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Demand shocks, supply shocks and the cyclicality of real wages

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The behaviour of real wages over the business cycle has received increasing attention in recent years. The cyclicality of real wages constitutes an important aspect of recent models of the business cycle. However, empirical studies undertaken to determine whether real wages are procyclical or countercyclical have reported conflicting findings. In this paper we use vector-autoregressions to analyse the cyclicality of real wages. We find that the source of the disturbance plays a decisive role in the cyclical behaviour of real wages. In particular, we demonstrate that a supply shock generates procyclical real wages, whereas a demand shock yields countercyclicality.

I. INTRODUCTION

The cyclical behaviour of real wages has received increasing attention in recent years. Though important in its own right, the cyclicality of real wages may be crucial in determining the plausibility of current theories of the business cycle. The Keynesian models attribute business cycles to demand shocks. The assumed stickiness of nominal wages generates countercyclical real wage behaviour when shocks are caused by aggregate demand disturbances. Accordingly, some current Keynesian versions of disequilibrium models try to explain the procyclicality of real wages – if it is in fact observed – by 'excess-capacity' or 'labour-hoarding' theories (Shapiro, 1987; Mankiw, 1989). Procyclical behaviour of real wages is consistent with the real business cycle (RBC) models. The RBC models, based on classical and new classical theories, attribute fluctuations in real quantities, such as output, primarily to shocks in aggregate supply, stressing the roles of technology and agents' preferences.[1] Mankiw argues that since these models stress the intertemporal substitution of leisure for goods, the quantity of goods demanded decreases during a recession, while the quantity of leisure demanded increases as the relative price of leisure, i.e. real wage, declines. Therefore, it is easy to reconcile the RBC models with procyclical real wages.

Empirical studies investigating the behaviour of real wages over the business cycle have not reached a definite conclusion. While Neftci (1978), Sargent (1978), Otani (1978) and Chirinko (1980) reported a countercyclical behaviour of real wages, Dunlop (1938), Tarshis (1939), Kuh (1966), Bils (1985) and Keane *et al.* (1989) provided evidence of procyclical real wages. Bodkin (1969) and Geary and Kennan (1982) found that the data cannot reject the hypothesis that real wages and employment are statistically independent over the business cycle.

In this paper we use vector autoregressions (VAR) to gain insights into the dynamic interrelations between output, unemployment, and real wages. More precisely, we analyse the responses of output, unemployment and real wages when shocks occur in nominal money (aggregate demand) and in the relative price of oil or a measure of productivity (aggregate supply).[2] We find that supply shocks generate significant

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[1]For a detailed description of these views, see Long and Plosser (1983), King and Plosser (1984), Eichenbaum and Singleton (1986) and Shapiro (1987).

[2]In some instances it may be difficult to identify the source of a given disturbance. For example, a shock in oil prices is ordinarily viewed as a supply shock. As Plosser (1989) argues, such a change could as easily have come from an increase in the demand for oil, caused by an increase in aggregate demand. Nevertheless, referring to a shock in money as a demand shock, and disturbances in the relative price of oil and productivity as supply shocks is the convention which we follow.

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procyclical behaviour of real wages, whether one uses the product wage (nominal wage deflated by the WPI) or the consumption wage (nominal wage deflated by CPI). Following a demand shock, real wages and output move in opposite directions. For the most part, however, these countercyclical responses of real wages to a demand shock are found to be not significant. In all cases, the responses of unemployment are the mirror-images of the output responses.

II. EMPIRICAL IMPLEMENTATION

Variables and the data

Our basic system consists of real output (Y), the rate of unemployment (U), nominal money (M), the relative price of oil (OIL), and the product wage (W_p). Versions of this system containing a measure of productivity ($PROD$) and a different measure of real wages (the consumption wage (W_c)) are also estimated. The variables are defined as follows: Y is the real GNP (1982 = 100); U is the rate of unemployment of the civilian population; M is nominal M1; OIL is generated by taking the ratio of the price of crude petroleum to the GNP deflator; W_p is given by the ratio of nominal average hourly earnings in manufacturing to the Wholesale Price Index, industrial goods; W_c is the nominal average hourly earnings in manufacturing deflated by the Consumer Price Index; and $PROD$ is the ratio of real GNP to total employment. The data are obtained from Citibank Economic Database except for M1, which is provided by Salih Neftci. As shown by Shapiro and Watson (1988), unlike the oil price increases during the 1970s, the sharp decline in the price of oil during 1986 cannot be interpreted as a supply shock since the latter coincided with sluggish output growth. Thus we estimate our model for the period 1948:1–1985:4.

Specification

We examine the responses of real wages, unemployment and output to unanticipated one standard deviation shocks in nominal money, the relative price of oil or productivity within the following five-variable unrestricted VAR systems:

1. OIL, M, Y, U, W_p
2. OIL, M, Y, U, W_c
3. $M, Y, PROD, U, W_p$
4. $M, Y, PROD, U, W_c$

We use the log levels of the variables.[3] Each of the five equations in all systems contains a set of three seasonal dummies as well as five lags of each variable. Also, linear and quadratic trend terms along with a constant are included. To check the specification of the model two tests were performed. First, to see if the lag specification adequately captures the dynamics of the model, the system with five lags was tested as a restriction on the same system with eight lags in model 1. The test was based on the difference in the log-determinants of the system-wide variance–covariance matrix of the restricted versus unrestricted equations.[4] The null hypothesis of no difference was accepted. The chi-square was 88.47 with 75 degrees of freedom.

Second, a Lagrange Multiplier (LM) test was applied to the residuals of the wage equations in all four systems.[5] The

Table 1. *Lagrange multiplier tests*

LM-statistic, Chi-square[a]		System 1	System 2	System 3	System 4
H_0:	$\rho_1=0$	3.34	0.46	0.02	0.08
H_0:	$\rho_1=\rho_2=0$	2.06	0.22	0.20	0.13
H_0:	$\rho_1=\rho_2=\rho_3=0$	1.45	0.30	0.39	0.44
H_0:	$\rho_1=\rho_2=\rho_3=\rho_4=0$	1.13	0.50	0.93	0.29

[a] In the LM test for serial correlation, the residuals from the real wage equations of the four systems are regressed on the complete set of independent variables and a set of lagged residuals. An F-statistics is computed for the coefficients on the lagged residuals. Multiplying F by the number of lagged residuals yields the Chi-square statistic. The degrees of freedom is the number of lagged residuals. The critical value for Chi-square at the 0.05 level is 3.841 for 1 degree of freedom, 5.991 for 2 degrees of freedom, 7.815 for 3 degrees of freedom, and 9.488 for 4 degrees of freedom.

[3]Whether one should use levels or differences in time-series analysis is still disputed. As some claim that the analysis can result in misleading conclusions if the levels are used whereas the variables contain stochastic trends (Nelson and Plosser, 1982; Stock and Watson, 1988), others argue that differencing results in a loss of valuable long-run information in the data (Sims, 1988; Sims and Uhlig, 1988). We also estimated the models using the differences of all variables except money supply and unemployment. The results, which were essentially the same, are available from the authors upon request.

[4]This is the modified chi-square test proposed by Sims (1980).

[5]The Durbin–Watson statistic is not appropriate when the specification includes a lagged dependent variable; nor strictly speaking, is the Box–Pierce Q-statistic. The LM statistic provides a general test for autocorrelation of errors, and is valid when the set of regressors includes lagged dependent variables (Breush, 1978; Godfrey, 1978).

tests are based on additional regressions in which the real wage variables are regressed on the same set of variables plus a set of lagged residuals. One rejects the null hypothesis of no autocorrelation (white noise errors) if the set of lagged residuals is different from zero. Table 1 shows the Chi-square statistics for the coefficients of lagged errors in each equation. As is evident, none of these coefficients are significant at the 5% level. Thus we accept the hypothesis that the errors of the systems are white noise, and the systems are well specified.

The data cover a long time period which creates the possibility of the existence of more than one structure. One important event that might have caused some structural change is the OPEC oil shock of 1973. Following Mocan (1990), we applied a likelihood ratio test to check the structural stability. The null hypothesis was the existence of one structure between 1948 and 1985. After estimating the basic model 1 for the whole sample and for the two subsamples, 1973 being the separation point, we failed to accept the hypothesis of no structural change. Rather, the test revealed that the structure between 1948 and 1973 was different from the one of 1974 to 1985. χ^2 statistic for the likelihood ratio test was 490 with 155 degrees of freedom.[6] The estimation of the systems using the data from 1974 to 1985 revealed that the results were robust. All responses to the shocks were very similar to those obtained from the whole sample. The only difference was, as expected, the confidence bands become larger in some cases.

III. IMPULSE RESPONSE FUNCTIONS

This section describes the impulse response functions generated by unanticipated shocks in aggregate demand and aggregate supply. These functions enable us to characterize the dynamic interactions among variables, and observe the speed of adjustment of variables in the system. One criticism of such simulations is that, if the contemporaneous correlations among innovations are substantial, then the assumption of a unique error structure, on which the interpretation of the responses depends, is invalid. This problem can be avoided by triangularizing the variance–covariance matrix of residuals, which transforms the unrestricted VAR systems to block-recursive systems (Sims, 1980). This procedure requires imposition of some causal ordering of the variables. The ordering is especially important when the variables exhibit strong correlations. Although in most studies employing VAR methodology the ordering remains arbitrary and controversial, the researchers try several orderings, placing the variables which are known to respond most strongly to contemporaneous events at the bottom of the ordering list (Gordon and King, 1982). In the systems we estimate, the variables are ordered as OIL, M, Y, U, and W_p (or W_c), and M, Y, $PROD$, U, and W_p (or W_c). In all systems several orderings were tried and yielded very similar impulse responses.

The impulse responses of output, unemployment and the product wage to an unanticipated one standard deviation shock in the relative price of oil in the basic system 1 are given in Figs 1(a)–(c). One standard deviation bands around the impulse responses are obtained by Monte Carlo simulations. Output starts declining after two quarters following the shock, reaching a minimum after two years. It then starts rising and returns to its steady-state level. The response of unemployment reveals the negative nature of the output–unemployment correlation. Unemployment initially rises sharply, reaching its maximum level in seven quarters. Thereafter it declines, and eventually returns to its initial level. Finally, the shock in the relative price of oil reduces the real wage rate. The real wage rate declines abruptly after the shock, and it returns to the pre-shock level after three years. These results clearly indicate the procyclicality of real wages, that is, the negative (positive) correlation between unemployment (output) and real wages which is the result of a negative supply shock.

The impulse responses of output, unemployment and the product wage to a one standard deviation shock in money in the same system are presented in Figs 1(d)–(f). A positive demand shock leads to an increase in output and a decrease in unemployment for about 10 periods. Although the product wage declines below its initial level following the shock in money, this response is not significant at the beginning as the band includes both positive and negative values. However, after the 17th period the real wage stays significantly in the negative region. Hence, a demand shock, exemplified by an unexpected increase in money supply, leads to countercyclical behaviour; i.e. a negative (positive) relationship between the product wage and output (unemployment).

In our second system where the product wage is replaced by the consumption wage, the responses of output and unemployment to a shock in the relative price of oil and in money (not shown) are virtually the same as those illustrated in Figs 1(a), 1(b) and 1(d), 1(e).[7] The responses of the consumption wage to a shock in the relative price of oil and in money are presented in Figs 2(a) and 2(b) respectively. Following the adverse supply shock, the consumption wage demonstrates procyclical behaviour and declines below its initial level. After the disturbance in money, the real wage rate increases above its preshock level for three periods. The absolute size of the movement in real wage in this case is relatively smaller than the one following a shock in the

[6] χ^2 statistic is equal to $T\{\ln|R|-\ln|U|\}$, where $|R|$ and $|U|$ are the determinants of the restricted and unrestricted variance–covariance matrices. The degrees of freedom is the number of restrictions.

[7] The figures which are not reported are available from the authors upon request.

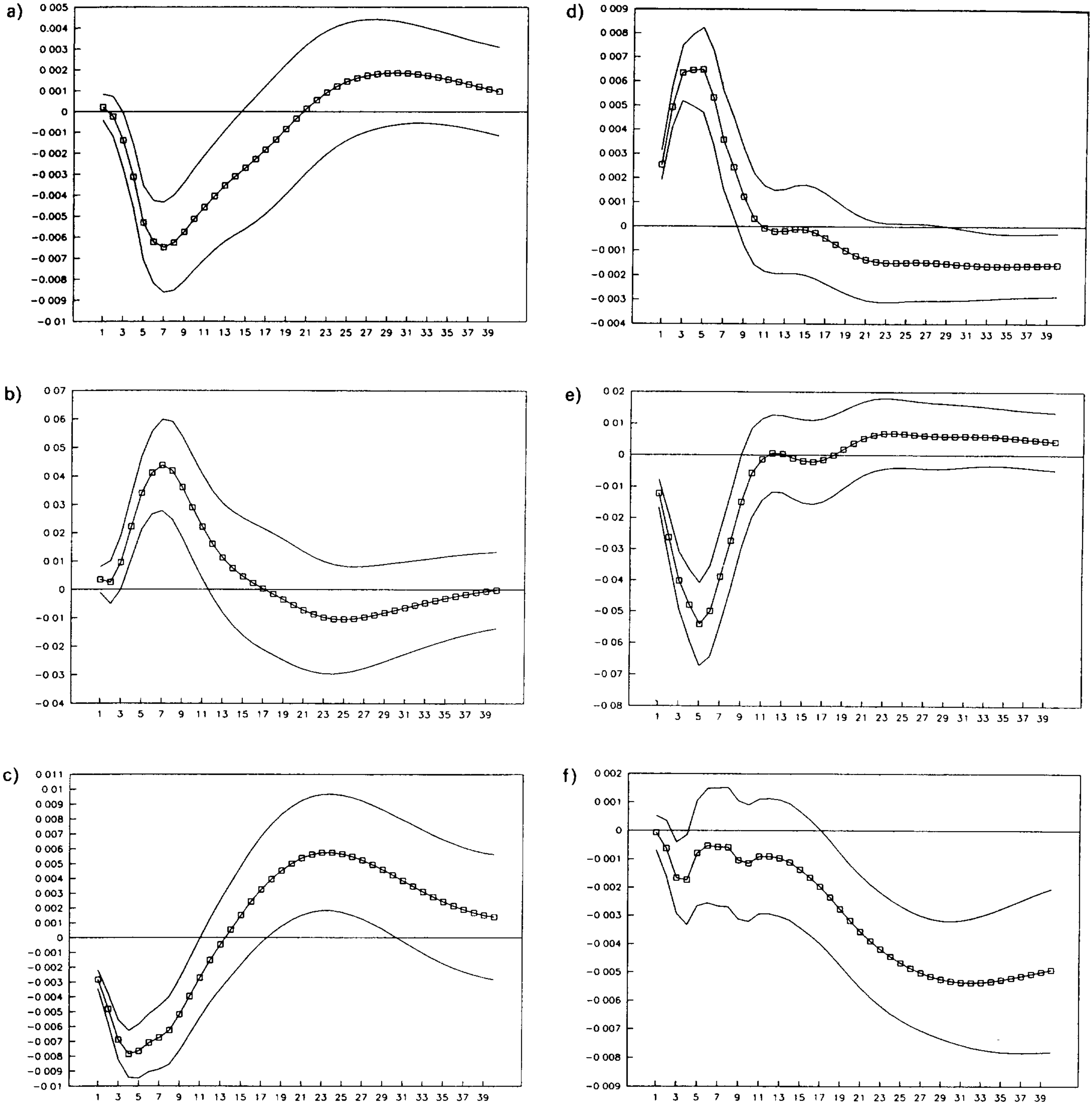

Fig. 1. *(a–c) Shock to the relative price of oil. System: OIL, M, Y, U, Wp. a)* □ *=output. b)* □ *=unemployment rate. c)* □ *=product wage. (d–f) Shock to money. System: OIL, M, Y, U, Wp. d)* □ *=output. e)* □ *=unemployment rate. f)* □ *=product wage.*

relative price of oil. Moreover, this response of the consumption wage is not significant as indicated by the band. Once again the response of the real wage rate to a supply shock generates procyclicality. The demand shock, on the other hand results in a weak and not significant consumption wage and output (unemployment) relationship.

The dynamic effects of a favourable supply shock are characterized in Figs 3(a)–(c). The system now includes

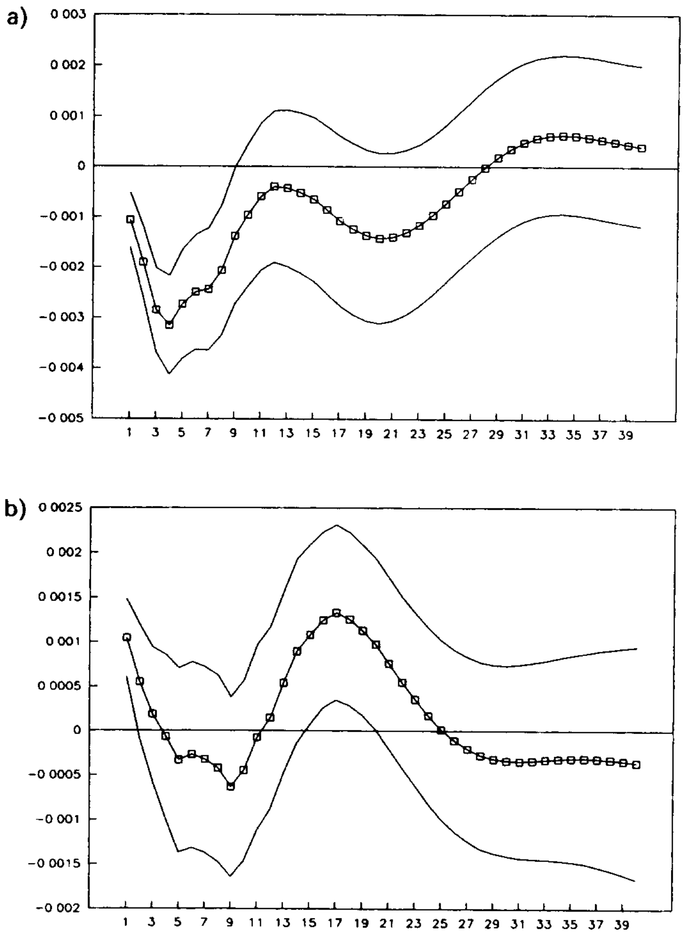

Fig. 2. *a) Shock to the relative price of oil. b) Shock to money. System: OIL, M, Y, U, Wc; □ = consumption wage.*

productivity in place of relative price of oil, along with money, output, unemployment and the product wage. A one standard deviation shock in productivity generates an increase in output after the third quarter. In the case of unemployment, we see that it initially rises above its pre-shock level. After the fifth quarter, the unemployment rate declines below its initial level and stays there for nine quarters. Blanchard and Quah (1989, p. 663) who report the same behaviour of unemployment, attribute the initial increase in unemployment to nominal rigidities. They entertain the hypothesis that '... (following an increase in productivity), aggregate demand does not initially increase enough to match the increase in output needed to maintain constant unemployment'. As Fig. 3(c) demonstrates, the real wage rises after the shock in productivity. Thus, a favourable supply shock, like an unfavourable one, leads to the procyclicality of real wages. The impulse responses of output, unemployment and product wage to a monetary shock in this system, which are not reported, are almost the same as those given in Figs 1(d)–(f).

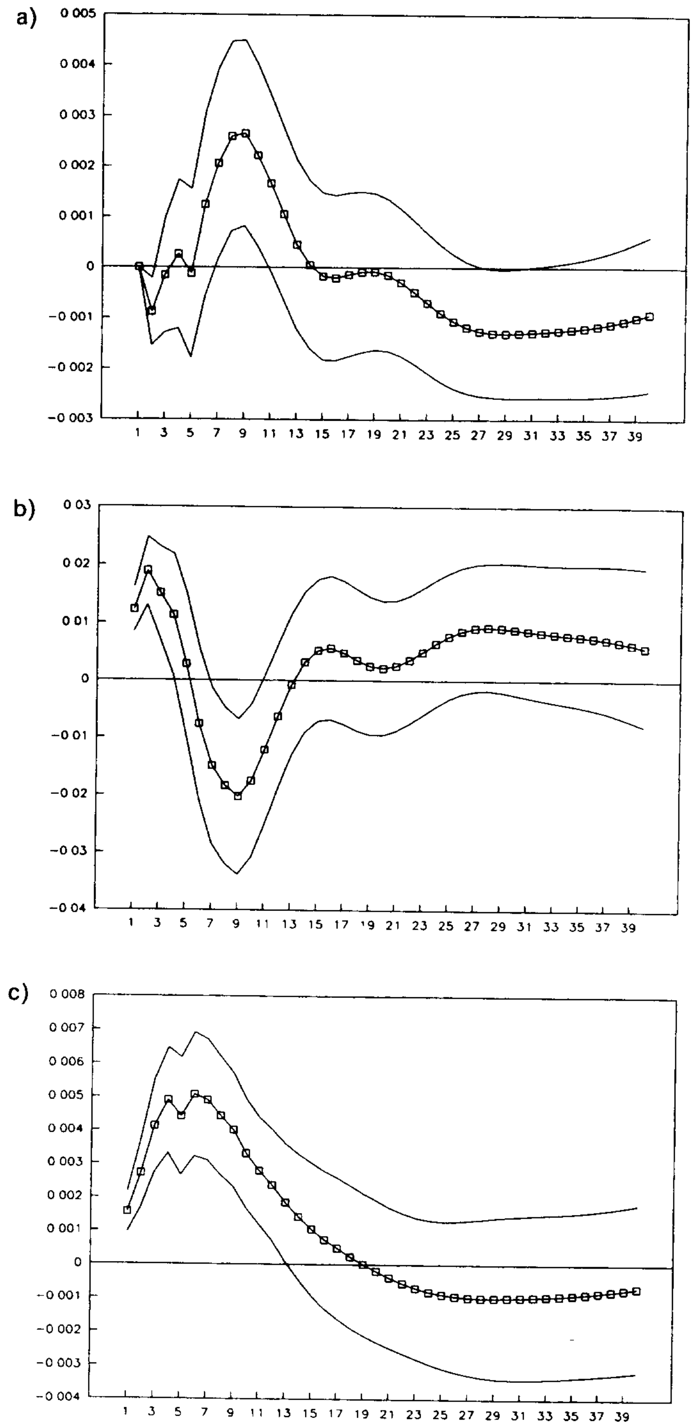

Fig. 3. *Shock to productivity. System: M, Y, PROD, U, Wp. a) □ = output. b) □ = unemployment rate. c) □ = product wage.*

Our fourth and final system consists of the consumption wage along with productivity, money, output and unemployment. Figure 4 shows the reaction of the consumption wage to a shock in productivity. The other impulse response functions obtained in this system are not different from their counterparts in systems 1 to 3, hence are not

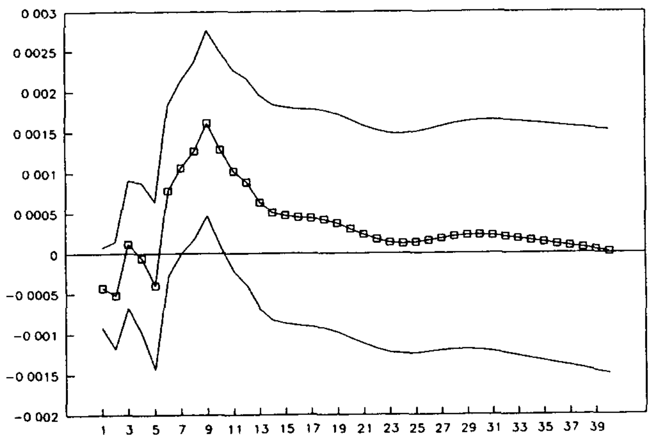

Fig. 4. *Shock to productivity. System: M, Y, PROD, U, Wc.* □ = *consumption wage.*

reported here. An increase in productivity generates procyclical consumption wage, but the response is not significant given that the confidence band contains both positive and negative regions.

To sum, irrespective of whether one uses the consumption wage or the product wage as the real wage measure, both favourable and unfavourable supply shocks produce procyclical behaviour in real wages. A demand shock on the other hand generates countercyclical real wages even though in most cases that behaviour is not significant. Our results are in agreement with those of a study by Sumner and Silver (1989) with the exception that the procyclicality of the product wage and the countercyclicality of the consumption wage are significant in that study.[8]

IV. CONCLUSION

The question of whether real wages are procyclical or countercyclical has preoccupied economists since Keynes. Most recent studies, which have found conflicting evidence have added to the uncertainty surrounding this question. In this paper using vector autoregressions we demonstrate that the cyclicality of real wages depends on the source of the disturbances. In particular, we show that the shocks in aggregate supply, represented by the relative price of oil and productivity, produce procyclical real wages whether the nominal wage is deflated by the wholesale price index of industrial goods or the consumer price index. On the other hand, shocks in aggregate demand, represented by money supply, generate countercyclical but mostly insignificant behaviour of real wages.

Our results postulate that the cyclicality of real wages depends on the type of the shock which generates the cycle. Thus, they yield insights into the conflicting findings of previous studies which have employed different sample periods that may have been dominated by different types of shocks.

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[8]Sumner and Silver (1989) depart from the premise that aggregate demand shifts must be associated with a procyclical inflation rate. It follows that real wages should be countercyclical during periods in which the correlation between the inflation rate and the unemployment rate is negative, assuming sticky nominal wages. On the other hand, real wages should be procyclical during periods dominated by supply shocks, i.e. during periods in which the above-mentioned correlation is positive.

They divide the 1900–1985 period into two subsamples, the first consisting of years during which the first differences of inflation and unemployment have the opposite sign, and the second consisting of years during which they have the same sign. Using OLS regressions they find countercyclical real wages in the first sample, and procyclical real wages in the second one.

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