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The Effect of Wage Rigidity on the Transmission of Monetary Policy to Inequality

Momo Komatsu

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Department of Economics
Manor Road Building, Manor Road
Oxford, OX1 3UQ

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Abstract

What is the effect of wage rigidities on the transmission of monetary policy to inequality? This paper investigates this question with a Two-Agent New Keynesian model with financially constrained and unconstrained households, and with search-and-matching frictions. I study the relative effects of the wage channel and the labour market channel in the transmission of conventional and unconventional monetary policy, and how these change with degrees of wage rigidity. My main result is that the stickier the wage, the more a contractionary monetary policy shock reduces consumption inequality, whether that is conventional monetary policy or quantitative tightening, driven by the wage channel.

JEL codes: E17, E24, E52, J30

Keywords: Consumption inequality, monetary policy, constrained households, transmission channels, wage rigidity

1 Introduction

This paper studies the effect of wage rigidities on the transmission of monetary policy to inequality through a two-agent New Keynesian (TANK) model with search-and-matching frictions. Central bankers have recently showed interest in the distributional consequences of monetary policy (Carney, 2016; Draghi, 2016; Yellen, 2016). In this paper I investigate the role that sticky wages play in

*University of Oxford. Email: momo.komatsu@economics.ox.ac.uk

such consequences. I find that contractionary monetary policy decreases inequality, and expansionary monetary policy increases it, and that the effect is larger when wages are stickier.

I study how wage rigidities affect different transmission channels of monetary policy to inequality. I use a TANK model based on the model developed by Debortoli and Galí (2018) in which a fraction of households are credit-constrained. Those households do not have access to the asset market and are therefore poorer than the unconstrained households who can save and borrow. To the TANK model I add search-and-matching frictions in a similar way to Dolado et al. (2021) and Komatsu (forthcoming) in order to identify the transmission channel involving unemployment and other labour market variables. Empirical researchers show that such channels are important in the transmission of monetary policy to inequality (Lenza & Slacalek, 2018). I examine both conventional and unconventional monetary policy. For the unconventional monetary policy, I consider quantitative tightening and quantitative easing under the zero lower bound.

I focus on two transmission channels of monetary policy to inequality: The wage channel and the labour market channel. The wage channel is an adaptation of what the existing literature refers to as the income composition channel. The income composition channel looks at how monetary policy can affect income sources heterogeneously, which can have distributional consequences (Davtyan, 2017). In this paper, this channel narrows down to wage income since the credit-constrained households do not have any other income sources. When real wage for these households increases, inequality decreases. The labour market channel is also referred to as the earnings heterogeneity channel. This channel considers the heterogeneous effects that monetary policy can have on the labour market conditions across the income distribution (Casiraghi et al., 2018). A decrease in unemployment rate or an increase in vacancies from monetary policy reduces inequality, since such effects increases the income of credit-constrained households.

My main result is that the stickier the wages, the more consumption inequality reduces as an effect of a contractionary monetary policy shock, whether that is conventional monetary policy or quantitative tightening. Since inflation decreases after a contractionary monetary policy shock, real wages increase in a country where nominal wages are stickier. This increase in real wages favours the consumption of the credit-constrained households disproportionately through the wage channel because they only depend on labour income. The labour market channel affects consumption inequality in the opposite direction by decreasing labour income of the constrained by increasing unemployment, but this effect is not strong enough to counter the wage channel.

I also investigate the role of the zero lower bound and the effect of quantitative easing. Rigid wages significantly reduce the simulatory effect of a quantitative easing shock on the economy under the zero lower bound. For the same quantitative easing shock, the rigid wage economy takes longer to emerge from the zero lower bound. Moreover, the inflation increase is substantially higher in the flexible wage economy, because rigid wages dampen such a response. As a consequence, the real wages in the rigid wage country decreases after a quantitative easing shock, but increases in the flexible wage country. Through the wage channel, this effect results in a decrease in consumption inequality in the flexible wage country and an increase in the rigid wage country. As in the contractionary monetary policy case, the labour market channel is not big enough to counter the wage channel.

This paper combines two strands of literature, on the effect of monetary policy on inequality, and on the importance of wage rigidities for macroeconomic fluctuations. Within the literature on monetary policy and inequality, my paper adds to the theoretical analysis of the topic. The New Keynesian literature uses heterogeneous agent models to investigate whether monetary policy has an effect on inequality. Bilbiie (2008), Debortoli and Galí (2018), and Komatsu (forthcoming) use TANK models to study what role credit-constrained households play in the transmission of monetary policy. They confirm that monetary policy can have distributional consequences. This paper builds upon their results. Other papers like Broer et al. (2020) and Dolado et al. (2021) have different heterogeneous agent specifications but consider similar research questions. Papers by Coibion et al. (2017), Furceri et al. (2018), Lenza and Slacalek (2018), and Mumtaz and Theophilopoulou (2017) investigate the effect of monetary policy on inequality empirically.

The literature on the importance of wage rigidities initiated by researchers like Christiano et al. (2005), Edge et al. (2003), and Galí et al. (2001) conclude that wage rigidities are an essential feature of macroeconomic models because they can explain the observed persistence in the economy. More recently, Gertler et al. (2020) find that wage rigidity is important for macroeconomic fluctuations. Christoffel et al. (2009) suggest that wage rigidity matters more in the transmission of monetary policy to inflation than other labour market rigidities. This result is closely related to my result of the wage channel playing a bigger role in the transmission of monetary policy to inequality than the labour market channel.

The rest of the paper is as follows: In the next section, I present the model and calibration. In Section 3 I show the result of the three different simulations of the model: (i) conventional contractionary monetary policy, (ii) quantitative tightening, and (iii) quantitative easing under the zero lower bound. In the last section, I conclude the paper.

2 Model

In this section I present the model used in the analyses of this paper. I base the two-agent modelling on Debortoli and Galí (2018) and incorporate labour market frictions as in Dolado et al. (2021). In addition, I also add wage rigidities following Gertler and Trigari (2009). The full model is similar to the Search-and-Matching Two-Agent New Keynesian (SAMTANK) model with sticky wages in Komatsu (forthcoming). I allow for quantitative easing (QE) following the model developed by Harrison (2017). Each period is a quarter of a year. The list of equations in log-deviations from the zero-inflation steady state used to solve the model are in Appendix A.

2.1 Households

There are two time-invariant types of households in the model: Share $\lambda \in (0,1)$ of the households are constrained and $1-\lambda$ are unconstrained. Constrained households do not have access to the financial market and consume their income hand-to-mouth, whereas unconstrained households smooth their consumption by lending and borrowing. I assume a complete financial market setup such that there is perfect insurance against idiosyncratic unemployment risk within a household type. In this way, we can think of the two households as representative households of each type. Throughout the model, superscript $k=c$ stands for variables concerning constrained households and $k=u$ concerning unconstrained households.

Both types of households maximise their lifetime utility given by $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \mathcal{U}(c_t^k)$ where $\beta \in [0,1)$ is the discount factor. $c_t^k = \left(\int_0^1 c_t^k(i)^{(\epsilon-1)/\epsilon} di\right)^{\epsilon/(\epsilon-1)}$ is a consumption index where $c_t^k(i)$ is the quantity of good i consumed by household of type k in period t. ϵ is the elasticity of substitution across goods. The utility function takes the standard form:

$$\mathcal{U}(c_t^k) = \frac{(c_t^k)^{1-\sigma}}{1-\sigma}, \tag{1}$$

where σ is the coefficient of constant relative risk-aversion.

Crucially, the two types of households maximise their utility subject to different budget constraints.

The nominal budget constraint for the constrained household is:

$$\int_0^1 P_t(i)c_t^c(i)di = W_t^c n_t^c + P_t T_t^c + P_t T^b u_t^c \tag{2}$$

for $t = 0, 1, 2, ...$ where $P_t(i)$ is the price of good i at time t. W_t is the nominal wage per unit of labour, T_t indicates real government transfers, and T^b is real unemployment benefits. $P_t = \int_0^1 \left(P_t(i)^{1-\epsilon}\right)^{1/(1-\epsilon)} di$ is the aggregate price index. The budget constraint confirms the hand-to-mouth behaviour of the constrained households.

The nominal budget constraint of the unconstrained households is:

$$\int_0^1 P_t(i)c_t^u(i)di + b_{L,t}^h + b_t^h = W_t^u n_t^u + R_{L,t} b_{L,t-1}^h + R_{t-1} b_{t-1}^h + P_t \tau_t + \frac{1-\delta}{1-\lambda} D_t + P_t T_t^u - P_t HC_t + P_t T^b u_t^c \tag{3}$$

for $t = 0, 1, 2, ...$ where b_t^h are purchases of one-period bonds with interest rate R_t and $b_{L,t}^h$ are purchases of long-term bonds with interest rate $R_{L,t}$. Later I explain in detail the structure of bond holdings. Holding a ratio of short-term and long-term bonds different to the steady state δ_b comes with adjustment cost $HC_t = \frac{\tilde{\nu}}{2}\left[\delta_b \frac{b_t^h}{b_{L,t}^h} - 1\right]^2$. Unconstrained households have access to firm profits D_t, but the fiscal authority imposes a tax rate $\delta \in (0, 1)$ and uses it for fiscal transfers.

I aggregate consumption and labour as follows:

$$C_t^c = \lambda c_t^c, \quad C_t^u = (1-\lambda)c_t^u, \quad C_t = C_t^c + C_t^u \tag{4}$$

$$N_t^c = \lambda n_t^c, \quad N_t^u = (1-\lambda)n_t^u, \quad N_t = N_t^c + N_t^u. \tag{5}$$

2.2 Labour market

I model the labour market with standard search-and-matching frictions. The labour market is homogeneous so that $n_t^c = n_t^u = n_t$ and $u_t^c = u_t^u = u_t$. n_t is the employment rate in the economy and u_t the unemployment rate. Both representative households have a time endowment of 1 and allocate their time as following:

$$1 = n_t + u_t \tag{6}$$

I aggregate unemployment in the same way as consumption and labour:

$$U_t = \lambda u_t^c + (1-\lambda)u_t^u \tag{7}$$

The matching technology determines the number of matches in the labour market depending on the number of vacancies v_t and the unemployed U_t:

$$m_t(v_t, U_t) \equiv m_t = \psi(v_t)^{\zeta}(U_t)^{(1-\zeta)}. \tag{8}$$

I define the labour market tightness θ_t, the probability of filling a vacancy $q(\theta_t)$ and the probability of finding a job $p(\theta_t)$ as in standard search-and-matching literature:

$$\theta_t = \frac{v_t}{U_t} \tag{9}$$

$$q(\theta_t) = \frac{m_t}{v_t} \tag{10}$$

$$p(\theta_t) = \frac{m_t}{U_t} = \psi_t(\theta_t)^{\zeta} \tag{11}$$

The transition dynamics in the labour market is as follows:

$$N_t = (1-\gamma)N_{t-1} + q(\theta_t)v_t \tag{12}$$

where I assume that jobs have an exogenous separation rate of γ.[1]

2.3 Firms

There is monopolistic competition amongst a continuum of firms $i \in [0, 1]$ where each firm produces a differentiated good i. The production technology is identical across firms:

$$Y_t(i) = A_t N_t(i), \tag{14}$$

where $N_t(i) = N_t^c(i) + N_t^u(i) = \lambda n_t^c(i) + (1-\lambda)n_t^u(i) = n_t(i)$. A_t is the total factor productivity that follows an AR(1) process $\ln A_t \equiv a_t = \rho_a a_{t-1} + \varepsilon_t^a$ where $\varepsilon_t^a \sim_{\text{i.i.d.}} \mathcal{N}(0, \sigma_a^2)$ is an exogenous technology shock. Since constrained and unconstrained households supply labour in a homogeneous market, their nominal wage are the same: $W_t^c = W_t^u = W_t$.

Firms face quadratic adjustment costs à la Rotemberg (1982) $FC_t(i) = \frac{\xi}{2}\left(P_t(i)/P_{t-1}(i) - 1\right)^2$, a

[1] When used as a constraint to the household problem, I rewrite the transition dynamics equation as:

$$n_t = (1-\gamma)n_{t-1} + p(\theta_t)u_t \tag{13}$$

standard demand curve $Y_t(i) = (P_t(i)/P_t)^{-\epsilon} Y_t$, and the transition dynamics in the labour market (13) when maximising over the lifetime real profits:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{t+1} \left[\frac{P_t(i)}{P_t} Y_t(i) - \frac{W_t}{P_t} N_t(i) - Y_t FC_t - \kappa v_t(i) \right], \tag{15}$$

where $\Lambda_{t,t+1} = \beta \left(c_{t+1}/c_t \right)^{-\sigma}$ is the stochastic discount factor and κ the real cost of posting a vacancy.

The firm's maximisation problem gives us the standard New Keynesian Philips Curve for Rotemberg (1982) pricing (see Appendix A for details) and the hiring condition for firms:

$$\frac{\kappa}{q(\theta_t)} = \mu_t A_t - \frac{W_t}{P_t} + (1-\gamma)\mathbb{E}_t \left[\Lambda_{t+1} \frac{\kappa}{q(\theta_{t+1})} \right] \tag{16}$$

where μ_t is the real marginal cost, obtained as the Lagrange multiplier on the production function. The hiring condition sets the expected cost of posting a vacancy equal to the expected benefits.

The aggregate real profits of firms are:

$$\frac{D_t}{P_t} = Y_t \left(1 - FC_t\right) - \frac{W_t}{P_t} N_t - \kappa v_t \tag{17}$$

where $FC_t = \int_0^1 FC_t(i) di$ is the aggregate price adjustment costs.

2.4 Staggered wage bargaining: Sticky nominal wages

Households and firms split the surplus from a match in the labour market by Nash bargaining. The bargaining takes place in a staggered setting as proposed by Gertler and Trigari (2009) with nominal wage rigidities:

$$\max_{W_{t*}} \left[\mathcal{W}_t \left(W_t, \mathbf{s_t}\right)^{\eta} \mathcal{J}_t \left(W_t, \mathbf{s_t}\right)^{1-\eta} \right] \quad \text{subject to} \quad W_{t+1} = \begin{cases} W_t & \text{with probability } \alpha \\ W^*_{t+1} & \text{with probability } 1-\alpha \end{cases} \tag{18}$$

where $\mathbf{s_t}$ is the set of variables defining the aggregate state and η is the bargaining power of the household. The surplus of the household being hired is $\mathcal{W}_t$ and of the firms having an employee is $\mathcal{J}_t$:

$$\mathcal{W}_t = W_t - P_t T^b + (1-\gamma)\,\mathbb{E}_t \left[\Lambda_{t,t+1} \left(1 - p\left(\theta_{t+1}\right)\right) \mathcal{W}_{t+1} \right] \tag{19}$$

$$\mathcal{J}_t = \frac{\kappa}{q(\theta_t)} = P_t \mu_t A_t - W_t + (1-\gamma)\,\mathbb{E}_t \left[\Lambda_{t,t+1} \frac{\kappa}{q\left(\theta_{t+1}\right)} \right] \tag{20}$$

α is the probability that wages are non-negotiable in a period and thus is a measure of wage stickiness. I assume that when an unemployed finds a job in a certain period, they take as given the wage negotiated by the employees already hired at the beginning of that period. The solution to this problem is:

$$\eta \mathcal{J}_t(\Gamma_t^{\mathcal{W}}) = (1-\eta)\mathcal{W}_t(\Gamma_t^{\mathcal{J}}) \tag{21}$$

where $(\Gamma_t^{\mathcal{W}}) = (\partial \mathcal{W}_t/\partial W_t) = 1 + \alpha\,(1-\gamma)\,\mathbb{E}_t\left[\Lambda_{t+1}(1-p(\theta_{t+1}))(\Gamma_{t+1}^{\mathcal{W}})\right]$ and $(\Gamma_t^{\mathcal{J}}) = -(\partial \mathcal{J}_t/\partial W_t) = 1 + \alpha\,(1-\gamma)\,\mathbb{E}_t\left[\Lambda_{t+1}(\Gamma_{t+1}^{\mathcal{J}})\right]$ are the workers' and firms' stake in the wage respectively. I rewrite the above equation as:

$$H_t \mathcal{J}_t = (1-H_t)\mathcal{W}_t \tag{22}$$

where the effective bargaining power of households is:

$$H_t = \frac{\eta}{\eta + (1-\eta)(\Gamma_t^{\mathcal{J}})/(\Gamma_t^{\mathcal{W}})}. \tag{23}$$

In this way, we can obtain the wage determination equation by substituting in the workers' and firms' surplus into the rewritten solution:

$$\frac{W_t^*}{P_t} = (1-H_t)T^b + H_t\left(\mu_t A_t + (1-\gamma)\mathbb{E}_t\left[\Lambda_{t+1}\pi_{t+1}p(\theta_{t+1})\frac{\kappa}{q(\theta_{t+1})}\right]\right). \tag{24}$$

where $\pi_t = P_t/P_{t-1}$ is gross inflation. When household have no bargaining power, i.e. $\eta = H_t = 0$, the negotiated wage is equal to the household's reservation wage, and when they have all bargaining power, i.e. $\eta = H_t = 1$, the wage is equal to the firms' reservation wage. I substitute the wage determination condition into the hiring condition (16) to get the job creation condition

$$\frac{\kappa}{q(\theta_t)} = (1-H_t)\left(\mu_t A_t - T^b\right) + (1-\gamma)\,\mathbb{E}_t\left[\Lambda_{t+1}\left(1-\pi_{t+1}H_t p(\theta_{t+1})\right)\frac{\kappa}{q(\theta_{t+1})}\right]. \tag{25}$$

Finally, I construct a wage index to obtain the average nominal wage in the economy:

$$W_t = (1-\alpha)W_t^* + \alpha W_{t-1} \tag{26}$$

2.5 Monetary and fiscal policies

At times when the zero lower bound (ZLB) is not binding in the economy, the monetary policy authority follows a standard Taylor rule. The central bank sets nominal interest rate on short-term bonds R_t responding to deviations of inflation from its steady-state and to deviations of output from its natural level Y_t^n:

$$R_t = \frac{1}{\beta}\left(\frac{\pi_t}{\bar{\pi}}\right)^{\phi_\pi}\left(\frac{Y_t}{Y_t^n}\right)^{\phi_y}\exp(\nu_t) \tag{27}$$

where the monetary policy shock ν_t follows an AR(1) process $\nu_t = \rho_\nu \nu_{t-1} + \varepsilon_t^\nu$ and $\varepsilon_t^\nu \sim_{\text{i.i.d.}} \mathcal{N}(0, \sigma_\nu^2)$ is the exogenous monetary policy shock.[2]

The central bank can also conduct unconventional monetary policy through quantitative tightening (QT), or quantitative easing (QE) when the ZLB on the short-term nominal interest rates is binding. I model the unconventional monetary policy as in Harrison (2017) with short-term bond stock B_t and long-term bond stock $\tilde{B}_{L,t}$. The government's nominal budget constraint is:

$$B_t + V_t\tilde{B}_{L,t} = R_{t-1}B_{t-1} + (1+\chi_b V_t)\tilde{B}_{L,t-1} + Z_t - P_t\vartheta_t \tag{30}$$

where Z_t is net asset purchases by the central bank and ϑ_t the net transfers to households. As in standard macroeconomic models, B_t is a bond purchased at $t-1$ which matures at t with a nominal payoff of R_{t-1}. Long-term bonds $\tilde{B}_{L,t}$, priced at V_t, pay a geometrically declining coupon so that when issued j periods ago it is equivalent to a χ_b^j nominal holding of a bond issued today. In the budget constraint, long-term bond holdings are measured in terms of the equivalent quantity of newly issued bonds. With these assumptions, we can rewrite the government's budget constraint as:

$$B_t + B_{L,t} = R_{t-1}B_{t-1} + R_{L,t}B_{L,t-1} + Z_t - P_t\tau_t \tag{31}$$

where $B_{L,t} \equiv V_t\tilde{B}_{L,t}$ is the nominal value of long-term bond holdings and $R_{L,t} \equiv (1+\chi_b V_t)/V_{t-1}$ the one-period rate of return on these holdings. The government implements debt issuance policies as

[2] Results are quantitatively and qualitatively similar when I use a persistent Taylor rule with independent and identically distributed shocks:

$$\hat{R}_t = \rho_R\hat{R}_{t-1} + (1-\rho_R)\hat{R}_t^* \tag{28}$$

$$\hat{R}_t^* = \phi_\pi\hat{\pi}_t + \phi_y\tilde{y}_t + \varepsilon_t^R, \tag{29}$$

where $\varepsilon_t^R \sim_{\text{i.i.d.}} \mathcal{N}(0, \sigma_R^2)$.

following:

$$\frac{B_t}{P_t} \equiv b_t \quad = b > 0, \quad \forall t \tag{32}$$

$$\frac{B_{L,t}}{P_t} \equiv b_{L,t} = \delta_b b, \quad \forall t \tag{33}$$

which ensure that, without QT or QE operations by the central bank, households achieve their desired ratio of long-term and short-term bonds.

I define net asset transfers from the central bank Z_t as:

$$Z_t = Q_t - R_{L,t} Q_{t-1} \tag{34}$$

where $Q_t = q_t B_{L,t}$ is the policy rule on purchasing long-term bonds. A QT or QE shock would therefore be a shock to q_t that determines the share of long-term bonds held by the central bank. q_t follows an AR(1) process $q_t = \rho_q q_{t-1} + \varepsilon_t^q$ where $\varepsilon_t^q \sim_{\text{i.i.d.}} \mathcal{N}(0, \sigma_q^2)$ is the exogenous unconventional monetary policy shock. A positive shock to q_t indicates that the central bank holds more long-term bonds, i.e. a quantitative easing shock, whereas a negative shock is a quantitative tightening shock.

The fiscal policy redistributes the taxed firms' profits in the following way:

$$T_t^c = (1-\tau)\left[\delta \frac{D_t}{P_t} - T^b \left(U_t^c + U_t^u\right)\right] \tag{35}$$

$$T_t^u = \left(1 + \frac{\tau\lambda}{1-\lambda}\right)\left[\delta \frac{D_t}{P_t} - T^b \left(U_t^c + U_t^u\right)\right] \tag{36}$$

so that $P_t \left[\lambda T_t^c + (1-\lambda) T_t^u\right] = \delta D_t - P_t T^b \left(U_t^c + U_t^u\right)$, i.e. the transfers to households, including unemployment benefits, add up to tax revenue from profits. τ determines the fraction of firms' profits that go to unconstrained households. Since unconstrained households have acces to the nontaxed part of the profits $(1-\delta)D_t$, $\tau = 1$ implies that all profits go to unconstrained households. With $\tau = 0$ the fiscal authority distributes the remaining taxed profits uniformly across all households.

2.6 Market clearing

Market clearing in the goods market requires $Y_t(i) = C_t^c(i) + C_t^u(i) = C_t(i)$ for all $i \in [0,1]$ and all $t = 0, 1, 2, \ldots$. Defining aggregate output as $Y_t = \left(\int_0^1 Y_t(i)^{(\epsilon-1)/\epsilon} di\right)^{\epsilon/(\epsilon-1)}$, I reach the goods market clearing condition:

$$Y_t = C_t + Y_t FC_t + \kappa v_t \tag{37}$$

For bonds market clearing, we need both the short-term and long-term bond markets to clear:

$$(1-\lambda)\frac{b_t^h}{P_t} = b \tag{38}$$

$$\frac{Q_t}{P_t} + (1-\lambda)\frac{b_{L,t}^h}{P_t} = \delta b \tag{39}$$

2.7 Heterogeneity

To analyse the effect of monetary policy on inequality, I need to track the heterogeneity between the two different types of households. As in Debortoli and Galí (2018), I define the heterogeneity factor as the consumption gap between the representative constrained and unconstrained household. The higher the heterogeneity factor, the bigger consumption inequality between the two households:

$$\omega_t = 1 - \frac{c_t^c}{c_t^u} \tag{40}$$

$$= 1 - \frac{\frac{W_t}{P_t} n_t + T_t^c}{\frac{W_t}{P_t} n_t + \frac{1-\delta}{1-\lambda}\frac{D_t}{P_t} + T_t^u} \tag{41}$$

$$= \frac{(1-\delta(1-\tau))\left[Y_t\left(1-\frac{\xi}{2}(\pi_t-1)^2\right) - \frac{W_t}{P_t}n_t - \kappa v_t\right]}{(1-\lambda)\frac{W_t}{P_t}n_t + (1-\delta\lambda(1-\tau))\left[Y_t\left(1-\frac{\xi}{2}(\pi_t-1)^2\right) - \frac{W_t}{P_t}n_t - \kappa v_t\right]} \tag{42}$$

$$= \frac{(1-\delta(1-\tau))\left(\frac{A_t}{W_t/P_t}\left(1-\frac{\xi}{2}(\pi_t-1)^2\right) - 1 - \kappa\frac{v_t}{n_t W_t/P_t}\right)}{(1-\lambda) + (1-\delta\lambda(1-\tau))\left(\frac{A_t}{W_t/P_t}\left(1-\frac{\xi}{2}(\pi_t-1)^2\right) - 1 - \kappa\frac{v_t}{n_t W_t/P_t}\right)} \tag{43}$$

where the third equality assumes $T^b = 0$. In the last line, I express the heterogeneity factor in terms of real wage, employment, and vacancies. Therefore, I can decompose the effect of a monetary policy shock on the heterogeneity factor in the two channels: wage channel and labour market channel.[3]

$$\hat{\omega}_t = \underbrace{\frac{\omega_{aux2} - \omega_{aux1}}{\omega_n \omega_d}\hat{w}_t}_{\text{wage channel}} + \underbrace{\frac{\omega_{aux2}\frac{\bar{u}}{\bar{n}}}{\omega_n \omega_d}\hat{u}_t - \frac{\omega_{aux2}}{\omega_n \omega_d}\hat{v}_t}_{\text{labour market channel}} + \frac{\omega_{aux1}}{\omega_n \omega_d}\hat{a}_t \tag{44}$$

[3]The expression also depends on total factor productivity A_t and inflation π_t. These terms are irrelevant when looking at how monetary policy shocks affect the heterogeneity factor in percentage deviations from steady state.

where I define the auxiliary variables as:

$$\omega_n = (1-\delta(1-\tau))\left(\bar{\Omega}_1 - 1 - \kappa\bar{\Omega}_2\right) \tag{45}$$

$$\omega_d = (1-\lambda) + (1-\delta\lambda(1-\tau))\left(\bar{\Omega}_1 - 1 - \kappa\bar{\Omega}_2\right) \tag{46}$$

$$\omega_{aux1} = \left[(1-\delta(1-\tau))\omega_d - (1-\delta\lambda(1-\tau))\omega_n\right]\bar{\Omega}_1 \tag{47}$$

$$\omega_{aux2} = \left[(1-\delta(1-\tau))\kappa\omega_d - (1-\delta\lambda(1-\tau))\kappa\omega_n\right]\bar{\Omega}_2 \tag{48}$$

Hatted values are log-linear deviations from the zero-inflation steady state (See Appendix A for more details). Finally, rearranging Eq. (41) gives a link aggregate consumption and consumption of unconstrained agents:[4]

$$C_t = c_t^u(1-\lambda\omega_t) \tag{49}$$

2.8 Calibration

I calibrate the model with common values used in New Keynesian literature and values estimated my empirical papers that correspond to the parameters in my model. I calibrate the model to fit characteristics of advanced economies. I present all calibrated parameters in Table 1. In Appendix B, I perform some robustness checks with different values.

Many papers investigate empirically the share of constrained households λ. I set the value equal to 10% to reflect the fraction of households in advanced economies that do no have access to the financial market. The Household Finance and Consumption Survey (HFCS, 2022) collects household-level data in the Eurozone and estimate that credit-constrained households make up around 5-10% of the population. In Japan, Hara et al. (2016) find that about 13% of the population consume hand-to-mouth, of which three quarters are wealthy hand-to-mouth households. In my model, all hand-to-mouth households fall under the category of poor hand-to-mouth households since they do not have any illiquid assets. Kaplan et al. (2014) estimate the same fractions in the United States and find that about 10% of the households are poor hand-to-mouth households.

I set the coefficient of constant relative risk-aversion $\sigma = 1$, the discount factor $\beta = 0.99$, and the elasticity of substitution across goods $\epsilon = 11$ to match standard New Keynesian literature. For the monetary policy rule I calibrate the coefficient on inflation $\phi_\pi = 1.5$ and on output gap $\phi_y = 0.125$ as proposed by Taylor (1993). In line with standard literature, I set the persistence of the monetary

[4] Verify this identity by using $\omega_t = 1 - \frac{c_t^c}{c_t^u}$: $C_t = c_t^u\left[1-\lambda\left(1-\frac{c_t^c}{c_t^u}\right)\right] = c_t^u - \lambda c_t^u + \lambda c_t^c = \lambda c_t^c + (1-\lambda)c_t^u$.

policy shock at $\rho_\nu = 0.5$ and that of the technology shock at $\rho_a = 0.9$.

I calibrate the Rotemberg (1982) price-adjustment costs parameter ξ such that the slope of the New Keynesian Philips Curve (NKPC) matches the slope of the NKPC under Calvo (1983) price rigidities for a Calvo parameter of 0.75. This value implies an expected price duration of four quarters, consistently with empirical evidence (Galí, 2008). When the Calvo parameter is 0.75, the corresponding Rotemberg price-adjustment costs is $\xi = [(\epsilon-1)0.75]/[(1-0.75)(1-0.75\beta)] \approx 93.20$.

For the parameters in the labour market, I take values that Krause et al. (2008) use: Matching elasticity $\zeta = 0.3$, steady-state matching efficiency $\bar{\psi} = 0.7$, barganinig power $\eta = 0.5$, and the real cost of posting vacancies $\kappa = 0.05$. The values are all standard in the search-and-matching literature.

I set the tax rate on firms' profits at $\delta = 0.266$, the average corporate tax rate between 2000 and 2018 in the Organisation for Economic Co-operation and Development countries (OECD, 2020). I set the fiscal policy rule parameter as $\tau = 1$ so that all profits go to unconstrained households. Piketty and Goldhammer (2014) claim that in advanced economies most profits go to the wealthiest.

I follow Harrison (2017) for calibrating the parameters related to quantitative easing: Adjustment portfolio costs $\tilde{\nu}1.25$, steady-state ratio of long-term to short-term bonds $\delta_b = 0.3$, and long-term bond coupon decay rate $\chi_b = 0.975$. The persistence of quantitative tightening and easing operations ρ_q is 0.9.

The key parameter in my model is the wage rigidity parameter α. I simulate the model with two different calibrations for the parameter. Since α is the probability that the firm does not renegotiate the wage, the higher the parameter the stickier the wages. Empirical papers show that wage rigidity is heterogeneous across countries. For example, Muto and Shintani (2020) show that wages are much more flexible in Japan than the United States. They estimate a wage rigidty parameter between 0.302-0.606 for Japan and 0.621-0.924 for the United States. Even within the Eurozone, the Wage Dynamics Network show that there are significant differences in wage setting behaviour across countries: In France, the wage stickiness parameter is around 0.75, whereas in Germany it is close to 0.85. In the flexible wage setting, I set α to 0.67, whereas in the rigid wage setting I set it to 0.85.

3 Results

This section outlines the results of the simulation exercises. I solve the model with Dynare, a software that solves dynamic stochastic general equilibrium models (Adjemian et al., 2011). In the first and second subsection I perturb the log-linearised model with the calibrated parameters around its non-

Table 1: Baseline calibration of parameters

Parameter	*Description*	*Value*
Households		
λ	Fraction of constrained households	0.1
σ	Coefficient of constant relative risk-aversion	1
β	Discount factor	0.99
ϵ	Elasticity of substitution across goods	11
Labour market		
ζ	Matching elasticity	0.3
ψ	Steady-state matching efficiency	0.7
γ	Separation rate	0.1
η	Bargaining power	0.5
κ	Real cost of posting vacancies	0.05
Firms		
ρ_a	Technology shock persistence	0.9
ξ	Adjustment costs parameter	93.20
Monetary and fiscal policy		
ϕ_π	Taylor-coefficient on inflation	1.5
ϕ_y	Taylor-coefficient on output	0.125
ρ_ν	Monetary policy shock persistence	0.5
$\tilde{\nu}$	Adjustment portfolio costs	1.25
δ_b	Steady-state ratio of long-term to short-term bonds	0.3
χ_b	Long-term bond coupon decay rate	0.975
ρ_g	Persistence quantitative tightening/easing	0.85
δ	Tax rate on firms' profits	0.266
τ	Fiscal policy rule	1
Wage rigidities		
α	Stickiness of wages, flex	0.67
	Stickiness of wages, rigid	0.85

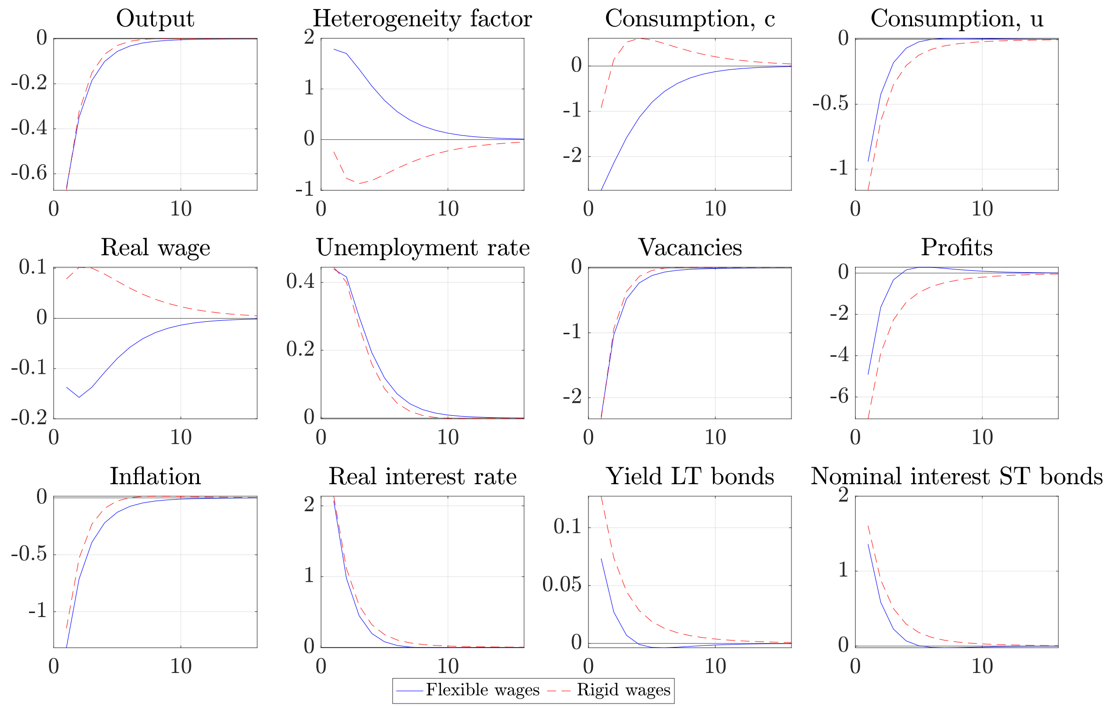
stochastic steady state to get impulse response functions (IRFs) to conventional monetary policy shocks and quantitative tightening (QT) shocks respectively. In the third subsection I consider a zero lower bound (ZLB) constraint to the nominal interest rate and investigate the effect of quantitative easing (QE) shocks. I impose this constraint with a piecewise linear solution as in Guerrieri and Iacoviello (2015). I simulate the model in two settings: A flexible wage country setting with the wage stickiness parameter $\alpha = 0.67$ and a rigid wage country setting with $\alpha = 0.85$.

3.1 Conventional monetary policy

In Figure 1 I plot the IRFs to a 1% contractionary monetary policy shock in the flexible nominal wage and rigid nominal wage country. For most aggregate variables like output, inflation, and real interest rate, the degree of wage rigidity does not matter much for the transmission of conventional monetary policy shocks. Even for labour market variables, like unemployment rate and vacancies, wage stickiness does not play an important role in the transmission.

Obviously for real wage responses, nominal wage rigidity does matter. Since inflation decreases after a contractionary monetary policy shock, real wages increase in a country where nominal wages

Figure 1: IRFs to a conventional monetary shock



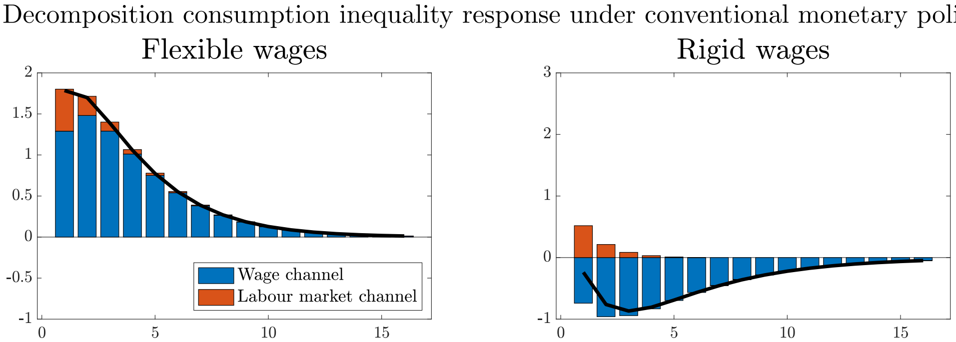
are sticky. In the flexible wage country, real wages decrease after the shock, indicating that the nominal wages decreases more than inflation. This discrepancy in the response of real wages directly affects the consumption of the constrained households because they consume their income hand to mouth. After the contractionary monetary policy shock the consumption of constrained households in the flexible wage country decreases more than in the rigid wage country. The consumption of the unconstrained households reflects the changes in the nominal interest rate, because these households are Ricardian and smooth their consumption.

The consumption responses of the two households determine the response of the heterogeneity factor to the contractionary monetary policy shock. In the flexible wage country the heterogeneity factor, and therefore consumption inequality, increases after the shock, whereas in the rigid wage country it decreases. I analyse this effect through IRF decomposition. As outlined in the model section, the log-linearised equation for the heterogeneity factor shows that there are two channels in the transmission of monetary policy to consumption inequality: The wage channel and the labour market channel. To quantify the channels under the 1% contractionary monetary policy shock, I decompose the IRF of the heterogeneity factor into the two channels in Figure 2.

The labour market channel increases consumption inequality similarly in both types of countries, since the unemployment rate and vacancy responses in Figure 1 are similar in both countries. The labour market channel has an increasing effect on the consumption inequality after the contractionary monetary policy shock, because the unemployment rate increases and vacancies decreases. As constrained households depend on labour income for their consumption, those fluctuations increase inequality.

The wage channel makes the consumption inequality response differ between two countries. As suggested in Figure 1, a decrease in real wage increases the consumption inequality in the flexible wage country. Therefore, this effect amplifies the labour market channel and increases inequality even further after the contractionary monetary policy shock. In the rigid wage country, the two channels have an opposite effect on consumption inequality. From this result I can conclude that the stickier the wages, the more favourable the effect of a contractionary monetary policy shock on consumption inequality.

Figure 2: Decomposition consumption inequality response under conventional monetary policy shock

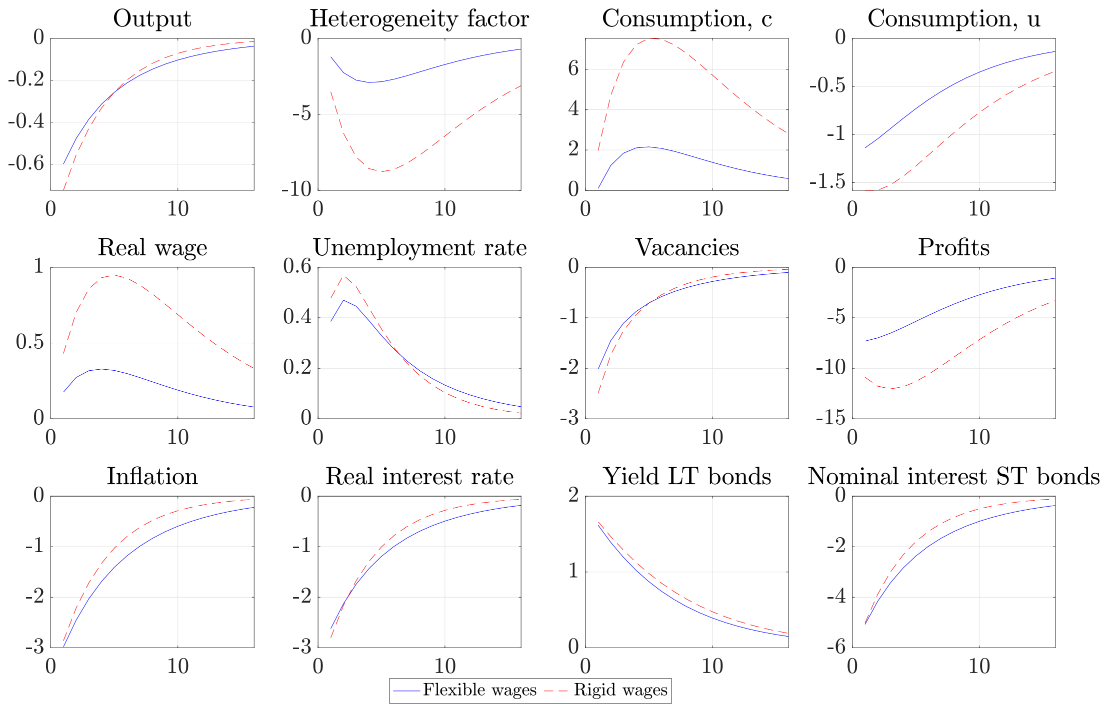


3.2 Quantitative tightening

In this section I present the IRFs of a quantitative tightening (QT) shock. I calibrate the QT shock such that the output response is similar to the output response under the 1% increase in nominal interest rates in the previous subsection. The results are in Figure 3.

Wage rigidity matters more in the transmission of a QT shock to variables like output and unemployment rate than in the transmission of a conventional monetary policy shock. Sticky nominal wages increase the contractionary effect of QT because the economy has to adjust through other variables.

Figure 3: IRFs to a QT shock

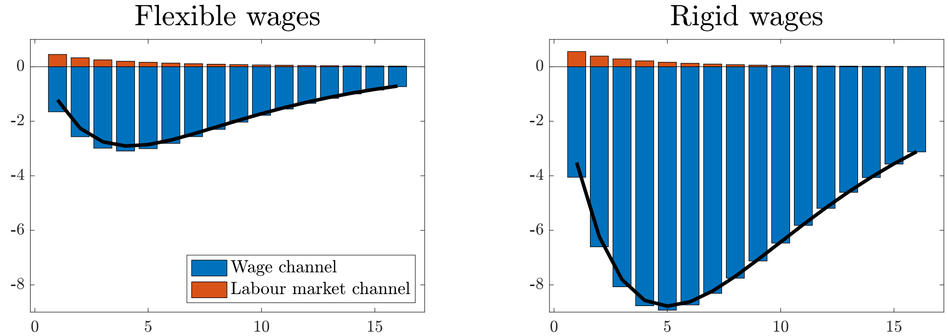


Moreover, for a similar contractionary effect on output, the QT shock has a much stronger effect on inflation and real interest rates than the conventional monetary policy shock. The QT shock does not have a direct effect on output, like a conventional shock has through the Taylor rule. Therefore, to create a similar output response, the QT shock is a larger shock to the rest of the economy.

Real wages respond in a consistent way given the inflation responses. Since the inflation decreases by around the same amount in both economies, the real wage in the rigid wage economy increases by more than in the flexible wage economy. The consumption of the constrained households reflect these fluctuations well: The increase of consumption by the constrained in the rigid wage country is larger than in the flexible wage country.

As with the conventional monetary policy shock, I quantify the relative importance of the wage and labour channel by decomposing the IRF for the heterogeneity factor, in Figure 4. We can see that the wage channel has a decreasing effect on inequality in both economies, which makes sense because both real wages increase after the QT shock. However, quantitatively this effect in the rigid wages country is much stronger than in the real wages country.

Figure 4: Decomposition consumption inequality response under QE shock



The labour market channel has an increasing effect on the heterogeneity factor in both economies. We can see that in Figure 3 the QT shock increases unemployment rate and decreases the number of vacancies. Because of the hand-to-mouth behaviour of the constrained households, those fluctuations affect their consumption negatively, and therefore increases inequality. The response of the unemployment rate and vacancies is stronger in the rigid wage country which shows as a slightly stronger labour market channel in the decomposition.

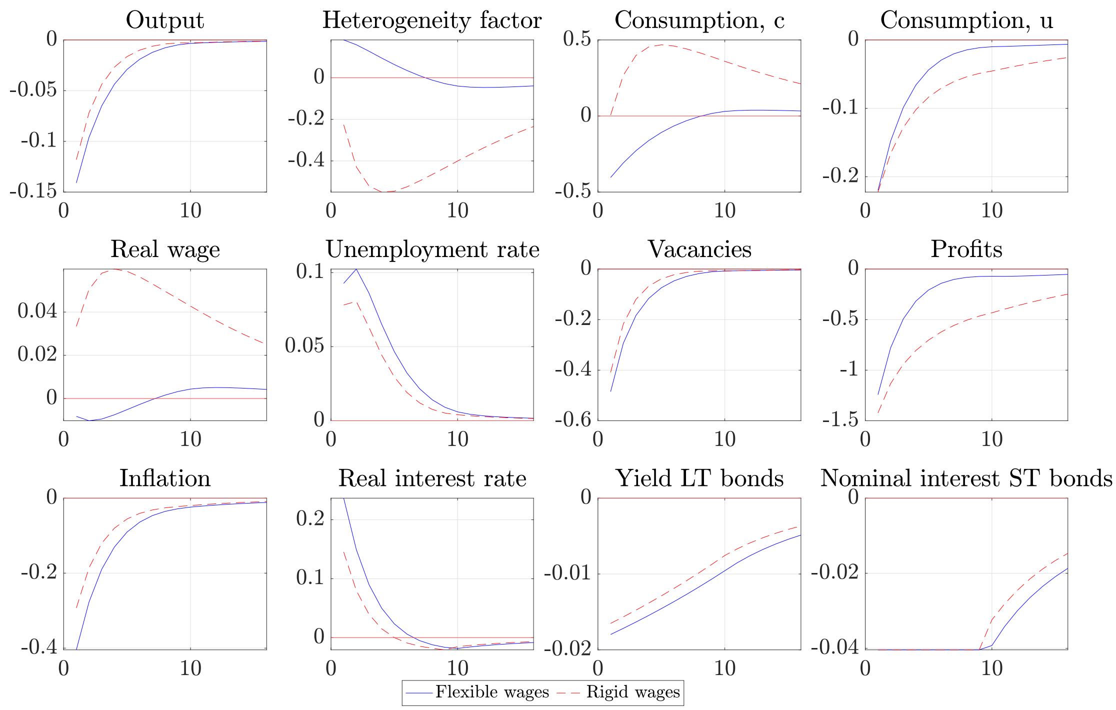
I can conclude that under a QT shock, the decrease in inflation is strong enough to even increase real wages in the flexible nominal wage country. Therefore, the wage channel decreases consumption inequality in both types of economies as opposed to the case of the conventional shock, when the wage channel has an increasing effect on consumption inequality under flexible wages. The labour market channel has an increasing effect on inequality, but is not strong enough to offset the wage channel. This result is similar to the conventional shock case.

3.3 The role of the ZLB and quantitative easing

In this section I investigate the role of the ZLB and the effect of quantitative easing on the economy under different degrees of wage rigidity. First, I analyse results of a demand shock that forces the economy to the zero lower bound (ZLB) for nine quarters. Then, I investigate the effect of a quantitative easing (QE) shock on the economy at the ZLB.

I simulate both types of economy with a demand shock such that the nominal interest rate of short-term bonds is at the ZLB for nine quarters. The results are in Figure 5. In practice, this shock to the natural real interest rate is -0.013 in the flexible wage economy and -0.02 in the rigid wage economy. The shock is bigger in the rigid wage economy because such wages dampen the effect of the shock to the economy.

Figure 5: IRFs to a demand shock

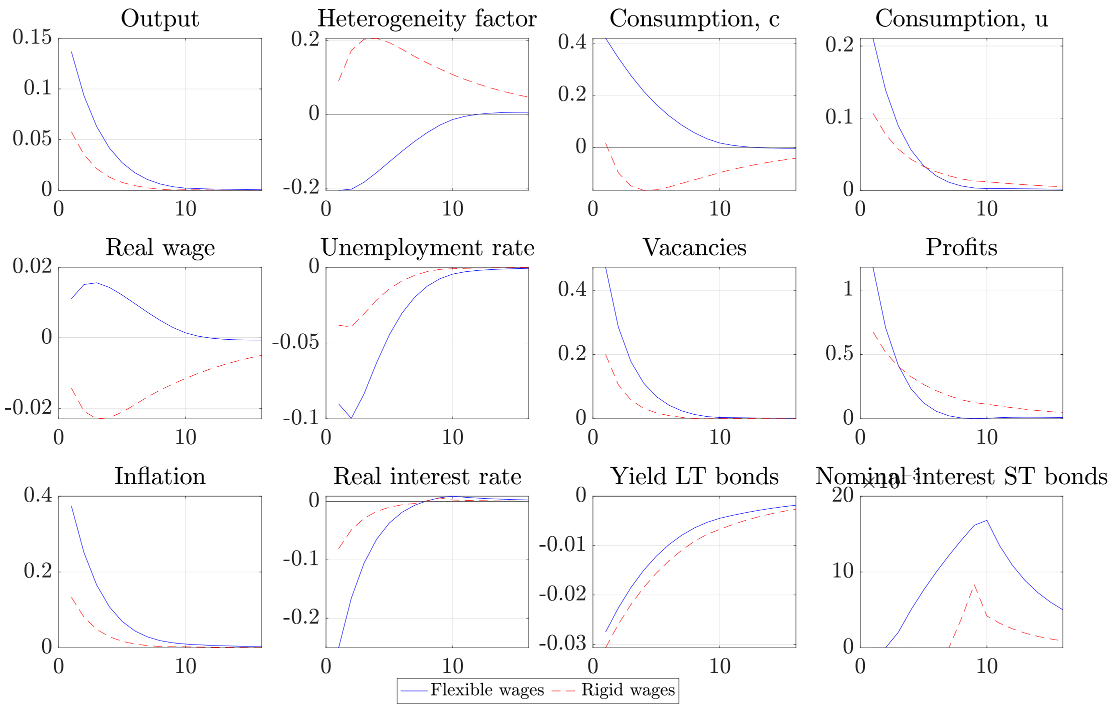


The IRFs of the demand shock are somewhat in-between the contractionary conventional monetary policy shock and the quantitative tightening shock in the previous two sections: Inflation decreases and therefore the real wage in the rigid wage economy increases, which increases the consumption of the constrained households and decreases inequality through the wage channel. The labour market channel increases the inequality in both economies through increased unemployment, but in the rigid economy this effect is not enough to counter the wage channel.

Now, I investigate the effects of an identical QE shock on these economies at the ZLB. I calibrate the QE shock such that both economies stay at the ZLB for at least two periods. I present the results in Figure 6. I show the IRFs as a subtraction of the IRFs of the demand and QE shock from the IRFs of the demand shock alone, to show the pure effect of QE.

First, we notice that wage rigidity matters more in the transmission of a QE shock to variables like output and inflation than in the transmission of a conventional monetary policy shock. Sticky wages reduce the expansionary effect of QE. We can also see this effect in the nominal short-term interest

Figure 6: IRFs to a QE shock



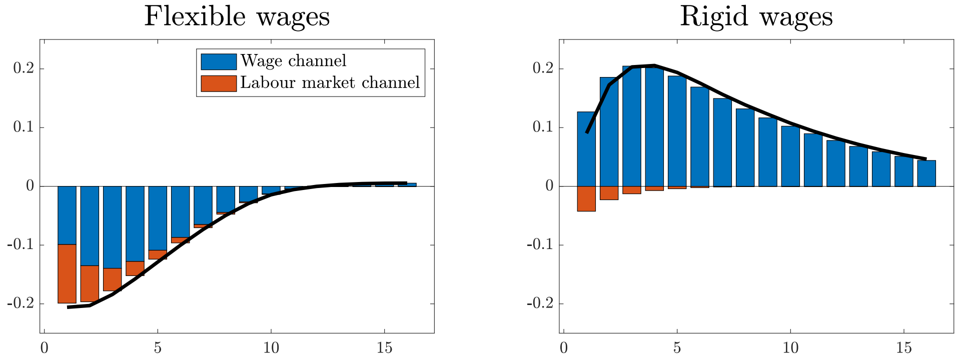
rates, where the ZLB binds longer in the sticky wage economy. Since nominal wages are sticky, the increase in inflation decreases real wages in the rigid wage country and increases inequality through the wage channel.

Second, the labour market channels enforces the wage channel in the flexible wage economy. The expansionary effect of QE reduces unemployment rate and decreases the heterogeneity factor even further. In the rigid wage economy, the expansionary effect in the labour market is not enough to counter the decrease in real wages. The IRF decomposition of the heterogeneity factor in Figure 7 confirms the above results. The labour market channel decreases inequality in both economies, but the wage channel determines the overall effect.

4 Conclusion

By analysing the Two-Agent New Keynesian (TANK) model with search-and-matching frictions I conclude that wage rigidities matter in the transmission of monetary policy to consumption inequality. In this paper, I find that wage stickiness plays an important role in the transmission of monetary policy

Figure 7: Decomposition consumption inequality response under QE shock



to consumption inequality, for three types of policy shocks:

- Conventional contractionary monetary policy shock: Inflation drops due to shock, which in a **rigid wage economy** leads to an increase in real wages, and therefore a **decrease in inequality**. In a **flexible wage economy**, real wages increase, and thus **inequality increases**.
- Quantitative tightening shock: Inflation drop is bigger than after the conventional contractionary shock. Therefore, real wages in **both types of economy** increases, so the **inequality decreases**.
- Quantitative easing shock: Inflation increases due to shock, which in a **rigid wage economy** decreases real wages, and therefore **increases inequality**. In a **flexible wage economy**, real wages increase, so the **inequality decreases**.

In the two contractionary monetary policy shock cases, conventional and unconventional, the stickier the wage, the bigger the decrease in inequality after the shock. Since inflation decreases after such a shock and nominal wages are sticky, the real wage increases which increases consumption of the constrained households disproportionately. Hence, consumption inequality decreases more when wages are stickier.

The wage channel drives the above results: Inflation reacts to a monetary policy shock and so do nominal wages. The rigidity of nominal wages determine the effect of the monetary policy on real wages. The effect on real wages, through the wage channel, determines the effect on consumption inequality.

The labour market channel increases inequality after a contractionary monetary policy shock, because there is more unemployment and less vacancies. For an expansionary monetary policy shock, the effect is the opposite. Quantitatively, the labour market channel can amplify the wage channel, but is not big enough to counter the effect of the wage channel when the two channels have opposing effects.

A limitation of this paper is that the model does not take into account the transmission channel of asset prices. Especially under unconventional monetary policy, debates about asset prices affecting inequality are prominent. In my model, since there is infinite wealth inequality by default through credit-constrained and unconstrained households, any channel considering assets is superfluous since the model setup is such that there is full inequality in asset holdings. A way to address this limitation is to include wealthy hand-to-mouth households, who hold some kind of (illiquid) assets.

Another way to undertake this limitation is to move towards a fully-fledged Heterogeneous Agent New Keynesian (HANK) model with heterogeneous asset holdings by agents, following canonical papers like Kaplan et al. (2018). A potential HANK model with search-and-matching frictions and wage rigidities could shed more light on how monetary policy affects inequality under different degrees of wage rigidity, by also emphasising the asset inequality.

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Appendices

A Log-linear model equations

The log-linearized equations as deviations from the zero-inflation steady state describe the equilibrium dynamics of the model. The hatted values are $\hat{z}_t = \log(Z_t) - \log(\bar{Z}) \approx \frac{Z_t - \bar{Z}}{\bar{Z}}$ and $\bar{Z}$ is the steady-state value of a variable. Thus, $\hat{z}_t$ is the percentage deviation of variable Z_t from its steady state.

A.1 Households

$$\text{Budget constraint: } \hat{c}_t = \hat{w}_t + \hat{n}_t \tag{A1}$$

$$\text{Aggregate consumption: } \hat{c}_t = \lambda \hat{c}_t^c + (1 = \lambda)\hat{c}_t^u \tag{A2}$$

where $\hat{w}_t$ is the real wage.

A.2 Labour market

$$\text{Time endowment: } 0 = \bar{n}\hat{n}_t + \bar{u}\hat{u}_t \tag{A3}$$

$$\text{Matching function: } \hat{m}_t = \zeta \hat{v}_t + (1 - \zeta)\hat{u}_t \tag{A4}$$

$$\text{Labour market tightness: } \hat{\theta}_t = \hat{v}_t - \hat{u}_t \tag{A5}$$

$$\text{Probability of filling a vacancy: } q(\hat{\theta}_t) = \hat{m}_t - \hat{v}_t \tag{A6}$$

$$\text{Probability of finding a job: } p(\hat{\theta}_t) = \hat{m}_t - \hat{u}_t \tag{A7}$$

$$\text{Transition dynamics in the labour market: } \hat{n}_t = (1 - \gamma)\, \hat{n}_{t-1} + \gamma \left(p(\hat{\theta}_t) + \hat{u}_{t-1} \right) \tag{A8}$$

[5]

A.3 Firms

$$\text{New Keynesian Philips Curve: } \hat{\pi}_t = \beta \mathbb{E}_t \hat{\pi}_{t+1} + \frac{\epsilon}{\xi \mathcal{M}} \hat{\mu}_t \quad \text{(A9)}$$

$$\text{Total factor productivity: } \hat{a}_t = \rho_a \hat{a}_{t-1} + \varepsilon_t^a \quad \text{(A10)}$$

$$\text{Real marginal cost: } \hat{\mu}_t = \left(\frac{\sigma}{s_c} + \varphi \right) \hat{y}_t - \sigma \kappa \frac{s_v}{s_c} \hat{v}_t - (1+\varphi) a_t \quad \text{(A11)}$$

$$\text{Real profits: } \hat{d}_t = \frac{1}{\mathcal{D}} \left[\bar{Y} \hat{y}_t - \frac{\bar{W}}{\bar{P}} \bar{N} \left(\hat{w}_t + \hat{n}_t \right) - \kappa \bar{v} \hat{v}_t \right] \quad \text{(A12)}$$

$$\text{Natural level of output: } \hat{y}_t^n = \frac{1+\varphi}{\frac{\sigma}{s_c} + \varphi} \hat{a}_t \quad \text{(A13)}$$

$$\text{Output gap: } \tilde{y}_t = \hat{y}_t - \hat{y}_t^n \quad \text{(A14)}$$

where $\mathcal{M} = \frac{\epsilon}{\epsilon - 1}$ is the price mark-up under flexible prices.

A.4 Staggered wage bargaining

$$\text{Worker's stake in wage: } (\hat{\Gamma}_t^{\mathcal{W}}) = \theta_w \beta \left(1 - \gamma^c\right) \mathbb{E}_t \left[-\bar{p}(\bar{\theta}) \hat{p}(\hat{\theta}_{t+1}) + \left(1 - \bar{p}(\bar{\theta})\right) \left(\hat{\Lambda}_{t+1} + (\hat{\Gamma}_{t+1}^{\mathcal{W}}) \right) \right] \quad \text{(A15)}$$

$$\text{Firm's stake in wage: } (\hat{\Gamma}_t^{\mathcal{J}}) = \theta_w \beta \left(1 - \gamma\right) \mathbb{E}_t \left[\hat{\Lambda}_{t+1} + (\hat{\Gamma}_{t+1}^{\mathcal{J}}) \right] \quad \text{(A16)}$$

$$\text{Effective bargaining power: } \hat{\Theta}_t = -(1 - \bar{\Theta}) \left[(\hat{\Gamma}_t^{\mathcal{J}}) - (\hat{\Gamma}_t^{\mathcal{W}}) \right] \quad \text{(A17)}$$

$$\text{Wage index: } \hat{w}_t = (1 - \theta_w) \hat{w_t^{opt}} + \theta_w \left(\hat{w}_{t-1} - \hat{\pi}_t \right) \quad \text{(A18)}$$

$$\begin{aligned} \text{Job creation condition: } -q(\hat{\theta}_t) = {} & \frac{1}{\Xi_0} \left[-\left(\bar{\mu} - T^b\right) \bar{\Theta} \hat{\Theta}_t + \left(1 - \bar{\Theta}\right) \bar{\mu} \left(\hat{\mu}_t + \hat{a}_t\right) \right] \\ & + \frac{1}{\Xi_0} \beta \left(1 - \gamma\right) \mathbb{E}_t \left[\left(\Xi_1 - \Xi_2\right) \hat{\Lambda}_{t+1} - \Xi_1 \hat{\psi}_{t+1} + \left(\Xi_1 (1 - \zeta) - \Xi_2\right) \hat{\theta}_{t+1} - \Xi_2 \left(\Theta_t + \pi_{t+1}\right) \right] \end{aligned} \quad \text{(A19)}$$

where $\Xi_0 = \left(1 - \bar{\Theta}\right) \left(\bar{\mu} - T^b\right) + \beta \left(1 - \gamma\right) \left(\frac{\kappa}{\bar{\psi}} \bar{\theta}^{1-\zeta} - \kappa \bar{\Theta} \bar{\theta} \right)$, $\Xi_1 = \frac{\kappa}{\bar{\psi}} \bar{\theta}^{1-\zeta}$, and $\Xi_2 = \kappa \bar{\theta} \bar{\Theta}$

A.5 Monetary policy

$$\text{Taylor rule: } \hat{i}_t = \phi_\pi \hat{\pi}_t + \phi_y \tilde{y}_t \nu_t \tag{A20}$$

$$\text{Monetary policy shock: } \nu_t = \rho_\nu \nu_{t-1} + \varepsilon_t^\nu \tag{A21}$$

$$\text{Quantitative easing/tightening: } \hat{q}_t = \rho_q \hat{q}_{t-1} + \varepsilon_t^q \tag{A22}$$

A.6 Market clearing

$$\text{Goods market clearing: } \hat{y}_t = s_c \hat{c}_t + s_v \kappa \hat{v}_t \tag{A23}$$

$$\text{Bonds arbitrage: } \mathbb{E}_t \hat{R}_{L,t+1} = \hat{R}_t - (1+\delta_b) \frac{\tilde{\nu}}{b_L^h} q_t \tag{A24}$$

$$\text{Yield to maturity of long-term bonds: } \hat{\mathcal{R}}_t = \chi_b \beta \mathbb{E}_t \hat{\mathcal{R}}_{t+1} + (1-\chi_b \beta)\left(\hat{R}_t - \tilde{\nu}(1+\delta) q_t\right) \tag{A25}$$

where $s_c = \frac{\bar{C}}{\bar{Y}}$ and $s_v = \frac{\bar{v}}{\bar{Y}}$

A.7 Heterogeneity

$$\text{Heterogeneity factor: } \hat{\omega}_t = \frac{1}{\omega_n \omega_d} \Big\{ \left[(1-\delta(1-\tau))\omega_d - (1-\delta\lambda(1-\tau))\omega_n\right] \bar{\Omega}_1 \hat{\Omega}_{1,t} - \left[(1-\delta(1-\tau))\kappa\omega_d - (1-\delta\lambda(1-\tau))\kappa\omega_n\right] \bar{\Omega}_2 \hat{\Omega}_{2,t} \Big\} \tag{A26}$$

$$\text{Consumption and heterogeneity: } \hat{c}_t = \hat{c}_t^u - \frac{\lambda}{1-\lambda\omega} \hat{\omega}_t \tag{A27}$$

where

$$\hat{\Omega}_{1,t} = \hat{a}_t - \hat{w}_t \tag{A28}$$

$$\hat{\Omega}_{2,t} = \hat{v}_t - \hat{w}_t - \hat{n}_t \tag{A29}$$

and $\omega_n = (1-\delta(1-\tau))\left(\bar{\Omega}_1 - 1 - \kappa\bar{\Omega}_2\right)$ and $\omega_d = (1-\lambda) + (1-\delta\lambda(1-\tau))\left(\bar{\Omega}_1 - 1 - \kappa\bar{\Omega}_2\right)$.

A.8 Dynamic IS equation and natural real interest rate

$$\text{Dynamic IS equation: } \tilde{y}_t = \mathbb{E}_t\tilde{y}_{t+1} - \frac{s_c}{\sigma}\left[\frac{1}{1+\delta_b}\hat{R}_t + \frac{\delta_b}{1+\delta_b}\mathbb{E}_t\hat{R}_{L,t+1} - \mathbb{E}_t\hat{\pi}_{t+1} - \hat{r}^n_t\right] - \kappa s_v\mathbb{E}_t[\Delta\hat{v}_{t+1}] - \frac{\lambda}{1-\lambda\omega}s_c\mathbb{E}_t[\Delta\hat{\omega}_{t+1}] \tag{A30}$$

$$\text{Natural real interest rate: } \hat{r}^n_t = -\frac{\sigma}{s_c}(1-\rho_a)\frac{1+\varphi}{\frac{\sigma}{s_c}+\varphi}\hat{a}_t \tag{A31}$$

B Robustness checks

Figure 8: Robustness checks for the fraction of constrained households λ: Conventional MP shock

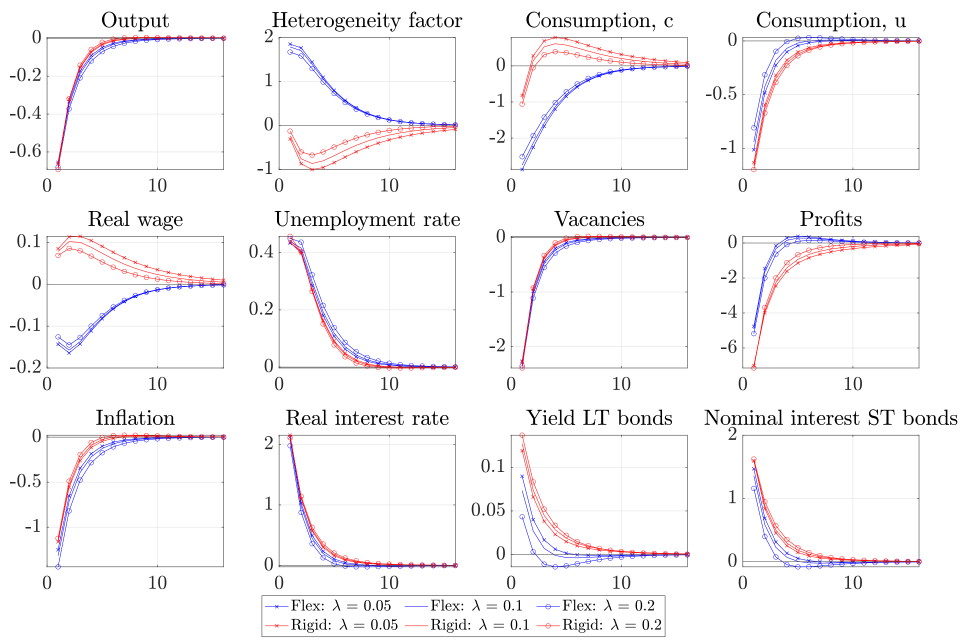

Figure 9: Robustness checks for the fraction of constrained households λ: QT shock

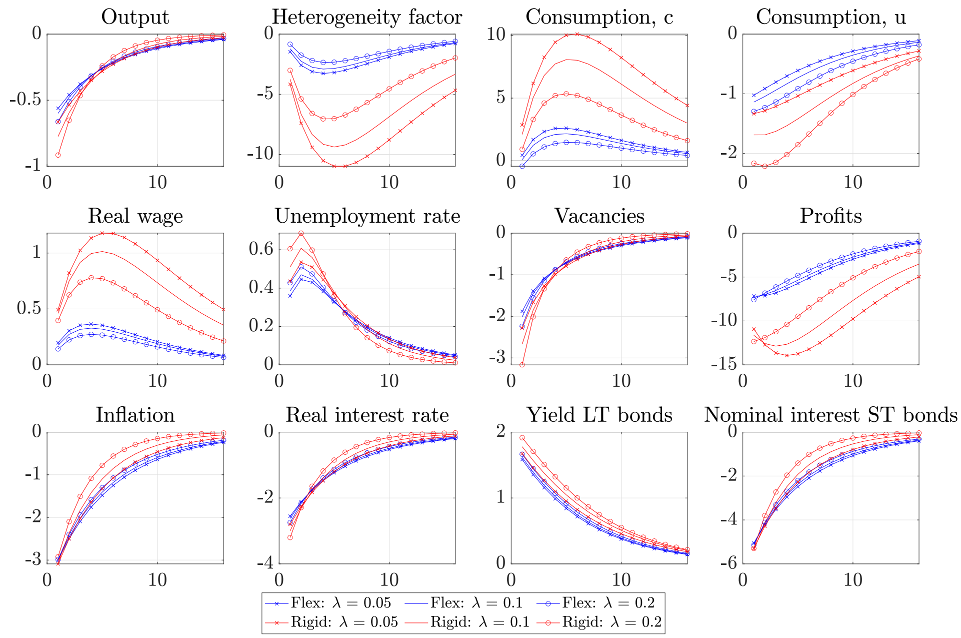

Figure 10: Robustness checks for the bargaining power of households ζ: Conventional MP shock

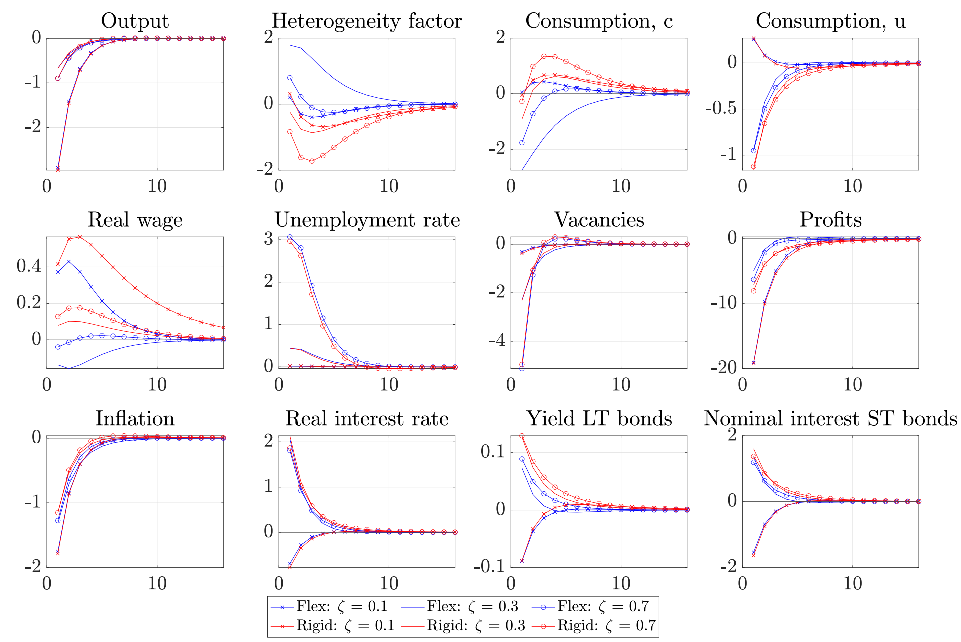

Figure 11: Robustness checks for the bargaining power of households ζ: QT shock

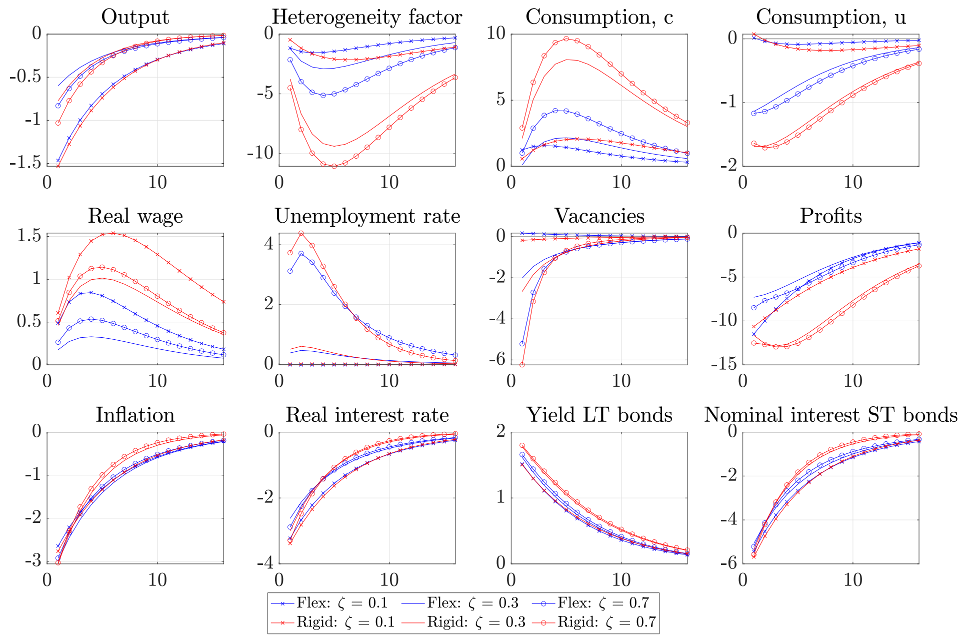

Figure 12: Robustness checks for the steady-state matching efficiency $\bar{\psi}$: Conventional MP shock

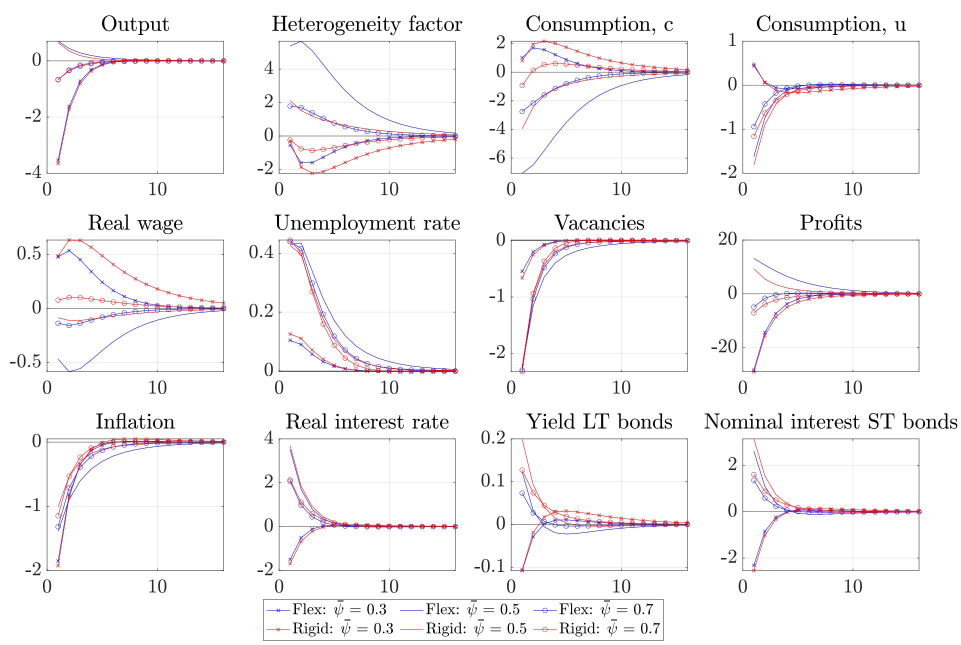

Figure 13: Robustness checks for the steady-state matching efficiency $\bar{\psi}$: QT shock

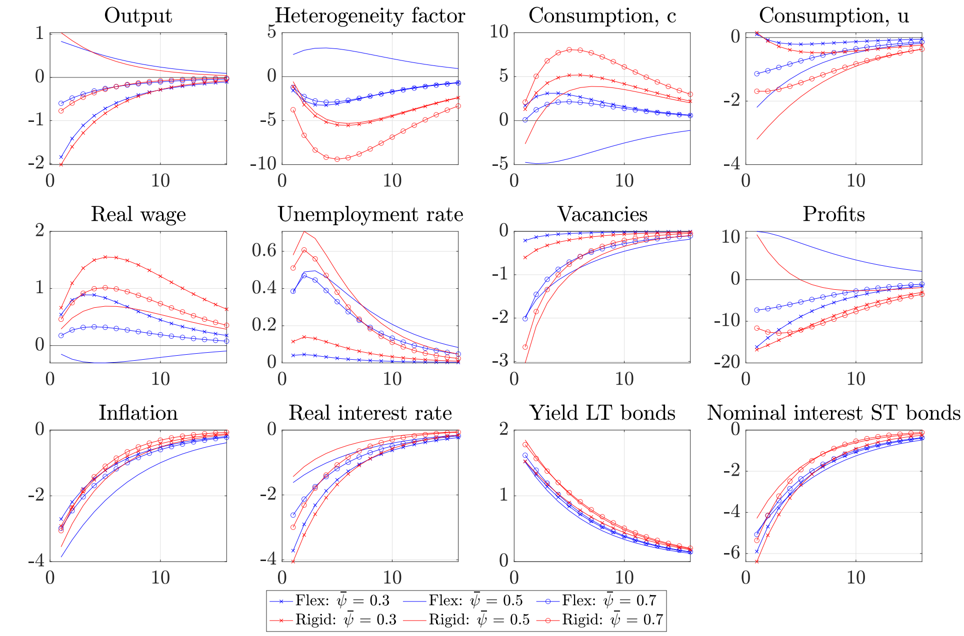

Figure 14: Robustness checks for the separation rate γ: Conventional MP shock

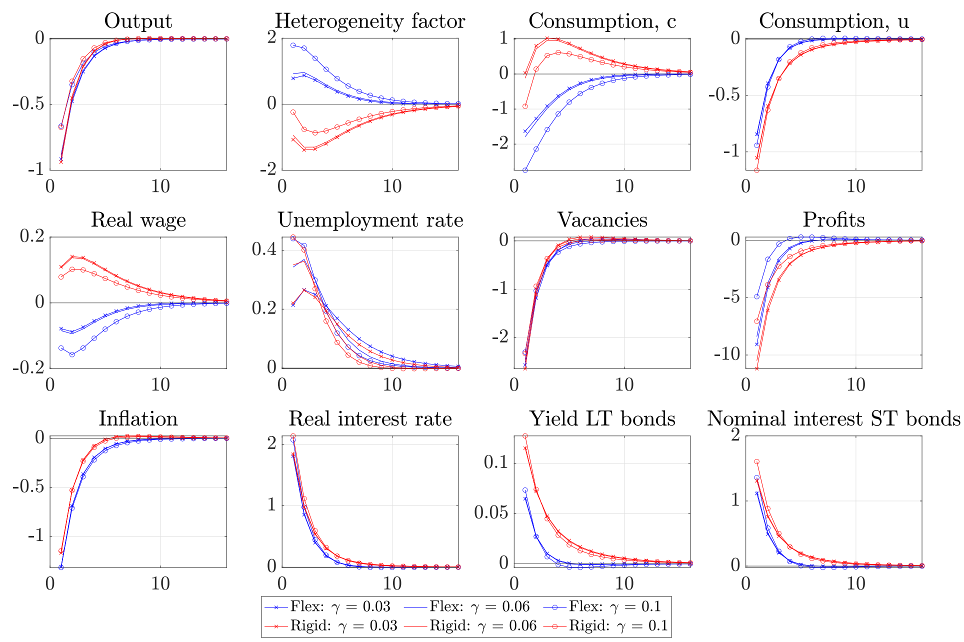

Figure 15: Robustness checks for the separation rate γ: QT shock