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Campbell, Carl

Northern Illinois University

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Carl M. Campbell III
Department of Economics
Northern Illinois University
DeKalb, IL 60115
U.S.A
(email: carlcamp@niu.edu)

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Abstract

In new Keynesian models of wage setting, wage inflation is generally assumed to depend on one lagged value of price inflation. In addition, in purely backward-looking wage Phillips curves, wage inflation is generally assumed to depend on several lagged values of price inflation. This study demonstrates both that current wage inflation is more closely related to lagged wage inflation than to lagged price inflation and that specifications with multiple lags of inflation outperform specifications with only one lag of inflation. Thus, wage inflation can be predicted more accurately by a model that includes multiple lags of wage inflation as independent variables.

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1. Introduction

In new Keynesian models of wage setting, it is often assumed that firms that cannot reoptimize their wages in the current period automatically index their wages to last period's price inflation. Examples include the hybrid new Keynesian wage Phillips curve (HNKWPC) of Galí (2011), the model of Erceg, Henderson, and Levin (2000), and many dynamic stochastic general equilibrium models, such as Christiano, Eichenbaum, and Evans (2005) and Smets and Wouters (2003). In addition, in purely backward-looking wage Phillips curve models such as Fuhrer (1995), it is generally assumed that current wage inflation depends on lagged price inflation.[1]

The present study makes two arguments. First, in both hybrid models and purely backward-looking models, current wage inflation is more closely related to lagged wage inflation than to lagged price inflation, both when price inflation is measured by the GDP deflator and by the Consumer Price Index. Second, specifications with multiple lags of inflation outperform models that include only one lag.

Evidence from Perry, Baily, and Poole (1978) suggests that current wage inflation is more closely related to lagged wage inflation than to lagged price inflation. They regress the change in current average hourly earnings (*AHE*) on unemployment and on lagged changes in either *AHE*, the consumer price index (*CPI*), or the private nonfarm GDP deflator (*GDPD*) with annual data from 1954-1977. The regression with lagged *AHE* has the lowest standard error, the sum of

[1] One exception is Phelps (1968), which has lagged wage inflation on the right-hand side, resulting in a wage-wage Phillips curve.

coefficients on lagged inflation that is closest to 1.0, and the Durbin-Watson statistic that is closest to 2.

The present study repeats the analysis with quarterly data and includes more recent data. It also considers a broader array of specifications, estimates both a purely backward-looking Phillips curve and a hybrid Phillips curve, and performs out-of-sample analyses. It is found that the regressions with lagged wages almost always have a higher $\bar{R}^2$, a Durbin-Watson statistic that is closer to 2, and a sum of coefficients on lagged inflation (in the purely backward-looking models) or a sum of coefficients on expected future and lagged inflation (in the hybrid models) that is closer to 1. In addition, the out-of-sample performance is better with lagged wage inflation than with lagged price inflation. By the same metrics, specifications with multiple lags of inflation outperform specifications with only one lag of inflation.

2. Empirical Estimation

This study estimates both a purely backward-looking wage Phillips curve and a hybrid wage Phillips curve. The specification for the purely backward-looking Phillips is

$$\pi_t^w = \alpha - \beta u_t + \sum_{i=1}^{T} \lambda_i \pi_{t-i}^j ,$$

and the equation for the hybrid Phillips curve is

$$\pi_t^w = \alpha - \beta u_t + \theta \pi_{t+1}^w + \sum_{i=1}^{T} \lambda_i \pi_{t-i}^j ,$$

where π_t^w is wage inflation, u_t is the deviation of the unemployment rate from the Congressional Budget Office's estimate of the natural rate, and j represents, alternatively, lagged wage inflation (*W*), lagged GDP deflator price inflation (*GDPD*), and lagged CPI price inflation (*CPI*). Wage inflation is measured by the percentage change in average hourly earnings for production and non-supervisory workers, a series available since 1964:1.

Table 1 reports the results with the backward-looking model, which is estimated with ordinary least squares. Table 2 reports the results of the hybrid model. The hybrid model includes expected future wage inflation, which is proxied by actual future wage inflation. The hybrid model is estimated with two-stage least squares, since, as discussed in Galí and Gertler (1999), future inflation may be correlated with the model's error term. The variables used to instrument future wage inflation are four lagged values of the changes in technology, per worker nominal GDP, and the Federal Reserve's estimates of the net worth of households and nonprofit organizations (expressed on a per worker basis).[2] Three inflation variables are considered: lagged wage inflation, lagged GDP deflator inflation, and lagged CPI inflation. Regressions are run with one lagged value, four lagged values, eight lagged values, and 12 lagged values of inflation.

Tables 1 and 2 list the inflation variable and the number of lags, the $\bar{R}^2$, the sum of coefficients on either lagged inflation (in Table 1) or on future and lagged inflation (in Table 2), the Durbin-Watson (D.W.) statistic, the root mean squared error (RMSE) of the out-of-sample forecast (in Table 1), the coefficient on the unemployment rate, and the coefficient on future wage inflation (in Table 2). The out-of-sample forecasts are calculated by estimating the model with data from the first part of the sample, applying the estimated coefficients to the actual values of unemployment and various measures of inflation to calculate predicted values for the rest of the sample, and calculating the RMSE of the difference between actual and predicted wage inflation. Out-of-sample forecasts are preformed using a split of 1967:2-1993:4/1994:1-2009:4 (approximately the first half and the second half of the sample) and 1967:2-2009:4/2010:1-2009:4

[2] Tests of overidentifying restrictions cannot reject the null hypothesis of no overidentification, except in three specifications with a short lag structure, again showing the value of including multiple lags of inflation.

(the first part of the sample and the last ten years of the sample). Out-of-sample forecasts are not calculated for the hybrid model, because inflation in period *t* depends on inflation in period *t*+1 in the hybrid model, and next period's inflation is not known in period *t*.

The $\bar{R}^2$ is always higher with lagged wage inflation than with lagged price inflation. The sum of coefficients on lagged inflation (in Table 1) or the sum of coefficients on future and lagged inflation (in Table 2) is always closer to 1 with lagged wage inflation than with lagged price inflation. Also, the Durbin-Watson statistic is closer to 2 with lagged wage inflation than with lagged price inflation, except with one lag of inflation in Table 2. Finally, the RMSE of the out-of-sample forecast is always lower with lagged wage inflation than with lagged price inflation.

Next, the effect of including more lags is considered. The $\bar{R}^2$ always increases with more lags of wage inflation and also almost always increases with more lags of price inflation. In Table 1, the sum of coefficients on lagged inflation is always closer to 1 as the number of lags increases, although this is not necessarily true in Table 2, probably because including future inflation tends to raise the sum of the coefficients in all specifications. In both Tables 1 and 2, the Durbin-Watson statistic is closer to 2 with multiple lags of wage inflation than with one lag, although not necessarily with lagged price inflation. Also, the coefficient on π_{t+1} is much lower with multiple lags of inflation than with one lag, suggesting that a specification with one lag biases the estimated coefficient upwards.

In terms of the out-of-sample predictive power, the RMSE is lower with 4, 8, or 12 lags of wage inflation than with one lag of wage inflation, and the out-of-sample performance is not greatly affected by the number of lags. The RMSE with four lags of wage inflation lies between 0.0178-0.0226. In contrast, the RMSE with one lag of GDPD inflation lies between 0.0490-0.0497, and the RMSE with one lag of CPI inflation lies between 0.0812-0.1031, demonstrating the substantially better fit of a wage inflation equation with multiple lagged values of wage inflation as compared to a specification with one lag of either measure of price inflation.

Table 3 report estimates of the backward-looking Phillips curve in which both lagged wage inflation and lagged price inflation are entered separately, with both measures of price inflation. The coefficient or the sum of coefficients on lagged wage inflation is always substantially higher than the coefficient or sum of coefficients on either measure of lagged price inflation.

3. Conclusion

Most specifications of the HNKWPC assume that wage inflation depends on one lagged value of price inflation. In addition, models of the backward-looking wage Phillips curve generally assume that current wage inflation depends on lagged values of price inflation. This study demonstrates that the wage inflation process is best modeled by a specification in which wage inflation depends on multiple lags of wage inflation and that a model with multiple lags of wage inflation substantially outperforms a model with one lag of price inflation along several metrics. It is important to utilize the correct specification for wage inflation in order to accurately predict future wage inflation. Studies by Erceg, Henderson, and Levin (2000), Mankiw and Reis (2003), and Bodenstein and Zhao (2020) demonstrate that optimal macroeconomic stabilization policy entails placing a large weight on stabilizing nominal wage inflation, showing the importance of correctly specifying the wage inflation process.

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Table 1
Purely Backward-Looking Wage Phillips Curve

Specification	$\bar{R}^2$	$\sum_{i=1}^{T} \lambda_i \pi_{t-i}^{j}$	D.W.	RMSE 1967:2-1993:4/ 1994:1-2019:4 split	RMSE 1967:2-2009:4/ 2010:1-2019:4 split	Coef. on u_t
W, 1	0.696	0.809	2.64	0.0390	0.0272	-0.0313
GDPD, 1	0.636	0.642	1.28	0.0497	0.0490	-0.0815
CPI, 1	0.475	0.414	1.06	0.1031	0.0812	-0.0756
W, 4	0.771	0.909	1.99	0.0226	0.0178	-0.0444
GDPD, 4	0.690	0.710	1.19	0.0560	0.0458	-0.1043
CPI, 4	0.589	0.534	0.95	0.0644	0.0420	-0.0960
W, 8	0.773	0.917	1.91	0.0227	0.0205	-0.0510
GDPD, 8	0.717	0.763	1.30	0.1191	0.0620	-0.1275
CPI, 8	0.655	0.614	1.04	0.0960	0.1020	-0.1352
W, 12	0.794	0.936	1.97	0.0316	0.0228	-0.0651
GDPD, 12	0.722	0.789	1.29	0.1754	0.0750	-0.1344
CPI, 12	0.678	0.671	1.08	0.2040	0.1302	-0.1511

Table 2
Hybrid Wage Phillips Curve

Specification	$\bar{R}^2$	$\theta\pi^{w}_{t+1} + \sum_{i=1}^{T} \lambda_i \pi^{j}_{t-i}$	D.W.	Coef. on u_t	Coef. on π_{t+1}
W, 1	0.720	0.914	2.99	-0.0264	0.156
GDPD, 1	0.671	0.749	1.59	-0.0739	0.151
CPI, 1	0.599	0.745	1.95	-0.0560	0.413
W, 4	0.769	0.905	1.97	-0.0447	-0.007
GDPD, 4	0.690	0.715	1.21	-0.1039	0.007
CPI, 4	0.644	0.710	1.43	-0.0832	0.233
W, 8	0.772	0.916	1.91	-0.0511	-0.003
GDPD, 8	0.704	0.728	1.19	-0.1313	-0.055
CPI, 8	0.685	0.725	1.34	-0.1249	0.151
W, 12	0.792	0.929	1.93	-0.0660	-0.011
GDPD, 12	0.691	0.708	1.03	-0.1451	-0.134
CPI, 12	0.682	0.689	1.14	-0.1488	0.027

Table 3

Specification	Coef. on lagged wages	Coef. on lagged prices
W, GDPD, 1	0.547	0.266
W, CPI, 1	0.682	0.119
W, GDPD, 4	0.733	0.167
W, CPI, 4	0.807	0.087
W, GDPD, 8	0.699	0.207
W, CPI, 8	0.787	0.108
W, GDPD, 12	0.736	0.189
W, CPI, 12	0.812	0.102