Real Wages, Employment, and the Phillips Curve

Scott Sumner

Bentley College

Stephen Silver

Virginia Military Institute

A recent study by Bils found real wages to be procyclical, contradicting previous findings by Geary and Kennan, who found no consistent relationship, and Neftci, who found countercyclical movements in real wages. These studies differed in both methodology and sample period. In this study, we found that real wages were either procyclical or countercyclical depending on the sample period chosen. Employment changes generated by aggregate supply shocks were associated with procyclical real wage movements, while during years dominated by shifts in aggregate demand, real wages were highly countercyclical.

The relationship between employment and real wages has perplexed economists since studies by Dunlop (1938) and Tarshis (1939) found evidence that the real wage moved procyclically. These findings contradicted both the neoclassical view and that expressed by Keynes in the *General Theory* (1936). Bodkin (1969) was unable to establish any consistent pattern in the cyclical behavior of real wages. Neftci (1978) and Sargent (1978) used distributed lags and found a significantly negative real wage–employment relationship.

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Still more recent studies have disputed the findings of Neftci and Sargent. Geary and Kennan (1982), deflating manufacturing wages by the wholesale price index (WPI) for manufactured goods rather than the consumer price index (CPI) and using an updated sample period, found that manufacturing employment and (detrended) real wages were approximately independent. Bils (1985) used disaggregated panel data collected by the National Longitudinal Survey for selected years from 1966 to 1980 to estimate the relationship between real wages and unemployment, and he found real wages to be strongly procyclical.

The conflicting findings of these studies raise two significant questions. First, why have these studies reached differing conclusions? And second, how useful are these real wage–employment regressions for evaluating the validity of business cycle models?

In both the Geary-Kennan and Bils studies, the authors noted that a significant portion of the variation between their findings and those of previous studies was due to the use of different sample periods.

To investigate the extent to which the choice of sample period affected the estimated real wage–employment relationship, we performed simple contemporaneous regressions between employment and real wages over various sample periods and found that real wages were either procyclical or countercyclical depending on the sample period chosen. In fact, the choice of sample period alone explained much of the difference between the findings of Bils and Neftci.

More important, we found that the impact of using different sample periods was not random. The effect on real wages of employment changes caused by aggregate supply shocks differed qualitatively, and perhaps quantitatively, from the effect of equivalent employment changes generated by shifts in aggregate demand. During periods dominated by aggregate demand shocks, the real wage was highly countercyclical, as predicted by a number of disequilibrium business cycle models.

I. Real Wage Cyclicality and Business Cycle Theory

There are good reasons for expecting an inverse relationship between real wages and employment. Under the assumption that firms operate with a level of capital and technology that is fixed in the short run and sell their output at market-clearing prices in competitive markets, the demand for labor should be stable in the short run. This means that observed real wage–employment observations will lie along a given demand curve, and real wages should move countercyclically.

Yet a priori, one would not necessarily expect the aggregate supply

of labor (i.e., worker preferences) to be any less stable than the demand for labor. It seems clear that the predictions of Keynes and his contemporaries were based on their particular models of the business cycle. For instance, Pigou (1927) developed a business cycle model that assumed nominal wages to be fixed in the short run. More recently, Fischer (1977) incorporated rational expectations into a model featuring long-term nominal wage contracts. In his model, unanticipated money supply (or velocity) shocks would generate countercyclical real wage movements. Similarly, Friedman (1968) argued that the greater flexibility of output prices, as compared with wages, results in countercyclical real wage movements during cycles generated by unanticipated monetary shocks.

Although equilibrium business cycle models have no necessary implications regarding real wage cyclicality, the recent studies showing procyclical real wages can be easily reconciled with real business cycle (RBC) models that explain output fluctuations primarily through shocks to technology.

In a survey of recent work in business cycle theory, McCallum (1986) found models based on nominal price stickiness better able to explain the stylized facts than real business cycle models. He also asserted that it was necessary to assume price stickiness since "if wage stickiness alone were responsible for the real effects of monetary actions, with product prices adjusting flexibly, then we should observe countercyclical movements in the real wage. That we do not has recently been reconfirmed in a study by Bils (1985)" (p. 408). Thus empirical studies of the cyclicality of real wages are viewed not only as having important implications regarding the plausibility of RBC versus non-RBC models, but also as rendering certain types of disequilibrium models unacceptable.

II. Methodology and Empirical Findings

In testing the cyclical behavior of real wages we followed Bils's approach of using the real wage as the dependent variable. We regressed the first difference of the log of real wages on two variables: the first difference of the log of manufacturing employment and time. The real wage series was generated by deflating average hourly earnings in manufacturing by the WPI for industrial goods.[1] Geary and Kennan argued that the wage rate deflated by the WPI rather than the CPI is the best measure of the firm's demand price of labor.

The equation was first estimated over the same sample period used by Bils, who used disaggregated panel data based on National Longi-

[1] See the Appendix for a description of data sources.

TABLE 1

REAL WAGE–EMPLOYMENT AND UNEMPLOYMENT-INFLATION REGRESSIONS, SELECTED SAMPLE PERIODS

Sample Period	Real Wage Equation Coefficient on Employment (1)	Adjusted R^2/ Durbin-Watson Statistic (2)	Unemployment Equation Coefficient on Inflation (3)	Adjusted R^2/ Durbin-Watson Statistic (4)
1966–80 (Bils;	.857	.717	.178	.323
$N = 10$)	(3.97)	1.84	(2.30)	2.46
1966–80 (annual;	.327	.209	−.051	.000
$N = 14$)	(1.17)	1.85	(−.87)	1.64
1948–77 (Geary-	−.008	.000	−.082	.108
Kennan; $N = 29$)	(−.06)	1.69	(−2.12)	2.09
1948–71 (Neftci;	−.124	.000	−.100	.132
$N = 23$)	(−1.19)	2.10	(−2.12)	2.17
1900–1985 ($N = 85$)	−.212	.067	−.102	.192
	(−2.49)	1.93	(−4.55)	1.26
1900–1985 (NIUC;	−.345	.251	...	...
$N = 59$)	(−4.51)	2.49		
1900–1985 (PIUC;	.578	.194	...	...
$N = 21$)	(2.34)	2.97		
1900–1985 (no	−.303	.139	...	...
price controls;	(−3.57)	2.15		
$N = 76$)				

NOTE.—Col. 1 shows the employment coefficient from an OLS regression of the first difference of the log of real wages on the first difference of the log of employment and time. Col. 3 shows the inflation coefficient from an OLS regression of the first difference of unemployment on the first difference of inflation. The NIUC regression used only those years during which the product of the first difference of inflation and unemployment was negative. The PIUC regression used only those years in which inflation and unemployment changed in the same direction. *t*-statistics are in parentheses.

tudinal Survey interviews of 5,225 young men between 1966 and 1980. Because no interviews were conducted during 1972, 1974, 1977, and 1979, this sample contained only 11 years. Despite the use of aggregate data, our results are qualitatively similar to those of Bils. There is strong evidence of procyclical wage movements, with the coefficient on employment positive and significant at the 1 percent level (see table 1).

Next we reestimated the equation using all 15 years between 1966 and 1980. Although the coefficient on employment was still positive, it was not significant at the 5 percent level, evidence of the sensitivity of the estimated coefficients to the choice of sample period. Bils's findings may have been affected by the longer spacing of observations, which emphasizes lower-frequency (secular) fluctuations and obscures higher-frequency (cyclical) disturbances.

The Geary-Kennan study used employment and real wage data that differed only slightly from our series and estimated a distributed

lag model between real wages and employment. For the 1948–77 time period, Geary and Kennan found a positive, but insignificant, employment coefficient; when reestimated over the 1948–71 period studied by Neftci, the employment coefficient was negative but still insignificant. Our regression coefficients for these two periods were qualitatively similar to those of Geary and Kennan; the real wage was slightly less countercyclical during 1948–77 than during 1948–71.

In order to see how the choice of sample period affected these results, we reestimated the equation for the 1900–1985 period. The coefficient on employment was negative and significant at the 2 percent level. Given that so few investigators found evidence that real wages are countercyclical and then only by using more sophisticated model specifications, it is somewhat surprising to obtain the predicted result using an ordinary least squares (OLS) model.

That real wages were either pro- or countercyclical, depending on the period studied, suggests that the cyclicality of real wages may depend on the cause of the cycle. In particular, if nominal wages are sticky, cycles caused by demand shocks should lead to countercyclical movements in the real wage, while cycles caused by supply shocks may exhibit a procyclical movement in real wages.[2] Economic theory suggests that employment changes produced by aggregate demand shifts are likely to be associated with a procyclical inflation rate. Thus countercyclical movements in the real wage should occur during periods in which there is a negative correlation between the inflation rate and the unemployment rate (referred to by the acronym NIUC). By contrast, real wage movements should be procyclical during periods dominated by positive inflation-unemployment correlations (PIUC).

To test this hypothesis, we regressed the first difference of unemployment on the first difference of inflation for each of the sample periods in table 1.[3] For each of the five sample periods we found that real wages became more procyclical as the coefficient on inflation became larger. Note that during the 1966–80 period studied by Bils, the inflation coefficient was positive and significant. (The countercyclical inflation rate during this period is presumably a result of the two oil shocks.)

Since business cycle models that incorporate nominal wage stickiness are, in part, motivated by empirical studies showing a negatively

[2] As this paper was going to press, Hoehn (1988) demonstrated this point in the context of a model featuring nominal wage contracts and productivity shocks.

[3] This technique of identifying aggregate demand shocks may appear inferior to one using unanticipated inflation shocks. However, the correct specification of such a model depends on exactly what assumptions are made regarding the length and structure of nominal wage contracts.

TABLE 2

REAL WAGE–EMPLOYMENT REGRESSIONS USING VARIOUS WAGE RATES, SELECTED SAMPLE PERIODS

Sample Period	Real Wage Equation Coefficient on Employment (1)	Adjusted R^2/ Durbin-Watson Statistic (2)	Real Wage Excluding Overtime Coefficient on Employment (3)	Adjusted R^2/ Durbin-Watson Statistic (4)
1966–80 (Bils; $N = 10$)	.857 (3.97)	.717 1.84	.740 (3.55)	.691 1.84
1966–80 (annual; $N = 14$)	.327 (1.17)	.209 1.85	.240 (.91)	.204 1.84
1948–77 (Geary-Kennan; $N = 29$)	−.008 (−.06)	.000 1.69	−.081 (−.59)	.019 1.64
1948–71 (Neftci; $N = 23$)	−.124 (−1.19)	.000 2.10	−.194 (−1.94)	.081 1.98

NOTE.—Col. 1 is identical to col. 1 of table 1. Col. 3 shows the employment coefficient from an OLS regression of the first difference of the log of real wages, excluding overtime, on the first difference of the log of employment and time. *t*-statistics are in parentheses.

sloped Phillips curve, we tested the cyclicality of real wages over the NIUC years. Between 1900 and 1985 there were 59 years during which the first difference of inflation and unemployment had the opposite sign, 21 years during which they had the same sign (PIUC), and five years during which there was no change in either inflation or unemployment. For the 59 NIUC years there was stronger evidence for countercyclical real wages than in any of the other five sample periods (see table 1). When regressed over the 21 PIUC years, real wages proved to be highly procyclical.

Since nominal price rigidity can result in procyclical real wages, we reestimated the real wage–employment regression for 1900–1985, omitting the nine years during which price controls were in existence for at least 6 months. We found much stronger evidence of a negative relationship between real wages and employment for these years than for the entire 1900–1985 period.

Lucas (1970) observed that cyclical changes in the ratio of overtime to straight-time employment give average hourly earnings a procyclical bias. In table 2 we report the results of a regression of the first difference of (the log of) average hourly earnings, excluding overtime, on the first difference of the log of employment. As expected, in each case the real wage is slightly less procyclical than in the regressions reported in table 1; however, the elimination of overtime did not affect the qualitative differences between sample periods.

III. Aggregation Bias

Changes in the composition of the labor force occurring over the course of the business cycle may lead to "biased" estimates of the cyclicality of manufacturing wages.[4] For instance, Bils found evidence that the average wage for workers with a cyclical employment pattern was 19 percent lower than that for workers with a steady employment pattern. This imparts a countercyclical bias to the aggregate real wage.

Bils found the countercyclical bias associated with changes in the composition of the work force to be "small relative to the large procyclical movement found above. Previous studies using longer time series, however, have found little movement in real wages. Relative to these studies' estimates this bias may be important" (1985, p. 679).

Heckman and Sedlacek (1985) found evidence of aggregation bias in the effects of cyclical shifts between manufacturing and nonmanufacturing. Workers leaving the manufacturing sector during a recession tend, on average, to be less skilled than other manufacturing workers. When there is a decline in manufacturing employment, the average skill level in the manufacturing sector will increase, while the average skill level in the nonmanufacturing sector will decline. This means that the average wage rate in manufacturing will decline less than the "quality-adjusted" wage rate, thus imparting a countercyclical bias to conventional (aggregated) estimates of the cyclicality of real wages in manufacturing.

Business cycle models based on nominal wage stickiness imply that the real wage for workers of a given skill level, in a given industry, should respond countercyclically to aggregate demand shocks. Yet much of the procyclicality of wages in the Bils study comes from workers switching jobs. Bils comes closest to accounting for the aggregation bias discussed by Heckman and Sedlacek when he estimates the cyclicality of wages for workers who do not change jobs. Surprisingly, Bils finds that the real wage for these workers is even less procyclical than that for all workers (aggregated or disaggregated).[5] Thus although he finds evidence that conventional tests of the cyclicality of real wages have a countercyclical bias relative to tests that adjust for movements in and out of the work force, his study does not

[4] Use of the term "bias" is somewhat misleading here since the appropriate way to measure the cyclicality of real wages is dependent on the theoretical model being tested.

[5] This finding may at first appear inconsistent with Heckman and Sedlacek's finding that the real wage of workers remaining in manufacturing is more procyclical than the average (aggregated) real wage of all manufacturing workers. However, Bils did not really test this question since the category of workers who did not change jobs also excludes workers who change jobs *within* the manufacturing sector. And, as previously noted, Bils found the wages of workers who change jobs to be highly procyclical.

TABLE 3

REAL WAGE–EMPLOYMENT REGRESSIONS USING CONSUMPTION AND PRODUCT WAGES, SELECTED SAMPLE PERIODS

Sample Period	Product Real Wage Equation Coefficient on Employment (1)	Adjusted R^2/ Durbin-Watson Statistic (2)	Consumption Real Wage Equation Coefficient on Employment (3)	Adjusted R^2/ Durbin-Watson Statistic (4)
1900–1985 (NIUC; $N = 59$)	−.345	.251	.205	.256
	(−4.51)	2.49	(4.33)	2.25
1900–1985 (PIUC; $N = 21$)	.578	.194	.563	.303
	(2.34)	2.97	(2.82)	2.34

NOTE.—Col. 1 is identical to col. 1 of table 1. Col. 3 shows the results of a regression of the first difference of the log of the consumption wage (W/CPI) on the first difference of the log of employment. See the note to table 1 for an explanation of NIUC and PIUC. t-statistics are in parentheses.

provide any evidence that these conventional tests are countercyclically biased relative to the test that would be appropriate for evaluating sticky-wage models of the business cycle.

IV. The Impact of Aggregate Supply and Demand on Real Wages

The cyclicality of real wages is also affected by the choice of deflator. Geary and Kennan found real wages to be more procyclical when deflated by the WPI, while Bodkin found real wages to be more procyclical when deflated by the CPI. In principle, the product wage (W/WPI) is the relevant cost variable for studies of labor demand, while the consumption wage (W/CPI) is most appropriate for labor supply.

The estimates in table 1 used the product wage since we were interested in business cycle models that assume labor demand to be stable in the short run. However, the procyclicality of real wages during the PIUC years suggests that supply shocks produce shifts in labor demand. If so, then the consumption wage should be procyclical during the PIUC years.

As expected, the consumption wage is highly procyclical during the PIUC period (see table 3). Surprisingly, the consumption wage is also strongly procyclical during the NIUC period. This finding suggests that the manufacturing sector as a whole is highly cyclical during periods dominated by aggregate demand shocks. To test this proposition, we regressed the ratio of wholesale prices in manufacturing to consumer prices against employment. As expected, this ratio was

highly procyclical during the NIUC period and slightly countercyclical during the PIUC period.[6]

If the model developed in Section II is correct, then the product wage should respond negatively to individual components of aggregate demand while the consumption wage should respond positively to individual components of aggregate supply. Leiderman (1983) found weak evidence that product wages respond negatively to unanticipated money growth (UMG). Heckman and Sedlacek found that increases in energy prices (an adverse supply shock) reduce the consumption wage of workers in manufacturing.

Table 4 shows the results of regressing the log of product and consumption wages on current and lagged UMG, temporary defense spending (TDEF), the relative price of oil (RPOIL), time (a proxy for productivity growth), and a dummy for price controls. (See the Appendix for a detailed explanation of these variables.) The coefficients on UMG and RPOIL have the expected sign in the appropriate regression equations; however, the coefficient on TDEF in the product wage equation is not significantly different from zero. It may be that the countercyclical effect on wages one would expect from the impact of defense spending on aggregate demand is offset by the impact of defense expenditures on the supply of workers to the manufacturing sector.

Table 4 also shows the results of regressing unemployment on the right-hand variables of the real wage regressions. The coefficients on the components of aggregate supply and demand all have the correct sign. Oil prices affect unemployment with a 1-year lag. (Hamilton [1983] found a similar lag between oil prices and output.)

V. Sample Period Choice and Business Cycle Theory

Lucas (1977, p. 10) found a positive relationship between prices and output to be one of the "regularities common to all decentralized market economies." He also observed that "real wages are not constant over the cycle, but neither do they exhibit consistent pro- or countercyclical tendencies. This suggests that any attempt to assign systematic real wage movements a central role in an explanation of business cycles is doomed to failure."

[6] We regressed the first difference of the log of the ratio of wholesale prices (industrial goods) to consumer prices on the first difference of the log of manufacturing employment. During the NIUC period, the coefficient on employment was .478 (t-statistic = 7.45, $\bar{R}^2$ = .485, D-W = 2.36); when regressed over the PIUC period, the coefficient on employment was −.247 (t-statistic = −1.33, $\bar{R}^2$ = .029, D-W = 2.26).

TABLE 4

REGRESSIONS OF THE REAL PRODUCT WAGE, THE REAL CONSUMPTION WAGE, AND UNEMPLOYMENT ON SELECTED COMPONENTS OF AGGREGATE SUPPLY AND DEMAND (Annual Data, 1903–85)

Dependent Variable	Product Real Wage (1)	Consumption Real Wage (2)	Unemployment Rate (First Difference) (3)
Constant	−45.88	−37.02	−92.45
	(−15.3)	(−9.3)	(−.42)
UMG	−.789	1.12	−11.29
	(−1.98)	(3.67)	(−4.68)
UMG_{-1}	−1.02	.818	−4.01
	(−2.54)	(2.67)	(−1.68)
TDEF	−.0005	.0127	...
	(−.138)	(4.55)	
DTDEF	...	...	−10.82
			(−1.58)
TIME	.0236	.0201	.0480
	(15.29)	(9.82)	(.422)
PC	.0194	−.0060	−13.52
	(.926)	(−.372)	(−1.56)
RPOIL	−.365	−.152	...
	(−8.57)	(−4.56)	
DRPOIL	...	...	−4.000
			(−.195)
$DRPOIL_{-1}$	...	...	46.01
			(2.09)
$DRPOIL_{-2}$	...	...	18.02
			(.83)
Adjusted R^2	.804	.519	.276
Durbin-Watson statistic	1.64	1.30	1.92

NOTE.—UMG and UMG_{-1} represent unanticipated money growth and its first lag; TDEF and DTDEF represent temporary defense spending and its first difference; PC is a dummy variable for price controls; RPOIL and DRPOIL are the relative price of oil and its first difference. The regression equations were estimated using the Cochrane-Orcutt iterative technique. See the Appendix for a detailed explanation of the variables. *t*-statistics are in parentheses.

Given the findings shown in table 1, these views are not really surprising. During the 1948–77 sample period (a period intensively studied by macroeconomists), we found no significant real wage–employment relationship, despite a procyclical inflation rate. In fact, for each of the five sample periods examined, there was stronger evidence for procyclical inflation rates than for countercyclical real wages. Is Lucas correct that the data do not support models based on countercyclical real wages? Clearly one cannot simply assert that 1948–77 is the "wrong" period for testing these models without severely limiting their usefulness.

It is important to recognize, however, that although during most periods the inflation rate is procyclical, shifts in the aggregate demand schedule cannot explain all output (or employment) fluctua-

tions. Furthermore, business cycle models that predict countercyclical real wages also generally predict, and were developed to explain, a negatively sloped Phillips curve. Therefore, it would seem preferable to test these models only in periods during which employment fluctuations can be attributed to aggregate demand shocks. Of course, if supply shocks had a random effect on real wages, then the choice of sample period would be unimportant. However, if supply shocks produce procyclical real wage movements, then testing the cyclicality of wages for all years will produce a procyclical bias.

One likely misconception is that as long as *most* employment variability, over a given period of time, is caused by aggregate demand shocks, then one could still expect to find a countercyclical tendency in real wages. This assumes that the change in real wages associated with a given change in employment is not dependent on which curve has shifted, and suggests an important empirical question: Is it possible that an aggregate supply shock has a greater impact on real wages than an equivalent (in terms of employment) shift in aggregate demand?[7]

The evidence presented in table 1 does not provide a definitive answer to this question. However, the coefficient on employment is larger (in absolute value) in the equation estimated during the PIUC period. This suggests that supply shocks may in fact have a greater impact on real wages than demand shocks. If so, then during periods in which employment fluctuations were caused in equal parts by shifts in aggregate supply and aggregate demand, the greater responsiveness of real wages to supply shocks would result in a procyclical movement in real wages. And where real wages show no cyclical pattern (as during 1948–77), aggregate demand shocks should predominate, resulting in a negative coefficient in the unemployment-inflation regression. Overall, one would expect to find stronger evidence for procyclical inflation rates than for countercyclical real wages.[8]

The finding that real wages move inversely to monetary shocks would seem to provide support for monetary models of the business cycle. King and Plosser (1984), however, suggest that observed correlations between nominal and real variables may be reflective of reverse causation whereby real shocks induce a response in the banking system that generates procyclical movements in inside money.

[7] If aggregate demand shocks affect the supply of labor and aggregate supply shocks affect the demand for labor, then supply shocks would affect real wages by more than equivalent (in terms of employment) shifts in aggregate demand, if the demand for labor is more elastic than the supply of labor.

[8] Hoehn (1988) reached a similar conclusion after performing a numerical simulation of his model.

Even if one accepts the preceding argument, however, the relationship between the cyclicality of real wages and the cyclicality of inflation would seem to create a problem for supporters of the RBC model. It seems highly unlikely that the sort of factors that RBC proponents might use to explain why the cyclicality of inflation varies over differing sample periods (i.e., changes in banking regulations or expectations of future monetary policy) would be the same factors that cause the cyclicality of *real* wages to vary between sample periods. Yet the cyclicality of real wages is strongly (and inversely) related to the cyclicality of inflation. Thus it is unlikely that any business cycle model that does not incorporate both real and monetary shocks will be able to explain the cyclicality of real wages.

Support for RBC models has come not only from findings of procyclical real wages but also from studies that show disturbances to real output in the United States to be highly persistent. This finding would appear to be inconsistent with natural rate models that assume output disturbances to be "cyclical" fluctuations around a stationary trend. It is interesting to note that these studies find output disturbances to have been much more transitory prior to World War II. Campbell and Mankiw (1987) suggest that this difference may be due to imperfections in prewar data. An alternative explanation of both the greater countercyclicality of prewar real wages and the greater evidence of prewar output fluctuations being trend-reverting would be that a relatively greater share of output variability was generated by aggregate demand shocks prior to World War II.

VI. Concluding Remarks

The objective of our study was not to introduce new variables or techniques that would yield novel results. In fact, there are good theoretical reasons why earlier studies of the cyclicality of real wages that used distributed lags or disaggregated data should have produced superior estimates of real wage cyclicality *for the period being studied.* What distinguishes this study from previous real wage studies is its examination of the role that sample period choice plays in the estimation of the cyclicality of real wages. The fact that we were able to replicate the important qualitative findings of previous studies using simple OLS regressions suggests that the choice of sample period is more important than technique.

The most interesting finding in our study is that real wages are strongly countercyclical over the 59 periods during which the inflation rate moves procyclically and that real wages are strongly procyclical over the 21 periods during which the inflation rate moves coun-

tercyclically. This indicates that business cycle theories that assume procyclical inflation rates should not be rejected simply because they also imply countercyclical real wage movements.

Economic theory suggests that sample periods experiencing procyclical movements in the inflation rate are dominated by aggregate demand shocks. If so, then aggregate demand shocks appear to generate countercyclical real wage movements. During periods dominated by supply shocks, real wages show procyclical tendencies. During periods experiencing both supply and demand shocks, the cyclicality of wages is ambiguous, even where the demand shocks have a quantitatively greater impact on employment. This conclusion is reinforced by the reduced-form estimates in table 4 that show that real wages respond negatively to both unanticipated money growth and increases in the relative price of oil.

More important, our findings suggest that the observed real wage–employment relationship is not inconsistent with the implications of business cycle models based on nominal wage stickiness. The finding that real wages are only countercyclical during periods in which inflation is procyclical may limit universality of this class of models. However, it is unlikely that *any* business cycle model based on nominal shocks can explain output fluctuations experienced during periods dominated by countercyclical inflation movements.

Appendix

A. *Data Sources*

Both the average hourly earnings of production workers in manufacturing (1919–85) and the average hourly earnings, excluding overtime, of production workers in manufacturing (1941–85) were taken from *Employment, Hours, and Earnings, United States, 1909–84*, volume 1 (Bull. 1312, U.S. Department of Labor, Bureau of Labor Statistics [BLS], March 1985) and *Supplement to Employment and Earnings* (BLS, July 1987). Total employment in manufacturing (1919–85) was also taken from these sources. Average hourly earnings in manufacturing (1900–1918) is from Rees (1960, 1961). Total employment in manufacturing (1900–1918) is from *Historical Statistics of the United States—Colonial Times to 1970* (U.S. Department of Commerce, Bureau of the Census). Also taken from this source was the wholesale price index (excluding farm products and food), 1900–1945 (BLS), and the consumer price index, all items, 1914–70 (BLS). (For the 1900–1913 CPI we used Rees data from the same source.) Also taken from the *Historical Statistics* were the unemployment rate, 1899–1970, and defense spending, 1880–1970. More recent data for the CPI, the unemployment rate, and defense spending were taken from various issues of the *Statistical Abstract of the United States* (U.S. Department of Commerce, Bureau of the Census). The wholesale price index, industrial goods (PWIC), 1946–85 (BLS), was taken from the *Citibank Economic Databank*. Also from the *Citibase* was the price of crude petroleum (PW561), 1946–85. The wholesale price of fuel and lighting, 1900–1945, is

from the same source as the WPI, 1900–1945. The M2 money supply and gross national product are from estimates made by Balke and Gordon (1986).

B. Variable Definitions

Wholesale price index data from 1900–1913 for industrial goods are available only in disaggregated form. We used regression analysis to estimate the weights on the eight constituent series for the years 1913–20. We then used these weights to generate a WPI series for the 1900–1913 period. The variable RPOIL was generated by taking the ratio of the price of oil (1946–85), or the price of fuel (1900–1945), to the GNP deflator. Estimates of calendar year defense spending were derived by taking a weighted average of defense spending during overlapping fiscal years. To compute TDEF we first took the ratio of defense spending to GNP (DEF/GNP); TDEF was then defined as the ratio of DEF/GNP to an average of 20 lags of DEF/GNP. The variable UMG is defined as the residual of an OLS regression of the first difference of the log of M2 (DMG) on 20 lags of DMG, the lagged unemployment rate, and TDEF. (Leiderman [1983] used a similar technique.) The price control regression in table 1 excluded the years 1918, 1942–46, 1951–52, and 1972.

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