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GOVERNMENT PURCHASES AND REAL WAGES

by

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Federal Reserve Bank of Dallas

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1. Introduction

Traditional discussions of the effects of government spending usually lump all government purchases together in a single measure, which is then usually identified with the series "Government Purchases of Goods and Services" in the national accounts. The implicit assumption is that all government purchases are goods or final output. In reality of course this is not the case. Governments are typically large consumers of intermediate products, in particular the services of factors. A significant proportion of the labor force is usually employed by the government at either the Federal or State and Local level. The national accounts measure of government expenditure includes payments for such services in addition to purchases of non-durable and durable (capital) goods. Rather than lump all of this together under one heading it is interesting to ask how higher employment by the government affects the macroeconomy differently to, say, higher government purchases of final goods.

Of particular interest is the question of how real wages respond to government purchases. Changes in government purchases, specifically military purchases, are commonly identified as a principal source of fluctuations in aggregate demand. And the cyclical behaviour of real wages is of crucial importance in distinguishing between alternative theories of the business cycle. Recently, Rotemberg and Woodford (1989) have argued that the inability of perfectly competitive general equilibrium models to account for the cyclical behaviour of real wages warrants the shifting of attention to models with oligopolistic market structures. In this paper I will show that the case against the ability of the competitive model to explain the cyclical movement in real wages is not at all robust. Using evidence from both quarterly and annual data sets I show that the competitive model does quite well in accounting for the response of real wages to changes in government purchases.

2. A static problem

The intuition of how government purchases of final output and purchases of factor services differ in their implications for the aggregate economy is easily developed in the context of a simple static representative agent ("Robinson Crusoe") economy. Our representative agent has access to a production technology that transforms effort, N_t, into output of final goods, Y_t. This output is either allocated to consumption, C_t, or is appropriated by the government, G_t. In addition to supplying effort to private production, the representative agent may be forced to work a certain number of hours for the government, N_t^g, so that total leisure time is $L_t = 1 - N_t - N_t^g$. The equilibrium allocations of effort and output are given by the solution to the following equations:

$$U_C(C_t, 1-N_t-N_t^g) = U_N(C_t, 1-N_t-N_t^g)F_N(N_t)$$

$$F(N_t) = C_t + G_t$$

Figure 1 shows the consumption possibilities of the representative agent in this economy. Initial equilibrium, where all of final goods output is consumed privately and the government demands no effort, is at the point of tangency between the consumption possibility frontier and the highest attainable indifference curve, at E_0. The implicit real wage is given by the slope of the line WW. At this wage rate, a competitive economy populated by a large number of identical firms and households trading factor service and final output would produce the same allocation of the fixed endowment of time between leisure and productive activity, and have the same levels of per capita output and consumption as the single agent economy.

Now let us see what happens if the government decides to purchase some of final goods output. The consumption possibility frontier will shift parallel to itself vertically by the amount of the government purchases G, as illustrated in Figure 2a. At the initial level of real wages there is an excess demand for final output. The relative price of final output in this economy is simply the inverse of the real wage. Excess demand for final output means that its relative price must rise to restore equilibrium, i.e. the real wage must fall. The new equilibrium is established at a point such as E_1. The real wage is lower, effort and output are higher, and consumption is lower.

What happens if instead of demanding final goods output the government demands labor services, the sole input to private production in this simple economy? This is illustrated in Figure 2b. The consumption possibility frontier now shifts parallel to itself horizontally by the amount of the effort demanded by the government, N^g. At the initial level of the real wage there is now excess demand for labor, requiring that the real wage increase. Equilibrium is established at a point such as E_1. Effort supplied to private production is lower, as is output, although total effort is increased and consumption is lower.

Total government purchases of goods and services in this economy can be measured as

$$\Gamma_t = F_N(N_t)N_t^g + G_t$$

To the extent that government must compete for labor services on a competitive labor market, this aggregate is not exogenous. Shocks to the economy that cause the real wage rate to vary (i.e. shocks to the marginal productivity of labor) will obviously cause this variable to change even in the absence of variations in the real quantities of labor services or goods absorbed by the government. Within the context of this model, there is no distinction between effort that is drafted or conscripted by the government and effort that it demands through a competitive labor market.

Does it matter whether the government cuts its purchases of final output and increases its purchases of factor services to produce the final output it requires? The answer is no, as long as the government can operate the technology as efficiently as the private sector, and the technology is subject to constant returns to scale. There may of course be certain types of output that the government cannot purchase from the private sector, such as "national defense". In this case the government only purchases factor services and uses them to produce the unmeasurable final output. The factor price implications of these purchases depend on the factor intensity of the technology for producing national defense: if national defense is labor intensive relative to private production activity, increased national defense purchases of factor services will raise real wages. The converse would apply if national defense is capital intensive. It is not clear to me which of the two factor intensity assumptions is more plausible, but these considerations do suggest a caveat to the results in section 4 below.

3. An Oligopolistic Alternative: Rotemberg and Woodford

In a recent paper, Rotemberg and Woodford (1989) have argued that one of the shortcomings of the competitive model is its inability to explain the response of the real wage to aggregate demand shocks. The competitive model explains variations in employment that come about in response to demand shocks as reflecting changes in the willingness of households to supply labor. None of the variation is due to changes in the demand for labor.[2] They argue that the procyclical behaviour of real wages and evidence that business fluctuations are accompanied by large changes in labor demand are incompatible with this aspect of the competitive model. In its stead they propose an oligopolistic model where firms collude to keep prices above marginal cost. For the collusive equilibrium to be sustainable as an equilibrium in the face of exogenous increases in aggregate demand it is necessary that the equilibrium markup fall at such times, thereby inducing an increase in the demand for labor. For plausible parameterisations of their model they predict that the real wage should increase in response to innovations in military purchases, which they take as being the major source of exogenous shocks to aggregate demand. They also report evidence from simple bivariate vector autoregressions to support this hypothesis.

The analysis of this paper suggests that real wage effects of changes in military purchases are different depending on whether the purchases are of goods or services. Increased purchases of goods depress the real wage, increase purchases of factor services raise it. In their empirical work Rotemberg and Woodford do not distinguish between the two. And since their criticism of the competitive model hinges on the response of the real wage to changes in military purchases, it is important to ask how robust their findings are to decomposition of military purchases along the lines of goods

[2] This is clearly true of simple competitive models of the sort outlined in this paper: it would not be true in a competitive model where, for example, government purchases enhanced the productivity of private factors of production. See Aschauer (1989).

and services. Rotemberg and Woodford look at quarterly data and so are confined to an examination of the post WWII period. If we use annual data we can include WWII, the biggest temporary increase in military purchases of both goods and services this country has seen.

4. Results

The empirical work reported in this section uses both quarterly and annual data. The reason for this is that use of annual data allows us to include World War II in the sample: most quarterly time series only start in 1947. The data appendix gives the sources and definitions of all variables. The theory outlined in section 2 above implicitly assumes that final output and effort absorbed by the government does not in any way enhance the productivity of the private production technology. Aschauer (1989) has shown that this is not true for all categories of government purchases. He shows that the stock of nonmilitary public capital does indeed enhance the productivity of private factors of production. He is unable to find any relationship between the stock of military capital, or any military variable for that matter, and the productivity of private capital, and it is this finding, along with common sense, that motivates my focusing on military purchases of final output and effort.

All of the empirical work started with OLS estimation of the following over-parameterized model:

$$\Delta w_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1,i}\Delta w_{t-i} + \sum_{i=0}^{l} \alpha_{2,i}\Delta g_{t-i} + \sum_{i=0}^{m} \alpha_{3,i}\Delta n^g_{t-i} + \sum_{i=0}^{n} \alpha_{4,i}\Delta UR_{t-i} + \alpha_5 dum73 + \epsilon_t$$

where w_t is a measure of the real wage rate, g_t is a measure of government purchases of final output, n^g is a measure of government purchases of labor services, UR is the civilian unemployment rate and DUM73 is a dummy variable that is equal to 1 up to 1973 and 0 thereafter. The inclusion of the 1973 dummy was motivated by a an initial examination of the real wage series which revealed clear signs of a change in the underlying growth rate in or around 1973. Estimation was carried out in first differences as all of the series seemed to be integrated of at least order 1.

The results from the postwar quarterly sample are reported in Table 1. The strategy followed in arriving at these specifications was to set k=l=m=n=5 initially and estimate (4). Inessential variables and lags were then deleted in repeated rounds of re-estimation until the final forms reported in the table were obtained.[3] The criterion used to determine whether a variable should be retained was that the absolute value of its t-statistic exceed 2. The models thus arrived at were then subjected to a variety of specification tests and out of sample forecasting to ensure that they were adequate representations of the data. Some of these tests are reported in Table 1, and are explained more fully in the notes to the table.

Equation (1) relates the growth in real wages in manufacturing to growth in real military purchases of goods (g_1), real compensation of employees in the military (n_1^g) and the change in the log of the unemployment rate. The coefficient estimates on Δg_1 and Δn_1^g are both significant at the 5% level have the signs predicted by our theory. The coefficient estimates on the unemployment rate variables are nearly equal and opposite in sign, suggesting that it might be more appropriate to include the variables in second difference form. Equation (2) reports the results when we do this. The

[3]The strategy of working from over-parameterized models such as (4) to the most parsimonious version that is compatible with the data is recommended by Hendry and Richard(1982).

coefficient estimates on Δg_1 and Δn^g_1 change little in absolute magnitude, and retain both their sign and significance. The robustness of the findings in equation (1) can also be checked by re-estimating the relationship in second differences. These results are reported in equation (3). Both of the government variables continue to have the signs predicted by the theory, and lags of each are retained in the preferred model.

Equation (4) reports the simplified model derived from (12) when Δn^g_1 is replaced by $\Delta \bar{n}^g_1$, a measure of the number of bodies on military payrolls rather than military compensation.[4] The variable $\Delta \bar{n}^g_1$ does not appear in the final form because none of its coefficients were significant. However the coefficient on Δg_1 in the final form does have the correct sign and is significant. The variable $\Delta \bar{n}^g_1$ is not significant when ΔUR is replaced by $\Delta^2 UR$, as in equation (5), nor when the model is re-estimated in second differences, as in equation (6). In both cases however, the coefficient estimates on Δg_1 and $\Delta^2 g_1$ are negative, as predicted by our theory.

Finally equations (6)-(9) report OLS estimates of the relationship between the real wage in manufacturing, the share of defense purchases of final output in GNP (g_2) and the size of the military relative to total employment (n^g_2). In no case are the coefficients estimates on n^g_2 significant, so it does not appear in any of the final forms. But once again

[4]It is not immediately obvious that $\bar{n}^g_1$ is a better empirical measure of the theoretical variable N^g than n^g_1. Both series have their merits. The advantage of $\bar{n}^g_1$ is of course that it is a physical quantity, the number of productive workers absorbed by the military. The advantage of n^g_1 is that it allows for workers of different productivities being absorbed by the military by weighting each worker by his real wage.

the coefficient estimates on g_2 are significantly negative.

How robust are the results reported in Table 1? Along with each regression I also report a number of test statistics that suggest that in each case the models are remarkably free from major specification error. This is all the more remarkable given the parsimonious specification of the equations. The reported test statistics do not however address the potential endogeneity of some of the regressors. There is good reason to believe that in a competitive economy the real compensation of the military will bear some relationship to the average level of real wages in the rest of the economy (here proxied by the real wage in manufacturing). There is also good reason to believe that there is some relationship between the unemployment rate and real wages. Exogeneity of Δn_1^g and ΔUR in equation (1) was tested using a Hausman-type specification test, with lags of Δn_1^g and ΔUR used as instruments. The results of these tests were ambiguous, apparently because the lagged values of these variables perform poorly as instruments.

Despite the ambiguous outcome of this test it was decided to go ahead and re-estimate some of the equations in Table (1) using instrumental variables. Table 2 reports the results of doing this. The most obvious consequence of replacing OLS with IV estimation is to cause a loss of statistical significance on all of the coefficient estimates. As the single test statistic reported with each regression indicates, we are unable to reject the null hypothesis that all of the IV coefficient estimates are jointly equal to zero. More specifically, Δn_1^g is no longer significant in explaining movements in real wages, as equations (1') and (2') indicate. Encouragingly, the sign of the coefficient estimate on this variable is still consistent with the predictions of our theory. The coefficient estimates on the measures of government purchases of final output, Δg_1 and Δg_2, generally retain their sign and significance. Finally, note that we are unable to reject the null hypothesis that the instruments are orthogonal to the error term using Sargan's(1964) test for the validity of instruments.

Table 3 reports the results of estimating a model similar to (12) using annual data. Except for the unemployment rate, variable definitions differ slightly from those used in the quarterly estimation. The real wage measure (w_t) is now a measure of real wage in total private industry rather than manufacturing industry. The deflator used to convert nominal wages to real wages is the fixed weight deflator for personal consumption expenditures from the national accounts. The real measure of productive resources absorbed by the military ($n^g_{1,t}$) is defined as wage and salary payments to the military deflated by the implicit price deflator for federal government purchases. Purchases of final output ($g_{1,t}$) are total defense purchases of goods and services, deflated by the implicit price deflator for federal government purchases, less the wage and salary component. Finally, the numbers on military payrolls ($\bar{n}^g_{1,t}$) is defined as the number of full time equivalent employees on military payrolls.

Both OLS and IV estimates are reported in the table. As with the quarterly estimates, the signs on the military variables in the wage equations are consistent with the predictions of the simple competitive model. IV estimation, using lags of Δ^2UR and Δn^g_1 or $\Delta \bar{n}^g_1$ as the case may be, as instruments results in some loss of statistical significance, but the general thrust of the results remains the same. Experimentation with the sample size reveals that the inclusion of the war years (1940-1947) in the sample is crucial to obtaining statistically significant results for the military variables with the annual data. This is hardly surprising as the annual variation in these series is quite small in the post-war period. All of the annual series can be extended back to 1929, to incorporate the Depression years. Not surprisingly, the estimated relationships are not stable when the sample is extended in this manner, although as the ξ_1 statistics reported with each model show, the relationships are stable when the sample is extended to include the 1980's.

5. Conclusions

This paper has addressed the question of how real wage rates respond to changes in government purchases of final output and factor services. For the category of government purchases that is least likely to have any feedback to private tastes or technology, namely military purchases, I have shown that the response of real wages depends crucially on whether the government appropriates final output or factor (labor) services. Quarterly data from the postwar period show that the finding that real wages decline in response to increased military purchases of final output is robust, but that the increase in real wages in response to increased military appropriation of factor services is less so. The failure to find increases in real wages in response to increases in the size of the military in the postwar period can, I think, be attributed to two things: first, the difficulty in obtaining good instrumental variables for real compensation of employees in the military, and, secondly, the relatively small variation in the measure of the size of the armed forces during this period. When we look at annual data and include World War II in the sample, we again find that the response of real wages to changes in different categories of military purchases is consistent with our theory. With the annual data, the finding that real wages increase in response to increases in the size of the military is more robust, although critically dependent on the inclusion of World War II in the sample.

It is not just real wages that respond differently to changes in different categories of government purchases. In a companion paper (Wynne (1990)) I have examined the response of real interest rates to changes in purchases of goods and services, with particular reference to the ability of the draft to explain the behaviour of real interest rates during wartime. I find that disaggregation of government purchases may be a more useful way to think about this question than some of the alternatives, such as the introduction of consumer durables.

Appendix: Dynamic Extension

The extension of this analysis to a dynamic framework is easily accomplished by the addition of physical capital, K_t, as an additional factor of production and the specification of an accumulation equation for this capital. The equilibrium of the dynamic economy is given by the solution to the following planning problem. Households maximize a time separable utility function over an infinite horizon. Utility at each point in time depends on consumption C_t and leisure L_t, both of which are assumed to be normal goods. They also have an endowment of one unit of time each period which is divided between leisure and effort. Total effort is divided between working for private firms and working for the government. This problem can be formally stated as

$$\max_{C_t, N_t} \sum_{t=0}^{\infty} \beta^t U(C_t, 1-N_t-N_t^g)$$

subject to

$$F(K_t, N_t)+(1-\delta)K_t=C_t+K_{t+1}+G_t$$

$$K_0=\overline{K}_0,$$

where K_0 denotes the initial endowment of productive capital.

The solution to this problem is given by the first order conditions

$$D_1U(C_t, 1-N_t-N_t^g)=\lambda_t$$

$$D_1U(C_t, 1-N_t-N_t^g)=\lambda_t D_2F(K_t, N_t)$$

$$\beta\lambda_{t+1}[(1-\delta)+D_1F(K_{t+1},N_{t+1})]=\lambda_t$$

$$F(K_t,N_t)+(1-\delta)K_t=C_t+K_{t+1}+G_t$$

and the transversality condition

$$\lim_{t\to\infty} \beta^t\lambda_t K_{t+1}=0.$$

Total government purchases are now given by

$$\Gamma_t= F_N(K_t,N_t)N_t^g+G_t$$

It is readily seen that the model reduces to a system of nonlinear difference equations. Since closed form solutions to this model can only be found in special cases, detailed analysis of the model can only be carried out by numerical methods. What is relevant for our current purposes is whether the predictions of the simple static model outlined in the text are changed when we move to a dynamic setting. Fortunately this question can be answered without a detailed analysis of the model. As long as the production technology F(.) exhibits constant returns to scale, real factor rewards in the steady state equilibrium of this model are determined solely by the parameters of tastes and technology and are invariant to the amount of final output or labor appropriated by the government.

Data Appendix

Quarterly

All of the quarterly data was taken from CITIBASE. CITIBASE variable names are included in brackets after each series.

1. Real wage (w_t) defined as the ratio of Gross Average Hourly Earnings of Production or Nonsupervisory Workers in Manufacturing Industry (LEHM) to the Consumer Price Index for Wage Earners and Clerical Workers(PRNEW).

2. Military purchases of final output (g_1) defined as National Defense Purchases of Goods and Services(GGFEN) less Compensation of Employees in National Defense(GGFNC), divided by the Implicit Price Deflator for National Defense Purchases(GDGFEN).

3. The share of military purchases of final output in GNP (g_2) defined as the ratio of National Defense Purchases of Goods and Services(GGFEN) less Compensation of Employees in National Defense(GGFNC) to Nominal GNP(GNP).

4. Effort absorbed by the military (n_1^g) defined as the ratio of Compensation of Employees in National Defense(GGFNC) to the Implicit Price Deflator for National Defense Purchases(GDGFEN).

5. Military payrolls ($\bar{n}_1^g$) defined as Resident Armed Forces in the United States(POAR).

6. Size of the military relative to total employment (n_2^g) defined as the ratio of Resident Armed Forces in the United States(POAR) to Workers on Nonagricultural Payrolls in Total Private Industry(LP).

7. Unemployment (UR) defined as the Civilian Jobless Rate(LHUR).

Annual

For the period 1947-1990 all annual data are from CITIBASE. Prior to

1947 data are from <u>The National Income and Product Accounts of the United States, 1929-1982</u> and <u>Historical Statistics of the United States: Colonial Times to 1970</u>.

1. Real wage defined as the ratio of Wages and Salaries per Full Time Equivalent Employee in Private Industry (source: National Income and Product Accounts (NIPA) Table 6.8A,B) to the Fixed Weight Price Index for Personal Consumption Expenditures (source: NIPA Table 7.9).

2. Military purchases of final output defined as National Defense Purchases of Goods and Services(source: NIPA Table 3.2; prior to 1939 data are from Table A-1 of Kendrick(1961)) less Wage and Salary Payments in the Military(source: NIPA Table 6.5A,B), deflated by the Implicit Price Deflator for Federal Government Purchases(source: NIPA Table 7.4).

3. Effort absorbed by the military defined as the ratio of Wage and Salary Payments in the Military divided by the Implicit Price Deflator for Federal Government Purchases.

4. Military payrolls defined as the number of Full Time equivalent Employees in the Military(source: NIPA Table 6.7A,B).

5. Unemployment (UR) is series LHUR from CITIBASE for the period 1947-1990, and series D86 from <u>Historical Statistics</u> for the period 1929-1946.

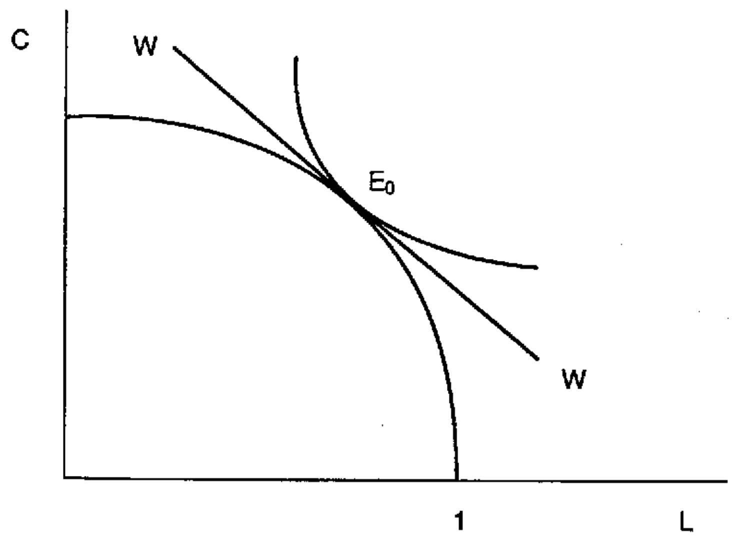

Figure 1

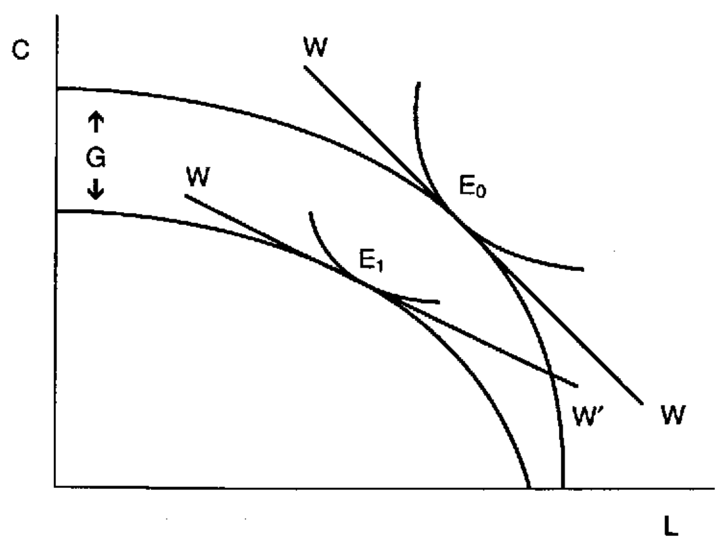

Figure 2a

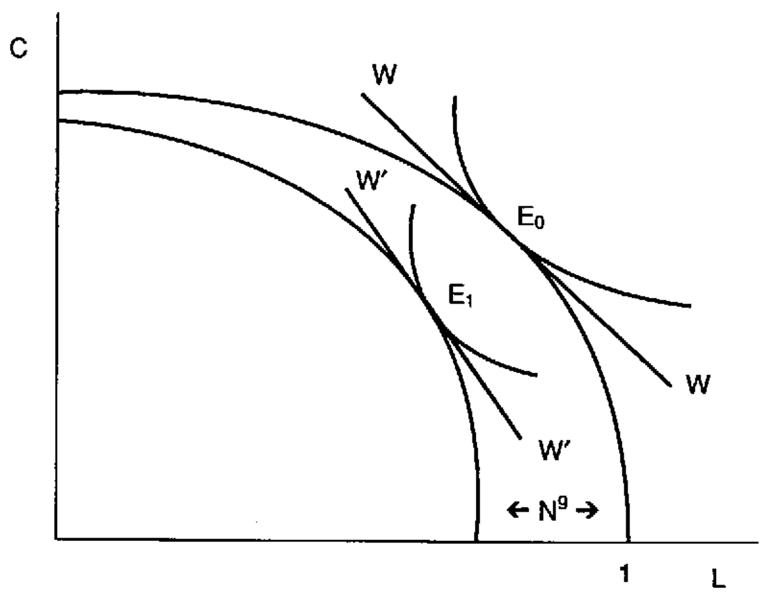

Figure 2b

Table 1

Quarterly Data: OLS Estimates

(1) $$\Delta w_t = \underset{(0.001)}{0.001} - \underset{(0.015)}{0.044}\Delta g_{1,t} + \underset{(0.027)}{0.109}\Delta n^g_{1,t} - \underset{(0.013)}{0.066}\Delta UR_t + \underset{(0.013)}{0.050}\Delta UR_{t-1}$$

T = 1961:2 - 1985:4 $\quad R^2 = 0.353 \quad DW = 1.661$

$\xi_1(20,94) = 1.66 \quad \xi_2(5,89) = 1.34 \quad \xi_3(8,85) = 1.54 \quad \xi_4(4,86) = 1.29$

(2) $$\Delta w_t = \underset{(0.001)}{-0.005\text{x}10^{-2}} - \underset{(0.016)}{0.031}\Delta g_{1,t} + \underset{(0.026)}{0.110}\Delta n^g_{1,t} - \underset{(0.012)}{0.057}\Delta^2 UR_t + \underset{(0.001)}{0.003}DUM73$$

T = 1961:2 - 1985:4 $\quad R^2 = 0.370 \quad DW = 1.629$

$\xi_1(20,94) = 1.26 \quad \xi_2(5,89) = 1.30 \quad \xi_3(7,86) = 1.80 \quad \xi_4(4,86) = 1.49$

(3) $$\Delta^2 w_t = \underset{(0.001)}{-1.527\text{x}10^{-4}} - \underset{(0.082)}{0.685}\Delta^2 w_{t-1} - \underset{(0.083)}{0.408}\Delta^2 w_{t-2} - \underset{(0.015)}{0.038}\Delta^2 g_{1,t} - \underset{(0.015)}{0.038}\Delta^2 g_{1,t-1} + \underset{(0.024)}{0.095}\Delta^2 n^g_{1,t} + \underset{(0.028)}{0.088}\Delta^2 n^g_{1,t-1} + \underset{(0.025)}{0.065}\Delta^2 n^g_{1,t-2} - \underset{(0.013)}{0.045}\Delta^2 UR_t$$

T = 1961:3 - 1985:4 $\quad R^2 = 0.558 \quad DW = 2.090$

$\xi_1(20,89) = 1.26 \quad \xi_2(5,84) = 0.79 \quad \xi_3(16,72) = 0.96 \quad \xi_4(4,81) = 0.25$

(4) $$\Delta w_t = \underset{(0.001)}{1.912\text{x}10^{-4}} - \underset{(0.017)}{0.032}\Delta g_{1,t} - \underset{(0.013)}{0.066}\Delta UR_t - \underset{(0.013)}{0.045}\Delta UR_{t-1} + \underset{(0.001)}{0.003}DUM73$$

T = 1960:3 - 1985:4 $\quad R^2 = 0.270 \quad DW = 1.666$

$\xi_1(20,97) = 1.09 \quad \xi_2(5,92) = 1.72 \quad \xi_3(7,89) = 0.84 \quad \xi(4,89) = 1.36$

Table 1 (Continued)

Quarterly Data: OLS Estimates

(5) $\Delta w_t = \underset{(0.001)}{-0.364\text{x}10^{-4}} - \underset{(0.017)}{0.027\Delta g_{1,t}} - \underset{(0.012)}{0.056\Delta^2 UR_t} + \underset{(0.001)}{0.003DUM73}$

T = 1960:3 - 1985:4 $\quad R^2 = 0.246 \quad$ DW = 1.590

$\xi_1(20,98) = 1.01 \quad \xi_2(5,93) = 2.17 \quad \xi_3(5,92) = 0.55 \quad \xi_4(4,90) = 1.33$

(6) $\Delta^2 w_t = \underset{(0.001)}{1.074\text{x}10^{-4}} - \underset{(0.084)}{0.651\Delta^2 w_{t-1}} - \underset{(0.080)}{0.356\Delta^2 w_{t-2}}$

$- \underset{(0.016)}{0.038\Delta^2 g_{1,t}} - \underset{(0.016)}{0.34\Delta^2 g_{1,t-1}} - \underset{(0.013)}{0.519\Delta^2 UR_t}$

T = 1960:4 - 1985:4 $\quad R^2 = 0.468 \quad$ DW = 2.121

$\xi_1(20,95) = 1.02 \quad \xi_2(5,90) = 1.14 \quad \xi_3(10,84) = 1.30 \quad \xi_4(4,87) = 2.25$

(7) $\Delta w_t = \underset{(0.001)}{-0.197\text{x}10^{-4}} - \underset{(0.442)}{0.809\Delta g_{2,t}} - \underset{(0.013)}{0.063\Delta UR_t}$

$+ \underset{(0.013)}{0.045\Delta UR_{t-1}} + \underset{(0.001)}{0.003DUM73}$

T = 1960:4 - 1990:4 $\quad R^2 = 0.269 \quad$ DW = 1.664

$\xi_1(20,96) = 1.06 \quad \xi_2(5,91) = 1.64 \quad \xi_3(7,88) = 0.78 \quad \xi_4(4,88) = 1.35$

(8) $\Delta w_t = \underset{(0.001)}{-1.772\text{x}10^{-4}} - \underset{(0.442)}{0.779\Delta g_{2,t}} - \underset{(0.012)}{0.053\Delta^2 UR_t} + \underset{(0.001)}{0.003DUM73}$

T = 1960:3 - 1985:4 $\quad R^2 = 0.249 \quad$ DW = 1.594

$\xi_1(20,98) = 1.00 \quad \xi_2(5,93) = 2.02 \quad \xi_3(5,92) = 0.38 \quad \xi_4(4,90) = 1.36$

Table 1 (Continued)

Quarterly Data: OLS Estimates

(9) $$\Delta^2 w_t = \underset{(0.001)}{-1.299\times10^{-4}} - \underset{(0.079)}{0.665\Delta^2 w_{t-1}} - \underset{(0.079)}{0.371\Delta^2 w_{t-2}}$$

$$- \underset{(0.386)}{0.733\Delta^2 g_{2,t}} - \underset{(0.013)}{0.054\Delta^2 UR_t}$$

T = 1960:2 - 1985:4 $\quad R^2 = 0.500 \quad$ DW = 2.076

$\xi_1(20,98) = 0.86 \quad \xi_2(5,93) = 0.92 \quad \xi_3(8,89) = 0.91 \quad \xi_4(4,90) = 3.00$

Notes to Table 1

(1) Standard errors are in parenthesis.

(2) $\xi_1(N,\bullet)$ is an F-test for parameter constancy when the sample used to estimate the model is extended by N observations.

$\xi_2(K,\bullet)$ is the F-form of Godfreys test for autocorrelation from lags 1 through K.

$\xi_3(\bullet,\bullet)$ is the F-form of a test for heteroskedasticity, formed by regressing the squared residuals on the original regression and their squares.

$\xi_4(n,\bullet)$ is the F-form of a test for ARCH, formed by regressing the squared residuals on a constant and the first through nth lags of the squared residuals and testing their joint significance.

Table 2

Quarterly Data: IV Estimates

$$(1') \quad \Delta w_t = \underset{(0.001)}{0.002} - \underset{(0.021)}{0.054\Delta g_{1,t}} + \underset{(0.151)}{0.015\Delta n^g_{1,t}}$$

$$- \underset{(0.054)}{0.169\Delta UR_t} + \underset{(0.034)}{0.107\Delta UR_{t-1}}$$

$\chi^2(5)/5$ for $\hat{\beta}_{IV} = 0$: 3.85

$$(2') \quad \Delta w_t = \underset{(0.001)}{-0.00007} - \underset{(0.017)}{0.031\Delta g_{1,t}} + \underset{(0.100)}{0.142\Delta n^g_{1,t}}$$

$$- \underset{(0.027)}{0.031\Delta^2 UR_t} + \underset{(0.001)}{0.003DUM73}$$

$\chi^2(5)/5$ for $\hat{\beta}_{IV} = 0$: 4.63

$$(4') \quad \Delta w_t = \underset{(0.001)}{0.00056} - \underset{(0.021)}{0.042\Delta g_{1,t}} - \underset{(0.064)}{0.149\Delta UR_t}$$

$$+ \underset{(0.042)}{0.0097\Delta UR_{t-1}} + \underset{(0.002)}{0.003DUM73}$$

$\chi^2(5)/5$ for $\hat{\beta}_{IV} = 0$: 3.70

$$(5') \quad \Delta w_t = \underset{(0.001)}{-0.00007} - \underset{(0.019)}{0.023\Delta g_{1t}} + \underset{(0.045)}{0.013\Delta^2 UR_t} + \underset{(0.001)}{0.003DUM73}$$

$\chi^2(4)/4$ for $\hat{\beta}_{IV} = 0$: 3.36

$$(7') \quad \Delta w_t = \underset{(0.001)}{0.00019} - \underset{(0.546)}{0.686\Delta g_{2,t}} - \underset{(0.072)}{0.154\Delta UR_t}$$

$$+ \underset{(0.047)}{0.103\Delta UR_{t-1}} + \underset{(0.002)}{0.002DUM73}$$

$\chi^2(5)/5$ for $\hat{\beta}_{IV} = 0$: 3.61

Table 2 (Continued)

Quarterly Data: IV Estimates

(8') $\Delta w_t = \underset{(0.001)}{-0.00012} - \underset{(0.500)}{0.903\Delta g_{2,t}} + \underset{(0.043)}{0.005\Delta UR_t} + \underset{(0.001)}{0.003DUM73}$

$\chi^2(4)/4$ for $\hat{\beta}_{IV} = 0$: 3.95

Notes to Table 2

(1) Standard errors in parenthesis.

(2) $\chi^2(k)/k$ is a test of the joint significance of all of the IV coefficient estimates.

Table 3

Annual Data

(1) $$\Delta w_t = \underset{(0.007)}{-0.016\Delta g_{1,t}} + \underset{(0.010)}{0.067\Delta n^g_{1,t}} - \underset{(0.004)}{0.018\Delta^2 UR_t} + \underset{(0.002)}{0.024DUM73}$$

$T = 1940 - 1980$ $R^2 = 0.911$ $DW = 1.640$

$\xi_1(9,37) = 0.99$ $\xi_2(2,35) = 2.53$ $\xi_3(7,28) = 0.26$ $\xi_4(1,35) = 26.45$

(1') $$\Delta w_t = \underset{(0.012)}{-0.025\Delta g_{1,t}} + \underset{(0.016)}{0.080\Delta n^g_{1,t}} - \underset{(0.014)}{0.021\Delta^2 UR_t} + \underset{(0.002)}{0.023DUM73}$$

$T = 1940 - 1980$ $\chi^2(4)/(4)$ for $\hat{\beta}_{IV} = 0$: 85.17

(2) $$\Delta w_t = \underset{(0.010)}{-0.034\Delta g_{1,t}} + \underset{(0.014)}{0.088\Delta \bar{n}^g_{1,t}} - \underset{(0.005)}{0.020\Delta^2 UR_t} + \underset{(0.002)}{0.025DUM73}$$

$T = 1940\text{-}1980$ $R^2 = 0.906$ $DW = 1.826$

$\xi_1(9,37) = 1.20$ $\xi_2(2,35) = 1.24$ $\xi_3(7,28) = 0.91$ $\xi_4(1,35) = 16.37$

(2') $$\Delta w_t = \underset{(0.026)}{-0.069\Delta g_{1,t}} + \underset{(0.034)}{0.137\Delta \bar{n}^g_{1,t}} - \underset{(0.020)}{0.035\Delta^2 UR_t} + \underset{(0.002)}{0.025DUM73}$$

$T = 1940\text{-}1980$ $\chi^2 = (4)/4$ for $\hat{\beta}_{IV} = 0$: 55.66

Notes to Table 3

(1) Standard errors in parenthesis.

(2) See notes to Tables 1 and 2 for explanation of the various test statistics.

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