Heterogeneous Downward Nominal Wage Rigidity: Foundations of a Nonlinear Phillips Curve

Stephanie Schmitt-Grohé

and

Martín Uribe

Columbia University and NBER

October 24, 2024

Motivation

• Two recent major economic events have rekindled interest in a nonlinear Phillips curve:

(1) Resilience of the labor market during the post-Covid-19 monetary tightening (the "missing unemployment" puzzle)
$\Rightarrow$ Is the Phillips curve steeper at high inflation? If so, then low cost of fighting high inflation in terms of unemployment.

(2) No significant increase in inflation in the recovery from the Global Financial Crisis of 2008 (the "missing inflation" puzzle)
$\Rightarrow$ Is the Phillips curve flatter at high unemployment rates? If so, then low cost of reducing high unemployment in terms of inflation.

This Paper

proposes a model with heterogeneous downward nominal wage rigidity (HDNWR) for individual labor varieties arising from:

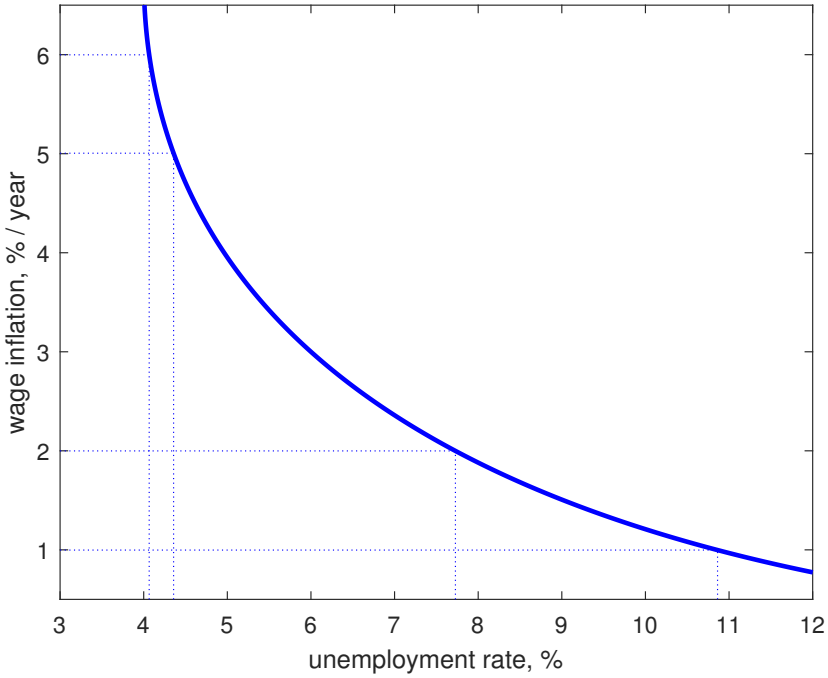
– cross-sectional dispersion in nominal fairness standards

– cross-sectional dispersion in labor productivity

This Paper (cont.)

• The model delivers a nonlinear wage Phillips curve linking current wage inflation with current unemployment that is relatively steep at high levels of inflation and relatively flat at low levels of inflation.

• Calibrated to the US economy, the model predicts that lowering wage inflation from 6 to 5 percent raises unemployment by 0.3 percentage points, whereas lowering wage inflation from 2 to 1 percent raises unemployment by 3 percentage points.



• Although the model features occasionally binding constraints for individual labor types, there are no such constraints in the aggregate, making the model amenable to perturbation analysis.

This Paper (cont.)

• **Missing unemployment and missing inflation**
Model can account for the resilience of the labor market in the tightening cycle following the Covid-19 inflation spike and for the missing inflation in the recovery from the 2008 great contraction.

• **What caused the post-pandemic inflation?**
For the pandemic era, the model predicts that in 2020 and 2021 the U.S. economy was hit by large adverse supply shocks, but that the inflation spike of 2022 was primarily due to demand shocks.

• **How does the model behave during tranquil times?**
For regular fluctuations around the inflation target, impulse responses (approximated to first-order accuracy) to conventional monetary and technology shocks are fairly similar to those predicted by a canonical NK sticky-wage model. $\Rightarrow$ The proposed model globally delivers a nonlinear Phillips curve, but locally preserves the dynamic properties of standard new-Keynesian models.

Related Literature

Empirical evidence on heterogeneity in downward nominal wage rigidity

• Fehr and Goette (2005) estimate significant heterogeneity in downward nominal wage rigidity across individual workers. Bewley (1999) provides survey evidence that nominal fairness standards are a key determinant of downward nominal wage rigidity. Fehr and Gächter (2000) provide experimental evidence of significant heterogeneity in nominal fairness standards.

• Davis and Krolikowski (2024) document heterogeneity in downward nominal wage rigidity at the layoff margin using U.S. state-level survey data.

• Heterogeneity in downward nominal wage rigidity in firm level administrative data has been documented in: Murray (2021) for the United States; Faia and Pezone (2023) and Fanfani (2023) for Italy; and Adamopoulou, Díez-Catalán, and Villanueva (2024) for Spain.

⋆ present paper incorporates heterogeneity in downward nominal wage rigidity into a dynamic general equilibrium model.

Empirical evidence on the non-linearity of the Phillips Curve

• Phillips (1958): empirically documents a negative and "highly nonlinear" relation between wage inflation and unemployment; conjectures that the source of nonlinearity is downward nominal wage rigidity, but does not offer any theory.

• Leduc and Wilson (2017) relate the missing inflation post Great Recession to a flattening of the Phillips curve; Crust, Lansing, and Petrosky-Nadeau (2023) interpret the missing unemployment post Covid-19 as a steepening of the Phillips curve.

• Cerrato and Gitti (2022) show that post Covid-19 the slope of regional Phillips curves was three times larger than pre Covid-19. Gitti (2024) documents nonlinearities in regional Phillips curves.

⋆ present paper explains observed non-linearity of Phillips curve as a consequence of cross-sectional dispersion in fairness standards or in labor productivity

Theoretical models with linear and non-linear Phillips curves

• Erceg, Henderson, and Levin (2000): new-Keynesian framework with sticky wages à la Calvo.

• Casares (2010) and Galí (2011) derive the log-linear wage-Phillips curve of that model.

• Harding, Lindé, and Trabandt (2022, 2023) characterize numerically the Phillips curve of a (non-linearized) NK model with price and wage rigidity and a Kimball aggregator.

• Schmitt-Grohé and Uribe (2016, 2017): homogeneous downward nominal wage rigidity in open and closed economies; L-shaped Phillips curve; not amenable to perturbation.

• Benigno and Eggertsson (2023): downward nominal wage rigidity in new-Keynesian labor search model; nonlinearity (piecewise linearity) arises from the assumption that wages are flexible when $v/u > 1$, but downwardly rigid when $v/u \leq 1$.

Related literature on causes of post-pandemic inflation

The fact that according to our model by 2022 supply conditions had largely returned to normal implies that the model interprets the 2022 inflation surge as driven by demand shocks. This finding is in line with:

• the empirical analyses of Bergholt et al. (2024) and Giannone and Primiceri (2024) identifying demand shocks as the key drivers of the post-Covid inflation surge.

The HDNWR Model

Fairness Standards

Firms

- price and wage takers
- production

$$y_t = z_t F(h_t)$$

- profits

$$\Phi_t = P_t z_t F(h_t) - W_t h_t$$

- labor input

$$h_t = \left[\int_0^1 h_{jt}^{1-\frac{1}{\eta}} dj \right]^{\frac{1}{1-\frac{1}{\eta}}}; \quad \eta > 0$$

- demand for labor of type j

$$h_{jt} = \left(\frac{W_{jt}}{W_t} \right)^{-\eta} h_t,$$

$$\text{where} \quad W_t^{1-\eta} = \int_0^1 W_{jt}^{1-\eta} dj.$$

Households

- price and wage takers
- preferences: $E_0 \sum_{t=0}^{\infty} \beta^t U(c_t)$
- inelastic labor supply:*

$$h_{jt} \leq \bar{h}(1 - u_t^n)$$

- budget constraint:

$$P_t c_t + \frac{B_t}{1 + i_t} + \tau_t = \int_0^1 W_{jt} h_{jt} dj + B_{t-1} + \Phi_t$$

*The case of endogenous labor supply will be presented below starting on slide 24.

Heterogeneous downward nominal wage rigidity

$$W_{jt} \geq \gamma(j)\, W_{t-1}$$

W_{jt} = nominal wage rate for labor of variety j in period t.
$\gamma(j)$ = nominal wage rigidity parameter; $\gamma(\cdot), \gamma'(\cdot) > 0$.
W_t = aggregate nominal wage rate in period t.

The Labor Market Slackness Condition

$$[\bar{h}(1-u_t^n)-h_{jt}]\,[W_{jt}-\gamma(j)W_{t-1}]=0$$

The Cutoff Variety j_t^* and the Cross-Sectional Determination of Labor and Wages

$$\bar{h}(1-u_t^n) = \left(\frac{\gamma(j_t^*)W_{t-1}}{W_t}\right)^{-\eta} h_t$$

$$\begin{cases} h_{jt} = \bar{h}(1-u_t^n) & \text{and} \quad W_{jt} = \gamma(j_t^*)W_{t-1} & \text{for } j \leq j_t^* \\ h_{jt} < \bar{h}(1-u_t^n) & \text{and} \quad W_{jt} = \gamma(j)W_{t-1} & \text{for } j > j_t^* \end{cases}$$

The Wage Phillips Curve: $\pi_t^W = f(u_t)$

Wage inflation and unemployment

$$W_t^{1-\eta} = \int_0^1 W_{jt}^{1-\eta} dj$$

$$u_t = \int_0^1 \frac{\bar{h} - h_{jt}}{\bar{h}} dj$$

Express as:

$$\begin{aligned}(1+\pi_t^W)^{1-\eta} &= j_t^* \gamma(j_t^*)^{1-\eta} + \int_{j_t^*}^1 \gamma(j)^{1-\eta} dj \\ u_t &= u_t^n + (1-u_t^n)\left[(1-j_t^*) - \int_{j_t^*}^1 \left(\frac{\gamma(j)}{\gamma(j_t^*)}\right)^{-\eta} dj\right]\end{aligned}$$

$\Rightarrow$ HDNWR model implies Phillips's Phillips Curve: a negative **nonlinear** relation between u_t and π_t^W (without a forward-looking component).

Calibration of the Predicted Wage Phillips Curve

Functional form for the wage lower bound

$$\gamma(j) = (1 + \pi^*)(\Gamma_0 + \Gamma_1 j)$$

Calibration of Γ_0 and Γ_1: Two targets

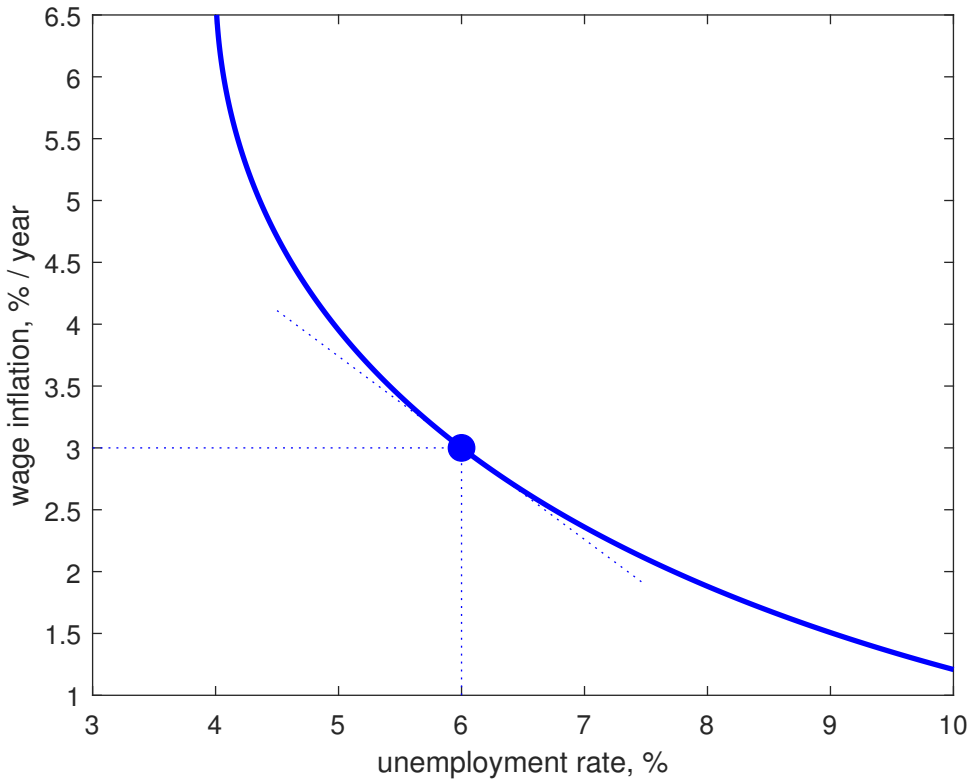
(1) the wage Phillips curve goes through $(u_t, \pi_t^W) = (0.06, 0.03)$, the median of US unemployment and wage inflation 1986–2007.

(2) at that point, the slope of the wage Phillips curve is -0.74 (Galí and Gambetti, 2019, estimate on 1986–2007 US data)

Set $u^n = 4\%$ (natural rate of unemployment) and $\eta = 11$ (elast. subs. across varieties), and $\pi^* = 0.03$ (annual inflation target).

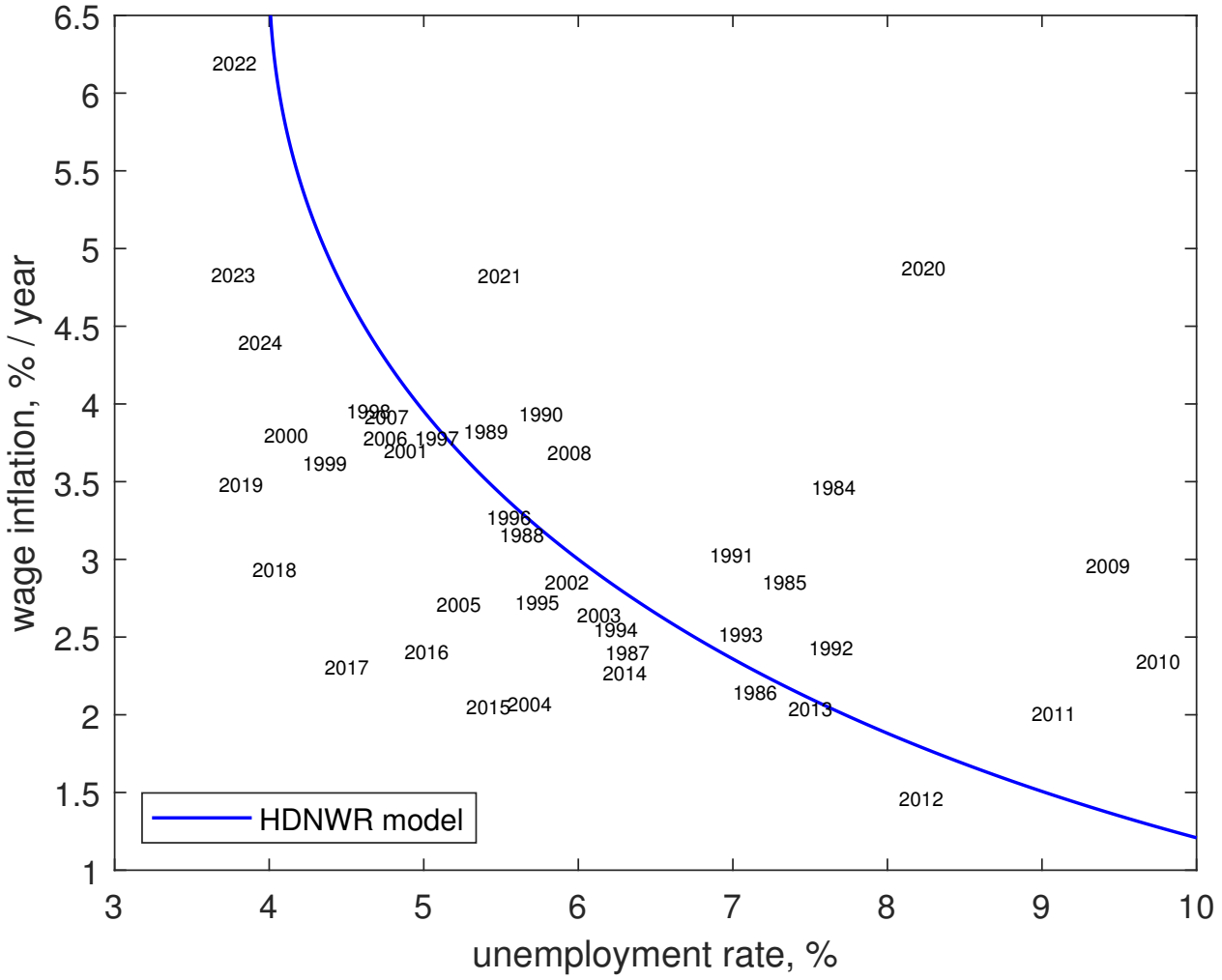
Result: $\Gamma_0 = 0.978$ and $\Gamma_1 = 0.031$ at quarterly frequency.

The Short-Run Wage Phillips Curve of the HDNWR Model



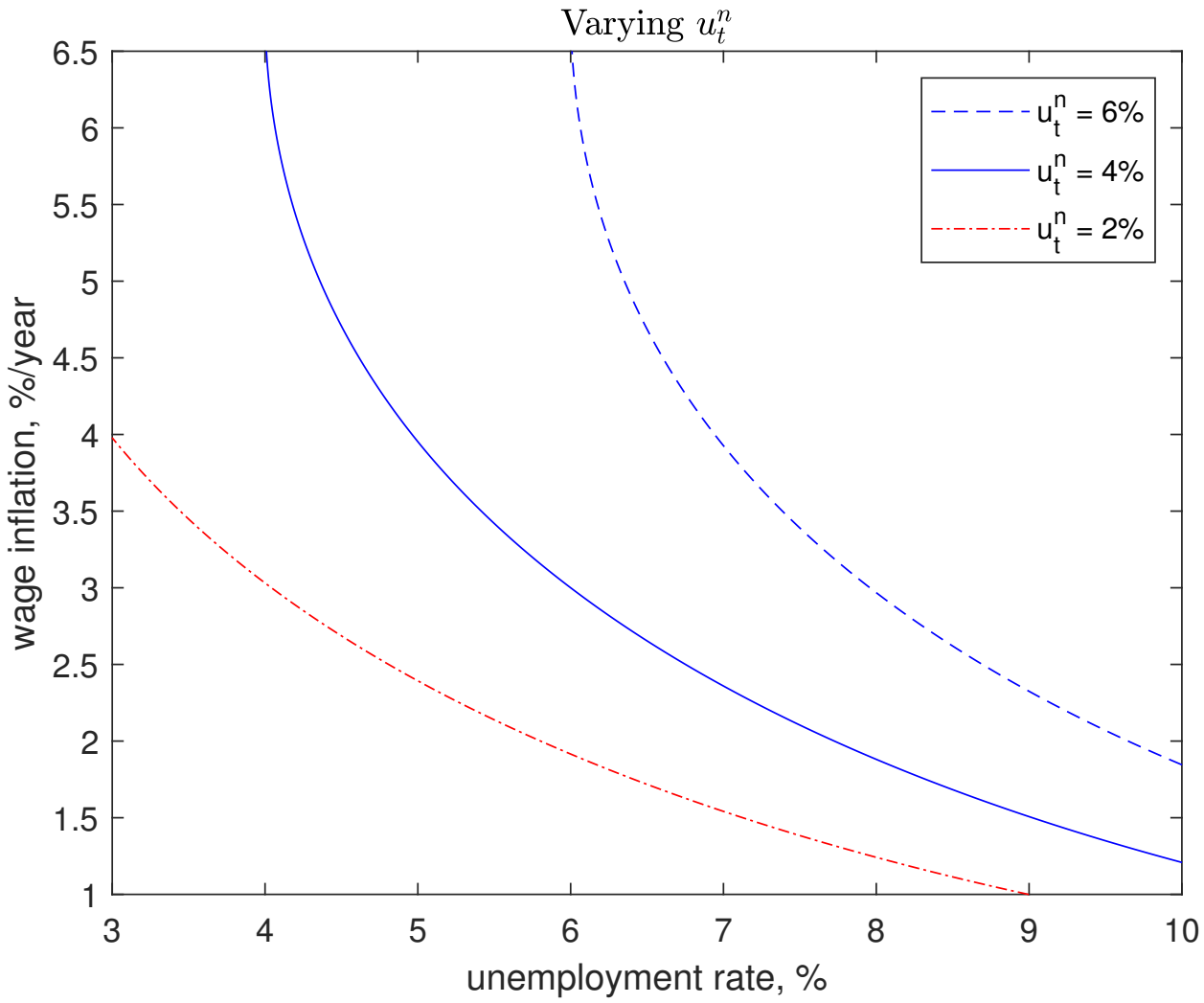
Nonlinearity: lowering inflation from 6 to 5 percent raises the unemployment rate by 0.3 percentage points, whereas lowering inflation from 2 to 1 percent raises the unemployment rate by 3 percentage points.

The HDNWR Wage Phillips Curve and U.S. Data



Notes. Annual wage inflation is computed as the average of year-over-year monthly wage inflation. The measure of monthly nominal wages is Average Hourly Earnings of Production and Nonsupervisory Employees, FRED series AHETPI. The annualized unemployment rate is the arithmetic mean of monthly unemployment rates, FRED series UNRATE. The observation labeled 2024 in the figure refers to unemployment and wage inflation in the first three months of 2024. Sample: 1984 to 2024.

Shifters of the Wage Phillips Curve
The Aggregate Supply Shock, u_t^n



Note. The solid line corresponds to the baseline calibration.

Identifying Supply Shocks During the Pandemic

Procedure:

- using the wage Phillips curve

$$(1+\pi_t^W)^{1-\eta} = j_t^* \gamma(j_t^*)^{1-\eta} + \int_{j_t^*}^1 \gamma(j)^{1-\eta} dj$$

$$u_t = u_t^n + (1-u_t^n)\left[(1-j_t^*) - \int_{j_t^*}^1 \left(\frac{\gamma(j)}{\gamma(j_t^*)}\right)^{-\eta} dj\right]$$

- feed actual values for π_t^W and u_t for $t =$ 2020, 2021, 2022, and 2023, and back out values for u_t^n and j_t^*.

Aggregate Supply Shocks in the Pandemic Era

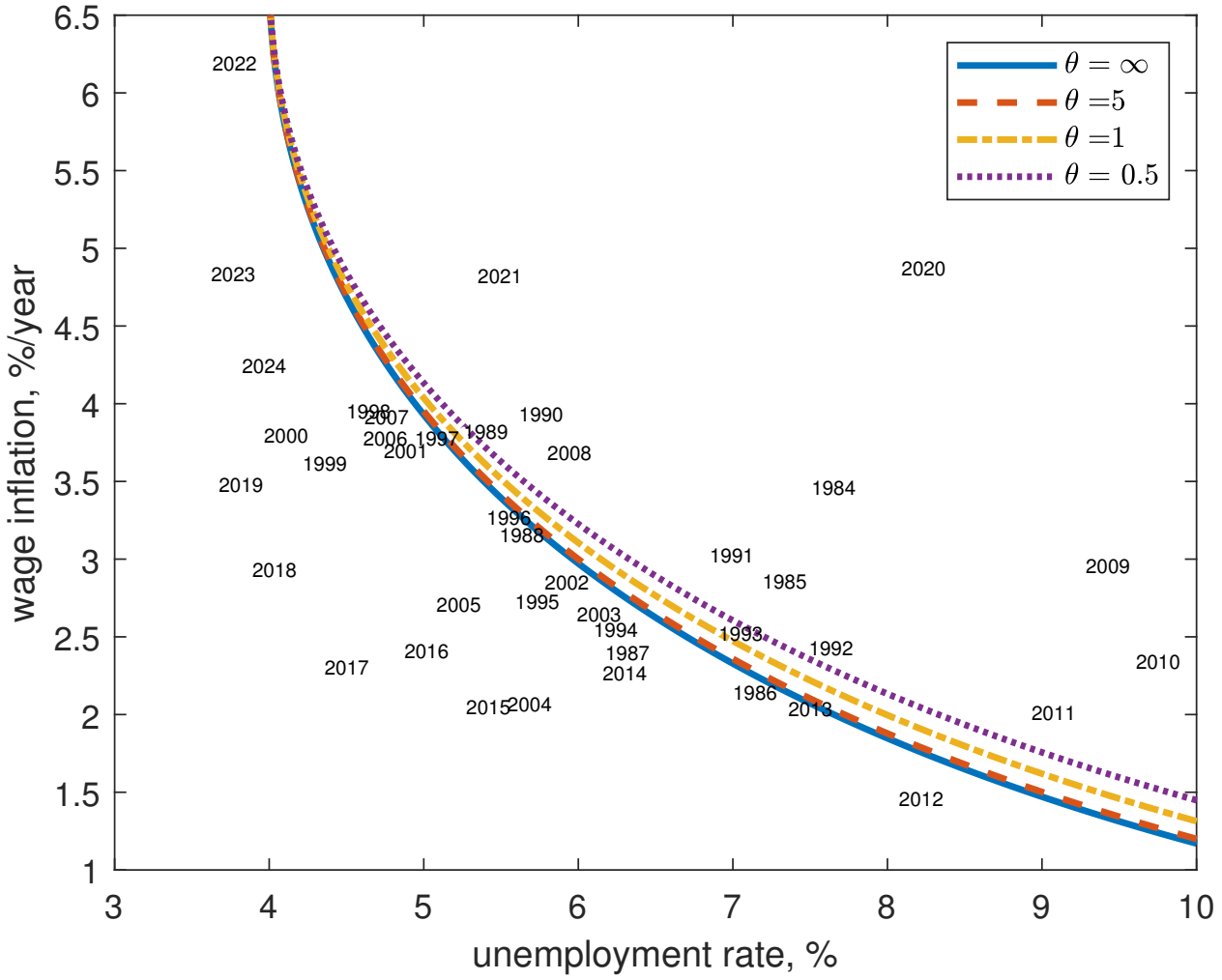
Year	Actual Wage Inflation π_t^W	Actual Unemployment u_t	Predicted Supply Shock $u_t^n - u^n$
2020	4.88	8.09	3.70
2021	4.83	5.35	0.92
2022	6.20	3.63	-0.40
2023	4.84	3.63	-0.81

This analysis suggests that:

• the predicted curvature of the Phillips curve is not at odds with the prediction that the economy was buffeted by significant supply shocks during the worst of the pandemic.

• the model interprets the 2022 inflation spike as primarily due to demand shocks.

The HDNWR Wage Phillips Curve in the Model with Endogenous Labor Supply: $E_0 \sum_{t=0}^{\infty} \beta^t \left[U(c_t) - \int_0^1 \frac{h_{jt}^{1+\theta}}{1+\theta} dj \right]$



The HDNWR Model

Heterogeneity in Labor Productivity

- heterogeneous labor productivity, z_{jt}, with log-normal distribution

- labor input: $h_t = \left[\int_0^1 \left(z_{jt} h_{jt}\right)^{1-1/\eta} dj\right]^{\frac{1}{1-1/\eta}}$; $\quad \eta > 1$

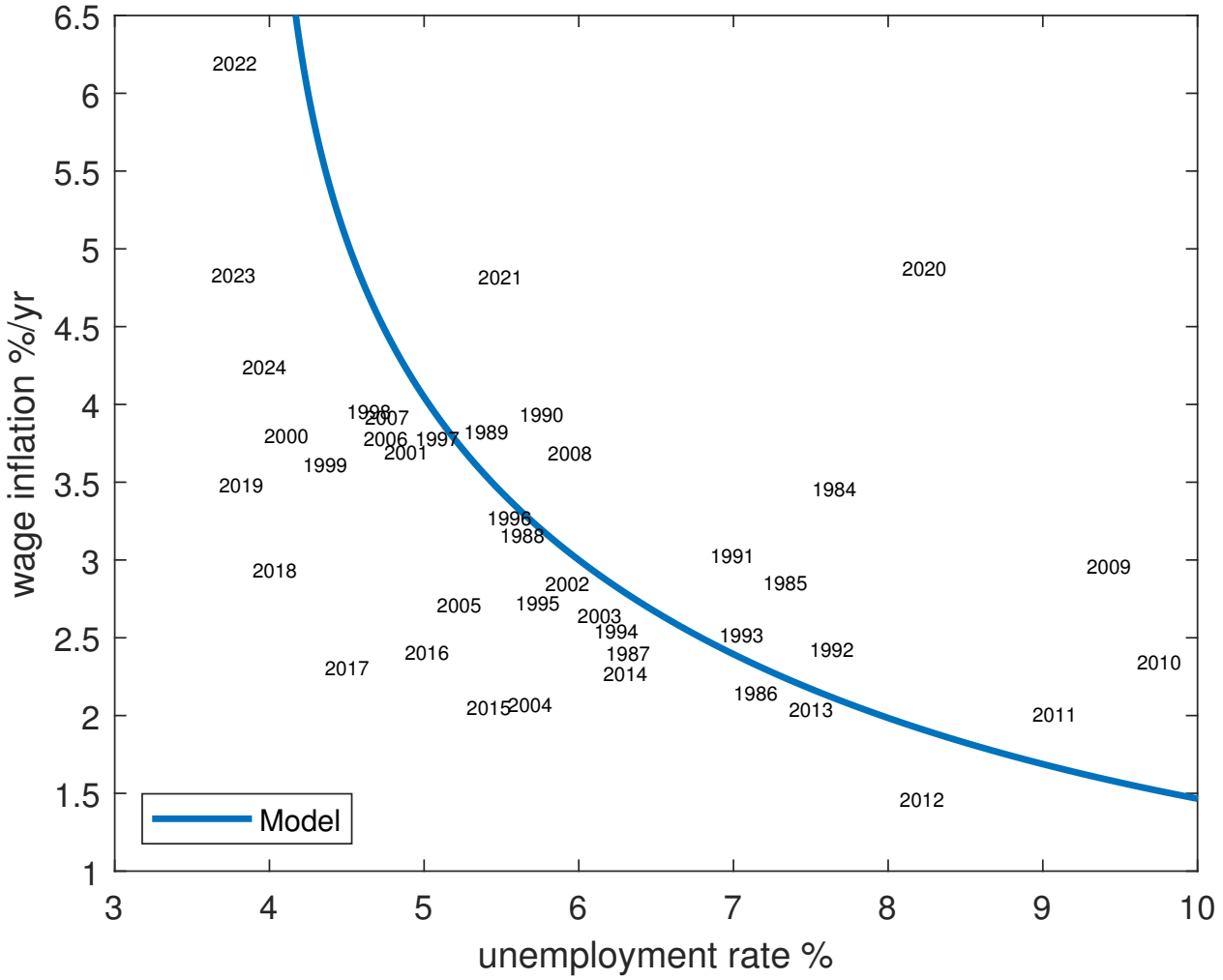
- heterogeneous downward nominal wage rigidity

$$W_{jt} \geq z_{jt}^{\xi} \gamma W_{t-1}; \qquad \text{with} \qquad \xi > 0$$

$\gamma =$ common degree of downward nominal wage rigidity

$\xi =$ productivity-related degree of downward nominal wage rigidity

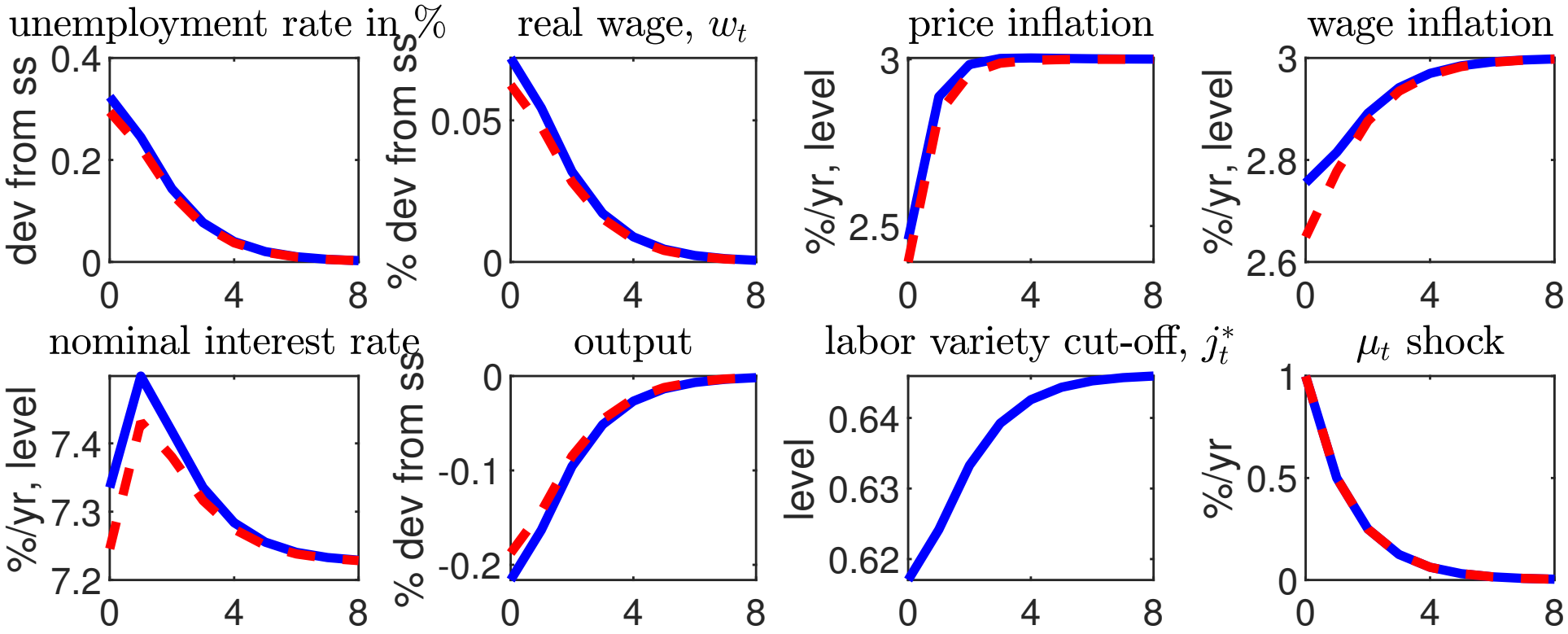
The Heterogeneous Productivity Wage Phillips Curve and U.S. Data



Notes. The figure shows with a solid line the short-run wage Phillips curve implied by the calibrated heterogeneous labor productivity model. The figure also shows the (u_t, π_t^W) pairs observed in annual U.S. data over the period 1984 to 2024. The observation labeled 2024 in the figure refers to unemployment and wage inflation in the first quarter of 2024.

Regular Dynamics

Impulse Responses to a Monetary Tightening in the HDNWR and NK Models



Notes. Solid lines correspond to the HDNWR model and dashed lines to the NK model with Calvo wage stickiness. The size of the monetary shock is 1 percent per annum and its serial correlation is 0.5. The horizontal axes measure quarters after the shock.

Conclusions

• This paper proposes a model with heterogeneous downward nominal wage rigidity (HDNWR)

• The model implies a nonlinear convex wage Phillips curve.

• The model can account for both the missing inflation in the aftermath of the 2008 great recession and the missing unemployment during the post-Covid-19 inflation stabilization.

• For the pandemic era, the model predicts that in 2020 and 2021 the U.S. economy was hit by large negative supply shocks, but that the inflation spike of 2022 was primarily due to demand shocks.