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The Phillips Curve's and Relative Phillips Curve's Slopes: Why So Different?*

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Abstract

I estimate the effect of labor market tightness on wage inflation from 2004-2019 using aggregate data and a hybrid New Keynesian Phillips curve. The Phillips curve slope, i.e., the effect of a unit increase in the vacancy-unemployment ratio on inflation, is about 3.4 percentage points. Then, I estimate the model using the corresponding panel-level data with a time-fixed-effect regression: The resulting regional (i.e., relative) Phillips curve slope is about 0.7. This large difference between the two slopes is robust to controlling for various measures of inflation expectations and for supply shocks. The gap arises because variation used in one regression is—by construction–orthogonal that used in the other. I explain how cross-region spillovers might explain the large gap between the aggregate and relative slopes.

1 Introduction

Macroeconomists have increasingly used regional data to study aggregative questions. Moreover, among macro research using cross-regional variation, analyses often employ panel regressions with time fixed effects.

Adding time fixed effects to a panel regression is equivalent to demeaning the regression's right- and left-hand side variables with respect to their cross-sectional averages before estimation. The standard justification for these fixed effects is to control for potentially confounding aggregate shocks. To fix ideas, suppose one estimates the effect of $X_{i,t}$ on $Y_{i,t}$

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in the presence of an aggregate confounder W_t. Here i is a U.S. state and t is time. The regression without time fixed effects is:

$$Y_{i,t} = \alpha X_{i,t} + \beta W_t + \epsilon_{i,t}$$

This regression would be infeasible if W_t were unobservable. As such, one route modifies the regression by adding time fixed effects. This is equivalent to estimating:

$$Y_{i,t} – Y_t = \alpha \left(X_{i,t} – X_t \right) + \beta \left(W_t – W_t \right) + \tilde{\epsilon}_{i,t}$$

where omitting an i denotes the cross-sectional average of the corresponding variable. The term multiplying β equals zero and the aggregate shock drops out, and thus the standard justification works: I have eliminated the aggregates shock from the regression.

But, time fixed effects do more than just this. Employing time fixed effects purges a regression of the aggregate covariation between Y and X that macroeconomists usually analyze to identify macro effects.

This paper addresses the disconnect that using time fixed effects introduces by illustration: estimating aggregate and regional Phillips curves. I first estimate the effect of the vacancy-unemploymnet ratio on wage inflation using aggregate data and a hybrid New Keynesian Phillips curve. The Phillips curve slope, i.e., the effect of a unit increase in the vacancy-unemployment ratio on inflation, is about 3.4 percentage points. Then, I estimate the model using the corresponding panel-level data with a time-fixed-effect regression: The resulting regional (i.e., relative) Phillips curve slope is about 0.7. The difference is remarkable.

Since my aggregate regression does not "difference out" potential confounding factors, i.e., W above, I next control for these factors using traditional measures from the literature. I find this large difference between the two slopes is robust to controlling for alternative supply shocks and measures of inflation expectations. In the conclusion, I explain how cross-region spillovers might explain the large gap between the aggregate and relative slopes.

While the literature using the unemployment rate or the output gap to estimate the Phillips curve is broad, only a few papers study the joint inflation v/u relationship. Aggregative studies include Ravenna and Walsh (2008), which builds a small-scale New Keynesian model with search frictions in which labor market tightness affects firms' marginal cost and thus inflation. Crust, et.al. (2024) fits a nonlinear Phillips curve relationship using inflation and the inverse of the v/u ratio using aggregate data. My paper differs from these in that I also study disaggregate data.

Barnichon and Shapiro (2024) study the Phillips curve using a regional panel and find that the v/u ratio outperforms other measures at predicting inflation. Also using panel data, Gitti (2025) estimates a nonlinear relationship between v/u and inflation and shows that the regional Phillips curve steepens dramatically at high levels of tightness. Both papers employ time fixed effects, which implies that the variation they exploit is orthogonal the variation identifying the aggregate Phillips curve. In contrast, by estimating both aggregate and regional (i.e., relative) Phillips curves using the same data set, I directly establish the empirical disconnect between the aggregate and relative Phillips curve slopes.

2 The Data and Models

Let $\pi^r_{i,t}$ denote the r-quarter moving average of quarterly wage inflation rate in manufacturing in state i.[1] Next, let $x^r_{i,t}$ denote the r-quarter moving average of the state i ratio of the number of vacancies to the number of unemployed. Wage, vacancy and unemployment data are from the Bureau of Labor Statistics.

Let $s_{i,t}$ denote the share of the population in state i in quarter t. I construct aggregate variables using share weights. The omission of a subscript i from a variable denotes the variable's corresponding share-weighted average. That is, for an arbitrary $q_{i,t}$, $q_{i,t} \equiv \sum_{i=1}^{N} q_{i,t} s_{i,t}$.

First, consider the state-level hybrid New Keynesian Phillips curve:

$$\pi^4_{i,t} = \beta^{rel} x^4_{i,t} + \Gamma' H_{i,t} + \gamma_t + \psi_i + \eta_{i,t} \tag{1}$$

γ_t and ψ_i are time and state fixed effects, respectively. $H_{i,t}$ is a vector of controls. Example elements of $H_{i,t}$ are lagged inflation, expected future inflation, and supply shocks.[2]

(1) is the relative Philips curve. This name is appropriate because the presence of time fixed effects means that the slope β^{rel} should be interpreted as the effect of a deviation of state tightness from economy-wide tightness on the deviation of state inflation from economy-wide wage inflation.

I estimate (1) using population-share weighted least squares and set $r = 4$. I compute standard errors using the Driscoll-Kraay approach. The sample covers 2004Q2 through

[1] $\pi^r_{i,t} \equiv r^{-1} \sum_{j=0}^{r-1} \pi_{t-j}$

[2] Each control that does not depend on i, such as an aggregate supply shock, will be subsumed by the time fixed effect and thus not impact β^{rel}, however, I carry it along since the control will impact the corresponding aggregate regression described below.

2019Q4 and excludes Delaware and Tennessee because of data unavailability. I end the sample before the post-lockdown inflation surge to avoid dealing with: (a) Phillips curve nonlinearities potentially in play after 2019 (e.g., Gitti (2025)) and (b) measuring inflation expectations during the one-of-a-kind episode.

The tightness measure is potentially correlated with the regression's error term. As such, I instrument for tightness using lagged tightness $x^0_{i,t-4}$.

Next, I estimate the aggregate analog of (1).

$$\pi^4_t = \kappa + \beta^{agg} x^4_t + \Phi' H_t + \mu_t \tag{2}$$

I instrument using x^0_{t-4}.

The hybrid New Keynesian Phillips curve posits a role for expected future inflation on current inflation. I consider a conventional measure of inflation expectations that includes a backward- and forward-looking component. At the state-level, I measure inflation expectations as:

$$\lambda \pi^4_{i,t-4} + (1-\lambda) E_t \left(\pi^4_{i,t+4} \right)$$

Rather than estimate λ, I calibrate the coefficient for various values between zero and one: backward ($\lambda = 0.95$), forward ($\lambda = 0.05$) and balanced ($\lambda = 0.5$). For each calibrated λ, I estimate the remaining parameters.

$E_t \left(\pi^4_{i,t+4} \right)$ is not observed. In my benchmark specification, I use the spread between the 10-year nominal and indexed bond to measure the forward-looking inflation component. For robustness, I use three alternative forward-looking inflation measures. For robustness, I also control for alternative supply shock measures: the one-year growth rate of the price of oil and the NY Fed supply chain disruption index.

3 Empirical Results

Table 1 reports estimates of relative Phillips curves in odd-numbered columns and the aggregate ones in even-numbered columns. Each estimate instruments the v/u ratio with its lagged value: the state-specific ratio for the panel-based equation and the economy-wide average ratio for the national one. Columns (1) and (2) contain my benchmark specification, which use balanced inflation expectations ($\lambda = 0.5$).

Column (1) reports the panel-based estimate with balanced inflation expectations, time and state fixed effects. Using time fixed effects means that this a relative Phillips curve.

Table 1: Phillips curve and relative curve slopes, instrumental variables

	(1)	(2)	(3)	(4)	(5)	(6)
V-U ratio	3.42***	0.69*	3.42***	0.61*	3.42***	0.71**
	(0.83)	(0.37)	(0.83)	(0.35)	(0.83)	(0.33)
Expected Inf	0.17*	−0.05	1.72*	−0.22	0.09*	0.08
	(0.10)	(0.35)	(0.99)	(0.24)	(0.05)	(0.25)
Aggregation	State	US	State	US	State	US
Expected Inf	Balanced	Balanced	Forward	Forward	Backward	Backward
Num. obs.	3024	63	3024	63	3024	63
Num. groups: state	48		48		48	
Num. groups: date	63		63		63	

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

Notes: Dependent variable=4-quarter average inflation rate. Columns (1) and (2) contain equally-weighted lagged and market-based future inflation expectations control. Columns (3) and (4) contain forward-looking market-based future inflation expectations control. Columns (5) and (6) contain backward looking inflation expectations control. The lowest partial F-statistic across all columns is 540.

The tightness coefficient equals 3.42 (SE=0.83), implying that a unit increase in a state's tightness measure relative to economy-wide tightness causes a 3.4 percent increase in that state's inflation rate relative to the economy-wide inflation rate. The relative Phillips curve is extremely steep and statistically different from zero at a one percent level. The coefficient on expected inflation is of the expected sign, positive.

Column (2) uses the aggregate time series data, and thus estimates a traditional Phillips curve. The Phillips curve slope equals 0.69 (SE = 0.37), which means a one unit increase in economy-wide tightness increases economy-wide inflation by about 0.7 percentage points. Thus, the relative Phillips curve slope is nearly five times larger than the aggregate one.

Treating the relative Phillips curve, i.e., one from a disaggregate regression with time fixed effects, as an aggregate Phillips curve would lead a policymaker to vastly overstate the effect of labor market tightness on inflation. For example, a one-standard deviation increase in v/u (0.29 units) would imply an approximately two-standard deviation increase in the inflation rate!

Column (3) and (4) estimate the identical specifications as columns (1) and (2) except I use forward looking expectations, i.e. $\lambda = 0.05$. The relative Phillips curve slope is unchanged at 3.42 (SE = 0.83) and the Phillips curve slope is 0.61 (SE = 0.35); a large gap between the two slopes remains.

Column (5) and (6) adjust the benchmark specification by using primarily backward looking expectations ($\lambda = 0.95$). The resulting coefficients are roughly the same as their benchmark counterparts and the large gap remains.

In results not reported here, I estimate the benchmark panel-based model except I exclude time fixed effects. Excluding time fixed effects reduces the relative slope coefficient more than three-fold, from 3.42 to 1.08. This accords with the wide gap between the aggregate and relative slopes discussed above. Relatedly, Barnichon and Shapiro (2024) estimates an MSA-level v/u Phillips curve and similarly finds that dropping the time fixed effect reduces the slope by a factor of almost three.

Next, Table 2 replaces the regression's 10-year break-even inflation rate with three alternative measures of the forward-looking inflation expectations component, and includes alternative supply shock controls. In each case, I set $\lambda = 0.5$. I use the University of Michigan median of the expected price change over the following year, the Cleveland Fed's one-year ahead inflation expectations series and the five-year, five-year forward expected inflation series. There is no state-level variation in any of these three series.

Table 2: Phillips curve and relative curve slopes, instrumental variables, and alternative inflation expectations measures and supply shocks

	(1)	(2)	(3)	(4)	(5)	(6)
V-U ratio	3.42***	0.74**	0.71**	0.74*	0.70*	0.68*
	(0.83)	(0.36)	(0.29)	(0.41)	(0.38)	(0.40)
Expected Inf	0.17*	0.13	-0.05	0.09	-0.00	
	(0.10)	(0.23)	(0.34)	(0.35)	(0.00)	
Oil price growth					-0.03	-0.07
					(0.40)	(0.37)
Supply Disruption						0.05
						(0.20)
Aggregation	State	US	US	US	US	US
Expected Inf	MI/CLEV/5YR	Michigan	Cleveland	5YR-5YR	Balanced/Mkt	Balanced/Mkt
Supply shock	Any/None	None	None	None	Oil	Supply Disrupt Idx
Num. obs.	3024	63	63	63	63	63
Num. groups: state	48					
Num. groups: date	63					

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Notes: Dependent variable=4-quarter average inflation rate. Column (1) contains the panel-based estimates, which have identical tightness coefficients across specifications. Columns (2) through (4) use alternative inflation expectations measures. Columns (5) and (6) add alternative supply shocks. The lowest partial F-statistic across all columns is 562.

The Michigan series arguably better represents consumer, as opposed to financial market participants, beliefs. Since the Cleveland Fed series measures one-year ahead inflation expectations, rather then my benchmark 10-year break-even rate, and it is closer to the shorter-run inflation expectations that arise in a New Keynesian structural model's Phillips curve. Finally, the five-year, five-year forward is a break-even inflation measure that combines four yields: the indexed and nominal returns on both five- and ten-year Treasuries.

The panel-based v/u coefficient estimate is identical across all panel-specifications and as such is reported once, in column (1). This is because each has two components, the backward-looking component, which is state specific and identical across the three specifications as well as the forward-looking component. Across specifications, this aggregratee component is absorbed by the time fixed effect. As in Table 1, the panel-based tightness coefficient equals 3.42 (SE = 0.83).

Columns (2) through (4) report the aggregate-based estimates using the three alternatives. Each tightness coefficient lays within the range of 0.71 and 0.74, and are close to my benchmark aggregate finding. Columns (5) and (6) add oil price growth and the NY Fed supply chain disruption controls, respectively. The coefficient on tightness changes negligibly across specifications.

4 Conclusion

Next, I explain how a spillover potentially explains the gap between the two slopes. Returning to the time-fixed-effect equivalent regression,

$$Y_{i,t}–Y_t = \beta^{rel} \left(X_{i,t}–X_t\right) + \tilde{\epsilon}_{i,t} \tag{3}$$

Next, consider the aggregate regression

$$Y_t = \beta^{agg} X_t + \nu_t$$

in which I have assume that any aggregate shocks are observable and have been previously projected out.

If both are correctly specified, then combining equations:

$$Y_{i,t} = \beta^{rel} X_{i,t} + \left(\beta^{agg} - \beta^{rel}\right) X_t + \eta_{i,t} \tag{4}$$

where $\eta_{i,t} \equiv \tilde{\epsilon}_{i,t} + \nu_t$.

$\beta^{agg} - \beta^{rel}$ is the spillover slope, which gives the relationship between the own-region dependent variable and the average right-hand side variable after controlling for the own-region right-hand side variable. When there is no gap between the relative and aggregate slopes, the spillover is zero. In my empirical results, the relative slope is larger than the aggregate slope, implying a negative spillover.

One potential explanations for a negative cross-region spillover is macro stabilization policy. Suppose A and B have a unified federal government and monetary authority. If monetary or federal fiscal policy works to stabilize inflation in response to shocks, this can also generate a negative spillover. Suppose for example monetary policy actively combats inflation. If state B experiences an increase in v/u, an active monetary policy will raise the interest rate in order to offset the inflationary effects of the tightness to the extent that it impacts the overall economy. This will *ceteris paribus* have a deflationary effect on state A inflation because the two states share a common monetary policy. This policy-induced negative spillover also steepens the relative Phillips curve with respect to the aggregate one.[3]

[3]Dupor, et.al. (2025) shows how changes in monetary policy can explain the changing Phillips curve slope through this policy spillover.

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