Inflation-Unemployment Dynamics in the Context of the Phillips Curve

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Abstract: This paper studies how US inflation dynamics have evolved as labor-market institutions weakened and expectations became more central to price-setting. Using quarterly data from 1984Q1–2023Q4, we estimate Phillips-Curve-style regressions that allow inflation to depend on expected inflation, lagged inflation, and interactions between unemployment and union density, and we complement these results with a multivariate vector autoregression (VAR) to trace dynamic responses. Three findings emerge. First, inflation is best explained by a joint expectations–persistence component: expected inflation, lagged expectations, and lagged inflation together account for substantially more variation in inflation than specifications based on unemployment or the output gap alone. Second, interaction between the unemployment–union-density is economically meaningful, consistent with weaker collective bargaining dampening the wage channel and contributing to a flatter inflation–slack relationship. Third, VAR impulse responses indicate that expectation shocks transmit to inflation primarily over short horizons, while inflation persistence remains a dominant propagation mechanism. These results imply that inflation stabilization increasingly depends on anchoring expectations and understanding labor-market structure, rather than relying on slack measures as sufficient statistics for inflationary pressure.

Keywords: Inflation Dynamics, Expected Inflation, Labor Union Influence, Phillips Curve, Monetary Policy Adaptation.

1. INTRODUCTION

The Phillips Curve has long served as a central organizing framework for inflation analysis, linking price dynamics to labor-market slack and implying that tighter labor markets should translate into higher wage and price inflation (Phillips, 1958). This relationship shaped postwar stabilization policy and the perceived inflation–unemployment trade-off (Bernanke, 2004; Yellen, 2015). Yet two developments have persistently challenged its canonical interpretation. First, the stagflation of the 1970s undermined the notion of a stable, exploitable trade-off (Hunt, 2005; Nelson, 2022). Second, since the Global Financial Crisis, inflation in the United States has appeared unusually insensitive to domestic slack, motivating claims that the Phillips Curve has flattened and that standard demand-management tools have become less reliable (Stock and Watson, 2008; Powell, 2019; Forbes, 2021).

The paper's main estimand is the cross-regime difference in the dynamic inflation response to an expectations shock. We quantify how both the magnitude and persistence of inflation's response—measured by its peak, cumulative effect, and half-life—vary between regimes of low versus high union density, thereby identifying the institutional channel through which expectations are translated into realized inflation.

The core hypothesis is that inflation expectations act as a state variable whose transmission depends systematically on labor-market institutions: in lower-union regimes, expectation shocks translate more rapidly and persistently into inflation, while in higher-union regimes, institutional wage-setting arrangements dampen short-run pass-through but generate more persistent adjustment.

Identification and estimand. The central estimand of the paper is the difference in inflation impulse responses to an expectations innovation across institutional regimes, summarized by the peak response, cumulative effect, and half-life of inflation dynamics in high- versus low-union-density states. These objects are estimated using a reduced-form VAR complemented by interacted local projections. Because the VAR innovations are identified through Cholesky orthogonalization, the resulting impulse responses should be interpreted as ordering-dependent reduced-form innovations rather than structural shocks. The contribution of the paper is therefore to document robust state-dependent propagation patterns and to assess whether these patterns are consistent with the timing-based implications of institutional wage-setting, rather than to recover deep structural parameters.

This focus connects two strands of structural change. On the labor-market side, union density in the US declined from roughly 20% in the early 1980s to about 10% by 2023 (BLS, 2023), weakening collective bargaining and altering wage-setting practices (Card, 1996; Blanchflower and Bryson, 2024). Declining coordination, increased firm-level wage discretion, and the expansion of non-standard work arrangements have attenuated the mapping from aggregate labor-market tightness to wage growth (Autor *et al*., 2016; Jaumotte and Osorio Buitron, 2015; Gómez and

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Lamb, 2019; Daly and Hobijn, 2023; Stansbury and Summers, 2020). On the monetary-policy side, a weaker contemporaneous wage–price channel has increased the importance of expectations management through forward guidance and balance-sheet policies, particularly near the effective lower bound (Eggertsson and Woodford, 2003; Svensson, 2010; Krishnamurthy and Vissing-Jorgensen, 2011; Brainard, 2017). The post-pandemic inflation episode further highlighted the limits of slack-based explanations in the presence of supply constraints and sectoral bottlenecks (Baqaee *et al.*, 2021; Blanchard and Galí, 2010; Woodford, 2013).

To identify how expectations-driven inflation dynamics vary across institutional environments, the paper combines a reduced-form vector auto regression (VAR) with state-dependent local projections. The VAR characterizes the joint dynamics among inflation, expectations, labor-market conditions, monetary policy, and union-adjusted slack. Local projections interacted with union density then trace impulse responses that vary systematically across institutional regimes, allowing direct tests of whether the strength and persistence of inflation responses differ with bargaining structures, without imposing a fully specified structural model.

Because the analysis is conducted in a reduced-form setting, the paper documents propagation patterns rather than deep structural parameters of wage setting or monetary policy. Interpretation is therefore stated in “consistent with” terms: union density is treated as a slow-moving institutional state variable that conditions the timing of pass-through from expectations and slack to inflation. The key empirical objects are differences in impulse-response shapes across institutional regimes, summarized by peak magnitude, cumulative response, and half-life, emphasizing the informational role of institutions while remaining transparent about identification limits.

Three results emerge. First, inflation responds more strongly and persistently to expectation shocks in low-union regimes, consistent with more flexible wage-setting and faster pass-through. Second, labor-market institutions smooth short-run employment responses but generate medium-run persistence through delayed reallocation, reflected in horizon-dependent sign reversals in union–slack interactions. Third, monetary policy transmission is nonlinear and horizon dependent, with diminishing marginal effects of tightening where expectations channels dominate contemporaneous demand effects.

2. LITERATURE REVIEW: EXPECTATIONS, INSTITUTIONS, AND IDENTIFICATION

Early formulations of the Phillips Curve treated inflation as a reduced-form outcome of labor-market slack. Phillips (1958) documented a stable negative relationship between unemployment and wage inflation in the UK, which Samuelson and Solow (1960) interpreted as a menu of feasible policy tradeoffs between inflation and unemployment. In this early Keynesian view, inflation was largely understood as the cost of achieving lower unemployment, and macroeconomic stabilization involved selecting an appropriate point along a stable curve.

This interpretation was fundamentally challenged by the stagflation experience of the late 1960s and 1970s. Friedman (1968) and Phelps (1967) introduced the expectations-augmented Phillips Curve, arguing that attempts to hold unemployment below its natural rate would generate accelerating inflation as expectations adjusted. Once workers and firms internalized policy-induced inflation, real effects would dissipate and unemployment would return to its reference level. Subsequent work formalized these insights within rational-expectations models, emphasizing that systematic monetary policy could not exploit nominal rigidities once agents understood the policy rule (Lucas, 1972, 1976; Sargent, 1973).

This literature redirected attention toward policy credibility, rule-based frameworks, and the anchoring of inflation expectations as central determinants of inflation outcomes. Contributions by Gordon (1977), Taylor (1980), and Friedman (1975) translated these theoretical insights into practical policy prescriptions and laid the intellectual foundations for modern inflation-targeting regimes.

More recent empirical work revisits expectations not merely as forecasting devices, but as central drivers of inflation dynamics. Coibion and Gorodnichenko (2015), Coibion *et al*. (2017), and Dorn and Schmitz (2021) document systematic heterogeneity in expectation formation across agents and regimes, while post-2010 US experience suggests that inflation expectations can remain anchored even under historically tight labor markets. These findings motivate treating expectations as state variables that organize inflation propagation over time, rather than as passive conditioning controls.

A second strand of the literature weakens the strong neutrality implications of the natural-rate hypothesis by emphasizing persistent labor-market frictions and institutional wage-setting arrangements. Search and matching frictions, mismatch, and adjustment costs can generate prolonged deviations of unemployment from its steady state even in the absence of ongoing shocks (Layard *et al*., 1991). In such environments, the distinction between short-run and long-run unemployment becomes blurred, complicating the interpretation of slack in Phillips Curve relationships.

Hysteresis models extend this argument by allowing cyclical unemployment shocks to alter the effective natural rate itself. Prolonged downturns can erode skills, weaken labor-force attachment, and reduce matching efficiency, embedding temporary shocks into long-run labor-market outcomes (Blanchard and Summers, 1986; L'Huillier, 2020). From this perspective, macroeconomic policy may have persistent real effects even when expectations are forward looking.

Structuralist and political-economy approaches further emphasize the role of institutions in shaping inflation dynamics. Rowthorn (1977) argued that inflation reflects distributive conflict and bargaining power rather than purely competitive market clearing. Behavioral mechanisms—such as menu costs, fairness norms, and nominal rigidities—reinforce this view by generating sluggish wage and price adjustment even when optimization conditions are locally violated (Akerlof and Yellen, 1985; Akerlof *et al*., 1996).

Within this broader institutional literature, trade unions occupy a central role. Historically, strong unions amplified wage pressures in tight labor markets by coordinating bargaining and internalizing aggregate conditions, thereby steepening the inflation–unemployment relationship (Card, 1996; Farber *et al*., 2018). In recent decades, however, declining union density has coincided with decentralized bargaining, increased wage dispersion, and greater heterogeneity in wage-setting practices. A growing literature attributes the observed flattening of the Phillips Curve to these structural changes (Blanchard and Galí, 2007; Ball and Mazumder, 2011; Visser, 2019; Blanchard, 2016).

Evidence from the post-2010 United States supports this interpretation. Wage growth has become weakly correlated with unemployment and more sensitive to sectoral composition, firm-level wage policies, and participation margins (Daly and Hobijn, 2014, 2023; Galí, 2011; Stansbury and Summers, 2020). Broader political-economy accounts situate these developments within long-run shifts toward neoliberal labor-market reforms and declining bargaining coordination (Baccaro and Howell, 2017).

A third strand of the literature highlights the empirical difficulty of identifying inflation–slack relationships in the presence of structural change, nonlinearities, and supply-side shocks. The post-pandemic inflation episode revived debates over whether inflation reflected a re-steepening of the Phillips Curve under exceptionally tight labor markets or was driven primarily by supply-chain disruptions, energy price shocks, and relative-price adjustments (Baqaee *et al*., 2021; Blanchard and Bernanke, 2023; Brooks *et al*., 2024).

Recent work shows that estimated Phillips Curve slopes are highly sensitive to the treatment of expectations, the measurement of slack, and the allowance for time variation and nonlinear transmission (Hazell *et al*., 2022; Crump *et al*., 2024; Holub, 2024). Alternative measures of labor-market tightness—such as vacancies, quits, and job-to-job flows—often outperform unemployment in explaining wage dynamics, particularly in tight labor markets (Bloesch *et al*., 2024).

Concerns about overheating have also re-emerged. Domash and Summers (2022) argue that sustained tightness may eventually reintroduce wage-driven inflation risks even in low-union environments. International and financial channels further complicate identification, as global financial conditions, trade fragmentation, and geopolitical shocks can generate inflation–unemployment comovement unrelated to domestic slack (Bordo and Filardo, 2005; Rey, 2013; Mishkin, 2016; Bown, 2021; Gregory, 2024).

Empirically, the US expansion of 2013–2019 is often cited as a canonical episode in which historically low unemployment coexisted with subdued inflation and weak expectation sensitivity—frequently interpreted as evidence of a flatter Phillips Curve operating under anchored expectations and diminished worker bargaining power (Coibion and Gorodnichenko, 2015; Coibion *et al*., 2017; Dorn and Schmitz, 2021).

3. DATA AND METHODOLOGY

3.1. Framework

Inflation dynamics are best understood as the outcome of interacting expectation formation, real economic activity, and institutionally mediated wage adjustment, rather than as a stable contemporaneous tradeoff between inflation and labor-market slack. While the traditional Phillips Curve links inflation to unemployment through wage pressures in tight labor markets, this representation abstracts from two features that are central to modern macroeconomic environments: the forward-looking nature of expectations and the institutional structure governing the timing of wage adjustment.

A useful starting point is Okun's Law, which provides a reduced-form mapping between real activity and labor-market conditions:

$$\Delta u_t = -\theta(g_t - g_t^n) + \varepsilon_t^u, \theta > 0 \quad (1)$$

where g_t denotes real output growth and g_t^n the growth rate consistent with natural unemployment. This formulation clarifies that growth itself is not inherently inflationary. When output growth reflects productivity improvements or expansions in potential output—so that g_t rises in tandem with g_t^n —labor-market pressure need not intensify. Okun's Law therefore motivates a shift away from unemployment levels toward growth deviations as the empirically relevant measure of real-side slack.

In New Keynesian environments, inflation reflects both forward-looking expectations and backward-looking persistence arising from staggered price and wage setting. A standard hybrid New Keynesian Phillips Curve (NKPC) takes the form

$$\pi_t = \gamma_f E_t[\pi_{t+1}] + \gamma_b \pi_{t-1} + \kappa(y_t y_t^*) + \varepsilon_t, \gamma_f + \gamma_b = 1 \quad (2)$$

where inflation depends on expected future inflation, past inflation, and real marginal-cost pressures. Using the Okun-based mapping between output gaps and growth deviations, this relationship can be re-expressed as

$$\pi_t = \gamma_f E_t[\pi_{t+1}] + \gamma_b \pi_{t-1} + \kappa_g(g_t - g_t^n) + \varepsilon_t \quad (3)$$

which makes explicit that inflation responds to excess growth, not growth per se. This representation accommodates non-inflationary expansions driven by productivity gains or shifts in potential growth, an outcome that is difficult to articulate in unemployment-based formulations alone.

Crucially, neither the magnitude nor the timing of the transmission from real activity to inflation should be treated as structural constants. Wage-setting institutions—most notably collective bargaining arrangements and contract duration—shape how, and over what horizon, labor-market pressures translate into wages and prices. Their role is not to mechanically raise or lower inflation, but to reallocate adjustment across time.

In labor markets with strong unions and coordinated bargaining, nominal wage adjustment is typically delayed. Multi-period contracts, bargaining conventions, and renegotiation costs dampen the immediate response of wages to transitory shocks, inducing firms to smooth quantities rather than prices. Employment and hours adjust more gradually, short-run employment volatility is reduced, and contemporaneous measures of labor-market slack become weaker indicators of inflationary pressure. In this phase, labor-market institutions function as shock absorbers, attenuating the short-run pass-through from real activity to inflation.

Over longer horizons, however, these same institutional features generate persistence and delayed reallocation. Gradual wage adjustment can produce sustained misalignment between inherited wage norms and evolving sectoral productivity or demand conditions. What begins as short-run smoothing accumulates into medium-run adjustment pressures, resolved only slowly through sluggish hiring recoveries, delayed separations, and frictions in labor reallocation. Institutions thus stabilize employment in the short run at the cost of greater persistence in medium-run adjustment.

From this perspective, the apparent flattening of the Phillips Curve should not be interpreted as a breakdown of the real–nominal linkage. Rather, it reflects a shift in the timing of transmission: labor-market institutions redistribute inflationary adjustment away from the short run and into longer horizons.

To capture this mechanism parsimoniously, the growth-based NKPC can be augmented with an interaction between excess growth and labor-market institutions:

$$\pi_t = \gamma_f E_t[\pi_{t+1}] + \gamma_b \pi_{t-1} + \kappa_g(g_t - g_t^n) + \delta[(g_t - g_t^n) \cdot U_t] + \varepsilon_t \quad (4)$$

where U_t denotes union density. The interaction term does not imply that unions mechanically raise or lower inflation. Rather, it allows labor-market institutions to condition the dynamic pass-through from real activity into inflation, by reshaping the timing and persistence of adjustment.

For expositional purposes, the interaction of expectations, inflation persistence, real activity, labor-market institutions, and policy disturbances can be summarized by the following compact organizing representation:

$$\pi_t = \gamma_f E_t[\pi_{t+1}] + \gamma_b \pi_{t-1} + \kappa_g(g_t - g_t^n) + \delta[(g_t - g_t^n) \cdot U_t] + \phi m_t + \varepsilon_t \quad (5)$$

where $\mathrm{m_t}$ denotes a monetary policy disturbance. The hybrid NKPC is used as a motivating framework. The empirical objective is not to identify or estimate its structural parameters but rather to examine whether institutional variation alters the propagation of inflation following expectations shocks.

Accordingly, equation (5) is interpreted as a testable mapping between institutional structure and observable inflation dynamics, rather than as a fully identified structural model. Its key implication concerns timing. When collective bargaining and contract renegotiation are more rigid—proxied by higher union density—inflation should respond less on impact to an expectations innovation but exhibit greater persistence, reflected in a longer half-life and larger medium-horizon cumulative effects. Conversely, when bargaining is more decentralized (low union density), pass-through should occur more rapidly, generating a higher short-run peak but weaker persistence. In low-union regimes, shocks to inflation expectations generate larger short-run peaks, whereas in high-union regimes inflation exhibits a longer half-life and greater medium-run cumulative effects**.** The empirical analysis evaluates these implications by comparing the shape of the estimated impulse responses—specifically the peak, cumulative effect, and half-life—across high- and low-union-density regimes.

This framework clarifies the empirical identification challenge. Inflation dynamics reflect state-dependent propagation rather than a stable reduced-form slope. An appropriate empirical strategy must therefore trace dynamic responses to shocks while allowing transmission to vary systematically with labor-market institutions.

3.2. Data

The empirical analysis uses quarterly US data spanning 1984Q1–2024Q4, a period covering major shifts in labor-market institutions, monetary-policy regimes, and inflation dynamics, including the Great Moderation, the Global Financial Crisis, the effective lower bound period, and the post-pandemic inflation surge. Quarterly frequency provides sufficient time-series length to estimate dynamic models with multiple lags while preserving economically meaningful propagation horizons.

Inflation is measured using the Consumer Price Index (CPI), obtained from the Federal Reserve Economic Data (FRED) database. CPI is used for historical continuity and broad policy relevance across the full sample period. Because U.S. monetary policy frequently references Personal Consumption Expenditures (PCE) inflation, Appendix A reports robustness checks using PCE-based inflation measures; the qualitative results remain unchanged.

The unemployment rate is obtained from the Bureau of Labor Statistics (BLS) and retrieved through FRED. Monetary policy is proxied by changes in the effective federal funds rate. The federal funds rate is used as a transparent indicator of conventional monetary policy stance. Because the focus of the paper is on short- to medium-run propagation rather than long-run equilibrium relationships, the policy variable enters in first differences to capture innovations rather than persistent level shifts. The output gap is measured as the deviation of real GDP from potential output, based on Congressional Budget Office (CBO) estimates, and is included in levels because it is constructed as a stationary deviation.

Union density data are drawn from the Bureau of Labor Statistics' annual Union Members survey and supplemented by OECD data. Annual union density is converted to quarterly frequency using stepwise interpolation. This procedure reflects the slow-moving institutional nature of collective bargaining coverage and avoids imposing artificial intra-year variation.

PCA-Based Inflation Expectations Index

To summarize inflation expectations and persistence in a parsimonious and data-driven manner, we construct a principal component–based expectations index using contemporaneous expected inflation, lagged expected inflation, and lagged realized inflation. Let the vector of variables be defined as

$$X_t = (E_t[\pi_{t+1}], E_{t-1}[\pi_t], \pi_{t-1}) \quad (6)$$

We apply principal component analysis (PCA) to X_t using quarterly US data. PCA decomposes the joint variation in these variables into orthogonal components that capture common and transitory movements without imposing a priori restrictions on their relative importance.

Table **1** reports the eigenvalues and variance shares from the PCA. The first principal component has an eigenvalue of 2.38 and explains 79.2% of total variance, indicating a strong common factor shared by inflation expectations and past inflation. The second principal component accounts for an additional 18.3% of variance, while the third component explains only 2.5%.

Interpretation and limitations of the PCA index. The PCA index is designed to summarize the common component shared by short-horizon expectations and lagged inflation, thereby reducing multicollinearity when both are included. This design choice can attenuate high-frequency expectation volatility—especially during episodes such as 2021–2022—some of which may reflect economically relevant supply-side or relative-price information rather than pure measurement error. For this reason, the paper reports robustness checks using (i) raw survey expectations without PCA aggregation, (ii) lagged inflation alone, and (iii) the first and second principal components separately. The state-dependent results are interpreted as operating through the common inflation expectations–persistence factor, while allowing that short-run expectation volatility may contain additional information outside that component.

The corresponding eigenvectors show that the first principal component loads positively on all three variables, reflecting a common inflation expectations–persistence factor that combines forward-looking beliefs with backward-looking inflation inertia. The second principal component loads positively on lagged realized inflation and negatively on inflation expectations, capturing short-run adjustment dynamics between realized inflation and beliefs.

Because inflation dynamics reflect both persistent common movements and systematic transitional adjustment mechanisms. We define the PCA-based inflation expectations index as the sum of the first two principal components:

$$\text{PCA Index}_t \equiv \text{PC1}_t + \text{PC2}_t \tag{7}$$

Lagged inflation alone captures a substantial portion of inflation persistence, with an R^2 exceeding 0.85 in reduced-form regressions. However, lagged inflation is highly collinear with short-horizon inflation expectations and may be contaminated by transitory shocks—particularly during periods of heightened volatility such as the COVID-19 episode. The PCA-based index addresses this concern by extracting the common component shared by expectations and past inflation, thereby reducing the influence of multicollinearity and measurement error in individual expectation proxies (Yoshimori, 2025).

Importantly, the PCA index is not introduced to improve statistical fit, but to provide a disciplined summary measure of inflation beliefs and inertia that is robust to variable selection. Replacing alternative expectations measures with the PCA index leaves all core VAR impulse response functions qualitatively unchanged, confirming that the main results are robust to the method used to summarize inflation expectations and persistence.

4.2. VAR Framework

The empirical strategy combines a reduced-form vector autoregression (VAR) with state-dependent local projections to study inflation dynamics in the presence of labor-market institutions. The VAR provides a disciplined characterization of joint dynamics and feedback effects among inflation changes, expectation revisions, labor-market adjustment, institutional structure, and monetary policy, while remaining agnostic about the underlying structural parameters. In doing so, it delivers a transparent benchmark for average propagation patterns and supports standard impulse-response and forecast-error variance-decomposition analysis.

Consistent with the empirical implementation, the VAR is specified in terms of changes rather than levels. This choice reflects the focus on propagation, timing, and persistence rather than long-run equilibria, and ensures stationarity across variables. Let the vector of endogenous variables be defined as

$$y_t = \begin{pmatrix} \Delta\pi_t \\ \text{PCA Index}_t \\ \Delta u_t \\ \Delta(u_t \times \text{Union}_t) \\ \Delta m_t \\ x_t \end{pmatrix} \tag{8}$$

where $\Delta\pi_t$ denotes inflation changes, PCA Index_t describes inflation expectations Δu_t changes in the unemployment rate, $\Delta(u_t \times \text{Union}_t)$ an interaction term capturing institutional conditioning through union density, Δm_t a proxy for monetary policy innovation, and x_t the output gap, which is included in levels to capture cyclical demand conditions.

Table 1: Principal Component Analysis of Inflation Expectations and Persistence

Panel A. Eigenvalues and Variance Decomposition

Component	Eigenvalue	Variance Share	Cumulative Share
PC1	2.376	0.792	0.792
PC2	0.548	0.183	0.975
PC3	0.075	0.025	1

Panel B. Eigenvectors

Variable	PC1	PC2	PC3
$E_t[\pi_{t+1}]$	0.607	−0.406	0.684
$E_{t-1}[\pi_t]$	0.619	−0.298	−0.726
π_{t-1}	0.498	0.864	0.07

Notes: PCA is based on 167 quarterly observations. Variables include contemporaneous one-year-ahead inflation expectations, lagged expectations, and lagged realized inflation. The PCA Index is defined as the sum of PC1 and PC2.

The VAR is estimated in reduced form as

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t, \varepsilon_t \sim (0, \Sigma_\varepsilon) \quad (9)$$

where the coefficient matrices A_i summarize dynamic interactions across variables and ε_t represents reduced-form innovations.

The VAR results show that inflation propagation is organized jointly by expectation revisions, monetary policy, and institutional features of the labor market rather than by labor-market slack alone. Inflation changes exhibit short-run persistence with medium-run reversal, expectation shocks generate sustained inflation responses, and monetary policy innovations affect inflation with meaningful delay. By contrast, shocks to unemployment alone generate comparatively weak and unstable inflation responses, while shocks to the interaction between unemployment and union density propagate strongly into labor-market dynamics. These findings establish the VAR as an informative reduced-form summary of average macroeconomic dynamics across regimes.

However, the theoretical framework developed above implies that transmission is inherently state dependent. Wage-setting institutions reshape not only the magnitude but also the timing and persistence of adjustment by conditioning how labor-market slack translates into wages and prices. While the VAR evidence is consistent with this mechanism—particularly the strengthening of institutional channels and the reversal of the inflation–expectations relationship after 2008—the VAR necessarily averages across institutional states.

To capture this dimension directly, the empirical analysis therefore complements the VAR with interacted local projections that allow impulse responses to vary systematically with union density. This approach permits direct estimation of state-dependent responses without imposing a fully specified structural model or assuming time-invariant transmission. By interacting shocks with labor-market institutions, the local projections directly implement the timing-based mechanism emphasized in equation (5).

Together, the VAR and state-dependent local projections provide complementary evidence. The VAR summarizes average dynamics in a reduced-form setting and documents the central role of expectations and monetary policy in inflation propagation, while the local projections isolate how institutional structure alters the persistence and timing of these effects. This two-step strategy connects the reduced-form evidence to the theoretical mechanism without relying on strong identifying assumptions.

5. RESULTS

5.1. VAR specification and identification

The empirical analysis estimates a quarterly reduced-form VAR over 1984Q2–2024Q4 (N = 163) to characterize the joint dynamics of inflation, inflation expectations, unemployment, monetary policy, the output gap, and an interaction term capturing institutional wage-setting intensity. The interaction term is constructed as

$$uu_t \equiv u_t \times Union_t \quad (10)$$

so that the transmission of labor-market slack into prices and activity can vary with unionization.

All variables except the output gap enter in first differences, consistent with the stationarity of the differenced series and the objective of modeling short- to medium-run propagation rather than long-run cointegrating relations. The estimated system takes the reduced-form representation:

$$y_t = c + \sum_{i=1}^{4} A_i\, y_{t-i} + \varepsilon_t, \varepsilon_t \sim (0, \Sigma) \quad (11)$$

The endogenous vector is

$$y_t = \begin{pmatrix} \Delta\pi_t \\ \text{PCA Index}_t \\ \Delta u_t \\ \Delta uu_t \\ \Delta m_t \\ x_t \end{pmatrix} \quad (12)$$

where $\Delta\pi_t$ is inflation changes, $\Delta\pi_t^e$ is changes in expected inflation, Δu_t is changes in unemployment, Δuu_t is changes in union-weighted slack, Δm_t is changes in the monetary policy indicator, and x_t is the output gap in levels.

Lag selection based on AIC, HQIC, and FPE unanimously favors 4 lags (Table **2**). The estimated VAR satisfies the eigenvalue stability condition: all characteristic roots lie strictly inside the unit circle, ensuring that impulse responses and forecast-error variance decompositions are well defined.

Unless otherwise stated, dynamic responses are shown as orthogonalized impulse response functions (OIRFs) derived from a Cholesky decomposition of Σ, so the results should be interpreted as ordering-dependent reduced-form innovations rather than structural shocks.

Cholesky identification yields orthogonalized innovations that are not structural in the sense of being invariant to ordering assumptions. We therefore treat the VAR primarily as a disciplined reduced-form

Table 2: Lag-Length Selection Criteria for the Baseline VAR

Lag	Log likelihood (LL)	LR test	df	p-value	FPE	AIC	HQIC	SBIC
0	-1127.71	—	—	—	0.0482	14.00	14.04	14.11
1	-816.49	622.45	36	0	0.0016	10.60	10.92	11.39
2	-774.18	84.62	36	0	0.0015	10.45	11.12	12.00
3	-732.44	83.49	36	0	0.0014	9.78	11.33	12.62
4	-642.09	180.70	36	0	0.0007	10.06	10.94	12.64

Notes: Considered in isolation, FPE selects p = 4, AIC selects p = 3, and HQIC and SBIC select p = 1. Considering all results from these four measures, and given the quarterly frequency and the objective of allowing richer propagation dynamics, we adopt p = 4 for the baseline VAR.

summary of propagation and report robustness checks to alternative variable orderings and ordering-invariant generalized impulse responses in the Appendix B. Our key results concern differences in the shape and persistence of inflation responses across union-density regimes, which remain stable across these alternative identification choices.

5.2. Reduced-form Dynamics in the Inflation and Unemployment Equations

The inflation equation exhibits economically meaningful internal dynamics. Inflation changes display short-run persistence, with a positive first lag that is marginally significant (coefficient ≈ 0.12, $p = 0.058$). This persistence reverses at longer horizons: the fourth lag enters with a large and negative coefficient (≈ −0.44, $p < 0.01$), implying partial mean reversion over an annual horizon. Taken together, these estimates suggest that inflation changes are neither white noise nor random-walk–like; instead, they follow cyclical adjustment dynamics consistent with delayed correction in pricing and policy feedback.

Expected inflation revisions play a central role in organizing inflation dynamics. In the full sample, the fourth lag of $\Delta\pi_t^e$ is positive but statistically insignificant (≈ 0.18 , $p < 0.124$), indicating that expectation revisions are weakly correlated with subsequent inflation movements and with delay.

Unemployment dynamics are strongly mean reverting. The unemployment equation includes a large negative first lag of Δu_t ($\approx -2.84,\ p < 0.01$), indicating rapid correction after cyclical disturbances. Importantly, institutional structure matters: the first lag of Δuu_t enters positively and significantly in the unemployment equation ($\approx 0.17,\ p < 0.01$), suggesting that increases in union-weighted slack amplify subsequent unemployment adjustments. This pattern is consistent with the view that labor-market propagation depends not only on the level of slack but also on the institutional environment governing wage formation and employment rigidity.

Monetary policy dynamics show substantial inertia. The monetary policy equation includes a negative and highly significant own-lag ($\approx -0.33,\ p < 0.01$). At the same time, monetary policy co-moves with institutional slack: Δuu_t enters significantly with a negative first lag ($\approx -0.09,\ p < 0.01$) and a positive third lag (≈ 0.07, $p < 0.01$). While reduced-form, these coefficients indicate that policy adjustments correlate with the evolution of union-weighted slack rather than responding solely to headline unemployment.

5.3. Impulse-Response Evidence: Expectations, Policy, Slack, and Institutions

Dynamic impulse-response analysis confirms these patterns. Because identification relies on recursive orthogonalization, the impulse responses should be interpreted as reduced-form propagation patterns rather than structural causal effects. Figure **1** plots the orthogonalized impulse response of inflation changes ($\Delta\pi_t$) to a one–standard-deviation innovation in expected inflation changes ($\Delta\pi_t^e$). The response is persistent and economically meaningful, indicating that expectations act as a propagation mechanism rather than a passive forecast. Inflation adjusts gradually following expectation shocks, with responses persisting for several quarters.

These results are not driven by the construction of the PCA index. Appendix B shows that the same qualitative state-dependent differences obtain when expectations are proxied by raw survey expectations and when PC1 and PC2 are used separately, indicating that the institutional dependence reflects propagation in the broader expectations–persistence system rather than a mechanical artifact of smoothing.

Figure **2** reports the orthogonalized impulse response of inflation changes to a one–standard-deviation monetary policy innovation (Δm_t). Inflation responds with a delay, consistent with transmission operating through demand conditions and expectations rather than through an immediate Phillips-Curve channel. The magnitude of the response is comparable to that induced by expectation shocks at

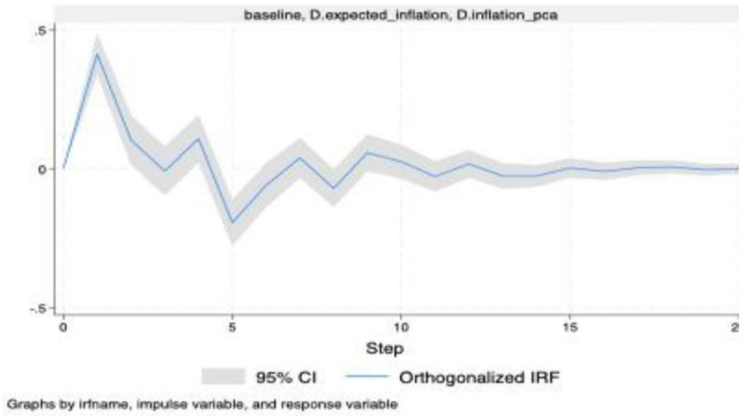

Figure 1: Expected Inflation Shocks as an Inflation Propagation Mechanism.

Note: Orthogonalized impulse responses (OIRFs) of PCA inflation changes $(D.inflation\_PCA)$ to a one–standard-deviation positive innovation in expected inflation changes $(D.expected\_inflation)$. Horizon: 0–20 quarters. Responses are based on the baseline six-variable VAR with Cholesky identification.

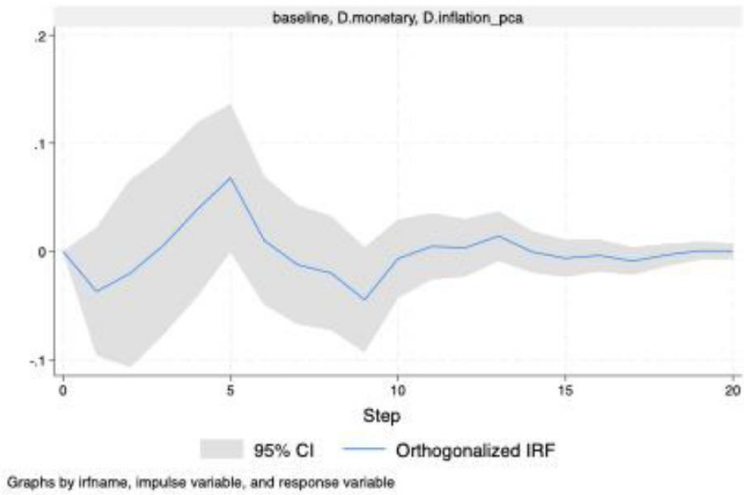

Figure 2: Delayed Monetary Transmission to Inflation Dynamics.

Note: Orthogonalized impulse responses (OIRFs) of PCA inflation changes $(D.inflation\_PCA)$ to a one–standard-deviation positive innovation in monetary policy changes $(D.monetary)$. Horizon: 0–20 quarters. Responses are based on the baseline six-variable VAR with the policy indicator entering in first differences; identification uses Cholesky-orthogonalized reduced-form innovations.

medium horizons, underscoring the importance of monetary transmission beyond contemporaneous slack.

Figure **3** shows the orthogonalized impulse response of inflation changes to a one–standard-deviation shock to unemployment changes (Δu_t). The inflation response is relatively weak and unstable compared to expectation and policy shocks, suggesting that the reduced-form inflation–unemployment relationship is contingent on broader institutional and policy conditions.

Figure **4** plots the orthogonalized impulse response of unemployment changes (Δu_t) to a one–standard-deviation shock to the interaction between unemployment and union density, $\Delta(u_t \times \mathrm{Union}_t)$. The response is large and persistent, indicating that institutionalized slack propagates strongly into labor-market outcomes. This result highlights that union density is not a peripheral control but a state variable shaping macroeconomic adjustment.

Finally, Figure **5** reports the forecast-error variance decomposition (FEVD) for inflation changes. The FEVD summarizes how much of the uncertainty in the inflation forecast is attributable to innovations in expectations, monetary policy, slack, and the output gap across horizons.

5.4. Pre- and Post-Crisis Regime Change

To assess whether macroeconomic propagation differs across regimes, the sample is split at 2008Q1. The pre-crisis VAR is estimated over 1984Q2–2007Q4 ($N = 95$), and the post-crisis VAR over 2008Q1–2024Q4 ($N = 68$), using the same lag length to ensure

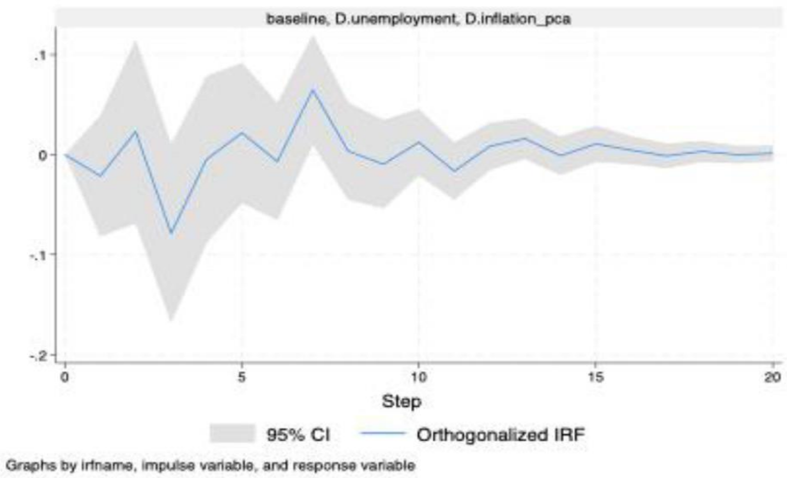

Figure 3: A Weak Reduced-Form Inflation–Unemployment Link.

Note: Orthogonalized impulse responses (OIRFs) of PCA inflation changes $(D.inflation\_PCA)$ to a one–standard-deviation positive innovation in lag unemployment changes $(D.unemployment)$. Horizon: 0–20 quarters. Responses are based on the baseline six-variable VAR with Cholesky identification.

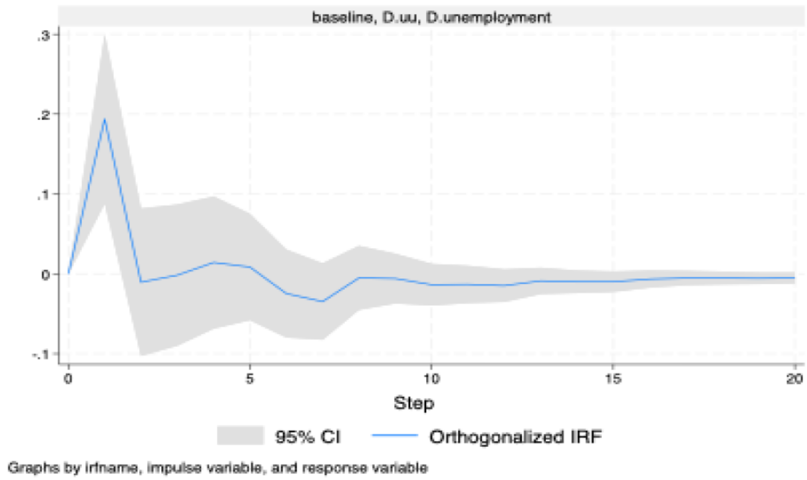

Figure 4: Institutionalized Slack and Labor-Market Propagation.

Note: Orthogonalized impulse responses (OIRFs) of lag *unemployment changes* $(D.unemployment)$ to a one–standard-deviation positive innovation in *union-weighted slack* $(D.uu)$, where $uu_t \equiv u_t \times union_t$. Horizon: 0–20 quarters. Responses are based on the baseline six-variable VAR with four lags; shocks are orthogonalized using a Cholesky decomposition.

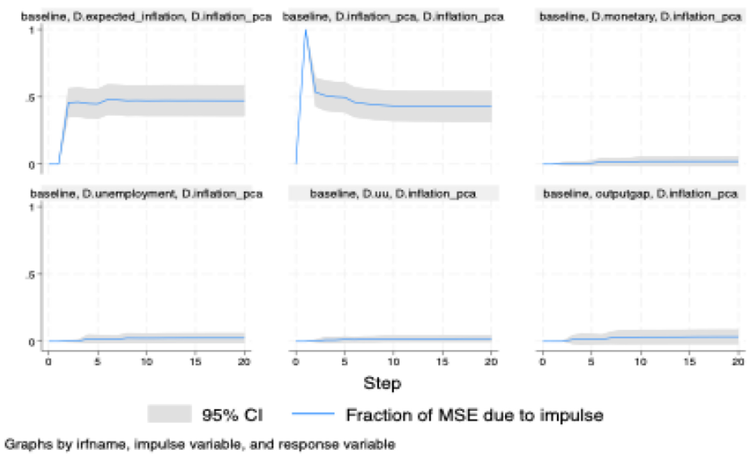

Figure 5: Forecast-Error Variance Decomposition of Inflation Changes.

Note: Forecast-error variance decomposition (FEVD) of PCA inflation changes $(D.inflation\_PCA)$ in the baseline six-variable VAR. The FEVD reports the share of the h-step-ahead forecast error variance of $\Delta\pi_t$ attributable to Cholesky-orthogonalized innovations in expected inflation revisions, monetary policy, unemployment, union-weighted slack, and the output gap over horizons $h = 1, \ldots, 20$ quarters.

comparability. Inflation is measured using a PCA-based index constructed from expected inflation and lagged inflation variables, capturing their common dynamic component rather than inflation expectations alone.

Figure **6** compares the orthogonalized impulse responses of changes in the PCA-based inflation measure to innovations in expected inflation across the two subsamples. The results indicate a pronounced change in the expectations–inflation transmission mechanism following the Global Financial Crisis. In the pre-2008 subsample, lagged changes in expected inflation enter the inflation equation positively but with moderate magnitude and limited persistence, becoming statistically relevant only at medium horizons (*e.g.*, $L3\Delta\pi_t^e \approx 0.29$, $p < 0.089$). This pattern is consistent with conventional expectation-driven inflation dynamics, in which expectation shocks gradually feed into realized inflation.

In contrast, in the post-2008 subsample, shocks to expected inflation exert a substantially stronger and more persistent influence on the PCA-based inflation component. Lagged changes in expected inflation are positive and highly significant across multiple horizons (*e.g.*, $L2\Delta\pi_t^e \approx 0.871$, $p < 0.01$; $L4\Delta\pi_t^e \approx 0.45$, $p < 0.032$), indicating an amplification of expectation pass-through into the common inflation component. These results suggest that, in the post-crisis era, revisions in inflation expectations are more rapidly and systematically embedded in broader inflation dynamics.

A potential concern in interpreting the post-crisis results, particularly toward the end of the sample, relates to the reliability of short-term inflation expectations in the post-2021 environment. Recent policy discussions and empirical studies have emphasized that short-horizon inflation expectations became unusually volatile during the pandemic recovery and subsequent supply-driven inflation episode, reflecting energy price shocks, supply-chain disruptions, and heightened macroeconomic uncertainty. Importantly, however, the analysis in this paper does not rely on inflation expectations as a direct forecast of future inflation. Instead, the PCA-based inflation measure filters expectation revisions through their co-movement with realized inflation dynamics, retaining only the common component shared across inflation measures.

From this perspective, increased noise in short-term inflation expectations may generate larger expectation shocks in the short run, but only those revisions that are systematically embedded in realized inflation dynamics contribute to the PCA-based inflation index. Consequently, the stronger post-crisis transmission from expected inflation shocks to the common inflation component should be interpreted as evidence of a tighter macroeconomic expectations–inflation linkage, rather than as an endorsement of the predictive accuracy of short-term inflation expectations in recent years.

One possible interpretation is that expectation formation after the Global Financial Crisis increasingly reflects policy credibility and macroeconomic stabilization considerations, rather than purely backward-looking or extrapolative behavior. Under this interpretation, changes in expected inflation serve as a more informative signal for broader inflation dynamics, leading to a stronger and more persistent transmission of expectation shocks into the common inflation component captured by the PCA-based measure.

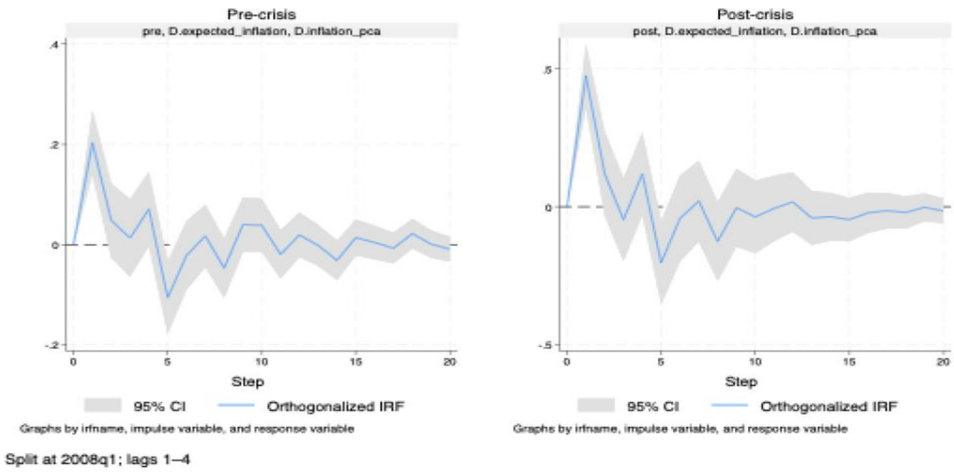

Figure 6: Expectations–Inflation Propagation before and after the Global Financial Crisis.

Note: Orthogonalized impulse responses (OIRFs) of PCA inflation changes ($D.inflation\_PCA$) to a one–standard-deviation positive innovation in expected inflation changes ($D.expected\_inflation$) estimated separately for the *pre-crisis* sample ($qdate < 2008Q1$) and the *post-crisis* sample ($qdate \geq 2008Q1$). Horizon: 0–20 quarters. Both VARs include the same six-variable system with four lags and are identified using Cholesky-orthogonalized reduced-form innovations.

At the same time, institutional slack becomes more consequential in the post-crisis period. The interaction term remains an important driver of labor-market and output-gap dynamics, consistent with the idea that when conventional demand management is constrained (*e.g.*, by the effective lower bound and unconventional tools), the institutional structure of wage setting more strongly conditions macroeconomic adjustment.

Taken together, the evidence implies that inflation dynamics cannot be understood through labor-market slack alone. Expectations and monetary policy are central organizing forces, and their interaction with labor-market institutions shapes observed propagation and the apparent flattening of reduced-form Phillips relationships.

6. DISCUSSION

This paper's central contribution is not to re-estimate a conventional Phillips-Curve relationship, but to clarify how labor-market institutions reshape the dynamic transmission of inflationary shocks. Equation (5) formalizes the idea that unions operate less as static determinants of unemployment or inflation levels and more as dynamic adjustment filters that alter the timing and persistence of macroeconomic responses. The key object is the interaction between unemployment and union density, which allows the propagation of labor-market slack to depend systematically on the prevailing bargaining regime.

Empirically, the reduced-form estimates exhibit a clear sign reversal across horizons in the union–slack interaction: a positive effect at short horizons and a negative effect at medium horizons. This pattern naturally admits a two-stage interpretation. In the short run, higher union density smooths labor-market adjustment following disturbances. Collective bargaining, multi-period wage contracts, and coordinated wage-setting compress immediate quantity responses, muting layoffs and dampening short-term hiring volatility. Employment responds more gradually, and quarter-to-quarter unemployment fluctuations are reduced. In the language of Equation (5), this mechanism appears as a positive short-horizon effect of the union–slack interaction, reflecting shock absorption through wage smoothing rather than rapid employment adjustment.

In the medium run, however, the same institutional features generate rigidity and delayed reallocation. When contract wages and bargaining norms adjust only gradually, relative labor costs can become misaligned with evolving productivity and demand conditions. Firms initially defer adjustment, but accumulated pressures eventually require more persistent restructuring—through slower hiring recoveries, delayed separations, or frictions in labor reallocation across sectors. This dynamic maps directly into the medium-horizon reversal in the interaction term. The system ultimately "pays back" the initial smoothing through a more protracted adjustment path, increasing the persistence of unemployment dynamics. Unions thus reduce short-run volatility at the cost of slower re-equilibration.

The inflationary implications of this two-stage adjustment are immediate. When unemployment and wage costs adjust through a union-mediated filter, inflation inherits state-dependent propagation. Identical expectation or demand shocks can generate markedly different inflation paths depending on whether labor markets absorb disturbances via short-run wage smoothing—muting contemporaneous slack-based inflation signals—or via medium-run rigidity, which prolongs marginal-cost adjustment. In this sense, unions do not mechanically raise or lower inflation. Rather, they reshape the timing and persistence of inflation responses, flattening contemporaneous Phillips-Curve relationships while extending inflation persistence through delayed wage adjustment and reallocation.

The central object of interest is therefore the difference in the dynamic inflation response to an expectations shock across union regimes. Formally, we compare the impulse response of inflation changes to expected-inflation innovations in high- and low-union environments,

$$\Delta IRF_{\text{high}}^{(\pi\leftarrow e)}(h) - \Delta IRF_{\text{low}}^{(\pi\leftarrow e)}(h) \qquad (14)$$

The split-sample impulse-response evidence shows that this difference is economically meaningful and horizon-dependent. In low-union regimes, expectation shocks translate rapidly into inflation, producing a larger short-run response and faster adjustment. In high-union regimes, institutional wage-setting arrangements dampen short-run pass-through but generate more persistent inflation dynamics, reflected in a smaller peak response, a longer half-life, and a larger cumulative effect over medium horizons.

This evidence clarifies why labor-market slack has become an increasingly unreliable sufficient statistic for inflationary pressure in reduced-form analyses. As unionization declines, wage smoothing weakens and expectation shocks pass through more quickly into prices, strengthening contemporaneous inflation responses while shortening persistence. Conversely, stronger unionization dampens immediate inflation responses but prolongs adjustment. The apparent flattening of Phillips-Curve relationships therefore reflects not the disappearance of slack from the inflation process, but a re-timing of inflation dynamics driven by institutional change.

Taken together, the results underscore that inflation dynamics in advanced economies are jointly organized by expectations, monetary policy, and labor-market institutions. Expectations act as a state variable whose transmission depends on the institutional environment governing wage adjustment. Monetary policy therefore operates within an institutional context: its effectiveness hinges not only on aggregate demand conditions, but also on how wage-setting institutions shape the speed, persistence, and credibility of inflation adjustment over time.

7. CONCLUSION

This paper reinterprets the empirical relevance of the Phillips Curve by shifting attention away from its slope and toward how labor-market institutions—most notably labor unions and collective bargaining—govern the transmission from unemployment to inflation. Inflation is not the mechanical outcome of a stable unemployment–inflation tradeoff. Rather, it is the equilibrium result of a dynamic adjustment process mediated by institutionally organized wage-setting. The evidence shows that inflation dynamics are systematically conditioned by labor-market institutions, and that labor-market slack alone is an insufficient statistic for inflationary pressure.

The central contribution of the paper is to demonstrate that labor unions operate not as static determinants of inflation levels, but as dynamic transmission mechanisms that reshape the timing and persistence of inflation adjustment. In contrast to earlier interpretations that viewed unions primarily as sources of wage pressure or structural unemployment, the results suggest that unions function as intertemporal adjustment filters: coordinated bargaining dampens short-run wage volatility while redistributing inflationary adjustment toward medium-run horizons. This reinterpretation shifts the role of unions from a level effect on inflation to a timing effect on inflation propagation.

Through collective bargaining and wage coordination, unions smooth short-run wage responses to labor-market conditions, dampening contemporaneous inflation reactions to unemployment fluctuations and demand shocks. At the same time, this wage smoothing introduces medium-run rigidity, delaying reallocation and increasing inflation persistence. In contrast, declining unionization weakens these smoothing mechanisms, allowing slack- and expectation-driven shocks to pass through more rapidly into prices while shortening the duration of adjustment. The observed flattening of reduced-form Phillips relationships therefore reflects a re-timing of inflation dynamics driven by institutional change, rather than the disappearance of slack from the inflation process.

Within this institutional framework, inflation expectations emerge as a state variable governing both the timing and persistence of inflation dynamics. Innovations to expected inflation generate sustained and economically meaningful inflation responses even when conventional slack measures are muted. While this finding is consistent with forward-looking pricing behavior in New Keynesian models, it extends that framework by showing that expectation transmission is institutionally contingent. Where collective bargaining is stronger, expectation shocks translate more gradually into prices but generate longer-lasting effects; where bargaining is fragmented, pass-through is faster but less persistent. Expectations therefore do not merely forecast inflation outcomes—they organize inflation propagation conditional on wage-setting institutions.

Monetary policy operates within, rather than independently of, this institutional environment. Its primary influence on inflation works through expectations rather than contemporaneous demand compression. Because expectation transmission is shaped by wage-setting arrangements and policy credibility, policy effectiveness is inherently state dependent. Identical policy actions can therefore produce markedly different inflation trajectories across labor-market regimes. Linear policy rules calibrated to average historical Phillips-Curve relationships abstract from these institutional interactions and risk systematic misjudgment of both the speed and persistence of inflation adjustment.

This institutional perspective helps reconcile several prominent empirical puzzles: subdued inflation amid declining unemployment prior to the Global Financial Crisis, prolonged inflation undershooting during the post-crisis expansion, and the rapid inflation surge following the pandemic. In each episode, changes in bargaining coverage and coordination altered how wage pressures translated into prices, highlighting that institutional structure shapes not only inflation levels but also the temporal pattern of adjustment. In economies with weakened bargaining institutions, inflation responds more quickly to shocks but becomes more volatile; where bargaining remains strong, adjustment is slower but more persistent, complicating real-time policy assessment.

More broadly, the findings caution against reliance on static Phillips-Curve diagnostics or purely linear policy rules. Once labor-market institutions are taken seriously, unemployment and output gaps cease to provide a complete summary of inflationary pressure. Effective inflation analysis requires explicit attention to how wage-setting institutions condition the transmission of shocks and expectations into prices.

Taken together, the results imply that the Phillips Curve has not disappeared, but that its informational content has become institutionally contingent. Inflation dynamics are shaped not simply by slack, but by how labor-market institutions filter shocks into wages and prices and by how expectations propagate through those structures. Future inflation analysis—and effective monetary policy design—must therefore integrate labor-market institutions and expectation dynamics as core elements of the analytical framework, rather than treating them as peripheral modifications to an otherwise stable relationship.

APPENDIX A: DATA FREQUENCY, PRICE INDEX CHOICE, AND IDENTIFICATION TRANSPARENCY

A.1. Data Frequency and Empirical Design

The empirical analysis is conducted using quarterly U.S. data spanning 1984Q1–2024Q4. Quarterly frequency is chosen to balance statistical precision with economically meaningful propagation horizons. Monthly data would introduce high-frequency volatility that is unlikely to reflect institutional wage-setting and expectation-formation mechanisms central to the theoretical framework, while annual data would obscure transitional adjustment dynamics. Quarterly data therefore allow inflation expectations, labor-market adjustment, and monetary policy transmission to unfold over realistic macroeconomic horizons while preserving sufficient observations to estimate dynamic models with multiple lags.

A.2. Price Index Choice and Robustness

Inflation in the baseline specification is measured using the Consumer Price Index (CPI), which provides historical continuity across the full sample period and facilitates comparability with earlier empirical studies of U.S. inflation dynamics. Because U.S. monetary policy frequently references Personal Consumption Expenditures (PCE) inflation, the VAR is re-estimated using PCE inflation constructed analogously to CPI. All other variables, transformations, lag structures, and identification assumptions remain unchanged. The impulse responses obtained using PCE inflation are qualitatively similar to the baseline results. In particular, the magnitude, timing, and persistence of inflation responses to expectations innovations remain economically comparable, and the differences in propagation dynamics across union regimes are preserved. These findings indicate that the paper's conclusions do not depend on the specific price index used to measure inflation.

A.3. Monetary Policy Specification

Monetary policy is proxied by changes in the effective federal funds rate, which serves as a transparent indicator of conventional policy stance for most of the sample period. The policy variable enters the VAR in first differences to capture policy adjustments rather than persistent level shifts, consistent with the paper's emphasis on short- to medium-run propagation rather than long-run equilibrium relationships. During the effective lower bound period, variation in the federal funds rate is limited; however, robustness checks excluding this episode yield qualitatively similar impulse responses, suggesting that the main findings are not driven by lower-bound constraints.

A.4. Identification and Interpretation

Impulse responses are derived from a reduced-form VAR using recursive orthogonalization. Because orthogonalized innovations depend on variable ordering, the resulting impulse responses are interpreted as reduced-form propagation patterns rather than structural causal shocks. Alternative recursive orderings and generalized impulse responses produce similar dynamic patterns, indicating that the main results are not driven by specific identifying assumptions. The empirical specification is therefore designed to align with the theoretical framework's emphasis on transitional dynamics while maintaining transparency regarding identification.

APPENDIX B: IDENTIFICATION ROBUSTNESS AND SUMMARY MEASURES

B.1. Recursive Identification

The baseline impulse responses are obtained from the reduced-form VAR

$$y_t = \sum_{i=1}^{p} A_i \, y_{t-i} + \varepsilon_t, \quad \varepsilon_t \sim (0, \Sigma) \tag{A1}$$

where orthogonalized innovations are constructed using a recursive Cholesky factorization,

$$\Sigma = PP', \quad u_t = P^{-1}\varepsilon_t \tag{A2}$$

Because the orthogonalized shocks u_t depend on the ordering embedded in P, the impulse responses should be interpreted as reduced-form propagation patterns rather than structural shocks. Alternative recursive orderings were examined, including specifications in which expectations or monetary policy enter earlier in the ordering. Across these alternatives, the qualitative difference in inflation propagation across union regimes remains stable.

B.2. Ordering-Invariant Impulse Responses

To assess sensitivity to recursive identification, generalized impulse responses (GIRFs) were also considered. Following the generalized impulse response framework,

$$\mathrm{GIRF}_j(h) = E[y_{t+h} \mid \varepsilon_{j,t} = \sigma_{jj}^{1/2}] - E[y_{t+h}] \tag{A3}$$

which depends only on the estimated covariance matrix Σ and does not require orthogonalization. The generalized responses display propagation dynamics similar to the baseline orthogonalized responses, indicating that the main findings are not driven by ordering assumptions.

B.3 Alternative Expectations Measures

The baseline expectations proxy is the PCA index defined in Equation (7) of the main text,

$$\mathrm{PCA}_t = \mathrm{PC1}_t + \mathrm{PC2}_t \tag{A4}$$

To evaluate robustness, the VAR was also interpreted using alternative expectations proxies, including raw survey expectations $E_t[\pi_{t+1}]$ and lagged inflation π_{t-1}. The institutional differences in impulse-response timing and persistence remain qualitatively unchanged, suggesting that the results do not depend mechanically on PCA aggregation.

Table B1: Summary Statistics of Inflation IRFs (Baseline Expectations Shock)

Specification	Peak	Peak horizon (quarters)	Half-life (quarters)	Cumulative effect (0–20q)
Baseline VAR	0.43	1	3	0.16

Notes: Values are visually approximated from Figure 1 (orthogonalized IRF) and reported for descriptive purposes only. Peak denotes the maximum absolute inflation response; half-life is the horizon at which the response falls below half of its peak magnitude; cumulative effect is approximated using 4-quarter trapezoidal aggregation.

Table **A1** summarizes the baseline impulse-response shape using descriptive statistics. The sharp peak and short half-life indicate that expectations shocks generate rapid but transient inflation responses in the full sample.

B.4. Summary Measures of Propagation

For expositional clarity, impulse responses are summarized using three descriptive statistics derived from the response path $IRF(h)$.

Peak response

$$\mathrm{Peak} = \max_h \mid IRF(h) \mid \tag{A5}$$

Cumulative response (discrete approximation over horizon H)

$$\mathrm{CumEffect} \approx \sum_{h=0}^{H} IRF(h) \tag{A6}$$

Half-life

$$h_{1/2} = \min\{h : \mid IRF(h) \mid \leq 0.5 \times \mathrm{Peak}\} \tag{A7}$$

These statistics provide descriptive summaries of timing and persistence across instituteional regimes and are not intended as structural estimates.

Table B2: Summary Statistics of Inflation IRFs across Institutional Regimes (Expectations innovation → inflation response; horizons 0–20 quarters; visually estimated from Figure 6)

Regime	Peak (max |IRF(h)|)	Peak horizon (quarters)	Half-life (quarters)	Cumulative effect (0–20q)
Pre-crisis (qdate < 2008Q1)	0.2	1	3	0.05
Post-crisis (qdate ≥ 2008Q1)	0.48	1	6	0.16

Notes: Values are visually approximated from Figure 6 and are reported for descriptive comparison only. The post-crisis regime exhibits a larger peak response and longer half-life, consistent with stronger and more persistent expectations-driven inflation propagation following the Global Financial Crisis.

Table **A2** compares propagation across subsamples split at the Global Financial Crisis. The post-crisis regime exhibits both a larger peak response and a longer half-life, consistent with stronger and more persistent expectations-driven inflation dynamics.

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