DICE

# DISCUSSION PAPER

NO 378

## How Should Central Banks React to Household Inflation Heterogeneity?

Ulrike Neyer
Daniel Stempel

January 2022

hhu Heinrich Heine Universität Düsseldorf

## IMPRINT

### DICE DISCUSSION PAPER

**Published by:**
Heinrich-Heine-University Düsseldorf,
Düsseldorf Institute for Competition Economics (DICE),
Universitätsstraße 1, 40225 Düsseldorf, Germany
www.dice.hhu.de

**Editor:**
Prof. Dr. Hans-Theo Normann
Düsseldorf Institute for Competition Economics (DICE)
Tel +49 (0) 211-81-15125, E-Mail normann@dice.hhu.de



ISSN 2190-9938 (online) / ISBN 978-3-86304-377-3
The working papers published in the series constitute work in progress circulated to stimulate discussion and critical comments. Views expressed represent exclusively the authors' own opinions and do not necessarily reflect those of the editor.

# How Should Central Banks React to Household Inflation Heterogeneity?

Ulrike Neyer* Daniel Stempel†

January 2022

**Abstract**

Empirical evidence suggests that considerable differentials in inflation rates exist across households. This paper investigates how central banks should react to 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 a negative demand shock, the consumer price inflation rates of both households diverge less from their steady states when the central bank only considers the individual inflation rate of the household experiencing the higher inflation rate. Furthermore, output fluctuates less under that regime. After a negative supply shock, a central bank only considering the household experiencing the higher inflation rate mitigates the immediate effects of the shock on both consumer price inflation rates more effectively. Our results imply that central banks, which react discretionarily to differing inflation experiences in an economy, lead to a more efficient attainment of an economy-wide inflation target and to lower fluctuations of all inflation rates.

**JEL classifications**: E31, E32, E52

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

*Heinrich Heine University Düsseldorf, Universitätstraße 1, 40225 Düsseldorf, Ulrike.Neyer@hhu.de

†Corresponding Author, Heinrich Heine University Düsseldorf, Universitätstraße 1, 40225 Düsseldorf, Daniel.Stempel@hhu.de

## 1 Introduction

For central banks, an accurate measure of inflation is vital in order to appropriately implement monetary policy. However, commonly used consumer price indices (CPI) hide substantial 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 instance).

Against this background, this paper analyzes how central banks that aim to stabilize the economy-wide inflation rate should react to household inflation heterogeneity. We introduce two households into a tractable New Keynesian model: 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 mitigates the impact of the shock more effectively. The CPI inflation rates of both households and output exhibit lower volatility under that regime. After a negative supply shock, a central bank that only considers CPI inflation of the low-income household mitigates the initial impact of the shock on CPI inflation of both households more effectively. However, these inflation rates as well as output exhibit higher volatility under that regime. These results are generalizable and do not depend on income differences but rather only on inflation differentials across households. In particular, 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.

Moreover, our results have considerable monetary policy implications. In particular, 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. 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), Gürer and Weichenrieder (2020), or Argente and Lee (2021). As shown by Hobijn et al. (2009), Portillo et al. (2016), and Gürer and Weichenrieder (2020), this property can be ascribed to the fact that low-income households spend a higher share of their income on essential goods (like food, electricity, gas, or rent), as these goods exhibit above-average inflation. In addition, there is evidence that high-income households can substitute goods more effectively (Gürer and Weichenrieder, 2020; Argente and Lee, 2021), contributing to the inflation differential. 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 states the model before Section 3 describes the model responses to a demand and a supply shock. Section 4 concludes.

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

# 2 A Model with Household Inflation Heterogeneity

## 2.1 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 $\kappa$, the share of household $H$ by $1{-}\kappa$. The period utility function of household $k$ is given by

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

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

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

similar to Rabanal (2009). The parameter $\gamma_k$ 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 $\vartheta_C^k$ 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

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

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

with $\epsilon$ 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

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

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

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.[2] 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

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

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

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

[2] We denote type $h$ goods as good $h$ in the following.

consumption level, labor, and bond holdings:

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

subject to the budget constraint

$$P_t^{C,k}C_t^k + P_{1,t}C_1^* + Q_tB_t^k = B_{t-1}^k + W_t^kN_t^k + D_t^k, \tag{10}$$

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

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

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

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:

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

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.

### 2.2 Firms

There are two types of firms in the economy: type 1 firms producing good 1 and type 2 firms producing good 2.[3] We assume perfectly separated labor markets, with household $L$ working in firm 1 and household $H$ working in firm 2.[4] 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.

#### 2.2.1 Firm 1

Firm 1 produces with a simple production function given by

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

where $\alpha_1$ is the output elasticity labor, governing the marginal productivity of labor from household $L$. The firm's real total cost function is given by

$$TC_{i,t} = w_t^L N_{i,t}^L A_t, \tag{15}$$

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

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

subject to

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

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

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

[3] We denote type $h$ firms as firm $h$ in the following.

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

with $\mu \equiv \frac{\epsilon}{\epsilon-1}$ and $mc\left(Y_{i,t}\right) = \frac{1}{1-\alpha_1} w_t^L A_t Y_{i,t}^{\frac{\alpha_1}{1-\alpha_1}}$ 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

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

where the auxiliary variables are defined as

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

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

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

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

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 $\lambda_1$ of firms that keep the price of the previous period.

### 2.2.2 Firm 2

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

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

where $\alpha_2$ 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

$$TC_{j,t} = w_t^H N_{j,t}^H. \tag{22}$$

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

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

subject to

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

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

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

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

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

where the auxiliary variables are defined as

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

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

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

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

## 2.3 Monetary Policy

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

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

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 $\delta_\pi$ is of particular importance for our analysis. If $\delta_\pi = \kappa$, the central bank reacts to the average, economy-wide inflation rate given by

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

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

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

## 2.4 Market Clearing

Bonds markets clear

$$B_t^k = -B_t^{-k}, \tag{31}$$

as well as labor markets

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

Finally, goods markets clear for both goods

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

and overall production is given by

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

### 2.5 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

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

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 inflation can be derived as

$$\hat{\pi}_{h,t} = \Psi_h\left(\hat{mc}_{h,t} - \hat{v}_{h,t}^C\right) + \beta\,\mathbb{E}_t\left[\hat{\pi}_{h,t+1}\right], \tag{36}$$

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

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

and

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

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

$$\hat{\upsilon}_{h,t}^{C,k} - \hat{\upsilon}_{h,t-1}^{C,k} = \hat{\pi}_{h,t} - \hat{\pi}_t^{C,k}. \tag{39}$$

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. 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 $\varphi_k$, 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 impact of the relative prices is strengthened by larger values of $\vartheta_C^k$ 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

$$\hat{\pi}_{h,t} = \Psi_h \sum_{\iota=0}^{\infty} \beta^{\iota} \, \mathbb{E}_t \left[ \hat{mc}_{h,t+\iota} - \hat{\upsilon}_{h,t+\iota}^{C} \right]. \tag{40}$$

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

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

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.

Finally, aggregate output is given by

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

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

# 3 Results

## 3.1 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).

Table 1: Calibration.

| | Description | Value | | Target/Source |
|---|---|---|---|---|
| | | Households | | |
| | | L | H | |
| $\kappa$ | Share of households | 0.5 | 0.5 | Equal share of $L$ and $H$ households |
| $\sigma_k$ | Inverse intertemporal elasticity of substitution | 2.5 | 1.5 | Average intertemporal elasticity of substitution: 0.53 |
| $\varphi_k$ | Inverse Frisch elasticity of labor supply | 5 | 5 | Frisch elasticity of labor supply: 0.2 |
| $\gamma_k$ | 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 |
| $\vartheta_C^k$ | 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 |
| $\epsilon$ | Price elasticity of demand | 9 | 9 | Steady state markup: 12.5% |
| $\beta$ | 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 |
| $\alpha_h$ | Output elasticity labor | 0.5 | 0.33 | Higher income of household $H$ |
| $\lambda_h$ | Calvo parameter | 0.6 | 0.8 | Higher flexibility of good 1 prices |
| | | Central Bank | | |
| $\phi_\pi$ | Taylor rule coefficient | 1.5 | | Galí (2015) |
| $\delta_\pi$ | CPI inflation weight | 0; 0.5; 1 | | Analysis parameter |

We set the average intertemporal elasticity 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.[5] 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 $\gamma_k$ 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.[6] The remaining standard household parameters are chosen as in Galí (2015).

On the firms' side, we follow Kaplan et al. (2018) by setting $\alpha_2$ to 0.33. We continue by 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).

## 3.2 Dynamic Analysis

### 3.2.1 Demand Shock

Figure 1 shows the impulse responses of the model 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:

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.[7] 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

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

[6]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.

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

rates than high-income households (see Section 1).[8] 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.

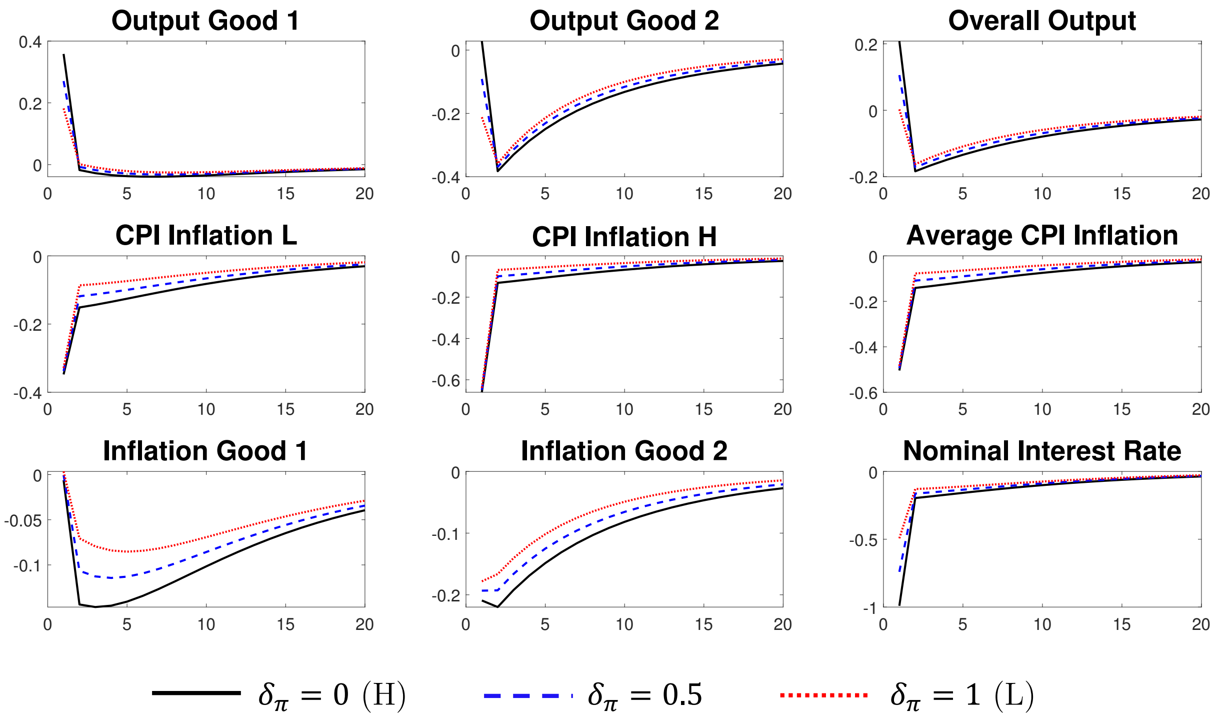


Figure 1: Impulse Responses to a Negative 0.5% Demand Shock with Persistence $\rho_Z = 0.9$.

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

[8]Note 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.

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 $\delta_\pi$ is, as consumption for both goods is higher the larger $\delta_\pi$ is. Therefore, the 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 $\delta_\pi$ 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.

Table 2: 0.5% Demand Shock Volatilities.

| | | | Volatility | |
|---|---|---|---|---|
| Variable | Description | $\delta_\pi = 0$ (H) | $\delta_\pi = 0.5$ | $\delta_\pi = 1$ (L) |
| $\hat{c}_t^L$ | Overall consumption L | 0.803 | 0.775 | 0.754 |
| $\hat{c}_t^H$ | Overall consumption H | 0.874 | 0.798 | 0.738 |
| $\hat{y}_{1,t}$ | Output good 1 | 0.382 | 0.292 | 0.202 |
| $\hat{y}_{2,t}$ | Output good 2 | 0.788 | 0.736 | 0.711 |
| $\hat{y}_t$ | Overall output | 0.470 | 0.395 | 0.342 |
| $\hat{\pi}_t^{C,L}$ | CPI inflation L | 0.528 | 0.463 | 0.404 |
| $\hat{\pi}_t^{C,H}$ | CPI inflation H | 0.740 | 0.697 | 0.662 |
| $\hat{\pi}_t^C$ | Average CPI inflation | 0.622 | 0.570 | 0.525 |
| $\hat{\pi}_{1,t}$ | Inflation good 1 | 0.452 | 0.439 | 0.285 |
| $\hat{\pi}_{2,t}$ | Inflation good 2 | 0.513 | 0.395 | 0.368 |

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

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.

### 3.2.2 Cost-Push Shock

Figure 2 shows the impulse responses of the model 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.

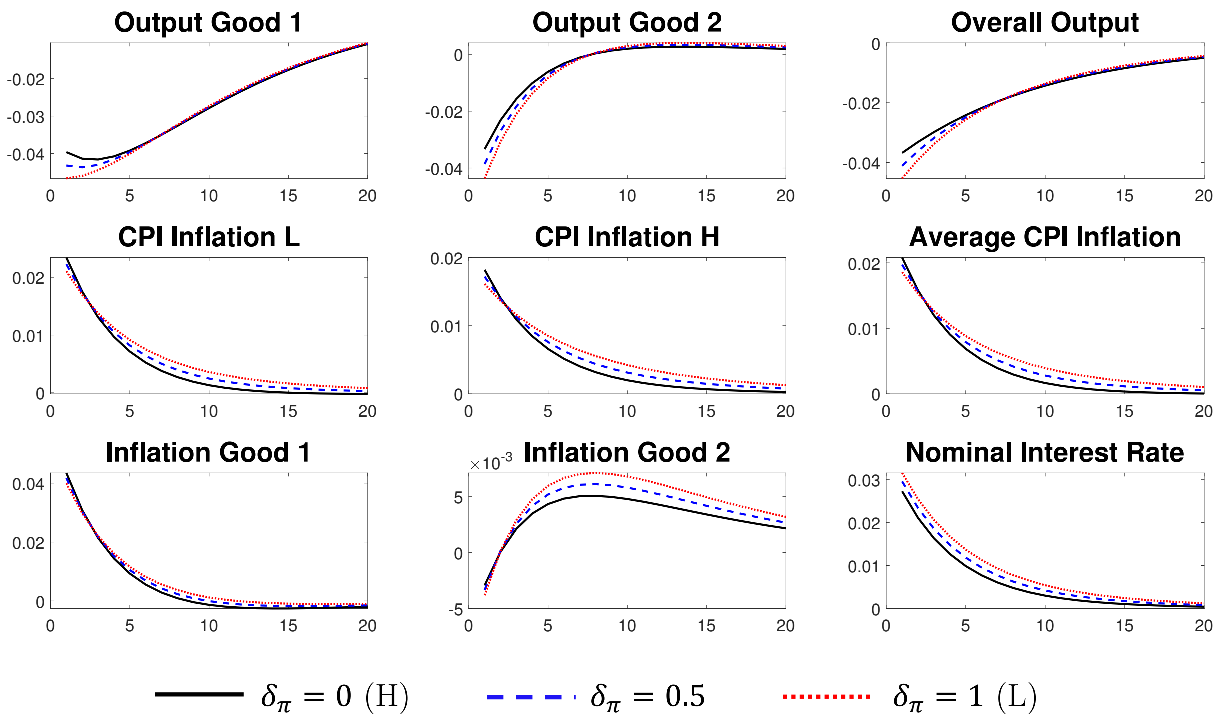


Figure 2: Impulse Responses to a Positive 1% Cost-Push Shock with Persistence $\rho_A = 0.9$.

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.

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 3, 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 $\delta_\pi$ is higher: consumption (and thereby output) decreases more in the initial period.

Table 3: 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 | 0.052 | 0.056 | 0.059 |
| $\hat{c}_t^H$ | Overall consumption H | 0.112 | 0.117 | 0.122 |
| $\hat{y}_{1,t}$ | Output good 1 | 0.132 | 0.134 | 0.136 |
| $\hat{y}_{2,t}$ | Output good 2 | 0.046 | 0.054 | 0.061 |
| $\hat{y}_t$ | Overall output | 0.085 | 0.088 | 0.093 |
| $\hat{\pi}_t^{C,L}$ | CPI inflation L | 0.035 | 0.036 | 0.036 |
| $\hat{\pi}_t^{C,H}$ | CPI inflation H | 0.029 | 0.030 | 0.031 |
| $\hat{\pi}_t^C$ | Average CPI inflation | 0.032 | 0.033 | 0.034 |
| $\hat{\pi}_{1,t}$ | Inflation good 1 | 0.061 | 0.060 | 0.059 |
| $\hat{\pi}_{2,t}$ | Inflation good 2 | 0.017 | 0.021 | 0.025 |

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 $\delta_\pi$ 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 $\delta_\pi$ is.

## 4 Conclusion

Inflation differentials across households are a well-documented phenomenon. For instance, low-income households experience higher inflation rates than households with higher income. This paper 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. 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 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. This allows for the central bank to react discretionarily to the 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.

## References


Al-Marhubi, F. (1997). A note on the link between income inequality and inflation. *Economics Letters 55*(3), 317–319.

Albanesi, S. (2007). Inflation and inequality. *Journal of Monetary Economics 54*(4), 1088–1114.

Andrés, J., E. Ortega, and J. Vallés (2008). Competition and inflation differentials in EMU. *Journal of Economic Dynamics and Control 32*(3), 848–874.

Angeloni, I. and M. Ehrmann (2007). Euro area inflation differentials. *The B.E. Journal of Macroeconomics 7*(1), 1–34.

Argente, D. and M. Lee (2021). Cost of living inequality during the great recession. *Journal of the European Economic Association 19*(2), 913–952.

Atkeson, A. and M. Ogaki (1996). Wealth-varying intertemporal elasticities of substitution: Evidence from panel and aggregate data. *Journal of Monetary Economics 38*(3), 507–534.

Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics 12*(3), 383–398.

Canzoneri, M. B., R. E. Cumby, B. T. Diba, and O. Mykhaylova (2006). New Keynesian explanations of cyclical movements in aggregate inflation and regional inflation differentials. *Open Economies Review 17*, 27–55.

Chetty, R., A. Guren, D. Manoli, and A. Weber (2012). Does invisible labor explain the difference between micro and macro elasticities? A meta-analysis of extensive margin elasticities. *NBER Macroeconomics Annual 27*, 1–56.

Duarte, M. and A. L. Wolman (2008). Fiscal policy and regional inflation in a currency union. *Journal of International Economics 74*(2), 384–401.

Galí, J. (2015). *Monetary Policy, Inflation, and the Business Cycle* (2nd ed.). Princeton University Press.

Gnocchi, S., D. Hauser, and E. Pappa (2016). Housework and fiscal expansions. *Journal of Monetary Economics 79*, 94–108.

Gornemann, N., K. Kuester, and M. Nakajima (2016). Doves for the rich, hawks for the poor? Distributional consequences of monetary policy. *International Finance Discussion Papers 1167*.

Gürer, E. and A. Weichenrieder (2020). Pro-rich inflation in Europe: Implications for the measurement of inequality. *German Economic Review 21*(1), 107–138.

Hall, R. E. (1988). Intertemporal substitution in consumption. *Journal of Political Economy 96*(2), 339–357.

Havranek, T., R. Horvath, Z. Irsova, and M. Rusnak (2015). Cross-country heterogeneity in ntertemporal substitution. *Journal of International Economics 96*(1), 100–118.

Hobijn, B., K. Mayer, C. Stennis, and G. Topa (2009). Household inequality expereinces in the U.S.: A comprehensive approach. *Federal Reserve Bank of San Francisco Working Paper Series 19.*

Jaravel, X. (2019). The unequal gains from product innovations: Evidence from the U.S. retail sector. *The Quarterly Journal of Economics 143*(2), 715–783.

Kamakura, W. A. and R. Yuxing Du (2012). How economic contractions and expansions affect expenditure patterns. *Journal of Consumer Research 39*(2), 229–247.

Kaplan, G., B. Moll, and G. L. Violante (2018). Monetary policy according to HANK. *American Economic Review 108*(3), 697–743.

Kaplan, G. and S. Schulhofer-Wohl (2017). Inflation at the household level. *Journal of Monetary Economics 91*, 19–38.

Kaplan, G. and G. L. Violante (2018). Microeconomic heterogeneity and macroeconomic shocks. *Journal of Economic Perspectives 32*(3), 167–194.

Loxton, M., R. Truskett, B. Scarf, L. Sindone, G. Baldry, and Y. Zhao (2020). Consumer behaviour during crises: Preliminary research on how coronavirus has manifested consumer panic buying, herd mentality, changing discretionary spending and the role of the media in influencing behaviour. *Journal of Risk and Financial Management 13*(8), 1–21.

Luetticke, R. (2018). Transmission of monetary policy with heterogeneity in household portfolios. *CFM Discussion Paper Series*.

Peterman, W. B. (2015). Reconciling micro and macro estimates of the Frisch labor supply elasticity. *Economic Inquiry 54*(1), 100–120.

Portillo, R., L.-F. Zanna, S. O'Connell, and R. Peck (2016). Implications of food subsistence for monetary policy and inflation. *IMF Working Paper 70*.

Rabanal, P. (2009). Inflation differentials between Spain and the EMU: A DSGE perspective. *Journal of Money, Credit and Banking 41*(6), 1141–1166.

Rupert, P., R. Rogerson, and R. Wright (2000). Homework in labor economics: Household production and intertemporal substitution. *Journal of Monetary Economics 46*(3), 557–579.

United States Department of Agriculture (2012). The demand for disaggregated food-away-from-home and food-at-home products in the United States. *Economic Research Report 139*.

# PREVIOUS DISCUSSION PAPERS

378 Neyer, Ulrike and Stempel, Daniel, How Should Central Banks React to Household Inflation Heterogeneity?, January 2022.

377 Döpper, Hendrik and Rasch, Alexander, Combinable Products, Price Discrimination, and Collusion, January 2022.

376 Cobb-Clark, Deborah A., Dahmann, Sarah C., Kamhöfer, Daniel A. and Schildberg-Hörisch, Hannah, Self-Control and Unhealthy Body Weight: The Role of Impulsivity and Restraint, January 2022.

375 Martin, Simon and Schmal, W. Benedikt, Collusive Compensation Schemes Aided by Algorithms, December 2021.

374 Kouli, Yaman and König, Jörg, Measuring European Economic Integration 1880 - 1913 – A New Approach, December 2021.

373 Hunold, Matthias and Schad, Jannika, Single Monopoly Profits, Vertical Mergers, and Downstream Entry Deterrence, December 2021.

372 Werner, Tobias, Algorithmic and Human Collusion, November 2021.

371 Jovanovic, Dragan, Wey, Christian and Zhang, Mengxi, On the Social Welfare Effects of Runner-up Mergers in Concentrated Markets, September 2021.
Published in: Economics Bulletin, (2021), Article 201.

370 Jeschonneck, Malte, Collusion among Autonomous Pricing Algorithms Utilizing Function Approximation Methods, August 2021.

369 Gösser, Niklas, Gürer, Kaan, Haucap, Justus, Meyring, Bernd, Michailidou, Asimina, Schallbruch, Martin, Seeliger, Daniela and Thorwarth, Susanne, Total Consumer Time – A New Approach to Identifying Digital Gatekeepers, August 2021.

368 Fischer, Kai, Reade, J. James and Schmal, W. Benedikt, The Long Shadow of an Infection: COVID-19 and Performance at Work, August 2021.

367 Suedekum, Jens, Place-Based Policies – How to Do Them and Why, August 2021.

366 Heiss, Florian, Ornaghi, Carmine and Tonin, Mirco, Inattention vs Switching Costs: An Analysis of Consumers’ Inaction in Choosing a Water Tariff, July 2021.

365 Cobb-Clark, Deborah A., Dahmann, Sarah C., Kamhöfer, Daniel A. and Schildberg-Hörisch, Hannah, Sophistication about Self-Control, July 2021.

364 Bie, Xiaodong and Ciani, Andrea, Born Similar, Develop Apart: Evidence on Chinese Hybrid Exporters, July 2021.

363 Ali, Nesma and Stiebale, Joel, Foreign Direct Investment, Prices and Efficiency: Evidence from India, July 2021.

362 Banerjee, Ritwik, Ibanez, Marcela, Riener, Gerhard and Sahoo, Soham, Affirmative Action and Application Strategies: Evidence from Field Experiments in Columbia, April 2021.

361 Wellmann, Nicolas and Czarnowske, Daniel, What Would Households Pay for a Reduction of Automobile Traffic? Evidence From Nine German Cities, March 2021.

360 Haucap, Justus, Moshgbar, Nima and Schmal, Wolfgang Benedikt, The Impact of the German “DEAL” on Competition in the Academic Publishing Market, March 2021.
Published in: Managerial and Decision Economics, 42 (2021), pp. 2027-2049.

359 Korff, Alex, Competition in the Fast Lane – The Price Structure of Homogeneous Retail Gasoline Stations, January 2021.

358 Kiessling, Lukas, Chowdhury, Shyamal, Schildberg-Hörisch, Hannah and Sutter, Matthias, Parental Paternalism and Patience, January 2021.

357 Kellner, Christian, Le Quement, Mark T. and Riener, Gerhard, Reacting to Ambiguous Messages: An Experimental Analysis, December 2020.

356 Petrishcheva,Vasilisa, Riener, Gerhard and Schildberg-Hörisch, Hannah, Loss Aversion in Social Image Concerns, November 2020.

355 Garcia-Vega, Maria, Kneller, Richard and Stiebale, Joel, Labor Market Reform and Innovation: Evidence from Spain, November 2020.
Published in: Research Policy, 50 (2021), 104213.

354 Steffen, Nico, Economic Preferences, Trade and Institutions, November 2020.

353 Pennerstorfer, Dieter, Schindler, Nora, Weiss, Christoph and Yontcheva, Biliana, Income Inequality and Product Variety: Empirical Evidence, October 2020.

352 Gupta, Apoorva, R&D and Firm Resilience During Bad Times, October 2020.

351 Shekhar, Shiva and Thomes, Tim Paul, Passive Backward Acquisitions and Downstream Collusion, October 2020.
Forthcoming in: Economics Letters.

350 Martin, Simon, Market Transparency and Consumer Search – Evidence from the German Retail Gasoline Market, September 2020.

349 Fischer, Kai and Haucap, Justus, Betting Market Efficiency in the Presence of Unfamiliar Shocks: The Case of Ghost Games during the COVID-19 Pandemic, August 2020.
Substantially revised version forthcoming in: Kyklos.

348 Bernhardt, Lea, Dewenter, Ralf and Thomas, Tobias, Watchdog or Loyal Servant? Political Media Bias in US Newscasts, August 2020.

347 Stiebale, Joel, Suedekum, Jens and Woessner, Nicole, Robots and the Rise of European Superstar Firms, July 2020.

346 Horst, Maximilian, Neyer, Ulrike and Stempel, Daniel, Asymmetric Macroeconomic Effects of QE-Induced Increases in Excess Reserves in a Monetary Union, July 2020.

345 Riener, Gerhard, Schneider, Sebastian O. and Wagner, Valentin, Addressing Validity and Generalizability Concerns in Field Experiments, July 2020.

344 Fischer, Kai and Haucap, Justus, Does Crowd Support Drive the Home Advantage in Professional Soccer? Evidence from German Ghost Games during the COVID-19 Pandemic, July 2020.
Published in: Journal of Sports Economics, 22 (2021), pp. 982-1008.
.

343 Gösser, Niklas and Moshgbar, Nima, Smoothing Time Fixed Effects, July 2020.

342 Breitkopf, Laura, Chowdhury, Shyamal, Priyam, Shambhavi, Schildberg-Hörisch, Hannah and Sutter, Matthias, Do Economic Preferences of Children Predict Behavior?, June 2020.

341 Westphal, Matthias, Kamhöfer, Daniel A. and Schmitz, Hendrik, Marginal College Wage Premiums under Selection into Employment, June 2020.

340 Gibbon, Alexandra J. and Schain, Jan Philip, Rising Markups, Common Ownership, and Technological Capacities, April 2021 (First Version June 2020).

339 Falk, Armin, Kosse, Fabian, Schildberg-Hörisch, Hannah and Zimmermann, Florian, Self-Assessment: The Role of the Social Environment, May 2020.

338 Schildberg-Hörisch, Hannah, Trieu, Chi and Willrodt, Jana, Perceived Fairness and Consequences of Affirmative Action Policies, April 2020.

337 Avdic, Daniel, de New, Sonja C. and Kamhöfer, Daniel A., Economic Downturns and Mental Wellbeing, April 2020.
Published in: European Economic Review, 140 (2021), 103915 under the title "Economic Downturns and Mental Health in Germany".

336 Dertwinkel-Kalt, Markus and Wey, Christian, Third-Degree Price Discrimination in Oligopoly When Markets Are Covered, April 2020.

335 Dertwinkel-Kalt, Markus and Köster, Mats, Attention to Online Sales: The Role of Brand Image Concerns, April 2020.
Forthcoming in: Journal of Economics and Management Strategy

334 Fourberg, Niklas and Korff, Alex, Fiber vs. Vectoring: Limiting Technology Choices in Broadband Expansion, April 2020.
Published in: Telecommunications Policy, 44 (2020), 102002.

333 Dertwinkel-Kalt, Markus, Köster, Mats and Sutter, Matthias, To Buy or Not to Buy? Price Salience in an Online Shopping Field Experiment, April 2020.
Revised version published in: European Economic Review, 130 (2020), 103593.

332 Fischer, Christian, Optimal Payment Contracts in Trade Relationships, February 2020.

331 Becker, Raphael N. and Henkel, Marcel, The Role of Key Regions in Spatial Development, February 2020.

330 Rösner, Anja, Haucap, Justus and Heimeshoff, Ulrich, The Impact of Consumer Protection in the Digital Age: Evidence from the European Union, January 2020.
Published in: International Journal of Industrial Organization, 73 (2020), 102585.

Older discussion papers can be found online at:
http://ideas.repec.org/s/zbw/dicedp.html

**Heinrich-Heine-Universität Düsseldorf**

**Düsseldorfer Institut für Wettbewerbsökonomie (DICE)**

Universitätsstraße 1, 40225 Düsseldorf

ISSN 2190-992X (online)
ISBN 978-3-86304-377-3

www.dice.hhu.de