Envy, Guilt, and the Phillips Curve

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Abstract

We incorporate inequality aversion into an otherwise standard New Keynesian dynamic stochastic equilibrium model with Calvo wage contracts and positive inflation. Workers with relatively low incomes experience envy, whereas those with relatively high incomes experience guilt. The former seek to raise their income and the latter seek to reduce it. The greater the inflation rate, the greater the degree of wage dispersion under Calvo wage contracts, and thus the greater the degree of envy and guilt experienced by the workers. Since the envy effect is stronger than the guilt effect, according to the available empirical evidence, a rise in the inflation rate leads workers to supply more labor over the contract period, generating a significant positive long-run relation between inflation and output (and employment), for low inflation rates. Provided that wage adjustments are costly, this tradeoff remains significant even once the degree of wage stickiness adjusts to the inflation rate. This Phillips curve relation, together with an inefficient zero-inflation steady state, provides a rationale for a positive long-run inflation rate. Given standard calibrations, optimal monetary policy is associated with a long-run inflation rate around 2 percent.

JEL classification: D03, E20, E31, E50.
Keywords: inflation, long-run Phillips curve, fairness, inequality aversion.

1 Introduction

Despite a well-known, growing body of empirical literature calling the classical dichotomy into question, it is still the conventional wisdom in contemporary macroe-

conomic theory that monetary policy is roughly neutral with respect to aggregate employment and output in the long run. Even though the standard New Keynesian model implies a non-neutrality due to time discounting and inefficiencies due to relative price instability, these long-run effects of monetary policy are quantitatively small for reasonable values of the interest rate and low inflation rates (Ascari, 1998; Graham and Snower, 2004; Levin and Yun, 2007).[1] This paper, by contrast, offers a new rationale for long-run real effects of monetary policy, resting on envy and guilt. We find that for reasonably calibrated values of the relevant parameters, these long-run effects are substantial. This result has important implications for the conduct of monetary policy. Our results suggest an optimal inflation rate in the neighborhood of 2 percent.

In particular, we incorporate fairness considerations into an otherwise standard dynamic stochastic general equilibrium (DSGE) model of New Keynesian type with Calvo nominal wage contracts and positive trend inflation. In this context, we show that the classical dichotomy (whereby nominal variables have no long-run effect on real variables) breaks down in an empirically significant and theoretically novel way. Our rationale for the long-run non-neutrality of monetary policy does not rest on money illusion, departures from rational expectations, or permanent nominal rigidities. Instead, we assume that workers are inequality-averse with respect to real incomes, following the seminal work from Fehr and Schmidt (1999) and Bolton and Ockenfels (2000). Accordingly, workers with relatively low income experience envy, whereas those with relatively high income experience guilt. Both experiences generate disutility and, in accordance with the evidence, the influence of envy is stronger than that of guilt.

In the presence of Calvo nominal wage contracts, higher inflation implies greater wage dispersion and thus greater dispersion of incomes, generating more envy and guilt. Since workers seek to mitigate envy and guilt, they adjust their employment accordingly. Those who experience envy seek to raise their income and do so by increasing their employment, where those who experience guilt reduce their employment. Since the envy effect is stronger than the guilt effect, higher inflation is associated with greater employment and output, thereby generating a long-run Phillips curve trade-off. Provided that wage adjustments are costly, this tradeoff remains significant even once the degree of wage stickiness (measured by the Calvo probability) adjusts to the inflation rate.

We find that the optimal long-run inflation rate (maximizing the representative worker's discounted stream of utilities in the steady state) is positive, in the neighborhood of 2 percent, for the standard calibrations. This result is in stark contrast to earlier studies of DSGE models with trend inflation (e.g., King and Wolman, 1996; Khan et al., 2003; Yun, 2005; Schmitt-Grohé and Uribe, 2007, 2011a), which find the optimal inflation rate to be either zero or negative. Our results are in line with the aims of practical monetary policy as practiced by central bankers.

The paper is organized as follows. Section 2 reviews the relevant literature. Section 3 describes our microfounded macro model and calibrates it. Section 4 presents the numerical implications of the model for the long-run Phillips curve, discusses the underlying intuition, and investigates the sensitivity of the results with respect to key

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[1]This holds true for the standard assumption of exponential discounting. Graham and Snower (2008) show that hyperbolic discounting leads to a long-run tradeoff of reasonable magnitude.

parameters. Section 5 examines optimal monetary policy in the presence of envy and guilt. Section 6 analyzes the long-run tradeoff in the presence of an endogenous frequency of nominal adjustment. Finally, section 7 concludes.

2   Relation to the Literature

Although evidence regarding verticality of the long-run Phillips curve had been mixed over the past century, recent years have witnessed a rapidly growing literature calling the classical dichotomy into question.[2] As Gregory Mankiw puts it "... if one does not approach the data with a prior view favoring long-run neutrality, one would not leave the data with that posterior. The data's best guess is that monetary shocks leave permanent scars on the economy" (Mankiw, 2001, p. 48). This paper provides a new rationale for such empirical findings.

The paper also contributes to a growing theoretical literature explaining how a non-vertical long-run Phillips curve can arise.[3] For instance, Cooley and Hansen (1989) find a long-run relationship between inflation and real macroeconomic activity in the face of cash-in-advance constraints. Sidaruski (1967) achieves his well-known superneutrality result only under a utility function which is separable in consumption and labor. Bénabou and Konieczny (1994) derive technical constraints for demand and supply functions for which a non-vertical Phillips curve arises under costly price changes.[4] Hughes-Hallet (2000) shows that a non-vertical long-run Phillips curve can arise through the aggregation of sectoral Phillips curves with different short-run slopes. Holden (2003) shows that strategic considerations between large wage-setters, such as industry-unions, can give rise to a non-vertical long-run Phillips curve. By contrast, we do not include cash-in-advance constraints or non-separable utility functions. We do show, however, that costly adjustment gives rise to a non-vertical long-run Phillips curve.

In seminal contributions, Akerlof and co-authors derive a non-vertical long-run Phillips curve from the assumption of money illusion. In their analysis, money illusion manifests itself either in the form of downward nominal wage rigidities (Akerlof et al., 1996; Akerlof and Dickens, 2007) or departures from rational expectations (Akerlof et al., 2000). Our analysis, by contrast, rests on neither permanent downward nominal wage rigidity nor non-rational expectations.

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[2]For the United States, see for example Beyer and Farmer (2007), Karanassou et al. (2008), Russell and Banerjee (2008), Favara and Giordani (2009), Karanassou and Sala (2010), and Berentsen et al. (2011). For a wider set of industrialized countries, examples include Fisher and Seater (1993), King and Watson (1994), Koustas and Veloce (1996), Ball (1997), Koustas (1998), Ball (1999), Dolado et al. (2000), Fair (2000), Ericson et al. (2001), Koustas and Serletis (2003), Gottschalk and Fritsche (2005), and Schreiber and Wolters (2007). Empirical studies that study the Phillips curve in terms of the underlying structural macro models include Bullard and Keating (1995), Ahmed and Rogers (1998), Karanassou et al. (2003, 2005), and Coenen et al. (2004). Concerning developing and emerging countries, see Bae and Ratti (2000) for Argentina and Brazil, Wallace et al. (2004) for Nicaragua, Chen (2007) for Taiwan, Wallace and Shelley (2007) for Mexico, and Puah et al. (2008) for Singapore.

[3]For a thorough survey on the assumptions which lead to non-vertical Phillips curves, refer to Orphanides and Solow (1990).

[4]Related contributions are Kuran (1986), Naish (1986), and Konieczny (1990).

In the context of standard New Keynesian models, a non-vertical long-run Phillips curve arises from time discounting and real price or wage dispersion.[5] This micro-founded long-run Phillips curve is nonlinear, being negligibly positive (due to time discounting) at very low inflation rates and significantly negative (due to wage or price dispersion) at higher inflation rates (Ascari, 1998, 2004; Graham and Snower, 2004).

The notion of fairness that we incorporate into a New Keynesian model is based on inequality aversion. This phenomenon, covering both envy and guilt, is supported by a massive empirical literature.[6] A large body of empirical studies in the behavioral economics literature argues that relative income matters substantially for one's subjective well-being.[7]

We model inequality aversion along the lines of Fehr and Schmidt (1999) and Bolton and Ockenfels (2000). In our analysis, workers compare their real incomes with the average real income of all the workers, feeling envy when their incomes are relatively low and guilt when they are relatively high.[8] Envy is stronger than guilt, a finding supported by much empirical evidence.[9]

The novel contribution of this paper is to show that, in the context of a standard DSGE model with staggered wages, such inequality aversion implies a significant, positive long-run relation between inflation and macroeconomic activity for reasonably low inflation rates.[10] The optimal long-run inflation rate is positive and near 2 percent.

This policy implication is noteworthy, since much of the previous literature on optimal monetary policy suggests that prices should decline or remain stable in the long run. According to the Friedman rule, the optimal rate of deflation is equal to the real interest rate. Models that include cash-in-advance constraints, shopping time technologies, and frictions related to the transactional money demand[11] imply that the optimal inflation rate exceeds the Friedman rule, but is still negative. Schmitt-Grohé and Uribe (2011b, 2012) find negative optimal inflation when considering the quality bias in measurement of inflation. Other models focussing on the costs of price dispersion[12] suggest

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[5]Among many others, King and Wolman (1996), Ascari (1998, 2000, 2004), Devereux and Yetman (2002), Graham and Snower (2003, 2004), Khan et al. (2003), Karanassou et al. (2005), Amano et al. (2007), Bakhshi et al. (2007a), Levin and Yun (2007), Ascari and Merkl (2009), and Coibion et al. (2012).

[6]See, for example, Güth et al. (1982), Roth et al. (1991), Forsythe et al. (1994), Henrich et al. (2001), Karni et al. (2008), and Cappelen et al. (2010, 2011). For surveys of the medical, psychological, and neuroeconomic background for this behavior, see Camerer et al. (2005) and Loewenstein et al. (2008). See also the neuroeconomic evidence of Sanfrey et al. (2003) and Tricomi et al. (2010).

[7]For example, Argyle (1972, 1989), Easterlin (1974, 1995), Kapteyn and Van Herwaarden (1980), van de Stadt et al. (1985), Scitovsky (1992), Clark and Oswald (1996), Solnick and Hemenway (1998), Blanch-flower and Oswald (2004), and Layard et al. (2009). For a thorough survey on the theoretical and empirical literature of the impact of level and relative income on happiness refer to Clark et al. (2008).

[8]This idea draws on theory developed by the psychologists Homans (1961), Adams (1965), and Walster et al. (1978).

[9]See, for example, Jaques (1956, 1961), Messik and Sentis (1979), and Loewenstein et al. (1989).

[10]Other contributions which find such backward-bending shape of the long-run Phillips curve in New Keynesian models are, e.g. Graham and Snower (2008) under hyperbolic discounting, Vaona and Snower (2008) under increasing returns to scale, and Vaona (2013) under fair wages.

[11]For example, King and Wolman (1996), Khan et al. (2003), Schmitt-Grohé and Uribe (2007, 2011a), and Aruoba and Schorfheide (2011).

[12]For example, Goodfriend and King (1997), Galí (2003), Woodford (2003), Yun (2005), and Schmitt-Grohé and Uribe (2011a).

that the optimal inflation rate is zero. Adam and Billi (2006) even find zero optimal inflation, when the zero lower bound on nominal interest rates is binding. Such policy implications are completely at odds with the practice of monetary policy, where positive inflation targets commonly play a central role. Developed countries typically target low inflation rates in an interval from 2 to 3 percent, while developing countries often apply target values which are slightly higher.[13] There are few theoretical rationales for such practices.[14] Against this backdrop, we provide a new justification for positive inflation targeting.

3 The Model Economy

As noted, we incorporate inequality aversion into a standard DSGE model with nominal rigidities and positive trend inflation. Firms are perfectly competitive, while workers are monopolistic competitors. Workers are infinitely lived and worker types are located on the unit interval. Wages are fixed according to the Calvo (1983) nominal contract scheme.[15] The government prints money, issues riskless bonds, and rebates seignorage gains in equal shares to workers as a lump sum. It conducts monetary policy by controlling the growth rate of money supply Δm, which determines long-run inflation[16] π.

3.1 Firms

We assume a large number of identical firms. Firms produce a homogenous good according to a Dixit and Stiglitz (1977) CES production function with differentiated labor n_j as single input.

$$y_t = \left[\int_0^1 n_{j,t}^{\frac{\theta-1}{\theta}} \, \mathrm{d}j \right]^{\frac{\theta}{\theta-1}} \tag{1}$$

The parameter θ denotes the elasticity of substitution between the different labor types and y_t is output. A firm minimizes total costs subject to the firm's production function (1). This yields the firm's demand function for the individual labor type j, given by

$$n_{j,t} = w_{j,t}^{-\theta} y_t, \tag{2}$$

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[13]See, for example, Roger and Stone (2005) and Carare and Stone (2006).

[14]For example, Kim and Ruge-Murcia (2009), Coibion et al. (2012), and Graham and Snower (2013), who find an optimal positive inflation rate in the presence of downward nominal wage rigidity, the zero lower bound on nominal interest, and hyperbolic discounting, respectively.

[15]Alternatively, we can apply the Taylor (1979) staggered contracts scheme. Qualitatively, the result are similar across both approaches. Quantitatively, as has been shown by Ascari (2004), the Calvo approach yields in a stronger sensitivity of real aggregates to trend inflation.

[16]See Nelson (2007, 2008). We choose money growth over an interest rate rule because, as Reynard (2007) shows, the short term interest rate empirically fails to deliver accurate information on subsequent inflation, while monetary aggregates have a much greater explanatory power for the developments of subsequent inflation and output. This view is strongly supported by Favara and Giordani (2009). Karanassou and Sala (2010) argue that money growth captures well the effects of changes in the short term interest rate on inflation, but also covers additional stances of monetary policy such as banking regulations or possible transmission effects of fiscal measures on the yield curve.

where $w_{j,t}$ is the period-t real value of worker j's nominal contract wage. Since nominal wages are fixed for some time $w_{j,t} = \frac{w_{j,t-\iota}}{(1+\pi)^{\iota}}$ with $\iota \in \mathbb{N}_0$ denoting the number of periods since the last reset of worker j's nominal wage. Due to perfect competition in the product market, firms take wages and prices as given and produce output at which the price equals marginal cost. Thus the firms' markup is zero and the aggregate real wage is constant and equal to unity.

3.2 Workers

Workers are monopolistic competitors, maximizing utility subject to the labor demand curves (2) that they face. Wages are fixed according to the Calvo (1983) nominal contract scheme: in every period, a worker has probability $(1 - \alpha)$ to be allowed to reset her contract wage. The worker's utility u depends positively on consumption c_j and negatively on labor n_j. In addition, the worker dislikes employment fluctuations, due to rising marginal disutility of labor. The worker j's preferences are represented by the (social) utility function[17]

$$u_t(c_{j,t}, n_{j,t}, I_{j,t}) = c_{j,t} - \zeta \frac{n_{j,t}^{1+\eta}}{1+\eta} - \psi_{j,t} \frac{I_{j,t}^2}{2}, \tag{3}$$

where η is the inverse of the labor supply elasticity and ζ is the weight of labor in the utility function. The term $I_{j,t}$ denotes the relative real income position of worker j, which is defined as

$$I_{j,t} = w_{j,t} n_{j,t} - \int_0^1 w_{k,t} n_{k,t} \mathrm{d}k, \tag{4}$$

where $w_{k,t} = \frac{w_{k,t-\rho}}{(1+\pi)^{\rho}}$ are the real values of the current wages of all other workers k, where $\rho \in \mathbb{N}_0$ denotes the number of periods since the last reset of worker k's nominal wage and $n_{k,t}$ denotes worker k's employment. In the spirit of Bolton and Ockenfels (2000), worker j compares her real income (first term on the right hand side of equation (4)) to the average real income of all other workers $j \neq k$ (second term on the right hand side of equation (4)).[18] Inequality aversion is captured by the third term of the utility function (3): workers who fall short of average income experience envy, whereas those who exceed it experience guilt. The parameter $\psi_{j,t}$ is an indicator function:

$$\psi_{j,t} = \begin{cases} \varepsilon & \text{for} \quad I_{j,t} < 0 \\ \gamma & \text{for} \quad I_{j,t} > 0 \end{cases}, \tag{5}$$

where ε represents envy and γ represents guilt, under the standard restrictions $0 < \gamma < 1$ and $\varepsilon > 0$ (Fehr and Schmidt, 1999). Furthermore, in line with the experimental evidence, the envy effect exceeds the guilt effect: $\varepsilon = \kappa \gamma$ where $\kappa > 1$ is the coefficient of egocentric bias. For unequal incomes, egocentric bias measures the degree to which

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[17] Karni and Safra (2002) derive an additively separable social utility function of a form comparable to equation (3) from a set of basic axioms.

[18] Alternatively, workers could compare themselves to each other worker individually. Such comparison on a bilateral basis has been suggested by Fehr and Schmidt (1999). Ahrens (2012) explores this alternative and shows that the results of this paper remain fully valid.

workers prefer to be on the favorable side of the income distribution (Messik and Senits, 1979, 1985).[19]

Worker j's period budget constraint is

$$c_{j,t} + m_{j,t+1} + b_{j,t+1} = w_{j,t} n_{j,t} + \frac{R_t b_{j,t} + m_{j,t}}{1+\pi} + \Upsilon_{j,t}, \tag{6}$$

where m_j and b_j are worker j's real money and bond holdings, R is the real interest rate, and Υ_j are net lump sum transfers from the government to worker j. When worker j is allowed to reset her wage, she maximizes her expected discounted utility, with β as the discount factor and α as the Calvo probability (i.e. the probability of holding the wage constant in any given period):

$$\max_{w_{j,t}} E_t \sum_{i=0}^{\infty} (\alpha\beta)^i u_{t+i} (c_{j,t+i}, n_{j,t+i}, I_{j,t+i}), \tag{7}$$

subject to her budget constraint (6) and her labor demand function (2). The optimal wage is set as a markup over the marginal rate of substitution between the present value of the marginal disutilities of labor (the numerator) and the sum of the present values of the marginal utilities of consumption and income (the denominator):

$$w_{j,t}^* = \mu \frac{\zeta E_t \sum_{i=0}^{\infty} (\alpha\beta)^i n_{j,t+i}^{1+\eta}}{E_t \sum_{i=0}^{\infty} (\alpha\beta)^i \frac{n_{j,t+i}}{(1+\pi)^i} - E_t \sum_{i=0}^{\infty} (\alpha\beta)^i \psi_{j,t+i} I_{j,t+i} \frac{n_{j,t+i}}{(1+\pi)^i}}, \tag{8}$$

where $\mu = \frac{\theta}{\theta-1} > 1$ is the monopolistic competitive wage markup. Rearranging equation (8), we obtain the labor supply equation

$$\mu \zeta E_t \sum_{i=0}^{\infty} (\alpha\beta)^i n_{j,t+i}^{1+\eta} = E_t \sum_{i=0}^{\infty} (\alpha\beta)^i (1 - \psi_{j,t+i} I_{j,t+i}) \frac{w_{j,t}^* n_{j,t+i}}{(1+\pi)^i}. \tag{9}$$

3.3 The General Equilibrium

The government prints money m, issues bonds b, and gives direct transfers Υ to the workers. The government's budget constraint is

$$m_{t+1} + b_{t+1} = \frac{R_t b_t + m_t}{1+\pi} + \Upsilon_t. \tag{10}$$

The product market clears:

$$c_t = y_t. \tag{11}$$

Aggregate labor is

$$n_t = \int_0^1 n_{j,t} \mathrm{d}j. \tag{12}$$

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[19] Egocentric bias can be interpreted as Tversky and Kahneman's (1991) loss aversion in social comparison.

Parameter	Symbol	Value
Interest rate	R	4%
Calvo probability	α	0.75
Elasticity of labor substitution	θ	5
implying wage markup		25%
Elasticity of labor supply	ν	4
implying an inverse labor supply elasticity	η	0.25
Envy	ε	0.85
Guilt	γ	0.32
Labor weight in utility function	ζ	1.05
implying share of work in steady state		33%

Table 1: Base calibration

The aggregate wage index is

$$w_t = \left[\int_0^1 w_{j,t}^{1-\theta} \mathrm{d}j \right]^{\frac{1}{1-\theta}}. \tag{13}$$

Since we focus on the long-run relations between inflation and real variables, we consider the behavior of economic agents in the symmetric steady state. By the aggregate wage index (13), the reset wage (i.e. the real wage in the time period when the wage is reset) in the steady state is

$$w_j^* = \left[\frac{1-\alpha}{1-\alpha \left(1+\pi\right)^{\theta-1}} \right]^{\frac{1}{\theta-1}}. \tag{14}$$

The model contains three equations (the reset wage (14), the labor supply (9), and the labor demand (2)) and three variables (the reset wage, aggregate employment, and aggregate output $\left\{ w_j^*, n, y \right\}$).

We solve the model numerically, along the following simple lines. The reset wage w_j^* follows directly from the calibration. Substituting this into the labor supply equation (9) yields the steady state labor supply. Finally, the downward sloping labor demand curve (2) together with the reset wage enables us to solve for aggregate output y.

3.4   Calibration

We calibrate the model in accordance with the standard values in the literature. The annual interest rate R is 4 percent, equivalent to a quarterly discount factor $\beta = 0.99$. Following Talyor (1999), nominal wages are assumed to remain fixed for one year, on average. Given that the Calvo pricing scheme follows a Poisson process, this average duration is generated by a Calvo probability $\alpha = 0.75$. The elasticity of substitution among the different types of labor is $\theta = 5$, implying a steady state wage markup of 25 percent, supported by Graham and Snower (2013) and close to values reported by Ascari (2000), Erceg et al. (2000), and Galí et al. (2011). Following Yun (1996) and
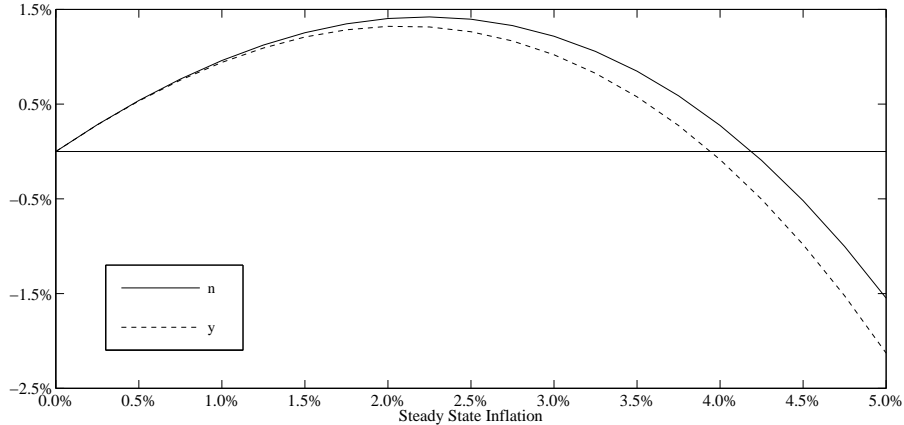
Figure 1: Relation of inflation to real variables

empirical evidence from Imai and Keane (2004) and Ransom and Sims (2010), we set the elasticity of labor supply to $v = 4$, implying that $\eta = 0.25$. Furthermore, following Ascari and Merkl (2009), the weight of labor in the utility function $\zeta = 1.05$ is chosen so that workers work approximately one-third of their available time endowment in the zero-inflation steady state.

Finally, we calibrate the parameters governing envy and guilt in accordance with results from the experimental literature on ultimatum games. Fehr and Schmidt (1999) compute distributions for the envy and guilt parameters. Averaging these distributions yields $\gamma = 0.32$ and $\varepsilon = 0.85$. These parameter values imply that envy is stronger than guilt by a factor $\kappa = 2.7$, identical to the value reported by Loewenstein et al. (1989).[20] Table 1 summarizes our base calibration.

4 Results

Figure 1 presents the Phillips curve for the base calibration given in Table 1. On the vertical axis we show the deviations of aggregate employment and output from their respective values at the zero-inflation steady state. The horizontal axis measures the steady state inflation rate.[21]

This figure shows that monetary policy has substantial long-run real effects. Expansionary monetary policy that raises inflation from $\pi = 0$ percent to $\pi = 2$ percent is associated with an increase in aggregate employment by 1.40 percent and in aggregate output by 1.32 percent. (This positive relation between inflation and macroeconomic

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[20]The authors find the disadvantageous part of the utility function to be approximately 2.7 times as steep as the advantageous part for neutral relationships.

[21]From Ascari (2004), Amano et al. (2007), and Bakhshi et al. (2007a) we know that the Calvo staggering scheme is inadequate for steady state inflation rates exceeding 5 percent. Therefore, we restrict ourselves to inflation rates up to 5 percent.

activity is almost entirely driven by the influence of envy and guilt, as we will show in Section 4.2.) The expansionary effect of monetary policy declines as the inflation rate rises. For inflation rates above around $\pi = 2.25$ percent, further increases in the rate of money growth lead to reduced aggregate employment and output.

4.1 Intuition

There are four channels whereby monetary policy affects output and employment in the long run.

1. *The employment cycling effect:* When inflation is positive, the real wage falls over the contract period (since the nominal wage is constant over the contract period while the price level rises). Under Calvo wage staggering, different workers reset their nominal wages at different times. For those workers that have recently reset their nominal wages, the real wage is relatively high; whereas for those workers that have not done so, the real wage is relatively low. Thus inflation is accompanied by fluctuations of relative wages. These fluctuations lead to fluctuations in relative employment rates across workers, as firms substitute cheap workers for expensive ones. This substitution is inefficient (i.e. it reduces output, ceteris paribus), since workers are imperfect substitutes. The greater is the inflation rate, the greater is the amount of labor substitution and, due to the resulting inefficiency, the lower is aggregate output. Consequently employment cycling implies an inverse relation between inflation and macroeconomic activity.

2. *The labor smoothing effect:* The greater the inflation rate, the more the worker's labor supply varies over the cycle. Workers dislike variable labor supply trajectories, since their marginal disutility of labor rises with labor supplied. Thus a rise in inflation leads to a rise in the average real reservation wage over the contract period and thereby to a fall in employment and output. Thus the labor smoothing effect also yields an inverse relation between inflation and macroeconomic activity.

3. *The envy-guilt effect:* Workers experience relatively low incomes early in the contract period and relatively high incomes later.[22] Thus they experience envy early in the expected contract period. To reduce their disutility from envy, they increase their average employment over the expected contract period. Furthermore, they experience guilt later in the contract period, inducing them to decrease their average employment. But since the effect of envy is stronger than that of guilt, average employment rises over the expected contract period. The greater is the inflation rate, the greater is the associated employment and output. Thereby the envy-guilt effect generates a positive relation between inflation and macroeconomic activity.

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[22]Since workers are monopolistic competitors in the labor market, the elasticity of labor demand is greater than unity at the utility-maximizing employment level. Thus the relatively high real wages early in the contract period are associated with relatively low labor incomes.
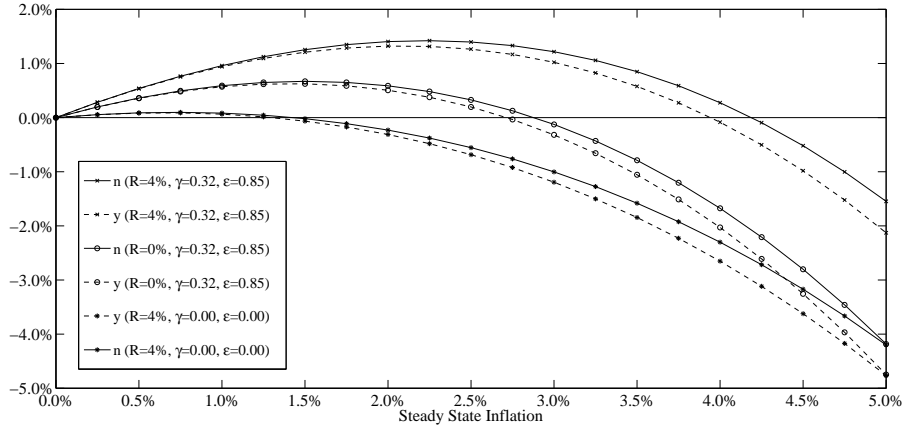
Figure 2: The complementarity between the discounting and envy-guilt effects

4. *The discounting effect:* Since future utilities are discounted more heavily than present ones, the relatively high marginal disutilities of work occurring late in the contract period are discounted more heavily than the relatively low marginal disutilities of work occurring earlier. Accordingly, the discounting effect leads workers to supply more labor. Furthermore, guilt (felt late in the contract period) is more heavily affected by discounting than envy (felt early in the contract period). Since guilt reduces labor supply while envy stimulates it, the discounting effect leads to a further increase in labor supply.

Clearly, the latter discounting effect is complementary with the envy-guilt effect. This complementarity is illustrated in Figure 2, where the upper two Phillips curves portray the relation between inflation (on the horizontal axis) and employment and output (on the vertical axis) in the presence of both the discounting and the envy-guilt effects (as well as the other effects above), whereas the middle two Phillips curves portray this relation in the absence of the discounting effect. The vertical difference measures the size of the complementarity between the discounting effect and the envy-guilt effect (with respect to employment and output).

The lower two Phillips curves portray the long-run relationship between inflation and macroeconomic activity in the absence of inequality aversion, so that only the discounting, employment cycling, and labor smoothing effects are operative. This is the standard case in the existing literature, where the positive long-run tradeoff is quantitatively negligible and turns significantly negative already for very low inflation rates (Ascari, 1998, 2004; Graham and Snower, 2004; Levin and Yun, 2007). Therefore, in the absence of envy and guilt, monetary policy is barely effective at very low inflation rates, and counterproductive even at moderate ones.
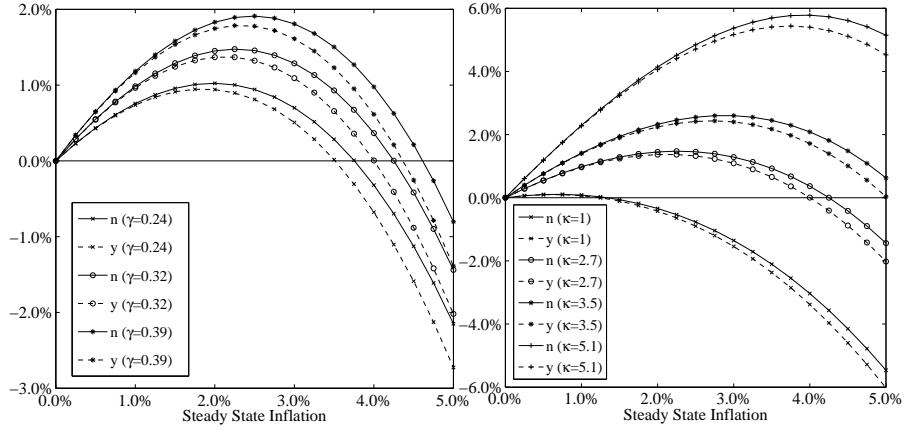
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Figure 3: Sensitivity with respect to guilt parameters

4.2 Sensitivities

Figure 3 shows the sensitivity of the Phillips curve with respect to a range of values for the envy and guilt parameters that have been found in the literature. Holding egocentric bias constant (κ, representing the relation between envy and guilt: $\varepsilon = \kappa\gamma$), the left panel of Figure 3 shows the Phillips curve for the following values of the guilt parameter: $\gamma \in (0.24; 0.32; 0.39)$. Whereas our base case is $\gamma = 0.32$, the value $\gamma = 0.24$ was supported by Fehr and Schmidt (2003) and the value $\gamma = 0.39$ was found by Goeree and Holt (2000).[23] Figure 3 shows, not surprisingly, that the guilt and envy effects strengthen the positive long-run effect of monetary policy on output and employment.

The right panel of Figure 3 indicates that this positive effect rises with the degree of egocentric bias, i.e. the greater the envy associated with any given level of guilt, the more monetary policy stimulates output and employment in the long run. This result is also not surprising in the light of the analysis above. The figure shows the Phillips curve for the following values of the egocentric bias parameter: $\kappa \in (1; 2.7; 3.5; 5.1)$, where our base case is $\kappa = 2.7$. With the exception of $\kappa = 1$, all values of the egocentric bias parameter are taken from Loewenstein at al. (1989). The authors find that egocentric bias increases, if workers have an emotional relationship to the subject they compare with. If they like the other subject, egocentric bias mildly increases to $\kappa = 3.5$, while it almost doubles to $\kappa = 5.1$, if they dislike the other subject. When $\kappa = 1$, there is no egocentric bias. In this case, the envy-guilt effect has a relatively small influence in generating a positive tradeoff between inflation and macroeconomic activity. This result holds irrespective of the value of γ.

Figure 4 shows the sensitivity of the Phillips curve with respect to reasonable

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[23]Goeree and Holt (2000) estimate the Fehr and Schmidt parameters with experimental data from a two-stage ultimatum game. Support for their estimates comes from Blanco et al. (2011), who apply the same estimation methodology but resort to observations obtained from ultimatum games, dictator games, public goods games, and prisoner's dilemma games. They find the value $\gamma = 0.38$.
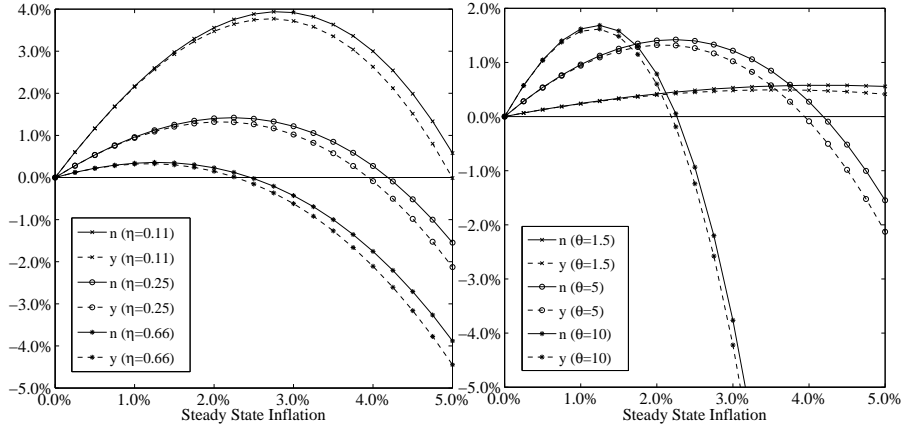
Figure 4: Sensitivity with respect to elasticities

values for the labor supply elasticity ($\nu = \frac{1}{\eta}$) and labor substitution elasticity (θ). The left panel of Figure 4 juxtaposes Phillips curves for the labor supply elasticities $\nu \in (1.5; 4; 9)$, where our base case is $\nu = 4$ ($\eta = 0.25$). The higher labor supply elasticity $\nu = 9$ (and $\eta = 0.11$) was estimated by Abowd and Card (1989) and the lower value $\nu = 1.5$ ($\eta = 0.66$) was found by Mulligan (1999) and Heckman et al. (1998). The latter is also very close to the values chosen by Rotemberg and Woodford (1996) and Hansen and Wright (1992) in their theoretical contributions. As is apparent from the left panel of Figure 4, the lower the labor supply elasticity (i.e. the higher η), the smaller the effect of monetary policy on aggregate employment and output. Intuitively, the greater the convexity of utility with respect to labor, the stronger is the labor smoothing effect,[24] which shifts the Phillips curve downwards.

The right panel of Figure 4 shows how the Phillips curve is affected by the degree of labor substitutability over the interval $\theta \in (1.5; 5; 10)$. The higher the value θ, the more substitutable are the labor types. We contrast our base case $\theta = 5$ with a very low degree of substitutability $\theta = 1.5$ as estimated by Ciccone and Peri (2005) and a high degree of substitutability $\theta = 10$ as found in Fagan and Messina (2009).[25] As the right panel of Figure 4 indicates, the more substitutable labor types are, the greater the real effects of monetary policy, but over a narrower range.[26] Intuitively, raising the substitutability of labor types has three effects on aggregate employment and output.

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[24]Furthermore, the higher η, the larger the weight of disutility of labor in the utility function (ζ). For $\eta = 0.66$, ζ increases from 1.05 to 1.65, while it decreases to 0.9025 for $\eta = 0.11$.

[25]On the basis of various country studies, Aidt and Tzannatos (2002) summarize that the average wage markup in industrialized as well as in developing countries lies in the interval between 10 percent and 25 percent, which implies $5 \le \theta \le 10$. The low value found by Ciccone and Peri (2005) arises from the fact that they explicitly estimate the markup for high skilled workers over low skilled workers.

[26]The high sensitivity of the Phillips curves to steady state inflation for large values of θ is a common technical problem of the Calvo staggering mechanism and has been intensively discussed by Ascari (2004) and Bakhshi et al. (2007a).
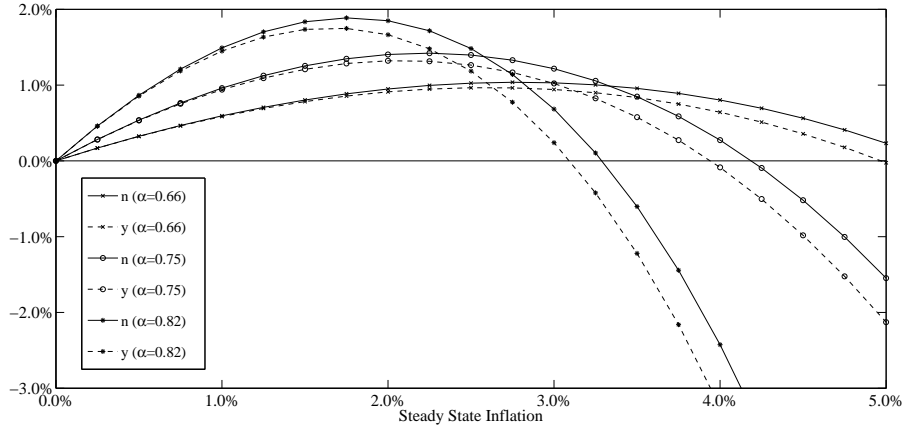
Figure 5: Sensitivity with respect to wage stickiness

First, it reduces the inefficiencies from labor substitution, so that for a given amount of employment cycling, output increases. Second, as labor substitution becomes cheaper, there is more employment cycling, so that output decreases[27] (ceteris paribus). Third, the increase in employment cycling is associated with more dispersion of incomes, eliciting more envy and guilt. Since the envy effect is greater than the guilt effect, aggregate output increases (ceteris paribus).

As is apparent from the right panel of Figure 4, the positive effects on output, driven primarily by the envy-guilt effect,[28] are dominant at low inflation rates, whereas the negative effects on output (from additional employment cycling) are dominant at higher inflation rates.

Figure 5 shows the Phillips curve for different Calvo probabilities over the range $\alpha \in (0.66; 0.75; 0.88)$. While in our base calibration wages change on average once a year ($\alpha = 0.75$), Barattieri et al. (2010) find wages to be a little less flexible, with wages changing on average every six quarters ($\alpha = 0.82$). Christiano et al. (2005) estimate wages to be sticky for approximately half a year ($\alpha = 0.66$). As in the previous figure, Figure 5 indicates that the stickier wages are, the more effective is monetary policy, but over a narrower range. Intuitively, the lower is the probability of holding the nominal wage constant in any given period, the larger is wage dispersion and thus also income dispersion. Consequently, there is more envy and guilt, and since the envy effect is stronger, output increases. On the other hand, a larger real wage dispersion implies more labor substitution, which promotes employment cycling and thereby reduces output. The envy effect dominates at low inflation rates, while the employment cycling effect dominates at high inflation rates.

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[27]Employment cycling has a direct, negative effect on output, as well as an indirect, negative effect via the worker's reservation wage (which rises because the worker's utility falls when employment cycling increases).

[28]It can be shown that these positive effects are negligible in the absence of envy and guilt.

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	$\gamma = 0.24$	$\gamma = 0.32$	$\gamma = 0.39$
$\kappa = 2.7$	1.70%	1.83%	1.92%
$\kappa = 3.5$	1.97%	2.16%	2.30%
$\kappa = 5.1$	2.47%	2.75%	2.96%

Table 2: Welfare with respect to envy and guilt

5   Optimal Monetary Policy

In this section we analyze the influence of inequality aversion for optimal monetary policy. In contrast to the standard analysis, in which the optimal inflation rate lies between zero and a negative number, we show that the presence of envy and guilt implies a positive inflation target for optimal monetary policy. Inflation targets result to live in the neighbourhood of two percent.

In the long run, the optimal rate of money growth (equal to the optimal inflation rate) maximizes the lifetime utility of the representative worker:

$$\max_{1+\pi} E_t \sum_{i=0}^{\infty} (\alpha\beta)^i u_{t+i} \left(c_{j,t+i}, n_{j,t+i}, I_{j,t+i} \right), \tag{15}$$

subject to the labor demand constraint (2), the labor supply constraint (9), and the reset wage (14).

Table 2 presents the optimal inflation rate for standard values of the envy-guilt parameters. In the base case ($\kappa = 2.7$ and $\gamma = 0.32$) we find that optimal inflation is slightly below 2 percent (namely, 1.83%). The higher is the value of the guilt parameter (with constant egocentric bias), the higher is the optimal inflation rate. Also, greater egocentric bias (with a constant guilt parameter) implies higher optimal inflation.

The intuition underlying these results is straightforward. When the inflation rate is zero, output and employment are inefficiently low, since workers are monopolistic competitors in the labor market. When money growth (and thus the long-run inflation rate) rises above zero, welfare is affected through the following distinct channels: (1) it reduces the inefficiency from monopolistic competition and thereby raises the utility from consumption, (2) it raises the inefficiency from employment cycling, (3) it increases the disutility of labor due to a more volatile labor trajectory and (4) it increases the disutility from envy and guilt. While the size of the effects (2)-(4) increases with the rate of inflation, the size of the effect (1) is independent of the inflation rate. On this account, effect (1) is relatively large at low inflation rates, while effects (2)-(4) are relatively large at higher inflation rates. These influences are pictured in Figure 2. Due to the envy-guilt effects (and, to a much lesser degree, the discounting effect[29]), higher money growth leads to higher employment and output, for low inflation rates. Thereby the envy and guilt effects provide a mechanism whereby a positive long-run rate of money growth is able to reduce the inefficiency from monopolistic competition.[30]

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[29]As indicated in Figure 2, the discounting effect alone makes a negligible contribution to the long-run expansionary influence of monetary policy, in line with Ascari (2004), Graham and Snower (2004), and Levin and Yun (2007). Accordingly, the optimal money growth rate is close to zero in this case.

[30]Note that in the absence of both discounting and inequality aversion, the inefficiencies due to wage dis-

	$\gamma = 0.24$	$\gamma = 0.32$	$\gamma = 0.39$
alternative η:			
$\eta = 0.11$	2.32%	2.54%	2.70%
$\eta = 0.66$	0.92%	0.97%	1.01%
alternative θ:			
$\theta = 1.5$	3.23%	3.54%	3.81%
$\theta = 10$	0.96%	0.97%	0.99%
alternative α:			
$\alpha = 0.66$	1.94%	2.13%	2.27%
$\alpha = 0.82$	1.51%	1.59%	1.65%

Table 3: Welfare with respect to model parameters

Needless to say, there are many further reasons (other than monopolistic competition in the labor market) why output and employment may be inefficiently low at zero inflation, such as distortionary taxes, efficiency-wages, insider-outsider or union-power effects. Furthermore, such inefficiencies can be reduced through many policies other than monetary policy. However, the overarching implication of our analysis is this: If, for whatever reason the equilibrium levels of output and employment are inefficiently low – after the government has implemented all its chosen fiscal and structural policies – then expansionary monetary policy can be welfare-promoting by reducing the residual inefficiency.

Table 3 shows how the optimal inflation rate varies with respect to various values for the elasticity of labor substitution (θ), the inverse labor supply elasticity (η), and the Calvo probability (α).

The first two rows of Table 3 show that the optimal inflation rate falls with the inverse labor supply elasticity η. Intuitively, when the convexity of utility with respect to labor rises, the disutility of work increases relative to the utility of consumption. Since the benefits of extra output decline more rapidly, this reduces the optimal inflation rate.

The next two rows of Table 3 show that the greater the substitutability among labor types, the lower is the optimal inflation rate. The lower θ, the higher is the market power of each labor type, and thus the larger is the inefficiency from monopolistic competition, implying a higher optimal inflation rate.

Finally, the last two rows of Table 3 indicate that the higher is the Calvo probability (α), the lower is the optimal inflation rate. Intuitively, the greater the degree of wage stickiness (measured by a higher Calvo probability α) the more dispersed the real wage distribution and the greater employment cycling. This reduces utility due to the inefficiency of employment cycling, workers' aversion to volatile incomes, and the envy and guilt effects. Thus the optimal inflation rate falls.

persion - the employment cycling and labor smoothing effects - drive down aggregate output and employment at any positive rate of steady state inflation, calling for a zero optimal inflation rate.

6 Endogenous Frequency of Nominal Adjustment

Thus far we have assumed that the average frequency of nominal wage adjustments is constant, independent of the inflation rate. This assumption, however, is vulnerable to the Lucas critique, since agents have an incentive to respond to higher trend inflation with more frequent wage adjustments. Recent empirical evidence for such a positive relationship between the average frequency of wage adjustment and inflation is provided by Druant et al. (2009) for the euro area and by Barattieri et al. (2010) for the United States.[31]

We now ask whether a substantial, positive tradeoff between inflation and macroeconomic activity remains after this effect is taken into account. Our analysis shows that though this positive tradeoff is weakened somewhat, it remains strong for standard calibrations. The reason for this result is to be found in the costs of nominal wage adjustments, which include not only negotiation costs, but also the concomitant performance and salary reviews. When expansionary monetary policy leads to higher long-run inflation, the average frequency of nominal wage adjustments rises, but on account of the cost of these wage adjustments, it does not rise sufficiently to eliminate the Phillips curve tradeoff.

We endogenize the average frequency of nominal wage adjustments in the following way. Following Levin and Yun (2007), we suppose that workers can choose the probability of wage adjustment in each period. Each wage adjustment is assumed to involve a fixed cost F. The greater the probability of wage adjustment, the greater is the probability of incurring this cost.[32] Each worker sets the Calvo probability (α) so as to maximize the discounted sum of her current and future expected utilities:

$$\max_{\alpha} \frac{1-\alpha\beta}{1-\beta} \left[\sum_{i=0}^{\infty} (\alpha\beta)^i \left(c_{j,t+i} - \zeta \frac{n_{j,t+i}^{1+\eta}}{1+\eta} - \psi_{j,t+i} \frac{I_{j,t+i}^2}{2} \right) - F \right], \qquad (16)$$

subject to her budget constraint (6) and her labor demand function (2).

The fixed cost F is calibrated to yield an average duration of wage contracts of one year, given a steady state inflation rate of 2 percent. This is broadly consistent with macroeconomic empirical evidence on the average duration of wage contracts (Taylor, 1999; Barattieri et al., 2010; Druant et al., 2009) and average inflation rates in the OECD in recent past (Pain et al., 2008).

Figure 6 juxtaposes the Phillips curves associated with exogenous (crossed) and endogenous (circled) wage adjustment probabilities. The figure shows that a significant long-run tradeoff survives even in the face of endogenous wage adjustment. The reason, as noted, lies in the costs of wage adjustments. As noted, an increase in steady state inflation raises employment cycling, which workers seek to avoid. They can do so by raising the average frequency of wage adjustments. This is costly, however. Consequently workers raise the frequency of wage adjustments only slightly in response to an increase in inflation arising from expansionary monetary policy.

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[31] Early cross-country empirical evidence for such a relationship is summarized by Taylor (1999).

[32] Alternative endogenizations of nominal adjustment in the Calvo model include Romer (1990), Dotsey et al. (1999), Devereux and Yetman (2002), and Bakhshi et al. (2007b). Endogenizations of the Taylor model (Taylor, 1979) of wage staggering include Kiley (2000) and Graham and Snower (2004).
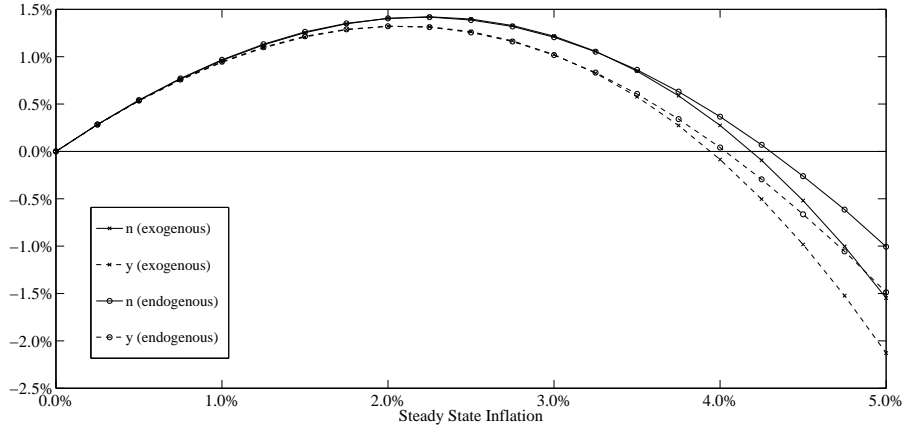
Figure 6: Relation of inflation to real variables with endogenous contract length

In the absence of such costs, workers would adjust wages immediately and fully to every change in inflation (i.e. $\alpha = 0$), so that the classical dichotomy would be reestablished. Since the calibration above implies large wage adjustment costs, however, much of the Phillips curve tradeoff survives.[33]

7   Conclusion

This paper has incorporated inequality aversion into an otherwise standard New Keynesian DSGE model with staggered, monopolistically competitive nominal wage contracts. In this context, the relation between inflation and macroeconomic activity is generated by four phenomena: employment cycling, labor supply variability, discounting, and envy-guilt effects. The first two phenomena imply an inverse relation between inflation and macroeconomic activity, whereas the last two are complementary and imply a positive relation. Furthermore, the last two dominate at low inflation rates, whereas the first two dominate at high inflation rates. Consequently, the Phillips curve is backward-bending, so that increases in money growth lead to higher employment and output at low inflation, but to lower employment and output at high inflation.

What is striking about this tradeoff is that inequality aversion generates a positive tradeoff between inflation and macroeconomic activity over a substantial range of low inflation rates. We show that, along this tradeoff, the optimal inflation rate is significantly positive. For our base calibration, the optimal inflation rate is just under 2 percent.

This result is consonant with central banking practice. By contrast, the mainstream literature on optimal monetary policy places the optimal inflation rate in the range between zero and a negative number (minus the real interest rate, as implied by the

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[33]This result is in line with the finding of Graham and Snower (2004).

Friedman rule).

Endogenizing the probability of wage adjustment does not restore monetary long-run neutrality, as long as wage changes are costly.

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Appendix

1. Worker j's Labor Supply Curve

The worker maximizes her expected discounted utility (17)

$$\max_{w_{j,t}} E_t \sum_{i=0}^{\infty} (\alpha\beta)^i \left[c_{j,t+i} - \zeta \frac{n_{j,t+i}^{1+\eta}}{1+\eta} - \psi_{j,t+i} \frac{I_{j,t+i}^2}{2} \right], \tag{17}$$

subject to her budget constraint (6) and her downward-sloping labor demand function (2). The first order condition of this maximization problem yields

$$E_t \sum_{i=0}^{\infty} (\alpha\beta)^i \left[(1-\theta) \frac{n_{j,t+i}}{(1+\pi)^i} + \theta\zeta \frac{n_{j,t+i}^{1+\eta}}{w_{j,t}} - (1-\theta)\psi_{j,t+i} I_{j,t+i} \frac{n_{j,t+i}}{(1+\pi)^i} \right] = 0. \tag{18}$$

Rearranging equation (18) and solving for $w_{j,t}$ yields the optimal reset wage (8) as in Section 3.2.

2. Steady State Relative Wage

Given the Calvo (1983) mechanism, the aggregate wage index (13) can be written as a weighted average of newly set wages and the past periods wage index.

$$w_t = \left[(1-\alpha) w_{j,t}^{*1-\theta} + \alpha \left(\frac{w_{t-1}}{1+\pi} \right)^{1-\theta} \right]^{\frac{1}{1-\theta}}. \tag{19}$$

In the steady state we drop time indices

$$w^{1-\theta} = (1-\alpha) w_j^{*1-\theta} + \alpha \left(\frac{w}{1+\pi} \right)^{1-\theta}. \tag{20}$$

Given $w = 1$, (20) breaks down to the optimal relative steady state wage given by equation (14).

3. The Long-Run Tradeoff Between Inflation and Aggregate Output

In the following we derive the long-run Phillips curve based on the optimal reset wage (8), the downward-sloping labor demand curve (2), and the steady state reset wage (14). Applying the downward sloping labor demand equation (2), we can write equation (8) in terms of aggregate labor

$$w_{j,t}^{*(1+\theta\eta)} = \mu \frac{\zeta E_t \sum_{i=0}^{\infty} \left(\alpha\beta (1+\pi)^{\theta(1+\eta)} \right)^i y_{t+i}^{1+\eta}}{E_t \sum_{i=0}^{\infty} \left(\alpha\beta (1+\pi)^{(\theta-1)} \right)^i (1 - \psi_{j,t+i} I_{j,t+i}) y_{t+i}}. \tag{21}$$

Substituting (4) for $I_{j,t+i}$ and dropping time indices yields the steady state expression of (21) given by

$$w_j^{*(1+\theta\eta)} = \mu \frac{\phi}{\chi}, \tag{22}$$

with

$$\phi = y^{\eta} \zeta E \sum_{i=0}^{\infty} \left(\alpha\beta \left(1+\pi\right)^{\theta(1+\eta)} \right)^{i}, \tag{23}$$

$$\chi = E \sum_{i=0}^{\infty} \left(\alpha\beta \left(1+\pi\right)^{(\theta-1)} \right)^{i} \left(1 - \psi_{j,i} y \left[\left(\frac{w_j^*}{(1+\pi)^i} \right)^{1-\theta} - 1 \right] \right). \tag{24}$$

Next, to solve the model numerically, we need to let the infinite sums in equations (23) and (24) converge. The sum formulation in (23) can be written in terms of the infinite geometric sum according to the rule $\sum_{k=o}^{\infty} x^k = \frac{1}{1-x}$, which results in

$$\phi = y^{\eta} \zeta \frac{1}{1 - \alpha\beta \left(1+\pi\right)^{\theta(1+\eta)}}. \tag{25}$$

For equation (24), this is different. Note that the summation in (24) includes periods of envy as well as periods of guilt. While the worker feels envy in periods $t = 0, \dots, \tau - 1$, she feels guilt in periods $t = \tau, \dots, \infty$. The threshold τ denotes the switching point of the sign on the left hand side of equation (4). Applying the indicator function (5), equation (24) reads

$$\chi = E \sum_{i=0}^{\tau-1} \left(\alpha\beta \left(1+\pi\right)^{(\theta-1)} \right)^{i} \left(1 - \varepsilon y \left[\left(\frac{w_j^*}{(1+\pi)^i} \right)^{1-\theta} - 1 \right] \right) \tag{26}$$

$$+ \ E \sum_{i=\tau}^{\infty} \left(\alpha\beta \left(1+\pi\right)^{(\theta-1)} \right)^{i} \left(1 - \gamma y \left[\left(\frac{w_j^*}{(1+\pi)^i} \right)^{1-\theta} - 1 \right] \right).$$

The sum formulation in (26) can be written in terms of (in-)finite geometric sums. We apply the rules $\sum_{k=0}^{\tau-1} x^k = \frac{1-x^{(\tau-1)+1}}{1-x}$ and $\sum_{k=\tau}^{\infty} x^k = \frac{x^{\tau}}{1-x}$. After some manipulations equation (26) becomes

$$\chi = \frac{y^{-1} + \left(\varepsilon + (\gamma - \varepsilon) \left(\alpha\beta(1+\pi)^{\theta-1} \right)^{\tau} \right)}{1 - \alpha\beta(1+\pi)^{\theta-1}} - \frac{\left(\varepsilon + (\gamma - \varepsilon) \left(\alpha\beta(1+\pi)^{2(\theta-1)} \right)^{\tau} \right)}{w_j^{*(\theta-1)} \left(1 - \alpha\beta(1+\pi)^{2(\theta-1)} \right)}. \tag{27}$$

Plugging (25) and (27) back into (22) yields

$$w_j^{*(1+\theta\eta)} = \mu \frac{y^{\eta-1} \zeta \left(1 - \alpha\beta(1+\pi)^{\theta(1+\eta)} \right)^{-1}}{\frac{y^{-1} + \left(\varepsilon + (\gamma-\varepsilon) \left(\alpha\beta(1+\pi)^{\theta-1} \right)^{\tau} \right)}{1 - \alpha\beta(1+\pi)^{\theta-1}} - \frac{\left(\varepsilon + (\gamma-\varepsilon) \left(\alpha\beta(1+\pi)^{2(\theta-1)} \right)^{\tau} \right)}{w_j^{*(\theta-1)} \left(1 - \alpha\beta(1+\pi)^{2(\theta-1)} \right)}}. \tag{28}$$

Exploiting the steady state reset wage (14), equation (28) fully describes the relationship between output and steady state inflation, which can be solved for numerically. Therefore, equations (14) and (28) describe our long-run Phillips curve tradeoff. Note that for zero steady state inflation, i.e. $\pi = 0$, it holds that $w_j^* = 1$ and the envy and guilt parts cancel each other out and vanish. What remains is the standard formulation from a model without envy and guilt, i.e. $1 = \mu \zeta y^{\eta}$.

4. The Long-Run Tradeoff Between Inflation and Aggregate Employment

To derive the relationship between inflation and aggregate labor, we first combine the equations for aggregate labor (12) and individual labor demand (2). This yields

$$n_t = y_t \underbrace{\int_0^1 w_{j,t}^{-\theta} \mathrm{d}j}_{s_t}, \tag{29}$$

where s_t denotes the wage dispersion term, which can be written as

$$s_t = (1-\alpha)w_{j,t}^{-\theta} + \alpha(1-\alpha)\left(\frac{w_{j,t-1}}{(1+\pi)^{-1}}\right)^{-\theta} + \alpha^2(1-\alpha)\left(\frac{w_{j,t-2}}{(1+\pi)^{-2}}\right)^{-\theta} + \dots . \tag{30}$$

Equation (30) can be recursively written as

$$s_t = (1-\alpha)w_{j,t}^{-\theta} + \alpha(1+\pi)^{\theta}s_{t-1}. \tag{31}$$

In the steady state this yields

$$s = \frac{(1-\alpha)w_j^{-\theta}}{1-\alpha(1+\pi)^{\theta}}. \tag{32}$$

Therefore, the steady state version of (29) - including the definition for s given by (32) - and long-run Phillips curve (28) yields the long-run tradeoff between inflation and aggregate employment.