

Stempel, Daniel; Neyer, Ulrike

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Should Central Banks Consider Household Inflation Heterogeneity?

Ulrike Neyer*

Daniel Stempel†

Abstract

Using data from the United States and Europe, this paper shows that considerable differentials in inflation rates exist across households. Against this background, we investigate whether central banks should consider household inflation heterogeneity in a tractable New Keynesian model. We include two households that differ in their consumer price inflation rates after adverse shocks. The central bank reacts to either an average of the households' consumer price inflation rates or their individual rates, respectively. After demand and supply shocks, a central bank that only considers the household whose individual inflation rate diverges less from steady state achieves lower fluctuations of the inflation rates of both households and of output. Our results imply that central banks, which discretionarily consider differing inflation experiences in an economy, lead to a more efficient attainment of an economy-wide inflation target and to higher welfare.

JEL classifications: E31, E32, E52

Keywords: Business cycles, inflation, inequality, household heterogeneity, New Keynesian models

*Heinrich Heine University Düsseldorf, Ulrike.Neyer@hhu.de

†Corresponding Author, Heinrich Heine University Düsseldorf, Daniel.Stempel@hhu.de

1 Introduction

Central banks aim to stabilize prices by pursuing an adequate inflation target. However, the inflation rate does not only serve as a measure for assessing the achievement of price stability but also as an indicator for the implementation of monetary policy. In order to measure inflation, typically changes in a general consumer price index (CPI) are considered. The inflation rate then reflects the price changes experienced by an average consumer. However, this inflation rate hides substantial inflation heterogeneity across households, depending on various household characteristics. For instance, studies show that households with lower income experience considerably higher inflation rates than households with higher income (see Gürer and Weichenrieder (2020), for example). Using data from the United States, the European Union, France, Germany, Italy, Spain, and the United Kingdom, we calculate the inflation rates experienced by income quintiles from 2001 to 2020. We find considerable inflation heterogeneity across quintiles in all countries. In particular, the aggregated inflation differential between the lowest and the highest quintile is always positive, with values up to 8.31 percentage points (pp). A main driver for these inflation differentials is the fact that low-income households spend a higher share of their income on essential goods (like food or housing), as these goods exhibit above-average inflation. Conversely, non-essential goods (such as recreational activities), which exhibit below-average inflation rates, are more prevalent in the consumption baskets of high-income households.

Against this background, we examine the consequences of utilizing different inflation rates as indicators for the implementation of monetary policy. In particular, we analyze how central banks that aim to stabilize the economy-wide inflation rate should react to household inflation heterogeneity in a tractable New Keynesian model. We find that central banks are able to stabilize the volatility of the economy-wide inflation rate more effectively after demand and supply shocks when only considering the household whose CPI inflation rate is less affected by these shocks. The model includes two households: a low- and a high-income household, with the low-income household experiencing higher CPI inflation after adverse shocks. In our model, the central bank is assumed to follow a Taylor rule considering either only the CPI inflation rate of one of the households or a weighted average of both CPI inflation rates, respectively. We find that household inflation heterogeneity, and therefore the weight the central bank assigns to the respective CPI inflation rates, has significant effects on the model outcomes. After a

negative demand shock, a central bank that only reacts to the inflation rate experienced by the low-income household, i.e., to the inflation rate that diverges less from its steady state, mitigates the impact of the shock more effectively. The CPI inflation rates of both households and output exhibit lower volatility under that regime and economy-wide welfare is higher. After a negative supply shock, a central bank that only considers CPI inflation of the high-income household (i.e., the inflation rate that diverges less from its steady state) mitigates the impact of the shock on the CPI inflation rates of both households more effectively. The inflation rates as well as output exhibit lower volatility under that regime, implying higher economy-wide welfare. These results are generalizable and do not depend on income differences but rather only on inflation differentials across households.

Our results have considerable monetary policy implications. Discretionary reactions of central banks likely lead to lower fluctuations of economy-wide inflation rates after shocks. In particular, it seems sensible for central banks to consider a range of inflation rates experienced in an economy as indicators for the implementation of monetary policy. This implies adding inflation differentials to the list of variables utilized to determine the appropriate stance of monetary policy, for instance, within the economic projections of the European Central Bank or the Federal Reserve. Depending on the type of shock, the central bank could then choose to react to specific inflation rates in order to reach its economy-wide inflation target more effectively and stabilize all inflation rates in the economy. Considering the Taylor rule in our model, this discretion implies a central bank that is able to choose the weight of the household-specific inflation rates depending on the type of shock.

Our paper relates to the literature in the following ways. It connects to the strand of literature investigating the relationship between inflation and income inequality, such as Al-Marhubi (1997), or Albanesi (2007). Our paper further complements work that empirically investigates inflation differentials between households and that relates these differentials to certain household characteristics. In particular, 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.

Our paper also relates to theoretical literature examining the various 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). Lastly, our paper links to work that analyzes the effects of various types of household heterogeneity in New Keynesian models. In particular, this includes studies examining income and wealth inequality, such as Gornemann et al. (2016), Kaplan et al. (2018), or Luetticke (2018).¹ We contribute to these strands of the literature by theoretically examining how central banks should react to inflation differentials across households, thereby analyzing the effects of household inflation heterogeneity on business cycle fluctuations.

The paper is organized as follows: Section 2 reports inflation heterogeneity across households in the United States and Europe, Section 3 states the model before Section 4 describes the model responses to a demand and a supply shock. Section 5 concludes.

2 Household Inflation Heterogeneity in the US and Europe

2.1 Data

Reporting household inflation heterogeneity in the United States and Europe requires the gathering of household consumption and inflation data on an expenditure category level. In particular, we collect data on the share of (subsequently defined) expenditure categories in the overall consumption of income quintiles in the US, the European Union², France, Germany, Italy, Spain, and the United Kingdom. While household inflation heterogeneity is prevalent on a number of different dimensions of household characteristics (such as age, education, or number of children, see Hobijn et al., 2009), we focus our empirical and theoretical examination on the example of inflation differentials between income groups.

United States. The Bureau of Labor Statistics (BLS) publishes the CPI³ for several expenditure categories. Matching these categories with BLS data on the consumption of goods and services of income quintiles from the Consumer Expenditure Survey (CES), we create a data set containing the annual CPI inflation rate as well as the annual, quintile-specific consumption share of nine expenditure categories between 2001 and 2020: Food and non-alcoholic beverages; alcoholic beverages; housing; apparel; transportation; medical care; recreation; education and communication; other goods and services. Note that these categories refer to the category-specific CPI inflation rates provided by the BLS. The expenditure categories reported

¹For a comprehensive overview, see Kaplan and Violante (2018).

²We consider the current 27 member states of the EU.

³In particular, we use the standard CPI for all urban consumers, based on the US city average.

by the CES are similar but not identical. In particular, the CES provides the consumption expenditures of income quintiles divided into 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. In order to consistently match the consumption shares with the inflation rate of expenditure categories, we add entertainment and reading to receive a consumption measure for recreation as well as personal care products and services, tobacco products, and miscellaneous to receive a measure for other goods and services. This procedure ensures consistent measures of all expenditure categories as defined within the CPI. The inflation rate for each quintile is then calculated as the sum of the category-specific CPI inflation rate weighted by the quintile-specific share of the respective category in the quintile’s consumption basket on an annual basis. In Appendix A, we report the average inflation rate of the expenditure categories as well as their respective average consumption share per quintile between 2001 and 2020 for the US.

Europe. The statistical office of the European Union (Eurostat) publishes the annual harmonized index of consumer prices (for symmetry, also abbreviated as CPI) of several expenditure categories for all European countries and the EU. Furthermore, Eurostat reports the consumption share of identical categories in income-quintile-specific consumption baskets (“structure of consumption expenditure by income quintile and COICOP⁴ consumption purpose”). Hence, matching annual inflation and consumption share data per quintile for the EU, France, Germany, Italy, Spain, and the UK is straightforward. The reported categories are: Food and non-alcoholic beverages; alcoholic beverages, tobacco, and narcotics; clothing and footwear; housing, water, electricity, gas, and other fuels; furnishing, household equipment, and routine household maintenance; health; transport; communications; recreation and culture; education; restaurants and hotels; miscellaneous goods and services. However, the consumption share of expenditure categories per quintile are not provided on a yearly basis but only for 1988, 1994, 1999, 2005, 2010, and 2015. Therefore, the annual inflation rate per quintile for each country and the EU is calculated as the sum of the category-specific CPI inflation rate weighted by the quintile-specific share of each category closest to the respective year. In particular, for our considered time frame 2001–2020⁵, the reported consumption share per

⁴Classification of individual consumption by purpose.

⁵Note that the UK data ends in 2019.

quintile in 1999 is used for the year 2001, the reported share in 2005 for the years 2002–2007, the share in 2010 for 2008–2012, and the share in 2015 for the remaining years.⁶ Naturally, this procedure might lead to inaccuracies in our results. However, the consistent data treatment for all quintiles ensures comparable inflation rates between quintiles for all European countries and the EU. In Appendix B, we report the average inflation rate of the expenditure categories as well as their average consumption share per quintile between 2001 and 2020.

2.2 Results

Figure 1 shows the calculated inflation rates for each quintile between 2001 and 2020 as well as the official CPI inflation rate of the US. In the vast majority of years, households in lower income quintiles experience higher inflation rates than households with higher income. Over time, the highest income quintile experiences the lowest average inflation rate, while the second lowest income quintile experiences the highest. In the considered time span, the aggregated inflation differential between these two quintiles is 3.26 pp.

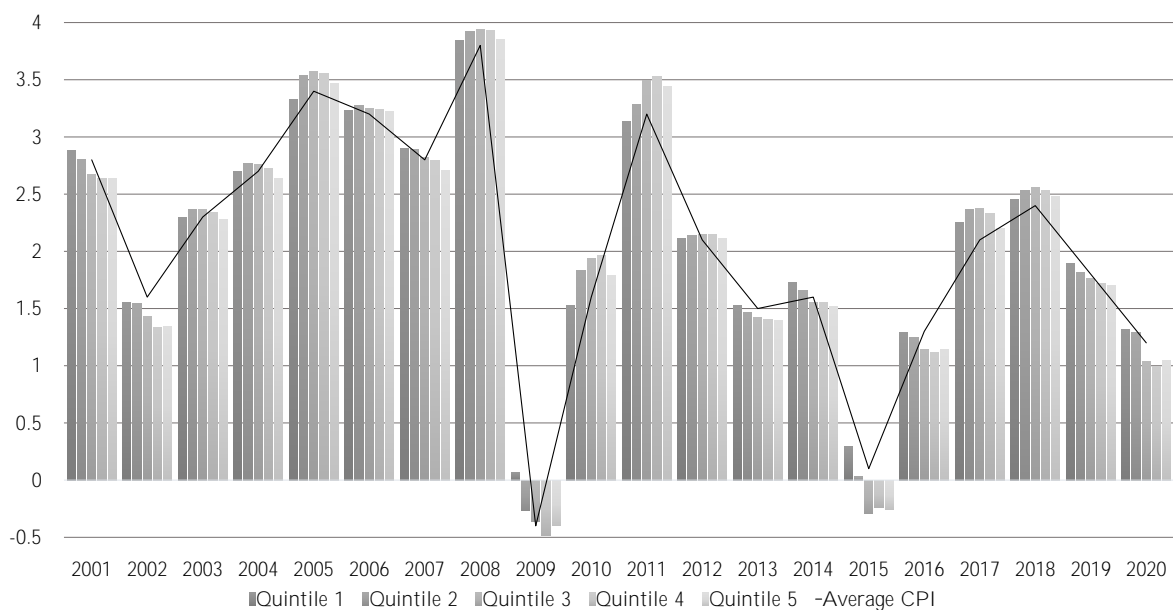


Figure 1: Inflation Rate (in Percent) per Income Quintile in the United States 2001–2020.

One reason for this heterogeneity in inflation rates is the difference in the structure of household expenditures: as shown in Table A.1, households with lower income consume a

⁶For the EU, Eurostat only reports the value for 2015. For Italy, only the values for 1999 and 2005 are available. The general procedure stays the same.

larger share of goods and services that exhibit high inflation rates. In particular, higher expenditures on food and non-alcoholic beverages, on housing, and on medical care (essential goods, which exhibit above-average inflation) by lower quintiles and a larger share of spending on apparel, transportation, and recreation (non-essential goods, which exhibit below-average inflation) by higher quintiles seem to be main drivers of these inflation differentials. These results tally with the studies conducted by Hobijn et al. (2009), Portillo et al. (2016), or Gürer and Weichenrieder (2020).

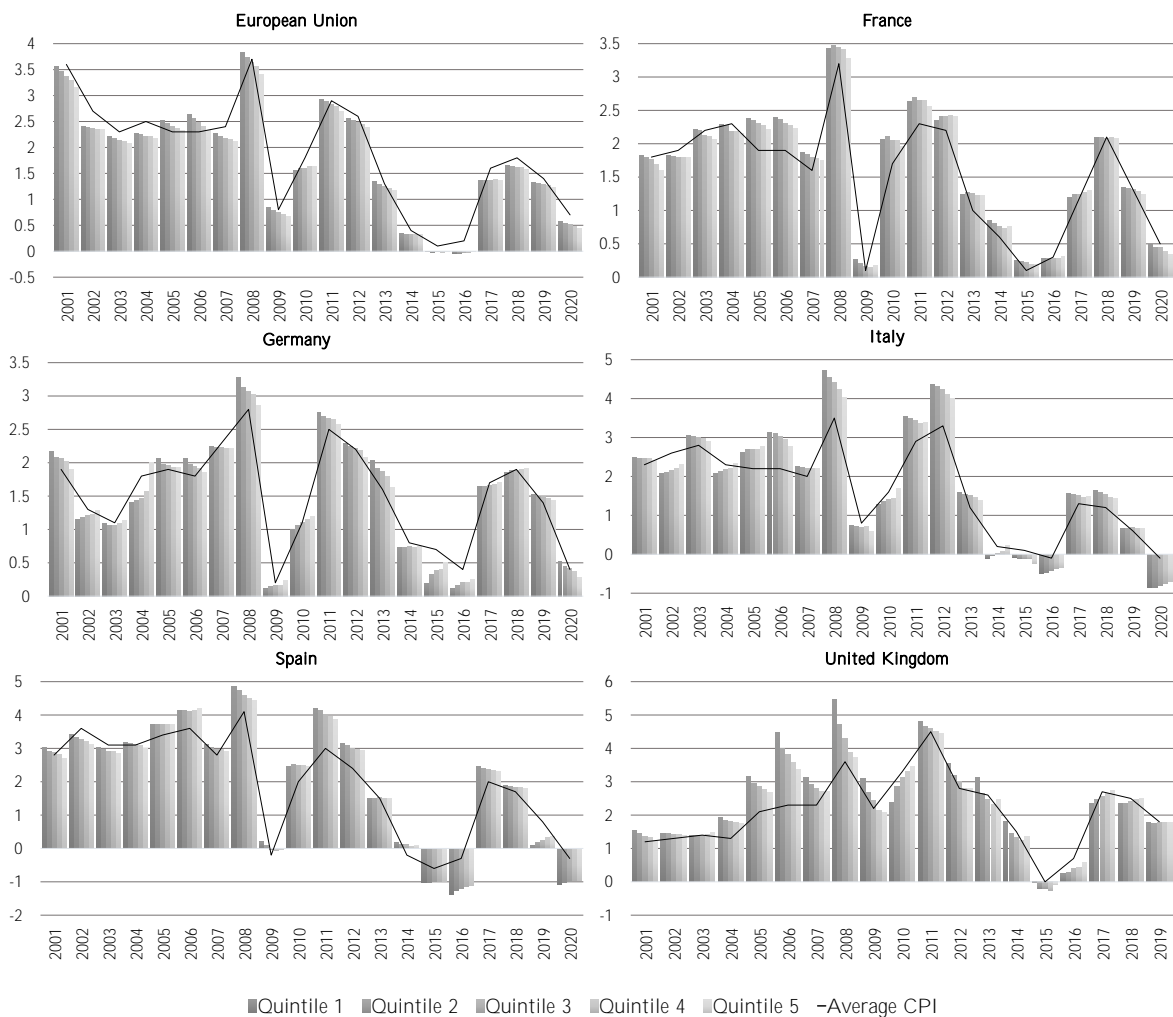


Figure 2: Inflation Rate (in Percent) per Income Quintile in Europe 2001–2020.

As Figure 2 shows, we find qualitatively similar results when analyzing inflation differentials between income quintiles in Europe. In the vast majority of years, households with lower income experience higher inflation rates than households with higher income. The extent

of this heterogeneity differs across countries: in the EU, the aggregated inflation differential between the lowest and the highest income quintile is 3.73 pp, in France 2.30 pp, in Germany 0.69 pp, in Italy 1.38 pp, in Spain 2.64 pp, and in the UK 8.31 pp.

As in the US case, we find that one driver for these inflation differentials are heterogeneous consumption shares of expenditure categories, as shown in Tables B.1–B.6. In particular, essential goods (such as food and non-alcoholic beverages and housing), which exhibit above-average inflation in all considered countries and the EU, play a more prevalent role in the consumption basket of households with lower income, while the share of non-essentials goods (clothing and footwear, recreation and culture), exhibiting below-average inflation, is higher in the consumption basket of households with higher income.

Note that the heterogeneity in consumption shares between quintiles is not the only possible explanation for the reported inflation differentials. In particular, Gürer and Weichenrieder (2020) and Argente and Lee (2021) show that households with higher income substitute goods more effectively than households with lower income. These differences in substitution capabilities are only partly captured in our data set for Europe as the consumption shares are not available on a yearly basis. Hence, our results are likely to understate actual inflation heterogeneity between households. This effect might additionally be strengthened by the broad categorization of expenditures and the use of income quintiles, as the consideration of more heterogeneity in terms of expenditure category inflation rates and of household income is likely to lead to larger household inflation heterogeneity. Nevertheless, our results depict considerable inflation differentials between income quintiles in the US and Europe, raising the question of how central banks should react to this heterogeneity. In the following, we present a model that replicates key findings reported in this section in order to analyze different central bank responses to inflation heterogeneity across households.

3 A Model with Household Inflation Heterogeneity

3.1 Households

There exist two households, $k=L,H$. We will calibrate L to be the household with lower income and H to be 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

$$U_t^k = \frac{(C_t^k)^{1-\sigma_k}}{1-\sigma_k} - \frac{(N_t^k)^{1+\varphi_k}}{1+\varphi_k}, \quad (1)$$

where σ_k is the inverse intertemporal elasticity of substitution, N_t^k denotes labor supply, φ_k the inverse Frisch elasticity of labor supply, and C_t^k is defined as a constant elasticity of substitution (CES) index given by

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

similar to Rabanal (2009). The parameter γ_k determines the household-specific share of type 1 goods, presented by the consumption index $C_{1,t}^k$, in the overall consumption index. We interpret type 1 goods as essential goods (such as food, gas, or rent) with a subsistence level of C_1^* that has to be met at all times. We further 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. The parameter ϑ_C^k is defined as the elasticity of substitution between the two types of goods and Z_t is an AR(1) demand shock affecting solely non-essential goods. This property tallies with the results of empirical analyses, showing that households decrease non-essential good consumption rather than essential good consumption after adverse economic shocks (see Kamakura and Yuxing Du (2012) and Loxton et al. (2020), for instance). Both indices, $C_{h,t}^k$ with $h=1,2$, are CES functions over all goods $i \in [o, s]$ and $j \in [s, 1]$, with s being the share of firms producing good 1 in the economy, given by

$$C_{1,t}^k \equiv \left(\int_0^s C_{i,t}^k{}^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}, \quad (3)$$

$$C_{2,t}^k \equiv \left(\int_s^1 C_{j,t}^k{}^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}, \quad (4)$$

with ϵ denoting the elasticity of substitution between the varieties.

With respect to its consumption, the household chooses its optimal consumption of individual goods within each type, its optimal consumption of good types, and its optimal overall

consumption level. The optimal consumption of the individual goods of each type is given by

$$C_{i,t}^k = \left(\frac{P_{i,t}}{P_{1,t}} \right)^{-\epsilon} C_{1,t}^k, \quad (5)$$

$$C_{j,t}^k = \left(\frac{P_{j,t}}{P_{2,t}} \right)^{-\epsilon} C_{2,t}^k, \quad (6)$$

with $P_{1,t} \equiv \left(\int_0^s P_{i,t}^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}$ and $P_{2,t} \equiv \left(\int_s^1 P_{j,t}^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}}$ being the overall price indices of good 1 and good 2, respectively.⁷ Optimal consumption of each variety negatively depends on the relative price of the good and the overall level of consumption of the good type.

The optimal consumption of the each good type is given by

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

$$C_{2,t}^k = \left(V_{2,t}^{C,k} \right)^{-\vartheta_C^k} (1 - \gamma_k) Z_t C_t^k, \quad (8)$$

where $V_{h,t}^{C,k} \equiv \frac{P_{h,t}}{P_t^{C,k}}$ and $P_t^{C,k} \equiv \left(\gamma_k P_{1,t}^{1-\vartheta_C^k} + (1 - \gamma_k) Z_t P_{2,t}^{1-\vartheta_C^k} \right)^{\frac{1}{1-\vartheta_C^k}}$ is defined as the household-specific CPI. In general, 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^* , and the optimal level of good 2 consumption is affected by the demand shock.

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

$$\mathbb{E}_t \left[\sum_{\iota=0}^{\infty} \beta^{\iota} U_{t+\iota}^k \right], \quad (9)$$

subject to the budget constraint

$$P_t^{C,k} C_t^k + P_{1,t} C_1^* + Q_t B_t^k = B_{t-1}^k + W_t^k N_t^k + D_t^k, \quad (10)$$

where B_t^k are one-period, nominally risk-free bonds purchased in period t at price Q_t , W_t^k is the

⁷We denote type h goods as good h in the following.

nominal wage, and D_t^k are dividends from the ownership of firms. The optimality conditions are given by

$$\left(N_t^k\right)^{\varphi_k} = w_t^k \left(C_t^k\right)^{-\sigma_k}, \quad (11)$$

$$Q_t = \beta \mathbb{E}_t \left[\Lambda_{t,t+1}^k \frac{1}{\Pi_{t+1}^{C,k}} \right], \quad (12)$$

where $w_t^k \equiv \frac{W_t^k}{P_t^{C,k}}$ is defined as the real wage, $\beta \Lambda_{t,t+1}^k \equiv \beta \left(\frac{C_{t+1}^k}{C_t^k} \right)^{-\sigma_k}$ as the stochastic discount factor, and $\Pi_{t+1}^{C,k} \equiv \frac{P_{t+1}^{C,k}}{P_t^{C,k}}$ as CPI inflation. Equation (11) describes the optimal labor supply of household k , equating the marginal disutility from working to its marginal utility. Equation (12) 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 (12) for each household k , with $-k$ denoting the respective other household:

$$\left(C_t^k\right)^{-\sigma_k} = \left(C_t^{-k}\right)^{-\sigma_k} \Phi^k \frac{P_t^{C,k}}{P_t^{C,-k}}, \quad (13)$$

with $\Phi^k \equiv \frac{C_{SS}^k^{-\sigma_k}}{C_{SS}^{-k-\sigma_{-k}}}$, where the subscript SS denotes the zero inflation steady state of a variable. Equation (13) 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 2.⁸ We assume perfectly separated labor markets, with household L working in firm 1 and household H working in firm 2.⁹ Following Calvo (1983), we assume that only a fraction $1-\lambda_h$ of firms can reset their price in each period, independently from the last adjustment.

⁸We denote type h firms as firm h in the following.

⁹Note that, for the sake of simplicity, we assume that household L owns firm 1 and household H owns firm 2.

3.2.1 Firm 1

Firm 1 produces with a simple production function given by

$$Y_{i,t} = (N_{i,t}^L)^{1-\alpha_1}, \quad (14)$$

where α_1 is the output elasticity labor, governing the marginal productivity of labor from household L . The firm's real total cost function is given by

$$TC_{i,t} = w_t^L N_{i,t}^L A_t, \quad (15)$$

where A_t is an AR(1) cost-push shock. The firm maximizes its expected discounted stream of profits

$$\mathbb{E}_t \left[\sum_{\iota=0}^{\infty} \beta^\iota \Lambda_{t,t+\iota}^L \lambda_1^\iota \left(\frac{P_{i,t}}{P_{t+\iota}^{C,L}} Y_{i,t+\iota|t} - TC(Y_{i,t+\iota|t}) \right) \right], \quad (16)$$

subject to

$$Y_{i,t+\iota|t} = \left(\frac{P_{i,t}}{P_{1,t+\iota}} \right)^{-\epsilon} Y_{1,t+\iota}, \quad (17)$$

where $Y_{i,t+\iota|t}$ is defined as the output in period $t+\iota$ for a firm that adjusts its price in period t , with $Y_{1,t+\iota}$ denoting the economy-wide output of good 1. The optimality condition is

$$0 \stackrel{!}{=} \mathbb{E}_t \left[\sum_{\iota=0}^{\infty} \beta^\iota \Lambda_{t,t+\iota}^L \lambda_1^\iota Y_{i,t+\iota|t} \left(\frac{P_{i,t}}{P_{t+\iota}^{C,L}} - \mu mc(Y_{i,t+\iota|t}) \right) \right], \quad (18)$$

with $\mu \equiv \frac{\epsilon}{\epsilon-1}$ and $mc(Y_{i,t}) = \frac{1}{1-\alpha_1} w_t^L A_t Y_{i,t}^{\frac{\alpha_1}{1-\alpha_1}}$ being defined as real marginal costs of firm i . The optimal price is equal for all firms that are able to adjust, due to symmetry. It is given by

$$(p_{1,t}^*)^{1+\frac{\epsilon\alpha_1}{1-\alpha_1}} = \mu \left(V_{1,t}^{C,L} \right)^{-1} \frac{b_{1,t}}{d_{1,t}}, \quad (19)$$

where the auxiliary variables are defined as

$$b_{1,t} \equiv (C_t^L)^{-\sigma_L} Y_{1,t} mc_{1,t} + \beta \lambda_1 \mathbb{E}_t \left[\Pi_{1,t+1}^{\frac{\epsilon}{1-\alpha_1}} b_{1,t+1} \right],$$

$$d_{1,t} \equiv (C_t^L)^{-\sigma_L} Y_{1,t} + \beta \lambda_1 \mathbb{E}_t \left[\Pi_{1,t+1}^\epsilon \left(\Pi_{t+1}^{C,L} \right)^{-1} d_{1,t+1} \right],$$

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

$$1 = (1 - \lambda_1) (p_{1,t}^*)^{1-\epsilon} + \lambda_1 \left(\frac{1}{\Pi_{1,t}} \right)^{1-\epsilon}. \quad (20)$$

The overall price level is a weighted average of the price set by firms that are able to adjust their prices in t (given by equation (19)) and the remaining share λ_1 of firms that keep the price of the previous period.

3.2.2 Firm 2

As for firm 1, we assume a simple production function for firm 2 given by

$$Y_{j,t} = (N_{j,t}^H)^{1-\alpha_2}, \quad (21)$$

where α_2 is the output elasticity labor of firm 2, determining the marginal productivity of labor from household H . The firm's real total cost function is given by

$$TC_{j,t} = w_t^H N_{j,t}^H. \quad (22)$$

Note that firm 2 does not face cost-push shocks. The firm maximizes its expected discounted stream of profits

$$\mathbb{E}_t \left[\sum_{\iota=0}^{\infty} \beta^\iota \Lambda_{t,t+\iota}^H \lambda_2^\iota \left(\frac{P_{j,t}}{P_{t+\iota}^{C,H}} Y_{j,t+\iota|t} - TC(Y_{j,t+\iota|t}) \right) \right], \quad (23)$$

subject to

$$Y_{j,t+\iota|t} = \left(\frac{P_{j,t}}{P_{2,t+\iota}} \right)^{-\epsilon} Y_{2,t+\iota}, \quad (24)$$

with $Y_{2,t+\iota}$ denoting the economy-wide output of good 2. The optimality condition is

$$0 \stackrel{!}{=} \mathbb{E}_t \left[\sum_{\iota=0}^{\infty} \beta^\iota \Lambda_{t,t+\iota}^H \lambda_2^\iota Y_{j,t+\iota|t} \left(\frac{P_{j,t}}{P_{t+\iota}^{C,H}} - \mu mc(Y_{j,t+\iota|t}) \right) \right], \quad (25)$$

with $mc(Y_{j,t}) = \frac{1}{1-\alpha_2} w_t^H Y_{j,t}^{\frac{\alpha_2}{1-\alpha_2}}$ being defined as real marginal costs of firm j . The optimal price is given by

$$(p_{2,t}^*)^{1+\frac{\epsilon\alpha_2}{1-\alpha_2}} = \mu \left(V_{2,t}^{C,H} \right)^{-1} \frac{b_{2,t}}{d_{2,t}}, \quad (26)$$

where the auxiliary variables are defined as

$$b_{2,t} \equiv (C_t^H)^{-\sigma_H} Y_{2,t} mc_{2,t} + \beta \lambda_2 \mathbb{E}_t \left[\Pi_{2,t+1}^{\frac{\epsilon}{1-\alpha_2}} b_{2,t+1} \right],$$

$$d_{2,t} \equiv (C_t^H)^{-\sigma_H} Y_{2,t} + \beta \lambda_2 \mathbb{E}_t \left[\Pi_{2,t+1}^\epsilon \left(\Pi_{t+1}^{C,H} \right)^{-1} d_{2,t+1} \right],$$

and $p_{2,t}^* \equiv \frac{P_{2,t}^*}{P_{2,t}}$. The variable $mc_{2,t}$ denotes the economy-wide real marginal costs of good 2 and $\Pi_{2,t+1} \equiv \frac{P_{2,t+1}}{P_{2,t}}$ is defined as inflation of good 2. Aggregate price dynamics are defined as

$$1 = (1 - \lambda_2) (p_{2,t}^*)^{1-\epsilon} + \lambda_2 \left(\frac{1}{\Pi_{2,t}} \right)^{1-\epsilon}. \quad (27)$$

3.3 Monetary Policy

We assume that the central bank wants to stabilize economy-wide inflation. The central bank follows a Taylor rule given by

$$i_t = \rho + \phi_\pi \left(\delta_\pi \pi_t^{C,L} + (1 - \delta_\pi) \pi_t^{C,H} \right), \quad (28)$$

where $i_t \equiv \log \left(\frac{1}{Q_t} \right)$, $\rho \equiv \log \left(\frac{1}{\beta} \right)$, and $\pi_t^{C,k} \equiv \log \left(\Pi_t^{C,k} \right)$. The parameter $\phi_\pi > 1$ denotes the reaction coefficient of the central bank to the weighted (with $\delta_\pi \in [0, 1]$) CPI inflation rates of households L and H . The parameter δ_π is of particular importance for our analysis. If $\delta_\pi = \kappa$, the central bank reacts to the average, economy-wide inflation rate given by

$$\pi_t^C = \kappa \pi_t^{C,L} + (1 - \kappa) \pi_t^{C,H}. \quad (29)$$

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

Furthermore, the Fisher equation holds for each household

$$i_t = r_t^k + \mathbb{E}_t \left[\pi_{t+1}^{C,k} \right]. \quad (30)$$

3.4 Market Clearing

Bonds markets clear

$$B_t^k = -B_t^{-k}, \quad (31)$$

as well as labor markets

$$N_t^L = \int_0^s N_{i,t}^L di, \quad N_t^H = \int_s^1 N_{j,t}^H dj. \quad (32)$$

Finally, goods markets clear for both goods

$$Y_{1,t} = \kappa C_{1,t}^L + (1 - \kappa) C_{1,t}^H, \quad Y_{2,t} = \kappa C_{2,t}^L + (1 - \kappa) C_{2,t}^H, \quad (33)$$

and overall production is given by

$$Y_t = sY_{1,t} + (1 - s)Y_{2,t}. \quad (34)$$

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 dynamic IS equation is given by

$$\hat{c}_t^k = \mathbb{E}_t \left[\hat{c}_{t+1}^k \right] - \frac{1}{\sigma_k} \left(\hat{i}_t - \mathbb{E}_t \left[\hat{\pi}_{t+1}^{C,k} \right] \right), \quad (35)$$

implying 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.

For each firm h , a sort of New Keynesian Phillips curve relating the inflation rate of good

h to marginal costs, relative prices, and future inflation can be derived as

$$\hat{\pi}_{h,t} = \Psi_h (\hat{m}c_{h,t} - \hat{v}_{h,t}^C) + \beta \mathbb{E}_t [\hat{\pi}_{h,t+1}], \quad (36)$$

with $\Psi_h \equiv (1 - \beta\lambda_h) \frac{1-\lambda_h}{\lambda_h} \frac{1-\alpha_h}{1-\alpha_h+\epsilon\alpha_h}$, $\hat{v}_{1,t}^C \equiv \hat{v}_{1,t}^{C,L}$, $\hat{v}_{2,t}^C \equiv \hat{v}_{2,t}^{C,H}$, and where

$$\begin{aligned} \hat{m}c_{1,t} = & \frac{(\alpha_1 + \varphi_L)g_{L,1}\kappa \frac{1}{l_{L,1}}\gamma_L + \sigma_L(1 - \alpha_1)}{1 - \alpha_1} \hat{c}_t^L + \frac{(\alpha_1 + \varphi_L)g_{H,1}(1 - \kappa) \frac{1}{l_{H,1}}\gamma_H}{1 - \alpha_1} \hat{c}_t^H \\ & - \frac{(\alpha_1 + \varphi_L)g_{L,1}\kappa \frac{1}{l_{L,1}}\gamma_L \vartheta_C^L}{1 - \alpha_1} \hat{v}_{1,t}^{C,L} - \frac{(\alpha_1 + \varphi_L)g_{H,1}(1 - \kappa) \frac{1}{l_{H,1}}\gamma_H \vartheta_C^H}{1 - \alpha_1} \hat{v}_{1,t}^{C,H} + a_t, \end{aligned} \quad (37)$$

and

$$\begin{aligned} \hat{m}c_{2,t} = & \frac{(\alpha_2 + \varphi_H)g_{L,2}\kappa}{1 - \alpha_2} \hat{c}_t^L + \frac{(\alpha_2 + \varphi_H)g_{H,2}(1 - \kappa) + \sigma_H(1 - \alpha_2)}{1 - \alpha_2} \hat{c}_t^H \\ & - \frac{(\alpha_2 + \varphi_H)g_{L,2}\kappa \vartheta_C^L}{1 - \alpha_2} \hat{v}_{2,t}^{C,L} - \frac{(\alpha_2 + \varphi_H)g_{H,2}(1 - \kappa) \vartheta_C^H}{1 - \alpha_2} \hat{v}_{2,t}^{C,H} + \frac{(\alpha_2 + \varphi_H)(\kappa g_{L,2} + (1 - \kappa)g_{H,2})}{1 - \alpha_2} z_t, \end{aligned} \quad (38)$$

where $g_{k,h} \equiv \frac{C_{h,SS}^k}{Y_{h,SS}}$, $l_{k,h} \equiv \frac{C_{h,SS}^k}{C_{SS}^k}$, and the relative price $\hat{v}_{h,t}^{C,k} = \hat{p}_{h,t} - \hat{p}_t^{C,k}$ can be rewritten in terms of inflation rates as

$$\hat{v}_{h,t}^{C,k} - \hat{v}_{h,t-1}^{C,k} = \hat{\pi}_{h,t} - \hat{\pi}_t^{C,k}. \quad (39)$$

Equations (36)–(38) imply that the inflation rate of firm h positively depends on the consumption of the respective good by each household, since higher consumption leads to higher demand for labor by firms which in turn increases wages (i.e, costs). Furthermore, inflation of firm h negatively depends on the relative price of good h with respect to the CPI of households L and H . Consider, for instance, an increase in the CPI of household k , while the price of good h remains unchanged. In this case, the relative price of good h decreases and its demand increases. This implies an increase in output and labor demand by firm h , leading to higher wages, i.e., higher marginal costs.

The described impact of consumption and relative prices positively depends on φ_k , governing the convexity of the utility function in labor, as a higher disutility of labor necessitates higher increases in wages and thereby marginal costs (see equation (11)). Furthermore, the im-

fact of the relative prices is strengthened by larger values of ϑ_C^k due to a corresponding higher importance of the relative price of a good for its demand (see equations (7) and (8)). More pronounced changes in demand lead to larger changes in marginal costs. Naturally, marginal costs and thereby inflation of good 1 positively depend on the cost-push shock.

Finally, inflation of good 2 depends positively on the demand shock. Consider, for instance, a negative demand shock: the decrease in demand for good 2 leads to lower labor demand by firm 2, implying lower wages and marginal costs.

Solving equation (36) forward, we get

$$\hat{\pi}_{h,t} = \Psi_h \sum_{\iota=0}^{\infty} \beta^{\iota} \mathbb{E}_t [\hat{m}c_{h,t+\iota} - \hat{v}_{h,t+\iota}^C]. \quad (40)$$

Equation (40) reveals that inflation in period t depends on current and (discounted) future changes in marginal costs, as firms that can adjust their prices consider that they might not be able to do so in the future. Furthermore, inflation negatively depends on current and (discounted) future changes in the relative price, implying that inflation of the individual firm co-moves with the CPI inflation rate. Consider, for instance, an increase in the CPI: in that case, firm h is also able to set a higher price without losing demand.

CPI inflation follows

$$\hat{\pi}_t^{C,k} = \gamma_k \hat{\pi}_{1,t} + (1 - \gamma_k) \hat{\pi}_{2,t} + \frac{1 - \gamma_k}{1 - \vartheta_C^k} \Delta z_t, \quad (41)$$

where $\Delta z_t \equiv z_t - z_{t-1}$. CPI inflation of each household is a weighted average of the inflation rates of both firms and further depends positively on the demand shock.

Aggregate output is given by

$$\begin{aligned} \hat{y}_t = & \left(m_1 \kappa g_{L,1} \frac{1}{l_{L,1}} \gamma_L + m_2 \kappa g_{L,2} \right) \hat{c}_t^L + \left(m_1 (1 - \kappa) g_{H,1} \frac{1}{l_{H,1}} \gamma_H + m_2 (1 - \kappa) g_{H,2} \right) \hat{c}_t^H \\ & - \left(m_1 \kappa g_{L,1} \frac{1}{l_{L,1}} \gamma_L \vartheta_C^L \right) \hat{v}_{1,t}^{C,L} - \left(m_2 \kappa g_{L,2} \vartheta_C^L \right) \hat{v}_{2,t}^{C,L} \\ & - \left(m_1 (1 - \kappa) g_{H,1} \frac{1}{l_{H,1}} \gamma_H \vartheta_C^H \right) \hat{v}_{1,t}^{C,H} - \left(m_2 (1 - \kappa) g_{H,2} \vartheta_C^H \right) \hat{v}_{2,t}^{C,H} \\ & + (\kappa g_{L,2} + (1 - \kappa) g_{H,2}) m_2 z_t, \end{aligned} \quad (42)$$

where $m_1 \equiv \frac{s Y_{1,SS}}{Y_{SS}}$ and $m_2 \equiv \frac{(1-s) Y_{2,SS}}{Y_{SS}}$. Equation (42) reveals that overall output depends pos-

itively on the overall consumption of both households and negatively on all relative prices. The first line of the equation shows that higher consumption increases output of each firm and thereby overall output. The weighted sum multiplying \hat{c}_t^k corresponds to the share of a change in overall consumption that translates into a change in the consumption of good 1 and 2. An increase in the relative price leads to lower output of each firm and, consequently, to lower overall output. The strength of this effect positively depends on the share of the respective good in consumption and output as well as on ϑ_C^k , as a higher elasticity of substitution between good 1 and 2 leads to a higher relevance of the relative price for the consumption of the good (equations (7) and (8)). These effects are symmetric for the low-income (second line of equation (42)) and the high-income household (third line). Lastly, a negative demand shock leads to a decrease in overall output due to lower demand for good 2, as displayed in the fourth line of equation (42).

Finally, we define the average, economy-wide welfare loss as

$$\mathbb{W}_t \equiv -\hat{u}_t, \quad (43)$$

where \hat{u}_t is the log-linear deviation of average, economy-wide utility given by

$$U_t \equiv \kappa U_t^L + (1 - \kappa) U_t^H$$

from its steady state.

4 Results

4.1 Calibration

Table 1 shows the calibration of the model. We calibrate household H to be the household with higher income. Accordingly, we set $\vartheta_C^L < \vartheta_C^H$ in order to reflect that households with higher income can substitute goods more effectively (Gürer and Weichenrieder, 2020; Argente and Lee, 2021). The values are chosen to represent data retrieved from the United States Department of Agriculture (2012).

We set the average intertemporal elasticity of substitution to an empirically plausible value of 0.53 (see Hall, 1988; Atkeson and Ogaki, 1996; Rupert et al., 2000; Gnocchi et al., 2016).

Note that we set $\sigma_L > \sigma_H$, taking into account the fact that households with lower income exhibit a lower intertemporal elasticity of substitution.¹⁰ We set $\varphi_k=5$, 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), for instance. We calibrate γ_k and C_1^* to match the relative consumption of good 1 and 2 in steady state, as presented in Gürer and Weichenrieder (2020). In particular, Gürer and Weichenrieder (2020) find that low-income households spend roughly 65% of their consumption expenditures on goods with above-average CPI inflation, while that share amounts to about 50% for high-income households.¹¹ The remaining standard household parameters are chosen as in Galí (2015).

Table 1: Calibration.

Description		Value		Target/Source
Households				
		L	H	
κ	Share of households	0.5	0.5	Equal share of L and H households
σ_k	Inverse intertemporal elasticity of substitution	2.5	1.5	Average intertemporal elasticity of substitution: 0.53
φ_k	Inverse Frisch elasticity of labor supply	5	5	Frisch elasticity of labor supply: 0.2
γ_k	Weight of good 1 in overall consumption	0.57	0.46	$\frac{C_{1,SS}^L}{C_{1,SS}^L+C_{2,SS}^L} = 0.65, \frac{C_{1,SS}^H}{C_{1,SS}^H+C_{2,SS}^H} = 0.5,$ internally calibrated
ϑ_C^k	Elasticity of substitution between good 1 and 2	0.15	0.5	Larger substitution capabilities of household H
C_1^*	Subsistence level of good 1	0.2	0.2	$\frac{C_{1,SS}^L}{C_{1,SS}^L+C_{2,SS}^L} = 0.65, \frac{C_{1,SS}^H}{C_{1,SS}^H+C_{2,SS}^H} = 0.5,$ internally calibrated
ϵ	Price elasticity of demand	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	Output elasticity labor	0.5	0.33	Higher income of household H
λ_h	Calvo parameter	0.6	0.8	Higher flexibility of good 1 prices
Central Bank				
ϕ_π	Taylor rule coefficient	1.5		Galí (2015)
δ_π	CPI inflation weight	0; 0.5; 1		Analysis parameter

On the firms' side, we follow Kaplan et al. (2018) by setting α_2 to 0.33. We continue by

¹⁰For a comprehensive overview of empirical studies on this property, see Havranek et al. (2015).

¹¹Note 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.

choosing $\alpha_1 > \alpha_2$, implying lower productivity of household L and thereby lower income of that household. In order to account for the fact that food prices are more flexible and volatile than non-food prices (Portillo et al., 2016), we set $\lambda_1 < \lambda_2$, since we assume good 1 to be the essential good which includes food, for instance. Lastly, we solve the model with three different weights on CPI inflation of household L in the Taylor rule: 0, 0.5, and 1. The central bank considers only the low-income household ($\delta_\pi=1$), only the high-income household ($\delta_\pi=0$), or a weighted average of both households ($\delta_\pi=0.5$).

4.2 Dynamic Analysis

4.2.1 Demand Shock

Figure 3 shows the impulse responses of the model (as percentage deviations from the zero inflation steady state) to a negative 0.5% demand shock on non-essential goods for the three monetary policy regimes. In general, i.e., independently from the regime of the central bank, the effects of the demand shock are as follows:

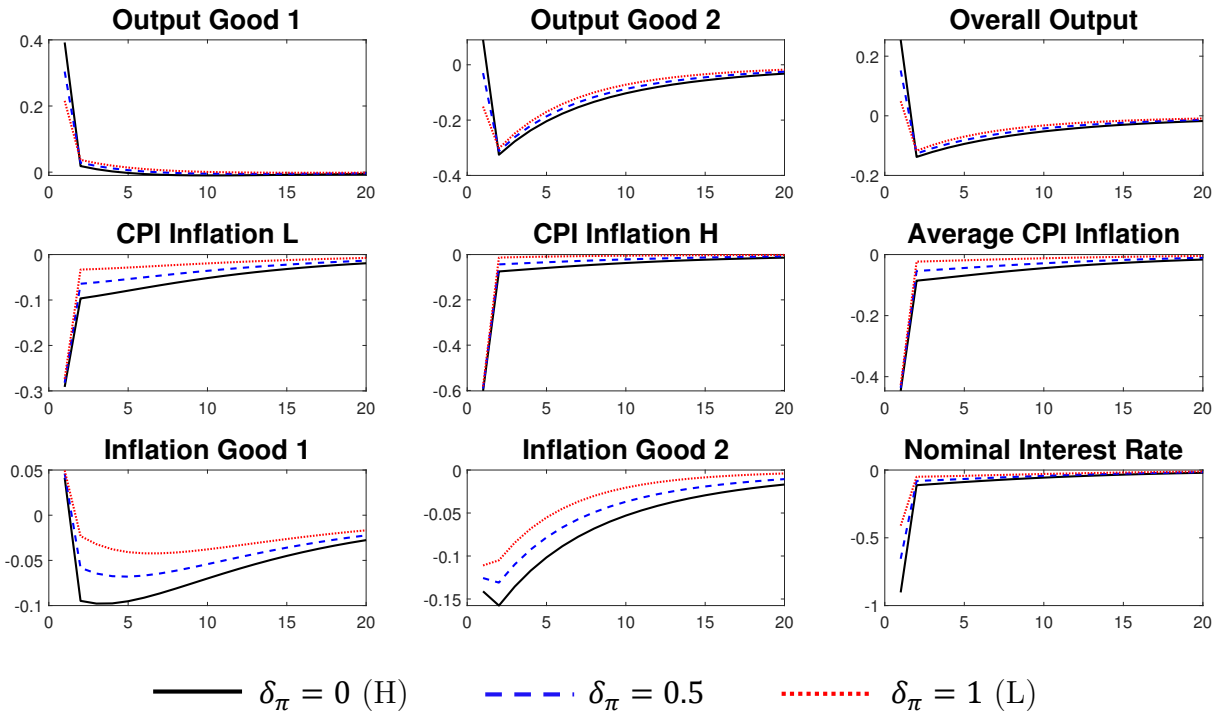


Figure 3: Impulse Responses to a Negative 0.5% Demand Shock with Persistence $\rho_Z = 0.9$.

The shock implies that both households decrease their consumption of the non-essential

good 2. This lower demand leads to a lower output and a decrease in inflation of non-essential goods. All CPI inflation rates decrease.¹² The decrease is larger for household H than for household L , as the high-income household spends a higher share of its income on non-essential goods. This result tallies with the fact that low-income households experience higher inflation rates than high-income households (see Section 1).¹³ Note that the decrease in CPI inflation implies downward pressure on the prices of essential goods as the CPI decreases and essential goods become relatively more expensive (see equation (40)). The central bank reacts to the decrease in CPI inflation by decreasing the nominal interest rate. The resulting drop in the real interest rate incentivizes the consumption of both goods. This implies that the displayed decrease of good 2 output is already mitigated and the output of good 1 even increases due to the expansionary monetary policy reaction. Furthermore, the decrease in inflation of both essential and non-essential goods caused by the demand shock is mitigated, as higher demand due to lower interest rates leads firms to adjust their prices upwards.

Upon examining the effects of the different central bank regimes, we find that the weight on the respective CPI inflation rates has a significant impact on the model outcomes. Overall, the higher the weight on the CPI inflation rate of the high-income household is, the more expansionary the central bank reacts as this household experiences a stronger drop in its CPI inflation rate. However, the central bank reaches its goal of economy-wide consumer price stability most efficiently when only considering the low-income household (i.e., the household experiencing higher CPI inflation): the CPI inflation rates of both households—and thereby also the economy-wide, average CPI inflation rate—diverge less from their steady states when the central bank only reacts to household L , as the inflation rates of good 1 and 2 fluctuate less. Since household L 's CPI inflation rate drops less, the nominal interest rate decreases less and households shift less consumption from the future into the initial period, implying higher demand for goods over time. Therefore, the incentive to increase consumption is lower and output of both goods increases less. This implies a lower initial increase in marginal costs. However, firms do not only consider current but also future marginal costs when setting their price (see equation (40)). After the initial shock period, marginal costs are consistently higher the larger δ_π is, as consumption for both goods is higher the larger δ_π is. Therefore, the

¹²Note that the strong initial decrease in the CPI inflation rates is due to the relationship between $\hat{\pi}_t^{C,k}$ and Δz_t , as derived in equation (41).

¹³Note that in case of a positive demand shock, the consumer price inflation rate of household H is larger than the one of household L . However, the results of our analysis remain unchanged.

deviations of all inflation rates from their steady states are lower in every period.

This result is further underscored by Table 2, which displays the volatilities of model variables under the different Taylor rules. All variables fluctuate less when only the CPI inflation rate of the low-income household is considered. These results are driven by decreasing fluctuations of the nominal interest rate when δ_π increases: the less expansionary reaction of the central bank results in a smaller increase in the nominal interest rate between the initial and the subsequent period, i.e., the nominal interest rate displays lower volatility. This leads households to shift less consumption from the future into the initial period and consume more over time. Hence, consumption and output exhibit less volatility, and thereby also the inflation rates of essential and non-essential goods, the more the central bank weights the CPI inflation rate of the low-income household. This further implies less volatility of both CPI inflation rates.

Table 2: 0.5% Demand Shock Volatilities.

Variable	Description	Volatility		
		$\delta_\pi = 0$ (H)	$\delta_\pi = 0.5$	$\delta_\pi = 1$ (L)
\hat{c}_t^L	Overall consumption L	0.448	0.394	0.351
\hat{c}_t^H	Overall consumption H	1.184	1.129	1.087
$\hat{y}_{1,t}$	Output good 1	0.394	0.307	0.222
$\hat{y}_{2,t}$	Output good 2	0.652	0.592	0.564
\hat{y}_t	Overall output	0.391	0.299	0.227
$\hat{\pi}_t^{C,L}$	CPI inflation L	0.385	0.330	0.288
$\hat{\pi}_t^{C,H}$	CPI inflation H	0.636	0.601	0.583
$\hat{\pi}_t^C$	Average CPI inflation	0.497	0.458	0.432
$\hat{\pi}_{1,t}$	Inflation good 1	0.310	0.230	0.154
$\hat{\pi}_{2,t}$	Inflation good 2	0.351	0.279	0.211

Notes. All variables are deviations from their zero inflation steady state.

The differing volatilities of model variables implied by the three monetary policy regimes lead to disparate responses of utility and average, economy-wide welfare to the shock, as displayed in Figure 4. Naturally, solely considering the CPI inflation rate of the low-income household leads to larger utility gains of this household than under the other monetary policy regimes. Furthermore, after the initial shock period, both the high-income household's utility and the economy-wide welfare gain (indicated by a negative welfare loss) are larger when the central bank only considers the low-income household's CPI inflation rate due to the lower volatility of all model variables.

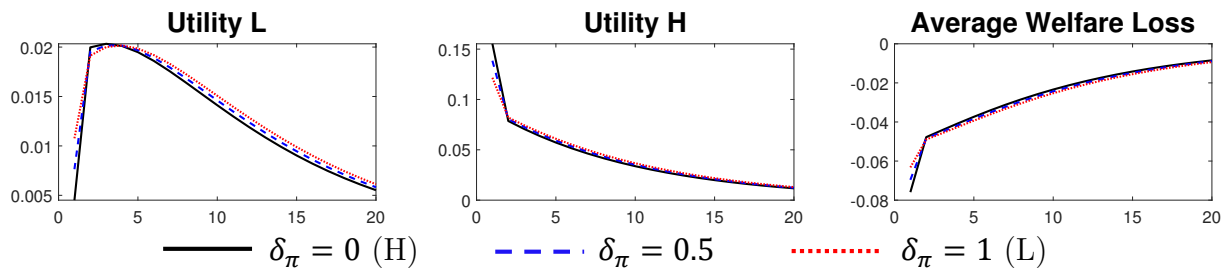


Figure 4: Welfare Loss and Utility After a Negative 0.5% Demand Shock with Persistence $\rho_Z = 0.9$.

These results are further underscored by Table 3. Upon examining the cumulated utility and welfare loss response within the first 20 periods of the demand shock, we find that only considering household L 's CPI inflation rate is welfare-improving for both households and thus also for the entire economy, as all model variables exhibit lower volatility under that regime.

Table 3: Cumulated Welfare Loss and Utility After a 0.5% Demand Shock.

Variable	Description	Cumulated Response		
		$\delta_\pi = 0$ (H)	$\delta_\pi = 0.5$	$\delta_\pi = 1$ (L)
\hat{u}_t^L	Utility L	0.255	0.264	0.273
\hat{u}_t^H	Utility H	0.834	0.842	0.850
\mathbb{W}_t	Average welfare loss	-0.529	-0.538	-0.546

Notes. All variables are deviations from their zero inflation steady state. Cumulated response is defined as the sum over the deviations from steady state within the first 20 periods of the shock. Negative welfare losses indicate a welfare gain.

4.2.2 Cost-Push Shock

Figure 5 shows the impulse responses of the model (as percentage deviations from the zero inflation steady state) to a positive 1% cost-push shock on essential goods for the three monetary policy regimes. Again, we start with a general description of the effects of the shock on the model variables, independently of the central bank's regime.

The increase in marginal costs prompts firm 1 to increase its price, causing households to consume less of the essential good 1. In addition, CPI inflation of both households increases. The low-income household is affected more strongly than the high-income household, as the low-income household spends a higher share of its income on essential goods. The central bank increases the nominal interest rate in order to mitigate the effects of the shock on CPI inflation. The resulting increase in the real interest rate incentivizes households to save rather

than to consume. Hence, consumption (and thereby output) of both goods decreases. This effect strengthens the decrease of good 1 output caused by the shock—the typical problem for monetary policy when facing supply shocks. Furthermore, there are two opposing effects on the inflation rate of non-essential goods: the increase in the CPI of both households allows firm 2 to increase its price, while the decrease in demand implies downward pressure on prices. After the initial period, the first effect dominates and inflation of non-essential goods increases.

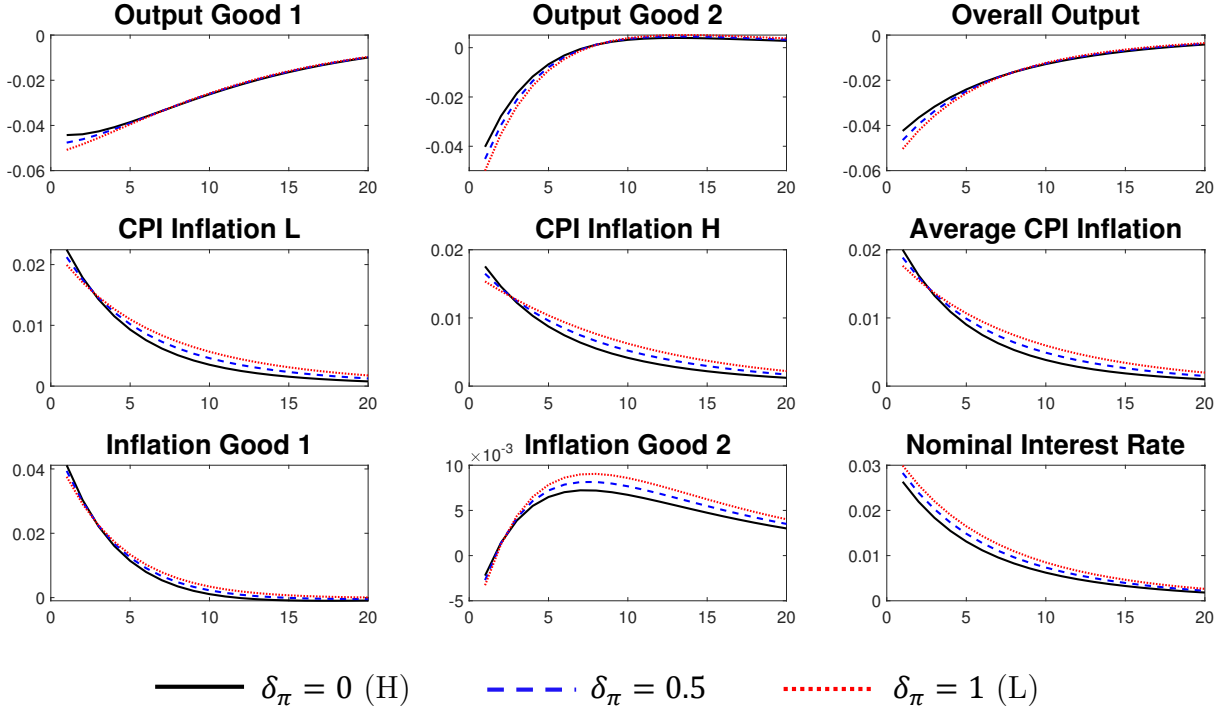


Figure 5: Impulse Responses to a Positive 1% Cost-Push Shock with Persistence $\rho_A = 0.9$.

Moreover, when examining the impact of the three monetary policy regimes, the impulse responses again show that the weight assigned to the respective CPI inflation rates significantly affects the model outcomes. In particular, when only considering the CPI inflation rate of the low-income household, the central bank manages to mitigate the effect of the cost-push shock on all inflation rates more effectively in the initial period: the inflation rates of essential and non-essential goods as well as the CPI inflation rates of both households are lower under this regime. However, all inflation rates deviate more from their steady states over time. The stronger contractionary monetary policy reaction under that regime leads households to shift more consumption from the initial period into the future. The inflation rates of essential and

non-essential goods—and therefore also the CPI inflation rates—respond accordingly: in the initial shock period, all inflation rates are lower due to the stronger contractionary monetary policy reaction. However, over time, higher demand for goods implied by the consumption shift leads to higher marginal costs for both types of firms and therefore to higher prices and larger deviations of all inflation rates from their steady states. Hence, the central bank faces a trade-off between mitigating the initial impact of the shock (and therefore only considering the more strongly affected low-income household’s CPI inflation rate) and stabilizing inflation rates over time (only considering the less affected high-income household’s CPI inflation rate).

This result is further underscored when examining the volatilities of the model variables. As displayed in Table 4, a higher weight on the CPI inflation rate of the low-income household stabilizes the inflation rate in the affected sector (i.e., good 1) but leads all other variables to fluctuate more. This is caused by the increasing strength of the contractionary monetary policy reaction when δ_π is higher: consumption (and thereby output) decreases more in the initial period.

Table 4: Corrected 1% Cost-Push Shock Volatilities.

Variable	Description	Volatility		
		$\delta_\pi = 0$ (H)	$\delta_\pi = 0.5$	$\delta_\pi = 1$ (L)
\hat{c}_t^L	Overall consumption L	0.078	0.080	0.084
\hat{c}_t^H	Overall consumption H	0.106	0.115	0.117
$\hat{y}_{1,t}$	Output good 1	0.130	0.133	0.135
$\hat{y}_{2,t}$	Output good 2	0.056	0.063	0.070
\hat{y}_t	Overall output	0.087	0.091	0.096
$\hat{\pi}_t^{C,L}$	CPI inflation L	0.038	0.039	0.040
$\hat{\pi}_t^{C,H}$	CPI inflation H	0.033	0.034	0.036
$\hat{\pi}_t^C$	Average CPI inflation	0.035	0.037	0.038
$\hat{\pi}_{1,t}$	Inflation good 1	0.060	0.060	0.059
$\hat{\pi}_{2,t}$	Inflation good 2	0.025	0.028	0.031

Notes. All variables are deviations from their zero inflation steady state.

Over time, as the shock fades, demand for goods increases again, moving back towards the steady state. This increase is larger the higher δ_π is, since the initial decrease in output is larger as a consequence of the stronger increase in the nominal interest rate in this case. This implies that households have more of an incentive to postpone consumption to future periods, implying higher levels and fluctuations in consumption over time. Therefore, the CPI inflation rates as well as output also fluctuate more the higher δ_π is.

Figure 6 shows that the stronger contractionary monetary policy reaction implied by $\delta_\pi=1$

leads to lower utility of both households and a larger economy-wide welfare loss within the first 7 periods of the shock. Similar to the previously described development of the other model variables, this relationship reverses over time and both households' utility and the economy-wide welfare gain are higher when the central bank only considers household L 's CPI inflation rate.

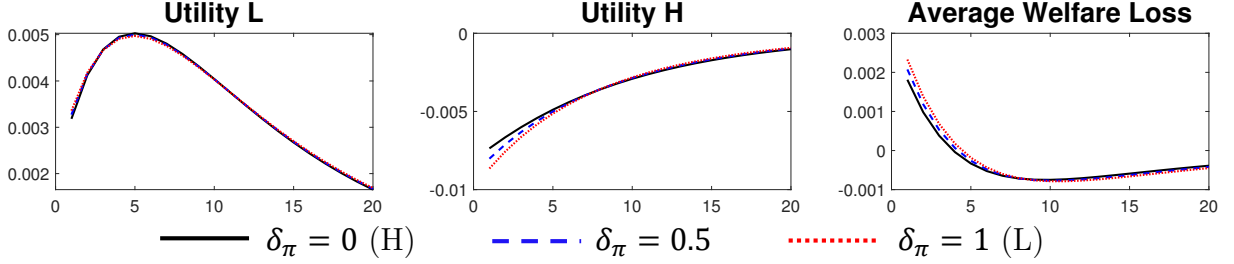


Figure 6: Welfare Loss and Utility After a Positive 1% Cost-Push Shock with Persistence $\rho_A = 0.9$.

Table 5 shows that over all 20 simulated periods, both households benefit most from the central bank regime that only considers their respective CPI inflation rate. The economy-wide welfare gain is highest when the central bank only reacts to household H 's CPI inflation rate. As previously discussed, the vast majority of model variables fluctuates less under that regime, implying higher welfare.

Table 5: Cumulated Welfare Loss and Utility After a 1% Cost-Push Shock.

Variable	Description	Cumulated Response		
		$\delta_\pi = 0$ (H)	$\delta_\pi = 0.5$	$\delta_\pi = 1$ (L)
\hat{u}_t^L	Utility L	0.0708	0.0709	0.0710
\hat{u}_t^H	Utility H	-0.0655	-0.0667	-0.0679
\mathbb{W}_t	Average welfare loss	-0.0062	-0.0058	-0.0052

Notes. All variables are deviations from their zero inflation steady state. Cumulated response is defined as the sum over the deviations from steady state within the first 20 periods of the shock. Negative welfare losses indicate a welfare gain.

5 Conclusion

We report significant inflation differentials across households in the United States and Europe. In particular, we show that low-income households experience higher inflation rates than households with higher income. This paper then examines how central banks that aim to stabilize the economy-wide inflation rate should react to this household inflation heterogeneity.

In particular, we incorporate a low- and a high-income household in a New Keynesian model, with the low-income household experiencing higher inflation after adverse shocks. The central bank in our model reacts to either the individual CPI inflation rate of one of the households or to the weighted average of both rates. We find that the weight that the central bank assigns to the inflation rates experienced by the households significantly affects model outcomes. After a negative demand shock, a central bank that only takes into account CPI inflation of the low-income household leads to lower volatility of all model variables and higher welfare. After a negative supply shock, a central bank that only considers the inflation experience of the low-income household mitigates the initial effects of the shock on inflation more effectively, while allowing for larger overall volatility and lower welfare in the economy. Generally, the central bank manages to stabilize the volatility of the economy-wide inflation rate more effectively after demand and supply shocks when only considering the household whose CPI inflation rate is less affected by these shocks.

These findings raise important questions with respect to the implementation of monetary policy. In particular, reacting to the average inflation rate experienced by households in the economy might lead to larger fluctuations in inflation rates and output in comparison to reacting to specific inflation rates. This should be taken into account when determining optimal monetary policy to reach the economy-wide inflation target in response to shocks. For instance, it seems sensible for central banks to consider a range of inflation rates experienced in an economy, specifically after shocks that lead to a deviation of the economy-wide inflation rate from its target. In particular, considering inflation differentials as additional indicators within its economic projections would allow a central bank to react discretionarily to differing inflation experiences: depending on the type of shock, the central bank could choose to react to specific inflation rates in order to reach its economy-wide inflation target more effectively and stabilize all inflation rates in the economy. As an example, consider the Taylor rule in our model: it would be at the discretion of the central bank to choose the weight of the household-specific inflation rates depending on the type of shock.

Finally, our paper builds a basis for future research. Specifically, we consider shocks that affect households symmetrically. An investigation of the effects of asymmetric, household-specific shocks seems interesting to further our understanding of the macroeconomic effects of household inflation heterogeneity.

Appendix

A Consumption Shares per Quintile in the United States

Table A.1: Average Inflation Rate and Share of Consumption per Quintile of Expenditure Categories in the United States 2001–2020.

Category	Average Inflation Rate	Average Share				
		Q1	Q2	Q3	Q4	Q5
Food	2.4%	16.68%	15.75%	15.30%	15.25%	14.04%
Alcoholic Beverages	2.0%	0.86%	0.89%	1.00%	1.09%	1.23%
Housing	2.4%	41.72%	39.71%	38.69%	37.78%	38.52%
Apparel	−0.5%	3.98%	3.86%	3.87%	4.03%	4.48%
Transportation	1.5%	15.78%	18.95%	20.94%	21.54%	20.28%
Medical Care	3.5%	8.41%	9.54%	8.77%	8.15%	6.80%
Recreation	0.8%	5.00%	5.51%	5.71%	6.28%	7.17%
Education	1.6%	3.15%	1.35%	1.38%	1.81%	3.68%
Other	2.7%	4.42%	4.44%	4.35%	4.08%	3.79%
Average CPI	2.1%					

Notes. Average inflation rate refers to the average, percentage increase in the price of an expenditure category between 2001 and 2020. Average share indicates the average, percentage share of an expenditure category in overall consumption per quintile (Q) between 2001 and 2020. Food refers to the category food and non-alcoholic beverages; education to education and communication; other to other goods and services.

B Consumption Shares per Quintile in Europe

Table B.1: Average Inflation Rate and Share of Consumption per Quintile of Expenditure Categories in the European Union 2001–2020.

Category	Average Inflation Rate	Average Share				
		Q1	Q2	Q3	Q4	Q5
Food	2.3%	16.20%	15.20%	14.60%	13.80%	11.90%
Alcohol and Tobacco	4.0%	2.50%	2.30%	2.20%	2.10%	1.80%
Clothing	0.5%	3.10%	3.30%	3.60%	4.00%	4.50%
Housing	2.7%	33.80%	31.00%	28.50%	26.10%	23.30%
Household Equipment	1.0%	3.00%	3.50%	3.80%	4.00%	4.70%
Health	2.0%	2.90%	3.00%	3.00%	2.90%	3.00%
Transport	1.9%	6.10%	8.00%	9.10%	10.70%	12.00%
Communications	−1.5%	3.20%	3.00%	2.90%	2.80%	2.40%
Recreation	0.6%	5.20%	5.60%	6.20%	6.50%	7.60%
Education	2.3%	0.60%	0.50%	0.60%	0.70%	1.20%
Restaurants and Hotels	2.5%	3.40%	3.70%	4.20%	4.80%	5.80%
Miscellaneous	2.0%	6.40%	7.20%	7.60%	7.90%	8.10%
Average CPI	1.9%					

Notes. Average inflation rate refers to the average, percentage increase in the price of an expenditure category between 2001 and 2020. Average share indicates the average, percentage share of an expenditure category in overall consumption per quintile (Q) between 2001 and 2020. Food refers to the category food and non-alcoholic beverage; alcohol and tobacco to alcoholic beverages, tobacco, and narcotics; clothing to clothing and footwear; housing to housing, water, electricity, gas, and other fuels; household equipment to furnishing, household equipment, and routine household maintenance; recreation to recreation and culture; miscellaneous to miscellaneous goods and services.

Table B.2: Average Inflation Rate and Share of Consumption per Quintile of Expenditure Categories in France 2001–2020.

Category	Average Inflation Rate	Average Share				
		Q1	Q2	Q3	Q4	Q5
Food	1.7%	15.96%	15.83%	15.76%	14.80%	12.91%
Alcohol and Tobacco	4.3%	3.33%	2.94%	2.58%	2.40%	2.08%
Clothing	0.3%	5.21%	4.79%	4.83%	5.04%	5.42%
Housing	2.3%	32.91%	30.63%	28.16%	26.30%	24.29%
Household Equipment	0.9%	4.11%	4.40%	4.86%	5.22%	6.59%
Health	1.0%	2.52%	2.96%	2.96%	2.72%	2.82%
Transport	1.8%	9.97%	11.97%	13.43%	14.98%	15.00%
Communications	−2.1%	3.73%	3.13%	2.84%	2.63%	2.22%
Recreation	−0.3%	6.19%	6.41%	7.03%	7.51%	8.55%
Education	2.7%	0.70%	0.38%	0.38%	0.43%	0.66%
Restaurants and Hotels	2.2%	4.07%	4.14%	4.59%	5.35%	6.78%
Miscellaneous	1.9%	11.35%	12.40%	12.58%	12.63%	12.68%
Average CPI	1.5%					

Notes. Average inflation rate refers to the average, percentage increase in the price of an expenditure category between 2001 and 2020. Average share indicates the average, percentage share of an expenditure category in overall consumption per quintile (Q) between 2001 and 2020. Food refers to the category food and non-alcoholic beverage; alcohol and tobacco to alcoholic beverages, tobacco, and narcotics; clothing to clothing and footwear; housing to housing, water, electricity, gas, and other fuels; household equipment to furnishing, household equipment, and routine household maintenance; recreation to recreation and culture; miscellaneous to miscellaneous goods and services.

Table B.3: Average Inflation Rate and Share of Consumption per Quintile of Expenditure Categories in Germany 2001–2020.

Category	Average Inflation Rate	Average Share				
		Q1	Q2	Q3	Q4	Q5
Food	1.8%	15.13%	13.41%	12.37%	11.28%	8.91%
Alcohol and Tobacco	3.2%	2.67%	2.32%	2.13%	1.92%	1.48%
Clothing	0.5%	4.33%	4.69%	4.85%	4.99%	4.99%
Housing	1.9%	39.08%	34.49%	32.80%	31.08%	26.62%
Household Equipment	0.6%	4.15%	5.09%	5.64%	5.76%	6.18%
Health	1.9%	2.55%	2.82%	3.04%	3.45%	5.11%
Transport	1.6%	8.21%	10.73%	12.11%	13.55%	16.67%
Communications	−1.4%	3.94%	3.26%	2.85%	2.55%	2.05%
Recreation	0.9%	9.21%	10.76%	11.11%	11.14%	11.22%
Education	1.7%	0.64%	0.65%	0.71%	0.77%	0.80%
Restaurants and Hotels	2.1%	3.37%	4.12%	4.57%	4.82%	5.29%
Miscellaneous	1.5%	6.68%	7.59%	7.94%	8.71%	10.48%
Average CPI	1.5%					

Notes. Average inflation rate refers to the average, percentage increase in the price of an expenditure category between 2001 and 2020. Average share indicates the average, percentage share of an expenditure category in overall consumption per quintile (Q) between 2001 and 2020. Food refers to the category food and non-alcoholic beverage; alcohol and tobacco to alcoholic beverages, tobacco, and narcotics; clothing to clothing and footwear; housing to housing, water, electricity, gas, and other fuels; household equipment to furnishing, household equipment, and routine household maintenance; recreation to recreation and culture; miscellaneous to miscellaneous goods and services.

Table B.4: Average Inflation Rate and Share of Consumption per Quintile of Expenditure Categories in Italy 2001–2020.

Category	Average Inflation Rate	Average Share				
		Q1	Q2	Q3	Q4	Q5
Food	1.9%	26.66%	22.98%	20.63%	18.36%	13.67%
Alcohol and Tobacco	3.4%	2.38%	2.01%	1.92%	1.80%	1.43%
Clothing	0.9%	6.15%	6.57%	7.21%	7.42%	7.74%
Housing	2.2%	29.33%	29.51%	28.83%	27.89%	24.79%
Household Equipment	1.3%	5.06%	5.40%	5.47%	6.36%	8.47%
Health	1.8%	3.79%	4.15%	4.12%	4.10%	4.23%
Transport	2.1%	9.93%	10.66%	11.37%	11.93%	15.78%
Communications	−3.4%	3.03%	2.71%	2.45%	2.27%	1.87%
Recreation	0.9%	4.04%	4.85%	5.74%	6.23%	7.25%
Education	1.0%	0.52%	0.65%	0.74%	0.78%	0.81%
Restaurants and Hotels	2.0%	2.25%	3.26%	3.97%	5.22%	6.41%
Miscellaneous	2.2%	6.93%	7.27%	7.56%	7.62%	7.59%
Average CPI	1.6%					

Notes. Average inflation rate refers to the average, percentage increase in the price of an expenditure category between 2001 and 2020. Average share indicates the average, percentage share of an expenditure category in overall consumption per quintile (Q) between 2001 and 2020. Food refers to the category food and non-alcoholic beverage; alcohol and tobacco to alcoholic beverages, tobacco, and narcotics; clothing to clothing and footwear; housing to housing, water, electricity, gas, and other fuels; household equipment to furnishing, household equipment, and routine household maintenance; recreation to recreation and culture; miscellaneous to miscellaneous goods and services.

Table B.5: Average Inflation Rate and Share of Consumption per Quintile of Expenditure Categories in Spain 2001–2020.

Category	Average Inflation Rate	Average Share				
		Q1	Q2	Q3	Q4	Q5
Food	2.4%	22.19%	19.42%	17.48%	15.80%	12.52%
Alcohol and Tobacco	4.2%	3.02%	2.66%	2.37%	2.19%	1.67%
Clothing	1.1%	5.83%	6.09%	6.39%	6.35%	6.33%
Housing	2.4%	31.89%	30.71%	29.96%	28.98%	29.85%
Household Equipment	1.1%	3.92%	4.15%	4.22%	4.54%	5.64%
Health	0.9%	2.62%	2.89%	3.00%	2.92%	2.73%
Transport	2.0%	9.77%	11.01%	11.80%	12.37%	12.22%
Communications	−1.1%	2.91%	2.91%	2.81%	2.72%	2.41%
Recreation	0.1%	4.49%	5.19%	5.90%	6.57%	7.42%
Education	3.1%	0.57%	0.81%	0.96%	1.18%	1.89%
Restaurants and Hotels	2.6%	7.12%	8.08%	8.75%	9.63%	10.44%
Miscellaneous	2.2%	5.61%	6.13%	6.41%	6.67%	6.93%
Average CPI	1.9%					

Notes. Average inflation rate refers to the average, percentage increase in the price of an expenditure category between 2001 and 2020. Average share indicates the average, percentage share of an expenditure category in overall consumption per quintile (Q) between 2001 and 2020. Food refers to the category food and non-alcoholic beverage; alcohol and tobacco to alcoholic beverages, tobacco, and narcotics; clothing to clothing and footwear; housing to housing, water, electricity, gas, and other fuels; household equipment to furnishing, household equipment, and routine household maintenance; recreation to recreation and culture; miscellaneous to miscellaneous goods and services.

Table B.6: Average Inflation Rate and Share of Consumption per Quintile of Expenditure Categories in the United Kingdom 2001–2019.

Category	Average Inflation Rate	Average Share				
		Q1	Q2	Q3	Q4	Q5
Food	2.4%	13.71%	13.20%	12.28%	11.20%	9.10%
Alcohol and Tobacco	3.8%	3.61%	3.12%	2.84%	2.53%	2.09%
Clothing	−2.3%	4.26%	4.75%	5.06%	5.52%	5.71%
Housing	3.6%	37.74%	29.55%	24.34%	21.26%	17.91%
Household Equipment	1.2%	5.97%	6.90%	6.94%	7.03%	8.04%
Health	2.8%	0.92%	1.16%	1.28%	1.24%	1.44%
Transport	2.8%	8.56%	11.03%	13.65%	15.54%	17.66%
Communications	0.8%	3.17%	3.22%	3.01%	2.93%	2.43%
Recreation	0.5%	9.70%	11.89%	13.37%	14.29%	14.77%
Education	7.3%	1.13%	0.82%	1.15%	1.22%	2.74%
Restaurants and Hotels	3.0%	5.94%	7.23%	8.38%	9.44%	9.90%
Miscellaneous	2.0%	5.36%	7.15%	7.72%	7.84%	8.24%
Average CPI	2.1%					

Notes. Average inflation rate refers to the average, percentage increase in the price of an expenditure category between 2001 and 2019. Average share indicates the average, percentage share of an expenditure category in overall consumption per quintile (Q) between 2001 and 2019. Food refers to the category food and non-alcoholic beverage; alcohol and tobacco to alcoholic beverages, tobacco, and narcotics; clothing to clothing and footwear; housing to housing, water, electricity, gas, and other fuels; household equipment to furnishing, household equipment, and routine household maintenance; recreation to recreation and culture; miscellaneous to miscellaneous goods and services.

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