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Household inflation heterogeneity and the relative price elasticity channel of monetary policy ☆

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ABSTRACT

This paper shows that considerable differences in inflation rates exist among households in the United States. Against this background, we theoretically show that a central bank that considers household inflation heterogeneity can stabilize overall inflation more effectively. Using a tractable, multi-sector New Keynesian model with a low- and a high-income household, we show that a central bank that reacts to the inflation rate of the household less affected by price changes can achieve lower deviations of all households' inflation rates from their steady states. The reason is that a weaker central bank reaction dampens an adverse relative price elasticity channel of monetary policy, allowing for more favorable relative price adjustments. The strength of this channel depends on household heterogeneity.

1. Introduction

Central banks aim to stabilize prices and, where applicable, output/employment. Policymakers consider the development of several variables, including changes in consumer prices, when deciding on appropriate monetary policy measures. Therefore, the inflation rate does not only serve as a measure for assessing the achievement of the price stability objective but also as an indicator for concrete monetary policy decisions. To measure inflation, changes in a general consumer price index (CPI) are typically considered. The inflation rate then refers to the average consumption behavior within an economy. However, this inflation rate conceals substantial inflation heterogeneity across households, depending on various household characteristics such as age, gender, or income. Against this background, we analyze whether central banks should consider household inflation heterogeneity. We find that such a consideration stabilizes the inflation rates of all households more effectively following a shock. The driver of this result is a *relative price elasticity channel of monetary policy*.

Our analysis comprises a data and a theoretical part. First, we show by constructing several time series that considerable differentials in inflation rates exist across income quintiles in the United States both in terms of levels and deviations from their long-term trend. We create a data set for the United States to calculate the inflation rates for different income quintiles between 2001 and 2023. We find considerable inflation heterogeneity across quintiles. In particular, low-income households experienced higher inflation on average. A main driver for these inflation differentials is low-income households spending a higher share of their consumption expenditures on essential goods (e.g., food or housing) with above-average inflation. Because monetary policy does not react to long-term, structural factors that might cause these inflation rate differentials, we show that considerable differentials exist even after controlling for the long-term trend. This provides a rationale for monetary policy to consider household-specific inflation rates.

Second, we show theoretically that if a central bank considers household inflation heterogeneity, it can stabilize the inflation rates of all households more effectively. We set up a tractable New Keynesian model with household heterogeneity, including a low- and a high-income household whose CPI-inflation rates diverge after shocks. We consider two sectors: an essential and a non-essential good sector.

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Furthermore, we include a subsistence level for essential-good consumption, which is crucial for the transmission of monetary policy because it reduces the relative price elasticity of demand for essential goods, particularly for low-income households.

In our multi-sector model with a subsistence level on essential-good consumption, shocks cause a divergence in relative prices.[1] Assume that a shock leads to an increase in prices, prompting the central bank to implement a contractionary monetary policy. The central bank raises its interest rate, consumer demand and prices fall due to the standard interest rate channel of monetary policy. However, due to the subsistence level of essential-good consumption, the demand for essential goods decreases less than for non-essential goods. Consequently, the relative price of essential goods increases, whereas the relative price of non-essential goods decreases. Thus, the monetary policy reaction to the shock also affects relative prices. These policy-induced changes in relative prices positively affect non-essential goods demand but negatively affect essential goods demand. Because the relative price elasticity of demand for non-essential goods is greater than that for essential goods, the positive effect of these relative price changes on demand prevails, counteracting the intended impact of contractionary monetary policy. Similarly, the intended impact of expansionary monetary policy is dampened. There is an adverse relative price elasticity channel of monetary policy. Note that low-income households endogenously exhibit larger differences in price elasticities of demand for different goods. Thus, the relative price elasticity channel is particularly impactful through its effect on low-income households.

The adverse relative price elasticity channel will weaken if the central bank responds to the inflation rate of the household less affected by shock-induced price changes, rather than the average inflation rate across all households. This approach implies a less pronounced monetary-policy induced change in demand, resulting in smaller monetary-policy induced relative price developments, i.e., the central bank can achieve more favorable relative price adjustments by reducing the adverse relative price elasticity channel. Consequently, prices will be stabilized more effectively if the central bank responds less strongly to shock-induced price changes for a given inflation-reaction coefficient in the monetary policy rule. Given these findings, one could argue that central banks could achieve an even more effective stabilization of prices by generally reacting less to inflation (i.e., if the inflation reaction coefficient were lower). This is not the case. The reasons are twofold: (i) the stabilization effect through the interest rate channel is weaker, and (ii) the adverse price elasticity channel becomes even stronger.[2]

Household heterogeneity is critical in determining the extent to which the central bank can weaken the adverse price elasticity channel by reacting to the inflation rate of the household that is less affected by shock-induced price changes, rather than the average inflation rate across all households. As household heterogeneity increases, so do the differences in shock-induced individual inflation rates. Consequently, a high degree of heterogeneity implies that the inflation rate of the household less affected by the shock deviates more strongly from the average inflation rate across households, indicating a high potential for the central bank to weaken the adverse relative price elasticity channel.

Our paper relates to the literature in the following ways. It connects to the strand of literature investigating the relation between inflation and income inequality, such as Al-Marhubi (1997), and Albanesi (2007). Our paper further complements work that has empirically investigated inflation differentials between households and linked these differentials to specific household characteristics. This includes studies showing that households with lower income experience higher inflation rates than households with higher income, such as Hobijn et al. (2009), Kaplan and Schulhofer-Wohl (2017), Jaravel (2019), and Argente and Lee (2021) for the United States, or Gürer and Weichenrieder (2020) for Europe. We contribute to this empirical literature by additionally reporting trend-adjusted inflation rate differentials across income groups in the United States. Thus, we provide a rationale for central banks to potentially consider heterogeneous household inflation rates.

Our paper also relates to theoretical literature investigating the effects of inflation differentials. Most of this work focuses on regional inflation differentials within currency unions (Canzoneri et al., 2006; Duarte and Wolman, 2008), in particular on the European Monetary Union (Angeloni and Ehrmann, 2007; Andrés et al., 2008; Rabanal, 2009). More closely related are papers investigating which inflation measure central banks should target in multi-good or multi-country New Keynesian models. In particular, Benigno (2004) finds that a central bank operating in a (two-region) monetary union should assign a higher weight to the country with higher price stickiness because it improves welfare. Aoki (2001) finds that optimal monetary policy should target sticky-price inflation in a model with a sticky- and a flexible-price sector. Mankiw and Reis (2003) extend this result by constructing a stability price index that also assigns higher weights to sectors with stickier prices. Both emphasize the relevance of favorable relative price adjustments in stabilizing inflation. Similar findings are reported by Huang and Liu (2005), Carvalho (2006), Woodford (2011), and Petrella et al. (2019), who investigate sectoral differences in price developments due to different levels of price stickiness. Conversely, Anand et al. (2015) show that targeting headline inflation is welfare-improving to targeting core/sticky-price inflation in developing countries with a subsistence level on food. Bragoli et al. (2016) extend a multi-good model to include multiple countries within a monetary union and find that the welfare-maximizing weight on sectors and countries is determined by various factors such as price stickiness and region/sector size. Our paper differs from this literature in two important dimensions: (i) although we set up a multi-good model, we do not focus on the effect of different exogenous levels of price stickiness (in fact, we assume prices to be equally sticky across sectors) to (ii) elaborate the role of household heterogeneity, as sectoral differences in price developments affect households differently. Thus, our results complement the literature on the importance of relative price adjustments; however, we specifically focus on the role of household heterogeneity in response to relative price movements, thereby putting forward the relative price elasticity channel of monetary policy.

Another relevant strand of literature examines the effect of varying elasticities of substitution on firms' pricing decisions and shock transmission. Cavallari and Etro (2020) consider variable elasticities of substitution across good varieties, thereby creating endogenous markup variability in a Real Business Cycle model. Cavallari (2020) extends this approach by considering price stickiness and examining the effects on monetary policy. We contribute to this literature by examining a multi-sector model and households with varying relative price elasticity of demand. We further assess the impact of heterogeneous price elasticities on the effectiveness of monetary policy.

Finally, our paper refers to work that analyzes the effect of different types of household heterogeneity in New Keynesian models. In a broader sense this includes heterogeneous agent New Keynesian (HANK) models such as Kaplan et al. (2018), Auclert (2019) Gornemann et al. (2021), or Luetticke (2021),[3] as well as the work by Kreamer (2022) who argues that monetary policy should take into account heterogeneity in sectoral interest rate sensitivity — a result that is consistent with the implication that monetary policy should consider household heterogeneity in inflation and price elasticities, as derived in this paper. Particularly relevant to this paper are the two-agent New Keynesian (TANK) models in Chan et al. (2024) and Lan et al.

[1] Here, the relative price of a good refers to its price relative to the overall price level.

[2] We discuss the role of the inflation-reaction coefficient in Appendix B.

[3] For a comprehensive overview, see Kaplan and Violante (2018).

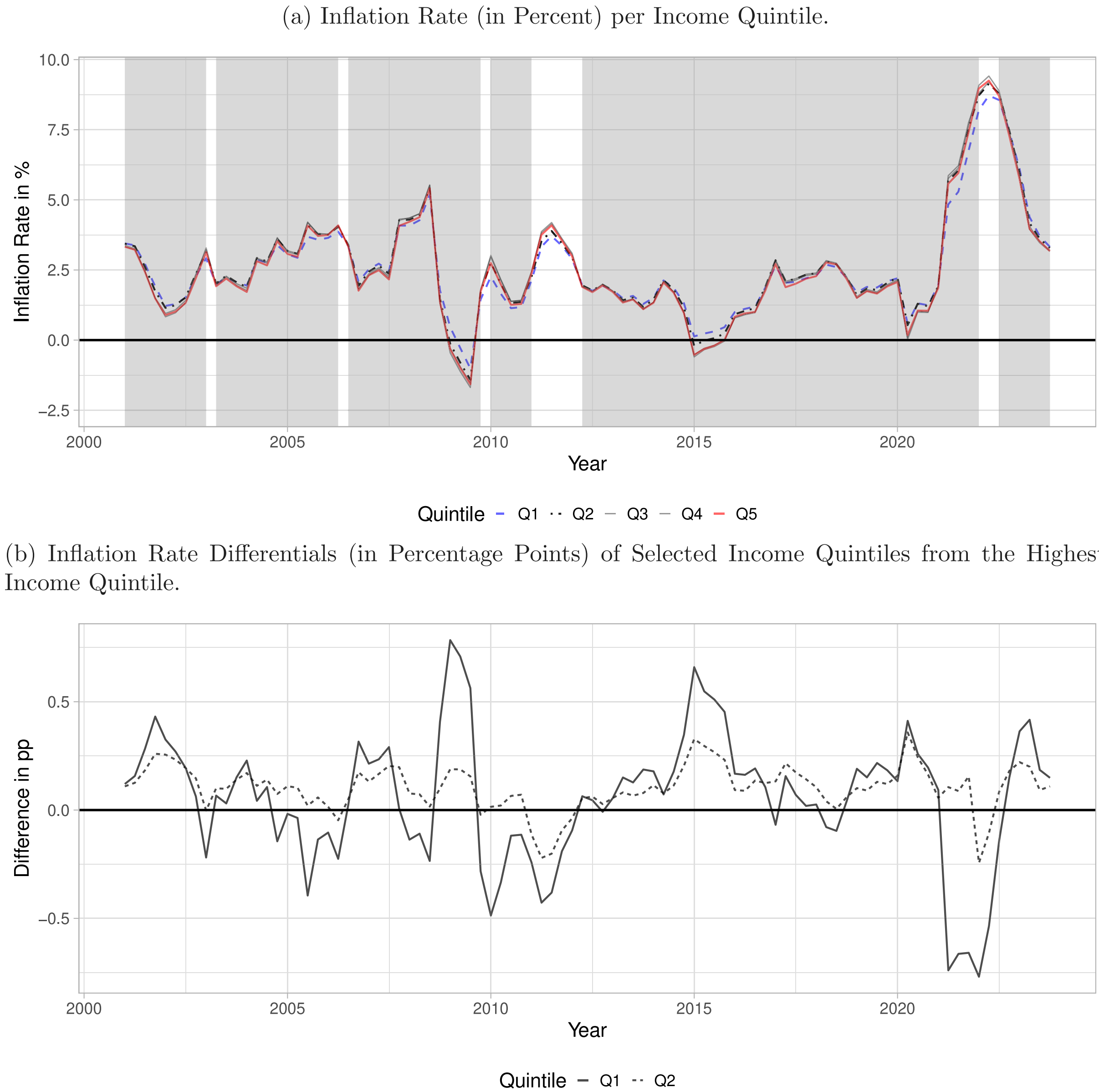


Fig. 1. Inflation rate developments in the United States,2001–2023.
Notes: The shaded areas represent quarters in which the inflation rate of Q1 or Q2 was higher than that of Q5. Data ranges from 2001Q1 to 2023Q4.

(2024). Chan et al. (2024) show that in a TANK model, central banks should react less contractionary to inflationary pressures caused by energy price shocks than in a representative agent environment. In contrast, we depart from homogeneous consumption baskets in our model to generate and analyze inflation heterogeneity. The multi-sector TANK model in Lan et al. (2024) includes differing consumption baskets across households. They find that monetary policy is less effective when heterogeneous consumption baskets are considered and that optimal monetary policy assigns a lower weight to the inflation rates of sectors with stickier prices when the share of credit-constrained households is high. We focus on a different aspect in a similar environment, namely on differing relative price elasticities across households due to the introduction of a subsistence level.

The rest of the paper is structures as follows: Section 2 reports inflation heterogeneity across households in the United States. Section 3 states the model before Section 4 describes the model responses to demand and supply shocks and discusses the role of household heterogeneity. Finally, Section 5 concludes the paper.

2. Household inflation heterogeneity in the United States

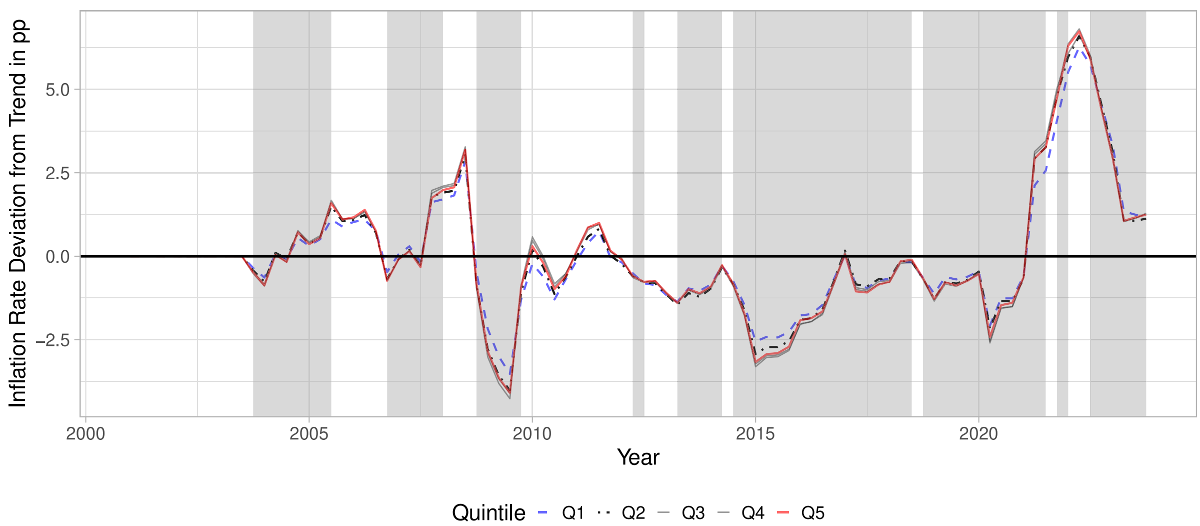
2.1. Data

We collect data on household consumption and inflation rates in the United States. In particular, we gather data on the share of eight expenditure categories in each income quintile's (Q) consumption basket and their respective inflation rates. Although household inflation heterogeneity is prevalent on several different dimensions of household characteristics (e.g., age, education, or number of children, see Hobijn et al., 2009), we focus our data and theoretical examination on the example of inflation differentials among income groups.

The Bureau of Labor Statistics publishes the CPI[4] for eight expenditure categories: food and beverages, housing, apparel, transportation, medical care, recreation, education and communication, and other

[4] We use the standard CPI for all urban consumers.

(a) Hamilton-Filtered Inflation Rate Deviation (in Percentage Points) from Trend per Income Quintile.



(b) Hamilton-Filtered Inflation Rate Differentials (in Percentage Points) of Selected Income Quintiles from the Highest Income Quintile.

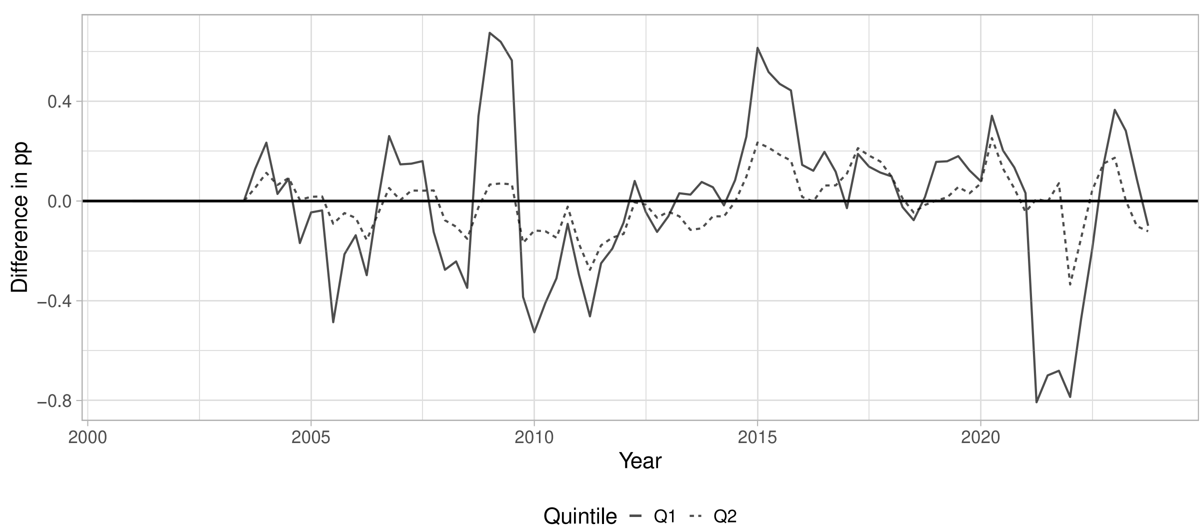


Fig. 2. Hamilton-filtered inflation rate developments in the United States,2001–2023.
Notes: The shaded areas represent quarters in which the Hamilton-filtered inflation rate of Q1 or Q2 was higher than that of Q5. The data ranges from 2001Q1 to 2023Q4. The Hamilton filter with $h = 8$ and $p = 4$ implies the loss of 11 quarters at the beginning of the data set.

goods and services. We create a data set based on these categories, which includes the annual percentage price change for each month between January 2001 and December 2023. Monthly rates are converted to quarterly rates by calculating the average inflation rate reported for each month in a quarter. We then match the quarterly inflation rates of each expenditure category to its respective proportion in the consumption basket of income quintiles. The Consumer Expenditure Survey reports the consumption expenditures of income quintiles in the following categories: food (including non-alcoholic beverages), alcoholic beverages, housing, apparel and services, transportation, health care, entertainment, personal care products and services, reading, education, tobacco products and smoking supplies, miscellaneous expenditures, cash contributions, personal insurance and pensions. Adding food and alcoholic beverages (receiving a measure for food and beverages), entertainment and reading (recreation), and personal care products and services, tobacco products, and miscellaneous (other goods and services) provides consistent measures[5] for the eight expenditure categories defined within the CPI. Consumption data are available on an annual basis from 2001 to 2022. The inflation rate for each quintile within each quarter is then calculated by adding the category-specific, quarterly CPI-inflation rate weighted by the quintile-specific share of the respective category in the quintile's consumption basket in the relevant year. The quarterly inflation rates for 2023 are calculated using the consumption shares from 2022.

[5] Cash contributions as well as personal insurance and pensions cannot be clearly classified into one of the CPI's categories. Thus, expenditures in these categories are not considered.

Table 1
Average inflation rate and share of consumption per quintile of expenditure categories in the United States 2001–2023.

Category	Average inflation rate	Average share				
		Q1	Q2	Q3	Q4	Q5
Food & Beverages	2.86%	17.50%	16.54%	16.28%	16.32%	15.27%
Housing	2.81%	41.87%	39.88%	38.80%	37.85%	38.53%
Apparel	0.06%	3.90%	3.77%	3.81%	3.94%	4.37%
Transportation	2.68%	15.73%	18.99%	20.88%	21.48%	20.26%
Medical Care	3.30%	8.62%	9.62%	8.91%	8.30%	6.95%
Recreation	1.21%	4.96%	5.47%	5.68%	6.25%	7.20%
Education	1.53%	3.04%	1.33%	1.35%	1.80%	3.66%
Other	3.03%	4.39%	4.40%	4.28%	4.06%	3.76%

Notes. Average inflation rate refers to the average percentage increase in the price of an expenditure category between 2001 and 2023. The average share represents the percentage share of an expenditure category in total consumption per quintile between 2001 and 2023. Education refers to education and communication, whereas other refers to other goods and services.

2.2. Results

Fig. 1 shows the quarterly inflation rate development from 2001 to 2023 in the United States. Panel 1(a) shows that in almost every quarter within the last two decades, lower-income quintiles experienced higher inflation rates: at least one of the lowest or second-lowest income quintile (Q1 or Q2) had a higher inflation rate than the highest quintile (Q5) in 82 of the 92 quarters studied.

To illustrate the magnitude of this first result, Panel 1(b) depicts the inflation rate differential between Q1 and Q5 and Q2 and Q5, respectively. These differentials are relatively large (with up to ~ 0.8 percentage points in certain quarters) and persistent.

One reason for these results is that household's consumption baskets differ. Lower quintiles spend a higher share of their income on expenditures for essential goods (food, housing), which exhibited relatively high inflation as shown in Table 1. In contrast, higher quintiles' consumption baskets contain a greater proportion of non-essential goods (recreation) with relatively low inflation rates. Furthermore, note that these inflation differentials will likely understate the actual inflation differentials between quintiles. In particular, households with relatively high incomes are usually able to substitute their consumption of more expensive varieties with less expensive ones, whereas households with relatively low incomes are not. This implies that high-income households' higher substitution capabilities provide a mechanism to avoid increases in their experienced inflation rate, whereas low-income households are completely exposed to price increases (Brainard, 2022; Stempel, 2022). Furthermore, considering a broad classification into eight expenditure categories and income quintiles will likely conceal considerable additional heterogeneity across households.

The time series presented in Fig. 1 confirm the results of more sophisticated empirical analyses; see the references in Section 1. The finding that lower-income households are generally more affected by inflation is undoubtedly relevant for policymakers, particularly regarding social policies. Our analysis, however, focuses on its potential relevance for monetary policy, which is not equipped to combat long-term, structural factors that may cause inflation rates for different goods and services to develop differently. Thus, we also control for the long-term trend of the inflation rates of income quintiles by applying a Hamilton (2018) filter.

Fig. 2 shows the Hamilton-filtered inflation rate development per income quintile in the United States. Panel 2(a) shows that in 54 of the 81 quarters studied, at least one of the bottom two income quintiles had a higher trend-adjusted inflation rate than the top quintile. The trend-adjusted inflation differentials are smaller but comparable to the ones discussed previously, as shown in Panel 2(b). Thus, the result that lower-income quintiles experienced higher inflation rates than higher income quintiles applies to both inflation levels and trend-adjusted rates.

However, examining the cyclical component of the quintile-specific inflation rates reveals an additional pattern. When inflation deviations from the long-run trend were negative, lower-income quintiles experienced higher inflation rates, and vice versa (Panel 2(a)). Thus, although households with relatively lower income experienced structurally higher inflation rates in the last two decades, the cyclical component of the quintile-specific inflation rates suggests that households with higher income experienced greater volatility with respect to the deviations of their inflation rates from their long-term trends.

One important reason for this disparity in volatility is the unequal development of inflation rates in specific expenditure categories. The Hamilton-filtered inflation rate development of the expenditure categories (Fig. 3) shows that the inflation rate of transportation is very volatile in comparison to recreation, food, and housing. Note that transportation plays a more vital role in the consumption baskets of higher income quintiles. Thus, the inflation rate development of higher-income quintiles follows the inflation rate development of transportation more closely than lower-income quintiles, resulting in higher (lower) inflation rates for higher quintiles when deviations from trend are positive (negative).

We show that both structural (level) and trend-adjusted (cyclical) inflation differentials exist across income quintiles. The following section presents a model that replicates key findings from this section to analyze different central bank responses to inflation heterogeneity across households.

3. A model with household inflation heterogeneity

3.1. Households

There exists a continuum households with two types, $k{=}L,H$. We will calibrate L as the household with lower income and H as the household with higher income. The share of household L is denoted by κ, the share of household H by $1{-}\kappa$. The period utility function of household k is given by

$$U_t^k = \frac{Z_t\left(C_t^k\right)^{1-\sigma}}{1-\sigma} - \frac{\left(N_t^k\right)^{1+\varphi}}{1+\varphi}, \tag{1}$$

where Z_t is an AR(1) demand shock affecting the utility of consumption C_t^k, σ is the inverse intertemporal elasticity of substitution (ES), N_t^k denotes labor supply, φ the inverse Frisch elasticity of labor supply, and C_t^k is defined as

$$C_t^k \equiv \left(\gamma^{\frac{1}{\vartheta_C^k}}\left(C_{1,t}^k - C_1^*\right)^{\frac{\vartheta_C^k-1}{\vartheta_C^k}} + (1-\gamma)^{\frac{1}{\vartheta_C^k}}\left(C_{2,t}^k\right)^{\frac{\vartheta_C^k-1}{\vartheta_C^k}}\right)^{\frac{\vartheta_C^k}{\vartheta_C^k-1}}, \tag{2}$$

similar to Rabanal (2009) and Anand et al. (2015). The parameter γ determines the household-specific share of type-1 goods, represented by the consumption index $C_{1,t}^k$, in the overall consumption index. We interpret type-1 goods as essential goods (e.g., food, gas, or rent) with a subsistence level of C_1^* that must always be met. We assume that households always have enough income to finance this subsistence level. $C_{2,t}^k$ denotes the consumption index of type-2 goods (i.e., non-essential goods). Thus, households gain utility from consuming more

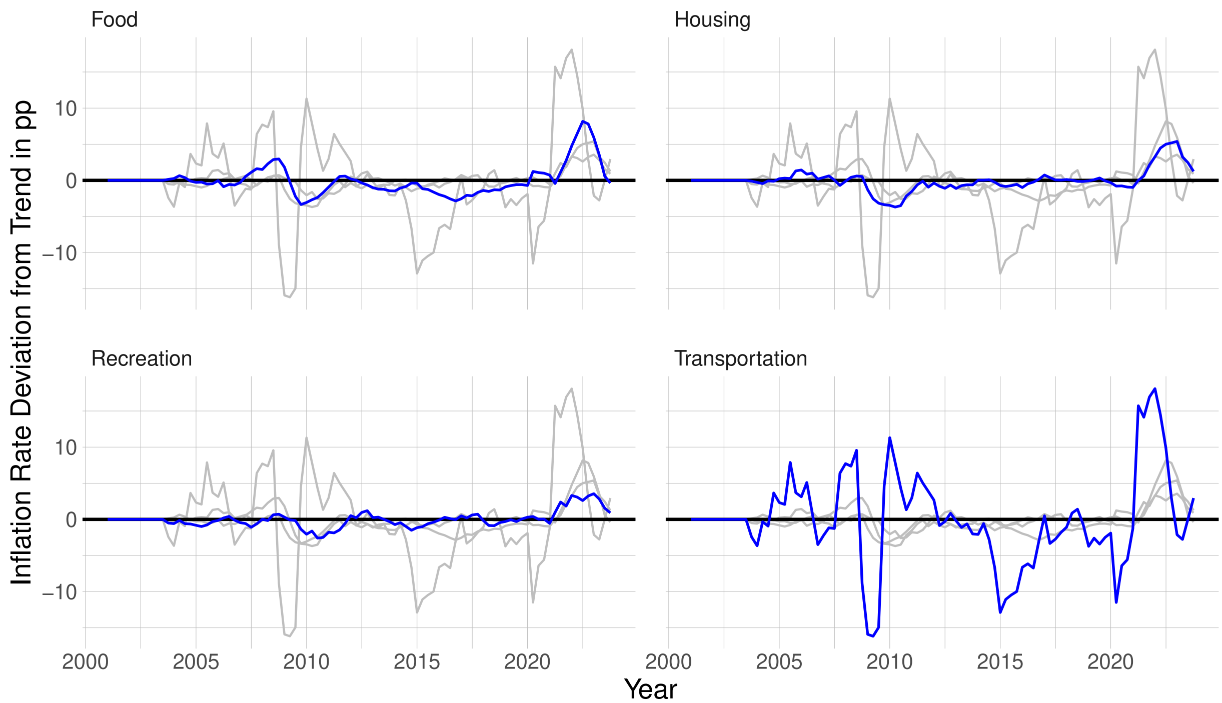


Fig. 3. Hamilton-filtered inflation rate (in percent) of selected expenditure categories in the United States 2001–2023.
Notes: Each panel shows the inflation rate deviation from its long-term trend for a specific expenditure category (blue line) in comparison to the development of the other categories (gray lines). The data ranges from 2001Q1 to 2023Q4. The Hamilton filter with $h = 8$ and $p = 4$ implies the loss of 11 quarters at the beginning of the data set.

than the subsistence level, i.e., C_t^k denotes excess consumption. Another important property of the consumption index arises from the inclusion of the subsistence level. The ES between the two types of goods is given by

$$\epsilon_{C,t}^k \equiv \begin{cases} \vartheta_C^k \left[1 - \dfrac{(1-\gamma)^{\frac{1}{\vartheta_C^k}} \frac{C_1^*}{C_{1,t}^k}}{\gamma^{\frac{1}{\vartheta_C^k}} \left(\frac{C_{1,t}^k - C_1^*}{C_{2,t}^k} \right)^{\frac{\vartheta_C^k - 1}{\vartheta_C^k}} + (1-\gamma)^{\frac{1}{\vartheta_C^k}}} \right] & \text{if} \quad C_1^* > 1, \\ \vartheta_C^k & \text{if} \quad C_1^* = 0, \end{cases} \tag{3}$$

with $0 < \epsilon_{C,t}^k \leq \vartheta_C^k$. For $C_1^* = 0$, Eq. (2) represents a constant ES (CES) index with ϑ_C^k being defined as the ES between the two types of goods. However, for $C_1^* > 0$, the ES decreases in the relevance of the subsistence level in a household's consumption basket. Thus, as the importance of the subsistence level for a household decreases, the ES increases and the household can substitute better. A thorough discussion of the properties of the ES with a subsistence level of consumption can be found in Baumgärtner et al. (2017).

The consumption indices $C_{h,t}^k$, with $h = 1, 2$ denoting the type of good, are CES functions over all goods $i \in [0, s]$ and $j \in [s, 1]$, with s being the share of firms producing good 1 in the economy, given by

$$C_{1,t}^k \equiv \left(\int_0^s C_{i,t}^{k \; \frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}, \tag{4}$$

$$C_{2,t}^k \equiv \left(\int_s^1 C_{j,t}^{k \; \frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}, \tag{5}$$

with ϵ denoting the ES between the varieties.

With respect to its consumption, the household chooses its optimal consumption of individual varieties within each type, its optimal consumption of each good type, and its optimal overall consumption level. The optimal consumption of a variety within each type is

$$C_{g,t}^k = \left(\frac{P_{g,t}}{P_{h,t}} \right)^{-\epsilon} C_{h,t}^k, \tag{6}$$

with $g = i$ if $h = 1$ and $g = j$ if $h = 2$, and $P_{1,t} \equiv \left(\int_0^s P_{i,t}^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}$ as well as $P_{2,t} \equiv \left(\int_s^1 P_{j,t}^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}}$ being the overall price indices of good 1 and good 2, respectively.[6] Optimal consumption of each variety is negatively related to the relative price of the good and the overall level of consumption of the good type.

The optimal consumption of each good type is given by

$$C_{1,t}^k = \left(V_{1,t}^k \right)^{-\vartheta_C^k} \gamma C_t^k + C_1^*, \tag{7}$$

$$C_{2,t}^k = \left(V_{2,t}^k \right)^{-\vartheta_C^k} (1-\gamma) C_t^k, \tag{8}$$

where $V_{h,t}^k \equiv \frac{P_{h,t}}{P_t^{C,k}}$ denotes the price of good h relative to the price index of utility-relevant excess consumption given by $P_t^{C,k} \equiv \left(\gamma P_{1,t}^{1-\vartheta_C^k} + (1-\gamma) P_{2,t}^{1-\vartheta_C^k} \right)^{\frac{1}{1-\vartheta_C^k}}$. In general, the optimal consumption of each good type depends on its relative price and overall consumption. In addition, the optimal level of good 1 consumption is determined by the subsistence level C_1^*. Based on these demand functions, we can determine the relative price elasticity of demand for both goods:

$$\epsilon_{P,h,t}^k \equiv \begin{cases} \left(1 - \frac{C_1^*}{C_{1,t}^k} \right) \vartheta_C^k & \text{if} h = 1, \\ \vartheta_C^k & \text{if} h = 2. \end{cases} \tag{9}$$

While the price elasticity of good-2 demand is given by ϑ_C^k, i.e., it is unaffected by the subsistence level of good-1 consumption, its counterpart decreases in the relative importance of the subsistence level in good-1 consumption, as does the ES.

The household maximizes its expected discounted lifetime utility with respect to its consumption, labor, and bond holdings:

$$\mathbb{E}_t \left[\sum_{\iota=0}^{\infty} \beta^\iota U_{t+\iota}^k \right], \tag{10}$$

[6] We denote type-h goods as good h in the following.

subject to the budget constraint

$$P_t^{C,k}C_t^k + P_{1,t}C_1^* + Q_t B_t^k = B_{t-1}^k + W_t^k N_t^k + D_t^k, \tag{11}$$

where B_t^k are one-period, nominally risk-free bonds purchased in period t at price Q_t, W_t^k denotes the nominal wage, and D_t^k are dividends from the ownership of firms. The optimality conditions are given by

$$\left(N_t^k\right)^{\varphi} = w_t^k Z_t \left(C_t^k\right)^{-\sigma}, \tag{12}$$

$$Q_t = \beta \mathbb{E}_t \left[\Lambda_{t,t+1}^k \frac{1}{\Pi_{t+1}^{C,k}} \right], \tag{13}$$

where $w_t^k \equiv \frac{W_t^k}{P_t^{C,k}}$ is defined as the real wage, $\beta\Lambda_{t,t+1}^k \equiv \beta \frac{Z_{t+1}}{Z_t}\left(\frac{C_{t+1}^k}{C_t^k}\right)^{-\sigma}$ as the stochastic discount factor, and $\Pi_{t+1}^{C,k} \equiv \frac{P_{t+1}^{C,k}}{P_t^{C,k}}$ as inflation. Eq. (12) describes the optimal labor supply of household k, equating the marginal disutility from working to its marginal utility. Eq. (13) is the Euler equation governing intertemporal consumption.

Due to the shared bond market, we can obtain the following risk sharing conditions between the two households by combining (13) for each household k, with $-k$ denoting the respective other household:

$$\left(C_t^k\right)^{-\sigma} = \left(C_t^{-k}\right)^{-\sigma} \Phi^k \frac{P_t^{C,k}}{P_t^{C,-k}}, \tag{14}$$

with $\Phi^k \equiv \frac{C_{SS}^{k\ -\sigma}}{C_{SS}^{-k\ -\sigma}}$, where the subscript SS denotes the zero inflation steady state of a variable. Eq. (14) implies that consumption of both households co-moves proportionally over time.

3.2. Firms

There are two types of firms in the economy: type-1 firms producing good 1 and type-2 firms producing good 2.[7] We assume perfectly separated labor markets, with households L and H working in firms 1 and 2, respectively.[8] Following Calvo (1983), we assume that only a fraction $1-\lambda$ of firms can reset their price in each period, independently from the last adjustment.

A representative firm produces with a simple production function given by

$$Y_{g,h,t} = \left(N_{g,t}^k\right)^{1-\alpha_h}, \tag{15}$$

where α_h is the labor elasticity of output, governing the marginal productivity of labor from household k, with $k=L$ if $h=1$ and $k=H$ if $h=2$. The firm's real total cost function is given by

$$TC_{g,h,t} = A_{h,t} w_t^k N_{g,t}^k, \tag{16}$$

with $A_{h,t}$ being defined as a firm-type-specific AR(1) supply shock.

The firm maximizes its expected discounted stream of profits

$$\mathbb{E}_t \left[\sum_{\iota=0}^{\infty} \beta^{\iota} \Lambda_{t,t+\iota}^k \lambda^{\iota} \left(\frac{P_{g,h,t}}{P_{t+\iota}^{C,k}} Y_{g,h,t+\iota|t} - TC\left(Y_{g,h,t+\iota|t}\right) \right) \right], \tag{17}$$

subject to

$$Y_{g,h,t+\iota|t} = \left(\frac{P_{g,h,t}}{P_{h,t+\iota}}\right)^{-\epsilon} Y_{h,t+\iota}, \tag{18}$$

where $Y_{g,h,t+\iota|t}$ is defined as the output in period $t+\iota$ for a firm that adjusts its price in period t, with $Y_{h,t+\iota}$ denoting the economy-wide output of good h. The optimality condition is

$$0 \overset{!}{=} \mathbb{E}_t \left[\sum_{\iota=0}^{\infty} \beta^{\iota} \Lambda_{t,t+\iota}^k \lambda^{\iota} Y_{g,h,t+\iota|t} \left(\frac{P_{g,h,t}}{P_{t+\iota}^{C,k}} - \mu mc\left(Y_{g,h,t+\iota|t}\right) \right) \right], \tag{19}$$

with $\mu \equiv \frac{\epsilon}{\epsilon-1}$ and $mc\left(Y_{g,h,t}\right) = \frac{1}{1-\alpha_h} A_{h,t} w_t^k Y_{g,h,t}^{\frac{\alpha_h}{1-\alpha_h}}$ being defined as real marginal costs of firm g. Due to symmetry, the optimal price is the same for all firms of a particular type that can adjust. It is given by

$$\left(p_{h,t}^*\right)^{1+\frac{\epsilon\alpha_h}{1-\alpha_h}} = \mu \left(V_{h,t}^k\right)^{-1} \frac{b_{h,t}}{d_{h,t}}. \tag{20}$$

The auxiliary variables are defined as

$$b_{h,t} \equiv Z_t \left(C_t^k\right)^{-\sigma} Y_{h,t} mc_{h,t} + \beta\lambda \mathbb{E}_t \left[\Pi_{h,t+1}^{\frac{\epsilon}{1-\alpha_h}} b_{h,t+1} \right],$$

$$d_{h,t} \equiv Z_t \left(C_t^k\right)^{-\sigma} Y_{h,t} + \beta\lambda \mathbb{E}_t \left[\Pi_{h,t+1}^{\epsilon} \left(\Pi_{t+1}^{C,k}\right)^{-1} d_{h,t+1} \right],$$

with $p_{h,t}^* \equiv \frac{P_{h,t}^*}{P_{h,t}}$. The variable $mc_{h,t}$ denotes the economy-wide real marg inal costs of producing good h and $\Pi_{h,t+1} \equiv \frac{P_{h,t+1}}{P_{h,t}}$ is defined as inflation of good h. Aggregate price dynamics are given by

$$1 = (1-\lambda)\left(p_{h,t}^*\right)^{1-\epsilon} + \lambda \left(\frac{1}{\Pi_{h,t}}\right)^{1-\epsilon}. \tag{21}$$

The overall price level is a weighted average of the price set by firms that can adjust their prices in t (given by Eq. (20)) and the remaining share λ of firms that keep the price of the previous period.

3.3. Monetary policy

We assume that the central bank's goal is to stabilize economy-wide inflation. Monetary policy is conducted according to the reaction function.[9]

$$i_t = \rho + \phi\left(\delta \pi_t^{CPI,L} + (1-\delta)\pi_t^{CPI,H}\right), \tag{22}$$

where $i_t \equiv log\left(\frac{1}{Q_t}\right)$, $\rho \equiv log\left(\frac{1}{\beta}\right)$, and $\pi_t^{CPI,k} \equiv log\left(\Pi_t^{CPI,k}\right)$. The parameter $\phi > 1$ denotes the reaction coefficient of the central bank to the weighted (with $\delta \in [0,1]$) CPI-inflation rates of households L and H which are given by

$$\pi_t^{CPI,k} = \frac{C_{SS}^k}{C_1^* + C_{SS}^k}\pi_t^{C,k} + \frac{C_1^*}{C_1^* + C_{SS}^k}\pi_{1,t}. \tag{23}$$

Thus, the CPI-inflation rate of household k is the weighted average of the inflation rate of excess consumption ($\pi_t^{C,k} \equiv log\left(\Pi_t^{C,k}\right)$) and good-1 inflation due to the subsistence level.

The parameter δ is of particular importance for our analysis. If $\delta=\kappa$, i.e., the weight of each household's CPI-inflation rate in the monetary policy rule coincides with the respective share of the household in the economy, the central bank reacts to the average, economy-wide inflation rate given by

$$\pi_t^{CPI} = \kappa\pi_t^{CPI,L} + (1-\kappa)\pi_t^{CPI,H}. \tag{24}$$

However, we additionally consider $\delta \neq \kappa$, i.e., the central bank reacts more strongly to the CPI-inflation rate of either household H ($\delta<\kappa$) or L ($\delta>\kappa$) than suggested by the economy-wide inflation rate.

Finally, the Fisher equation holds for each household

$$i_t = r_t + \mathbb{E}_t\left[\pi_{t+1}^{C,k}\right]. \tag{25}$$

3.4. Market clearing

Bonds markets clear

$$B_t^k = -B_t^{-k}, \tag{26}$$

as well as labor markets

$$N_t^L = \int_0^s N_{i,t}^L di \ , \ N_t^H = \int_s^1 N_{i,t}^H di. \tag{27}$$

[7] We denote type-h firms as firm h in the following.

[8] Note that, for the sake of simplicity, we assume that household L owns firm 1 and household H owns firm 2.

[9] Including the output gap in the reaction function does not qualitatively change the results, see Appendix A.1

Finally, goods markets clear for both goods

$$Y_{1,t} = C^L_{1,t} + C^H_{1,t} \ , \ \ Y_{2,t} = C^L_{2,t} + C^H_{2,t}, \tag{28}$$

and overall production is given by

$$Y_t = Y_{1,t} + Y_{2,t}. \tag{29}$$

3.5. Aggregate dynamics

In log-linear fashion, with $\hat{x}$ being defined as the log-linear deviation of variable X from its steady state and $x{\equiv}log(X)$, the inflation rate of excess consumption follows

$$\hat{\pi}^C_t = \gamma\hat{\pi}_{1,t} + (1-\gamma)\hat{\pi}_{2,t}. \tag{30}$$

Each household's inflation rate of excess consumption is a weighted average of the inflation rates for both goods and is unaffected by household-specific parameters. Thus, we drop the index k.

The dynamic IS equation is given by

$$\hat{c}^k_t = \mathbb{E}_t\left[\hat{c}^k_{t+1} + \Delta Z_{t+1}\right] - \frac{1}{\sigma}\left(\hat{\imath}_t - \mathbb{E}_t\left[\hat{\pi}^C_{t+1}\right]\right), \tag{31}$$

with $\Delta Z_{t+1}{\equiv}Z_{t+1} - Z_t$. As always, the dynamic IS equation implies that consumption in period t depends positively on expected consumption in t+1 representing consumption smoothing and negatively on the real interest rate due to a lower incentive to consume when the real interest rate is high.

For each firm h, a sort of New Keynesian Phillips curve (NKPC) relating the inflation rate of good h to marginal costs, relative prices, and future inflation can be derived as

$$\hat{\pi}_{h,t} = \Psi_h\left(\hat{mc}_{h,t} - \hat{\upsilon}_{h,t}\right) + \beta\mathbb{E}_t\left[\hat{\pi}_{h,t+1}\right], \tag{32}$$

with $\Psi_h{\equiv}(1-\beta\lambda)\frac{1-\lambda}{\lambda}\frac{1-\alpha_h}{1-\alpha_h+\epsilon\alpha_h}$ and where

$$\begin{aligned}\hat{mc}_{1,t} \;=\; & \frac{(\alpha_1+\varphi)\frac{C^L_{1,SS}-C^*_1}{Y_{1,SS}} + \sigma(1-\alpha_1)}{1-\alpha_1}\hat{c}^L_t + \frac{(\alpha_1+\varphi)\frac{C^H_{1,SS}-C^*_1}{Y_{1,SS}}}{1-\alpha_1}\hat{c}^H_t \\ & - \frac{(\alpha_1+\varphi)\left(\frac{C^L_{1,SS}}{Y_{1,SS}}\epsilon^L_{P,1,SS} + \frac{C^H_{1,SS}}{Y_{1,SS}}\epsilon^H_{P,1,SS}\right)}{1-\alpha_1}\hat{\upsilon}_{1,t} + a_{1,t},\end{aligned} \tag{33}$$

and

$$\begin{aligned}\hat{mc}_{2,t} \;=\; & \frac{(\alpha_2+\varphi)\frac{C^L_{2,SS}}{Y_{2,SS}}}{1-\alpha_2}\hat{c}^L_t + \frac{(\alpha_2+\varphi)\frac{C^H_{2,SS}}{Y_{2,SS}} + \sigma(1-\alpha_2)}{1-\alpha_2}\hat{c}^H_t \\ & - \frac{(\alpha_2+\varphi)\left(\frac{C^L_{2,SS}}{Y_{2,SS}}\epsilon^L_{P,2,SS} + \frac{C^H_{2,SS}}{Y_{2,SS}}\epsilon^H_{P,2,SS}\right)}{1-\alpha_2}\hat{\upsilon}_{2,t} + a_{2,t},\end{aligned} \tag{34}$$

where the relative price $\hat{\upsilon}_{h,t}{=}\hat{p}_{h,t}{-}\hat{p}^C_t$ can be rewritten in terms of inflation rates as

$$\hat{\upsilon}_{h,t} - \hat{\upsilon}_{h,t-1} = \hat{\pi}_{h,t} - \hat{\pi}^C_t. \tag{35}$$

Eqs. (32)–(34) imply that the inflation rate of good h positively depends on good-h consumption by each household, since higher consumption increases firms' demand for labor, which in turn increases wages (i.e., costs). Furthermore, inflation of good h negatively depends on the relative price of good h with respect to the price index of households' excess consumption. Consider, for instance, an increase in the excess consumption price index, while the price of good h remains unchanged. In this case, the relative price of good h decreases, leading to increased demand and thus inflation.

Importantly, the impact of the relative prices is strengthened by larger values of $\epsilon^k_{P,h,t}$ due to a corresponding higher importance of the relative price of a good for its demand (see Eqs. (7)–(9)). The relationship between inflation and relative prices (i) arises solely from the model's two-sector structure, and (ii) is dependent on household heterogeneity in income and, therefore, in their relative price elasticity of demand.

Aggregate output is given by

$$\begin{aligned}\hat{y}_t \;=\; & \left(\frac{C^L_{1,SS}-C^*_1}{Y_{SS}} + \frac{C^L_{2,SS}}{Y_{SS}}\right)\hat{c}^L_t + \left(\frac{C^H_{1,SS}-C^*_1}{Y_{SS}} + \frac{C^H_{2,SS}}{Y_{SS}}\right)\hat{c}^H_t \\ & - \left(\frac{C^L_{1,SS}}{Y_{SS}}\epsilon^L_{P,1,SS} + \frac{C^H_{1,SS}}{Y_{SS}}\epsilon^H_{P,1,SS}\right)\hat{\upsilon}_{1,t} \\ & - \left(\frac{C^L_{2,SS}}{Y_{SS}}\epsilon^L_{P,2,SS} + \frac{C^H_{2,SS}}{Y_{SS}}\epsilon^H_{P,2,SS}\right)\hat{\upsilon}_{2,t}.\end{aligned} \tag{36}$$

Eq. (36) reveals that overall output positively depends on both households' overall consumption and negatively on both relative prices. The first line of the equation shows that higher consumption increases each firm's output and thus overall output. The sums multiplying $\hat{c}^k_t$ correspond to the share of a change in overall consumption that translates into a change in good-1 and good-2 consumption. Moreover, an increase in the relative price reduces demand and thus output of each firm, resulting in lower overall output. The strength of this effect positively depends on the share of the respective good in consumption and output (as a larger share implies that the good plays a larger role in determining overall output) and on ϵ^k_P (as a larger relative price elasticity implies larger adjustments of demand to changes in the relative price).

4. Results

4.1. Calibration

Table 2 shows the calibration of the model. We calibrate household H to be the household with higher income. We set the average intertemporal ES to an empirically plausible value of 0.5 (see Hall, 1988; Atkeson and Ogaki, 1996; Rupert et al., 2000; Gnocchi et al., 2016) as well as φ=5, leading to a Frisch elasticity of labor supply of 0.2, which is in line with the findings of Chetty et al. (2012) or Peterman (2015).

We further choose γ and C^*_1 to be equal across households, implying that the subsistence level of consumption is the same for L and H and that preferences between goods do not differ, i.e., they would both consume the same amount of good 1 and 2 if they had the same income. The values are calibrated to roughly match the relative consumption of good 1 and good 2 in steady state, as presented in Section 2 and in Gürer and Weichenrieder (2020). In particular, we calibrate the share of essential goods in the consumption basket of low-income households to be 65% in steady state, whereas that share amounts to about 50% for high-income households.[10] Correspondingly, household L has a lower ES and a lower price elasticity of demand, despite setting $\vartheta^L_C{=}\vartheta^H_C$.[11] The higher importance of the subsistence level implies a realized ES $\epsilon^L_C \sim 0.28$ and $\epsilon^H_C \sim 0.36$ for L and H in steady state, respectively. The realized price elasticity of demand is $\epsilon^L_P \sim 0.15$ for L as opposed to $\epsilon^H_P \sim 0.28$ for H in steady state. This reflects that higher-income households can substitute goods more effectively (Gürer and Weichenrieder, 2020; Argente and Lee, 2021). The remaining standard household parameters are chosen as in Galí (2015).

On the firms' side, we follow Kaplan et al. (2018) by setting α_2 to 0.33. We continue by choosing $\alpha_1{>}\alpha_2$, implying lower productivity of household L.[12] Following Galí (2015), we set the Calvo parameter for

[10] Note that in Gürer and Weichenrieder (2020), these values correspond to the lowest and highest income decile. Our results remain qualitatively unchanged when considering a lower difference between the households' consumption shares spent on goods with above-average CPI inflation.

[11] We examine the effect of exogenous differences in ϑ^k_C as a robustness check.

[12] We consider equal productivity as a robustness check.

Table 2
Calibration.

	Description	Value		Target/Source
		Households		
		L	H	
κ	Share of household L	0.5	0.5	Equal share of households
σ	Inverse intertemporal elasticity of substitution	2	2	Intertemporal elasticity of substitution: 0.5
φ	Inverse Frisch elasticity of labor supply	5	5	Frisch elasticity of labor supply: 0.2
γ	Weight of good 1 in overall consumption	0.36	0.36	$\frac{C^L_{1,SS}}{C^L_{1,SS}+C^L_{2,SS}}=0.65$, $\frac{C^H_{1,SS}}{C^H_{1,SS}+C^H_{2,SS}}=0.5$, internally calibrated
ϑ^k_C	Elasticity of substitution parameter	0.5	0.5	United States Department of Agriculture (2012)
C^*_1	Subsistence level of good 1	0.3	0.3	$\frac{C^L_{1,SS}}{C^L_{1,SS}+C^L_{2,SS}}=0.65$, $\frac{C^H_{1,SS}}{C^H_{1,SS}+C^H_{2,SS}}=0.5$, internally calibrated
ϵ	Price elasticity of demand for varieties	9	9	Steady state markup: 12.5%
β	Discount rate	0.99	0.99	Yearly nominal interest rate: 4%
		Firms		
		1	2	
s	Share of firm 1	0.5	0.5	Equal share of firms
α_h	Labor elasticity of output	0.5	0.33	Kaplan et al. (2018)
λ_h	Calvo parameter	0.75	0.75	Galí (2015)
		Central Bank		
ϕ	Taylor rule coefficient	1.5		Galí (2015)
δ	CPI inflation weight	0; 0.5; 1		Analysis parameter

both firms to 0.75.[13] Lastly, we solve the model with three different weights on CPI inflation of household L in the Taylor rule. The central bank considers only the low-income household (δ=1), only the high-income household (δ=0), or a weighted average of both households (δ=0.5).[14]

4.2. Dynamic analysis

4.2.1. Demand shock

Fig. 4 depicts the impulse responses of the model (as percentage deviations from the zero inflation steady state) to a negative 1% demand shock for the three monetary policy regimes. In general, i.e., independently from the central bank's regime, the effects of the demand shock are as follows: The shock implies that both households' consumption of both types of goods decreases. This decreased demand leads to lower output and lower inflation for both goods. Both CPI-inflation rates decrease. However, due to the subsistence level of good-1 consumption, the decrease in good-1 demand, and therefore in good-1 output and inflation, is lower than that of good 2. The less pronounced drop in good-1 inflation compared to good-2 inflation leads household L's CPI-inflation rate to decrease less than household H's. This is due to the fact that the low-income household L spends a larger share of its consumption expenditure on the essential good 1. This result is consistent with the fact that low-income households experience higher inflation rates than high-income households when inflation rates deviate negatively from their trend (see Section 2). The central bank reacts to the decrease in CPI inflation by decreasing the nominal interest rate, incentivizing consumption of both goods and mitigating the shock-induced effects on output and inflation.

Upon examining the effects of the different central bank regimes, we find that the weight on the respective CPI-inflation rates changes the model outcomes.[15] Overall, the central bank achieves its goal of economy-wide consumer price stability most efficiently when it only reacts to the CPI-inflation rate that diverges less from its steady state, i.e., to the inflation rate of the low-income household (δ=1). For a more convenient comparison between the monetary policy regimes, Fig. 4 also reports the difference between the absolute inflation responses under δ=0 and δ=1 for each period as bars. Thus, the positive difference in (almost) all periods indicates that inflation stabilization improves overall when the central bank reacts to the less affected household. This result tallies with the findings of Aoki (2001) and Mankiw and Reis (2003), despite arising from a different premise. Aoki (2001) finds that optimal monetary policy should target sticky-price inflation in a model with a flexible- and a sticky-price sector. Mankiw and Reis (2003), in a multi-sector model, also find that assigning a larger weight to sectors with stickier prices is welfare improving. We do not assume exogenous differences in price stickiness across sectors. However, the subsistence level causes endogenous differences in price developments between good types. In particular, we highlight the role of a *relative price elasticity channel* through which monetary policy affects the inflation rates. To illustrate this, consider the log-linearized demand for a good (see Eqs. (7)–(9)) given by

$$\hat{c}^k_{h,t} = \frac{C^k_{h,SS} - C^*_h}{C^k_{h,SS}} \hat{c}^k_t - \epsilon^k_{P,h,SS} \hat{v}_{h,t} = \begin{cases} \frac{C^k_{1,SS} - C^*_1}{C^k_{1,SS}} \hat{c}^k_t - \left(1 - \frac{C^*_1}{C^k_{1,SS}}\right) \vartheta^k_C \hat{v}_{1,t} & \text{if} h = 1, \\ \hat{c}^k_t - \vartheta^k_C \hat{v}_{2,t} & \text{if} h = 2. \end{cases} \tag{37}$$

[13] We are aware of the fact that, for instance, food prices are more flexible and volatile than non-food ones (Portillo et al., 2016), which would imply $\lambda_1 < \lambda_2$, since we assume that good 1 is the essential good, which includes food. However, to focus on household heterogeneity, we choose to abstract from other types of heterogeneity.

[14] Note that determinacy is virtually unaffected by the choice of δ or C^*_1 as the central bank's monetary policy affects both households via their Euler equations, and their CPI inflation rates are highly positively correlated.

[15] Note that the impact of the demand shock varies by household but is similar in the extent it affects the households' CPI-inflation rates. This is due to our assumption that both households consume more than the subsistence level of good-1 consumption, resulting in similar responses to a demand shock on excess consumption. The differences between the three monetary policy regimes are, therefore, small. Consequently, this type of demand shock cannot explain the large inflation differentials shown in Section 2. However, the analysis of this shock allows us to demonstrate the main mechanism of the model.

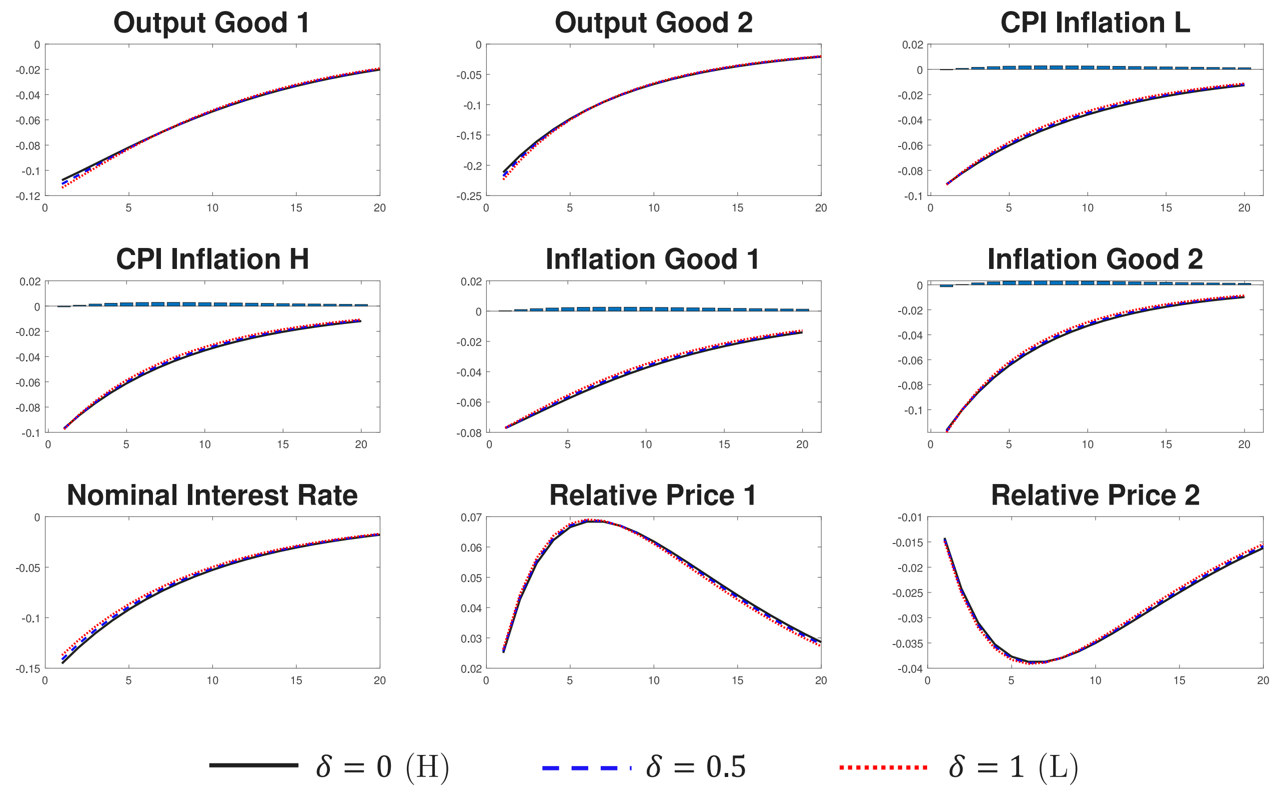


Fig. 4. Impulse responses to a negative 1% demand shock with persistence $\rho_Z = 0.9$. Bars: $|x_{t|\delta=0}| - |x_{t|\delta=1}|$.

Eq. (37) reveals that because of the subsistence level of good-1 consumption a change in aggregate demand affects good-1 and good-2 consumption in different ways. This implies an inverse development of relative prices: When aggregate demand decreases, for instance, good-1 demand decreases less than good-2 demand. As a result, the relative price of good 2 decreases whereas the relative price of good 1 increases. The demand for each good, in turn, is affected by its relative price — an increase in the relative price reduces demand and vice versa. However, the impact of a change in relative prices, $\hat{v}_{h,t}$, is weaker for good-1 than for good-2 consumption as the relative price elasticity of good-1 consumption is smaller ($\epsilon^k_{P,1,SS} < \epsilon^k_{P,2,SS}$). This effect is larger the more relevant the subsistence level is for a household, measured by the share of C_1^* in overall consumption of good 1. Consequently, changes in relative prices of good 1 have a lower impact on its demand by household L than by H. The different impacts of relative price changes on the demand for good 1 and 2 imply different effects on the firms' price setting behavior. For simplicity, assume that households are equally productive and that $\vartheta^L_C = \vartheta^H_C$ in the baseline. Then, the NKPCs can be derived from Eqs. (32)–(34) as

$$\hat{\pi}_{1,t} = \Psi \left(\frac{(\alpha+\varphi)\frac{C^L_{1,SS}-C_1^*}{Y_{1,SS}} + \sigma(1-\alpha)}{1-\alpha}\hat{c}^L_t + \frac{(\alpha+\varphi)\frac{C^H_{1,SS}-C_1^*}{Y_{1,SS}}}{1-\alpha}\hat{c}^H_t \right.$$
$$\left. - \frac{(\alpha+\varphi)\left(\frac{C^L_{1,SS}}{Y_{1,SS}}\epsilon^L_{P,1,SS} + \frac{C^H_{1,SS}}{Y_{1,SS}}\epsilon^H_{P,1,SS}\right) + (1-\alpha)}{1-\alpha}\hat{v}_{1,t} + a_{1,t} \right)$$
$$+ \beta\mathbb{E}_t\left[\hat{\pi}_{1,t+1}\right], \tag{38}$$

$$\hat{\pi}_{2,t} = \Psi \left(\frac{(\alpha+\varphi)\frac{C^L_{2,SS}}{Y_{2,SS}}}{1-\alpha}\hat{c}^L_t + \frac{(\alpha+\varphi)\frac{C^H_{2,SS}}{Y_{2,SS}} + \sigma(1-\alpha)}{1-\alpha}\hat{c}^H_t \right.$$
$$\left. - \frac{(\alpha+\varphi)\epsilon_{P,2,SS} + (1-\alpha)}{1-\alpha}\hat{v}_{2,t} + a_{2,t} \right) + \beta\mathbb{E}_t\left[\hat{\pi}_{2,t+1}\right]. \tag{39}$$

Eqs. (38) and (39) show that an increase in the relative price of a good negatively affects its inflation rate. Due to the higher relative price elasticity of good-2 demand ($\epsilon_{P,2,SS} > \epsilon^k_{P,1,SS}$ and thus $\epsilon_{P,2,SS} > \frac{C^L_{1,SS}}{Y_{1,SS}}\epsilon^L_{P,1,SS} + \frac{C^H_{1,SS}}{Y_{1,SS}}\epsilon^H_{P,1,SS}$) the impact of a change in the respective relative price is stronger on good-2 than on good-1 inflation.

When these observations are applied to the negative demand shock and the corresponding monetary policy response, we find the following: The shock-induced decrease in aggregate demand results in a decrease in $\hat{v}_{2,t}$ and an increase in $\hat{v}_{1,t}$. Because the relative price elasticity of demand for good 2 is greater than that for good 1, shock-induced relative price adjustments have a stabilizing effect on overall demand and thus on inflation. In contrast, the expansionary monetary policy response increases aggregate demand. The resulting policy-induced changes in relative prices analogously weaken the beneficial shock-induced adjustments in relative prices.

Thus, monetary policy affects the inflation rate via an adverse relative price elasticity channel, which weakens the interest rate channel. The central bank can decrease the adverse effects of this channel by reacting less expansionary to the shock. A less expansionary monetary policy causes a greater decrease in the relative price of good 2, thereby stabilizing economy-wide inflation. Consequently, reacting to the CPI-inflation rate of household L implies that all inflation rates are stabilized more effectively.[16] This implies that the standard divine coincidence does not hold after demand shocks. The strength of the relative price elasticity channel significantly depends on household heterogeneity, as the relevance of the subsistence level in a household's consumption basket is critical. A more detailed discussion follows in Section 4.2.3.

16 Relating this result to our findings presented in Section 2, one could argue that central banks should specifically consider the inflation rates of lower income quintiles when inflation rates are below trend.

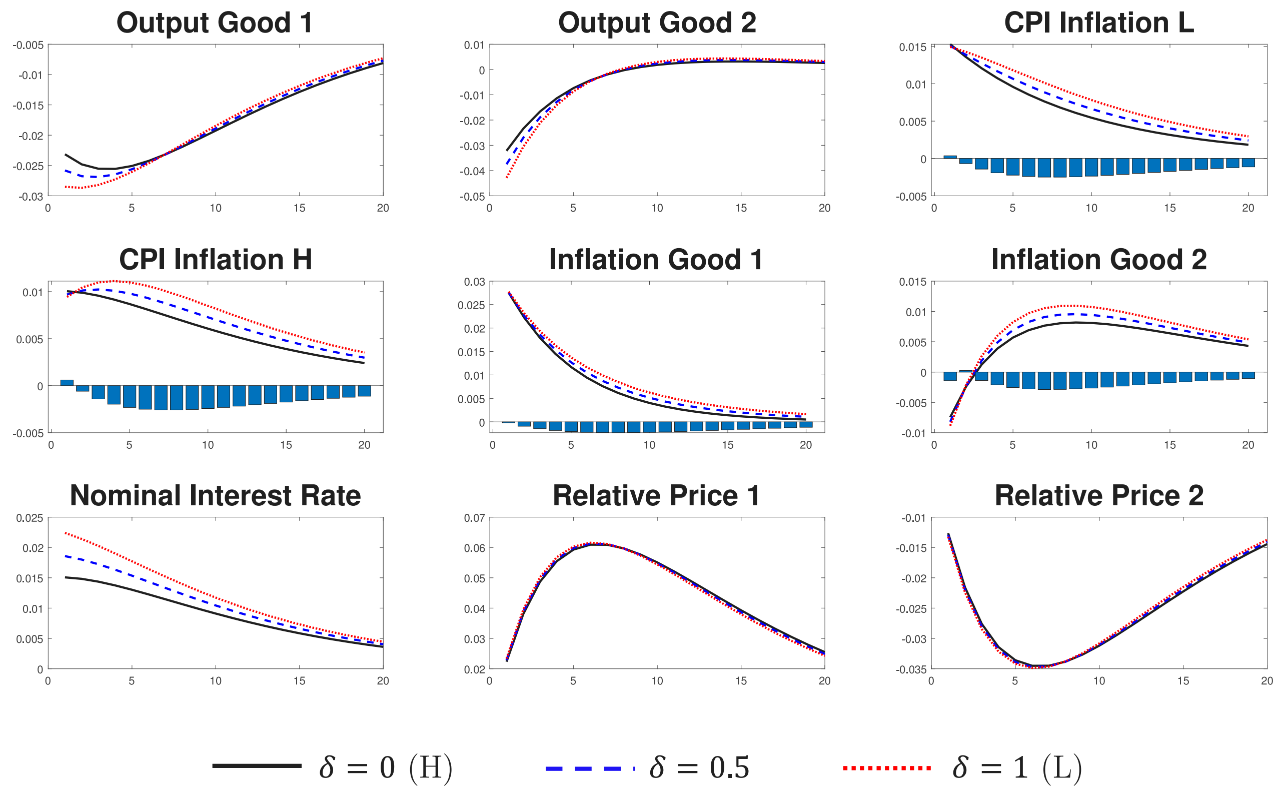


Fig. 5. Impulse responses to a negative 1% supply shock on good 1 with persistence $\rho_{A_1} = 0.9$. Bars: $|x_{t|\delta=0}| - |x_{t|\delta=1}|$.

4.2.2. Supply shocks

Figs. 5 and 6 show the impulse responses to a positive 1% cost-push shock on the essential and the non-essential good for the three monetary policy regimes. Again, we begin with a general description of the shock's effects on the model variables, independently of the central bank's regime. The shock-induced increase in marginal costs prompts the affected firm to increase its price. The relative price of the respective good increases, leading households to consume less of this good. Furthermore, both households' CPI inflation increases. The households are affected differently, with L's (H's) CPI-inflation rate increasing more when the supply shock hits essential (non-essential) goods. This implies that the cost-push shock on non-essential goods yields similar inflation rate responses as discussed in Section 2. Output of both good types decreases as real income falls. Due to the subsistence level, output of non-essential goods decreases more strongly than output of essential-goods. The central bank reacts to the increase in CPI inflation by increasing the nominal interest rate. This incentivizes households to save rather than consume, further decreasing output while stabilizing the inflation rate — the typical trade-off for monetary policy when facing supply shocks.

Upon examining the effects of the different central bank regimes, we find again that the central bank achieves its goal of economy-wide consumer price stability most effectively when it only reacts to the CPI-inflation rate that deviates less from its steady state, as indicated by the negative (positive) deviations between regimes displayed by the bars. The main driver of this result is the relative price elasticity channel which weakens the stabilizing effect of the interest rate channel. In response to the supply shock, costs and prices of the affected firm increase and the central bank reacts by conducting contractionary monetary policy to decrease demand and prices. Due to the subsistence level of good-1 consumption, the drop in demand is greater for good 2. Thus, the central bank's response to the shock leads to a decrease (increase) in the relative price of good 2 (1). This has an increasing (a decreasing) effect on the demand for good 2 (1) and, as a result, good-2 (good-1) prices. Thus, the effect of the contractionary monetary policy reaction is dampened by its effect on good 2 but strengthened by its effect on good 1. The dampening effect outweighs the strengthening effect because the relative price elasticity of demand is higher for good 2 than for good 1. Consequently, the more contractionary the monetary policy reaction, the stronger the dampening effect of the relative price elasticity channel.

Therefore, the relative price elasticity channel implies that the central bank should react to the CPI-inflation rate of the less-affected household to stabilize inflation more effectively,[17] which is equivalent to the result derived when examining the demand shock. These results hold for a given central bank reaction coefficient ϕ_π to inflation. Appendix B shows that a lower overall reaction to inflation does not have the same effect on stabilizing inflation, and the results regarding the relative price elasticity channel remain unchanged. Notably, another feature of our model is that a kind of divine coincidence arises in the context of supply shocks: the relative price elasticity channel implies that a lower drop in consumption is required to combat inflation.

4.2.3. The role of household heterogeneity

In order to properly identify how household heterogeneity affects the aforementioned outcomes, we examine how the responses of both households' inflation rates depend on key model parameters. Fig. 7 depicts the impulse responses of the households' CPI-inflation rates to the three shocks under the baseline calibration and two additional specifications. In the first departure from our baseline, we assume that both households are equally productive, implying that households are calibrated fully symmetrically in that specification (note that they still work for different firms). In the second departure from the baseline we assume that households not only differ in their productivity but also

[17] Our findings from Section 2 again imply that central banks should specifically consider the inflation rates of lower income quintiles when inflation rates are above trend.

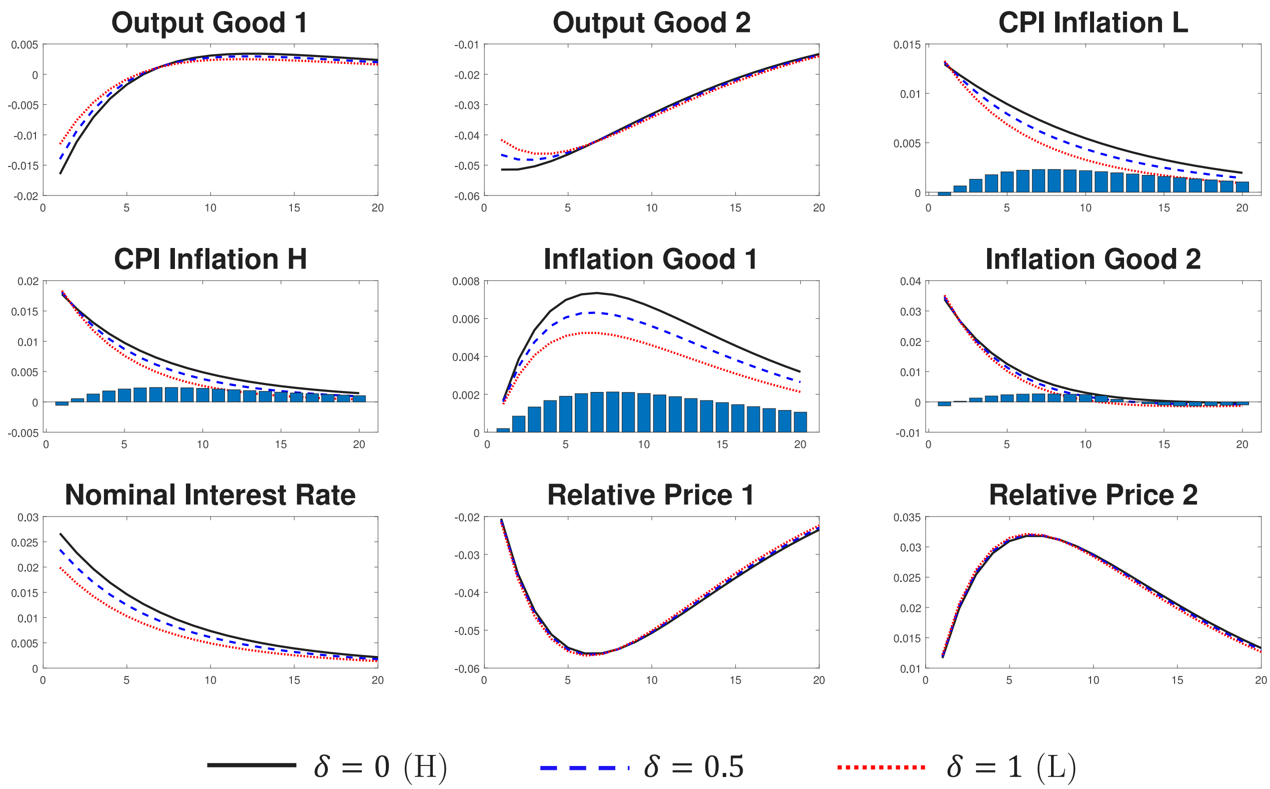


Fig. 6. Impulse responses to a negative 1% supply shock on good 2 with persistence $\rho_{A_2} = 0.9$. Bars: $|x_{t|\delta=0}| - |x_{t|\delta=1}|$.

in ϑ_C^k, i.e., the parameter governing both the ES (see Eq. (3)) and the relative price elasticity of demand. As previously state lower-income households have lower substitution capabilities. Although this property emerges endogenously in our model, we check the robustness of our results by additionally setting $\vartheta_C^H > \vartheta_C^L$.

Generally, the figures show that household heterogeneity plays an important role monetary policy transmission via the relative price elasticity channel. Upon comparing the impulse responses of the three shocks[18] under the baseline calibration with the ones with symmetric households, we find the following. Although both households' inflation rates remain more stabilized when the central bank reacts to households whose inflation rates deviate less from steady state, the benefit of reacting less strongly diminishes when households are symmetric. Hence, the relative price elasticity channel becomes less relevant. The intuition behind this result is simple: the symmetric calibration implies a higher income of household L than in the baseline,[19] leading to higher consumption of both goods and a higher relative price elasticity of demand for good 1. Thus, the differences in price elasticities between goods are smaller, implying that the adverse relative price elasticity channel is more relevant when household income is lower and, for a given level of productivity/income of high-income households, when income differences across households are larger.

We continue by comparing the impulse responses under the baseline calibration with those where we also assume exogenous differences in the ES parameter ϑ_C^k. We find that a larger exogenous substitution capability by household H tends to decrease the relevance of the relative price elasticity channel. This is due to two reasons: (i) relative prices deviate less strongly from steady state as relative price elasticities increase, and (ii) the relative price elasticity of demand for good 1 of household H increases in comparison to the baseline, as for given income and consumption a larger ϑ_C^k implies a larger $\epsilon_{1,P,t}^k$. Both properties weaken the adverse effects of the relative price elasticity channel of monetary policy.

In general, an increase in household heterogeneity that implies a greater difference in household-specific inflation rates also leads to a larger potential for the central bank to weaken the adverse relative price elasticity channel.

5. Conclusion

We report significant inflation differentials across income quintiles in the United States between 2001 and 2023. In particular, we show that low-income households experience higher inflation rates than households with higher income. When controlling for trend inflation, we find that lower quintiles still experienced higher inflation rates in most quarters over the last 20 years. As these differentials are quite large, these results provide a rationale for central banks to consider household inflation heterogeneity. Against this background, this paper then theoretically examines whether it is beneficial for central banks that aim to stabilize the economy-wide inflation rate to do so. We incorporate a low- and a high-income household in a multi-sector (essential and non-essential) New Keynesian model. Households experience different inflation rates after shocks due to a subsistence level on essential good consumption: Low-income households spend a higher share of their income on essential goods due to the subsistence level. Furthermore, the subsistence level plays a crucial role for monetary policy transmission because it impacts relative prices and the relative price elasticity of demand. The greater the relevance of the subsistence level in a household's consumption basket, the lower the relative price elasticity of demand for essential goods. We show that monetary policy is more effective in attaining price stability when it

[18] Note that, for the reasons discussed in the previous subsection, the differences between the monetary policy regimes for the demand shock remain small, regardless of the calibration. However, the role of household heterogeneity described in the following still applies.

[19] Note that household L's income is still lower than H's even when they are equally productive. This is due to separated labor markets and the fact that households have a higher preference (and thus demand) for non-essential goods.

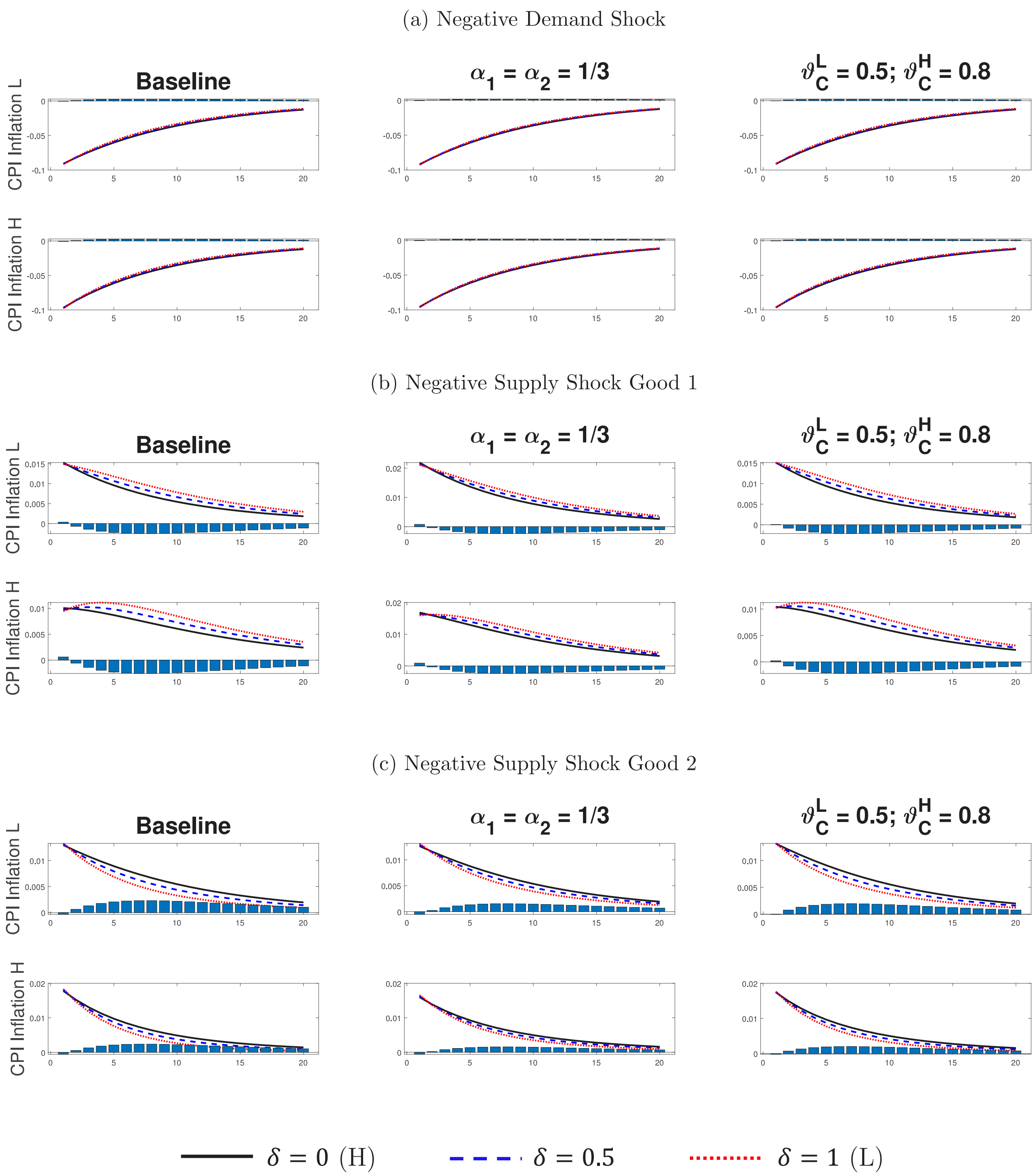


Fig. 7. Impulse responses to demand and supply shocks with persistence $\rho = 0.9$ for different calibrations. Bars: $|x_{t|\delta=0}| - |x_{t|\delta=1}|$.

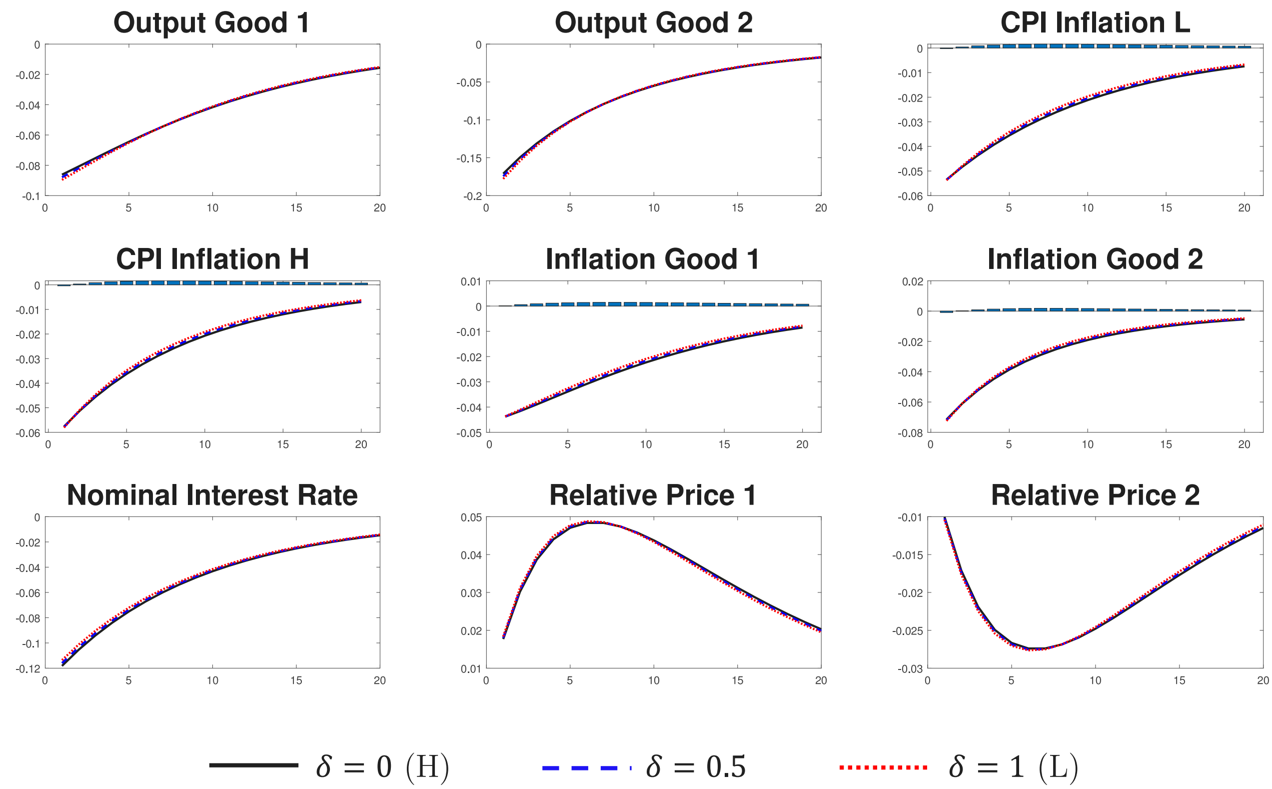


Fig. A.1. Impulse responses to a negative 1% demand shock with persistence $\rho_Z = 0.9$, modified monetary policy rule. Bars: $|x_{t|\delta=0}| - |x_{t|\delta=1}|$.

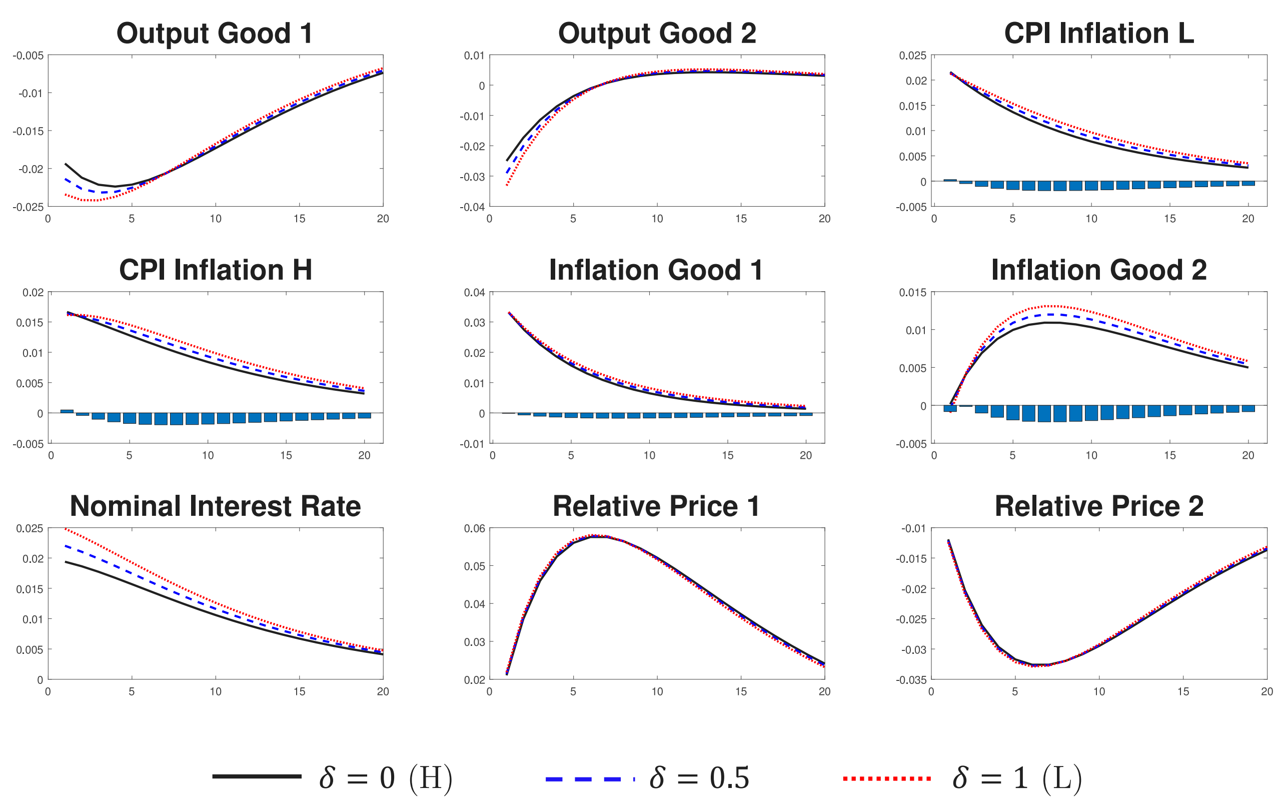


Fig. A.2. Impulse responses to a negative 1% supply shock on good 1 with persistence $\rho_{A_1} = 0.9$, modified monetary policy rule. Bars: $|x_{t|\delta=0}| - |x_{t|\delta=1}|$.

considers the differences in relative price elasticities across goods and households. In general, the central bank can stabilize the economy-wide inflation rate more effectively after shocks when only considering the household whose CPI-inflation rate is less affected. A less pronounced reaction of the central bank implies that monetary policy can achieve beneficial relative price adjustments by mitigating the adverse effects of

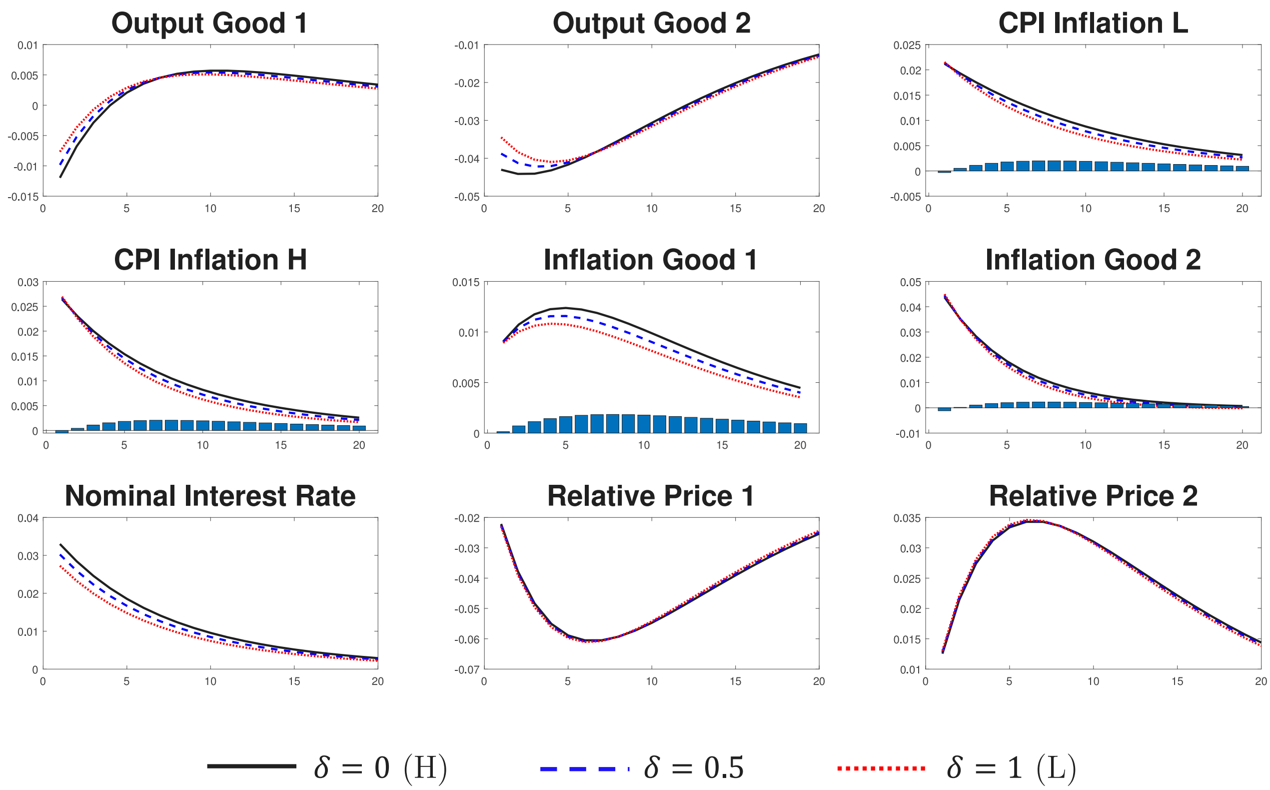


Fig. A.3. Impulse responses to a negative 1% supply shock on good 2 with persistence $\rho_{A_2} = 0.9$, modified monetary policy rule. Bars: $|x_{t|\delta=0}| - |x_{t|\delta=1}|$.

a relative price elasticity channel that weakens the interest rate channel of monetary policy. We show that the strength of this channel depends on the extent of household heterogeneity.

Our results have considerable monetary policy implications. Discretionary reactions of central banks to different inflation rates are likely to result in lower fluctuations in economy-wide inflation rates. In particular, it will be beneficial if central banks consider a range of inflation rates experienced in an economy and the price elasticities of demand for different goods as indicators for the conduct of monetary policy. This implies adding different consumer price inflation rates and price elasticities to the variables utilized to determine the appropriate stance of monetary policy. While considering these consumer price inflation rates and price elasticities may pose an additional challenge to central bank communication, the overall stabilizing effect on the inflation rates experienced by all households could support anchoring inflation expectations.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

A.1. Output deviations in monetary policy rule

We consider a different specification of the central bank's reaction function, in particular,

$$i_t = \rho + \phi \left(\delta \pi_t^{CPI,L} + (1-\delta)\, \pi_t^{CPI,H} \right) + \phi_y \hat{y}_t, \tag{A.1}$$

with ϕ_y denoting the central bank's reaction coefficient to overall output deviations, set to a standard value of 0.125 (see, for instance, Galí, 2015). The following figures show the impulse responses to the three shocks under consideration. Our results remain qualitatively unchanged when considering a modified version of the central bank's reaction function (see Figs. A.1–A.3).

Appendix B. Lower reaction to inflation in monetary policy rule

The main result of our analysis is that the central bank can better stabilize all inflation rates better if it only reacts to the least affected household after a shock. An intuitive conclusion from this result is that the central bank would be able to stabilize inflation even more effectively if it generally reacted less to inflation, i.e., if the reaction coefficient ϕ_π were lower. To check the robustness of our results and address this potential conclusion, we simulate the model responses with a (significantly) lower reaction coefficient ($\phi_\pi = 1.00005$). Our findings are twofold: (i) inflation rate responses to all shocks are generally larger, implying that decreasing the reaction coefficient does not result in a more effective attainment of price stability, and (ii) the stabilizing effect of reacting to the less affected household is larger in comparison to our baseline responses, implying that our results regarding the relative price elasticity channel remain valid. These results are due to the fact that a less forceful overall reaction to inflation implies a weaker initial inflation stabilization via the interest rate channel. In general, this results in larger inflation and relative price responses, as well as a quantitatively larger interest rate response in general equilibrium (while the reaction coefficient is smaller than in our baseline calibration, it must still be greater than one to satisfy the Taylor principle, implying larger general equilibrium effects on the nominal interest rate when inflation responses are large due to a low reaction coefficient). This implies larger relative price adjustments and an even more pronounced adverse relative price elasticity channel (see Figs. B.1–B.3).

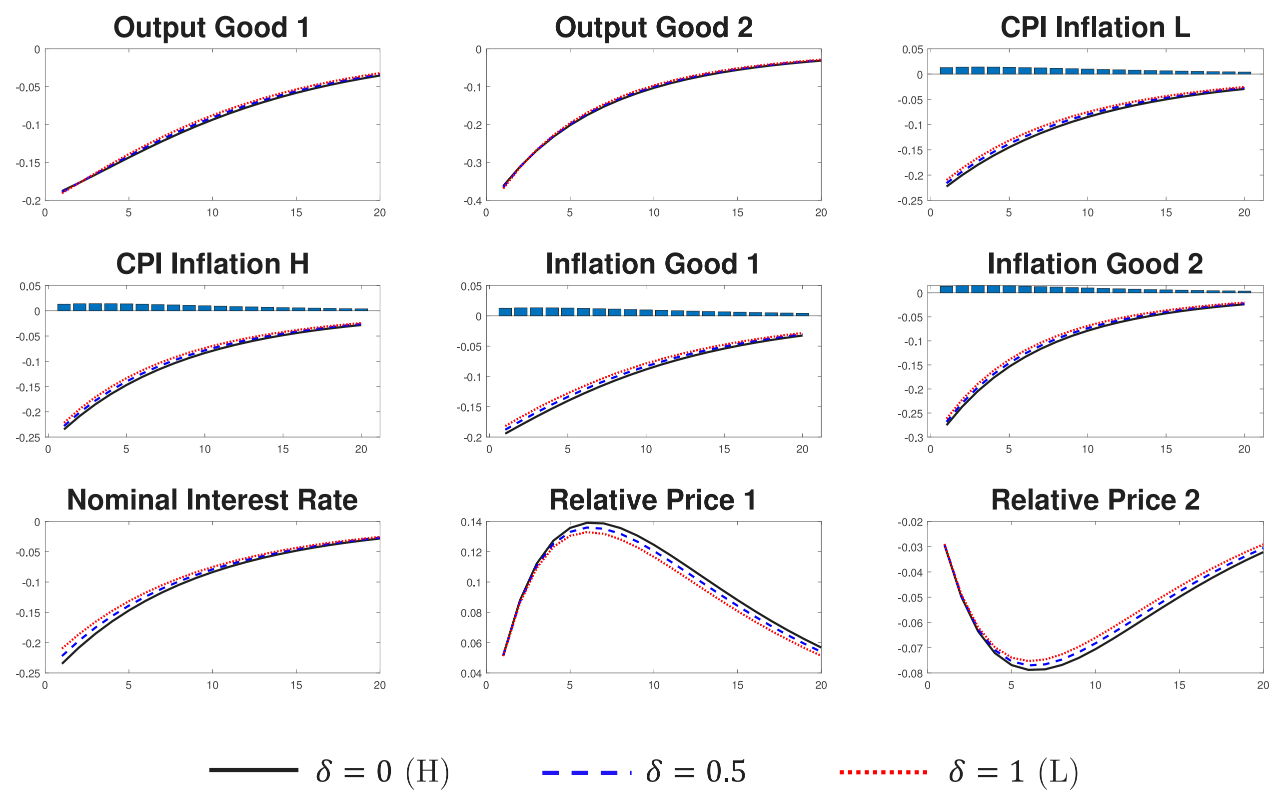


Fig. B.1. Impulse responses to a negative 1% demand shock with persistence $\rho_Z = 0.9$, $\phi_\pi = 1.00005$. Bars: $|x_{t|\delta=0}| - |x_{t|\delta=1}|$.

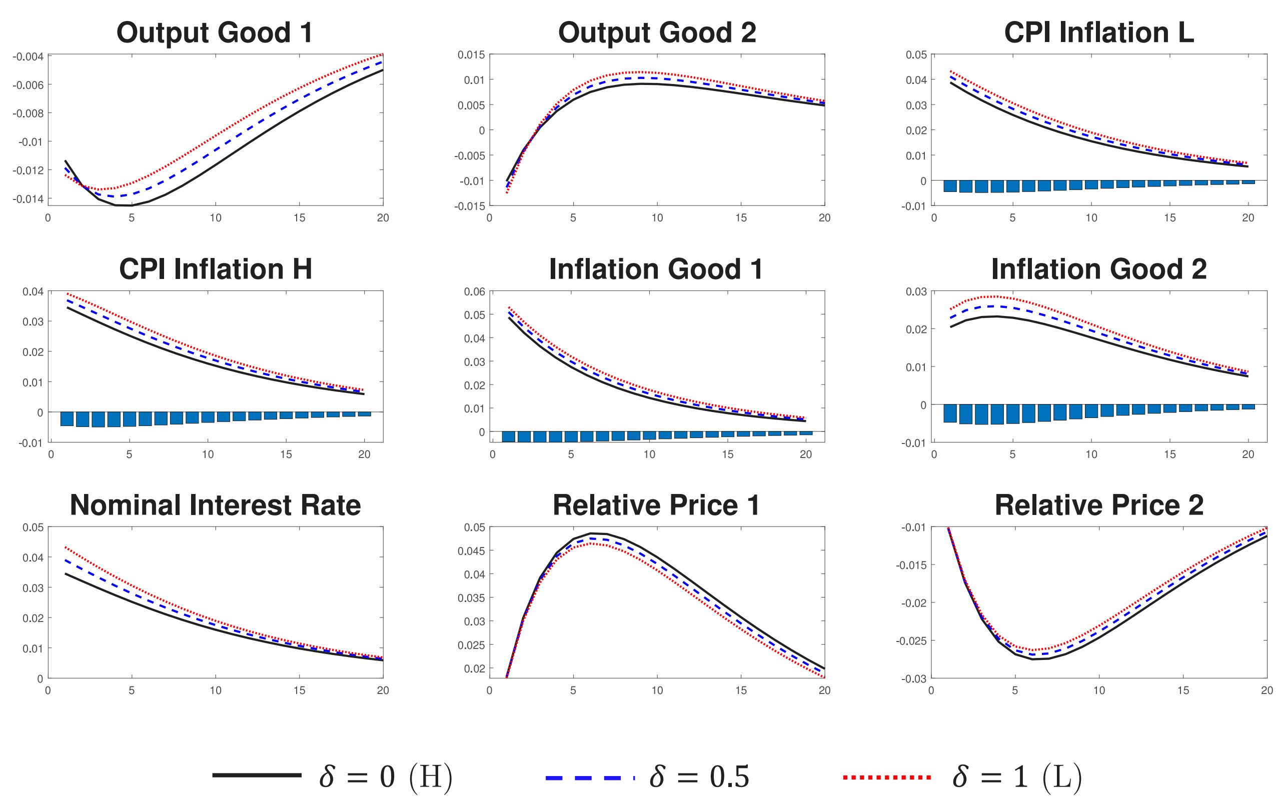


Fig. B.2. Impulse responses to a negative 1% supply shock on good 1 with persistence $\rho_{A_1} = 0.9$, $\phi_\pi = 1.00005$. Bars: $|x_{t|\delta=0}| - |x_{t|\delta=1}|$.

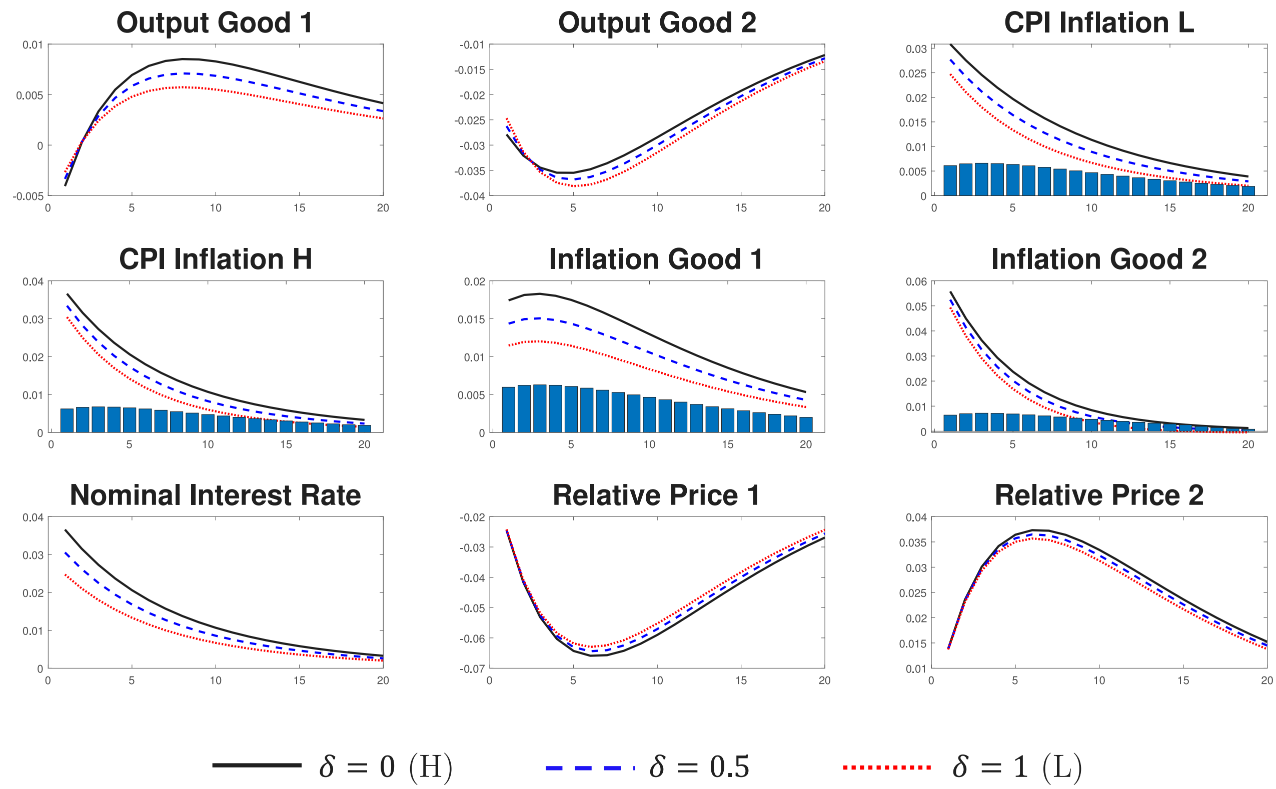


Fig. B.3. Impulse responses to a negative 1% supply shock on good 2 with persistence $\rho_{A_2} = 0.9$, $\phi_\pi = 1.00005$. Bars: $|x_{t|\delta=0}| - |x_{t|\delta=1}|$.

Data availability

Link to Mendeley Repository attached

Household Inflation Heterogeneity and the Relative Price Elasticity Channel of Monetary Policy Replication Files (Original data) (Mendeley Data)

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