From Deviations to Shortfalls: The Effects of the FOMC's New Employment Objective[*]

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Abstract

The Federal Open Market Committee (FOMC) recently revised its interpretation of its maximum employment mandate. In this paper, we analyze the possible effects of this policy change using a theoretical model with frictional labor markets and nominal rigidities. A monetary policy which stabilizes "shortfalls" rather than "deviations" of employment from its maximum level leads to higher inflation and more hiring at all times due to expectations of more accommodative future policy. Thus, offsetting only shortfalls of employment results in higher nominal policy rates on average which provide more policy space and better outcomes during a zero lower bound episode. Our model suggests that the FOMC's reinterpretation of its employment mandate could alter the business-cycle and longer-run properties of the economy and result in a steeper reduced-form Phillips curve.

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1 Introduction

At the conclusion of the Federal Reserve's recent policy review, the Federal Open Market Committee (FOMC) made several changes to its Statement on Longer-Run Goals and Strategy. One important change was the Committee's reinterpretation of its maximum employment mandate. Specifically, the Statement now communicates that, "the Committee seeks over time to mitigate shortfalls of employment from the Committee's assessment of its maximum level ..." In contrast, the previous consensus statement cited a desire to stabilize "deviations" of employment from its maximum level. In explaining this policy change, Federal Reserve Chair Jerome Powell stated that, this change "means that we will not tighten monetary policy solely in response to a strong labor market."[1]

This policy change from offsetting both positive and negative employment deviations to instead stabilizing one-sided shortfalls introduces an asymmetry in the monetary policy reaction function. In this paper, we analyze the possible effects of this new policy using a theoretical model which combines frictional labor markets, nominal rigidities, and the zero lower bound. To properly account for the asymmetric policy reaction function, we solve our model using a global solution method. In addition, we discipline our model's calibration using observed fluctuations in unemployment, inflation, hours worked, and nominal interest rates over the 25 years immediately preceding the new consensus statement.

A monetary policy which stabilizes "shortfalls" rather than "deviations" of employment from its maximum level affects firm price setting and hiring behavior in all states of the world. Since policymakers will not lean against a tight labor market under a shortfalls-stabilization rule, the expectation of more accommodative policy leads forward-looking price setters to set higher prices to maintain their desired markups in the face of higher expected future demand. Similarly, expectations for greater demand for their products cause firms to increase their demand for labor and hiring. This expansionary expectations effect of the shortfalls rule is strongest when the economy is in an expansion and unemployment is below its longer-run value. In contrast, the differences between the hiring and price setting decisions under both policies are smaller when unemployment is high since the expectations of more accommodative policy under a shortfalls policy is sufficiently far off in the future.

The greater price increases and increased hiring under the shortfalls-stabilization rule leads to higher inflation, employment, and nominal policy rates on average. Switching to a shortfalls rule raises average inflation by about 50 basis points and lowers the longer-run unemployment rate by 20 basis points in our calibrated model. The shift in average inflation more than offsets the downward bias in average inflation stemming from the presence of the zero lower bound and adverse fluctuations in the labor market. Finally, the higher inflation and lower unemployment combine to increase the average nominal policy rate in the economy by roughly 50 basis points. Thus, adopting a shortfalls-stabilization rule provides additional policy space to a central bank facing a zero lower bound (ZLB) constraint.

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[1] See Powell (2021). The FOMC revised its Statement on Longer-Run Goals and Monetary Policy Strategy in August 2020 and is available at
`www.federalreserve.gov/monetarypolicy/files/FOMC_LongerRunGoals.pdf`.

In addition to these changes in average outcomes for the economy, changing to a one-sided shortfalls rule increases the likelihood of robust expansions with higher inflation and lower unemployment. Specifically, our model predicts a pronounced decline in the probability of inflation outcomes below 1% while the realizations of inflation above 3% become more likely. With respect to the labor market, our model implies that low unemployment outcomes (4% or below) become more frequent under the shortfalls rule while we see little change in the frequency of high unemployment rates above 7%. Thus, a shortfalls rule does not prevent high unemployment rates during recessions but instead ensures a more rapid return to full employment in a recovery and more sustained periods of low unemployment during expansions. Taken together, our model implies a steepening of the reduced-form Phillips curve if policymakers change to a shortfalls-stabilization rule.

These changes in the business-cycle and longer-run properties of the economy under a shortfalls-stabilization rule also lead to better outcomes at the zero lower bound relative to a symmetric deviations rule. A shortfalls-only policy rule helps stabilize the economy at the zero lower bound since households and firms understand that the central bank will deliver a more accommodative policy in the future. This helps offset the contractionary effects of the zero lower bound today. Specifically, a one-sided shortfalls rule performs better than a deviations-stabilization rule as it does not try and offset positive employment developments during the recovery. Moreover, the zero lower bound binds less often and results in shorter zero lower bound episodes under a shortfalls-stabilization rule since higher average inflation and employment lead to higher nominal interest rates on average.

Our primary goal is examining the *descriptive* outcomes of the FOMC's change in employment objective rather than evaluating the optimality of this choice under prescriptive optimal policy. At first glance, the higher average inflation under the shortfalls rule could imply lower household welfare due to the presence of nominal price rigidities. However, when we compute household welfare under both the deviations and shortfalls rule, we find that households actually are better off under the one-sided shortfalls rule (at least in our calibrated model). Thus, the benefits to households of more sustained periods of low unemployment under the shortfalls rule more than offsets the negative welfare effects of higher average inflation.

Our work complements other recent research on the FOMC's adoption of a flexible average inflation targeting framework, another key change adopted in its most recent Statement on Longer-Run Goals and Strategies.[2] In addition to changing its interpretation of its employment mandate, the FOMC stated that its intention for inflation to *average* two percent over time. Thus, if inflation has run persistently below two percent, the Committee will pursue inflation modestly above two percent for some time going forward. Mertens and Williams (2019), Amano et al. (2020), and Nessen and Vestin (2005) show that average inflation targeting can help alleviate the downward pressure on longer-term inflation expectations caused by the zero lower bound. Our model shows that a policy rule which only offsets employment shortfalls also raises longer-term inflation, suggesting that the reinterpretation of the employment mandate complements and reinforces the likely desired policy outcomes of the FOMC's flexible average inflation targeting framework.

Our model shares features with a large literature which studies the interactions between search and matching frictions in the labor market and nominal pricing rigidities such as Walsh (2005), Krause and Lubik (2007), Gertler, Sala and Trigari (2008), Christiano, Eichenbaum and Trabandt (2016), and many others. In particular, Krause and Lubik (2007), emphasize that the measure of marginal cost relevant for inflation includes the present-value of a new hire in a frictional labor market, a feature at the center of some of our main results. However, our model also incorporates the zero lower bound and demand shocks, two features which are often absent from models in the literature. We examine outcomes at the zero lower bound since the FOMC cited it as an important rationale behind the recent changes to its framework. In addition, the inclusion of demand shocks in our model help reproduce the downward-sloping Phillips curve between inflation and unemployment we observe in the data and generate reasonable zero lower bound episodes. Thus, our model is closest to both Albertini and Poirier (2015) which examine an extension of unemployment benefits at the zero lower bound in a model with frictional labor markets, nominal rigidities, and demand shocks.

Our work also contributes to the large literature on the conduct of monetary policy in the presence of search frictional labor markets beginning with Cooley and Quadrini (1999),

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[2] See Altig et al. (2020) for an overview of the research undertaken as part of the Federal Reserve's 2019 review of its monetary policy framework.

Walsh (2005), and many others. In this context, our work relates to Sala, Soderstrom and Trigari (2008) and Faia (2008) which compares the performance of central bank policy rules targeting different measures of output or unemployment. Another strand of this work, such as Blanchard and Galí (2010), focuses on the role of real-wage rigidity for the conduct of optimal monetary policy. To keep our model as simple as possible, our baseline model features bilateral Nash bargaining between workers and firms over hours worked and wages, instead of either staggered wage bargaining as in Gertler and Trigari (2009) or alternative offers bargaining as in Hall and Milgrom (2008) or Christiano, Eichenbaum and Trabandt (2016).

Lastly, our work relates to the literature on optimal monetary policy in the face of nonlinearities in economy. Orphanides and Wieland (2000) and Dolado, Maria-Dolores and Naveira (2005) derive the implications of a nonlinear Phillips curve for optimal monetary policy rules within a conventional symmetric quadratic loss function framework. They argue that the policy reaction function should include an asymmetry with a stronger reaction to inflation or employment when they are above their respective targets. In contrast, Surico (2007) and Gust, López-Salido and Meyer (2017) show that asymmetric loss functions naturally lead to asymmetries in the central bank's reaction function which result in a positive inflation bias when policymakers have greater aversion to contractions than expansions. Relative to this work, the changes in the economy's reduced-form Phillips curve we highlight arise endogenously if policymakers adopt a shortfalls-stabilization rule. In addition, our shortfalls-stabilization rule shares features with the endogenous regime switching policy rules originally examined by Davig and Leeper (2006). Finally, Coibion, Gorodnichenko and Wieland (2012) show that, when policymakers face a zero lower bound constraint, raising the inflation target may be too blunt an instrument to effectively reduce the severity of zero lower bound episodes. While we do not explicitly consider optimal policy in this paper, our results suggest that adopting a shortfalls rule may provide an alternative solution for improving outcomes at the zero lower bound.

The rest of the paper is organized as follows: Section 2 describes the model environment, specifies the monetary policy reaction functions under both deviations- or shortfalls-stabilization rules, and provides details on the calibration of the model to the US economy. Section 3 describes the main results of the paper and gives the intuition for the impact of the shortfalls stabilization-rule on the economy.

2 A Model of Labor Markets & Nominal Rigidities

To examine the possible effects of the FOMC's new interpretation of its employment mandate, we posit, calibrate, and solve a theoretical model of the U.S. economy. The key features of our economic environment are frictional labor markets, nominal rigidities in price setting, and a zero lower bound constraint on short-term nominal interest rates. To capture the asymmetry in the FOMC's new employment objective, we allow for the central bank's policy reaction function to change as a function of the current state of the economy. Fluctuations in the economy are driven by changes in household demand and productivity. To account for the potentially asymmetric policy reaction function, we solve our model using a global solution method and discipline our model's calibration using observed fluctuations in economy over the 25 years immediately preceding the new interpretation of its employment mandate. Since our primary focus is determining the possible effects from the change in the policy reaction function, we first describe our specifications for monetary policy before providing details on the other features of the model.

2.1 Monetary Policy

In our model, monetary policy sets the short-term nominal interest rate to systematically offset adverse fluctuations in inflation and unemployment. To examine the possible effects from the change in the FOMC's employment objective, we posit two different rules for the central bank's reaction function. The first rule intends to capture the setting of the nominal policy rate prior to the announcement of the new consensus statement in August 2020. We refer to the first specification as the *Deviations* rule as it treats deviations of inflation and unemployment from their respective targets symmetrically:

$$r_t^d = r + \phi_\pi \Big(\pi_t - \pi^*\Big) + \phi_u \Big(U_t - U^*\Big), \tag{1}$$

where r_t^d is the central bank's desired policy rate, $\pi_t = \log(P_t \,/\, P_{t-1})$ denotes inflation, P_t denotes the price level, and U_t denotes the unemployment rate. The parameters $\phi_\pi > 0$ and $\phi_u < 0$ determine the policy reactions to deviations of inflation from the central bank's inflation target π^* and fluctuations of unemployment from its longer-run natural rate U^*.[3]

In the second rule, monetary policy no longer reacts to a labor market when unemployment falls below its longer-run level. We denote this second specification as the *Shortfalls* rule as it aims to capture the reinterpretation of the employment mandate in the recent Goals and Strategies statement.

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[3] Equivalently the policy rule may be expressed in terms of setting the gross nominal rate and the reaction function in proportional departures from target. See Section B.2 of the Appendix for a more detailed discussion and mapping between the two representations.

$$r_t^d \quad = \quad \begin{cases} r + \phi_\pi \Big(\pi_t - \pi^*\Big) + \phi_u \Big(U_t - U^*\Big) & \text{if } U_t \geq U^* \\ r + \phi_\pi \Big(\pi_t - \pi^*\Big) & \text{if } U_t < U^* \end{cases} \tag{2}$$

This policy is consistent with Powell (2021)'s discussion of the new employment objective as policymakers in the model will not adjust the stance of policy solely to a tight labor market. Under both the deviations and shortfalls rules, however, monetary policy faces a zero lower bound constraint such that actual nominal policy rates r_t cannot fall below zero:

$$r_t = \max\Big(0\,, r_t^d\Big) \tag{3}$$

In this paper, we examine the possible macroeconomic effects if the central bank chooses to follow the one-sided employment shortfalls rule versus the symmetric deviations rule.

2.2 Households

Our model features a representative household in which a fraction N_t of the unit mass of members are employed, work H_t hours on the job at an hourly wage W_t, and a fraction U_t are unemployed and searching for work. The representative household chooses consumption C_t and holdings of the one-period nominal bond B_t to maximize its lifetime utility J_t:

$$J_t = \max_{C_t, B_t} \left\{ \exp(\gamma_t) \frac{C_t^{1-\sigma}}{1-\sigma} + \nu_0 \frac{\big(1-H_t\big)^{1-\nu_1}}{1-\nu_1} N_t + \nu_u U_t + \beta E_t\Big[J_{t+1}\Big] \right\} \tag{4}$$

$$\text{subject to} \quad C_t + T_t + \frac{B_t}{P_t R_t} = \frac{B_{t-1}}{P_t} + W_t H_t N_t + b\, U_t + D_t,$$

where β represents household discount factor over time. The parameters $\sigma > 0$, $\nu_0 > 0$ and $\nu_1 > 0$ affect the utility of consumption and the disutility of hours worked out of a total amount of time available (which is normalized to 1 each period). ν_u affects the utility of non-employment and b denotes unemployment benefits. Finally, $R_t = \exp(r_t)$ denotes the gross nominal interest rate, T_t denotes lump sum taxes to fund unemployment benefits, and D_t denotes dividends from owning all shares in wholesale and retail firms. This specification of preferences over consumption, hours worked on the job, and employment is close the foundational work of the Andolfatto (1996) incorporating labor market search frictions into real business cycles.[4]

The variable γ_t is an exogenous random process that shifts the level of utility over consumption and changes in γ_t generate fluctuations in household demand over time through the household's stochastic discount factor. The law of motion for this preference shock process is as follows:

$$\gamma_t = \rho_\gamma \gamma_{t-1} + \sigma_\gamma \varepsilon_t^\gamma, \tag{5}$$

where $\rho_\gamma \in (0,1)$ and $\sigma_\gamma > 0$ control the persistence and volatility of the demand shocks, and ε_t^γ is an independently and identically-distributed standard normal shock.

Denote λ_t^C as the Lagrange multiplier on the household's budget constraint and denote $\Pi_t = P_t/P_{t-1}$ as the gross inflation rate. The household's first-order condition for bond holdings yields the Euler equation

$$1 = E_t \left\{ M_{t,t+1} \frac{R_t}{\Pi_{t+1}} \right\}, \tag{6}$$

in which the stochastic discount factor, $M_{t,t+1}$, is given by:

$$M_{t,t+1} \equiv \beta \left(\frac{\lambda_{t+1}^C}{\lambda_t^C} \right) = \beta \left(\frac{\exp(\gamma_{t+1})}{\exp(\gamma_t)} \right) \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma}. \tag{7}$$

2.3 The Labor Market

Firms post a number of job vacancies, V_t, to attract jobs seekers and employed workers are subject to a job separation shock at rate s at the end of a period. Each vacant position costs $\kappa_t = \kappa_0 + \kappa_1 q_t > 0$ units of final output per unit of time. $\kappa_0 > 0$ is a variable cost and κ_1 a fixed post hiring cost paid by a representative firm after hiring. q_t is the vacancy filling rate discussed below. Vacancies are filled via a constant returns to scale matching function,

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[4] Since Andolfatto (1996), a majority of the work studying the business cycle in models of equilibrium unemployment do not consider the intensive margin of hours adjustments and assumes risk neutral workers. These two elements have been found not to be central for the dynamics of the main outcomes of interest in that stream of research, namely the rate of unemployment and job vacancies, unless they enter and affect the dynamics of equilibrium wages (see Rudanko (2009) for an example of wage rigidity arising from employers offering wage contracts to risk averse workers). Among New Keynesian environments with frictional labor markets, in Krause and Lubik (2007), Walsh (2005), Gertler, Sala and Trigari (2008), and Christiano, Eichenbaum and Trabandt (2016) hours worked or employment do not enter the period utility function. The first assume CRRA preferences and the latter three works assume log-preferences with habit formation in consumption. Blanchard and Galí (2010), who study optimal monetary policy in a model with a search frictional unemployment, assume concave disutility to employment. Moscarini and Postel-Vinay (2017) assume households have concave preferences over consumption and linear preferences over leisure, where household members are either employed or unemployed.

$G(U_t, V_t)$. We define labor market tightness as $\theta_t \equiv V_t/U_t$. The probability for a worker searching in the labor market to find a job per unit of time (the job finding rate), denoted $f(\theta_t)$, is:

$$\frac{G(U_t, V_t)}{U_t} = f(\theta_t) \text{ with } f'(\theta_t) > 0. \tag{8}$$

The probability for a vacancy to be filled per unit of time (the vacancy filling rate) is:

$$\frac{G(U_t, V_t)}{V_t} = q(\theta_t) \text{ with } q'(\theta_t) < 0, \tag{9}$$

and such that $q(\theta_t)V_t$ is the number of new hires. Employment, N_t, evolves as

$$N_{t+1} = (1 - s)N_t + q(\theta_t)V_t. \tag{10}$$

The matching function is specified as $G(U_t, V_t) = \frac{U_t V_t}{(U_t^\iota + V_t^\iota)^{1/\iota}}$, in which $\iota > 0$ is a constant parameter. This matching function, specified as in Haan, Ramey and Watson (2000), has the desirable property that matching probabilities fall between zero and one. The job finding and filling rates are given by $f(\theta_t) = \left(1 + \theta_t^{-\iota}\right)^{-1/\iota}$ and $q(\theta_t) = (1 + \theta_t^\iota)^{-1/\iota}$, respectively.

2.4 Aggregating sector

The aggregation sector produces the aggregate final consumption good Y_t using a basket of differentiated retail goods as inputs. Denote by $Y_t(j)$ a type j retail good for $j \in [0, 1]$. We assume that

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\omega-1}{\omega}} \mathrm{d}j \right)^{\frac{\omega}{\omega-1}}, \tag{11}$$

where $\omega > 1$ denotes the elasticity of substitution between differentiated products. Expenditure minimization implies a demand for type j retail good that is inversely related to the relative price, with the demand schedule given by

$$Y_t^d(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\omega} Y_t, \tag{12}$$

where $Y_t^d(j)$ and $P_t(j)$ denote the demand for and the price of retail good of type j, respectively. The price index P_t is related to individual prices $P_t(j)$ through

$$P_t = \left(\int_0^1 P_t(j)^{\frac{1}{1-\omega}} \mathrm{d}j \right)^{1-\omega}. \tag{13}$$

2.5 Retail sector

There is a continuum of retail goods producers each producing a differentiated product using a homogenous intermediate good produced by a wholesale sector as input. The production function of a retail good of type $j \in [0, 1]$ is given by

$$Y_t(j) = I_t(j), \tag{14}$$

where $I_t(j)$ is the input of intermediate goods used by retailer j, purchased at the unit price ψ_t on a competitive intermediate goods market.

Retail goods producers are price takers in the input market and monopolistic competitors in the product markets, where they set the price for their goods taking as given by the demand schedule in equation (12) and in the price index in equation (13). We assume quadratic costs to adjusting prices:

$$\frac{\Omega}{2}\left(\frac{P_t(j)}{\Pi P_{t-1}} - 1\right)^2 Y_t \tag{15}$$

where the parameter $\Omega > 0$ measures the cost of price adjustments and Π denotes the deterministic steady state inflation rate. Price adjustment costs are assumed to be in units of aggregate output.

A retail firm that produces good j maximizes the value of its equity S_t^r by choosing the price $P_t(j)$ for its differentiated good, solving the problem:

$$S_t^r \equiv \max_{P_t(j)} E_t\left[\sum_{i=0}^{\infty} M_{t,t+i}\left[\left(\frac{P_{t+i}(j)}{P_{t+i}} - \psi_{t+i}\right) Y_{t+1}^d(j) - \frac{\Omega}{2}\left(\frac{P_{t+i}(j)}{\Pi P_{t+i-1}} - 1\right)^2 Y_{t+i}\right]\right] \tag{16}$$

The optimal price setting decision implies that, in a symmetric equilibrium with $P_t(j) = P_t$ for all j, the input price ψ_t and price inflation Π_t are related through the equilibrium condition:

$$\frac{\Pi_t}{\Pi}\left(\frac{\Pi_t}{\Pi} - 1\right) = \frac{\omega}{\Omega}\left(\psi_t - \frac{\omega - 1}{\omega}\right) + E_t M_{t,t+1}\frac{Y_{t+1}}{Y_t}\frac{\Pi_{t+1}}{\Pi}\left(\frac{\Pi_{t+1}}{\Pi} - 1\right) \tag{17}$$

in which currently inflation is increasing in the input price ψ_t, and in expected future demand (Y_{t+1}) and inflation (Π_{t+1}).

2.6 Wholesale sector

Firms in the wholesale sector produce with labor hired on from a labor market subject to search frictions. Output, sold at unit price ψ_t, is produced with a production technology $X_t N_t H_t^{\alpha}$, where H_t are hours of work on the job per worker, $\alpha \in (0, 1)$, and X_t is aggregate productivity in the wholesale sector. The latter follows the law of motion for $x_t \equiv \log(X_t)$:

$$x_t = \rho_x x_{t-1} + \sigma_x \varepsilon_t^x, \tag{18}$$

in which $\rho_x \in (0, 1)$ is the persistence, $\sigma_x > 0$ is the conditional volatility, and ε_t^x is an independently and identically-distributed standard normal shock.

The wage rate W_t and hours of work H_t are determined through bargaining with workers, as discussed below. The firm posts an optimal number of job vacancies to maximize the cum-dividend market value of equity, denoted S_t^w, taking the vacancy filling rate, employment, wage and hours of work as given:

$$S_t^w \equiv \max_{\{V_{t+i}, N_{t+i+1}\}_{i=0}^{\infty}} E_t \left[\sum_{i=0}^{\infty} M_{t,t+i} \left[\psi_{t+i} X_{t+i} N_{t+1} H_{t+i}^{\alpha} - W_{t+i} H_{t+i} N_{t+i} - \kappa_{t+i} V_{t+i} \right] \right], \tag{19}$$

subject to the employment accumulation equation (10) and a nonnegativity constraint on vacancies as the only source of job destruction in the model is the exogenous separation of employed workers from the firm:

$$V_t \geq 0. \tag{20}$$

Let λ_t^V denote the multiplier on the non-negativity constraint rewritten as $q(\theta_t) V_t \geq 0$. From the first-order conditions with respect to V_t and N_{t+1}, we obtain the intertemporal job creation condition:

$$\frac{\kappa_t}{q(\theta_t)} - \lambda_t^V = E_t \left[M_{t,t+1} \left[\psi_{t+1} X_{t+1} H_{t+1}^{\alpha} - W_{t+1} H_{t+1} + (1 - s) \left[\frac{\kappa_{t+1}}{q(\theta_{t+1})} - \lambda_{t+1}^V \right] \right] \right]. \tag{21}$$

Intuitively, the marginal cost of hiring at time t equals the marginal value of employment to the firm, which in turn equals the marginal benefit of hiring at period $t+1$, discounted to t. The marginal benefit at $t+1$ includes the marginal revenue from an employed worker, $\psi_{t+1} X_{t+1} H_{t+1}^{\alpha}$, net of the wage bill, $W_{t+1} H_{t+1}$, plus the marginal value of a retained worker into the next period, which is equal the marginal cost of hiring at $t+1$. Finally, the optimal vacancy policy also satisfies the Kuhn-Tucker conditions:

$$q_t V_t \geq 0, \quad \lambda_t^V \geq 0, \quad \text{and} \quad \lambda_t^V q_t V_t = 0. \tag{22}$$

2.7 Wages and Hours of Work

A common approach, which we follow here, is to assume workers and firms engage in bilateral Nash bargaining over hours and wages. Assuming this takes place at the beginning of each period, after observing the state of the economy, hours and wages are the solution to

$$\Lambda_t = \max_{W_t, H_t} \left(\frac{J_{Nt} - J_{Ut}}{\lambda_t^C} \right)^{\eta} \left(S_{N,t}^w - S_{V,t}^w \right)^{1-\eta}$$

where $\eta \in (0,1)$ is the workers' relative bargaining weight, and $(J_{Nt} - J_{Ut})$ and $(S_{N,t}^w - S_{V,t}^w)$ are the worker's and the firm's respective labor match surpluses (defined in appendix B, along with detailed derivations). This leads to an equilibrium condition for hours:

$$\frac{\nu_0}{\lambda_t^C} (1 - H_t)^{-\nu_1} \; = \; \alpha \psi_t X_t H_t^{\alpha - 1} \tag{23}$$

equating the marginal utility of hours of leisure to the marginal revenue product of an additional hour of work .

The resulting Nash bargained wage is most easily expressed as compensation per worker $W_t H_t$:

$$W_t H_t = \eta \left[\psi_t X_t H_t^{\alpha} + \kappa_t \theta_t \right] + (1 - \eta) Z_t, \tag{24}$$

which is increasing in the marginal revenue product of labor, conditions in the labor market through changes in labor market tightness θ_t, and in the variable $Z_t = b + \nu_u / \lambda_t^C - \nu_0 \frac{(1-H_t)^{1-\nu_1}}{1-\nu_1} / \lambda_t^C$ which capture the worker's reservation wage, a function of unemployment compensation b and the change in flow utility from employment compared to remaining unemployed.

2.8 Equilibrium

Financial markets clear in equilibrium. The risk-free asset is in zero net supply, and the household holds all the shares of the firms in retail and wholesale sectors. The goods market clearing condition is then given by:

$$C_t + \kappa_t V_t + \frac{\Omega}{2} \left(\frac{\Pi_t}{\Pi} - 1 \right)^2 Y_t = Y_t. \tag{25}$$

Intermediate goods market clearing implies

$$Y_t = X_t N_t H_t^{\alpha}. \tag{26}$$

The competitive equilibrium in the economy consists of vacancy posting, $V_t^\star \geq 0$; hours per worker $H_t^\star$; multiplier, $\lambda_t^{V,\star} \geq 0$; consumption, $C_t^\star$; prices $\Pi_t^\star$ and $\psi_t^\star$; and nominal interest rate $R_t^{N\star}$; such that (i) $V_t^\star$, $H_t^\star$ and $\lambda_t^{V,\star}$ satisfy the intertemporal job creation condition (21) and the Kuhn-Tucker conditions (22), while taking the stochastic discount factor in equation (7) and the hours and wage equations (23) and (24) as given; (ii) $C_t^\star$, satisfies the intertemporal consumption-portfolio choice conditions (6); (iii) retail price setting satisfies optimality condition (17); (iv) the desired nominal rate follows either the deviations (1) or the shortfalls (2) rule; (v) the nominal policy rate satisfies the zero lower bound constraint (3), and (vi) the goods markets clear as in equations (25) and (26)

2.9 Calibration

Our primary goal is examining the possible effects if monetary policymakers change from a symmetric deviations rule to a one-sided shortfalls rule. To ensure that our model provides a reasonable description of the U.S. economy prior to the policy change, we first assume that monetary policy follows the deviations rule and choose the parameters of our model to match key first- and second-moments in the labor market as well as inflation and nominal interest rates over the 1995–2019 sample period. Table 1 lists the resulting parameter values for the monthly-frequency calibration of our model. After calibrating the model, we then study the implications of moving from a deviations to shortfalls policy rule. We solve the model under both policy rules using a global solution method which accounts for the potential asymmetries in the policy reaction function as well as the zero lower bound and nonlinear dynamics in the labor market.[5]

Turning first to the parameters in the central bank's policy rule, we set the inflation target Π^* to be consistent with the Federal Reserve's stated goal for price stability of 2 percent inflation. Following the work of Taylor (1993) and many others, we set the central bank's inflation response to a standard value $\phi_\pi = 1.5$. In calibrating the unemployment response parameter ϕ_u, we follow a conservative approach. From Equations (1) and (2), the quantitative significant of changing from a deviations rule to a shortfalls rule crucially depends on the calibration of the central bank's response to unemployment ϕ_u. Recent work from Kahn and Palmer (2016) and Feroli et al. (2017) estimates the FOMC's implied policy reaction function in Equation (1) using the FOMC's quarterly Summary of Economic Projections. Using data prior to the new consensus statement, they find estimates for ϕ_u that range from -0.08 to -0.18 (at the monthly frequency of our model). Thus, in calibrating ϕ_u, we take a conservative approach and set ϕ_u = -0.05 under both the deviations and shortfalls rule. We assume monetary policymakers assess the long-run value of the unemployment rate U^* to be 5 percent, which is close to the average rate of unemployment observed in our sample period for the U.S.

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[5] Fernández-Villaverde et al. (2015) discusses the nonlinear dynamics present at the zero lower bound and Petrosky-Nadeau and Zhang (2017) study the nonlinear dynamics stemming from the matching frictions in the labor market.

We use this same value to target an average unemployment rate of 5% in the model, first setting the separation rate s to 3% based on the underlying labor market flows to take into account the two state (employed/unemployed) nature of the model (Petrosky-Nadeau and Valletta, 2020). This places a restriction on the average job finding rate f and will pin down the value of worker's bargaining weight in wage setting η given our calibration strategy for the remaining parameters. This results in a value of $\eta = 0.38$. This places the implied bargained weight in the middle of the range obtained in other work, from values as low as 0.05 in Hagedorn and Manovskii (2008) to a value of 0.72 in Shimer (2005).

We set the time discount factor, β, equal to $\exp(-0.5/1200)$ such that the annualized long-run neutral rate equals 0.5%. This target is informed by estimates of the longer-run equilibrium real rate of interest from a variety approaches (Laubach and Williams, 2003; Lubik and Matthes, 2015; Christensen and Rudebusch, 2019). We set the elasticity of substitution between differentiated goods to $\omega = 10$, such that the average markup $1/\psi$ is about 11%. This is broadly inline with microeconomic evidence presented in Basu and Fernald (1997). We choose the nominal price adjustment cost Ω such that the model generates the low volatility in inflation observed over the last two decades. To a first-order approximation (in which our quadratic-cost specification is observationally equivalent to a Calvo setting), our monthly calibrated value of $\Omega = 450$ implies that firms adjust prices about every seven months, which is broadly consistent with the micro evidence in Nakamura and Steinsson (2008).

For the household preference parameters, we set the coefficient of relative risk aversion $\sigma = 0.5$ which ensures a negative correlation between hours worked on the job and unemployment under our assumption of Nash bargained wages. The level parameter in the utility for leisure ν_0 is set such that employed individuals spend on average 20 percent of their time endowment working. The curvature parameters ν_1 is set to an individual labor supply elasticity of $\nu_1^{-1}\left(\frac{1}{H} - 1\right) = 1$ following the original contribution of Andolfatto (1996) and in line with estimates reviewed and discussed in Hall (2009). This results in $\nu_1 = 4$. Lastly, the utility associated with non-employment ν_u is set such that there is small gap between earnings and the reservation utility $Z/WH = 0.85$. This is close to the value calibrated in Rudanko (2009) and estimated by Christiano, Eichenbaum and Trabandt (2016), resulting in a value of $\nu_u = 0.24$.

We set the curvature parameter of the labor market matching function ι to 1.25, the value in the original work of Haan, Ramey and Watson (2000) and applied in Petrosky-Nadeau, Zhang and Kuehn (2018). Silva and Toledo (2009) report that recruiting costs are 14 percent of quarterly pay per hire, or 0.4 months of pay per hire, based on data collected by PriceWaterhouseCoopers. We set $\kappa = \kappa_0 + \kappa_1$ such that, on average, the cost of job creation $\kappa/q(\theta) = 0.4 \times WH$. We then use the volatility of unemployment in the data to determine the relative importance of variable and fixed costs κ_0 and κ_1. A greater fixed relative to variable cost increases the volatility of unemployment (Pissarides, 2009). This results in $\kappa_0 = 0.03$ and $\kappa_1 = 0.07$. Finally, with respect to the labor market, we set the value of unemployment benefit b such that on average $b/WH = 0.4$. This correspond to the typical earnings replacement rate across U.S. states reported by the Department of Labor (Department of Labor, 2019).

For the productivity process X_t, we set the persistence, ρ_x to 0.99 and its conditional volatility, $\sigma_x = 0.006$, to match the standard deviation of labor productivity in the data.[6] For the demand shock process, we also set the persistence $\rho_\gamma = 0.99$, which, at the monthly frequency of our model, is consistent with the quarterly estimated value of Ireland (2011). We calibrate the standard deviation of the demand shock process to match the empirical observed correlation between inflation and unemployment, which results in $\sigma_\gamma = 0.013$.

Table 2 compares the implied quarterly moments in our model under the deviations policy rule to their empirical counterparts. Overall, our model is able to generally reproduce the first and second moments of unemployment, hours, inflation, and the nominal policy rate we observe in the data. The model closely matches the average and volatility of unemployment over the 1995–2019 period. Moreover, the model generally reproduces the low volatility of hours worked in the data and the negative correlation observed between unemployment and hours. Despite the policymakers in our model targeting two percent inflation, the presence of the zero lower bound and asymmetric fluctuations in the unemployment rate pushes average inflation under the deviations rule below two percent, similar to actual inflation over the last few decades. The model also matches the volatility of inflation as well as the model-implied correlation between unemployment and inflation (the reduced-form Phillips curve). While

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[6] We measure the labor productivity as seasonally adjusted real average output per job in the nonfarm business sector (Series id: PRS85006163) from the Bureau of Labor Statistics. The sample is quarterly from 1951 to 2012. We detrend the series as the Hodrick-Prescott (1997, HP) filtered cyclical component of proportional deviations from the mean with a smoothing parameter of 1,600.

Table 1: Calibrated Model Parameters

Parameter	Notation	Value	Target/Source
Preferences:			
Discount factor	β	$\exp(-0.5/1200)$	0.5% annualized real risk free rate
Elast. of subst. btw. goods	ω	10	Average markup over marginal cost
Utility: consumption	σ	0.5	External
Utility: leisure, level	ν_0	0.74	Average hours worked
Utility: leisure, curvature	ν_1	4	Elasticity of labor supply
Non-employment utility	ν_u	0.24	Reservation to wage ratio
Price setting:			
Price adjustment cost	Ω	450	Volatility of inflation
Labor market:			
Matching function: curvature	ν	1.25	Den Haan et al (2000)
Worker bargaining weight	η	0.38	Unemployment rate
Vacancy cost	κ_0	0.03	Recruiting costs to monthly wage
Fixed hiring cost	κ_1	0.07	Volatility of unemployment
Job destruction rate	s	0.03	Unemployment flow accounting[1]
Unemployment benefits	b	0.12	Replacement rate
Monetary policy:			
Weight on inflation	ϕ_π	1.5	Estimated on U.S. data[2]
Weight on unemp. gap	ϕ_n	-0.05	Estimated on U.S. data[2]
Inflation target	π^*	$1.02^{(1/12)}$	FOMC target inflation
Unemployment: natural rate	U^*	0.05	Long run rate of unemployment
Shock processes:			
Technology: persistence	ρ_x	0.99	U.S. labor productivity[3]
Technology: standard deviation	σ_x	0.008	U.S. labor productivity[3]
Demand: persistence	ρ_γ	0.99	
Demand: standard deviation	σ_γ	0.02	

Notes: We calibrate the model to monthly frequency. (1) based on the underlying labor market flows to take into account the two state (employed/unemployed) nature of the model (Petrosky-Nadeau and Valletta, 2020); (2) See the discussion in the text; (3) Non-farm business labor productivity.

the model matches the average nominal interest rate quite well, our model slightly under predicts the volatility of the nominal policy rate and generates a bit too much correlation between the nominal policy rate and inflation.[7] Overall, however, the results in Table 2 suggests that our model likely provides a reasonable, but highly stylized, description of the economy that we can use to conduct policy experiments.

3 From Deviations to Shortfalls

We now analyze the qualitative and quantitative implications of changing from a symmetric deviations rule in Equation (1) to the one-sided shortfalls rule in Equation (2), leaving all other parameters unchanged. First, we use the policy functions of the model to examine the qualitative effects on inflation and unemployment of adopting a shortfalls-stabilization rule. Then, we discuss the quantitative impacts of the new policy rule on the inflation, unemployment and the nominal policy rate. Shifting to a shortfalls rule not only affects longer-term average outcomes in the economy but also changes the entire distribution of inflation and unemployment outcomes. Finally, we examine the model-implied implications for the economy's reduced-form Phillips curve and its performance in the presence of the zero lower bound on nominal interest rates.

3.1 Adopting a Shortfalls-Stabilization Rule: Intuition

While the difference in policymakers' behavior under the deviations or shortfalls rules in Equations (1) and (2) technically only becomes actualized when the unemployment rate falls below its longer-run value, changing to a shortfalls rule implies tighter labor markets and higher inflation in *all* states of the world. The top row Figure 1 plots the resulting policy functions for labor market tightness (θ_t) and the monthly gross inflation rate (Π_t) as a function of the demand shock ($\exp(\gamma_t)$) under both the deviations and shortfalls rule.[8]

Under a shortfalls-stabilization rule, forward-looking firms internalize that policymakers will not lean against a tight labor market. This expectation of more accommodative policy and higher demand in the future, in states of the world where unemployment falls below U^*, leads them to set higher prices and increases their demand for labor and hiring today.

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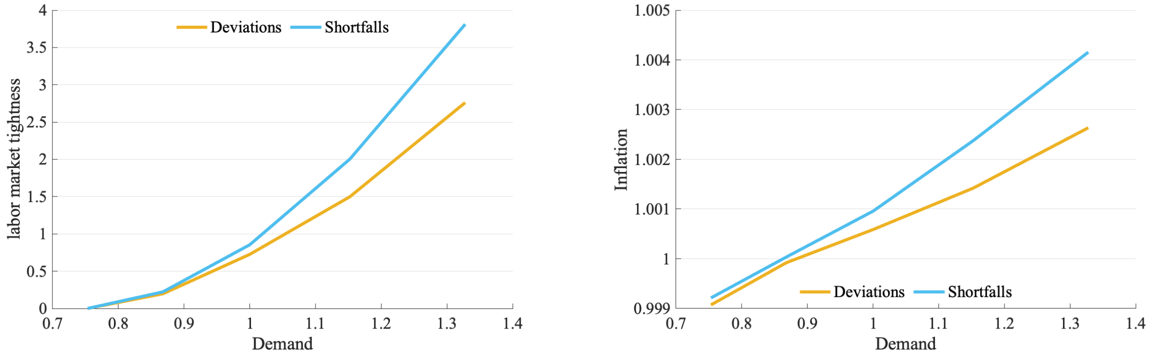
[7] If we were to include an additional exogenous policy shock in the central bank's rule, the model's fit along these dimensions would likely improve. However, we eschew this additional feature in order to keep the model simple and because our focus is on the central bank's *endogenous* reaction to inflation and unemployment.

[8] To produce these figures, we set employment N_t (the endogenous state variable in our model) equal to its longer-run value. Appendix Figure A.2 plots the policy functions for labor market tightness, inflation and hours worked on the job over employment and, separately, productivity and demand.

Figure 1: Policy Functions & Impulse Responses to Demand Shocks

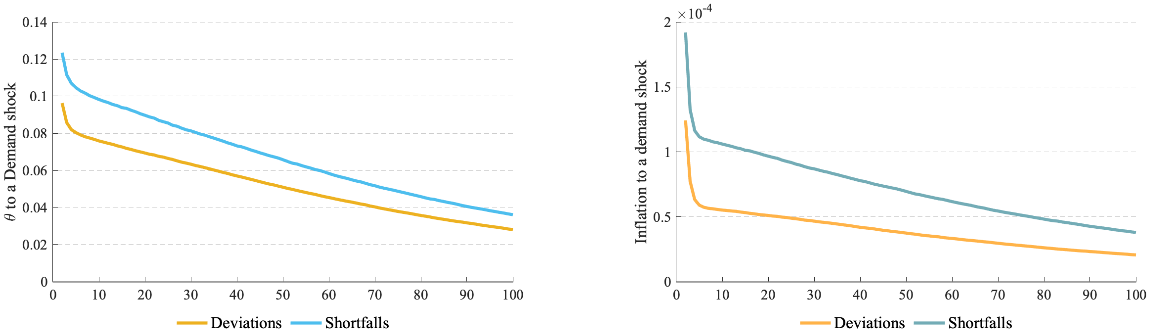


(a) Labor Market Tightness & Demand

(b) Inflation & Demand

(c) IRF: Labor Market Tightness

(d) IRF: Inflation



Note: Impulse responses to a one standard deviation innovation to demand, starting from the economy's stationary means for employment, productivity and demand and averaged across 5,000 simulations.

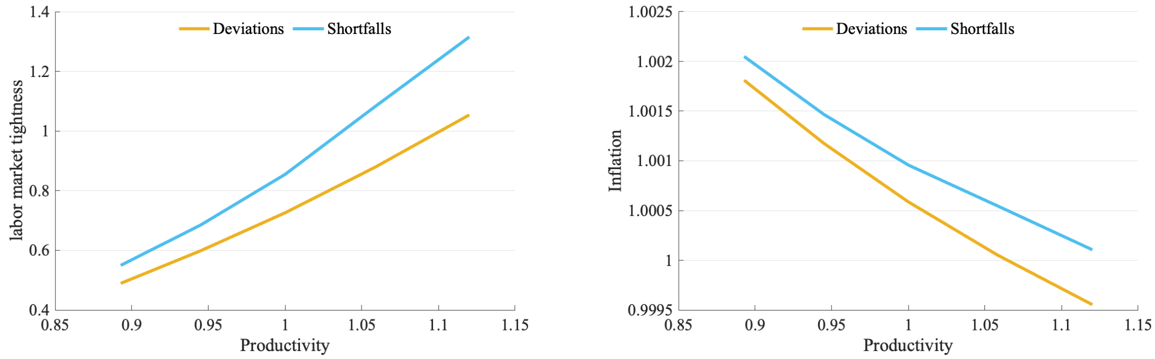
Figure 1a shows that this expansionary expectations effect of the shortfalls rule is stronger when the exogenous demand shock is above its longer run average (meaning the economy is in an expansion). Conversely, we also see diminishing differences in the policy functions between the two rules in low demand states as situations in which unemployment falls below U^* are sufficiently far off in the future as to have a weakened effect on current hiring and pricing decisions. The impulse responses to a demand shock, in the bottom row of Figure 1, also illustrate the increased slope of the labor market tightness and inflation policy functions under the shortfalls stabilization rule. Following a positive demand shocks, labor markets tighten more and firms set higher prices under the one-sided shortfalls rule.

The policy functions over values of exogenous productivity in the top row of Figure 2 also highlight this effect where we observe tighter labor markets and higher inflation for all levels of productivity. Moreover, as monetary policy no longer works to offset states of the world where unemployment falls below U^*, there is a flattening of the negative slope of inflation to

Figure 2: Policy Functions & Impulse Responses to Productivity Shocks

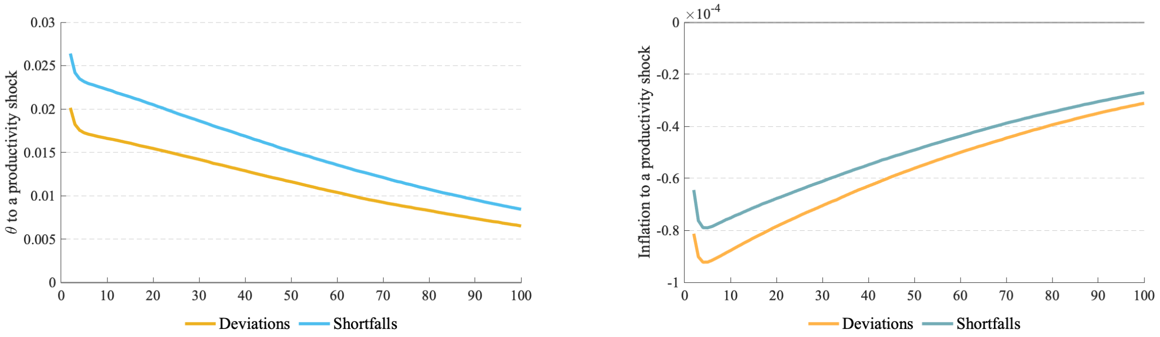
(a) Labor Market Tightness & Productivity

(b) Inflation & Productivity



(c) IRF: Labor Market Tightness

(d) IRF: Inflation



Note: Impulse responses to a one standard deviation innovation to productivity, starting from the economy's stationary means for employment, productivity and demand and averaged across 5,000 simulations.

productivity. That is, increases in productivity have a smaller downward pressure on price inflation under the shortfalls rule. The policy functions and impulse responses (bottom row of Figure 2) show that labor market tightness and inflation move in opposite directions in response to a change in productivity. Since unemployment is inversely related to labor market tightness, demand shocks need to be more important for driving aggregate fluctuations for the model to reproduce the negative relationship between unemployment and inflation that we observe in the data. However, the differences between the shortfalls and deviations rules in response to productivity shocks highlights that the FOMC's new employment objective may affect the economy's response to many types of shocks hitting the economy (including shocks we do not consider in our model).

3.2 Quantitative Impacts on Inflation & Unemployment

Moving to a shortfalls stabilization rule can have quantitatively significant effects on both the business-cycle properties and the longer-run outcomes for the economy. The last column of Table 2 reports the effect on first and second moments of interest of adopting the shortfalls-stabilization rule in Equation (2), keeping all other parameters fixed to their calibrated values. The more accommodative response to low unemployment under the shortfalls rule raises average inflation by roughly 50 basis points, and lowers the average unemployment rate from 5.3 percent to 5.1 percent. Despite only changing the policymaker's response to tight labor markets, the adoption of a shortfalls-stabilization rules generates higher inflation and tighter labor markets on average.

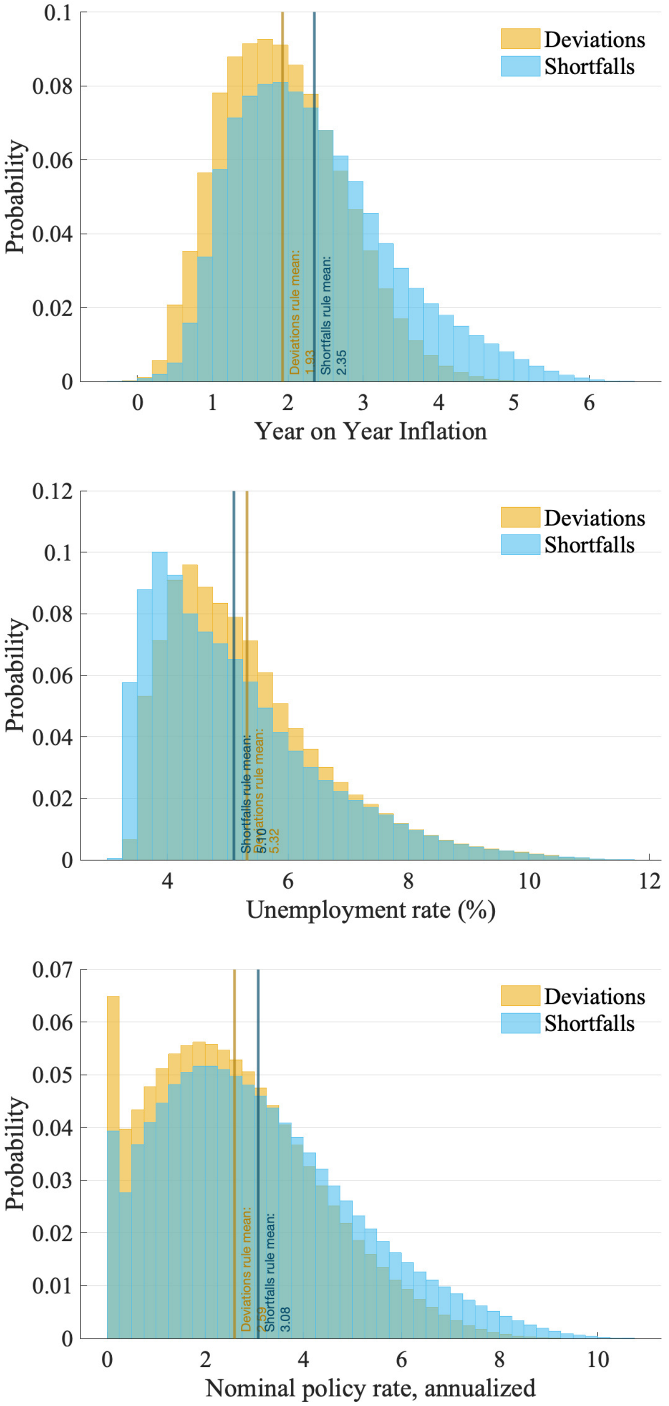
While changing to a shortfalls rule has only a modest impact on the volatility of inflation and unemployment, we see a significant impact on their respective distributions. The top two panels of Figure 3 reports the model's simulated distributions of inflation and unemployment under both the deviations (orange) and shortfalls (blue) rules. Changing to a one-sided shortfalls rule increases the likelihood of robust expansions with higher inflation and lower unemployment. We see a pronounced decline in the probability of inflation outcomes below 1% while the realizations of inflation above 3% become more likely. Specifically, the frequency of inflation below 1% declines from 12% to 6% and the frequency of inflation above 3% increases from 10% to 24% when adopting the shortfalls-stabilization rule. With respect to the labor market, our model implies that low unemployment outcomes (4% or below) become more frequent under the shortfalls rule while we see little change in the frequency of high unemployment rates above 7%. Specifically, the frequency of unemployment above 7% is about 11% under both the deviations and shortfalls rules while the frequency of unemployment below 4% increases from 13% to 25% when adopting the shortfalls-stabilization

Table 2: Empirical and Model-Implied Moments

	Data	Deviations Rule	Shortfalls Rule
Mean (%):			
U	5.7	5.3	5.1
π	1.8	1.9	2.4
R	2.5	2.6	3.1
Standard deviation:			
$\sigma(U)$	0.08	0.08	0.09
$\sigma(\pi)$	0.13	0.13	0.14
$\sigma(R)$	0.50	0.23	0.23
$\sigma(H)$	0.01	0.02	0.02
Cross. correlation:			
$corr(U,\pi)$	-0.23	-0.24	-0.36
$corr(U,H)$	-0.67	-0.76	-0.73
$corr(R,\pi)$	0.32	0.68	0.69
$corr(R,U)$	-0.82	-0.84	-0.89

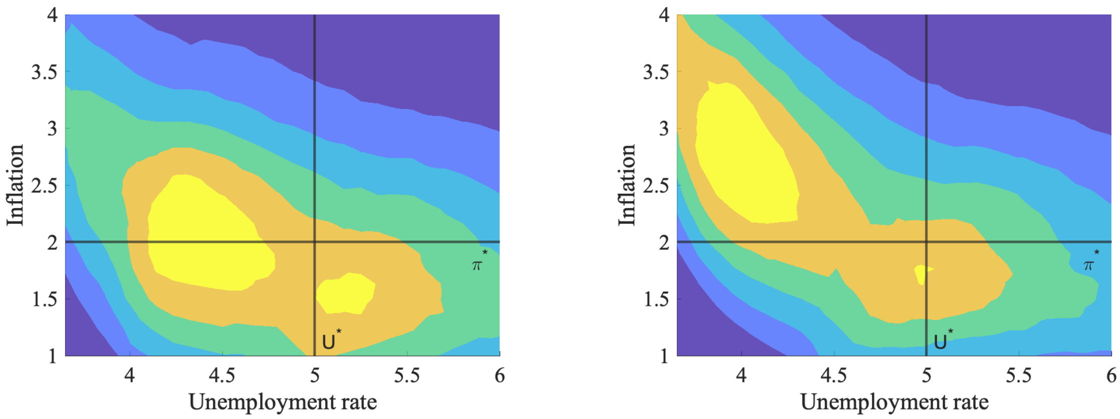
Notes: Details on the sources and transformation applied to the U.S data are available in Appendix Section A. The empirical sample period is 1995Q1–2019Q4. Model moments are computed on 10,000 simulations of 300 periods, equal to the number of months in the data sample and then average over three period for a quarterly frequency. Empirical and model data are converted to proportional deviations and Hodrick-Prescott filtered before computing second moments.

Figure 3: Model-Implied Stationary Distributions Under Deviations & Shortfalls Rules



Note: Model distributions obtain from 10,000 simulations of 300 periods, equal to the number of months in the data sample. Vertical lines correspond to sample means of the respective variables.

Figure 4: Model-Implied Joint Distributions of Inflation & Unemployment



(a) Deviations Rule

(b) Shortfalls-Stabilization Rule

Note: Model distributions obtained from 10,000 simulations of 300 periods.

rule. Thus, a shortfalls rule does not prevent high unemployment rates during recessions but instead ensures a more rapid return to full employment in a recovery and more sustained periods of low unemployment during expansions.[9]

3.2.1 Implications for the Phillips Curve

As we discussed, adopting a shortfalls-stabilization rule results in higher inflation and more hiring on average as well as increasing the likelihood of robust expansions with higher inflation and lower unemployment. Thus, we see a shift in the systematic relationship between inflation and unemployment in the model if policymakers adopt a shortfalls-only rule.

In terms of the reduced-form Phillips curve, a change in the monetary policy rule toward only stabilizing employment shortfalls increases the intercept and results in a steeper slope. Figure 4 plots the joint density of inflation and unemployment under the deviations rule in panel (a) and shortfalls rule in (panel (b)). When policymakers follow the deviations rule, the economy spends a large fraction of time with unemployment below its longer-run rate (lighter colors denote more likely outcomes). However, these periods of low unemployment are often associated with inflation either above or below the central bank's two percent objective. In contrast, under a shortfalls-stabilization rule, periods of low unemployment are typically accompanied with inflation somewhat above two percent. Quantitatively, the Phillips curve steepens under the shortfalls rule as Table 2 shows that the correlation between

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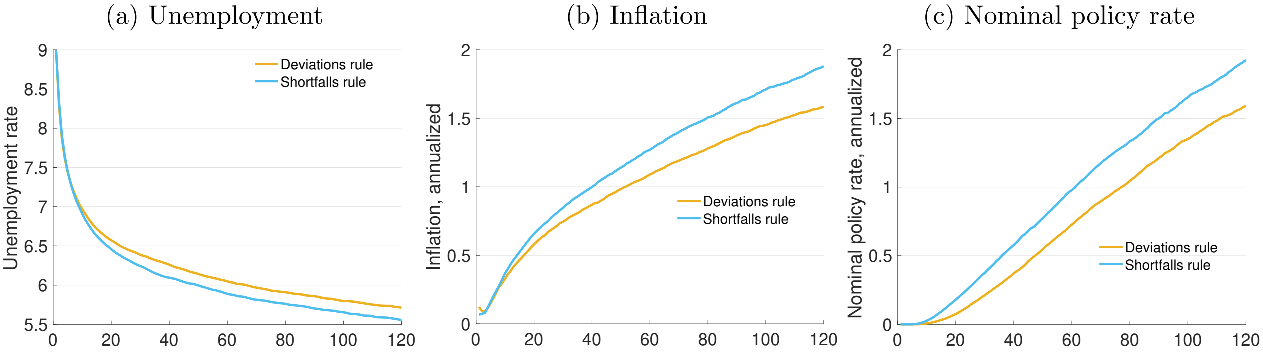
[9] In Appendix Table A.2, we report key model moments if we solve our model under the assumption that policymakers increase their weight on inflation stabilization under the shortfalls rule (ϕ_π increases to 2.25 from 1.5). Under this alternative calibration, the central bank in the model achieves two percent inflation on average under the asymmetric shortfalls rule.

Figure 5: Recovery From a Zero Lower Bound Episode Under Deviations & Shortfalls Rules



Note: Average paths from an initial state of 9% unemployment, demand at the 5th percentile of its ergodic distribution, productivity at the 95th percentile of its distribution, and no additional innovations.

inflation and unemployment falls from -0.23 to -0.36 if policymakers no longer try and lean against a tight labor market.

3.2.2 A Shortfalls Rule Helps Alleviate the Zero Lower Bound Constraint

These combined effects on inflation and unemployment under the shortfalls rule also help alleviate the contractionary effects of the zero lower bound in two ways. First, the zero lower bound constrains policymakers less often under a shortfalls rule. The last column of Table 2 shows that the higher inflation and employment on average leads to a 50 basis point increase in the average nominal interest rate. Higher average policy rates imply that policymakers become constrained less often under a shortfalls rule, which the bottom panel of Figure 3 illustrates. Specifically, the zero lower bound binds about half as often under the shortfalls rule when compared with the deviations rule (the frequency of zero policy rates falls from 6.5% to 4% under the shortfalls rule).

Second, conditional on hitting the zero lower bound, the expectations of higher inflation and lower unemployment imply a quicker recovery from a zero lower bound episode. Figure 5 plots the average path of the economy to its stationary mean (assuming no additional innovations) starting from a state in which the economy is at the lower bound. That is, demand is at the 5th percentile of its ergodic distribution and expected to rise, productivity is at the 95th percentile of its distribution and expected to decline, and unemployment is elevated at 9%. The figure shows there is a modest improvement in the path for unemployment under the shortfalls rule. Inflation, which returns to target over the period shown here under the shortfalls rule, just exceeds 1.5% under the deviations rule. With these more favorable outcomes, the nominal policy rate exits the zero lower bound earlier than under the deviations rule.[10]

3.3 Welfare Implications

Our primary goal in this paper is examining the *descriptive* outcomes of the FOMC's change in employment objective rather than evaluating the optimality of this choice under prescriptive optimal policy. However, in evaluating about the potential effects of the policy change, we would like to understand the policy tradeoffs in our model under both the deviations and shortfalls rule.

The adoption of a shortfalls-stabilization rule implies a trade-off for households welfare of lower unemployment versus higher inflation. To evaluate household welfare, we compute the household's value function in Equation (4) under both the deviations and shortfalls rule using our calibrated model. Figure 6 illustrates the simulated outcomes for the value function as well as reports the average value of the household's value function.

Despite the higher average inflation, we find that households are actually better off under the one-sided shortfalls rule. As Figure 3 illustrates, the shortfalls rule results in more sustained periods of low unemployment and high inflation. While higher inflation generates a loss of resources in our model (see Equation (25)), the lower rates of unemployment results in higher consumption and higher household welfare under the shortfalls rule. Figure 6 shows that these tighter labor market conditions shift the distribution of welfare to the right under the shortfalls rule and decreases the probability of households experiencing bad outcomes (associated with low realizations of the value function). Thus, we find that the benefits to households of more sustained periods of low unemployment under the shortfalls rule more than offsets the negative welfare effects of higher average inflation, at least in our calibrated model.

4 Conclusion

The Federal Open Market Committee recently revised its consensus statement indicating it seeks "over time to mitigate shortfalls of employment from the Committee's assessment of its maximum level ..." In contrast, the previous statement cited a desire to stabilize "devi-

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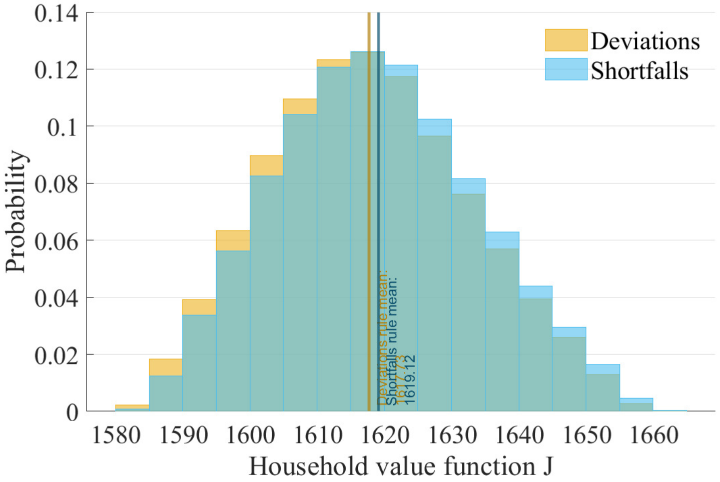
[10] In Appendix Table A.2, we also report the key model moments if we solve the model abstracting from the zero lower bound constraint. Since the zero lower bound does not bind too often in our baseline calibration, the effects of the zero lower bound on the model's average moments are generally small. However, we see more significant differences in outcomes with and without the zero lower bound in bad states of the world in which policymakers are unable to play their usual stabilizing role.

Figure 6: Model-Implied Stationary Distributions of Household Utility J_t Under Deviations & Shortfalls Rules



Note: Model distributions obtain from 10,000 simulations of 300 periods, equal to the number of months in the data sample. Vertical lines correspond to sample means of the respective variables.

ations" of employment from its maximum level. This paper analyzed the possible inflation and employment effects of this policy change using a theoretical model which combines frictional labor markets, nominal rigidities, and the zero lower bound.

A monetary policy which stabilizes "shortfalls" rather than "deviations" of employment from its maximum level affects firm price setting and hiring behavior in all states of the world. Since policymakers will not lean against a tight labor market under a shortfalls-stabilization rule, the expectation of more accommodative policy leads forward-looking firms to set higher prices and increase hiring due to the higher expected future demand. The higher prices and increased hiring under the shortfalls-stabilization rule leads to higher inflation and employment, on average. In addition to these changes in average outcomes for the economy, changing to a one-sided shortfalls rule increases the likelihood of robust expansions with higher inflation and lower unemployment and results in a steeper reduced-form Phillips curve.

The model shows that a policy rule which only offsets employment shortfalls also increases the average nominal policy rate and reduces the frequency of zero lower bound episodes. Moreover, it produces better outcomes during a ZLB episode due to the expectation of a more accommodative policy in the future. This suggest that the reinterpretation of the employment mandate complements and reinforces the desired policy outcomes of the FOMC's flexible inflation targeting framework.

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APPENDIX

A Data

The sources for the empirical data, and their transformations, are as follows.

Unemployment rate: Unemployment rate for the civilian population, 16 years old and over, monthly, seasonally adjusted. Obtained from FRED II, series ID UNRATE. The monthly series spans from Jan. 1948 to March 2021. Converted to quarterly by three-month averaging. The raw series is plotted in Figure A.1a.

Fed Funds rate: Effective Federal Funds rate, percent, monthly, NSA. Obtained from FRED II, series ID FEDFUNDS. The monthly series spans from July 1954 to Jan. 2021. Converted to quarterly by three-month averaging. The raw series is plotted in Figure A.1c.

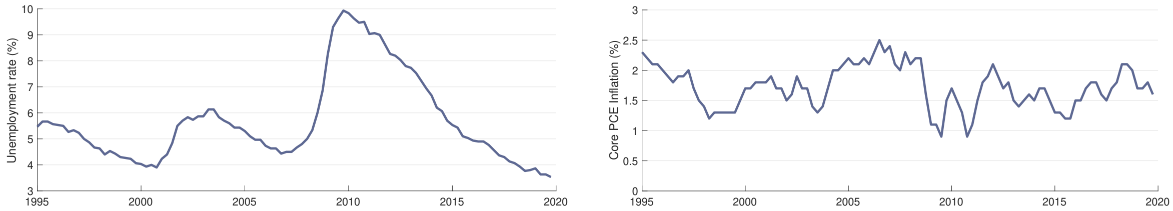
Inflation: The underlying price level series is the overall PCE Chain-type Price Index (2012=100), monthly and seasonally adjusted, obtained from FRED II, series ID PCEPI. The series spans from Jan. 1959 to Feb. 2021. For comparison we also use the core PCE Chain-type Price Index (2012=100), monthly and seasonally adjusted, obtained from FRED II, series ID PCEPILFE. The series are used to construct the following measures of price inflation, the third being the baseline reported in the paper:

(a) Month on month inflation, averaged to quarterly: We calculate the month on month change in the price index, annualize the rate, and convert to a quarterly frequency using 3 month averages.

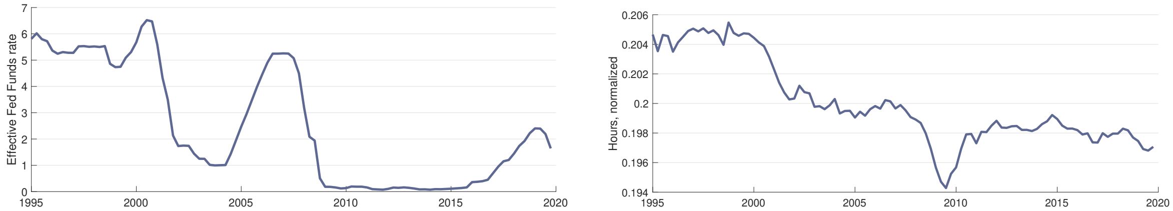
(b) Quarter on quarter inflation: We convert the monthly price index to a quarterly frequency using 3 month averages, then calculate the quarter on quarter change and annualize the rate.

(c) Year on year inflation: The monthly price index is converted to a quarterly frequency using 3 month averages. Then the year on year inflation is calculated using the quarterly series.

Key moments for the constructed inflation series, over three separate time frames, are reported in Table A.1.



(a) Unemployment rates (b) Inflation



(c) Nonimal policy rate (d) Hours worked on the job

Figure A.1: U.S. data

Note:

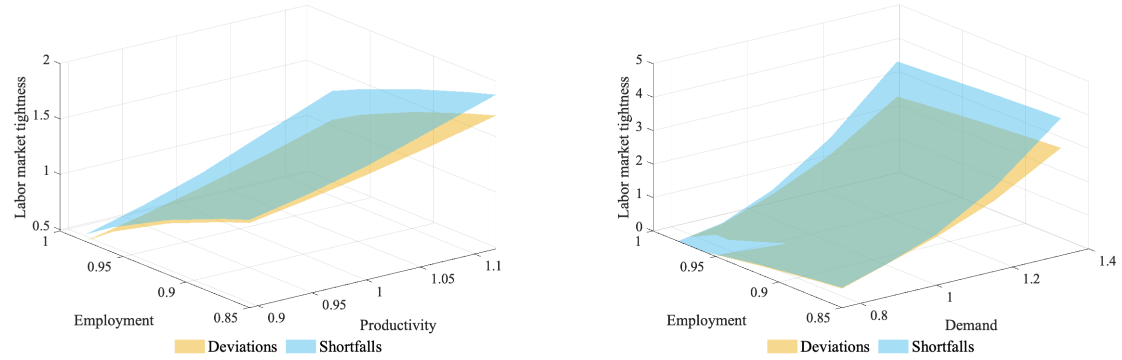
Hours worked: We use actual hours worked on the job constructed from the CPS micro data. The monthly series spans Jan. 1983 to March 2021 is seasonal adjusted with the Census Bureau's X-12 procedure, and converted to quarterly by three-month averaging. The raw series is plotted in Figure A.1d.

Table A.1: U.S. PCE and core PCE inflation, first and second moments

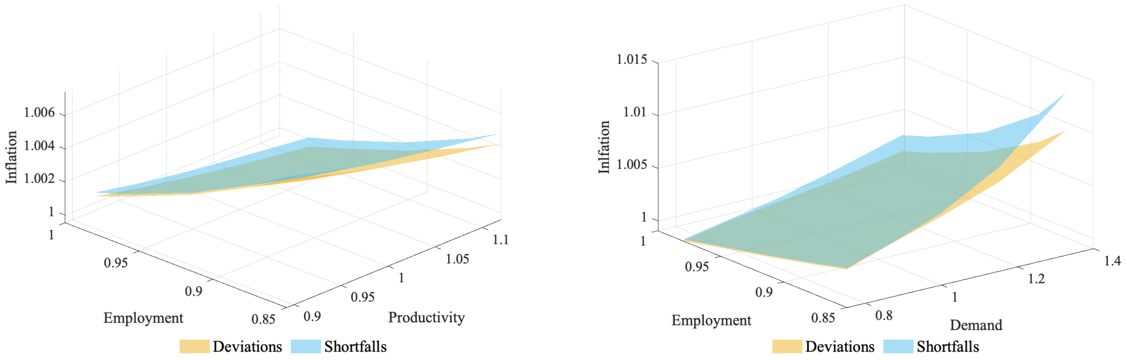
	PCE Iinflation			Core PCE inflation		
	$\pi(1)$	$\pi(2)$	$\pi(3)$	$\pi(1)$	$\pi(2)$	$\pi(3)$
1984Q1 to 2019Q4						
$E(\pi)$	2.25	2.23	2.25	2.26	2.25	2.28
$\sigma(\pi)$	0.92	0.82	0.62	0.55	0.30	0.15
$corr(U,\pi)$	-0.07	-0.13	-0.27	-0.10	-0.21	-0.41
$corr(H,\pi)$	–	–	–	–	–	–
$corr(R,\pi)$	0.06	0.10	0.34	0.11	0.24	0.47
1995Q1 to 2019Q4						
$E(\pi)$	1.82	1.80	1.80	1.72	1.71	1.72
$\sigma(\pi)$	0.93	1.00	0.70	0.61	0.28	0.13
$corr(U,\pi)$	-0.02	-0.10	-0.23	-0.06	-0.18	-0.45
$corr(H,\pi)$	-0.06	-0.01	0.08	-0.01	0.10	0.25
$corr(R,\pi)$	0.05	0.09	0.32	0.11	0.26	0.51
1984Q1 to 2007Q4						
$E(\pi)$	2.62	2.59	2.60	2.59	2.58	2.61
$\sigma(\pi)$	0.95	0.81	0.33	0.47	0.28	0.14
$corr(U,\pi)$	-0.11	-0.20	-0.44	-0.12	-0.25	-0.37
$corr(H,\pi)$	–	–	–	–	–	–
$corr(R,\pi)$	0.03	0.13	0.40	0.06	0.20	0.45
1995Q1 to 2007Q4						
$E(\pi)$	2.11	2.07	2.04	1.84	1.82	1.82
$\sigma(\pi)$	1.00	0.94	0.27	0.54	0.22	0.10
$corr(U,\pi)$	0.002	-0.20	-0.36	-0.007	-0.13	-0.32
$corr(H,\pi)$	-0.11	0.01	0.09	0.02	0.26	0.13
$corr(R,\pi)$	-0.02	0.11	0.35	0.01	0.16	0.47

Notes: Inflation 1 through 3 are defined as : (1) month on month inflation, annualized and averaged quarterly; (2) quarter on quarter inflation, annualized ; and (3) year on year inflation, quarterly price index. The underlying price level series are the PCE and core PCE Chain-type Price Indices (2012=100), monthly and seasonally adjusted, obtained from FRED II, series ID PCEPI and PCEPILF respectively. The series spans from Jan. 1959 to Feb. 2021.

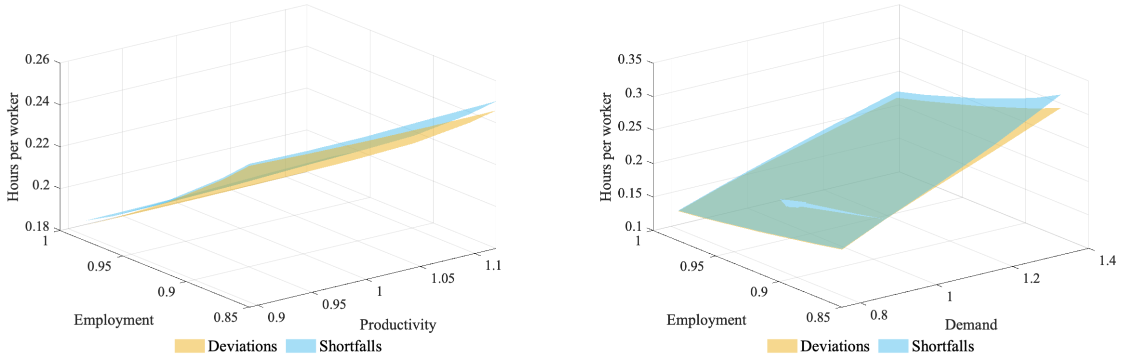
Figure A.2: Model economy policy function for labor market tightness, hours per worker and inflations under deviation and shortfall policy rules


(a) Labor market tightness and productivity

(b) Labor market tightness and demand


(c) Inflation and productivity

(d) Inflation and demand


(e) Hours per worker and productivity

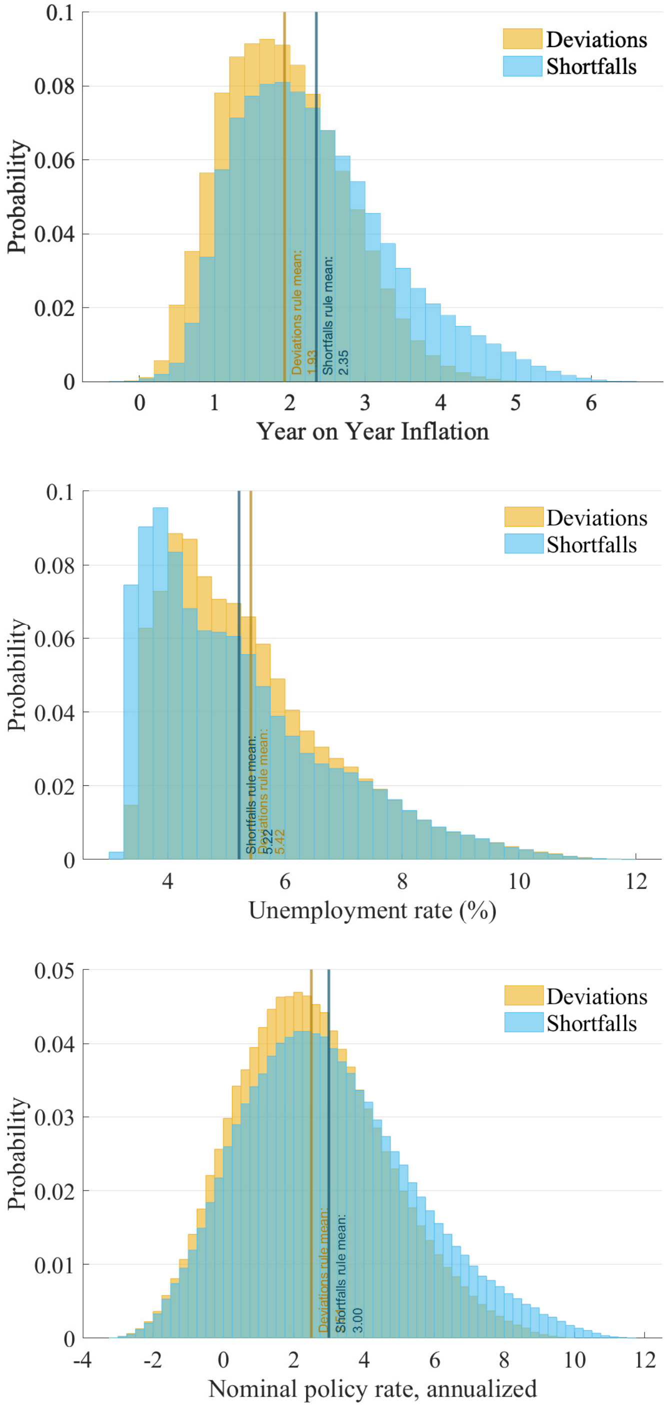
(f) Hours per worker and demand

Table A.2: Welfare under Deviations and Shortfalls, baseline and extensions

	Deviations	Shortfalls		No ZLB	
		Baseline	Greater π weight	Deviations	Shortfalls
Mean :					
U	5.3	5.1	5.2	5.3	5.2
π	1.9	2.4	2.0	1.9	2.3
Std. dev.:					
$\sigma(U)$	0.08	0.09	0.09	0.08	0.09
$\sigma(\pi)$	0.13	0.14	0.13	0.13	0.13
Cross. corr.:					
$corr(U,\pi)$	-0.24	-0.36	-0.28	-0.32	-0.39
Welfare:					
Mean J_t	1617	1619	1618	1617	1618

Notes: Model moments are computed on 10,000 simulations of 300 periods, equal to the number of months in the data sample and then average over three period for a quarterly frequency. Empirical and model data are converted to proportional deviations and Hodrick-Prescott filtered before computing second moments.

Figure A.3: Model-Implied Stationary Distributions Under Deviations & Shortfalls Rules, no ZLB Constraint



Note: Model distributions obtain from 10,000 simulations of 300 periods, equal to the number of months in the data sample. Vertical lines correspond to sample means of the respective variables.

B Detailed Derivations

B.1 Full model

B.1.1 Wholesale sector firm and worker marginal values and match surplus

Write the firm's value function as

$$S_t^w = \psi_t X_t N_t H_t^\alpha - W_t N_t H_t - \kappa_t V_t + E_t \left[M_{t,t+1} S_{t+1}^w\right] + \lambda_t^V q(\theta_t) V_t.$$

The optimality condition of this problem guarantees that

$$S_{Vt}^w \equiv \frac{\partial S_t^w}{\partial V_t} = 0. \tag{A.1}$$

The marginal value of a hired worker is obtained from differentiating the firm's value function with respect to N_t, using the law of motion for employment and the definition of the household's stochastic discount factor:

$$\begin{aligned} S_{Nt}^w &= \psi_t X_t H_t^\alpha - W_t H_t + E_t \left[M_{t,t+1} \left[S_{Nt+1}^w \frac{\partial N_{t+1}}{\partial N_t}\right]\right] \\ S_{Nt}^w &= \psi_t X_t H_t^\alpha - W_t H_t + (1-s)\beta E_t \left[\frac{\lambda_{t+1}^C}{\lambda_t^C} S_{Nt+1}^w\right] \end{aligned} \tag{A.2}$$

The household's problem (4) is described by:

$$\begin{aligned} J_t &= \mathcal{U}\left(C_t, H_t, N_t\right) + \nu_u U_t + \beta E_t \left[J_{t+1}\right] \\ &\quad + \lambda_t^C \left[\frac{B_{t-1}}{P_t} + W_t\, H_t\, N_t + b\, U_t + D_t - C_t - T_t - \frac{B_t}{P_t R_t}\right] \end{aligned}$$

and the laws of motion for employment, unemployment. We consider the case for household preferences over consumption and hours worked:

$$\mathcal{U}\left(C_t, H_t, N_t\right) = \exp(\gamma_t) \frac{C_t^{1-\sigma}}{1-\sigma} + \nu_0 \frac{\left(1-H_t\right)^{1-\nu_1}}{1-\nu_1} N_t \tag{A.3}$$

Differentiating the household's value function, we obtain the marginal values of an employed and unemployed worker to the representative household:

$$\begin{aligned} J_{N,t} &= \frac{\partial \mathcal{U}(\cdot)}{\partial N_t} + \lambda_t^C W_t H_t + \beta E_t \left[(1-s) J_{N,t+1} + s J_{U,t+1}\right] \\ J_{U,t} &= \frac{\partial \mathcal{U}(\cdot)}{\partial U_t} + \lambda_t^C b + \beta E_t \left[f_t J_{N,t+1} + (1-f_t) J_{U,t+1}\right] \end{aligned}$$

The marginal benefit being employed over unemployment is:

$$J_{N,t} - J_{U,t} \;=\; \lambda_t^C W_t H_t - \left(\lambda_t^C b + \frac{\partial \mathcal{U}(\cdot)}{\partial U_t} - \frac{\partial \mathcal{U}(\cdot)}{\partial N_t}\right) + (1 - f_t - s)\,\beta E_t\left[J_{N,t+1} - J_{U,t+1}\right]$$

for a match surplus to the household:

$$\frac{J_{N,t} - J_{U,t}}{\lambda_t^C} \;=\; W_t H_t - Z_t + (1 - f_t - s)\,\beta \frac{\lambda_{t+1}^C}{\lambda_t^C} E_t\left[\frac{J_{N,t+1} - J_{U,t+1}}{\lambda_{t+1}^C}\right]$$

where

$$Z_t \;=\; b + \frac{1}{\lambda_t^C}\left(\frac{\partial \mathcal{U}(\cdot)}{\partial U_t} - \frac{\partial \mathcal{U}(\cdot)}{\partial N_t}\right) = b + \frac{1}{\lambda_t^C}\left(\nu_u - \nu_0 \frac{(1-H_t)^{1-\nu_1}}{1-\nu_1}\right)$$

B.1.2 Wages and hours

Firms and workers engage in pairwise bargaining over wages and hours each period. Equilibrium wages and hours solve the problem

$$\Lambda_t = \max_{W_t, H_t} \left(\frac{J_{Nt} - J_{Ut}}{\lambda_t^C}\right)^{\eta} \left(S_{N,t}^w - S_{V,t}^w\right)^{1-\eta}$$

After first taking the log of the problem the first order condition for the wage is:

$$\begin{aligned}
\frac{\partial \Lambda_t}{\partial W_t} &= \eta \frac{\lambda_t^C}{J_{N,t} - J_{U,t}} \frac{\partial (J_{N,t} - J_{U,t})}{\partial W_t} + (1-\eta)\frac{1}{S_{N,t}^w}\frac{\partial S_{N,t}^w}{\partial W_t} = 0 \\
\frac{\partial \Lambda_t}{\partial W_t} &= \eta \frac{\lambda_t^C}{J_{N,t} - J_{U,t}} H_t - (1-\eta)\frac{1}{S_{N,t}^w} H_t = 0 \\
\Rightarrow \; (1-\eta)\frac{J_{N,t} - J_{U,t}}{\lambda_t^C} &= \eta S_{N,t}^w \qquad \text{(A.4)}
\end{aligned}$$

while the first order condition for hours is :

$$\begin{aligned}
\frac{\partial \Lambda_t}{\partial H_t} &= \eta \frac{\lambda_t^C}{J_{N,t} - J_{U,t}} \frac{\partial (J_{N,t} - J_{U,t})}{\partial H_t} + (1-\eta)\frac{1}{S_{N,t}^w}\frac{\partial S_{N,t}^w}{\partial H_t} = 0 \\
&= \eta \frac{\lambda_t^C}{J_{N,t} - J_{U,t}} \left(W_t - \frac{\partial Z_t}{\partial H_t}\right) + (1-\eta)\frac{1}{S_{N,t}^w}\left(\alpha \psi_t X_t H_t^{\alpha-1} - W_t\right) = 0 \\
&= \eta \frac{\lambda_t^C}{J_{N,t} - J_{U,t}} \left(-\frac{\partial Z_t}{\partial H_t}\right) + (1-\eta)\frac{1}{S_{N,t}^w}\left(\alpha \psi_t X_t H_t^{\alpha-1}\right) = 0 \\
&= \left(-\frac{\partial Z_t}{\partial H_t}\right) + \left(\alpha \psi_t X_t H_t^{\alpha-1}\right) = 0
\end{aligned}$$

which results in, depending on the assumption made for $\mathcal{U}()$ on either:

$$\frac{\nu_0}{\lambda_t^C}\left(1-H_t\right)^{-\nu_1} = \alpha\psi_t X_t H_t^{\alpha-1} \tag{A.5}$$

$$\nu_0\left(1-H_t\right)^{-\nu_1} = \alpha\psi_t X_t H_t^{\alpha-1} \tag{A.6}$$

To derive the wage:

$$\begin{aligned}
(1-\eta)\frac{J_{N,t}-J_{U,t}}{\lambda_t^C} &= \eta S_{N,t}^w \\
(1-\eta)\left[W_tH_t - Z_t + (1-f_t-s)\,\beta\frac{\lambda_{t+1}^C}{\lambda_t^C}E_t\left[\frac{J_{N,t+1}-J_{U,t+1}}{\lambda_{t+1}^C}\right]\right] &= \eta\left[\psi_t X_t H_t^\alpha - W_tH_t\right. \\
&\quad \left. +(1-s)\beta E_t\frac{\lambda_{t+1}^C}{\lambda_t^C}S_{Nt+1}^w\right] \\
(1-\eta)\left[W_tH_t - Z_t + (1-f_t-s)\,\beta\frac{\lambda_{t+1}^C}{\lambda_t^C}E_t\left[\frac{J_{N,t+1}-J_{U,t+1}}{\lambda_{t+1}^C}\right]\right] &= \eta\left[\psi_t X_t H_t^\alpha - W_tH_t\right. \\
&\quad \left. +(1-s)\beta E_t\frac{\lambda_{t+1}^C}{\lambda_t^C}S_{Nt+1}^w\right] \\
(1-\eta)\left[W_tH_t - Z_t - f_t\beta\frac{\lambda_{t+1}^C}{\lambda_t^C}E_t\left[\frac{J_{N,t+1}-J_{U,t+1}}{\lambda_{t+1}^C}\right]\right] &= \eta\left[\psi_t X_t H_t^\alpha - W_tH_t\right]
\end{aligned}$$

$$\begin{aligned}
W_tH_t &= \eta\alpha\psi_t X_t N_t^{\alpha-1}H_t^\alpha + (1-\eta)Z_t + (1-\eta)f_t\beta\frac{\lambda_{t+1}^C}{\lambda_t^C}E_t\left[\frac{J_{N,t+1}-J_{U,t+1}}{\lambda_{t+1}^C}\right] \\
W_tH_t &= \eta\psi_t X_t H_t^\alpha + (1-\eta)Z_t + \eta f_t\beta\frac{\lambda_{t+1}^C}{\lambda_t^C}E_t\left[S_{N,t+1}^w\right] \\
W_tH_t &= \eta\psi_t X_t H_t^\alpha + (1-\eta)Z_t + \eta f_t\left(\frac{\kappa_t}{q(\theta_t)-\lambda_t}\right) \\
W_tH_t &= \eta\left[\psi_t X_t H_t^\alpha + \kappa_t\theta_t\right] + (1-\eta)Z_t && \text{(A.7)}
\end{aligned}$$

B.2 Notes on the monetary policy rule

Consider the *deviations* monetary policy rule for the gross nominal rate in the absence of a zero lower bound:

$$R_t = R^r\Pi\left(\frac{\Pi_t}{\Pi^*}\right)^{\widehat{\phi}_\pi}\left(\frac{U_t}{U^*}\right)^{\widehat{\phi}_u} \tag{A.8}$$

where R^r is the real gross rate. The coefficient $\widehat{\phi}_\pi$ and $\widehat{\phi}_u$ correspond to the elasticities of R_t to inflation Π_t and U_t, respectively $\left(\left(\partial R_t/\partial\Pi_t\right)\left(\Pi_t/R_t\right)=\widehat{\phi}_\pi\right)$.

Take the log of (A.8):

$$\log(R_t) = \log(R^r) + \log(\Pi) + \widehat{\phi}_\pi \log\left(\frac{\Pi_t}{\Pi^*}\right) + \widehat{\phi}_u \log\left(\frac{U_t}{U^*}\right) \tag{A.9}$$

Using the approximation for $|x| < 1$, $\log(1+x) \approx x$, we have $\log\left(\frac{\Pi_t}{\Pi^*}\right) \approx \frac{\Pi_t - \Pi^*}{\Pi^*}$ and $\log\left(\frac{U_t}{U^*}\right) \approx \frac{U_t - U^*}{U^*}$, such that the previous expression may be approximately rewritten as :

$$R_t = r^r + \pi + \frac{\widehat{\phi}_\pi}{\Pi^*}\left(\pi_t - \pi^*\right) + \frac{\widehat{\phi}_u}{U^*}\left(U_t - U^*\right) \tag{A.10}$$

The empirical literature estimates Taylor-type rules for the central bank policy setting very often use a specification of the type described by (A.10) to obtain values of $\phi_\pi = \frac{\widehat{\phi}_\pi}{\pi^*}$ and $\phi_u = \frac{\widehat{\phi}_u}{U^*}$.

C Summary of the Baseline Model

C.1 System of Model Equations

The model's 17 endogenous variables, N_t, U_t, H_t, V_t, θ_t, q, f, W_t, M_t, λ_t^C, Z_t, Y_t, C_t, ψ_t, Π_t, κ_t, R_t, are determined by the 17 equations that follow (ignoring the conditions for the Lagrange multiplier on the non-negativity constraint λ_t^V):

$$\psi_t = \frac{\omega - 1}{\omega} + \frac{\Omega}{\omega}\left[\frac{\Pi_t}{\Pi}\left(\frac{\Pi_t}{\Pi} - 1\right) - E_t M_{t,t+1}\frac{Y_{t+1}}{Y_t}\frac{\Pi_{t+1}}{\Pi}\left(\frac{\Pi_{t+1}}{\Pi} - 1\right)\right] \tag{A.11}$$

$$\frac{\kappa_t}{q(\theta_t)} - \lambda_t^V = E_t\left[M_{t,t+1}\left[\psi_{t+1}X_{t+1}H_{t+1}^\alpha - W_{t+1}H_{t+1} + (1-s)\left[\frac{\kappa_{t+1}}{q(\theta_{t+1})} - \lambda_{t+1}\right]\right]\right] \tag{A.12}$$

$$W_t H_t = \eta\left[\psi_t X_t H_t^\alpha + \kappa_t \theta_t\right] + (1-\eta) Z_t \tag{A.13}$$

$$Z_t = b + \frac{1}{\lambda_t^C}\left(\nu_u - \nu_0 \frac{(1-H_t)^{1-\nu_1}}{1-\nu_1}\right) \tag{A.14}$$

$$\frac{\nu_0}{\lambda_t^C}\left(1 - H_t\right)^{-\nu_1} = \alpha \psi_t X_t H_t^{\alpha - 1} \tag{A.15}$$

$$\lambda_t^C = exp(\gamma_t) C_t^{-\sigma} \tag{A.16}$$

$$1 = E_t\left[M_{t,t+1}\frac{R_t}{\Pi_{t+1}}\right] \tag{A.17}$$

$$M_{t,t+1} = \beta\left(\frac{\lambda_{t+1}^C}{\lambda_t^C}\right) \tag{A.18}$$

$$Y_t = C_t + \kappa_t V_t + \frac{\Omega}{2}\left(\frac{\Pi_t}{\Pi} - 1\right)^2 Y_t \tag{A.19}$$

$$Y_t = X_t N_t H_t^\alpha \tag{A.20}$$

$$\begin{aligned}
\kappa_t &= \kappa_0 + \kappa_1 q_t && \text{(A.21)}\\
\theta_t &= \frac{V_t}{U_t} && \text{(A.22)}\\
N_{t+1} &= (1-s)N_t + q(\theta_t)V_t && \text{(A.23)}\\
U_t &= 1 - N_t && \text{(A.24)}\\
q_t &= \frac{1}{(1+\theta_t^{\iota})^{1/\iota}} && \text{(A.25)}\\
f_t &= \frac{1}{\left(1+\theta_t^{-\iota}\right)^{1/\iota}} && \text{(A.26)}
\end{aligned}$$

$$\text{Deviations rule:} \qquad R_t = \max\left[1, \quad R\left(\frac{\Pi_t}{\Pi^*}\right)^{\widehat{\phi}_\pi}\left(\frac{U_t}{U^*}\right)^{\widehat{\phi}_u}\right] \tag{A.27}$$

$$\text{Shortfalls rule:} \qquad R_t = \max\left[1, \quad R\left(\frac{\Pi_t}{\Pi^*}\right)^{\widehat{\phi}_\pi}\left(\max\left[1, \frac{U_t}{U^*}\right]\right)^{\widehat{\phi}_u}\right] \tag{A.28}$$