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A Decomposition of the Phillips Curve's Flattening*

Bill Dupor†, Marie Hogan‡, and Jingchao Li§

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Abstract

While the original papers on the inflation-unemployment relationship, i.e., the Phillips curve, studied aggregate data, a recent generation of work has moved to regional analysis. We estimate Phillips curves in the US based on regional data between 1958 and 2013, from which we can recover the national Phillips Curve. We find that the curves' evolution over time is characterized by changing cross-region spillovers largely due to a subset of 1970s observations. We show that for these observations, regional inflation exhibits strong negative comovement with national unemployment even after controlling for own region unemployment, resulting in a negative spillover in the regional Phillips curve regression. Aggregating across regional curves, the negative spillover works to steepen the national Phillips curve. The local (regional), spillover and national Phillips curve slopes observed in the data are qualitatively consistent with a simple multi-region monetary model with endogenous monetary policy.

1 Introduction

While economists have traditionally analyzed the correlation between inflation and unemployment (i.e., the Phillips curve) using national-level data, more recently some researchers have moved to using regional data. The slopes implied by these approaches differ. Although the regionally estimated slope has remained stable between sample periods, the nationally

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estimated slope flattens in later periods relative to earlier ones.[1] In this note, we reconcile these facts by showing how cross-region spillovers drive differences in estimates from the national and regional approaches.[2]

As a starting point, suppose $\Pi_{i,t}$ and $U_{i,t}$ are the inflation rate and unemployment rate for region i in year t. Let each of these two variables with the subscript i omitted denote its economy-wide average. Importantly, papers that use regional data often employ time fixed effects, which implicitly demean variables in each period by their corresponding cross-sectional averages. In its simplest version, one estimates

$$\Pi_{i,t} - \Pi_t = \alpha \left(U_{i,t} - U_t\right) + \epsilon_{i,t} \tag{1}$$

We call α the own or local (Phillips curve) slope.

Aggregate studies instead estimate:

$$\Pi_t = \beta U_t + \nu_t \tag{2}$$

Here β is the aggregate or national slope.

If both (1) and (2) are correctly specified, then we can combine equations to get

$$\Pi_{i,t} = \alpha U_{i,t} + \gamma U_t + \eta_{i,t} t \tag{3}$$

where $\gamma \equiv (\beta - \alpha)$ and $\eta_{i,t} \equiv \epsilon_{i,t} + \nu_t$.

We call γ the spillover slope or alternatively the average slope, conditional on local unemployment.[3] The spillover slope gives the relationship between own-region inflation and average unemployment after controlling for own-region unemployment. If the spillover equals zero, then the local and aggregate slopes are equal. Dupor et al. (2021) and Dupor et al. (2023) introduce the local-spillover decomposition in the context of the government spending multiplier and the government transfer multiplier, respectively.

Because the spillover equals $(\beta - \alpha)$, 2 and 2 together imply that the spillover has been in-

[1] Papers studying the flattening of the Phillips curve using national data include Atkeson and Ohanian (2001), Ball and Mazumder (2011), and Blanchard (2016); papers studying the flattening of the Phillips curve using regional data include McLeay and Tenreyro, 2019, Hazell et al. (2022), and Fitzgerald et al. (2024).

[2] Papers variously define the Phillips curve as either a correlation or a causal relationship from unemployment to inflation. In this paper, we use the former definition.

[3] The term U_t is an average and thus, from each region's perspective, includes own unemployment its summation. It is straightforward to instead rewrite (3) using leave-off averages. We use the above representation for the sake of simplicity.

creasing in later subsamples relative to earlier ones. According to our estimates, the spillover has gone from being negative to positive. In early periods, the negative spillover amplifies the negative local effect, resulting in a national slope larger than its regional counterpart. By contrast, in later samples, we see the positive spillover effect nearly offsets the negative local effect, resulting in a national slope that is approximately zero.

The historical evolution of the spillover can be explained by the change in U.S. monetary policy from passive (i.e., overly accommodative of inflation) to active (i.e., aggressively combating inflation) at the beginning of the 1980s with the start of Paul Volcker's chairmanship of the Federal Reserve.[4] Simply put, passive monetary policy steepens the national Phillips curve by introducing a negative spillover to the slope, while active monetary policy does the opposite.

The U.S. has many regions, each with differing inflation and unemployment rates, but a single monetary policy and integrated capital markets. Suppose Delaware experiences a fall in its unemployment. According to conventional wisdom, a tighter state labor market puts upward pressure on Delaware wages and prices, accounting for the negative local effect identified by the cross-sectional Phillips curve. Suppose, in the same year, that all other states experience a rise in unemployment. Under a passive monetary policy, a central bank responds to overall national labor market slackening by tightening policy. This is disinflationary for Delaware and results in a negative spillover slope consistent with the negative spillover observed during early sample periods. Since the local effect remains negative and the national slope is the sum of the local and spillover slopes, the national slope is negative and large.

On the other hand, suppose monetary policy is active. If—as above—states besides Delaware experience a rise in unemployment, a passive authority eases policy, which works to increase Delaware inflation. This is consistent with the positive spillover observed during post-Volcker sample periods. In Section 3, we use a simple model to demonstrate how an economy with a pure inflation targeting central bank in a monetary union will have a positive spillover that exactly offsets the negative local effect.

The rest of the paper proceeds as follows: In Section 2, we describe our data and estimate the local-spillover decomposition for 20-year rolling windows and early (1958-1983) and late (1988-2013) periods. Using these estimates, we corroborate and extend findings from existing research: (i) The local slope is negative and stable across subsamples; (ii) The national slope is negative in earlier subsamples but increases, moving closer to zero, in later subsamples;

[4]See for example Clarida et al. (2000) and Taylor (1999).

and (iii) the national slope's increase begins in the early 1980s. We show that the national slope's change occurs through the spillover component, then isolate the state-years pairs that most drive the large negative slope in early subsamples. These occur in the 1970s, a period during which monetary policy was passive. Section 3 explains the results using a stylized multi-region model of a monetary union. Section 4 discusses our paper's value added relative to existing related research. Section 5 concludes.

2 The Empirical Model and Results

We use data drawn from both the state and MSA geographic partitions, aggregated to the state level, to construct a balanced panel of 20 states covering the period 1958 to 2013.

We measure inflation using average annual percent change in MSA-specific headline CPI reported by the Bureau of Labor Statistics. The majority of states in our sample contain only one MSA for which we observe an inflation rate. In these states, we define a state's inflation rate as the observed MSA inflation rate. For the subset of state containing multiple observed MSAs, we compute the inflation rate as the population weighted average of observed MSA inflation rates. If a particular MSA straddles multiple states, we assign it to the state where the plurality of its population resides: For example, we assign the New York-Newark-Jersey City MSA to New York.

We measure unemployment using average annual unemployment rates at the state level. Because the Bureau of Labor Statistics did not consistently report state-level unemployment rates for all states in our sample until 1976, our state-level unemployment series comes from two sources: the insured unemployment rates (pre-1976) and the overall unemployment rates (1976 and onward).[5] For each state and for each of the two series, we HP filter the data to extract a cyclical state-level unemployment rate.[6] We create our unemployment series by concatenating the two and, lastly, smoothing the resulting series by defining a state's 1976 unemployment rate as the midpoint of its 1975 and 1977 values. Average cyclical unemployment in a given year is the average of state cyclical unemployment in the same year, weighted by state income share during the first year of our sample.

LAlthough we draw inflation data from MSAs, we use the word "state" throughout the

[5]Details on data sources and construction appear in an appendix.

[6]Using both insured and overall unemployment rates allows us to study differences between the local and national Phillips curve over a longer and earlier period. However, insured and overall unemployment rates differ in both level and cyclical patterns during periods in which both are available: Insured unemployment is consistently lower than overall unemployment and its cyclical variation is more muted.

rest of the paper when describing our model. Thus, much like the standard national Phillips curve, which regresses urban consumer inflation on nationwide unemployment, we regress urban consumer inflation (within observed MSAs) on statewide unemployment.

Letting $u_{i,t}$ and $\pi_{i,t}$ be the cyclical unemployment rate and inflation rate during year t in a state indexed by i, respectively, we estimate an augmented version of (3) from the introduction

$$\pi_{i,t} = \delta_i + \alpha u_{i,t} + \gamma u_t + \Gamma' x_{i,t-1} + \phi' X_{t-1} + \epsilon_{i,t} \tag{4}$$

where u_t is the average of $u_{i,t}$ over t weighted by the share of income in state i in the first period of the sample (s_i).[7] Other variables with an omitted subscript i are similarly the weighted averages of their corresponding i indexed counterparts unless otherwise noted. $x_{i,t-1}$ is a K by 1 vector of state-specific conditioning variables and $X_t - 1$ is an L by 1 vector of aggregate variables, with conformable regression coefficient vectors Γ and ϕ. For the remainder of the paper, the cyclical unemployment rate will be referred to as the unemployment rate.

In our benchmark specification, the state-level control vector $x_{i,t-1}$ contains $\pi_{i,t-1}$. The aggregate control vector X_{t-1} contains the change in the log price of oil at $t-1$ and π_{t-1}. We estimate the model using weighted least-squares with weights given by s_i and report Driscoll-Kraay standard errors, which allow for both serial and cross-sectional correlation.

As in the introduction, the local slope, α, is the change in state inflation in response to a one-unit change in state unemployment, holding fixed the weighted average of all states' unemployment. The coefficient on average inflation in equation (4), γ, gives the effect on state inflation in response to a one-unit change in the weighted average of unemployment across states, holding fixed state unemployment.[8]

Aligning the Decomposition with Aggregate and Time Fixed Effect Approaches

Next, we manipulate equation (4) in order to relate the local and spillover coefficients to the aggregate and two-way fixed effect estimates used in existing work. First, summing across i

[7] Here we reuse the notation and definitions for α and γ from the introduction.

[8] We could alternatively define the state i local slope to equal $\alpha + s_i\gamma$ because own-state inflation appears as a local effect and as part of the average unemployment value in the estimation equation. If N is large, then this alternative measure is approximately equal to α. Similarly, we could alternatively define the state i spillover slope to equal $(1 - s_i)\gamma$ because the weighted mean unemployment differs slightly from its leave-off weighted mean. If N is large, then this alternative measure is approximately equal to γ.

for each t using weights s_i, we have:

$$\pi_t = \delta + (\alpha + \gamma)\, u_t + \zeta' X_{t-1} + \epsilon_t \tag{5}$$

This indicates that the sum of the local and spillover from the panel regression is identical to the estimate one would get by estimating the aggregate regression directly. That is, the national Philips curve slope equals $\alpha + \gamma$. Moreover, suppose we estimate the national slope using aggregate data constructed with the same weights as used in the panel regression and assume the same error autocorrelation structure as with the panel. In this case, both the panel based and aggregate data based point estimates and standard errors will match.

We can use the two equations above to construct the panel regression's "fixed effect" analog equation. First, for any variable $z_{i,t}$, define $\tilde{z}_{i,t} \equiv z_{i,t} - z_t$. Then, subtracting (5) from (4), we have

$$\tilde{\pi}_{i,t} = \tilde{\delta}_i + \alpha \tilde{u}_{i,t} + \Gamma' \tilde{x}_{i,t-1} + \tilde{\epsilon}_{i,t} \tag{6}$$

Equation (6) is equivalent to a two-way fixed effect regression of $\pi_{i,t}$ on $u_{i,t}$ and the controls $x_{i,t-1}$, and α from the local spillover decomposition is identical to the coefficient on $u_{i,t}$ in the two way fixed effect regression. Note that the aggregate regressor vector X_{t-1} that appears in equations (4) and (5) is "differenced out" of (6).

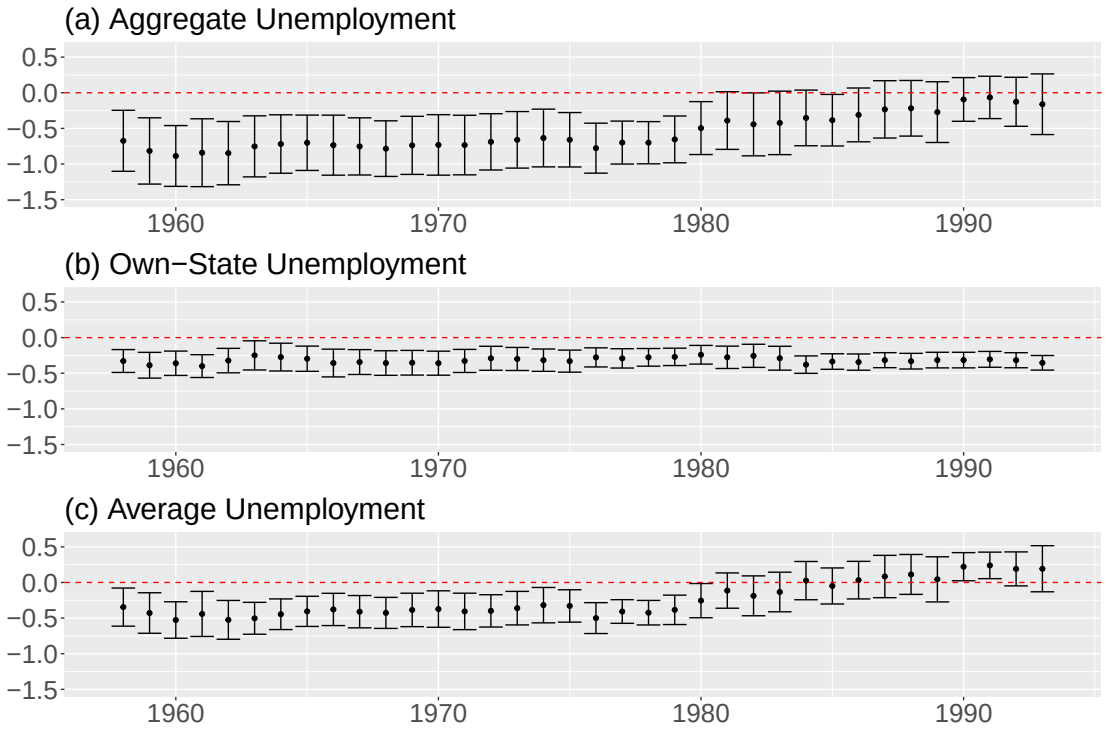
Estimating Changes to Local and Spillover Slopes Over the Sample Period

We begin by estimating the effects of average and own-state unemployment on inflation using 20-year rolling samples. Estimates are ordered on the x-axis by the earliest year included in their respective samples: For example, an estimate located at 1960 corresponds to a regression using data from 1960 to 1979.

Panel (a) of Figure 1 presents point estimates and 90 percent confidence intervals for the national slope (i.e. $\alpha + \gamma$) for each subsample. Panels (b) and (c) present the corresponding estimates for its decomposition.

Existing research finds that the national slope has flattened over time, a pattern apparent in panel (a). Observe that for the earlier sample windows, the aggregate estimates are negative, stable across samples, and statistically different from zero. However, for late-window samples, the aggregate effect nears zero. Our decomposition in equation (4) demonstrates that this is driven nearly entirely by the change in the average (or spillover) slope as seen in

Figure 1: Local spillover decomposition estimates, 20-year rolling samples, 1958-2013



Notes: Coefficient estimates from equation (4) with 90% confidence intervals calculated using Driscoll-Kraay standard errors.

panel (b).

The local slope (panel (b), the effect of own-state unemployment after conditioning on average unemployment) is relatively stable across subsamples even in the 1960s and becomes more precisely estimated for samples that include the Great Moderation. This matches findings in previous work identifying the Phillips curve with state and MSA level data (e.g. Hazell et al. (2022), Fitzgerald et al. (2024)).

In contrast, the spillover slope (panel (c), the effect of average unemployment after conditioning on own-state unemployment) shows marked changes over time. It remains roughly steady between -0.5 and -0.25 during the first half of the samples but begins to rise around 1980, contemporaneously with the start of Volcker's tenure as Fed Chairman. The point estimate's sign is negative, and the confidence interval excludes zero for all rolling windows starting prior to 1980. Point estimates are positive for all but one rolling window starting in subsequent years, although confidence intervals exclude zero for only two (1990-2010 and 1991-2011). Thus for early sample windows, increasing average unemployment tends to de-

crease unemployment, holding fixed own-state unemployment, a pattern that does not hold for later sample windows.

Next, we report estimates for a particular pair of early and late subsamples from the period. Table 1 contains the benchmark regression results for the first and last 25 years in our sample (columns (1) and (2), respectively).

Table 1: Local spillover decomposition estimates, early (1958-1983) and late (1988-2013) samples

Dependent Variable:	Own-State Inflation	
	Early	Late
Model:	(1)	(2)
Variables		
Own-State Unemployment	-0.24**	-0.30***
	(0.10)	(0.06)
Average Unemployment	-0.44***	0.16
	(0.12)	(0.13)
Aggregate Unemployment	-0.68***	-0.14
	(0.22)	(0.19)
Fit statistics		
Observations	390	390
R^2	0.89	0.63

Notes: Dependent variable in panel regressions is state-level average inflation. Panel regressions include state fixed effects, are weighted by state income shares and report Driscoll-Kraay standard errors.

For the early sample, the local slope equals -0.24 (SE=0.10). Holding fixed average employment, a one percentage point increase in the own-state unemployment rate is associated with a reduction in the own-state inflation rate of 24 basis points; low local unemployment correlates with higher local inflation. During the same period, the average slope equals -0.44 (SE=0.12). Holding fixed state unemployment, a one percentage point increase in the weighted average of national unemployment reduces own-state inflation by about 44 basis points. The national slope equals -0.68 (SE=0.22), the sum of local and spillover components. For the late sample, the local slope is negative, statistically different from zero and close in value to that from the earlier sample. On the other hand, the spillover slope is positive, switching sign relative to its value in earlier periods. The spillover relationship from the earlier sample is not operative in the late sample. In turn, the increase in the spillover slope closer to zero along with the local slope's stability across samples implies a flattening

of the national Phillips curve. Thus, our estimate is consistent with both aggregate studies that find a downward, statistically and economically significant Phillips curve during earlier periods and regional studies that find a flatter but stable regional Phillips curve during later periods.

What Years Drive the Negative Spillover Estimate?

Our above results show that the flattening aggregate slope was driven by the spillover. Without the negative–and large in absolute value–spillover slope in the early sample, both the local and national slope would be stable, negative and not too steep.

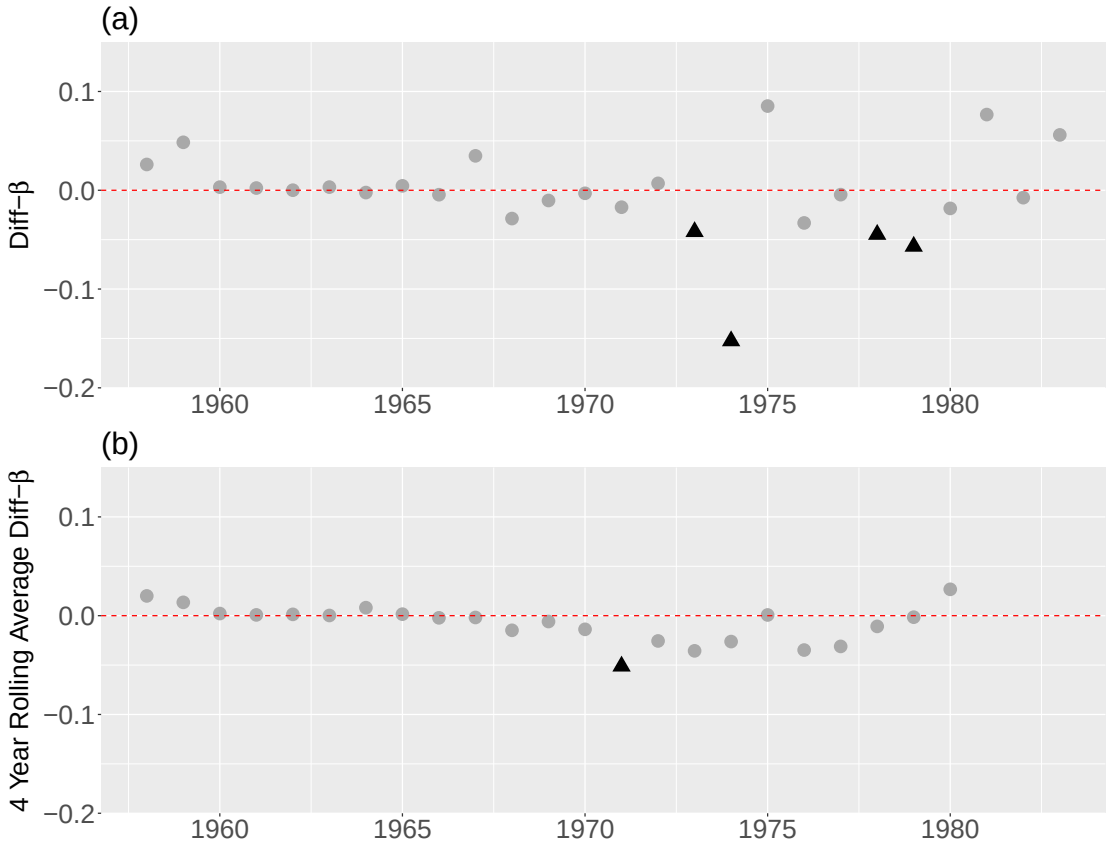
As such, we ask: What in the data results in the early subsample's negative spillover estimate? To answer this question, we estimate equation (5) using the aggregate time series and compute each year-observations' influence by calculating its corresponding diff-β (Belsley et al., 1980). This measure of influence reflects how the slope's point estimate changes in response to an observation's removal from a sample. For example, an observation-specific diff-β value of 0.1 for a slope estimate of 0.5 implies that dropping that observation reduces the point estimate of the coefficient from 0.5 to 0.4. Because we observe a stable local slope across subsamples and because the national slope is a sum of local and average slopes, large diff-β values in the aggregate regression indicate which years drive the large negative spillover.

Panel (a) of Figure 2 plots each year's diff-β for the national unemployment variable during the early sample. The four lowest values appear as black triangles: Each contributes heavily to the large negative national slope relative to other years in the sample. Each of the four years lies between 1973 and 1979, with the 1974 observation being the single most influential. However, the diff-β series in panel (a) exhibits noise (e.g., flipping from a minimum in 1974 to a maximum in 1975).

Panel (b) plots the same chart as in (a) except we plot the four-year moving average of these diff-β values. Panel (b) contains a single black triangle, which corresponds to the 4-year span 1971 through 1974. These are the four consecutive years that contribute most to the steep downward slope. 1971 through 1974 was the first major acceleration in inflation, rising from around 6 percent year over year in 1970 to a peak of 12 percent in 1974. It was also a time of a tight labor market nationwide.

Each of these high influence years occurred within a passive episode of U.S. monetary policy (see, for example, Clarida et al. (2000) and Taylor (1999)). Because monetary policy was accommodative, high inflation and low unemployment were met with pro- rather than counter-cyclical policy. According to this explanation, the "fueling of the fire" led to a steep-

Figure 2: Influence measures for each observation from aggregate data: diff-β, early sample



Notes: In panel (a), each marker corresponds to diff-β associated with national cyclical unemployment variable for a particular year observation. A negative value indicates that the year-observation influences the unemployment variable slope downward. A black triangle indicates that observation is within the lowest 15th percentile. Panel (b) is identical to (a) except it plots the 4-year moving average of diff-β.

ening of the Phillips curve, which appears as a larger and more negative diff-β. Importantly, this steepening works through a spillover rather than local channel: From an individual state's perspective, own-state unemployment does not determine monetary policy and its impact. Since the U.S. is a monetary union, policy reacts to average unemployment.

In light of this, one might consider re-estimating the panel regression by introducing a measure of the accommodative component of monetary policy; however, the Fed was not explicitly following an interest rate or systematic money growth rate rule during the '60s and '70s. Moreover, the Fed did not have forward guidance or an explicit communication strategy. As a result, constructing a variable measuring the underlying accommodative component of policy requires strong assumptions about Fed policy and would be vulnerable

to measurement error. By contrast, the spillover variable requires relatively few assumptions and avoids introducing additional bias into estimates of the local slope while still offering more insight than a time fixed effect.

Table 2: Early sample local-spillover decomposition, with and without influential years

Dependent Variable:	Own-State Inflation		
	All Years	Dropping Individual Years	Dropping Single Period
Model:	(1)	(2)	(3)
Variables			
Own-State Unemployment	-0.24**	-0.18	-0.24**
	(0.10)	(0.11)	(0.11)
Average Unemployment	-0.44***	-0.19	-0.23
	(0.12)	(0.17)	(0.15)
Aggregate Unemployment	-0.68***	-0.37	-0.47*
	(0.22)	(0.28)	(0.25)
Fit statistics			
Observations	390	330	330
R^2	0.89	0.89	0.90

Notes: The dependent variable in the panel regressions is state-level average inflation. Regressions include state fixed effects, state and national lagged inflation, and are weighted by state income shares and report Driscoll-Kraay standard errors.

Next, Table 2 reports the local-spillover decomposition estimates for three models, in each case limiting attention to the early sample. Column (1) contains the baseline results. Column (2) re-estimates the baseline model but omits all state-year pairs from the four most downwardly influential years, corresponding to panel (a) of the figure. Column (3) repeats the exercise for a single four-year period, corresponding to panel (b) of the figure.

Comparing columns (1) to (2), we see that dropping the four influential years flattens the aggregate slope substantially, from -0.67 to -0.37, and that this attenuation occurs mainly through the spillover channel, which goes from -0.44 to -0.19. Moreover, dropping these influential years results in all three Phillips curve slopes becoming statistically indistinguishable from zero.

Results dropping state-year pairs from 1971-1974 instead (column (3)) are very similar. Comparing columns (1) and (3), dropping the most influential four-year span flattens the

spillover slope, and thus the aggregate slope, whereas the local slope is nearly unchanged relative to estimates including observations from all years in the early sample.

Is the Negative Spillover Visible in the State-Level Data?

Table 3 reports state inflation and unemployment rates as well as the national unemployment rate, residualized and non-residualized, for ten state-year pairs from the early sample. These state-year pairs are chosen from the highly influential years identified in Table 2 and ordered from lowest to highest diff-β on the spillover coefficient, which are reported in the rightmost column. Because our estimate of the early sample spillover slope is negative when all years are included, a negative diff-β for an observation implies that dropping the observation from the sample shifts the estimated spillover slope closer to 0.

Table 3: Raw and Residualized Values of High Influence Observations in the Early Sample Period

State	State Inflation	State Unemp. Rate	Residualized State Inflation	Residualized National Unemp. Rate	Weight	Diff-β on Spillover Coefficient
TX (1978)	9.43	-0.80	2.74	-1.03	0.054	-0.022
IL (1974)	10.56	-0.78	-1.64	0.89	0.075	-0.016
CA (1978)	7.80	-0.84	1.15	-0.85	0.121	-0.014
TX (1979)	13.18	-1.44	2.43	-0.67	0.054	-0.014
NY (1973)	6.35	-0.60	1.84	-0.33	0.132	-0.013
CA (1974)	10.16	0.02	-1.46	0.36	0.121	-0.011
OH (1974)	10.53	-0.55	-1.57	0.74	0.064	-0.011
IL (1978)	8.69	-1.63	2.03	-0.36	0.075	-0.009
TX (1973)	5.75	-0.40	1.70	-0.62	0.054	-0.008
WI (1974)	9.68	-0.62	-2.54	0.84	0.024	-0.008

Notes: Residualized state inflation and national unemployment rate report residuals after regressing on state fixed effects, state unemployment, and the vector of controls (lagged oil and lagged state and average inflation). Diff-β values report the amount by which the estimated spillover coefficient would decrease in the absence of the observation. A negative value therefore indicates that the observation's exclusion would increase the estimated slope (in this context, "flatten").

Examining the first column, note that these influential observations are geographically spread out, including the South (Texas), West (California), Midwest (Illinois, Ohio and Wisconsin), and East (New York).

Texas in 1978 is the most influential observation contributing towards a negative spillover. In 1978, Texas' inflation and cyclical unemployment rates were 9.43 percent and -0.8 percent

respectively. Qualitatively, the state looked matches the traditional Phillips curve experience: high inflation and a tight labor market.

However, quantitatively, the state level unemployment to inflation channel was not sufficiently strong to explain all of Texas's inflation. The next column contains the residualized state inflation rate, which equaled 2.74 percent for that state-year. Note that here we are controlling for both state unemployment and lagged state inflation, so that *even after accounting for state unemployment*, Texas inflation was high in 1978.

The next column contains the residualized national unemployment rate, which equals -1.03 for the 1978-Texas observation. This negative relationship between state inflation and national unemployment (after controlling for state unemployment and other covariates) contributes to the negative spillover slope we reported above.

For three of the following four most influential observations, the residualized state inflation rate is positive. As with Texas, these states experienced high inflation even after controlling for state unemployment during years with low national unemployment. The 1974-Illinois observation is also among the five most influential observations; however, in this case, the residualized state inflation rate is negative and national unemployment positive.

3 The Mechanism in a Simple Model

We build a model with region-specific cost and demand shocks that generate movements in aggregate inflation and cross-regional inflation dispersion. The regions together constitute a monetary union, in which a central bank responds to the aggregate shock in a way that influence the aggregate but not local Phillips curve correlation.

Assume there is a continuum of regions on the unit interval, each indexed by k. Within each region lives a single family, indexed by l, with a unit continuum of members. Each member is specialized in a particular occupation k with a skill set that differentiates it from others in the same occupation. A firm in region k hires individuals from occupation k drawn from families of all regions to produce consumption good k. Let $N_t(k,l)$ denote the labor used in region k with an individual from family l specialized in occupation k. The region production function for output is

$$Y_t(k) = \left[\left(\int N_t(k,l)^{\frac{\theta-1}{\theta}} dl \right)^{\frac{\theta}{\theta-1}} \right]^{1-\alpha}$$

Each region k firm pays a random proportional labor tax, where one plus the tax rate equals $g_{k,t}$. The region k firm's problem is:

$$\max_{N_t(k,l)} P_t(k) Y_t(k) - g_{k,t} \int W_t(k,l) N_t(k,l) dl \tag{7}$$

where $P_t(k)$ is the dollar price of good k and $W_t(k,l)$ is the wage in region k of the occupation k member of the family residing in region l.

Cost minimization implies

$$N_t(k,l) = \left(\frac{W_t(k,l)}{W_t(k)} \right)^{-\theta} N_t^d(k) \tag{8}$$

Firms sell consumption goods at a competitive market price.

Household problem

We assume that, within a household, consumption and asset holdings are shared equally among occupation holders. Let $C_{l,t}(k)$ denote consumption good k purchases from the family residing in l.

The household residing in i maximizes expected lifetime utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_{l,t}^{1-\gamma}}{1-\gamma} - \frac{N_{l,t}^{1+\kappa}}{1+\kappa} \right) \tag{9}$$

where

$$C_{l,t} \equiv \left[\int (\delta_t(k) C_{l,t}(k))^{\frac{\sigma-1}{\sigma}} dk \right]^{\frac{\sigma}{\sigma-1}} \text{ and } N_{l,t} \equiv \int N_t(k,l) dk \tag{10}$$

Wealth evolves according to:

$$\int P_t(k) C_{l,t}(k) dk + M_{l,t} = H_t + \int W_t(k,l) N_t(k,l) dk + R_{t-1}^M M_{l,t-1} \tag{11}$$

where $H_t = M_t^\Delta + \Omega_t$. M_t^Δ is a lump-sum transfer and Ω_t is the nominal dividend. $M_{l,t-1}$ is the money holdings at the beginning of period t that are carried from the previous period.

A cash-in-advance constraint requires:

$$\int P_t(k) C_{l,t}(k) dk \leq M_{l,t} \tag{12}$$

The government pays interest on money, R_{t-1}^M, such that the cash-in-advance constraint

does not bind. See the appendix for the derivation of requisite R_{t-1}^M. Although the constraint does not bind, we assume household carry just enough cash to make purchases.

Each region's household l posts occupation-specific wage rates for $k \in [0,1]$. Once set, the household provides hours as demanded according to (8).

Cost minimization by households gives the following demand curves:

$$C_{l,t}(k) = \delta_t(k)^{\sigma-1} \left(\frac{P_t(k)}{P_t} \right)^{-\sigma} C_{l,t} \tag{13}$$

where $P_t \equiv \left[\int (P_t(k)/\delta_t(k))^{1-\sigma} dk \right]^{\frac{1}{1-\sigma}}$.

Fiscal and Monetary Policy

The government sets labor tax rates in each period and chooses a monetary injection. Tax rates are *iid* over time and potentially correlated across regions. Monetary policy depends potentially on the average tax rate, but is otherwise deterministic.

Timing and Shocks

The economy evolves as follows. First, anticipating the demand schedule for labor, households post nominal wages. Second, the region-specific tax rates and demand shocks are realized for all k. Third, the government chooses a monetary injection. Fourth, firms and households make additional decisions and markets clear.

Equilibrium

We characterize a fixed wage equilibrium, in which the $W_t(k,i)/M_{t-1}^s = w$ is identical over all i, k and t. Because shocks are non-Markovian and wages are set one period in advance, the pre-shock realization economy repeats itself every period. We additionally restrict attention to equilibria that are symmetric within an occupation. As such, it will no be longer necessary to track a worker's residency; all workers in an occupation have equal wages and hours worked.

Let $p_t(k) = P_t(k)/M_{t-1}^s$.We find the pair $(N_t(k), p_t(k))$ for all k. Suppressing the k index indicates the economy-wide average of the corresponding variable.

The relative consumption demand equation (24) implies:

$$\left(\frac{N_t(k)}{N_t(i)} \right)^{-(1-\alpha)/\sigma} = \left(\frac{\delta_t(k)}{\delta_t(i)} \right)^{-(\sigma-1)/\sigma} \frac{p_t(k)}{p_t(i)} \text{ for each pair } (i,k)$$

The cash-in-advance condition (12) implies:

$$\frac{M_t^s}{M_{t-1}^s} = \int p_t(k) N_t(k)^{(1-\alpha)} dk$$

The industry labor demand equation (7) implies:

$$(1-\alpha) N_t(k)^{-\alpha} p_t(k) = g_{k,t} w \text{ for each } k$$

Going forward, we omit time subscripts because the equilibrium defined with this transformation can be solved period-by-period. We log-linearize the above equilibrium conditions around a steady state for small variations in the tax rates and money growth rate.[9]

The log-linearized regional consumption demand, the cash-in-advance and regional labor demand conditions are

$$\hat{p}^k - \hat{p} = -\sigma^{-1}\left[(1-\alpha)\left(\hat{n}^k - \hat{n}\right) - (\sigma-1)\left(\hat{\delta}^k - \hat{\delta}\right)\right] \tag{14}$$

$$\hat{p} = -(1-\alpha)\hat{n} + \hat{\mu} \tag{15}$$

$$\hat{p}^k = \alpha\hat{n}^k + \hat{g}^k \tag{16}$$

Next, summing equation (16) across k, we have

$$\hat{p} = \alpha\hat{n} + \hat{g} \tag{17}$$

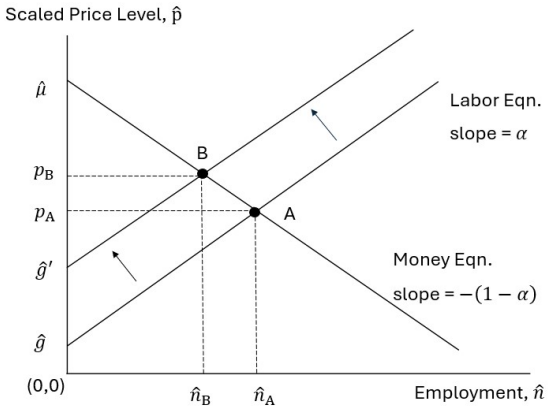
Since $\hat{g}$ and $\hat{\mu}$ are exogenous, we have are two equations, (15) and (17), in two endogenous unknowns, $\hat{p}$ and $\hat{n}$. We can solve for an equilibrium graphically. Figure 3 plots the two equations and their equilibrium intersection (point A) initially, followed by the new equilibrium (point B) in response to a positive cost shock. As seen in the figure, increasing the average tax rate, the cost shock, drives up $\hat{p}$ and lowers $\hat{n}$. Increasing the money growth, an aggregate demand shock, would raise both $\hat{p}$ and $\hat{n}$. Note that since the central bank sets $\hat{\mu}$ after the cost shock realization, it can stabilize $\hat{p}$ with the appropriate monetary policy response, a correctly-sized money growth reduction.

Solving the above equations for regional price level and employment as a function of exogenous variables, we have

$$\hat{p}^k = \Phi^{-1}\left[\alpha(\sigma-1)\left(\hat{\delta}^k - \hat{\delta}\right) + (1-\alpha)\hat{g}^k + \alpha(\sigma-1)(1-\alpha)\hat{g}\right] + \alpha\hat{\mu} \tag{18}$$

[9]For any variable x, $\hat{x}$ denotes the log deviation of x from its steady-state value.

Figure 3: Equilibrium in fixed nominal wage model, before and after a positive cost shock



Notes: Money equation is given by (15) and labor equation is given by (17).

$$\hat{n}^k = \Phi^{-1}\left[(\sigma-1)\left(\hat{\delta}^k - \hat{\delta}\right) - \sigma\hat{g}^k + (\sigma-1)(1-\alpha)\,\hat{g}\right] + \hat{\mu} \tag{19}$$

where $\Phi \equiv \alpha(\sigma-1)+1$.

Taking averages over k for (18), the aggregate price equation is

$$\hat{p} = \alpha\hat{\mu} + (1-\alpha)\,\hat{g}$$

which implies positive cost-push and positive money growth shocks drive up the price level.

Taking averages over k for (19), the aggregate employment equation is

$$\hat{n} = \hat{\mu} - \hat{g}$$

which implies that positive money growth shocks and negative cost shocks increase employment.

Next, the economic model can be mapped exactly into the local-spillover decomposition used in the paper's empirical section. To see this, assume there is no regional dispersion in the cost shock, i.e. $\hat{g}^k = \hat{g}$, and monetary policy reacts to the average cost shock according

to $\hat{\mu} = \phi\hat{g}$. Under these assumptions,

$$\hat{p}^k = \alpha\hat{n}^k + \frac{1}{\phi - 1}\hat{n}$$

if $\phi \neq 1$. In order to maintain sign consistency with the paper's earlier sections, assume the elasticity of the unemployment rate, $\hat{u}^k$, with respect to employment equals -1. Then, we have:

$$\hat{p}^k = -\alpha\hat{u}^k + \frac{1}{1 - \phi}\hat{u} \tag{20}$$

Examining (20), the local slope coefficient is negative and independent of the stance of monetary policy. Similarly, in the empirical section the local slope estimate is negative and stable across subsamples.

On the other hand, the spillover slope depends upon the monetary rule. If $\phi > 1$, this slope is negative and thus contributes to a steeper negative aggregate Phillips curve slope. If $\phi < 1$, the slope is positive. Finally, if $\phi = 1$, employment is perfectly stabilized.

In the empirical section, the spillover slope is negative in the early sub-samples. This contributes to a steep national slope in these subsamples. In the economic model, the negative spillover arises because the central bank does not stabilize the nominal price level in response cost shocks but rather amplifies them, i.e., $\phi > 1$. This also aligns with the narrative that, before the start of Paul Volcker's tenure as Fed Chair, the FOMC did not respond sufficiently to macroeconomic shocks.

In the later subsamples, the empirically estimated spillover slope is close to zero and positive in some cases. In the economic model, the spillover is positive when the central bank leans against cost shocks and thus works towards stabilizing the price level. The national Phillips curve slope is the sum of the local and spillover slopes. In the later subsamples, the positive spillover slope somewhat offsets the negative local slope which leads to a flat national Phillips curve.

4 Time Fixed Effects in Existing Phillips Curve Work

A large body of literature uses regional data to identify the Phillips curves. These papers estimate panel regressions and, for the most part, employ time fixed effects.[10] The authors

[10]Unless otherwise noted, these papers use time fixed effects in *all* or nearly all of their specifications. As one exception, Tuckett, 2018 uses a U.K. regional panel to estimate the regional Phillips curve and never employs time fixed effects, although he does not provide a reason for that modelling choice.

have various justifications, including controlling for the inflation expectations (Hazell et al., 2022; Gagliardone et al., 2023); aggregate shocks to supply costs, productivity, or the natural rate of unemployment (Kumar and M. Orrenius, 2016; Babb and Detmeister, 2017); endogenous monetary policy (Smith et al., 2023; Fitzgerald et al., 2024; Murphy, 2018); or some combination of the above (McLeay and Tenreyro, 2019; Leduc and Wilson, 2017; Hooper et al., 2019). Several of these explanations — changing inflation expectations and endogenous monetary policy — are related to ours.

Time fixed effects, however, go beyond simply removing the influence of one or more aggregate shocks; they purge a panel of *all* the aggregate time series variation that economists typically use to characterize macro relationships. As explained above, in the absence of spillovers, the cross-sectionally demeaned panel and the aggregate time series deliver the same coefficients of interest. In the presence of spillovers, the two will differ. Although authors sometimes report and discuss differences between these coefficients in depth (see, for example, Hazell et al. (2022)), the spillover itself is not explicitly modeled in the regression.

By omitting time fixed effects, our approach instead provides a unified framework for doing inference about the local, spillover and aggregate Phillips curve slopes that holds whether or not spillovers are present. Explicitly modeling the spillover also allows us to study the role of endogenous monetary policy under a monetary union without requiring us to take a stand on explanatory variables like the inflation target, which may be ill-suited for the longer time period we study.

5 Conclusion

By combining the use of cross-sectional variation and aggregate time series variation within a local spillover decomposition, we have shown that the national Phillips curve's instability over time can be traced to a changed pattern in the spillover relationship between state-level inflation and national unemployment. Moreover, we extend study of the spillover relationship to a longer and earlier span of time. Our research differs from a large group of papers using regional data to study the Phillips curve which, for the most part, focus instead on the Great Moderation and post-Great Moderation periods and control for aggregate time series variation using time fixed effects. We employ the decomposition's time series variation to locate the 1970s period as most influential for large spillovers in the mid-century Phillips curve. We then rationalize this spillover within a simple multi-region model with endogenous monetary policy.

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6 Appendix: Solving the Full Model

In this appendix, we solve the household problem. We include both a money holding and bond holding decision. We show that by the government appropriately choosing the rate of return on money—by equating its rate of return to the equilibrium bond rate—the cash-in-advance constraint is not binding on households. Then, in the body of the paper, we assume this money rate of return

is chosen by the government and thus are able to drop the CIA constraint from the household's optimization problem.

The household residing in region i maximizes expected lifetime utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_{i,t}^{1-\gamma}}{1-\gamma} - \frac{N_{i,t}^{1+\kappa}}{1+\kappa} \right) \tag{21}$$

where $C_{i,t}$ and $N_{i,t}$ are defined in the main text. The period-by-period budget constraint is

$$\int P_t(k) C_{i,t}(k) dk + M_{i,t} + B_{i,t} \leq H_t + \int W_t(k,l) N_t(k,l) dk + R_{t-1}^M M_{i,t-1} + R_{t-1} B_{i,t-1} \tag{22}$$

where $H_t \equiv M_t^{\Delta} + \Omega_t$. Moreover, each region i household posts occupation-specific wage rates for $k \in [0,1]$. Once set, the household provides hours as demanded according to (8).

M_t^{Δ} is the newly injected nominal money to all households. Ω_t is the nominal dividend that is equal across all households. $W_t(k,i)$ is nominal wage of the occupation k household member residing in region i. $M_{i,t-1}$ is the money holdings at the beginning of period t that are carried from the previous period. Money pays a gross interest rate R_{t-1}^M. Similarly, $B_{i,t-1}$ and R_t are nominal bond holding and gross risk-free rate on bonds. The cash-in-advance constraint is:

$$\int P_t(k) C_{i,t}(k) dk \leq M_{i,t} \tag{23}$$

Cost minimization by households gives the following demand curves

$$C_{l,t}(k) = \delta_t(k)^{\sigma-1} \left(\frac{P_t(k)}{P_t} \right)^{-\sigma} C_{l,t} \tag{24}$$

where $P_t \equiv \left[\int (P_t(k)/\delta_t(k))^{1-\sigma} dk \right]^{\frac{1}{1-\sigma}}$.

The household Lagrangian is

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^t \left[\begin{array}{l} \frac{{C_{i,t}}^{1-\gamma}}{1-\gamma} - \frac{N_{i,t}^{1+\kappa}}{1+\kappa} + \tilde{\theta}_t \left(M_{i,t} - P_t C_{i,t} \right) \\ + \tilde{\lambda}_t \left(H_t + \int W_t(k,i) N_t(k,i) dk + R_{t-1}^M M_{i,t-1} + R_{t-1} B_{i,t-1} - P_t C_{i,t} - B_{i,t} - M_{i,t} \right) \\ + \int \tilde{\chi}_t(k) \left[\left(\frac{W_t(k,i)}{W_t(k)} \right)^{-\theta} N_t^d(k) - N_t(k,i) \right] dk \end{array} \right] \tag{25}$$

Next, scale the variables according to: $p_t \equiv P_t / M_{t-1}^s$, $h_t \equiv H_t / M_{t-1}^s$, $w_t(k,l) \equiv W_t(k,l) / M_{t-1}^s$, $m_{i,t} \equiv M_{i,t} / M_{t-1}^s$ and $b_{i,t} \equiv B_{i,t} / M_{t-1}^s$. The scaled-Lagrangian is:

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^t \left[\begin{array}{l} \frac{C_{i,t}^{1-\gamma}}{1-\gamma} - \frac{N_{i,t}^{1+\kappa}}{1+\kappa} + \psi_t \left(m_{i,t} - p_t C_{i,t} \right) \\ +\lambda_t \left(h_t + \int w_t \left(k,i \right) N_t \left(k,i \right) dk + \left(\mu_t \right)^{-1} \left(R_{t-1}^M m_{i,t-1} + R_{t-1} b_{i,t-1} \right) - p_t C_{i,t} - b_{i,t} - m_{i,t} \right) \\ + \int \chi_t \left(k \right) \left[\left(\frac{w_t(k,i)}{w_t(k)} \right)^{-\theta} N_t^d \left(k \right) - N_t \left(k,i \right) \right] dk \end{array} \right] \tag{26}$$

where $\mu_t = M_t^s / M_{t-1}^s$.

The household's first-order conditions for $b_{i,t}$ and $m_{i,t}$ are:

$$\lambda_t \mu_t = \beta R_t E_t \left(\lambda_{t+1} \right)$$

$$\lambda_t \mu_t = \psi_t + \beta R_t^M E_t \left(\lambda_{t+1} \right)$$

Subtracting the second equation from the first, we have:

$$\psi_t = \beta \left(R_t - R_t^M \right) E_t \left(\lambda_{t+1} \right)$$

Suppose the central bank pays interest on money at the same rate as on bonds, $R_t = R_t^M$. Then, an equilibrium condition requires that $\psi_t = 0$ and the cash-in-advance constraint is not binding. We assume that, in this case, households demand no more cash that required to pay for goods.

We guess at and then characterize fixed wage equilibria, in which the $W_{i,t} \left(k \right) / M_{t-1}^s$ are identical over all i, k and t and equals w. Next, let $p_t \left(k \right) = P_t \left(k \right) / M_{t-1}^s$. We find the pair $\left(N_t \left(k \right), \rho_t \left(k \right) \right)$ for all k. Suppressing the k index indicates the economy-wide average of the corresponding variable.

Relative consumption demand implies:

$$\left(\frac{N_t \left(k \right)}{N_t \left(i \right)} \right)^{-(1-\alpha)/\sigma} = \frac{p_t \left(k \right)}{p_t \left(i \right)} \text{ for each pair } \left(i,k \right)$$

A single QTM equation implies:

$$\frac{M_t^s}{M_{t-1}^s} = \int p_t \left(k \right) N_t \left(k \right)^{(1-\alpha)} dk$$

The industry labor demand curves require:

$$\left(1 - \alpha \right) N_t \left(k \right)^{-\alpha} p_t \left(k \right) = g_{k,t} w \text{ for each } k$$

7 Data Appendix

Sources and Definitions for Data Series Included in Paper:

- **state** - state acronym
- **msa** – MSA(s) corresponding to inflation, referenced by central city
- **year** – year of observation
- **ih** – headline inflation calculated as year over year change in CPI-U for MSA as reported by BLS, from dataset constructed by Fitzgerald et al (2024); for MSA-years with more than one observation, inflation is averaged within MSA-year.
- **ih_avg** – sample average of headline inflation (ih), weighted by state income share in 1958 (inc_share_cons); for states with more than one MSA, inflation is first averaged within state-year
- **iur** – annual state insured unemployment rate; data collected by Davis and sourced from Nakamura and Steinsson dataset covering 1947-2015
- **iur_avg** – average insured unemployment rate (iur), weighted by income share in 1958 (inc_share_cons)
- **cyc_iur** – insured unemployment rates (iur) after removing trend, calculated by hp-filtering at the state level
- **avg_cyc_iur** – average cyclical insured unemployment rate (cyc_iur), weighted by state income share in 1958 (inc_share_cons)
- **ur** – annual state unemployment rate, from BLS LAUS and sourced from Haver; starts in 1976
- **cyc_ur** – unemployment rate (ur) after removing trend, calculated by hp-filtering at the state level
- **cyc_empc** – continuous unemployment rate constructed as cyclical insured unemployment pre-1976, cyclical unemployment post-1976; in 1976, value replaced by midpoint between 1975 insured unemployment rate and 1977 unemployment rate
- **avg_cyc_empc** - average continuous unemployment rate (cyc_empc), weighted by state income share in 1958 (inc_share_cons)
- **inc_share_cons** – state's share of national income in 1958, from BEA

- **oilprice** – annual average price of crude oil at West Texas Intermediate, from Dow Jones & Company and downloaded from FRED
- **L1_oilprice** – one year lag of year-over-year log change in crude oil price (oilprice)
- **L1_ih** – one year lag of MSA-state headline inflation (ih)
- **L1_ih_avg** – one year lag of average MSA-state headline inflation (ih_avg)