The Wage Curve and the Phillips Curve

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Abstract: Blanchflower and Oswald (1994) have argued that, in regional data, the level of unemployment is related to the *level* of wages. This result is at variance with an application of the original Phillips curve to regional data, which would predict that the *change* in wages ought to be related to the unemployment rate. On the other hand, there is considerable empirical support for the expectations-augmented Phillips curve using macroeconomic data. I resolve this tension by showing that a standard macroeconomic expectations-augmented Phillips curve can be derived from microfoundations that begin with the wage curve.

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In their book *The Wage Curve*, Blanchflower and Oswald (1994) argue that wages are determined by a "wage curve" that relates an individual's wage to the level of the unemployment rate in their region or industry. Blanchflower and Oswald also suggest that these microeconomic results may be inconsistent with a macroeconomic Phillips curve that relates the inflation rate to the level of the unemployment rate: Their microeconomic evidence suggests that there is a relationship between the *level* of the wage and the unemployment rate, and not the *change* in the wage, as was posited by Phillips (1958).

However, there is considerable empirical support for the expectations-augmented Phillips curve in macroeconomic data. For example, King and Watson (1994) have recently taken a thorough look at the evidence, and found that the expectations-augmented Phillips curve is a robust feature of the U.S. macroeconomic data over the past several decades. As a consequence, there appears to be some tension between the individual wage curve and the macroeconomic results. But as I show below, this tension is more apparent than real: Once account is taken of plausible nominal rigidities, a standard-looking, expectations-augmented Phillips curve can be derived from microfoundations that begin with the wage curve for individuals.

I also present empirical evidence that suggests that estimates of the slope of the wage curve that are taken from macroeconomic Phillips curves are close to the range of estimates that Blanchflower and Oswald obtain from microeconomic data. These empirical suggest that the aggregate data may be reflecting the same phenomena that Blanchflower and Oswald are describing.

1. Defining the Wage Curve and the Phillips Curve

The wage curve of Blanchflower and Oswald (1994) relates the level of a worker's wage to the (log of the) unemployment rate in their industry or region:

$$w_{it} = c_{0i} + c_1 \ln(RU_{it}) + c_2 Z_{it} + \eta_{it}, \qquad (1)$$

where w is the log of the individual wage; RU is the unemployment rate in the region or industry of the worker; Z is a vector of other factors that may affect the local wage; i is the index of workers; t is the index of time; c_0, c_1, and c_2 are constants; and η is an error term.

The expectations-augmented Phillips curve can be written as:

$$\Delta p_t = E_t \Delta p_{t+1} + \gamma\,(NR_t - RU_t) + \varepsilon_t, \qquad (2)$$

where Δp is the national inflation rate, $E_t \Delta p_{t+1}$ is expected inflation, RU is the national unemployment rate, and NR is the natural rate of unemployment. Notice that in this particular version of the Phillips curve, I have assumed that expectations of future inflation are important. This specification is a departure from that of Lucas (1973), which included the previous period's expectations of current inflation. While Lucas's specification rested on "price confusion" as the source of the Phillips curve relationship, I rely on "sticky price" justifications for the Phillips curve, such as the staggered contracts models of Taylor (1979) and Calvo (1983); in Roberts (1995), I have shown that this version of the Phillips curve can be derived from the sticky-price models.

The term "Phillips curve" has two common usages. In Phillips' original paper (1958), he discusses the relationship between the percent change in wages and the unemployment rate. However, many macroeconomics textbooks, such as Hall and Taylor (1993, pp. 507-8) and Dornbusch and Fischer (1994, p. 472), use the term "expectations-augmented Phillips curve" to refer to an aggregate relationship between inflation, expected inflation, and the unemployment rate, similar to equation 2. When Blanchflower and Oswald refer to the Phillips curve, they are thinking in terms of applying Phillips' original model to microeconomic data, and it is in this context that they claim that the evidence favors the wage curve rather than the Phillips specification.

Blanchflower and Oswald are careful to point out that "This book is not a study of inflation or the Phillips curve" (p. 367). However, they also state that "The idea of a Phillips curve may be inherently wrong" (p. 361). The validity of this second statement depends on what we mean by "the Phillips curve." Blanchflower and Oswald's proposition is that Phillips's original model does not apply to individual data. However, I show here that this proposition is nonetheless consistent with a macroeconomic expectations-augmented Phillips curve.

In a recent paper, Blanchard and Katz (1997) question Blanchflower and Oswald's empirical evidence that it is the level, rather than the change, in the wage that is related to the unemployment rate at the microeconomic level: They find that when the lag of the regional or industry wage is added as a regressor to equation 1, the coefficient is close to one. As Blanchard and Katz point out, if the microeconomic relationship involves the change rather than the level, it is easy to derive the macroeconomic Phillips curve. Since I am able to show that the aggregate Phillips curve can also be derived if Blanchflower and Oswald are correct, an implication is that *the form of the microeconomic relationship doesn't matter* for the derivation of the aggregate Phillips curve.

2. Deriving the Phillips Curve from the Wage Curve

The key assumption for the derivation of the macroeconomic Phillips curve is the assumption of nominal rigidity. The particular form of nominal rigidity that I assume is that an individual's wage is set for two periods, as in Taylor's staggered contracts model. The model is easily generalized for longer contracts, but two periods capture the main elements. For workers whose wage is set in period t, the "staggered contracts wage curve is:"

$$x_{it} = b_{0i} + b_1 \ln RU_{it} + (p_t + E_t p_{t+1})/2 + b_2 Z_{it} + \eta_{it}, \quad (3)$$

where x_{it} is the log of the individual wage set in period t, p_t is the national consumer price level and $E_t p_{t+1}$ is the expectation in period t of the price level in period t+1. This specification indicates that the worker is concerned about his or her wage relative to the national price level. Locally produced goods change the details of the derivation somewhat, but they do not affect the overall conclusions.[1]

The price term in equation 3 is a common national element. In Blanchflower and Oswald's estimates of the individual wage curve, as in equation 1, prices would be captured by the time dummies. If different individuals use different price expectations in setting their wages, the assumption of a common time dummy will introduce some measurement error.

For the nation as a whole, the wage set in period t will be:

$$x_t = \Sigma_i \sigma_i x_{it}, \quad (4)$$

where σ_i are productivity weights of individuals in the national economy. In derivations of the staggered contracts model, it is often assumed that prices are a simple markup over labor costs. In that case, because wages are set for two periods, the national price level will be:

$$p_t = (x_t + x_{t-1}) / 2 = (\Sigma_i \sigma_i x_{it} + \Sigma_j \sigma_j x_{jt-1}) / 2, \quad (5)$$

assuming that half of wages are set in each period.

1. Which measure of prices should the wage curve include? Blanchflower and Oswald argue that the wage curve should best be viewed as a kind of "quasi-labor supply curve" (pp. 12, 367). They have in mind such features of the labor market as bargaining and efficiency wages explaining the divergence of the "quasi" labor supply curve from the individual one (see chapter 3). A quasi-labor-supply interpretation would suggest that consumer prices are the most sensible measure to include in the model.

With these assumptions, the remaining steps to derive the expectations-augmented Phillips curve are straightforward. Equations 3 and 5 imply:

$$p_t = (p_{t-1} + p_t + E_{t-1}\, p_t + E_t p_{t+1})/4 \tag{6}$$
$$+ \Sigma_i \sigma_i [2\, b_{0i} + b_1 (\ln RU_{it} + \ln RU_{it-1}) + b_2 (Z_{it} + Z_{it-1}) + (\eta_{it} + \eta_{it-1})] / 2.$$

Rearranging the first line and aggregating the second line implies:

$$\Delta p_t - (E_t \Delta p_{t+1} + E_{t-1}\, \Delta p_t)/2 =$$
$$+ b_0 - b_1 (\ln RU_t + \ln RU_{t-1}) + b_2 (Z_t + Z_{t-1}) + (\eta_t + \eta_{t-1}), \tag{7}$$

where $b_0 = \Sigma_i \sigma_i b_{0i}/2$.

If we define:

$$NR_t \equiv -(b_0/2 + b_2 Z_t) / b_1,$$

then we have:

$$\Delta p_t - (E_t \Delta p_{t+1} + E_{t-1}\, \Delta p_t)/2 =$$
$$b_1\, [(NR_t - \ln RU_t) + (NR_{t-1} - \ln RU_{t-1})] + (\eta_t + \eta_{t-1}). \tag{8}$$

Equation 8 captures the key elements of the traditional expectations-augmented Phillips curve in equation 2: It says that inflation moves one-for-one with inflation expectations and negatively with the unemployment rate. Because of staggered contracts, inflation expectations, the unemployment rate, and the error term appear in moving average form.

It is the logic of staggered wage contracts that transforms the trade-off between the level of the unemployment rate and the level of the real wage into a trade-off between the unemployment rate and inflation: In the staggered contracts model, expected changes in the inflation rate imply fluctuations in the prospective real wage over the life of the contract. Real wage movements generated by changes in the inflation rate cannot be very large--in fact, in this model, which assumes a constant markup, the observed real wage does not vary at all. But the regional and industry variations in the real wage predicted by

Blanchard and Oswald's estimates of the wage curve are not very large, either. That suggests that the individual wage curve and the Phillips curve may be reflecting the same underlying economic behavior. To determine whether this may indeed be the case, the following section estimates the wage curve slope implicit in the macroeconomic Phillips curve.

3. Comparing Empirical Results

3.1 Background

Blanchflower and Oswald present a variety of estimates of the regression coefficient of the log of wages on the log of the unemployment rate. Their preferred estimate of the wage curve slope, based on data for individuals, is about -0.1. However, results that may be more relevant for comparison with aggregate data are those that use "cell averages:" Instead of regressing the wages of individuals on the regional or industry unemployment rate, they instead formed the average wage for a regional or industry "cell" and regressed the log of this on the log of the unemployment rate. Using the cell average data, Blanchflower and Oswald find smaller elasticities: Using regional aggregation, they find an elasticity around -0.05 (table 4.26, column 2), while with industry aggregation, the elasticity is -0.017 (table 4.30, column 2).[2]

In earlier work (Roberts, 1995, 1997), I estimated the coefficient on unemployment in the expectations-augmented Phillips curve. In this section, I extend my earlier results to line up as closely as possible to Blanchflower and

2. Blanchflower and Oswald do not speculate as to why the elasticity is smaller when the data are aggregated. Indeed, their motivation for looking at the aggregated results was not that the coefficient estimates were biased but rather that the standard errors in their equations using individual data might be biased. Nonetheless, because the expectations-augmented Phillips curve is estimated using aggregate data, these aggregative results may be more relevant.

Oswald's. In particular, I re-estimate using the log of the unemployment rate rather than the level, and I examine Blanchflower and Oswald's estimation period. Anticipating, I find the slope of the wage curve to be around -0.01, somewhat below the range of estimates Blanchflower and Oswald found using cell averages of regional and industrial data.

3.2 Data and other estimation issues

As in my earlier estimates of the aggregate Phillips curve, I use survey measures as proxies for inflation expectations: Two surveys have been conducted for some time, the Livingston survey of economists' expectations and the Michigan survey of household expectations. The properties of these surveys limit certain other aspects of the estimation. In particular, the surveys are of expectations of consumer prices, so I use the CPI as my measure of inflation. Inflation is measured as the change from the last month of the previous period to the last month of the current period. Also, the Livingston survey is only available on a semi-annual basis. As a consequence, I present semi-annual results for both the Livingston and Michigan surveys.

I use the overall civilian unemployment rate; to be consistent with Blanchflower and Oswald's preferred specification, I take the log of the unemployment rate. Standard tests suggest that the unemployment rate may be nonstationary. To control for this possibility, I have detrended the log unemployment rate using the Hodrick-Prescott filter with a smoothness parameter of 16,000.[3] Implicitly, the detrending procedure will pick up any slow-moving changes in the natural rate of unemployment--notably, the NR term in equation 8.

3. Hodrick and Prescott recommend the use of the smoothness parameter of their filter of 1,600. However, this value of the parameter leads to trend estimates that have pronounced cyclical movements. As a consequence, I use a smoothness parameter of 16,000. In Roberts (1997), I find that estimates of similar equations were not very sensitive to this choice.

In the estimation below, I have assumed that the unemployment rate is not correlated with the error term in the Phillips curve. This assumption is consistent with the results of King and Watson (1994), who found that inflation did not help predict unemployment, and concluded that it was also unlikely that the contemporaneous relationship between unemployment and inflation was the result of inflation affecting unemployment, rather than the reverse. Furthermore, in previous work (Roberts, 1995), I have found that related estimates are little different when OLS or instrumental variables estimation techniques are used, consistent with King and Watson's finding.

Preliminary results indicated that there was more serial correlation in the residuals than predicted by the simple two-period contract model outlined in section 2. As a consequence, I estimated the model assuming longer-period contracts. A complication is that when contracts last more than two periods, the model calls for inflation expectations for each of the future periods that the contract covers. Unfortunately, the surveys only provide information about inflation expectations at a single horizon, twelve months ahead. As an approximation, I have assumed that inflation expectations are the same in each period. To the extent that this assumption is not correct, it will introduce measurement error in the dependent variable. Ideally, this measurement error will be small; there is no particular reason to suspect that it is correlated with the unemployment rate.

The serial correlation in the residuals suggested that, for the Livingston-survey-based model, four-period contracts were needed to take account of the serial correlation. I used the same model for the Michigan survey-based estimates, although the serial correlation was not as pronounced for that model. The four-period contract model is:

$$\Delta p_t + (2\,\Delta p_{t-1} + \Delta p_{t-2})/3 - (\pi_t + \pi_{t-1} + \pi_{t-2} + \pi_{t-3})/2 = \qquad (9)$$
$$b_1\ [(NR_t - RU_t) + (NR_{t-1} - RU_{t-1}) + (NR_{t-2} - RU_{t-2}) + (NR_{t-3} - RU_{t-3})]/3$$
$$+ (\eta_t + \eta_{t-1} + \eta_{t-2} + \eta_{t-3}).$$

where π_t is the period t expectation of future inflation.

To adjust estimates of coefficient standard errors for the serial correlation in the equation errors, I have used the Newey-West procedure, allowing for up to sixth-order serial correlation.

I have also included the percent change in the relative price of crude oil in the estimated equations, since these are readily identifiable supply shocks that enter the Phillips curve error, η. I use the producer price index for crude oil relative to the consumer price index as my measure of relative crude oil prices, and I measured the percent change from the last quarter of the previous period to the last quarter of the current period. I included the current relative oil price change and two lags.

3.3 Estimates of the macroeconomic expectations-augmented Phillips curve

Table 1 presents estimates of the wage-curve slope. The period of estimation is 1963:H1 to 1987:H1, which corresponds most closely to Blanchflower and Oswald's estimation period.

As noted above, the equation errors have significant moving average components beyond MA(1). In the case of the Livingston survey, there was a large moving average coefficient through MA(3), consistent with the assumption of four-period contracts. For the Michigan survey, however, the moving average terms drop off more quickly. In both cases, there is no evidence of serial correlation beyond the MA(3) process.

With the Livingston survey used as a proxy for inflation expectations, the estimated wage-curve slope is -0.019, at the low end of the range that

Table 1

Estimates of the Wage-Curve Slope
Assuming Four-Period Staggered Contracts

Semi-annual data, 1963:1 to 1987:1

	Measure of Inflation Expectations	
	Livingston Survey	Michigan Survey
Wage-curve slope	-.019 (.003)	-.007 (.003)
Moving-average parameters:		
1	.74 (.15)	.72 (.15)
2	.52 (.17)	.44 (.17)
3	.16 (.15)	.01 (.15)
Probability level of Q test for correlation beyond MA(3):	.99	.94

Blanchflower and Oswald report. The coefficient is highly significant. Using the Michigan survey, the estimated wage-curve slope is -0.007. It is also statistically significant, but it is below the range reported by Blanchflower and Oswald. Still, the fact that the estimates of the wage-curve slopes from macroeconomic data are as close as they are to Blanchflower and Oswald's results is reassuring that the same underlying process may be at work in both cases.

4. Implications for Macroeconomics

Ball and Romer (1990) argue that business cycles are too large to be consistent with small nominal rigidities under conventional estimates of supply and demand elasticities. As a consequence, they argue that the economy must have "real rigidities," in the form of supply and demand curves that are flatter than those from microeconomic studies, to explain the size of business cycle fluctuations.

Estimates of individual labor supply suggest that the constant-utility elasticity of hours supplied with respect to changes in the wage are on the order of 0.1 for men (Pencavel, 1986, p. 82) and in the range of 0.5 to 2.0 for women (Killingsworth and Heckman, 1986, pp. 193-195). If these are also representative of the elasticity of employment, they would imply wage-curve slopes of around -10 for men and -0.5 to -2.0 for women. By comparison, estimates of Blanchflower and Oswald's regional and industry wage-curve slopes in the range of -0.02 and -0.1 are considerably flatter than this, and the estimates of -0.01 from the aggregate data are flatter still. Blanchflower and Oswald argue that the wage curve may be capturing the effects of labor-market institutions such as efficiency-wage and bargaining considerations, which affect local labor market outcomes and drive a wedge between individual and regional labor supply curves. Such institutional features would constitute real rigidities in the sense of Ball and Romer. Hence, the confirmation that the very flat labor supply implicit in Blanchflower and Oswald's results is also evident in the macroeconomic Phillips curve can be thought of as providing evidence in favor of the presence of the real rigidities posited by Ball and Romer.

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