Inequality, Nominal Rigidities, and Aggregate Demand

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Abstract

This paper studies the gains from wage flexibility in a New Keynesian model with price and wage rigidities and incomplete asset markets. When a fraction of households consume solely out of their labor income and have no access to financial markets, the real wage, and therefore, the relative nominal rigidities between wages and prices, directly determine the economy's aggregate demand. We show that when wages are flexible relative to prices, economic downturns are accompanied by a pronounced decline in real wages, which depresses aggregate demand, and exacerbates the economy's volatility. In this context, we conclude that enhancing wage flexibility when prices are highly rigid is an undesirable policy prescription.

Keywords: Nominal Rigidities, Two-Agent models, Business Cycles, Monetary Policy, Consumption.

JEL codes: E21, E32, E52

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1 Introduction

Letting wages adjust freely after an economic downturn is one of the main elements of the classical economists' toolkit. According to this argument, if wages fall, labor demand increases, and output returns to its potential level. However, as Galí (2013) shows, this is not necessarily true in the presence of price and wage rigidities. This paper revisits the benefits of wage flexibility in a heterogeneous agent New Keynesian model with price and wage rigidities and incomplete asset markets. We show that the relative rigidity of wages in relation to prices determines how resources redistribute across households, thereby affecting aggregate demand (AD) and activity when markets are incomplete.

Our work is motivated by the Keynesian observation that wages affect the AD, which matters in determining output (Keynes, 1936). The AD depends on wages if they affect (i) the return on assets or (ii) the distribution of resources across agents with distinct marginal propensities to consume (MPCs). The first channel operates if wages affect the interest rate, mainly through the endogenous response of monetary policy, switching the incentives to consume and invest (Galí, 2013). The second channel operates if wage adjustments redistribute resources between agents with different MPCs, affecting their consumption levels and aggregate demand (see Kaplan et al. (2018) and Auclert (2019), among others).

This paper builds on the second channel. We build a textbook New Keynesian model with limited asset markets participation and price and wage rigidities as in Colciago (2011) and Furlanetto and Seneca (2012). To capture market incompleteness, we assume there is a fraction of agents without access to financial markets as in Galí et al. (2007), Bilbiie (2008), and Debortoli and Galí (2017), implying different MPCs across households. We call this group constrained agents, hand-to-mouth, or workers.[1] We start by observing that when some agents cannot save or borrow, and income from labor and profits is unequally allocated across households, the AD depends on the interest rate (as in the standard New Keynesian model) *and* the distribution of income between the labor and the profit shares. Therefore, the evolution of the real wage matters in determining consumption dynamics.

[1] For this formulation, we rely on the vast empirical literature documenting the importance of price rigidities (see, among others, Bils and Klenow (2004), Dhyne et al. (2006), Nakamura and Steinsson (2013), Pasten et al. (2020)), wage rigidities (see, among others, Le Bihan et al. (2012) and Taylor (2016)), and the presence of hand-to-mouth agents (see Kaplan et al. (2014) and Aguiar et al. (2021)).

Based on these observations, our main result states that the desirability of wage flexibility depends on the degree of price rigidities, because the *relative* nominal rigidities between wages and prices determine real wages, and hence, the distribution of resources between workers and firm owners, and the AD. We call this the *distributional channel*. We analytically characterize the equilibrium of a simplified economy where prices and wages are set in advance. The AD explicitly depends on the real wage because hand-to-mouth agents consume solely out of their *real* labor income. Therefore, what matters for them is the flexibility of wages relative to prices; hence, the relative nominal rigidities. In a downturn, resources are redistributed from workers to firm owners if wages experience a sharp decrease relative to prices. Hence, the consumption response amplifies if workers have more restricted access to financial markets and a higher MPC. Therefore, limited access to financial markets activates the Keynesian channels, and relative nominal rigidities govern the final effect.

We also study the importance of monetary policy's conduct in determining the outcome of the economy, which is the *interest rate channel*. Through this channel, wage flexibility stabilizes activity. The reason is that more flexibility in wages leads to increased responsiveness of prices to shocks. Due to the endogenous response of monetary policy to inflation, output volatility is dampened. However, if prices are relatively rigid, the distributional channel gains prominence, and wage flexibility becomes destabilizing. Therefore, we show that monetary policy should react to wage inflation to dampen the distributional channel and restore the ability of wage flexibility to stabilize demand. In our model, monetary policy is more effective when it reacts to price *and* wage inflation rather than only to price inflation. We complement our analysis by characterizing the degree of reaction to wage inflation by the central bank required to stabilize output. As we show, this value depends on the degree of market incompleteness and relative nominal rigidities.

Finally, we analyze the gains from wage flexibility using a dynamic version of the model and show that the results presented in the simplified model hold. In this setup, there are no gains from wage flexibility when prices are highly sticky since it exacerbates the distributional channel. Additionally, we show that the destabilizing effects of wage flexibility are especially acute if monetary policy cannot endogenously react (i.e., at the zero lower bound); the excessive volatility of prices, wages and output increases the losses from wage flexibility.

This paper contributes to the literature by studying the benefits of wage flexibility when there are incomplete markets, and price and wage rigidities. Previous literature has not emphasized the interaction of these three frictions but somewhat detracted from the role of price rigidities in shaping redistribution. Most of this literature studies the interaction between wage rigidities and limited asset markets participation, taking as given the degree of price rigidities. We highlight that the relative degree of wage and price rigidities matter in determining output through aggregate demand. This paper is close to Broer et al. (2020), which shows that wage rigidities affect aggregate output. Relative to that paper, we contribute by showing how the gains from wage flexibility depend on price rigidities and the monetary policy stance. Moreover, we uncover the distributional channel of nominal rigidities arising in models with incomplete markets.

We also expand the findings by Ascari et al. (2017), who study monetary policy in the presence of limited asset markets participation and wage rigidities. Our analysis extends their results by showing that the real wage directly affects the AD, so the relative nominal rigidities matter for business cycles (and not each rigidity separately). This result implies that relative fluctuations in wages and prices shape consumption dynamics, affecting the desirability of wage flexibility.

The remainder of the paper is organized as follows. In Section 2, we solve the model analytically for a case in which prices and wages are set in advance. In Section 3, we conduct quantitative exercises in a fully dynamic model. Finally, Section 4 concludes.

2 Aggregate Demand Effects of Nominal Rigidities

We study the aggregate demand effects of nominal rigidities in a New Keynesian model with limited asset market participation and wage and price rigidities, building on the work by Ascari et al. (2017), Bilbiie (2008), Furlanetto and Seneca (2012) and Debortoli and Galí (2017), among others. In particular, we assume there is a fraction of agents that cannot borrow or lend and do not own firms. Workers supply labor in a monopolistically competitive environment and are subject to a staggered wage setting. Firms are also subject to price rigidities and supply their goods in a monopolistically competitive environment. Additionally, monetary policy follows a Taylor rule.

This section illustrates how price and wage rigidities shape redistribution over the business cycle and how they interact with incomplete markets to determine aggregate demand. To clarify the mechanisms present in our model, we assume the following processes for wage and price setting.

Workers supply labor in a monopolistically competitive environment, and staggered wage setting is incorporated by assuming that a fraction of workers set nominal wages in advance (i.e., before the realization of shocks). The remaining workers are not constrained to set wages. We use the same simplification for firms' pricing problem. The rest of the model is standard and follows Galí (2015). Online appendix A presents the details of the model and all intermediate derivations.

In this section, we aim to solve the model and obtain an IS equation with limited access to financial markets and price and wage rigidities. The resulting expression will help explain how market incompleteness interacts with price and wage rigidities to shape aggregate demand.

2.1 The Consumption Gap

Our setup features two types of agents, as in Debortoli and Galí (2017) and Bilbiie (2008). A fixed fraction λ, which we call *constrained*, has no access to financial markets and only perceive labor income. Their consumption is given by

$$C_t^c = \frac{W_t}{P_t} N_t, \tag{1}$$

where $\frac{W_t}{P_t} N_t$ is real labor income (with W_t denoting nominal wages, P_t the aggregate price level, and N_t hours worked). The remaining fraction $1-\lambda$, which we call *unconstrained*, has access to financial markets, and perceive labor and profit income. They behave following their Euler equation

$$1 = R_t \mathbb{E}_t \left\{ \beta \frac{\chi_{t+1}}{\chi_t} \left(\frac{C_t^u}{C_{t+1}^u} \right)^{\sigma} \frac{1}{\Pi_{p,t+1}} \right\}, \tag{2}$$

where R_t is the gross nominal interest rate, $\Pi_{p,t}$ the gross rate of inflation and χ_t is a preference shock. Combining equations (1) and (2), and defining aggregate consumption as $C_t = (1-\lambda)C_t^u + \lambda C_t^c$, we obtain the following Euler equation for aggregate consumption (in log deviations from the steady state)[2]

$$\widehat{c}_t = \mathbb{E}_t \left\{ \widehat{c}_{t+1} \right\} - \frac{1}{\sigma} \left(\widehat{r}_t - \mathbb{E}_t \left\{ \widehat{\pi}_{t+1}^p \right\} - \widehat{\chi}_t \right) + \frac{\lambda}{(1-\lambda)\gamma + \lambda} \mathbb{E}_t \left\{ \Delta \widehat{\gamma}_{t+1} \right\}, \tag{3}$$

[2] In what follows hat variables ($\hat{x}$) correspond to log-deviations with respect to steady-state.

where $\gamma_t \equiv \frac{C_t^u}{C_t^c}$ is the *consumption gap* between unconstrained and constrained households.[3] Notice that Equation (3) is the usual Euler equation with an additional term that depends on the growth rate of consumption inequality. This equation can be solved forward to obtain

$$\widehat{c}_t = -\frac{\lambda}{(1-\lambda)\gamma+\lambda}\widehat{\gamma}_t - \frac{1}{\sigma}\mathbb{E}_t\sum_{k=0}^{\infty}(\widehat{r}_{t+k} - \widehat{\pi}^p_{t+k+1} - \widehat{\chi}_{t+k}). \tag{4}$$

Equation (4) shows that aggregate consumption is directly affected by inequality, measured by the consumption gap. To derive the consumption gap, recall that unconstrained agents work and own the firms; hence their income is given by the sum of labor and profit earnings (denoted by D_t), implying $C_t^u = \frac{W_t}{P_t}N_t + \frac{1}{1-\lambda}\frac{D_t}{P_t}$. Constrained households, meanwhile, only receive labor income; hence, their consumption equals their real labor income, $C_t^c = \frac{W_t}{P_t}N_t$.[4] Then, the consumption gap can be expressed as

$$\gamma_t = \frac{W_tN_t + \frac{1}{1-\lambda}D_t}{W_tN_t}.$$

As Debortoli and Galí (2017) show, the consumption gap depends on the economy's price markup

$$\gamma_t = \frac{1-\alpha+\frac{1}{1-\lambda}\left(\mathcal{M}_t^p - (1-\alpha)\right)}{1-\alpha}, \tag{5}$$

where $\mathcal{M}_t^p$ is the average price markup and $1-\alpha$ is the degree of decreasing returns (where $\alpha = 0$ corresponds to constant returns to labor).[5] Equation (5) in log-deviations from the steady state reads

$$\widehat{\gamma}_t = \Psi\widehat{\mu}_t^p, \tag{6}$$

where $\Psi \equiv \frac{\mathcal{M}^p}{(1-\lambda)\left(1-\alpha+\frac{1}{1-\lambda}(\mathcal{M}^p-(1-\alpha))\right)}$ and $\widehat{\mu}_t^p \equiv \log(\mathcal{M}_t^p - \mathcal{M}^p)$. Equation (6) represents a relation which is at the core of the following results: only the price markup determines the consumption

[3] $\widehat{\gamma}_t = \widehat{c}_t^u - \widehat{c}_t^c$ represents the consumption gap in deviation from steady state.

[4] Recent literature argues that profit allocation scheme crucially determines the properties of an economy with heterogeneity; in particular, the cyclicality of income inequality (Bilbiie, 2020, 2021). We can consider alternative models in which constrained agents receive a fraction of profits in addition to the labor income. Such agents would be called "wealthy hand-to-mouth" (Kaplan et al., 2014). We can show that, as long as constrained agents do not receive a fraction of profits larger than their mass in the population (λ), all the qualitative properties of our model hold.

[5] To obtain this expression, we use $\frac{W_tN_t}{P_tY_t} = (1-\alpha)\frac{Y_t}{\mathcal{M}_t^pN_t}\frac{N_t}{Y_t} = \frac{1-\alpha}{\mathcal{M}_t^p}$ and $\frac{D_t}{P_tY_t} = \frac{P_tY_t - W_tN_t}{P_tY_t} = 1 - \frac{1-\alpha}{\mathcal{M}_t^p}$.

gap, as the only source of inequality in the model is the ownership of firms. The coefficient Ψ, which determines the relationship between the consumption gap and markups, depends negatively on the share of unconstrained agents (i.e., the fraction of firm owners) because having a lower share of firms' owners implies that any increase in the price markup (and hence in firms' profits) is distributed among a smaller share of agents. Therefore, firm owners experience a greater increase in their income, leading to a larger rise in the consumption gap. The next step is understanding how the price markup evolves over the business cycle.

Firms Average Markup. Using firms production function, $Y_t = N_t^{1-\alpha}$, the average markup is given by

$$\mathcal{M}_t^p = (1-\alpha)\frac{P_t Y_t}{W_t N_t},$$

which log-linearized around the steady state yields

$$\widehat{\mu}_t^p = -\frac{\alpha}{1-\alpha}\widehat{y}_t - \widehat{\omega}_t. \tag{7}$$

From (6) and (7) we get

$$\widehat{\gamma}_t = -\Psi\left(\frac{\alpha}{1-\alpha}\widehat{y}_t + \widehat{\omega}_t\right). \tag{8}$$

Equation (8) describes the evolution of the consumption gap and its drivers. We highlight two results from this expression. First, the consumption gap negatively depends on output because decreasing labor returns implies a reduction in the firms' average markup following an increase in production (and hence employment). Second, the gap depends negatively on real wages, $\widehat{\omega}_t$. As wages raise marginal costs, firms' markups go down. As a result, income redistributes toward workers, and the consumption gap drops.

2.2 Equilibrium Wages

In this subsection, we derive the real wage in equilibrium. To do so, we first obtain wage and price inflation schedules. We derive two Phillips-like equations for prices and wages and show how the real wage depends on relative nominal rigidities between prices and wages. The derivation of the price and wage inflation equations is summarized in Proposition 1.

Proposition 1 (Price and wage dynamics)**.** *Assume there is a continuum of measure one of firms (unions) in a monopolistically competitive environment, in which a share θ_p (θ_w) of firms (unions) set prices (wages) in advance, while the remainder $1-\theta_p$ ($1-\theta_w$) set prices (wages) considering the realization of the shocks in t. Assume also that firms maximize profits by taking into account their production function ($Y_t = N_t^{1-\alpha}$), and unions maximize the aggregate welfare of the members of the union of each task.*

Under these assumptions, the evolution of price inflation is given by

$$\widehat{\pi}_t^p = \kappa_\pi \left(\widehat{\omega}_t + \frac{\alpha}{1-\alpha} \widehat{y}_t \right) + \mathbb{E}_{t-1} \widehat{x}_t^p, \tag{9}$$

where $\kappa_\pi \equiv \frac{1-\theta_p}{\theta_p} \frac{1-\alpha}{1-\alpha+\alpha\epsilon_p}$ *and* $\widehat{x}_t^p \equiv \widehat{\omega}_t + \alpha \widehat{n}_t + \widehat{\pi}_t^p$.

The evolution of real wages is given by

$$\widehat{\omega}_t = \kappa_\omega (\varpi \widehat{y}_t + \overline{\varphi} \widehat{n}_t) - \varsigma \widehat{\pi}_t^p + \mathbb{E}_{t-1} \widehat{x}_t^w, \tag{10}$$

where $\kappa_\omega \equiv \frac{1-\theta_w}{1+\theta_w \overline{\varphi} \epsilon_w}$, $\varsigma \equiv \frac{\theta_w (1+\overline{\varphi}\epsilon_w)}{1+\theta_w \overline{\varphi} \epsilon_w}$ *and* $\widehat{x}_t^w \equiv \varsigma \left(\varpi \widehat{y}_t + \overline{\varphi} \widehat{n}_t + \widehat{\pi}_t^p \right)$. *Here,* $\varpi = \frac{\varpi_1}{1-\varpi_2}$ *and* $\overline{\varphi} = \frac{\varphi}{1-\varpi_2}$, *are the inequality-adjusted labor supply elasticities with respect to output and labor, respectively, with* $\varpi_1 = \sigma + \overline{u}\Psi \frac{\alpha}{1-\alpha}$, $\varpi_2 = \overline{u}\Psi$, $\overline{u} \equiv -\sigma \frac{\lambda(1-\lambda)\gamma^{-\sigma} - \lambda(1-\lambda)\gamma}{[(1-\lambda)\gamma+\lambda][\lambda+(1-\lambda)\gamma^{-\sigma}]}$ *and* $\Psi \equiv \frac{\mathcal{M}^p}{(1-\lambda)\left(1-\alpha+\frac{1}{1-\lambda}(\mathcal{M}^p-(1-\alpha))\right)}$. *Finally,* ϵ_w *and* ϵ_p *are the elasticities of demand for labor and goods' varieties, respectively.*

Proof. See Online Appendix B.2. □

Proposition 1 describes the evolution of inflation and the real wage. Equation (9) shows that price inflation depends on wages and output in our setting. On the other hand, Equation (10) describes the relationship between the real wage and output, labor, and price inflation. Both equations are a Phillips-like relationship for prices and wages as we obtain a positive relationship between the output gap and price inflation on the one hand and the marginal rate of substitution and wages on the other. These relationships depend on the price and wage stickiness parameters, θ_p and θ_w. If wages or prices are fully flexible, these relationships break. If wages are fully flexible, the labor supply always determines the real wage.[6,7] Notice that the real wage negatively depends on the price inflation rate, with this relation given by the parameter ς, which is a function of the degree of wage rigidities. Therefore, the real wage depends on the price inflation rate because of wage rigidities.

Our price and wage arrangements assume prices and wages are set in advance. This assumption implies that firms and unions set prices and wages taking an expectation of the future demand for goods and labor before the shocks realize (in $t-1$). That is why the terms $\mathbb{E}_{t-1}\hat{x}_t^p$ and $\mathbb{E}_{t-1}\hat{x}_t^w$ appear in the price and wage setting schedules. When prices and (or) wages are fully sticky, those expectations set the evolution of prices and wages because that is the best the restricted agents can do. Throughout this section, we assume shocks are iid with zero mean, so these expectation terms are zero.

As the real wage depends on price inflation, by combining Equations (9) and (10), we obtain the *real wage schedule*, which is presented in the following proposition.

Proposition 2 (The real wage schedule)**.** *From the evolution of the real wage and price inflation, the real wage is given by*

$$\widehat{\omega}_t = \Xi\widehat{y}_t + \mathbb{E}_{t-1}\widehat{x}_t, \tag{11}$$

where $\Xi \equiv \frac{\kappa_\omega\left(\varpi+\frac{\overline{\varphi}}{1-\alpha}\right)-\varsigma\kappa_\pi\frac{\alpha}{1-\alpha}}{1+\varsigma\kappa_\pi}$ *and* $\widehat{x}_t \equiv \frac{\widehat{x}_t^w-\varsigma\widehat{x}_t^p}{1+\varsigma\kappa_\pi}$.

Proof. This result follows directly from Proposition 1. □

Equation (11) describes the real wage in this economy, which is a function of the output gap. The parameter Ξ governs the cyclicality of the real wage, which depends on the relative wage and price rigidities. We further characterize this cyclicality in the following proposition.

Proposition 3 (The cyclicality of the real wage)**.** *For any parametrization,* $\varpi + \frac{\overline{\varphi}}{1-\alpha} \geqslant \Xi \geqslant -\frac{\alpha}{1-\alpha}$ *holds. Additionally,* $\frac{\partial\Xi}{\partial\theta_p} > 0$ *and* $\frac{\partial\Xi}{\partial\theta_w} < 0$.

Proof. See Online Appendix B.3. □

[6] With flexible wages $\hat{\omega}_t = \overline{\varpi}\hat{y}_t + \overline{\varphi}\hat{n}_t$.

[7] These two Phillips-like equations are very close to the ones derived in the basic New Keynesian model with Calvo rigidities. The difference is the backward-looking nature of these, while in the New Keynesian, they are forward-looking. We assume these simplifications to derive an analytical solution to our problem.

Proposition 3 states that the relative degrees of wage and price rigidities determine the cyclicality of the real wage. When wages are relatively more flexible than prices, the real wage is procyclical ($\Xi > 1$), implying that a reduction in the real wage accompanies recessions. On the contrary, when wages are rigid compared to prices, the real wage is countercyclical ($\Xi < 0$), meaning that an increase in the real wage accompanies recessions. The proposition also indicates that with a linear production technology ($\alpha = 0$), the real wage is never countercyclical ($\Xi \geqslant 0$). To further illustrate the relation between relative rigidities and the cyclicality of real wages, Figure 1 plots coefficient Ξ as a function of the degree of wage stickiness, for different degrees of price stickiness. Real wages are countercyclical when prices are fully flexible, and such cyclicality does not depend on the degree of wage rigidities. However, when prices show some degree of rigidity ($\theta_p > 0$), only high degrees of wage rigidities (i.e., high values of θ_w) make real wages countercyclical. In the limiting case of perfectly rigid prices, wages are always procyclical.

[Figure 1 about here]

2.3 Aggregate Demand

As in any New Keynesian model, the IS equation corresponds to the aggregate Euler equation combined with goods market clearing. For our model, as Equation (3) shows, the aggregate Euler equation depends on the consumption gap. Hence, before solving for the IS equation, Proposition 4 presents the equilibrium consumption gap.

Proposition 4 (The Consumption Gap)**.** *The equilibrium consumption gap is given by*

$$\widehat{\gamma}_t = -\Theta \widehat{y}_t - \Psi \mathbb{E}_{t-1} \widehat{x}_t, \tag{12}$$

where

$$\Theta \equiv \Psi \left(\underbrace{\frac{\alpha}{1-\alpha}}_{\text{Employment}} + \underbrace{\Xi}_{\text{Real Wage}} \right).$$

Proof. This result follows directly from replacing Equation (11) in the expression for the consumption gap in Equation (8). □

Equation (12) shows that consumption inequality depends on output, where the coefficient Θ represents the cyclicality of the consumption gap. The cyclicality depends on two channels, labeled as *Employment* and *Real Wage*. The former derives from the switch in the labor quantity required by firms in the presence of decreasing returns on labor. The latter enters due to the dependence of the consumption gap (through markups) on the real wage. More importantly, with wage rigidities, the real wage depends on both price and wage inflation. Hence, the cyclicality of the consumption gap depends on the dynamics of nominal wages and prices, represented by the parameters κ_ω and κ_π.

Price and wage rigidities have different effects on the cyclicality of the consumption gap. While κ_ω and κ_π fall when wages or prices are more rigid, their impact on inequality differs. When prices are more rigid (given a degree of wage stickiness), consumption inequality becomes more countercyclical, whereas when wages are more sticky, inequality becomes less countercyclical. The intuition is that these rigidities generate a distribution of resources between workers and firms' owners. When there is a recession, and wages do not fall by much, firms' owners bear the shock, implying that the consumption gap does not react as much as in the scenario with flexible wages.

We now present an IS equation with wage and price rigidities and limited access to financial markets, our main result. Given (3) and (12), we derive the IS equation, as presented by Proposition 5.

Proposition 5 (The IS equation)**.** *Under iid shocks, the IS equation of this economy with financial frictions and price and wage rigidities is given by*

$$\widehat{y}_t = -\frac{1}{\sigma}\Lambda\left(\widehat{r}_t - \widehat{\chi}_t\right), \tag{13}$$

where $\Lambda \equiv \frac{1}{1-\frac{\lambda}{(1-\lambda)\gamma+\lambda}\Theta}$.

Proof. See Online Appendix B.4 □

Equation (13) presents the IS equation after deriving the consumption gap, replacing it in the original Euler (Equation 3), and imposing goods market clearing. The main difference between this IS equation and the one derived from a representative agent without wage rigidities is that other model features significantly affect the slope (the relationship between output and the interest rate).

In particular, the slope depends on how resources are distributed in the cycle, which depends on relative nominal rigidities, as we explain below.

Before moving on, it is worth mentioning that this latter result is related to Ascari et al. (2017), who also show that the degree of wage rigidity directly enters the IS equation in the presence of hand-to-mouth agents and wage rigidities. Their result emphasizes that fluctuations in nominal wages affect aggregate demand. However, as Equation (13) shows (through the parameter Θ), aggregate demand also depends on the degree of price rigidities. This latter result is not present in the analysis of Ascari et al. (2017) and, as shown throughout this paper, is crucial to understanding aggregate fluctuations in a model with price and wage rigidities and incomplete markets.[8]

Equilibrium in the Simplified Economy. If the economy is subject to *iid* shocks, the equilibrium in this economy is summarized by the following equations

$$\widehat{y}_t = -\frac{1}{\sigma}\Lambda\left(\widehat{r}_t - \chi_t\right), \tag{14}$$

$$\widehat{\pi}_t^p = \Upsilon \widehat{y}_t, \tag{15}$$

$$\widehat{\omega}_t = \Xi \widehat{y}_t, \tag{16}$$

$$\widehat{r}_t = \phi_\pi \widehat{\pi}_t^p + \phi_\omega \widehat{\pi}_t^\omega + \varepsilon_t^{mp}, \tag{17}$$

$$\widehat{\pi}_t^\omega = \widehat{\omega}_t - \widehat{\omega}_{t-1} + \widehat{\pi}_t^p. \tag{18}$$

Equations (14)-(18) characterize: (i) the IS equation; (ii) the relation between price inflation and output (obtained by replacing the equation for real wages into the equation for price inflation);[9] (iii) the cyclicality of real wages; (iv) the evolution of the interest rate; and (v) the definition of wage inflation. Notice that due to the iid shocks assumption we made, the terms with expectations disappear (both past and future). Therefore, what follows in this section can be interpreted as the *impact* responses of the variables to shocks.

[8] In Online Appendix F, we show that our result also shows up in their setup by substituting the price Phillips curve explicitly.

[9] With $\Upsilon \equiv \frac{\kappa_\pi(\kappa_\omega((1-\alpha)\varpi+\overline{\varphi})+\alpha}{(1-\alpha)(1+\kappa_\pi\varsigma)}$

2.4 The Distributional Channel of Nominal Rigidities

As shown in Proposition 5, aggregate demand depends directly on price and wage rigidities. This dependence arises because nominal rigidities affect how income is distributed in the cycle, distorting the distribution of income across households with different marginal propensities to consume. In this way, we obtain the mechanism proposed by Keynes (1936): wages enter aggregate demand if there is a distribution of resources between agents with different MPCs. Our approach to obtaining this result is through nominal rigidities, and we call this *the distributional channel of nominal rigidities.*

To study the role of the distributional channel, let us assume for a moment that monetary policy fully controls the real interest rate, i.e., $\widehat{r}_t = \varepsilon_t^{mp}$, where ε_t^{mp} is an exogenous monetary policy shock and that there are no preference shocks.[10] With these assumptions, the output gap is given by

$$\hat{y}_t = -\frac{1}{\sigma}\frac{1}{1-\frac{\lambda}{(1-\lambda)\gamma+\lambda}\Psi\left(\frac{\alpha}{1-\alpha}+\frac{\kappa_\omega\left(\varpi+\frac{\varphi}{1-\alpha}\right)}{1+\varsigma\kappa_\pi}-\frac{\varsigma\kappa_\pi\frac{\alpha}{1-\alpha}}{1+\varsigma\kappa_\pi}\right)}\varepsilon_t^{mp}, \tag{19}$$

where we use the expression for Θ. The coefficient Θ shows that output (through aggregate demand) depends explicitly on the relative wage and price rigidities. This can be observed by the dependence of output on the parameters κ_ω, ς and κ_π. Hence, in this model, the impact of monetary policy on activity amplifies from incomplete markets and a higher degree of price stickiness relative to wage stickiness. That is the distributional channel of nominal rigidities on aggregate demand. Notice that when prices get more sticky (given a degree of nominal wage rigidity), the parameter κ_π falls, and the output response to the monetary policy shock is amplified.[11] The intuition is simple. When prices are stickier, markups rise by more in a downturn. That implies that workers with high MPCs (as they are more financially constrained) lose more than the unconstrained firm owners, who have low MPCs. Therefore, the response of consumption (and output) is amplified by the higher countercyclicality of markups generated by high price stickiness.

Differently, wage rigidity dampens the effect of monetary policy through redistribution. More rigid wages imply that workers are more protected from aggregate shocks, as their income fluctuates

[10] Another way of obtaining this type of rule is by having a monetary policy rule that fully targets the expected inflation, $r_t = \mathbb{E}_t\pi_{t+1} + \varepsilon_t^{mp}$, as in Bilbiie (2020). Notice that with our assumptions of iid shocks, we have $\mathbb{E}_t\pi_{t+1} = 0$, so these two rules are equivalent under the assumptions of Proposition 5.

[11] In Online Appendix D we show that the derivative of Equation (19) with respect to θ_p is negative, meaning that the economy becomes more sensitive to monetary policy shocks when price rigidity increases.

less in that setup, so firm owners bear the costs of recessions. In that case, conditional on a real rate shock, the distributional channel is weaker and the economy is more stable. Therefore, there are no gains from wage flexibility through the distributional channel.

Figure 2 describes how the distributional channel operates depending on price and wage rigidities. Focusing on the variance of the output gap, it shows that for real rate shock (i) there are never gains from wage flexibility: the variance of output monotonically increases with wage flexibility ($\theta_w \to 0$); (ii) the variance of output increases with price rigidity ($\theta_p \to 1$); and (iii) the destabilizing effect of wage flexibility on output is stronger when prices are more sticky. This latter point tells us that the degree of price rigidity is critical for the destabilizing effects of higher wage flexibility. The reason is that with highly sticky prices, wage flexibility translates into real wage volatility, hence generating strong distributional effects. As we will see later, flexible prices are crucial to obtain gains from more flexible wages.

[Figure 2 about here]

Importantly, we obtain the dependence of output in the relative wage and price rigidity because of wage rigidities. Recall from Proposition 1 that the parameters ς, κ_ω, and κ_π depend on the degrees of price and wage rigidities (θ_p and θ_w). When wages are fully flexible ($\theta_w = 0$), the parameter $\varsigma = \frac{\theta_w(1+\overline{\varphi}\epsilon_w)}{1+\theta_w\overline{\varphi}\epsilon_w}$ equals zero, so aggregate demand does not depend on price rigidities. Recall from Equation (10) that ς governs the pass-through from price inflation to the real wage, which is stronger when wages are more rigid. That happens because whenever nominal wages are rigid, an increase in price inflation makes the real wage fall. On the contrary, if wages are flexible, it can be shown that aggregate demand does not depend on any rigidity, and we get

$$\hat{y}_t = -\frac{1}{\sigma}\frac{1}{1-\frac{\lambda}{(1-\lambda)\gamma+\lambda}\Psi\left(\varpi+\frac{\alpha+\overline{\varphi}}{1-\alpha}\right)}\varepsilon_t^{mp}, \tag{20}$$

which is the expression obtained by Bilbiie (2008) and Debortoli and Galí (2017).

Finally, notice how the gains from more rigid wages vanish as $\theta_w \to 1$, as reflected by the flattening of the curves in Figure 2. As we will see in the next section, the reason is that the effectiveness of stickier wages to offset the amplification derived from the distributional channel is bounded (see Proposition 7).

2.5 Slope and Inversion of the IS Curve

In this section, we present two properties of the derived IS equation. First, the consumption gap ($\hat{\gamma}_t$) is always countercyclical in our setup, implying that the slope of the IS equation in TANK is never smaller than in its RANK counterpart. Second, both price and wage rigidities can lead to the inversion of the IS curve (in the sense of Bilbiie, 2008).

2.5.1 On the Cyclicality of the Consumption Gap and the Slope of the IS Curve

Before discussing the slope of the IS, the following proposition describes the evolution of firms' markups throughout the cycle.

Proposition 6 (The cyclicality of markups)**.** *Markups evolve according to*

$$\hat{\mu}_t^p = -\left(\Xi + \frac{\alpha}{1-\alpha}\right)\hat{y}_t - \mathbb{E}_{t-1}\hat{x}_t, \tag{21}$$

and their cyclicality is determined by $-\left(\Xi + \frac{\alpha}{1-\alpha}\right) \leqslant 0$.

Proof. Equation (21) is derived from (7) and (11). The countercyclicality of markups follows from Proposition 3. □

The proposition states that markups are always countercyclical. This result remains even with countercyclical real wages ($\Xi < 0$), implying that markups will rise during an economic downturn, despite an increase in real wages. The explanation is that decreasing returns ($\alpha > 0$) result in increased labor productivity, compensating for the negative effects of real wages on markups.

With this result at hand, we characterize the slope of the IS curve.

Proposition 7 (The slope of the IS curve)**.** *For any parametrization of price and wage rigidities, we have* $\Theta \geq 0$*, implying* $\Lambda \notin (0, 1)$*.*

Proof. See Online Appendix B.5. □

Proposition 7 claims that in an economy with incomplete markets (TANK) and sticky wages, the elasticity of output to the real interest rate cannot lay below that in the representative agent (RANK) model.[12] Therefore, the TANK economy never dampens the effect of the shock. This

[12] In a RANK, $\lambda = 0$, implying $\Lambda = 1$.

result is easy to understand. From Equation (6), we know that markups determine the consumption gap's cyclicality. According to Proposition 6, markups are always countercyclical, implying that redistribution favoring workers during a downturn is unfeasible. It follows that the consumption gap is countercyclical, and hence, dampening is ruled out.[13]

2.5.2 On the Inversion of the IS Curve

Once we understand the slope of the IS curve, Proposition 8 shows under what conditions this curve "inverts" and turns upward sloping.

Proposition 8 (Inversion of the IS curve)**.** *The slope of the IS equation with sticky prices and wages will turn positive for any* $\lambda > \lambda^* = \frac{\frac{\mathcal{M}^p}{1-\alpha}}{\frac{\kappa_\omega\left(\sigma+\frac{\varphi}{1-\alpha}\right)}{1+\varsigma\kappa_\pi}+\frac{1}{1+\varsigma\kappa_\pi}\frac{\alpha}{1-\alpha}+1}$.[14,15]

Proof. See Online Appendix B.6. □

Bilbiie (2008) finds that in a TANK model with sticky prices and flexible wages, the slope of the IS curve inverts when participation in asset markets is low enough, going from negative to positive. He shows that the inversion of the IS relates to an income effect on unconstrained households derived from the behavior of profits. In a model with sticky prices and wages, Ascari et al. (2017) show that conditions for the inversion crucially depend on the degree of wage stickiness. Particularly, sticky wages reduce the parameter space compatible with the inversion of the IS. With sticky wages, a positive slope is obtained only under extreme values for the share of constrained agents. The reason is that sticky wages limit the income effect by reducing the countercyclicality of markups. In Proposition 8, we show that the condition for a positive slope depends not only on wage rigidities, as stressed by Ascari et al. (2017), but also on price rigidities. We can check that a higher degree of price stickiness makes it more likely for the IS to invert as the threshold λ^* reduces. As opposed to wage stickiness, price rigidities exacerbate the countercyclicality of markups, hence the opposing effects on the condition for the inversion of the IS. To illustrate this relation, Figure 3 shows the threshold λ^* as a function of parameters θ_p and θ_w. Two results are worth noting. First,

[13] In the limiting case with full price flexibility, markups and hence the consumption gap is acyclical.

[14] To facilitate comparability of our results with existing literature, this derivation assumes labor unions set wages to maximize the utility of the average household.

[15] Assuming flexible wages ($\kappa_\omega = 1$, $\varsigma = 0$), a linear production function ($\alpha = 0$), and zero markups in steady state ($\mathcal{M}^p = 1$), the threshold reduces to $\lambda > \frac{1}{1+\sigma+\varphi}$. This expression coincides with Ascari et al. (2017) for the case of flexible wages, while differs slightly from Bilbiie (2008). The difference can be attributed to the different assumptions regarding the labor market structure.

as mentioned above, we check the opposing effects of price and wage rigidities on λ^*. Second, even with highly sticky prices, a low degree of wage stickiness is sufficient to prevent the inversion of the IS. In particular, notice that with fully rigid prices ($\theta_p = 1$), setting $\theta_w = 0.3$ implies the threshold value $\lambda^* > 0.7$, which is largely above standard parametrization for the share of constrained agents in the literature.

[Figure 3 about here]

2.6 Wage Flexibility and the Role of Monetary Policy with Inequality

As Galí (2013) uncovered, the effects of wage flexibility in the New Keynesian model depend crucially on how the central bank conducts monetary policy. The reason is that wage flexibility leads to increased responsiveness of prices to shocks. This, in turn, dampens output volatility due to the endogenous response of monetary policy to inflation. This is the *interest rate channel* of wage flexibility. Through this channel, wage flexibility stabilizes output, counteracting the destabilizing effects of more flexible wages through the distributional channel. In this section, we show that, when prices are highly rigid, it is not enough to respond only to price inflation to counteract the destabilizing effects of highly volatile wages through redistribution.[16]

Studying monetary policy design is critical in models with heterogeneity and market incompleteness. Most models with household heterogeneity assume simple monetary policy rules because they focus on the impact of heterogeneity and not the conduct of monetary policy. However, as we explained above, with income heterogeneity, price, and wage inflation affect aggregate demand directly through the real wage. Moreover, aggregate demand depends differently on prices and wages, which means that the responses to price and wage inflation might no longer be equivalent.

To start the analysis, let us reconsider the effects of preference shocks ($\widehat{\chi}_t$) and assume that the Taylor rule is given by

$$\widehat{r}_t = \phi_\pi \widehat{\pi}_t^p + \phi_\omega \widehat{\pi}_t^\omega,$$

where monetary policy reacts to deviations of price and wage inflation rates from their steady states

[16] In RANK, targeting price inflation is isomorphic to targeting wage inflation (unless we are interested in welfare). That is because prices are the only channel through which wage fluctuations affect output. Then, the role of higher wage flexibility depends primarily on the response to price inflation. Hence, having a rule that reacts to wages or prices has similar qualitative economic effects.

(assumed at zero). Substituting the Taylor rule into the Euler equation delivers

$$\widehat{y}_t = -\frac{1}{\sigma}\frac{1}{1-\frac{\lambda}{(1-\lambda)\gamma+\lambda}\Theta}\left[\phi_\pi \widehat{\pi}_t^p + \phi_\omega \widehat{\pi}_t^\omega - \widehat{\chi}_t\right].$$

Recalling that $\widehat{\pi}_t^\omega = \widehat{\omega}_t + \widehat{\pi}_t^p$, $\widehat{\omega}_t = \Xi \widehat{y}_t$, and $\widehat{\pi}_t^p = \Upsilon \widehat{y}_t$, the previous expression implies[17]

$$\widehat{y}_t = \frac{1}{\sigma}\left(1 - \frac{\lambda}{(1-\lambda)\gamma+\lambda}\Theta + \frac{1}{\sigma}\left[\phi_\omega\left(\Xi+\Upsilon\right) + \phi_\pi \Upsilon\right]\right)^{-1}\widehat{\chi}_t. \tag{22}$$

Hence, output depends on the cyclicality of prices Υ and the cyclicality of wages Ξ through the interest rate response, in addition to the distributional channel, represented by the expression $\frac{\lambda}{(1-\lambda)\gamma+\lambda}\Theta$.

With this type of policy rule, monetary policy can directly counteract the excessive volatility of wages if the response to them is sufficiently strong. Figure (4) shows the output variance for two alternative Taylor rules. The left-hand panel considers a Taylor rule that only responds to prices, while the right-hand panel shows the variance if monetary policy reacts to wage inflation too. When monetary policy reacts only to prices, it can offset the effects of the distributional channel is prices are flexible enough. However, when prices are highly rigid, monetary policy does not offset the amplifying effects of redistribution since the real wage is too volatile. That translates to output through aggregate demand. However, if monetary policy reacts (strongly) to wage inflation, it activates an additional countercyclical response. In this case, monetary policy reacts to the high volatility of wages and counteracts the distributional effect of high wage flexibility.

Therefore, we have two opposing effects of wage flexibility in our model. One depends on the share of constrained agents, while the other depends on the ability of monetary policy to react to aggregate outcomes, either prices or wages. The former controls the degree of redistribution, and the latter acts as a countercyclical device. The left-hand panel in Figure 4 shows that the strength of these effects depends on the degree of price rigidities: if prices are flexible (sticky), wage flexibility stabilizes (destabilizes). A corollary from this analysis is a threshold for θ_p, which turns wage flexibility from destabilizing to stabilizing. Moreover, this threshold depends on the strength of the monetary policy response to prices and wages, as the right-hand panel of Figure 4 shows. For that specific calibration, monetary policy can restore the ability of wage flexibility to stabilize

[17] Recall we are assuming that the economy is hit by an iid shock in period t.

output.

[Figure 4 about here]

However, the previous result does not hold for every $\phi_\omega > 0$. To show this, we compute the value of ϕ_ω that turns wage flexibility from amplifying to stabilizing, which is given by[18]

$$\overline{\phi}_\omega = \frac{\sigma\lambda(\epsilon_p - 1)(1-\alpha)(1-\alpha+\alpha\epsilon_p)\theta_p}{(\epsilon_p - \lambda(\epsilon_p - 1)(1-\alpha))(1-\alpha+\theta_p\alpha\epsilon_p)} - \frac{(1-\theta_p)(1-\alpha)}{1-\alpha+\theta_p\alpha\epsilon_p}\phi_\pi, \tag{23}$$

which we refer to as the threshold for ϕ_ω. Equation (23) and Figure 5 show that this threshold positively depends on the share of constrained agents and the degree of price rigidities. These two factors are the main drivers of the distributional channel. Hence, to offset the distributional channel, the response of monetary policy to wage inflation must be strong enough.

In the case of Figure 5, the threshold is a negative value for some combinations of parameters (i.e., low λ and low θ_p). We interpret that as a combination of parameters in which wage fluctuations are not a constraint for monetary policy when stabilizing output. The negative values result from having $\phi_\pi > 0$, which helps stabilize output when responding to prices. However, with sufficiently sticky prices, the role of ϕ_π disappears. Equation (23) also shows that when prices are fully sticky, the required response to wages is finite, meaning that monetary policy counteracts the distributional channel more effectively when it responds to wage inflation (i.e., monetary policy does not need to set $\phi_\omega \to \infty$ to stabilize output).

This latter point is more evident if we compare the threshold for ϕ_ω with the one for ϕ_π, which reads

$$\overline{\phi}_\pi = \frac{\sigma\lambda(\epsilon_p - 1)(1-\alpha+\alpha\epsilon_p)}{\epsilon_p - \lambda(\epsilon_p - 1)(1-\alpha)}\frac{\theta_p}{(1-\theta_p)} - \frac{1-\alpha+\alpha\epsilon_p\theta_p}{(1-\theta_p)(1-\alpha)}\phi_\omega. \tag{24}$$

Notice that if prices are fully sticky ($\theta_p = 1$), $\overline{\phi}_\pi \to \infty$, whereas for ϕ_ω that is not the case. This means that monetary policy is not sufficiently effective to counteract the impact of wage flexibility if prices are sticky, so policymakers should consider responding to wages.

[Figure 5 about here]

[18] In Appendix E we get this threshold by computing the derivative of the variance of output to θ_w, equalizing it to zero, and solving for the minimum parameter required to turn wage flexibility from amplifying to stabilizing.

The main takeaway of this exercise is that monetary policy plays a vital role in offsetting the effects of redistribution. When wages are too volatile relative to prices, monetary policy cannot offset the distributional effects of shocks and stabilize aggregate demand by only reacting to price inflation. Therefore, in economies with income inequality and incomplete markets, if wage inflation is more volatile than price inflation, the monetary authority should target wages in addition to prices to stabilize output effectively.

3 Gains from Wage Flexibility: Calvo Price and Wage Adjustment

In this section, we use our model to quantitatively investigate the gains from wage flexibility and how such gains depend on (i) relative nominal rigidities (price vs. wages); (ii) the degree of market incompleteness; and (iii) the ability of monetary policy to endogenously react to aggregate outcomes (for example, in a scenario where the zero lower bound (ZLB) on the nominal interest rate binds). For this analysis, we consider a setup where prices and wages are subject to Calvo pricing. Such setup allows us to consider agents' expectations and the dynamics of the economy, unlike in Section 2, and analyze how sensitive our results are to this assumption. Because these modifications are standard, we relegate them to the Appendix and focus here on the results.

3.1 Quantitative Analysis

Calibration. For the baseline calibration we set the parameter α to 0.25 and the discount factor, β, to 0.994. We initially set the Calvo price and wage parameters to 0.75, implying an average contract duration of four quarters. We set the parameters ϵ_p and ϵ_w to 6, which implies a steady state markup of 20%. We assume the inverse of the intertemporal elasticity of substitution, σ, and the inverse of the Frisch elasticity, φ, equal 1. Additionally, we fix the coefficient for price inflation in the Taylor rule, ϕ_π, to 1.5 and the one of wage inflation, ϕ_ω, to 0.[19] The interest rate smoothing parameter is set to 0.8.[20] We assume ρ_χ, the autoregressive coefficient of the exogenous preference shock, is 0.8. We assume two scenarios regarding the fraction of constrained agents: a representative agent (RANK) economy where all households are unconstrained (i.e., $\lambda = 0$) and an economy with a positive fraction of constrained agents, where $\lambda = 0.3$.

[19] We set these parameters to describe how the distributional channel affects the dynamics of the economy for a monetary policy that does not react to wages.

[20] For the following simulations we modify the Taylor rule in (A.10) to incorporate interest rate smoothing.

The Gains from Wage Flexibility without the ZLB. We simulate the economy's response to a contractionary preference shock in different scenarios, depending on the degree of wage flexibility and access to financial markets. We solve the model for combinations of $\theta_w = \{0.3, 0.75\}$, a flexible and a rigid wage case, and $\lambda = \{0, 0.3\}$, without and with inequality, and keep the remaining parameters as described in the calibration. We report the results for the four combinations of these parameters in the following plots.

Figure 6 shows the responses of output, price inflation, wage inflation, and the nominal interest rate to a demand shock in the abovementioned cases. Differences in wage rigidity primarily drive the differences in output responses: we have a stronger response when wages are more rigid. Naturally, in the case where wages are flexible, wage inflation falls considerably more than in the case in which wages are rigid. More volatile wages transmit to price inflation. Since prices are relatively sticky in this example, the response of inflation is not as strong as the wage inflation rate. However, it is strong enough to trigger a substantial response in the interest rate compared to the case of having rigid wages.

Although the interest rate responses with and without inequality are different, they are not quantitatively important. Therefore, monetary policy successfully counteracts the distributional channel of nominal rigidities. Then, wage flexibility reduces output volatility.

[Figure 6 about here]

In Figure 7, we set out the role of the distributional channel by assuming prices are very sticky (θ_p=0.95). When prices are sticky and monetary policy only responds to price inflation, the distributional channel comes into play. In the case of Figure 7, output with inequality and flexible wages falls persistently more than in the other three cases (in which we observe no differences). This is because monetary policy does not stimulate output, and the distributional effect operates very strongly. Moreover, the case with inequality and sticky wages behaves like the representative agent case, suggesting that wage rigidity is an insurance device for workers even if prices are highly sticky. We conclude that for wage flexibility to be desirable, wage reductions must translate into lower prices.

[Figure 7 about here]

The Gains from Wage Flexibility with the ZLB. Another way of analyzing the distributional channel is by studying the case in which monetary policy does not endogenously react, as in the ZLB case. We show this case in Figure 8. When the ZLB is present, wage flexibility is undesirable. Billi and Galí (2020) was the first to make this point by showing that, in the presence of the ZLB, there are always losses from wage flexibility because they are associated with a more severe deflation in such a case. Since the policy rate cannot be further reduced, deflationary expectations induce a drop in demand (due to the associated rise in the real rate), exacerbating output contraction. For our calibration, in a RANK economy, having highly flexible wages makes output fall by twice as much as in the case of rigid wages.

In an economy with inequality, the effect is considerably larger. We observe that the output gap falls twice as much as in the RANK case. In this scenario, the effects of greater wage flexibility via deflationary expectations and redistribution reinforce each other due to a feedback loop between the two channels. Redistribution puts downward pressure on output and thus prices, translating into a rise in the real rate that depresses activity. Given a countercyclical income gap, the latter implies redistribution against constrained households, further depressing demand, and output. A stronger cut in demand by the unconstrained agents, who respond to more severe deflationary expectations, together with the contractive effects of redistribution, explain the larger drop in activity compared to the RANK economy. Therefore, in our model, the distributional and monetary policy channels interact to give rise to a sizable drop in activity, largely beyond that observed in a RANK. All the previous analysis implies that nominal rigidities determine the distributional channel, and monetary policy is a crucial determinant in the transmission of shocks.

[Figure 8 about here]

Output Volatility and Welfare. We generate artificial time series for several variables subject to demand shocks. We consider the two alternative calibrations of the Calvo wage parameter and generate these series using the extended path method to explore the effects of greater wage flexibility. We set the volatility of the innovation so that the ZLB binds 5% of the time. Figure 9 shows that flexible wages in the RANK economy are associated with lower output variability in periods when monetary policy is active. At the same time, volatility increases in periods when the ZLB binds. The reduction in rigidities, however, has only a modest effect on output dynamics. When there are financial frictions (Figures 10 and 11), higher wage flexibility greatly exacerbates the contraction of output in periods when the ZLB constrains monetary policy. In line with our previous discussion, the more severe contraction is explained by a larger drop in unconstrained agents' consumption, who respond to increased deflationary expectations, and, to a larger extent, redistribution, which depress constrained agents' consumption. Notice that higher flexibility significantly affects constrained households, whose income is severely reduced due to a significant wage cut, triggering a sizable cut in spending. The present exercise clearly illustrates the relevance of considering the interest rate and distributional channels jointly, as they do not operate independently. Instead, they interact to enhance each other's effect, giving rise to a sizable drop in production.

How does wage flexibility affect volatility and welfare? Table 1 presents the results for the volatility of output, the rates of inflation, and the consumption gap for different calibrations of θ_w. In the RANK economy, higher flexibility is associated with a more stable output (while price and wage inflation volatility greatly increase). With inequality, we observe that: (i) more flexible wages destabilize output and (ii) price and wage inflation volatility rise. Regarding welfare losses, Table 2 shows that in an economy with limited asset market participation, greater wage flexibility increases losses related to all welfare-relevant variables.[21]

Finally, we study how the gains from more flexible wages depend on the degree of price rigidities. Figures 6 and 7 show that higher wage flexibility stabilizes output conditional on prices being flexible enough, that is, conditional on a high transmission of wage cuts to price reductions. We repeat the simulations above assuming less rigid prices to check if this result holds when the ZLB constrains the central bank. Tables 1 and 2 show that losses in terms of output volatility derived from more flexible wages exacerbate when prices are less rigid. We conclude that our previous results overturn when there is an inactive monetary policy. The reason is that with less rigid prices, higher wage flexibility translates into strong deflationary expectations when the ZLB binds.

[Figures 9, 10 and 11 about here]

[21] See Appendix C for a derivation of the welfare loss function.

	$\hat{y}$	$\hat{\pi}^p$	$\hat{\pi}^\omega$
$\theta_w = 0.75$	0.030	0.002	0.002
$\theta_w = 0.30$	0.029	0.004	0.015
Ratio	0.96	2.7	6.4

(a) $\lambda = 0$

	$\hat{y}$	$\hat{\gamma}$	$\hat{\pi}^p$	$\hat{\pi}^\omega$
$\theta_w = 0.75$	0.027	0.011	0.001	0.002
$\theta_w = 0.30$	0.036	0.055	0.006	0.019
Ratio	1.3	5	3.8	8.9

(b) $\lambda = 0.3$

	$\hat{y}$	$\hat{\gamma}$	$\hat{\pi}^p$	$\hat{\pi}^\omega$
$\theta_w = 0.75$	0.026	0.010	0.002	0.002
$\theta_w = 0.30$	0.040	0.044	0.014	0.027
Ratio	1.5	4.3	6.1	11.9

(c) $\lambda = 0.3$, $\theta_p = 0.6$

Table 1: Standard deviation

Notes: This table presents the standard deviation in selected variables of the model under different configurations for wage rigidities and market incompleteness. Row 'Ratio' shows the ratio between the case with high flexibility ($\theta_w = 0.30$) and low flexibility ($\theta_w = 0.75$).

	$\hat{y}$	$\hat{\pi}^p$	$\hat{\pi}^\omega$	Total Loss
$\theta_w = 0.75$	0.0012	0.0003	0.0010	0.0025
$\theta_w = 0.30$	0.0011	0.0019	0.0022	0.0052
Ratio	0.9	7.1	2.1	2.1

(a) $\lambda = 0$

	$\hat{y}$	$\hat{\gamma}$	$\hat{\pi}^p$	$\hat{\pi}^\omega$	Total Loss
$\theta_w = 0.75$	0.0010	0.0000	0.0002	0.0008	0.0021
$\theta_w = 0.30$	0.0017	0.0003	0.0032	0.0034	0.0087
Ratio	1.7	24.9	14.7	4.1	4.2

(b) $\lambda = 0.3$

	$\hat{y}$	$\hat{\gamma}$	$\hat{\pi}^p$	$\hat{\pi}^\omega$	Total Loss
$\theta_w = 0.75$	0.0009	0.0000	0.0002	0.0009	0.0020
$\theta_w = 0.30$	0.0021	0.0002	0.0066	0.0072	0.0162
Ratio	2.4	18.1	38.5	7.5	8.0

(c) $\lambda = 0.3$, $\theta_p = 0.6$

Table 2: Consumption equivalent welfare losses

Notes: This table presents consumption equivalent welfare losses under different configurations for wage rigidities and market incompleteness. Row 'Ratio' shows the ratio between the case with high flexibility ($\theta_w = 0.30$) and low flexibility ($\theta_w = 0.75$).

4 Conclusion

In this paper, we revisit the benefits of wage flexibility in a model with price and wage rigidities and incomplete asset markets. We show that the real wage enters the aggregate demand equation in the presence of limited asset market participation. Therefore, the relative rigidities between prices and wages determine the aggregate demand and the economy's response to shocks. Increased wage flexibility can amplify the cycle if prices are highly rigid, due to an excessive volatility of real wages. In this context, wage flexibility is undesirable.

We also show that the conduct of monetary policy is crucial in determining the final outcome from increased wage flexibility. We find that with incomplete asset markets, responding to price inflation is no longer isomorphic to responding to wage inflation. If monetary policy only reacts to price inflation, it misses the effects of higher wage volatility on aggregate demand. Our model shows that monetary policy is more effective if it responds to price and wage inflation.

Understanding the interaction of these three features (price and wage rigidities and limited access to financial markets) is important for several reasons. First, there is a growing literature that uses these features to study diverse macroeconomic questions, like the effects of fiscal and monetary policy in the presence of incomplete markets. Second, it is important to understand the effects of labor market policies, particularly the policies that pretend to stabilize the economy through wage deflation. We show that these kinds of policies are not desirable under some circumstances since they generate significant aggregate demand effects that could further depress the economy.

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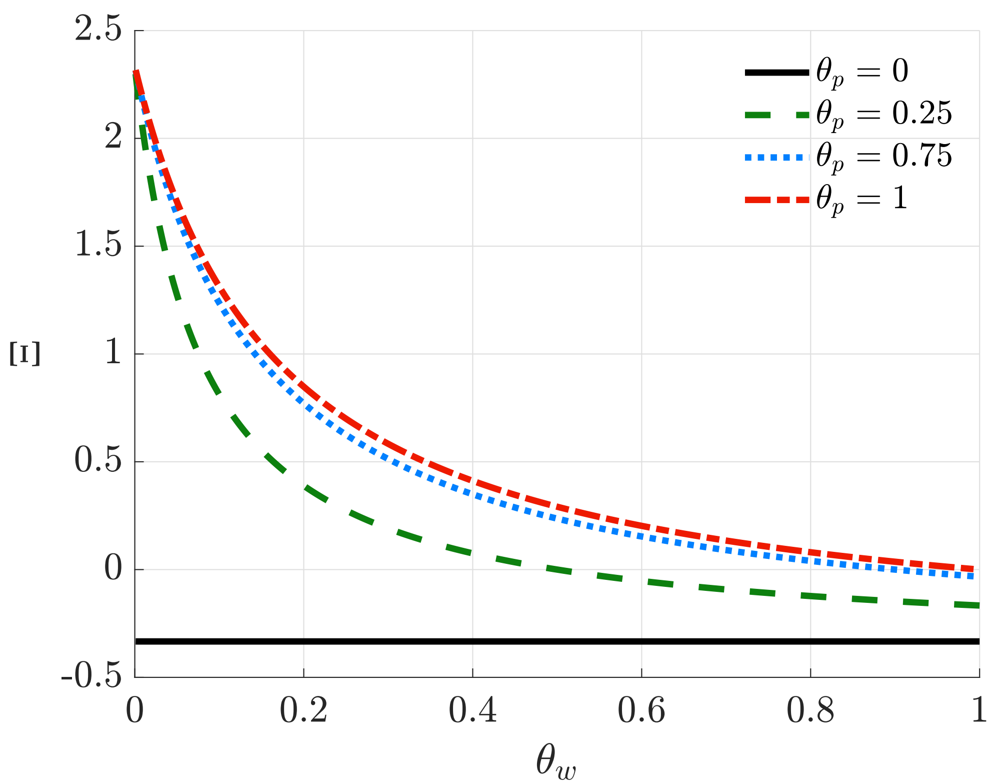
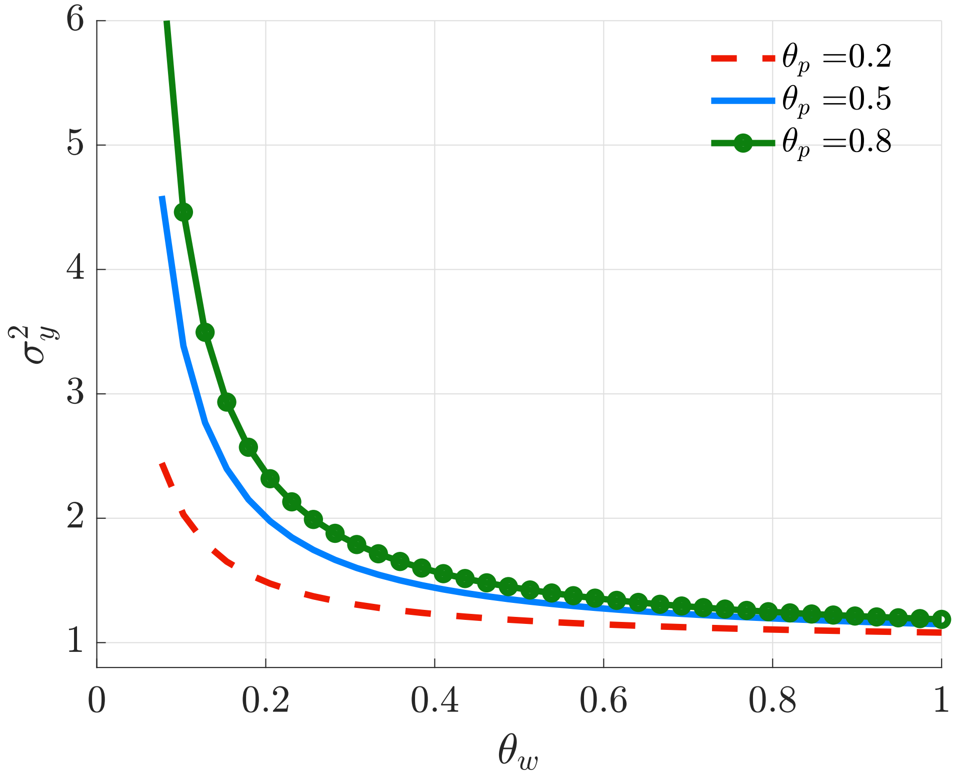
Main Figures

Figure 1: Cyclicality of the real wage.



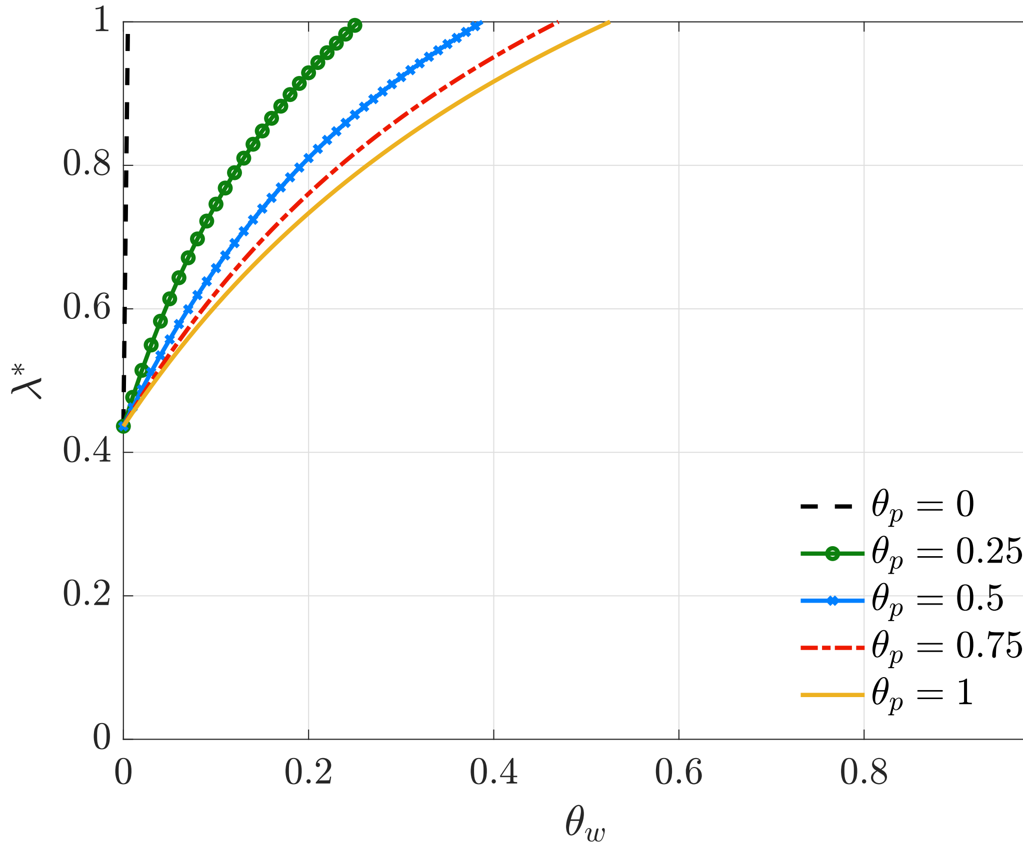
Notes: This figure shows the values adopted by Ξ for different levels of price rigidities, θ_p, as a function of wage rigidities, θ_ω. The calibration assumed in this figure is the following: $\lambda = 0.3$, $\alpha = 0.25$, $\epsilon_p = \epsilon_w = 6$, and $\sigma = \varphi = 1$.

Figure 2: Variance of output for different calibrations, conditional on a shock to the real interest rate.



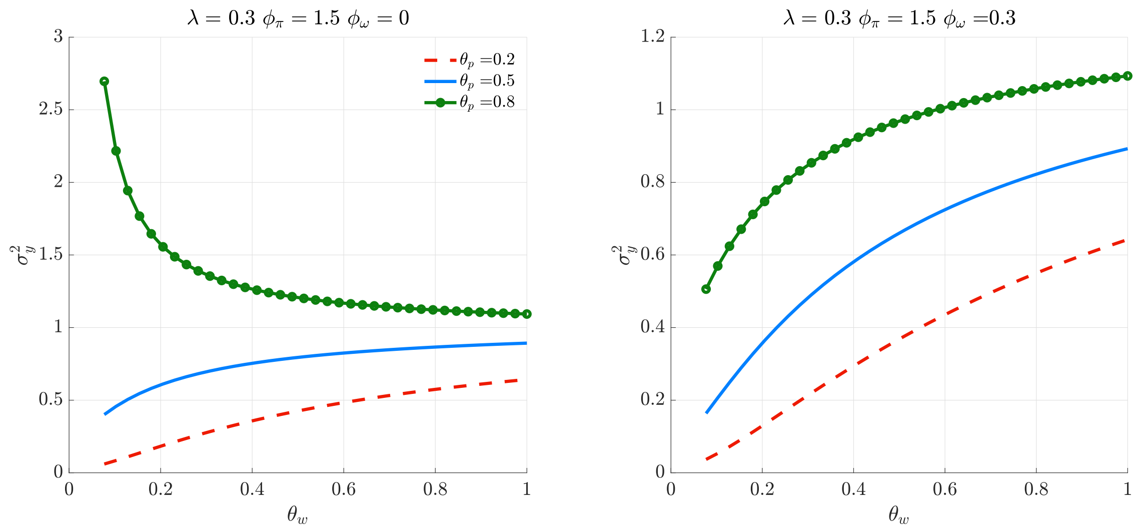
Notes: This figure shows the variance of the output gap for different levels of price rigidities, θ_p, as a function of wage rigidities, θ_ω. The calibration assumed in this figure is the following: $\lambda = 0.3$, $\alpha = 0.25$, $\epsilon = \epsilon_w = 6$, and $\sigma = \varphi = 1$.

Figure 3: Inversion of the IS curve.



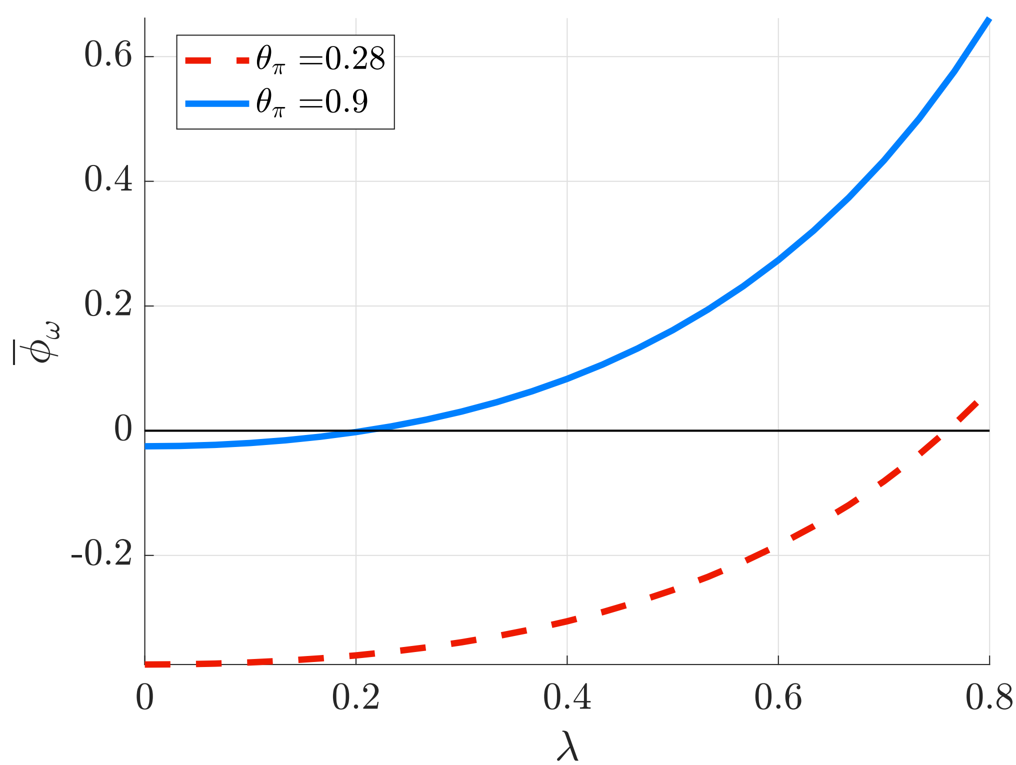
Notes: This figure shows the threshold value for the share of constrained households λ^* above which the slope of the IS becomes positive.

Figure 4: Variance with alternative Taylor rules.



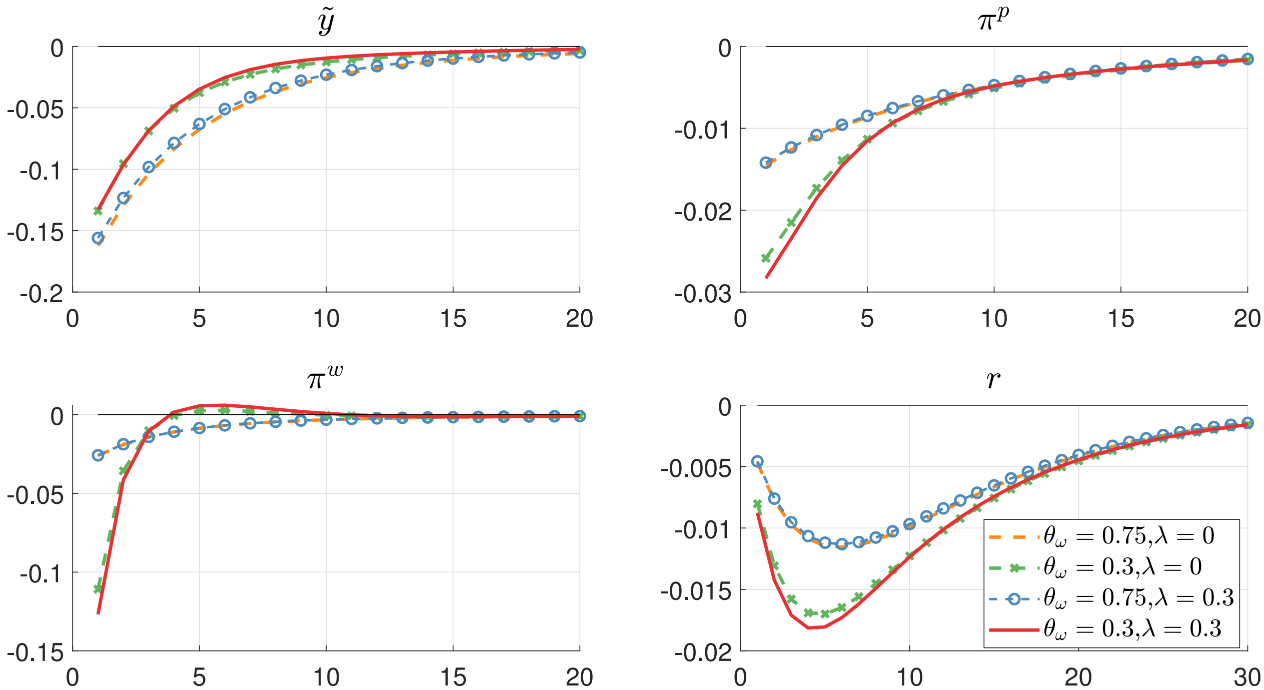
Notes: This figure shows the variance of the output gap for different levels of price rigidities, θ_p, as a function of wage rigidities, θ_ω. The calibration assumed in this figure is the following: $\lambda = 0.3$, $\alpha = 0.25$, $\epsilon_p = \epsilon_w = 6$, and $\sigma = \varphi = 1$.

Figure 5: Threshold for ϕ_ω.



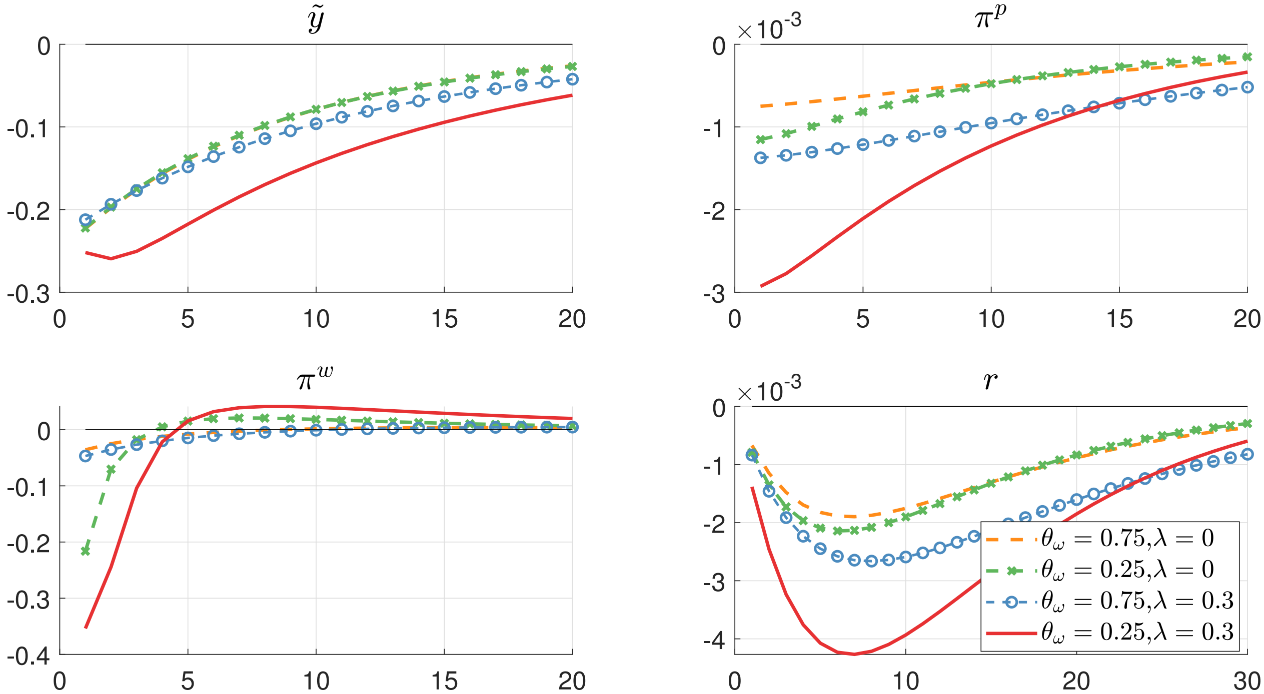
Notes: This figure shows the value of ϕ_ω that turns wage flexibility from amplifying to stabilizing as a function of the share of hand to mouth agents and the degree of price rigidities.

Figure 6: Response of output, price and wage inflation, and the nominal interest rate to a contractionary preference shock. Baseline calibration.



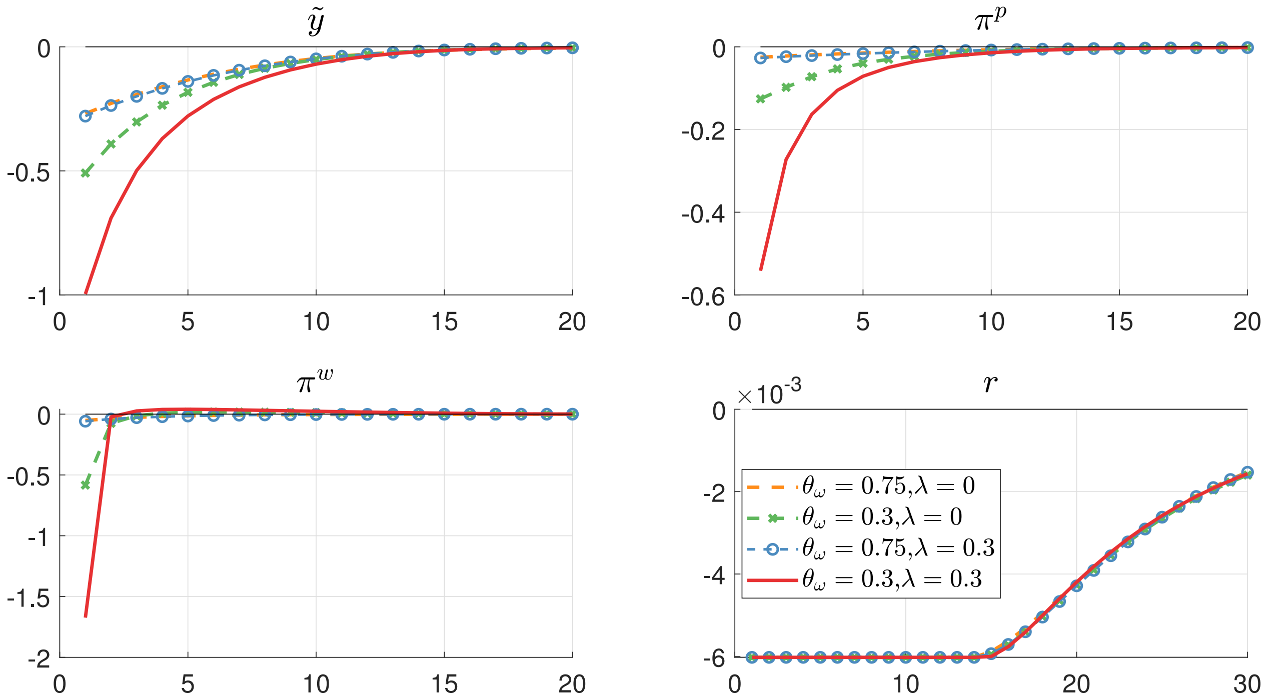
Notes: This figure shows the responses of output, price and wage inflation, and the nominal interest rate to a contractionary preference shock. We show four calibrations for combinations of $\theta_w = \{0.3, 0.75\}$ *and* $\lambda = \{0, 0.3\}$*. This plot assumes the baseline calibration.*

Figure 7: Response of output, price and wage inflation, and the nominal interest rate to a contractionary preference shock. High price rigidity, $\theta_p = 0.95$.



Notes: This figure shows the responses of output, price and wage inflation, and the nominal interest rate to a contractionary preference shock. We show four calibrations for combinations of $\theta_w = \{0.3, 0.75\}$ *and* $\lambda = \{0, 0.3\}$. *This plot considers* $\theta_p = 0.95$.

Figure 8: Response of output, price and wage inflation, and the nominal interest rate to a contractionary preference shock with the ZLB.



Notes: This figure shows the responses of output, price and wage inflation, and the nominal interest rate to a contractionary preference shock. We show four calibrations for combinations of $\theta_w = \{0.3, 0.75\}$ *and* $\lambda = \{0, 0.3\}$. *This plot assumes the baseline calibration and that monetary policy is subject to the ZLB.*

Figure 9: Fluctuations under preference shocks ($\lambda = 0$).

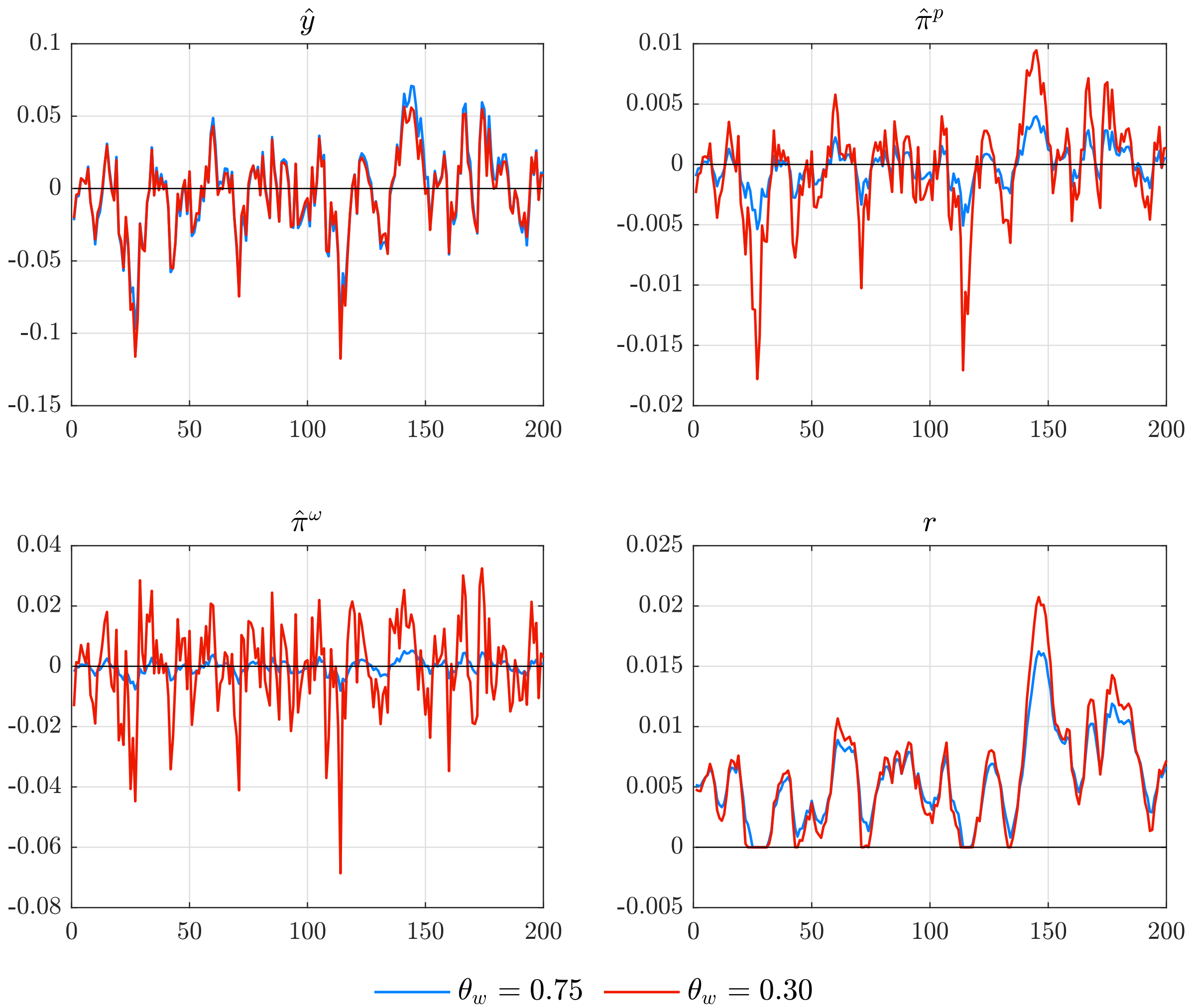


Figure 10: Fluctuations under preference shocks ($\lambda = 0.3$).

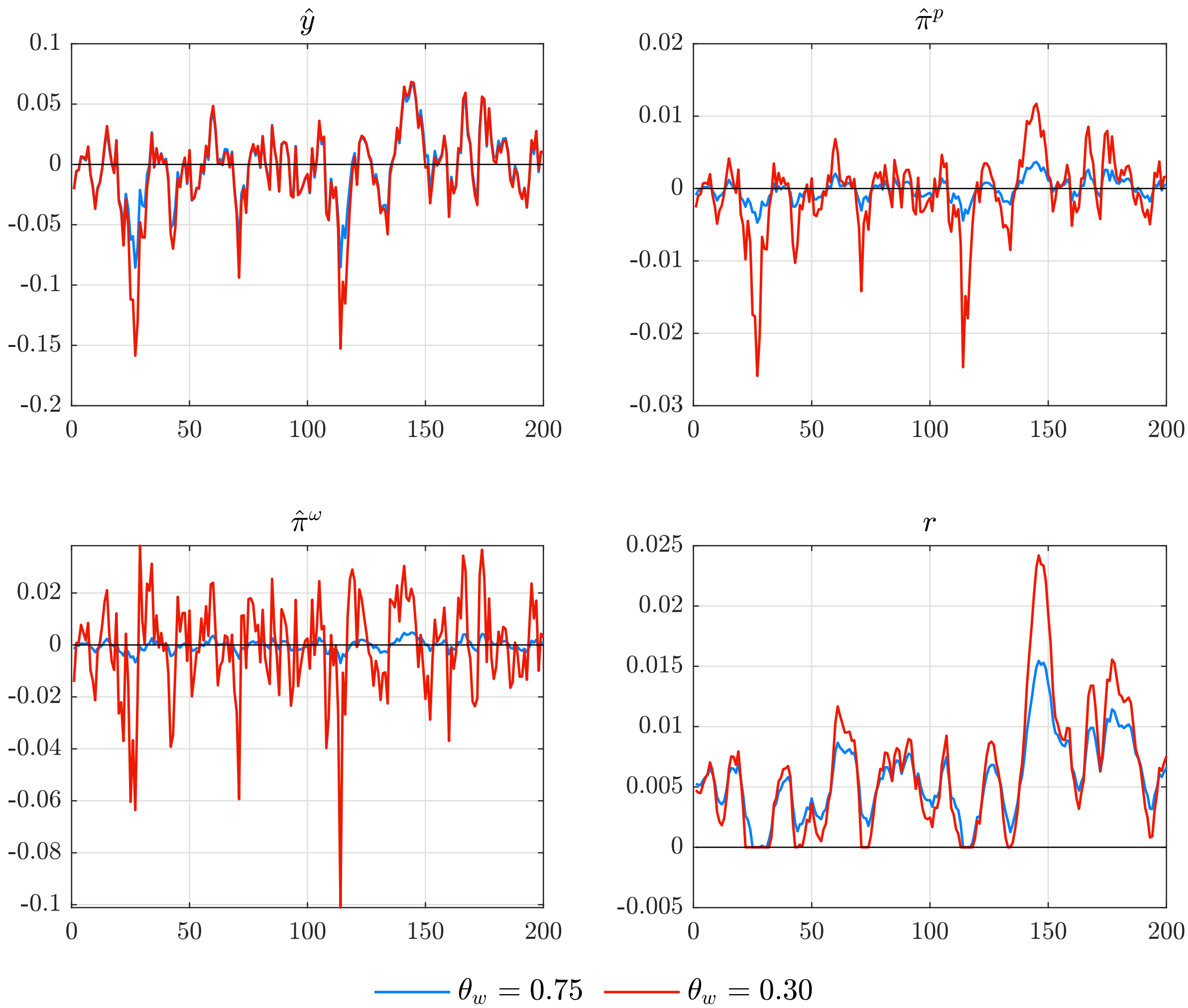


Figure 11: Fluctuations under preference shocks ($\lambda = 0.3$).