Online Appendix

A Measuring Full Employment

The FOMC's newly adopted consensus statement explicitly states that full employment cannot be summarized by a single statistic. However, public communications by members of the FOMC often reference the unemployment rate as a benchmark indicator for the labor market.

The employment-to-population ratio is an often discussed alternative indicator for the health of the labor market from the perspective of assessing the distance from a full employment objective. However, policymakers and economists equally discuss challenges associated with using the employment-to-population ratio as a measure of maximum employment. One concern is the clear downward trend in overall labor force participation caused by an aging workforce (see Aaronson et al., 2014, Krueger, 2017). That said, the Committee has discussed in the past and we show next, once an adjustment is made for the aging of the population, the employment-to-population ratio and unemployment rate convey a very similar degree of tightness in the labor market across time.[15]

The share of the working age population 55 years of age and older increased from 27% in 2000 to 37% in 2019. And while the employment-to-population ratio for this age group increased from about 32 to 40 percent between 2000 and 2008, stabilizing thereafter, it remains significantly below that of 25 to 54 year olds with rates around 83%. A standard approach to address the effect on the overall employment-to-population ratio of an aging population is to keep the population shares of different age groups fixed at a reference date. In this instance, we use the age groupings of 16 to 24, 25 to 34, 35 to 44, 45 to 54, 55 and older, and build a counterfactual, age-adjusted employment-to-population ratio as:

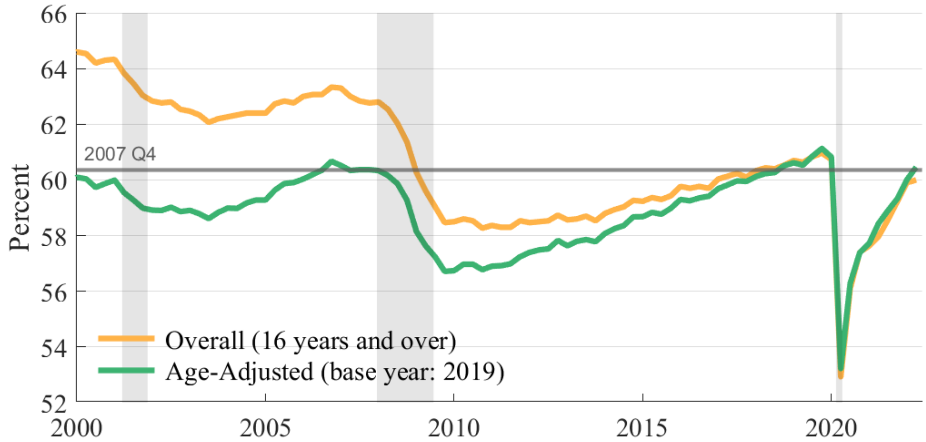
$$\widetilde{epop}(t) = \sum_i \omega(i, t_0) \times epop(i, t)$$

where $\omega(i, t_0)$ is the population share of age group i at a base date t_0 and $epop(i, t)$ is the employment-to-population ratio of group i at date t. By construction $\widetilde{epop}(t_0) = epop(t_0)$. Figure (A.1a) plots the actual and age-composition adjusted employment-to-population ra-

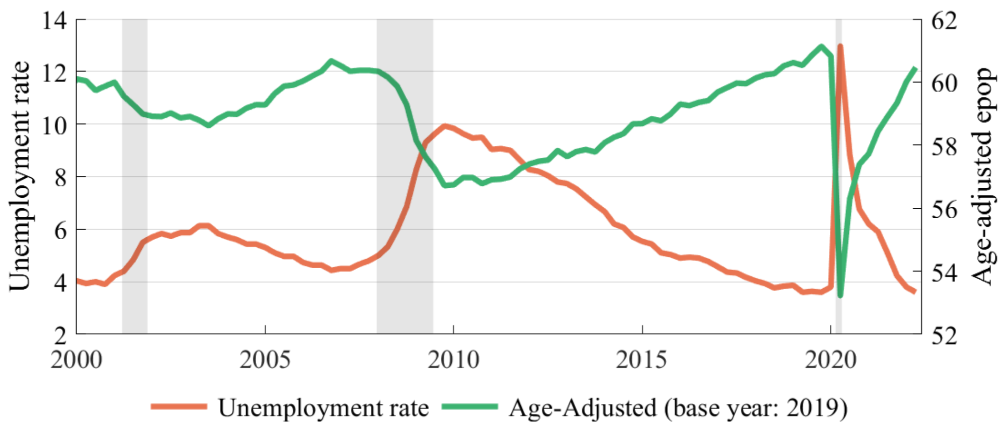
[15] For instance, the minutes from the Sept. 2019 meeting of the FOMC indicate participants focused on trends in labor force participation of prime age workers for the purpose of separating out the issue of an aging population. The minutes from the April 2019 meeting of the FOMC stated, "Participants agreed that labor market conditions remained strong [...] and, while the labor force participation rate moved down a touch, it remained high relative to estimates of its underlying demographically driven, downward trend."

Figure A.1: Measuring Labor Market Tightness:
Age-Adjusted Employment-to-Population Ratios and the Unemployment Rate

(a) Actual and Age-Adjusted Employment-to-Population Ratio



(b) Unemployment Rate and Age-Adjusted Employment-to-Population Ratio



tios over the last 25 years. We select 2019Q4 as the reference date which implies that the age-adjusted employment-to-population ratio in green is lower than the actual overall employment to population ratio in yellow prior to 2019. Moreover, the level in 2019 is now similar to that at the end of 2017, just prior to the Great Recession (this is indicated by the horizontal solid gray line).

Once we adjust for the age-composition of the population, there no longer appears to be a longer run downward trend of the employment-to-population ratio. Moreover, as Figure A.1b makes clear, the the employment-to-population ratio and unemployment rate convey a very similar degree of tightness in the labor market. The movements in each series closely mirror each other (the series are highly correlated at -0.85), signaling a similar degree of tightness in the labor market at a particular point in time.

B Additional Results Using a Textbook Model

B.1 Analytical Implications of Adopting a Shortfalls Rule

Using a simplified process for the natural rate r_t^n, we can use a three-period version of the model in Equations (4) and (5) to analytically highlight the macroeconomic effects if the central bank chooses to adopt the one-sided shortfalls rule versus the symmetric deviations rule. Suppose that the natural rate r_t^n takes either a positive value Δ or a negative value $-\Delta$ in period 2. Both outcomes occur with a probability of 1/2. Furthermore, assume that the natural rate takes a value of 0 in periods 1 and 3.

Beginning first with the outcomes under the deviations rule in Equation (6), we solve the model backwards in time to determine the paths for unemployment and inflation. Since the natural rate equals zero in period 3 (and the model economy ceases to exist after that period), this implies $u_3 = \pi_3 = 0$. Since households and firms fully understand this outcome for certain, we know $E_2\,\pi_3 = 0$ and $E_2\,u_3 = 0$. Then, we solve for unemployment and inflation in period 2 depending on if the economy experiences the positive (Δ) or negative ($-\Delta$) outcome:

$$u_2^{\Delta} = -\frac{1}{c}\left(\frac{1}{1+\phi_\pi\varphi - \phi_u/c}\right)\Delta \qquad u_2^{-\Delta} = \frac{1}{c}\left(\frac{1}{1+\phi_\pi\varphi - \phi_u/c}\right)\Delta$$

$$\pi_2^{\Delta} = \left(\frac{\varphi}{1+\phi_\pi\varphi - \phi_u/c}\right)\Delta \qquad \pi_2^{-\Delta} = -\left(\frac{\varphi}{1+\phi_\pi\varphi - \phi_u/c}\right)\Delta$$

In an expansion (Δ), the economy experiences low unemployment and above target inflation. The magnitude of these fluctuations depend on the size of the shock Δ, the slope of the Phillips curve φ, the assumed Okun's Law relation c, as well as the central bank's response of inflation ϕ_π and unemployment ϕ_u. In blue, we highlight parts of the solution that will play a key role in the coming analysis. Note that the solutions to unemployment and inflation in an expansion (Δ) are simply the symmetric inverse of the outcomes in a contraction ($-\Delta$). Using these possible solutions in period 2, we can compute expectations of unemployment and inflation in the period prior to the shock occurring:

$$E_1 u_2 = \frac{1}{2}\left(u_2^{\Delta}\right) + \frac{1}{2}\left(u_2^{-\Delta}\right) = 0,$$

$$E_1 \pi_2 = \frac{1}{2}\left(\pi_2^{\Delta}\right) + \frac{1}{2}\left(\pi_2^{-\Delta}\right) = 0,$$

Continuing to solve backward, since $r_1^n = 0$, $E_1 u_2 = 0$, & $E_1 \pi_2 = 0$, then it follows that $u_1 = 0$ & $\pi_1 = 0$ under the symmetric deviations rule.

However, if policy instead follows the shortfalls rule in Equation (7), we find the same outcomes after the shock occurs in period 3 ($\pi_3 = u_3 = 0$ and $E_2\,\pi_3 = E_2\,u_3 = 0$), but now the solutions in period 2 are no longer symmetric inverses (differences in red):

$$u_2^{\Delta} = -\frac{1}{c}\left(\frac{1}{1+\phi_\pi\varphi}\right)\Delta \qquad u_2^{-\Delta} = \frac{1}{c}\left(\frac{1}{1+\phi_\pi\varphi-\phi_u/c}\right)\Delta$$
$$\pi_2^{\Delta} = \left(\frac{\varphi}{1+\phi_\pi\varphi}\right)\Delta \qquad \pi_2^{-\Delta} = -\left(\frac{\varphi}{1+\phi_\pi\varphi-\phi_u/c}\right)\Delta$$

By not leaning directly against the labor market in good times, the economy experiences larger fluctuations in unemployment and inflation in the expansionary state. If the economy instead experiences a contraction, the outcomes for unemployment and inflation are the same under both the deviations and shortfalls rules. Given these outcomes (and recall $\phi_u < 0$), we can solve for expectations in period 1 under the shortfalls rule.

$$\begin{aligned}
E_1 u_2 &= \frac{1}{2}\left(u_2^{\Delta}\right) + \frac{1}{2}\left(u_2^{-\Delta}\right) \\
&= \frac{1}{2\,c^2}\,\frac{1}{(1+\phi_\pi\varphi)\;(1+1\phi_\pi\varphi-\phi_u/c)}\;\phi_u\,\Delta < 0 \\
E_1 \pi_2 &= \frac{1}{2}\left(\pi_2^{\Delta}\right) + \frac{1}{2}\left(\pi_2^{-\Delta}\right) \\
&= -\frac{1}{2\,c}\,\frac{\varphi}{(1+\phi_\pi\varphi)\;(1+1\phi_\pi\varphi-\phi_u/c)}\;\phi_u\,\Delta > 0
\end{aligned}$$

Under the shortfalls rule, expectations of more accommodative policy in expansions leads to higher inflation and lower unemployment. Since $r_1^n = 0$ and $E_1 u_2 < 0$, we know that $u_1 < 0$ in the shortfalls rule. So, we can solve for outcomes in period 1:

$$\begin{aligned}
u_1 &= \frac{1}{2\,c^2}\,\frac{1-\varphi\,(\phi_\pi\beta-1)}{(1+\phi_\pi\varphi)^2\;(1+\phi_\pi\varphi-\phi_u/c)}\;\phi_u\,\Delta < 0 \\
\pi_1 &= -\frac{1}{2\,c^2}\,\frac{\varphi\,(1+\beta+\varphi)}{(1+\phi_\pi\varphi)^2\;(1+\phi_\pi\varphi-\phi_u/c)}\;\phi_u\,\Delta > 0
\end{aligned}$$

Even without shocks in period 1, the economy experiences higher inflation and lower unemployment under the shortfalls rule despite the symmetric shocks hitting the economy.

B.2 Shortfalls Rule in a Model of Bounded Rationality

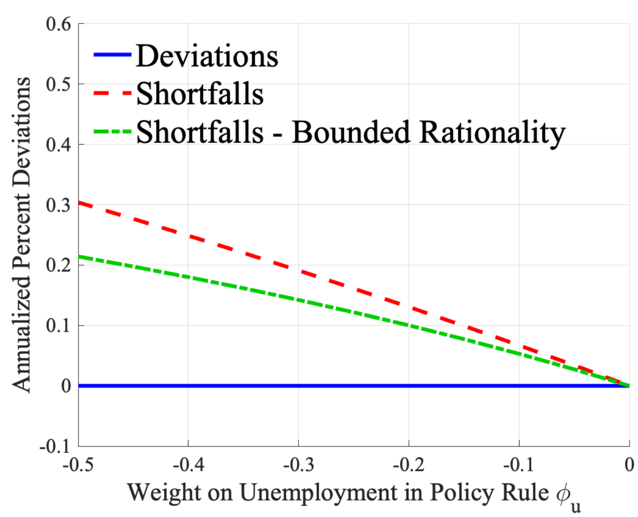
A recent criticism of the standard New Keynesian model in Equations (1) and (2) that we use in Section 2 is that it assumes too much forward-looking behavior by households and firms. In this section, we shows that the effects of adopting the shortfalls rule remain important for macroeconomic outcomes even in a model of bounded rationality, which tempers the response of current outcomes to expectations far in the future. Specifically, Gabaix (2020) derives a behavioral New-Keynesian model that introduces two additional parameters:

$$x_t = E_t\, m^h\, x_{t+1} - \Big(i_t - E_t\, \pi_{t+1} - r_t^n\Big),$$
$$\pi_t = \beta\, E_t\, m^f\, \pi_{t+1} + \varphi\, x_t,$$

where m^h and m^f control the sensitivity of current outcomes to future expectations for households (h) and firms (f). When $m^h = m^f = 1$, the model collapses back to the standard case we use in Section 2. To examine the effect of adopting a shortfalls rule in this model of bounded rationality, we redo the exercise in the top panel of Figure 2 in the main text using a calibration of $m^h = m^f = 0.9$. Figure B.1 shows that the assumption of bounded rationality only modestly reduces the quantitative impact of adoption a shortfalls rule. Thus, our key conclusions about the possible effects of adopting a shortfalls rule are robust to alternative assumptions on the forward-looking behavior of households and firms.

Figure B.1: Average Inflation Under Shortfalls Rule in Model of Bounded Rationality

(a) Varying Weight on Unemployment Gap ϕ_u



Note: Panel (a) sets $\phi_\pi = 1.5$ and varies the value of the weight on unemployment ϕ_u. In the bounded rationality model of Gabaix (2020), we set $m^h = m^f = 0.9$.

C Derivation & Results of the Quantitative Model

C.1 Notes on the Form of the Monetary Policy Rule

In this section, we provide some additional discussion on the mapping between the policy rules in log deviations from Section 2 versus the levels specification we use in solving the model of Section 3. Consider the *deviations* monetary policy rule for the gross nominal rate in the absence of a zero lower bound:

$$R_t = \ R^r \Pi \left(\frac{\Pi_t}{\Pi^*}\right)^{\widehat{\phi}_\pi} \left(\frac{U_t}{U^*}\right)^{\widehat{\phi}_u} \tag{C.1}$$

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 $((\partial R_t/\partial \Pi_t)(\Pi_t/R_t) = \widehat{\phi}_\pi)$.

Take the log of (C.1):

$$\log(R_t) = \log(R^r) + \log(\Pi) + \widehat{\phi}_\pi \log\left(\frac{\Pi_t}{\Pi^*}\right) + \widehat{\phi}_u \log\left(\frac{U_t}{U^*}\right) \tag{C.2}$$

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 :

$$R_t = r^r + \pi + \frac{\widehat{\phi}_\pi}{\Pi^*}(\pi_t - \pi^*) + \frac{\widehat{\phi}_u}{U^*}(U_t - U^*) \tag{C.3}$$

The empirical literature estimates Taylor-type rules for the central bank policy setting often use a specification of the type described by (C.3) to obtain values of $\phi_\pi = \frac{\widehat{\phi}_\pi}{\pi^*}$ and $\phi_u = \frac{\widehat{\phi}_u}{U^*}$.

C.2 Derivation of Match Surplus & Bargained Hours & Wage

This section provides additional detail on key derivations involving the labor market.

C.2.1 Wholesale Sector Firm and Worker Marginal Values & 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

$$S^w_{Vt} \equiv \frac{\partial S^w_t}{\partial V_t} = 0. \tag{C.4}$$

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:

$$\begin{aligned} S^w_{Nt} &= \psi_t X_t H_t^\alpha - W_t H_t + E_t \left[M_{t,t+1} \left[S^w_{Nt+1} \frac{\partial N_{t+1}}{\partial N_t} \right] \right] \\ S^w_{Nt} &= \psi_t X_t H_t^\alpha - W_t H_t + (1-s)\beta E_t \left[\frac{\lambda^C_{t+1}}{\lambda^C_t} S^w_{Nt+1} \right] \end{aligned} \tag{C.5}$$

The household's problem (14) is described by:

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

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

$$\mathcal{U}(C_t, H_t, N_t) = \exp(\gamma_t) \frac{C_t^{1-\sigma}}{1-\sigma} + \nu_0 \frac{(1-H_t)^{1-\nu_1}}{1-\nu_1} N_t \tag{C.6}$$

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

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

The marginal benefit being employed over unemployment is:

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

for a match surplus to the household:

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

where

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

C.2.2 Wages and hours

Firms and workers engage in pairwise Nash 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:

$$\begin{aligned}
\frac{\partial \Lambda_t}{\partial W_t} &= \eta \frac{\lambda_t^C}{J_{N,t} - J_{U,t}} \frac{\partial (J_{N,t} - J_{U,t})}{\partial W_t} + (1-\eta)\frac{1}{S_{N,t}^w}\frac{\partial S_{N,t}^w}{\partial W_t} = 0 \\
\frac{\partial \Lambda_t}{\partial W_t} &= \eta \frac{\lambda_t^C}{J_{N,t} - J_{U,t}} H_t - (1-\eta)\frac{1}{S_{N,t}^w} H_t = 0 \\
\Rightarrow \ (1-\eta)\frac{J_{N,t} - J_{U,t}}{\lambda_t^C} &= \eta S_{N,t}^w \qquad \text{(C.7)}
\end{aligned}$$

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:

$$\frac{\nu_0}{\lambda_t^C}(1-H_t)^{-\nu_1} = \alpha \psi_t X_t H_t^{\alpha-1} \qquad \text{(C.8)}$$

$$\nu_0 (1-H_t)^{-\nu_1} = \alpha \psi_t X_t H_t^{\alpha-1} \qquad \text{(C.9)}$$

To derive the wage:

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

$$
\begin{aligned}
W_t H_t &= \eta\alpha\psi_t X_t N_t^{\alpha-1} H_t^\alpha + (1-\eta)Z_t + (1-\eta)f_t\beta\frac{\lambda^C_{t+1}}{\lambda^C_t}E_t\left[\frac{J_{N,t+1}-J_{U,t+1}}{\lambda^C_{t+1}}\right] \\
W_t H_t &= \eta\psi_t X_t H_t^\alpha + (1-\eta)Z_t + \eta f_t\beta\frac{\lambda^C_{t+1}}{\lambda^C_t}E_t\left[S^w_{N,t+1}\right] \\
W_t H_t &= \eta\psi_t X_t H_t^\alpha + (1-\eta)Z_t + \eta f_t\left(\frac{\kappa_t}{q(\theta_t)-\lambda_t}\right) \\
W_t H_t &= \eta\left[\psi_t X_t H_t^\alpha + \kappa_t\theta_t\right] + (1-\eta)Z_t \qquad \text{(C.10)}
\end{aligned}
$$

C.3 Summary of the Quantitative Model

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):

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

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

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

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

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

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

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

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

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

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

$$\kappa_t = \kappa_0 + \kappa_1 q_t \tag{C.21}$$

$$\theta_t = \frac{V_t}{U_t} \tag{C.22}$$

$$N_{t+1} = (1-s)N_t + q(\theta_t)V_t \tag{C.23}$$

$$U_t = 1 - N_t \tag{C.24}$$

$$q_t = \frac{1}{(1+\theta_t^{\iota})^{1/\iota}} \tag{C.25}$$

$$f_t = \frac{1}{\left(1+\theta_t^{-\iota}\right)^{1/\iota}} \tag{C.26}$$

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

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

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

C.4 Computation

We adopt the globally nonlinear projection algorithm in Petrosky-Nadeau and Zhang (2017). In particular, given the state variables summarized in $\Gamma_t = \{x_t, \gamma_t, N_t\}$, we need to solve for the labor market tightness, $\theta_t = \theta(\Gamma_t)$, the multiplier function, $\lambda_t^V = \lambda^V(\Gamma_t)$, hours worked on the job, $H_t = H(\Gamma_t)$, intermediate input cost, $\psi_t = \psi(\Gamma_t)$, and inflation, $\Pi_t = \Pi(\Gamma_t)$ from the following five functional equations:

$$
\begin{aligned}
\frac{\kappa_t}{q(\theta(\Gamma_t))} - \lambda^V(\Gamma_t) &= E_t\left[M_{t,t+1}\left[\psi(\Gamma_{t+1})X_{t+1}H(\Gamma_{t+1})^{\alpha} - W_{t+1}H(\Gamma_{t+1})\right.\right.\\
&\quad \left.\left. +(1-s)\left[\frac{\kappa_{t+1}}{q(\theta(\Gamma_{t+1}))} - \lambda_{t+1}\right]\right]\right] \qquad \text{(C.29)}\\
\psi(\Gamma_t) &= \frac{\omega-1}{\omega} + \frac{\Omega}{\omega}\left[\frac{\Pi(\Gamma_t)}{\Pi}\left(\frac{\Pi(\Gamma_t)}{\Pi} - 1\right)\right.\\
&\quad \left. -E_t M_{t,t+1}\frac{Y_{t+1}}{Y_t}\frac{\Pi(\Gamma_{t+1})}{\Pi}\left(\frac{\Pi(\Gamma_{t+1})}{\Pi} - 1\right)\right] \qquad \text{(C.30)}\\
\frac{\nu_0}{\lambda_t^C}\left(1 - H(\Gamma_t)\right)^{-\nu_1} &= \alpha\psi(\Gamma_t)X_t H(\Gamma_t)^{\alpha-1}\\
1 &= E_t\left[M_{t,t+1}\frac{R_t}{\Pi(\Gamma_{t+1})}\right] \qquad \text{(C.31)}
\end{aligned}
$$

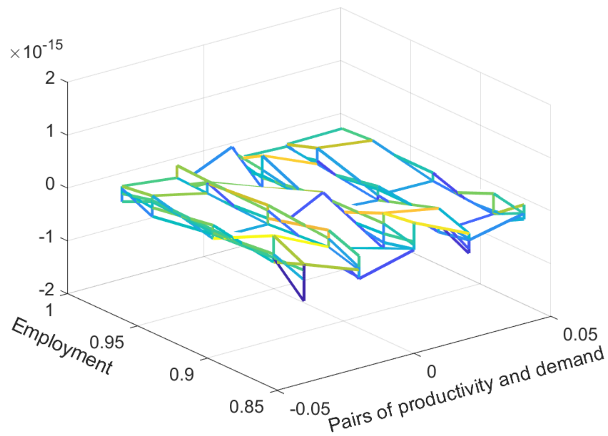
In addition, $\theta(\Gamma_t)$ and $\lambda^V(\Gamma_t)$ must also satisfy the Kuhn-Tucker conditions.

Rather than separately parameterizing $\theta(\Gamma_t)$ and $\lambda^V(\Gamma_t)$, we follow the approach in Christiano and Fisher and parameterize the conditional expectation in the right hand side of equation (C.29) a $\mathcal{E} \equiv \mathcal{E}(\Gamma_t)$. Specifically, after obtaining the parameterized $\mathcal{E}_t$, we first calculate $\tilde{q}(\theta_t) \equiv \kappa_t/\mathcal{E}_t$. If $\tilde{q}(\theta_t) < 1$, the nonnegativity constraint is not binding, we set $\lambda_t^V = 0$ and $q(\theta_t) = \tilde{q}(\theta_t)$. We then solve $\theta_t = q^{-1}(\tilde{q}(\theta_t))$, in which $q^{-1}(\cdot)$ is the inverse function of $q(\cdot)$ from equation (19), and $V_t = \theta_t(1-N_t)$. If $\tilde{q}(\theta_t) \geq 1$, the nonnegativity constraint is binding, we set $V_t = 0$, $\theta_t = 0$, $q(\theta_t) = 1$, and $\lambda_t^V = \kappa_t - \mathcal{E}_t$. We approximate the log productivity and the preference shock process, x_t and γ_t, with the discrete state space method of Rouwenhorst (1995). We use 25 grid points to cover pairs of values of x_t and γ_t. We use extensively the approximation toolkit in the Miranda and Fackler (2002) CompEcon Toolbox in Matlab and the model's steady state as an initial guess.

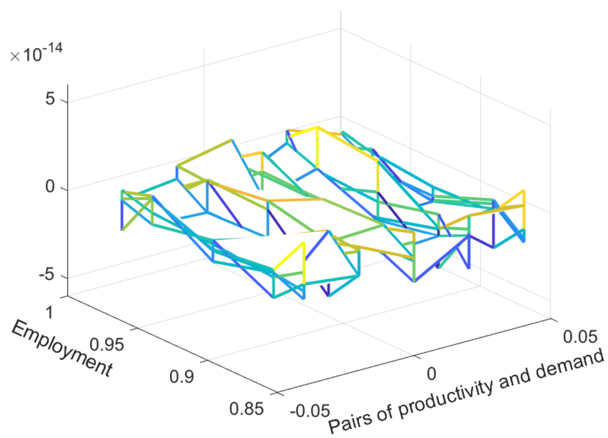
Figure C.1 reports the errors in the functional equation (A.29) through (A.31). The errors are extremely small, suggesting an accurate solution. See Petrosky-Nadeau and Zhang (2017) for more technical details on the global algorithm.

Figure C.1: Policy Function Approximation Errors

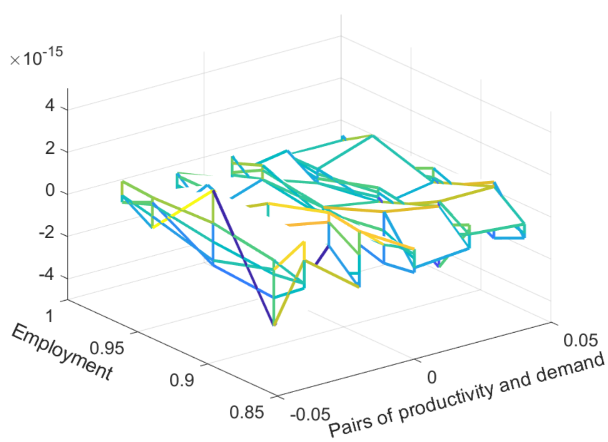
(a) Job creation condition



(b) Optimal price equation

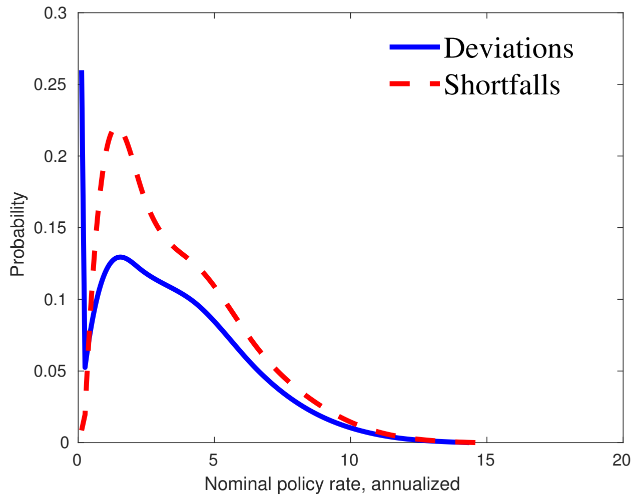


(c) Equilbrium hours condition



C.5 Additional Policy Functions and Simulation Results

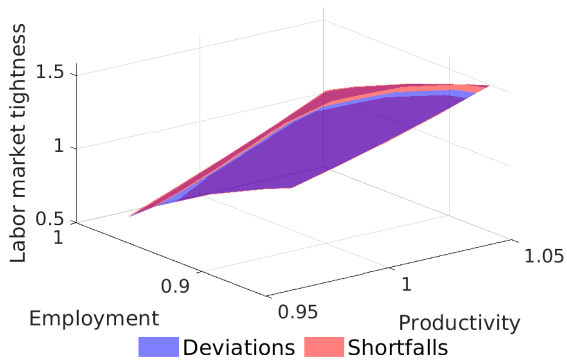
Figure C.2: Model-Implied Stationary Distributions Under Deviations & Shortfalls Rules



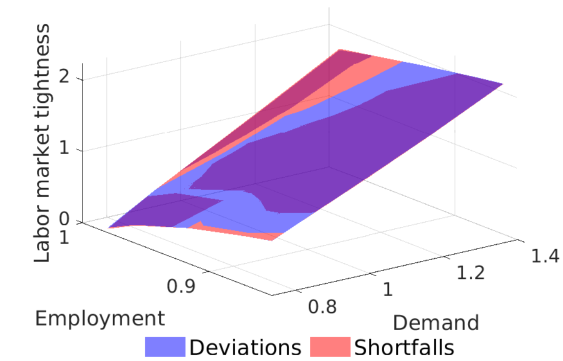
Note: Model distributions obtain from 10,000 simulations of 300 periods, equal to the number of months in the data sample. Vertical lines correspond to sample means of the respective variables.

Figure C.3: Model economy policy function for labor market tightness, hours per worker and inflations under deviation and shortfall policy rules

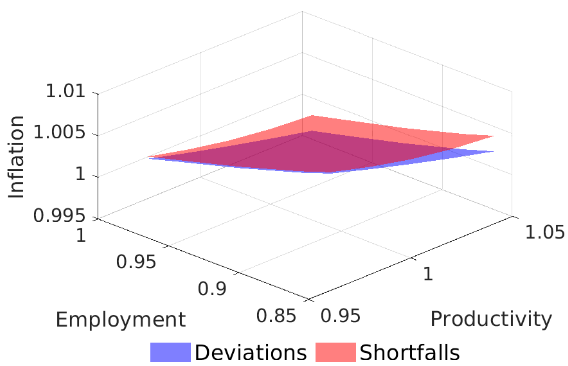
(a) Labor market tightness and productivity



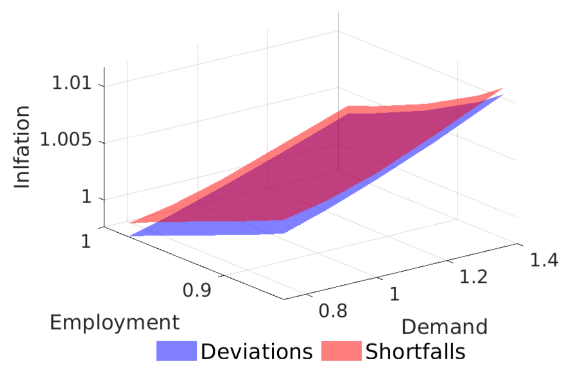
(b) Labor market tightness and demand



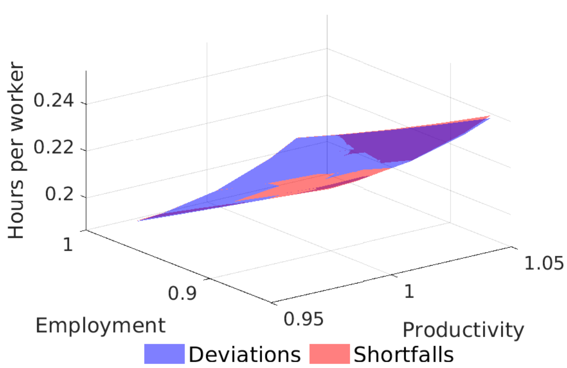
(c) Inflation and productivity



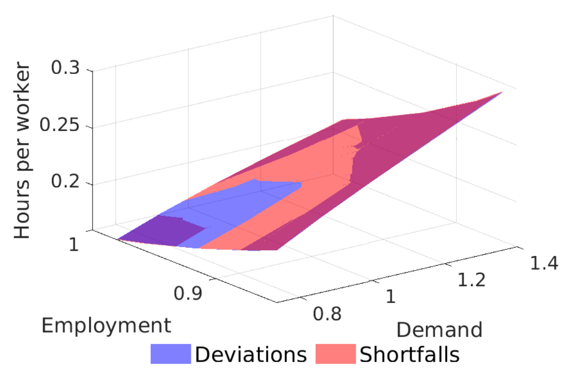
(d) Inflation and demand



(e) Hours per worker and productivity



(f) Hours per worker and demand



D Data

The sources for the empirical data used in the main analysis on the unemployment rate (Bureau of Labor Statistics (1948-2024*b*)), Fed Funds rate (Board of Governors of the Federal Reserve System (1954-2024)), headline (Bureau of Economic Analysis (1959-2024*a*)) and core (Bureau of Economic Analysis (1959-2024*b*)) inflation, and hours worked (Bureau of Labor Statistics (1947-2024*a*)) are as follows.

Unemployment rate: U.S. Bureau of Labor Statistics, Unemployment Rate [UNRATE], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/UNRATE, December 17, 2024.

Fed Funds rate: Board of Governors of the Federal Reserve System (US), Federal Funds Effective Rate [FEDFUNDS], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/FEDFUNDS, December 17, 2024.

Inflation:

- U.S. Bureau of Economic Analysis, Personal Consumption Expenditures: Chain-type Price Index [PCEPI], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/PCEPI, December 17, 2024
- U.S. Bureau of Economic Analysis, Personal Consumption Expenditures Excluding Food and Energy (Chain-Type Price Index) [PCEPILFE], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/PCEPILFE, December 17, 2024

Hours: U.S. Bureau of Labor Statistics, Nonfarm Business Sector: Average Weekly Hours for All Workers [PRS85006023], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/PRS85006023, December 17, 2024

Data for the online appendix section A for the employment to population ratio (Bureau of Labor Statistics (1948-204)) and age adjusted employment to population ratio (SF Fed Data Explorer (2000-2024)) are:

- Employment to population ratio: U.S. Bureau of Labor Statistics, Employment-Population Ratio [EMRATIO], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.o December 17, 2024.

- Age adjusted employment to population ratio: SF Fed Data Explorer, Federal Reserve Bank of San Francisco. Retrieved December 17, 2024; based on most recent Current Population Survey conducted by the U.S. Census Bureau for the Bureau of Labor Statistics. https://www.frbsf.org/research-and-insights/data-and-indicators/sf-fed-data-explorer/ located with chart code 111072010178000041010000948100.