in a lump-sum fashion); and ii) a different monetary policy setup where the central bank commits to a path for the real interest rate rather than sets the nominal rate according to a Taylor rule. All deviations are explained in detail along the model description.

Households. There is a continuum of households with an exogenous share $1-\lambda$ of savers (S) who hold and price all assets in the economy. The remaining share λ of households have no access to financial markets and live hand-to-mouth (H) by consuming their total income in each period.[19]

Each household has preferences over utility from consumption C and disutility from supplying labor L:

$$U\left(C_t, L_t\right)=\frac{C_t^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}}-\varphi \frac{L_t^{1+\nu}}{1+\nu},$$

where σ denotes the elasticity of intertemporal substitution, $\frac{1}{\nu}$ the Frisch elasticity of labor supply, and $\varphi>0$ represents the relative weight of leisure in the utility function.

Savers. Unconstrained agents can save and borrow in a liquid real government bond B at the real interest rate r^B. They can also hold illiquid assets A at rate r^A, but need to pay a transaction cost χ for depositing into or withdrawing from that account.[20] The presence of this cost implies that, in equilibrium, the illiquid asset return will be higher than the liquid asset return. Besides this, savers consume, earn labor and dividend income, and pay taxes.

[19] This type of household is labeled as spenders by Kaplan et al. (2018).

[20] In the HANK model of Kaplan et al. (2018), the two assets are used by households to self-insure against idiosyncratic labor income risk. In this paper, we dispense with cyclical risk and precautionary savings.

They each solve the following problem:

$$\max_{C_t^S, L_t^S, D_t, B_{t+1}^S, A_{t+1}} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t U\left(C_t^S, L_t^S\right) \quad \text{subject to}$$
$$C_t^S + B_{t+1}^S + D_t + \chi_t = (1 + r_{t-1}^B) B_t^S + (1-\tau) W_t L_t^S + \Gamma_t^S + T_t^S$$
$$A_{t+1} = (1 + r_t^A) A_t + D_t \ ,$$

where the notation for assets captures end-of-period values such that B_{t+1}^S and A_{t+1} denote savings in liquid and illiquid assets, respectively, at the end of period t. Moreover, D_t denotes deposits into ($D > 0$) or withdrawals from ($D < 0$) the illiquid account, W_t is the real wage, where labor income is taxed at rate τ, Γ_t^S are dividends from firms' profits net of taxes (specified below), and T_t^S are real lump-sum transfers from the government.[21] The functional form of the transaction cost depends on the deposit decision:

$$\chi_t = \chi_1 \left| D_t \right|^{\chi_2} \ ,$$

where $\chi_1 > 0$ and $\chi_2 > 1$ make sure that deposit rates are finite. The optimality conditions for this problem are:

$$\begin{aligned}
(C_t^S)^{-\frac{1}{\sigma}} &= \Lambda_t \\
\varphi (L_t^S)^{\nu} &= \Lambda_t (1-\tau) W_t \\
\Psi_t &= 1 + \text{sgn}(D_t) \left\{ \chi_1 \chi_2 \left| D_t \right|^{\chi_2 - 1} \right\} \\
\Lambda_t &= \mathbb{E}_t \left[\Lambda_{t+1} (1 + r_t^B) \right] \\
\Lambda_t \Psi_t &= \mathbb{E}_t \left[\Lambda_{t+1} \Psi_{t+1} (1 + r_{t+1}^A) \right] \ ,
\end{aligned}$$

where Λ_t and $\Lambda_t \Psi_t$ define the Lagrangian multipliers on the budget constraint and the illiquid asset accumulation equation, respectively, and $\text{sgn}(.)$ is a function that extracts the sign of D_t. By combining the expressions above, we can derive Euler equations for liquid and illiquid assets, respectively, and the standard intratemporal condition:

$$\begin{aligned}
1 &= \beta \mathbb{E}_t \left[\left(\frac{C_{t+1}^S}{C_t^S} \right)^{-\frac{1}{\sigma}} (1 + r_t^B) \right] \\
1 &= \beta \mathbb{E}_t \left[\left(\frac{C_{t+1}^S}{C_t^S} \right)^{-\frac{1}{\sigma}} \frac{1 + \text{sgn}(D_{t+1}) \left\{ \chi_1 \chi_2 \left| D_{t+1} \right|^{\chi_2 - 1} \right\}}{1 + \text{sgn}(D_t) \left\{ \chi_1 \chi_2 \left| D_t \right|^{\chi_2 - 1} \right\}} (1 + r_{t+1}^A) \right]
\end{aligned}$$

[21] Different from the simple TANK model presented in section 5.1, firms' profits are denoted here by Π_t and D_t captures deposits instead.

$$W_t = \frac{\varphi}{1-\tau} \left(L_t^S\right)^\nu \left(C_t^S\right)^{\frac{1}{\sigma}} \ .$$

Hand-to-mouth. Constrained households own no assets and just consume in every period their total after-tax labor income $W_t L_t^H$ together with transfers from the government. The latter consists of two parts: a redistributed part arising from taxed profits Γ_t^H and a lump-sum transfer T_t^H. Each hand-to-mouth household, therefore, solves the problem

$$\max_{C_t^H, L_t^H} U\left(C_t^H, L_t^H\right) \quad \text{subject to}$$
$$C_t^H = (1-\tau) W_t L_t^H + \Gamma_t^H + T_t^H \ .$$

The optimality condition is

$$W_t = \frac{\varphi}{1-\tau} \left(L_t^H\right)^\nu \left(C_t^H\right)^{\frac{1}{\sigma}} \ .$$

Firms. The supply side of the economy features monopolistically competitive producers that provide intermediate goods to perfectly competitive final goods firms.

Final goods producers. A representative firm in the final goods sector aggregates differentiated intermediate inputs j to a final good according to the CES production function $Y_t = \left(\int_0^1 Y_t(j)^{\frac{\epsilon-1}{\epsilon}} \, di\right)^{\frac{\epsilon}{\epsilon-1}}$ with elasticity of substitution across goods ϵ. Profit maximization yields the demand for each input, $Y_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\epsilon} Y_t$, where $P_t(j)$ is the price of intermediate good j and $P_t^{1-\epsilon} = \int_0^1 P_t(j)^{1-\epsilon} \, dj$ the aggregate price index.

Intermediate goods producers. There is a continuum of monopolistically competitive firms, each of which produces a variety j of the intermediate good using capital K and labor N as inputs:

$$Y_t(j) = K_t(j)^\alpha N_t(j)^{1-\alpha} \ ,$$

where α is the capital share and $1-\alpha$ is the labor share. Each firm rents capital and hires labor in competitive factor markets at rate r_t^K and wage W_t, respectively. Cost minimization results in the following conditions for the optimal factor shares:

$$r_t^K = \alpha \frac{Y_t(j)}{K_t(j)} MC_t$$
$$W_t = (1-\alpha) \frac{Y_t(j)}{N_t(j)} MC_t \ ,$$

where the real marginal cost is given by

$$MC_t = \left(\frac{r_t^K}{\alpha}\right)^{\alpha} \left(\frac{W_t}{1-\alpha}\right)^{1-\alpha} .$$

An intermediate goods producer sets its price $P_t(j)$ to maximize profits subject to consumers' demand and a quadratic price adjustment cost as in Rotemberg (1982):

$$\Theta_t = \frac{\theta}{2}\left(\frac{P_t(j)}{P_{t-1}(j)} - 1\right)^2 Y_t .$$

Considering the above, the price-setting problem looks as follows:

$$\max_{\{P_{t+k}(j)\}_{k=0}^{\infty}} \mathbb{E}_t \sum_{k=0}^{\infty} \Lambda_{t,t+k}\Psi_{t,t+k} \left\{ \left[\frac{P_{t+k}(j)}{P_{t+k}} - MC_{t+k}\right] Y_{t+k}(j) - \Theta_{t+k} \right\} \quad \text{subject to}$$

$$Y_{t+k}(j) = \left(\frac{P_{t+k}(j)}{P_{t+k}}\right)^{-\epsilon} Y_{t+k} ,$$

where P_t denotes the aggregate price level and $\Lambda_{t,t+k}\Psi_{t,t+k} = \frac{\Lambda_{t+k}\Psi_{t+k}}{\Lambda_t\Psi_t}$ is the stochastic discount factor for payoffs in period $t+k$. Since dividends will be categorized as illiquid asset streams below, we discount the flow of future profits by the respective interest rate r^a, captured here by the Lagrangian multipliers from the saver's optimization problem.

Since all firms are identical and face the same demand, they will all set the same price P_t and we can drop the j subscripts. It also implies that we can write the aggregate production function as $Y_t = K_t^{\alpha} N_t^{1-\alpha}$. All this eventually leads to the following Phillips curve, with inflation defined by $\pi_t = \frac{P_t}{P_{t-1}} - 1$:

$$\pi_t(1+\pi_t) = \mathbb{E}_t\left[\frac{\Lambda_{t+k}\Psi_{t+k}}{\Lambda_t\Psi_t}\,\pi_{t+1}(1+\pi_{t+1})\,\frac{Y_{t+1}}{Y_t}\right] + \frac{1}{\theta}\left[\epsilon MC_t - (\epsilon - 1)\right] .$$

Finally, aggregating over firms yields total profits

$$\Pi_t = \left(1 - MC_t - \frac{\theta}{2}\pi_t^2\right) Y_t .$$

Profit distribution and illiquid assets. The portfolio of illiquid assets available to savers is composed of capital K_t^S and equity shares S_t^S. The latter figures as a claim to a fraction ω of intermediate firms' profits that are reinvested directly into the illiquid account. A saver's end-of-period-t stock of illiquid assets can therefore be written as

$$A_{t+1} = K_{t+1}^S + q_t S_{t+1}^S ,$$

where end-of-period-t shares S^S_{t+1} are priced in period t by q_t. To keep the focus on the illiquid account as a whole, it is assumed that savers can allocate between the two illiquid asset types for free. Therefore, the return on equity must be equal to the return on capital (no-arbitrage condition):

$$\frac{\omega \Pi_t + (q_t - q_{t-1})}{q_{t-1}} = r^K_t - \delta \equiv r^A_t \ ,$$

where δ is the depreciation rate of capital. This expression considers changes in the share price, which will restore equality between the returns from shares and capital after a shock to the economy. The share price itself evolves according to

$$q_t = \frac{1}{1 + r^A_{t+1}} \left(\omega \Pi_{t+1} + q_{t+1}\right) \ ,$$

which justifies the choice of the interest rate r^a for the discounting of future profits of intermediate firms.

Drawing on the expression above, the law of motion for illiquid assets, $A_{t+1} = (1 + r^A_t)A_t + D_t$, can be rewritten as

$$A_{t+1} = (1 + r^K_t - \delta)K^S_t + (\omega \Pi_t + q_t)S^S_t + D_t \ .$$

Aggregated over all savers and imposing market clearing for capital and shares (see below), the last expression becomes

$$(1 - \lambda)A_{t+1} = (1 + r^K_t - \delta)K_t + (\omega \Pi_t + q_t) + (1 - \lambda)D_t \ .$$

The remaining share of profits $1 - \omega$ not reinvested in the illiquid account is transferred lump-sum in liquid form to savers. However, the government taxes the shareholders on the total amount of profits at rate τ^D. Hence, each saver receives an after-tax dividend income of

$$\Gamma^S_t = \frac{(1 - \omega) - \tau^D}{1 - \lambda} \Pi_t \ .$$

In the two-agent model version of Kaplan et al. (2018), even though only savers have an illiquid account, the fraction $(1 - \omega)\Pi_t$ is assumed to be equally distributed lump-sum to both household types and then to be taxed at the same rate as labor income (τ). Here we assume instead that, in the first place, savers receive all the profits net of the share that is reinvested into the illiquid account. At the same time, however, they can be taxed on total profits (if $\tau^D > 0$) and hand-to-mouth agents would receive the revenues from this through the government (see below).

Government. The government issues liquid real bonds B and collects taxes on households' labor income to finance public expenditures G_t, lump-sum transfers T_t, and interest payments on pre-existing debt. Its budget constraint is given by

$$B_{t+1} = (1 + r^B_{t-1})B_t - \tau W_t N_t + T_t + G_t \ ,$$

where B_{t+1} is end-of-period-t outstanding debt. We assume that the government adjusts transfers to balance its budget, while debt and expenditures remain fixed at their steady-state levels.

Besides labor income and equivalent to the analytical TANK model in section 5.1, the government levies taxes on monopolistic firms' profits, paid by savers who own those firms, and redistributes the revenues to constrained households. This policy is balanced in every period such that

$$\Gamma^H_t = \frac{\tau^D}{\lambda}\Pi_t \ .$$

Furthermore, the government runs a second lump-sum scheme with total transfers given by

$$T_t = \lambda T^H_t + (1-\lambda)T^S_t \ .$$

Unlike Kaplan et al. (2018) who model individual transfers as a fixed share of total transfers, we draw on the alternative specification from the analytical part and assume that transfers to constrained agents are dependent on the course of debt and the business cycle:

$$T^H_t = -\phi_1 r^B_t B - \phi_2 Y_t \ .$$

Monetary authority. Following McKay et al. (2016) and Kaplan et al. (2016), we assume that the central bank controls the real interest rate. More precisely, it implements monetary policy by setting and committing to a path for the interest rate, $\{r^B_k\}_{k\geq 0}$, that is perfectly credible and foreseen by agents. Prior to $\mathcal{T}$, the real rate remains fixed at its steady-state level r^B. After the change, monetary policy will be given by an exogenous rule. Formally, for $\mathcal{T} \geq 0$:

$$r^B_t = \begin{cases} r^B, & t < \mathcal{T} \\ r^B + \rho^{t-\mathcal{T}}\varepsilon_{\mathcal{T}}, & t \geq \mathcal{T} \end{cases}$$

where $\varepsilon_{\mathcal{T}} = r^B_{\mathcal{T}} - r^B$ denotes the policy shock and ρ its persistence. Moreover, the Fisher equation holds:

$$1 + r_t^B = \frac{1 + i_t}{1 + \pi_{t+1}} \ .$$

Aggregation and market clearing. Aggregate consumption and aggregate labor are given by

$$C_t = \lambda C_t^H + (1 - \lambda) C_t^S$$
$$N_t = \lambda L_t^H + (1 - \lambda) L_t^S \ .$$

Liquid asset market clearing requires

$$B_{t+1} = (1 - \lambda) B_{t+1}^S \ .$$

Aggregating capital and equity shares yields

$$K_{t+1} = (1 - \lambda) K_{t+1}^S$$
$$1 = (1 - \lambda) S_{t+1}^S \ ,$$

where we normalized the total number of shares to 1. The illiquid asset market then clears when

$$(1 - \lambda) A_{t+1} = K_{t+1} + q_t \ .$$

Finally, the goods market clearing condition reads

$$Y_t = C_t + I_t + G_t + (1 - \lambda)\chi_t + \Theta_t \ ,$$

where investment evolves according to $I_t = K_{t+1} - (1 - \delta) K_t$. By combining the law of motion and market clearing for illiquid assets, this can be rewritten as

$$I_t = r_t^K K_t + \omega \Pi_t + (1 - \lambda) D_t \ .$$

C.2 Calibration for the extended TANK model

Table 3 summarizes the parameterization for the extended TANK model. Besides the paper-specific parameters, all values are taken from Kaplan et al. (2018) except for the demand elasticity ϵ which is chosen to match a price markup of 20%. It is worth mentioning that the transfer rule coefficients as well as the tax rate on profits are set to the same values as in the analytical model.

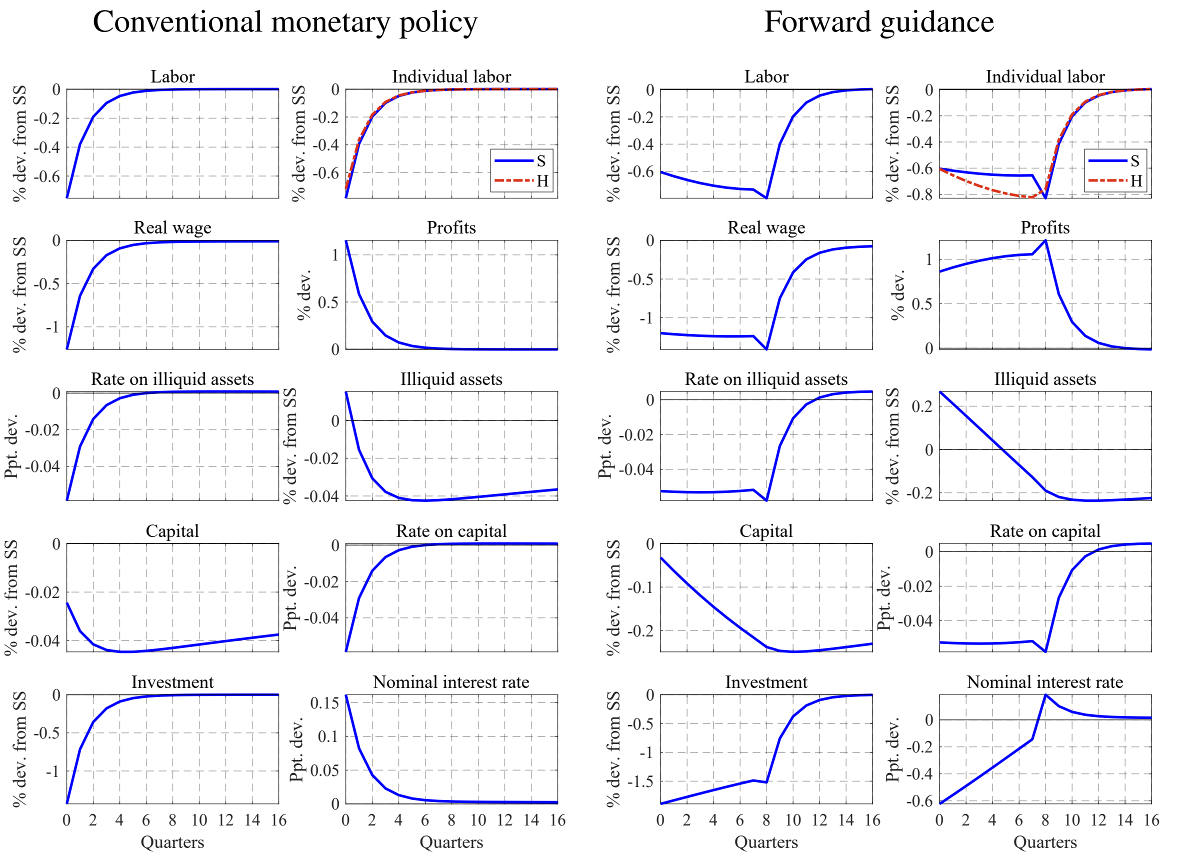
Table 3: Parameter values for the fully-fledged TANK model

Parameter	Description	Value
λ	Share of hand-to-mouth	0.3
β	Discount factor	1.0125^{-1}
σ	Intertemporal elasticity of substitution	1
$1/\nu$	Frisch elasticity of labor supply	1
$\chi_1 \mid \chi_2$	Deposit cost parameters	0.956 | 1.402
ϵ	Elasticity of substitution between goods	6
α	Capital share	0.33
δ	Depreciation rate	0.017
θ	Rotemberg price adjustment cost	100
ω	Share of profits reinvested into illiquid account	0.33
τ	Labor tax rate	0.25
τ^D	Tax rate on profits	0.27
ϕ_1	Transfer rule coefficient on debt	0.8
ϕ_2	Transfer rule coefficient on output	0.4
T	Steady-state lump-sum transfer (% of GDP)	0.06
$\lvert B^G\rvert/(4Y)$	Steady-state debt to annualized GDP	0.23
r^b	Steady-state real liquid return (p.a.)	0.05
ρ	Persistence of policy shock	0.5
$\varepsilon_{\mathcal{T}}$	Shock impact	0.0025

C.3 Additional figures for the extended TANK model

Figure 17 complements the set of impulse responses for the fully-fledged TANK model, with the main graphs located in Figure 6. Note that the responses for debt and government spending are not shown because both remain at their steady-state level over the full horizon.

Figure 17: Additional impulse responses: Fully-fledged TANK model



Notes: This figure depicts the remaining impulse responses for the extended TANK model to a 25-basis-points increase in the contemporaneous real interest rate (left panel) or in the real rate eight quarters in the future (right panel). It complements the results in Figure 6. The response of profits is in deviations from their steady-state level, relative to steady-state output. Plots with two lines show the results for savers (S) and hand-to-mouth agents (H).