A Traditional Interpretation of Macroeconomic Fluctuations

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Under the traditional interpretation of macroeconomic fluctuations, aggregate demand shocks move output and prices in the same direction, while aggregate supply shocks move output and prices in opposite directions. This paper examines the joint behavior of U.S. output, unemployment, prices, wages, and nominal money and asks whether it is consistent with this interpretation. The answer is a qualified yes.

The traditional interpretation of macroeconomic fluctuations—which I shall for concreteness but with some semantic qualms, refer to as the Keynesian model—relies on a conceptual framework made of two blocks, "aggregate demand" and "aggregate supply." Aggregate demand characterizes the behavior of the aggregate demand for goods given prices. Aggregate supply characterizes the behavior of prices given output, and includes a relation between unemployment and output—"Okun's law"—, a wage-setting equation—the "Phillips curve"—and a price-setting equation.

In that framework, in the short run, aggregate demand shocks move output and prices in the same direction, while supply shocks move them in opposite directions. Over time, the effects of aggregate demand shocks are reflected mostly in prices and wages, not in output. Aggregate supply shocks, which include shocks to productivity, are more likely to have long-run effects on output. Thus, movements of output are dominated by demand shocks in the short run, and by supply shocks in the long run.

While this framework remains dominant in textbooks as well as in macroeconometric models, it has come under heavy criticism. It has been accused of being theoretically flawed. More importantly perhaps, it has been accused of being empirically flawed, of not capturing important aspects of the data. Large macroeconometric models, the argument goes, have been constructed equation by equation, each of them estimated under strong and "incredible" identification restrictions (Christopher Sims, 1980). Nothing in the process of construction guarantees that the resulting collection of equations captures the major characteristics of the joint process of macroeconomic variables, that the story that they articulate is actually consistent with the data.

This paper examines this second criticism. It examines the joint behavior of U.S. output, unemployment, prices, wages, and nominal money and asks whether it is consistent with the traditional interpretation of fluctuations. The answer is a qualified yes. While there may well be other interpretations of the joint behavior of those major macroeconomic variables, their joint process can be interpreted as resulting from the dynamic effects of various demand and supply disturbances through the channels characterized in the Keynesian model. The rest of the paper documents and qualifies this proposition.

Section I lays down the basic approach, which is to estimate the joint process followed by the five variables, and to give it a structural interpretation by use of a set of

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just-identifying restrictions. Section II discusses the specific set of identification restrictions used in the paper. Section III gives the results of estimation and the characteristics of the estimated structural equations. Section IV gives and discusses the structural impulse responses, the response of the five variables to the structural disturbances. Section V relates the results to those of other recent econometric decompositions of macroeconomic fluctuations. Section VI concludes by pointing out successes as well as puzzles.

I. The Basic Approach

I consider the behavior of five variables, the logarithm of output, Y, the rate of unemployment, U, and the logarithms of the price level, P, of the wage level, W and of nominal money, M.[1]

I assume that the economy is described by a system of five equations, an aggregate demand equation (AD for short) giving the demand for goods given nominal prices and determining output, a relation between output and unemployment (OL for Okun's law), price-setting (PS) and wage-setting (WS) equations giving the behavior of nominal prices and wages, respectively, and a money rule (MR) giving the behavior of nominal money.

I assume the existence of five structural disturbances, autonomous shocks to aggregate demand, shocks to labor supply and technology, called for short supply shocks, shocks to price and wage setting, and shocks to nominal money. White-noise innovations to those disturbances are denoted e_d, e_Θ, e_p, e_w, and e_m, respectively, and are assumed to have zero cross-correlation.

Through the five equations, which form the propagation mechanism, the disturbances generate the dynamics of output, unemployment, prices, wages, and money. I assume the structural model has the following form:

$$(1)\quad AX = A(L)X(-1) + BZ + Ce$$
$$V(e) = D.$$

X is the vector of variables $[Y, U, P, W, M]'$, e is the vector of innovations to the structural disturbances, $[e_d, e_\Theta, e_p, e_w, e_m]'$. Z is a vector of deterministic variables, to be defined later. $A(L)$ is a matrix polynomial of order n. A, B, C are matrices of full rank. By normalization, the diagonal elements of A and C are equal to unity. The covariance matrix of the structural innovations is denoted by D which, given the assumption of zero correlation across innovations, is diagonal.

Contemporaneous interactions are captured by both the matrix A and the matrix C. The matrix A captures interactions between endogenous variables. To the extent that C differs from the identity matrix, the model allows for direct effects of innovations on other variables than those on the left-hand side of the structural equation. The normalizations on A and C are conventional: they associate each structural equation with a natural left-hand side variable, as well as with a structural disturbance, which has a coefficient of one in the equation.

Premultiplying both sides of (1) by A^{-1} gives the reduced form associated with the structural model:

$$(2)\quad X = A^{-1}A(L)X(-1) + A^{-1}BZ + A^{-1}Ce,$$

or defining matrices appropriately,

$$(3)\quad X = F(L)X(-1) + GZ + x,$$

where x is the vector of reduced-form innovations $[y, u, p, w, m]$. From equations (2) and (3), reduced-form innovations are related to structural innovations by:

$$(4)\quad Ax = Ce,$$

where from (1), $V(e) = D$.

[1]In his paper advocating the use of small VAR systems as data descriptors, Sims (1980) considers the behavior of a set of 6 variables, which includes the 5 variables used here and the logarithm of an import price, PM. I shall indicate similarities and differences in assumptions and results along the way.

The reduced form (3) summarizes the sample information about the joint process of the X variables. To go from the reduced from to the structural model, one needs a set of identifying restrictions on A and C. Given those restrictions, one can recover the structural equations, as well as the structural innovations.

The basic approach of this paper can now be stated more formally. I first estimate the reduced form (3). I specify the set of restrictions on A and C underlying the Keynesian model. I derive the class of structural models consistent with the reduced form evidence and the set of restrictions on A and C, and characterize the dynamic effects of the structural disturbances so obtained.

Before turning to the discussion of identification restrictions in the next section, I briefly take up two related issues.

The basic approach is similar to that used by Ben Bernanke (1986), Olivier Blanchard and Mark Watson (1986), Christopher Sims (1986), and John Taylor (1986). It has evolved from and is closely related to the VAR methodology. Like the VAR methodology, it estimates the unconstrained reduced form summarizing the joint process and uses a set of just-identifying restrictions to go from the reduced-form innovations to a set of uncorrelated structural innovations. Unlike that methodology however, the identifying restrictions are made explicit, and are given structural interpretations. By contrast, orthogonalization of reduced-form innovations through a Choleski decomposition, as in Sims (1980) is an implicit assumption that, in the structural model, $C^{-1}A$ is lower triangular, an assumption satisfied for example if C is diagonal and A is lower triangular. Those assumptions have in general no particular economic rationale.

The identifying restrictions used below are direct restrictions on the contemporaneous, short-run effects of innovations on the X variables. Recent research has exploited a different set of restrictions, long-run restrictions on the dynamic effects of the innovations on the X variables. For example, Olivier Blanchard and Danny Quah (1989), and Matthew Shapiro and Mark Watson (1988) assume that demand disturbances have no long-run effect on output. Jordi Gali (1988) and Sung In Jun (1988) use combinations of short-run and long-run restrictions. As long as these restrictions are not overidentifying, the same two-step approach can be used, with estimation of the unconstrained reduced form in the first stage. Long-run restrictions then impose restrictions across A and C, and the estimated coefficients of $F(L)$ in the reduced form. Such long-run restrictions are often appealing from a theoretical viewpoint; they rely however heavily on the low frequency characteristics of the time-series, and identification is more sensitive to the treatment of trend. I do not use them in this paper. In Section V, I compare the results obtained here to the results in the papers mentioned above.

II. Identification

In this section, I specify the identification restrictions which I take to capture the spirit of the Keynesian model.

Consider the following set of restrictions on the relation between reduced-form and structural innovations, equation (4):

$$
\begin{aligned}
(5)\qquad &(\mathrm{AD}) && y = && + c e_{\Theta} && + e_d,\\
&(\mathrm{OL}) && u = a_{21} y && && + e_{\Theta},\\
&(\mathrm{PS}) && p = a_{34} w + a_{31} y && + c_{32} e_{\Theta} && + e_p,\\
&(\mathrm{WS}) && w = a_{43} p + a_{42} u && + c_{42} e_{\Theta} && + e_w,\\
&(\mathrm{MR}) && m = a_{51} y + a_{52} u + a_{53} p + a_{54} w && && + e_m.
\end{aligned}
$$

Assume, to start with, that c in the first equation is equal to zero (c should be denoted c_{12}. As this parameter plays an important role, I drop the index for notational simplicity). The set of restrictions has then the following interpretation:

Innovations in output are entirely attributed to demand innovations, e_d. In Okun's law, innovations in unemployment given output are attributed to supply innovations, e_Θ. These innovations reflect either changes in productivity which affect employment given output, or changes in the labor force which affect unemployment given employment. Direct evidence on employment, the labor force, and output suggests that innovations to productivity play the dominant role in this composite disturbance.[2]

The price-setting equation allows price innovations to depend on wage and output innovations. It also allows prices to depend directly on supply innovations, which, to the extent that they reflect changes in productivity, affect unit labor costs. Finally, prices depend on the price-setting innovation, which reflects such factors as changes in markups, or changes in prices of other inputs not included in the system.

The wage-setting equation allows wage innovations to depend on price and unemployment innovations. It also allows wages to depend directly on supply innovations, as would be the case under most models of wage determination. Finally wages depend on the wage-setting innovation, which reflects such factors as changes in bargaining power, changes in taxation, composition effects, and so on.

Finally, nominal money innovations are allowed to respond to innovations in all variables, as well as to a money innovation. The money innovation is also a composite innovation: unless money supply is completely interest inelastic within the quarter, an implausible assumption, the money innovation will reflect both money demand and money supply innovations.[3]

The covariance matrix of the reduced form contains 15 independent moments. A count of unknown parameters—still imposing $c = 0$—yields 11 parameters and 5 standard deviations for the structural innovations. Thus, we are still one restriction short of identification. The Keynesian model however suggests a narrow range of values for either a_{34} and a_{43}, the contemporaneous effects of wages on prices, and of prices on wages. Given either a_{34} or a_{43}, the structural model is just identified and can be recovered from the data.[4] (How this is actually done will be described in the next section).

This, however, takes c to be equal to zero, productivity shocks to have no direct effect on demand and thus on output within the quarter. Given the recent set of results which emphasize the importance of productivity shocks even for short-run fluctuations, I want to allow for a direct effect of productivity shocks on aggregate demand. This may be the case if a favorable productivity shock leads to anticipations of higher income (as will be shown to be the case below) and leads to increased consumption, or if a favorable productivity shock is associated with higher investment.[5] We have little guidance

[2]Let 1, n, and y be the unexpected components of the logarithms of the labor force, employment, and output, defined as the residuals from regressions on lagged X's, lagged values of L and N, and on Z. The residual of the regression of n on y, which can more properly be interpreted as a productivity innovation has a variance of 0.13×10^{-4}. The residual of the regression of 1 on n, which can be interpreted as a labor supply innovation has a variance of 0.04×10^{-4}, thus three times smaller. To deal separately with labor supply and productivity disturbances would require increasing the size of the system to allow for both the labor force and employment. This is beyond the scope of this paper.

[3]Disentangling money demand and money supply innovations requires the introduction of the nominal interest rate as an additional variable in the system; this is again beyond the scope of this paper. Gali (1988) considers the joint behavior of output, nominal rates, prices, and money, and concludes that money supply innovations dominate money demand innovations in terms of their contribution to movements in money and output. The results below are consistent with his results.

[4]The fact that there are as many unknowns as independent moments in the covariance matrix of the reduced-form disturbances is clearly only a necessary condition for identification of all unknown parameters. Some parameters could be overidentified, while some remain unidentified. In the case presented in the text however, the set of restrictions yields just identification of all unknown parameters.

[5]The notion however that productivity shocks, defined as innovations in employment given output, come

as to the range of values for c. I therefore estimate the model under alternative values of c over a wide range. Note that alternative values of c affect only the identification of the structural demand and supply innovations, not the identification of the other three structural innovations. For a given value of c, identification proceeds as described in the previous paragraph.

Does this set of identifying restrictions do justice to the traditional approach? Probably not. The implicit assumption that many of the coefficients in (5) are equal to zero is surely too strong. In particular, real money balances may well affect aggregate demand within the quarter, and so may real wages, through income distribution effects on consumption, or through investment. But these effects are usually taken to be small; for example, the within-quarter elasticity of output to real money balances in the MPS model is less than 15 percent (Franco Modigliani, 1971). I have therefore also looked at a wide set of structural models obtained under assumptions that some of the coefficients in (5) are close but not equal to zero. Some of those results are reported in the next section. The general finding is that, given the basic interpretation of the data and identification restrictions in (5), these variations make little difference to the results.

I again end this section by taking up two related issues.

There is an obvious arbitrariness to any set of identification restrictions, and the discussion above is no exception. That discussion stands in contrast with the simplicity of the VAR approach and its alternative recursive orderings.[6] But, as emphasized in the previous section, orderings are implicit identification assumptions. They evade, rather than confront, the issue of identification.

The set of restrictions specified above is very different from those which would be imposed under alternative interpretations of fluctuations. Under a flexible price, real business cycle approach, the innovation of output for example would be interpreted as reflecting in large part the sum of productivity and labor supply innovations, rather than demand innovations as here.

III. Estimation

In this section, I discuss the choice of data, the issues associated with the differencing of time-series, the implications of alternative identification restrictions in equation (5), and, finally, the set of structural equations obtained under a particular set of restrictions.

A. *The Choice of Data*

The period of estimation is 1965:1 to 1986:4. U is the overall unemployment rate, Y is the logarithm of real GNP, M is the logarithm of $M1$. W is the logarithm of the hourly earnings index for the private nonfarm sector (which is available only post-1964 and thus determines the length of the sample), and P is the logarithm of the PCE deflator.

The choice of W and P requires comments. The manufacturing wage, which is available for a longer period of time, is often used instead of the larger index used here. The two wage series turn out to have very different time-series behavior (see Blanchard, 1987). For example, they are not cointegrated. Also, the manufacturing wage responds to the price level much faster than the wider index. Some of the differences

as surprises to firms which then proceed to invest more, is clearly naive. What is a productivity shock to the econometrician is likely to be largely the result of prior decisions by firms or the result of changes in the composition of output across sectors. To the extent that high investment demand antedates the increase in productivity, what the model identifies as demand innovations will reflect in part productivity innovations.

[6]Sims (1980) uses the ordering M, Y, U, W, P, PM. Under our structural interpretation of the joint process, this corresponds to the assumption that there is no feedback from other variables to money during the quarter, that aggregate demand is affected only by money and demand innovations within the quarter, that unemployment is affected by output innovations and supply shocks and so on.

across results on the pro- or countercyclical behavior of real wages in the literature can be traced to the choice of the wage series.[7] The PCE deflator is used in preference to the CPI; the differences when the CPI is used however are minor.

In addition to those variables, I allow for a set of Z variables which includes a set of seasonal dummies, and a set of wage price control dummies, which have been found by others to have important effects on wage and price behavior (Robert Gordon, 1983). The values of the dummies are proportional to the number of days during the quarter for which a particular set of guidelines was in force.

B. *Levels or First Differences?*

I take as a null hypothesis the hypothesis that U is stationary, possibly around a deterministic trend, and that $\Delta Y, \Delta M, \Delta P, \Delta W$ are stationary, also possibly around time trends. This null hypothesis is based in part on theoretical considerations. It is a maintained assumption of most of macroeconomics that unemployment is a stationary series, and while others and I have challenged this assumption elsewhere, I shall maintain it here. I also find plausible that productivity, and thus output, also have a unit root.

Standard tests for stationarity confirm the results of Schwert (1987) that the null hypothesis stated above is consistent with the data. The data cannot reject that unemployment is stationary around a deterministic trend, that output is integrated of order 1, with perhaps a decrease in the average rate of growth from the early 1970s, that money, prices, wages are also integrated of order 1, with a deterministic trend in the rate of change of all three series. But as is also well known, the data cannot reject other null hypotheses. In particular, the hypotheses that unemployment is nonstationary, that output is stationary around trend, that price and wage inflation themselves are nonstationary cannot be rejected by the data in my sample. Thus, the results below must be seen as dependent on a priori assumptions on the time-series properties of the series. I return to these issues at various points below.

Taking as given the null hypothesis, I check for cointegration of Y, M, P, and W. The tests of cointegration between subsets of the four variables, allowing or not for a time trend in the cointegrating regression, show no evidence of cointegration.[8]

These preliminary tests lead me to specify the system as a system in $(\Delta Y, U, \Delta P, \Delta W, \Delta M)$ allowing for a linear time tend as one of the variables in Z. As allowing for an unconstrained time trend in each equation may be too generous, I have examined two alternative specifications. In the first, I first regress U on a constant and a time trend, regress ΔP, ΔW, and ΔM on a common constant and a common time trend, and ΔY on a constant and a dummy for 1973 on, which allows for a change in the average rate of growth. I then use the residuals from those regressions in estimation of the structural model, which no longer includes time as an explanatory variable. This leads essentially to no change in either the estimated structural equations or the structural impulse responses. In the second specification, I assume—I believe incorrectly—that there is no time trend in any of the equations. This leads to some drastically different results, which I shall mention below.

To summarize, the structural model, (1), is specified as a system in $(\Delta Y, U, \Delta P, \Delta W, \Delta M)$. On the basis of likelihood tests on the reduced form, the order of $A(L)$ is chosen to be 3. Increasing the order to 4, which can potentially capture non-additive seasonality, makes little difference to the estimated structural model and impulse responses. The set of Z variables includes a constant, seasonal dummies, wage price control dummies, and a linear time trend.

[7] This also explains some of the differences between the results in this paper and those in Blanchard (1986).

[8] More specifically, augmented Dickey-Fuller statistics are, in all cases, below the 5 percent critical values computed by Robert Engle and Byung Sam Yoo (1987). See Jun (1988) for an extended economic and econometric discussion of cointegration in the context of a similar model.

TABLE 1—ESTIMATED CONTEMPORANEOUS EFFECTS UNDER ALTERNATIVE IDENTIFICATION RESTRICTIONS[a]

Alternative Values of the Effects of Supply Shocks on Aggregate Demand			
(1) $c = 0.00$; $a_{34} = 0.10$			
$y =$		$+ e_d$;	$\sigma(e_d) = 0.69 \times 10-2$
$u = -0.18y$		$+ e_\Theta$;	$\sigma(e_\Theta) = 0.17 \times 10-2$
$p = (0.10)w + 0.06y$	$-0.20e_\Theta$	$+ e_p$;	$\sigma(e_p) = 0.27 \times 10-2$
$w = 0.14p - 0.14u$	$-0.05e_\Theta$	$+ e_w$;	$\sigma(e_w) = 0.16 \times 10-2$
$m = 0.01p + 0.18w + 0.02y - 0.05u$		$+ e_m$;	$\sigma(e_m) = 0.35 \times 10-2$
(2) $c = 1.00$; $a_{34} = 0.10$			
$y =$	$+(1.0)e_\Theta$	$+ e_d$;	$\sigma(e_d) = 0.67 \times 10-2$
$u = -0.24y$		$+ e_\Theta$;	$\sigma(e_\Theta) = 0.18 \times 10-2$
$p = (0.10)w + 0.08y$	$-0.20e_\Theta$	$+ e_p$;	$\sigma(e_p) = 0.27 \times 10-2$
$w = 0.14p - 0.16u$	$-0.04e_\Theta$	$+ e_w$;	$\sigma(e_w) = 0.16 \times 10-2$
$m = 0.01p + 0.18w + 0.02y - 0.05u$		$+ e_m$;	$\sigma(e_m) = 0.35 \times 10-2$
(3) $c = 2.00$; $a_{34} = 0.10$			
$y =$	$+(2.0)e_\Theta$	$+ e_d$;	$\sigma(e_d) = 0.50 \times 10-2$
$u = -0.42y$		$+ e_\Theta$;	$\sigma(e_\Theta) = 0.23 \times 10-2$
$p = (0.10)w + 0.11y$	$-0.20e_\Theta$	$+ e_p$;	$\sigma(e_p) = 0.27 \times 10-2$
$w = 0.14p - 0.18u$	$-0.04e_\Theta$	$+ e_w$;	$\sigma(e_w) = 0.16 \times 10-2$
$m = 0.01p + 0.18w + 0.02y - 0.05u$		$+ e_m$;	$\sigma(e_m) = 0.35 \times 10-2$
Positive Effect of Real Money Balances on Aggregate Demand			
(4) $c = 0.00$; $a_{34} = 0.10$			
$y = (0.20)m - (0.20)p$		$+ e_d$;	$\sigma(e_d) = 0.65 \times 10-2$
$u = -0.18y$		$+ e_\Theta$;	$\sigma(e_\Theta) = 0.17 \times 10-2$
$p = (0.10)w + 0.09y$	$-0.20e_\Theta$	$+ e_p$;	$\sigma(e_p) = 0.27 \times 10-2$
$w = 0.14p - 0.14u$	$-0.06e_\Theta$	$+ e_w$;	$\sigma(e_w) = 0.16 \times 10-2$
$m = 0.00p + 0.18w - 0.02y - 0.05u$		$+ e_m$;	$\sigma(e_m) = 0.36 \times 10-2$
Larger Effect of Nominal Wages on Prices			
(5) $c = 0.00$; $a_{34} = 0.30$			
$y =$		$+ e_d$;	$\sigma(e_d) = 0.69 \times 10-2$
$u = -0.18y$		$+ e_\Theta$;	$\sigma(e_\Theta) = 0.17 \times 10-2$
$p = (0.30)w + 0.06y$	$-0.15e_\Theta$	$+ e_p$;	$\sigma(e_p) = 0.27 \times 10-2$
$w = 0.07p - 0.17u$	$-0.04e_\Theta$	$+ e_w$;	$\sigma(e_w) = 0.16 \times 10-2$
$m = 0.01p + 0.18w + 0.02y - 0.05u$		$+ e_m$;	$\sigma(e_m) = 0.36 \times 10-2$

[a] Coefficients in parentheses are fixed a priori to achieve identification.

C. *Identification Restrictions and Estimated Contemporaneous Responses*

In the first stage, I estimate the reduced form, (3), associated with this model. I then use the restrictions introduced in the previous section to recover A and C, and to go from the reduced-form innovations to the structural innovations. There is little point in presenting the results of estimation of the reduced form, of the VAR. I thus go directly, in Table 1, to the estimates of A and C obtained under alternative identification restrictions. The method of estimation of A and C depends on the set of identifying restrictions. If for example c is equal to zero, one can use instrumental variables: the first equation gives the demand innovation, which can be used as an instrument to estimate Okun's law and obtain the supply innovation. These two innovations can then be used as instruments in the price equation. Together with the estimated price innovation, they can be used in the wage equation. Finally, the four innovations can be used as instruments in the money rule. When c is different from zero, the instrumental variable approach can no longer be used, and I use a method of moments, as in Bernanke (1986).

The first three panels of Table 1 examine the effects of alternative values of the direct effect of supply innovations on aggregate demand, c. I consider three values for c, 0, 1, and 2. The value of 0 is a logical lower bound: The value of 2 is surely a generous upper bound: This can be seen as follows: Given this value, the structural impulse responses imply that a supply innovation of 1 percent has an effect on output of 2 percent in the short run (by assumption), which decreases to 1.3 percent in the long run. Thus, we would expect at most an increase of, say, 1.5 percent in consumption. Assuming unchanged government spending, for aggregate demand to increase by 2 percent investment would have to increase by at least 8 percent, which is very large indeed. An alternative way of thinking about the value of c is that for $c = 2$, innovations in GNP are attributed in roughly equal proportions to supply and to demand innovations. (This can be seen from the standard deviations of e_d and e_Θ given in Table 1 for this case). A value of 1 for c instead implies that supply innovations account only for roughly 6 percent of the variance of the output innovation. In all three panels, the effect of wages on prices, a_{34}, is assumed to be equal to 0.1. I take this value from my empirical work on disaggregated price equations at a monthly frequency (Blanchard, 1987).

For all three values of c, all estimated coefficients have signs consistent with traditional priors, except for the small negative effect of supply shocks on nominal wages. The elasticity of unemployment to output varies between -0.18 and -0.45. The coefficient increases, in absolute value, with the assumed direct effect of supply shocks on aggregate demand. Put another way, if productivity shocks affect output within the quarter, an OLS regression of unemployment on output overestimates the value of Okun's coefficient. Estimates in other equations are nearly invariant to the assumed value of c. Prices depend positively on output, negatively on productivity. Wages depend positively on prices, negatively on unemployment, and negatively on productivity. An increase in the unemployment rate of 1 percent decrease wages by 0.16 percent on average within the quarter. The money rule does not yield any strong effect of either prices, wages, output, or unemployment.

The last two panels of Table 1 examine the effects of alternative assumptions. Panel 4 assumes that the contemporaneous elasticity of output to real money balances is equal to 0.2 rather than 0. As can be seen, this makes little difference to the estimated coefficients or standard deviations. The effect of output on prices decreases slightly, and so does the effect of output on money. Panel 5 assumes that the effect of wages on prices is equal to 0.3 rather than 0.1. This also makes little difference to the estimates, decreasing —not surprisingly—the estimated effect of prices on wages.

The similarity of estimated contemporaneous responses under alternative identification assumptions does not logically carry over to the rest of the structural model, to structural impulse responses for example. But in fact, impulse responses turn out to be very similar for a large set of identification restrictions. The only coefficient which affects structural impulse responses substantially is c. Thus, in what follows, I report a complete set of results only for one benchmark case, the case reported in panel 2, and discuss in the text the effects of alternative identification restrictions.

D. *The Estimated Structural Model*

Using the A and C matrices given in panel 2, and the estimated reduced form, we can easily recover the structural model given by equation (1). This is done by premultiplying the reduced form by A and by using $Ax = Ce$ to recover e.

The estimated structural model so obtained is summarized in Table 2. To make results easier to relate to existing specifications for those equations, rather than to present the structural equations as giving the

TABLE 2—STRUCTURAL MODEL; ESTIMATES

		Aggregate Demand			$\sigma_d = 0.67-2$		
ΔY ON	ΔP	ΔW	ΔM	ΔY	U	$(\Delta P, \Delta W, \Delta M)$	$(\Delta Y, U)$
(LAGS)	1–3	1–3	1–3	1–3	0–3		
SUM	−0.29	−0.16	1.01	0.26	0.49		0.55
SF(SUM)	0.55	0.79	0.10	0.04	0.30−3	0.48	
SF(SET)	0.20	0.56	0.13	0.06	*	0.02	
		Okun's Law			$\sigma_\Theta = 0.18-2$		
U ON	ΔP	ΔW	ΔM	ΔY	U	$(\Delta P, \Delta W, \Delta M)$	$(\Delta Y, U)$
(LAGS)	1–3	1–3	1–3	0–3	1–3		
SUM	−0.02	0.03	−0.10	−0.46	0.98	−0.08	
SF(SUM)	0.84	0.80	0.37	0.2–6	0.2–16	0.50	
SF(SET)	0.17	0.69	0.41	0.2–15	0.53		
		Price Equation			$\sigma_p = 0.32-2$		
ΔP ON	ΔP	ΔW	ΔM	ΔY	U	$(\Delta P, \Delta W, \Delta M)$	$(\Delta Y, U)$
(LAGS)	1–3	0–3	1–3	0–3	0–3		
SUM	0.59	0.43	−0.13	−0.03	−0.08	0.90	
SF(SUM)	0.4−3	0.03	0.47	0.79	0.08	0.35	
SF(SET)	0.2−2	*	0.71	0.85	0.24	*	0.31
		Wage Equation			$\sigma_w = 0.19-2$		
ΔW ON	ΔP	ΔW	ΔM	ΔY	U	$(\Delta P, \Delta W, \Delta M)$	$(\Delta Y, U)$
(LAGS)	0–3	1–3	1–3	0–3	0–3		
SUM	0.27	0.68	−0.10	−0.07	−0.04	0.85	
SF(SUM)	0.01	0.01	0.38	0.44	0.10	0.28	
SF(SET)	0.4−1	0.9−5	0.74	0.84	0.29	0.1−15	0.46
		Money Rule			$\sigma_m = 0.43-2$		
ΔM ON	ΔP	ΔW	ΔM	ΔY	U	$(\Delta P, \Delta W, \Delta M)$	$(\Delta Y, U)$
(LAGS)	0–3	0–3	1–3	0–3	0–3		
SUM	−0.52	0.24	0.11	−0.06	−0.04	−0.17	
SF(SUM)	0.03	0.39	0.66	0.75	0.43	0.3−3	
SF(SET)	0.13	0.70	0.91	0.47	0.86	0.10	0.32

Notes on Table 2:

Period of Estimation: 65:1 to 86:4.

The notation "0.40−5" stands for 0.40×10^{-5}.

Other variables included in each regression, but not reported: constant term, linear time trend, seasonal dummies and wage price control dummies (see text). There are two dummies corresponding to wage price freezes, the first from August to November, 1971, and the second from June to August, 1973. There are three dummies corresponding to three control phases, from November 1971 to January 1973, from January to June, 1973, and from August 1973 to April 1974. Finally, there is a dummy for the period following decontrol, from May to June 1974.

"Lags" : lags for each variable. See text for details.
"σ" : standard deviation of the disturbance term.
"SUM" : sum of coefficients on each variable, or sets of variables.
"SF(SUM)": significance level of the test that the sum of coefficients on a variable is equal to 0, or to 1 in the case of own lags. In the case of $(\Delta W, \Delta P, \Delta M)$, the test is that the sum is equal to zero if the left-hand side variable is real, one if the right-hand side is nominal.
"SF(SET)" : significance level of the test that the set of coefficients on a variable, or set of variables, is equal to zero. Stars indicate cases where the value of one coefficient in the set is assumed a priori, so that the test is not appropriate.

left-hand side variable as a function of current and lagged variables and current disturbances, I express them as giving the left-hand side variable as a function of current and lagged variables and only that disturbance associated with that equation. More formally, I premultiply the structural model by C^{-1} in equation (1).

For each structural equation, I give the sum of the estimated coefficients on each endogenous variable, and the statistical significance of the sum and the set of coefficients on this variable. In the case of its own lagged values, the test is that the sum of coefficients on lagged values is equal to one, not zero. In some cases, the value of a coefficient on a specific variable has been set a priori so as to achieve identification; in this case, the test that the set of coefficients on that variable is equal to zero is not well defined.

Three main conclusions emerge from Table 2:

(1) Not surprisingly, relations between real variables and relations between nominal variables are much stronger statistically than relations between real and nominal variables.

(2) The structural equations have characteristics consistent with the Keynesian model:

Nominal money affects aggregate demand positively, while nominal prices do so negatively. The sets of coefficients on each variable are not however individually significant. The set of coefficients on all nominal variables is significantly different from zero at the 2 percent level. The sum of the coefficients on all nominal variables is poorly determined, but not significantly different from zero.[9]

In Okun's law, the sum of the weights on lagged unemployment is roughly equal to one, so that the relation is roughly a relation between rates of change of unemployment and rates of change of output. The long-run elasticity of unemployment to output (which cannot be derived from the table without more information) is equal to -0.45. Nominal variables have small and insignificant coefficients, individually or as a whole.

The price equation shows a significant effect of wages on prices. Nominal money is insignificant and the sum of coefficients on nominal variables is nearly equal to one. Real variables are insignificant, more so for output than for unemployment. If the equation is rewritten to allow for a contemporaneous effect of the supply shock and of the

[9]In Blanchard (1986), I showed that, if the processes generating nominal variables have a unit root, and estimation is done in levels, one may impose an homogeneity restriction on the reduced form, the restriction that a doubling of all nominal variables leaves all real variables unchanged. This in turn imposes that the sum of coefficients on nominal variables be equal to zero if the left-hand side variable is real, equal to one if the left-hand side variable is nominal. This does not necessarily extend to the case where estimation is done with some variables in first differences. (This contradicts, with apologies, Blanchard, 1987). A counterexample makes the point simply:

Consider the following price and wage equations:

$$P = W - \eta_\Theta$$

$$W = P(-1) + a(P(-1) - P(-2)) - bU + \eta_\Theta(-1) + \varepsilon_w,$$

where $\eta_\Theta = \eta_\Theta(-1) + \varepsilon_\Theta$; ε_w and ε_Θ white noise.

These equations have straightforward interpretations. The price is a fixed markup over labor cost. The price term in the wage equation is consistent with the wage depending on expected prices, and inflation following an AR(1) process, with coefficient a. The assumption that the wage adjusts to lagged productivity implies that while η_Θ is nonstationary, unemployment may still be stationary. The price and wage equations in levels satisfy the homogeneity restriction. Consider however the following transformation of those equations, eliminating lagged productivity from the wage equation:

$$\Delta P = \Delta W + \varepsilon_\Theta,$$

$$\Delta W = a\,\Delta P(-1) - bU + \varepsilon_w.$$

The wage equation—which looks very much like a standard Phillips Curve—no longer satisfies the homogeneity restriction.

TABLE 3—EFFECTS OF UNEMPLOYMENT ON AGGREGATE DEMAND

Coefficients on ΔY	$\Delta Y(-1)$	$\Delta Y(-2)$	$\Delta Y(-3)$	U	$U(-1)$	$U(-2)$	$U(-3)$	Σ
Reduced Form:								
0.00	−0.31	0.12	0.16	0.00	−1.38	2.65	−0.91	(0.36)
	(−1.97)	(0.79)	(1.28)		(−2.84)	(3.61)	(−1.81)	
Structural Model:								
0.24	−0.21	0.17	0.22	1.00	−2.49	2.89	−1.02	(0.42)
	(−1.42)	(1.20)	(1.78)		(−5.33)	(4.07)	(−2.12)	

Period of estimation : 65:1 to 86:4.

Other variables included in each regression, but not reported: constant term, linear time trend, seasonal dummies and wage price control dummies (see Table 2).

The "reduced form" reports the results of a regression of ΔY on lagged ΔY and U. Thus, the coefficients on ΔY and U are set equal to zero. The "structural model" reports the coefficients on ΔY and U in the estimated aggregate demand equation, in which the supply innovation has been eliminated. Thus, current U and ΔY appear as right-hand side variables, with constrained coefficients. The coefficient on U is c, which is assumed to be 1. The coefficient on ΔY is $-a_{21}c$, where a_{21} is obtained from estimation of the matrix A in Table 1, panel 2, and is equal to 0.24.

Σ: sum of coefficients on unemployment.

level of output—rather than a contemporaneous effect of output and unemployment—, there is stronger evidence of a positive effect of output on prices.

The wage equation shows a significant effect of prices on wages. Nominal money is again insignificant. The effect of unemployment on wages, the Phillips curve effect, is marginally significant. The sum of coefficients on nominal variables is less than one, but not significantly so.

The money rule shows few strong feedbacks from other variables to money. Only price inflation appears to have a negative effect on money growth.

(3) There is however one aspect of the structural model which does not easily fit the Keynesian model. It is the strong effect of unemployment in the aggregate demand equation: the Keynesian model does not lead one to expect such a strong effect, given lagged output. The set of coefficients on unemployment is significant at the 10^{-3} level, a level higher than for the coefficients on lagged output growth itself. Because this aspect of the data plays an important role in shaping the structural impulse responses below, the coefficients on lagged U and lagged ΔY are given in Table 3, both for the reduced-form output equation, and for the aggregate demand equation of the structural model. There are two important characteristics to the set of coefficients. The first is that unemployment lagged once has a large negative coefficient: low unemployment in the previous quarter, given past output growth implies higher output growth this quarter. The second is that the sum of coefficients is positive and significant: prolonged low unemployment, implies, *ceteris paribus*, lower output growth. Both characteristics are extremely robust.[10]

[10]Given its potential importance, I have explored at length the robustness of the result. The basic result is there in simpler specifications: in bivariate regressions of unemployment and output growth over the postwar period, unemployment strongly Granger-causes output growth. Within the model considered here, the result is robust to the alternative identification restrictions discussed earlier. Unemployment is not a proxy for the level of output: the result is robust to alternative treatments of trend, to the aggregate demand equation being estimated in levels for all variables including output. It does not appear to come from particular events: it is present across subsamples. When aggregate demand is decomposed between its components, fixed investment is the variable most Granger-caused by unemployment. Unemployment is not a proxy for capacity utilization; when capacity utilization is included, unemployment remains highly significant.

TABLE 4—VARIANCE DECOMPOSITIONS[a]

Output					
Proportion due to	Demand		Supply		
	e_d	e_m	e_Θ	e_p	e_w
1 Quarter Ahead	0.92	0.00	0.07	0.00	0.00
4 Quarters Ahead	0.85	0.09	0.04	0.01	0.00
	(0.07)	(0.01)	(0.01)	(0.02)	(0.01)
8 Quarters Ahead	0.62	0.09	0.20	0.09	0.00
	(0.10)	(0.02)	(0.07)	(0.06)	(0.02)
20 Quarters Ahead	0.32	0.05	0.46	0.13	0.03
	(0.09)	(0.04)	(0.09)	(0.09)	(0.05)
28 Quarters Ahead	0.26	0.05	0.53	0.11	0.03
	(0.08)	(0.06)	(0.09)	(0.09)	(0.05)

Unemployment					
Proportion due to	Demand		Supply		
	e_d	e_m	e_Θ	e_p	e_w
1 Quarter Ahead	0.61	0.00	0.39	0.00	0.00
4 Quarters Ahead	0.66	0.10	0.21	0.01	0.00
	(0.09)	(0.06)	(0.06)	(0.02)	(0.01)
8 Quarters Ahead	0.59	0.16	0.14	0.09	0.00
	(0.12)	(0.10)	(0.05)	(0.06)	(0.02)
20 Quarters Ahead	0.42	0.10	0.12	0.28	0.07
	(0.12)	(0.07)	(0.05)	(0.10)	(0.05)
28 Quarters Ahead	0.41	0.01	0.12	0.29	0.09
	(0.12)	(0.07)	(0.05)	(0.10)	(0.07)

[a] Estimated standard deviations in parentheses.

IV. Dynamic Effects of Structural Shocks

This section characterizes the dynamic effects of the structural innovations on the endogenous variables. Most of the section focuses on the benchmark case, corresponding to panel 2 in Table 1. Implications of alternative identification restrictions are discussed at the end.

A. *Variance Decompositions*

The best starting point is the set of variance decompositions, the contribution of each source of innovations to the variance of the n-quarter ahead forecast error for each endogenous variable. Table 4 gives variance decompositions for the levels (rather than first differences) of output and unemployment, together with one-standard deviation bands obtained by Monte Carlo simulations (assuming normally distributed errors, rather than bootstrapping). Two main results emerge from that table:

(1) Innovations to aggregate demand, e_d, and innovations to either labor supply or productivity, e_Θ, account for most of the variance of output and unemployment at all horizons. This is true by assumption for the one-quarter ahead variance: identification restrictions impose that innovations in output and unemployment be due only to e_d and to e_Θ. It is however true at longer horizons. Eight quarters ahead, they still account jointly for 82 percent of the variance of Y and 73 percent of the variance of U. Six years ahead, these proportions have decreased to 79 percent and 52 percent, respectively.

Given the identification restrictions which imply that e_d and e_Θ are linear combinations of innovations in y and u, and given the estimated weak cross effects between real and nominal variables in Table 2, this first result does not come as a large surprise. The second is more interesting:

(2) Innovations to aggregate demand dominate short-run fluctuations in Y but supply innovations dominate long-run fluctuations. Again, this result is true by assumption for the one-quarter ahead variance of Y: the short-run effect of supply innovations on output is assumed, not estimated. What is more interesting are the medium- and long-run results. Demand innovations account for 87 percent of the 4-quarter ahead variance of output supply innovations only for 4 percent. The proportion due to demand innovations steadily declines over time: 6 years ahead, those proportions have become 36 percent and 53 percent. This is very much consistent with the traditional interpretation of fluctuations.

B. *Impulse Responses*

Impulse responses, that is the dynamic response of the level of each of the endogenous variables to innovations in each of the five structural disturbances, are given in Figures 1a to 1e. Each figure gives both point estimates and one-standard deviation bands obtained by Monte Carlo simulations. Given the results of the variance decomposition, I focus mainly on the responses to e_d and e_Θ, and discuss briefly responses to other innovations.

The dynamic effects of a (nonmonetary) *demand innovation* on real and nominal variables are characterized in Figure 1a. They are very much consistent with the traditional interpretation. Positive demand innovations increase output and decrease unemployment for roughly 8 quarters. Thereafter, their effect on real variables is not significantly different from zero, and the point estimates of the long-run effects are close to zero. Demand innovations lead to an increase in prices and wages, despite a small decrease in nominal money: a one-standard deviation shock, which leads to an increase in output of 0.7 percent and a decrease in unemployment of 0.3 percent after 4 quarters, leads to an increase in the rate of inflation of 0.3 percent in the first year. Real money balances steadily decrease, to 1.7 percent in the long run. The real wage decreases slightly, though the decrease is statistically insignificant.[11]

The dynamic effects of a *supply innovation*, (labor supply or productivity) are characterized in Figure 1b. The effects of supply innovations on output, which are small by assumption in the short run, steadily increase over time: a one-standard deviation favorable shock increases output by 0.2 percent in the current quarter, by 0.6 percent after 8 quarters to reach a plateau of 0.5 percent in the long run. Unemployment is higher than normal for 6 quarters, increasing to 0.2 percent after two quarters; thereafter, unemployment is slightly lower, and eventually returns to its equilibrium value. Favorable supply innovations decrease both nominal prices and wages; the decrease in inflation is of 0.2 percent in the first year. The real wage is approximately constant. Nominal money increases, so that real money balances increase in the long run by 1 percent.

These effects are consistent with the traditional prior. In the Keynesian model, increases in productivity or labor supply may well increase unemployment in the short run, if aggregate demand does not increase enough to maintain employment in the face of productivity innovations, or to increase employment in the case of increases in the labor force. In the longer run, potential output is higher and so is actual output. As labor supply and productivity innovations affect the real wage in opposite directions, the observed rough constancy of the wage to a composite shock is also not surprising.

There is, however, one aspect of the dynamic response which I find difficult to reconcile with the Keynesian model. It is the temporary decrease in output in the quarter following a favorable supply shock. The Keynesian model naturally predicts an increase in unemployment, not a decrease in output. While this may appear minor, it is an extremely robust feature of the data. It

[11]This result is reversed when the manufacturing wage is used.

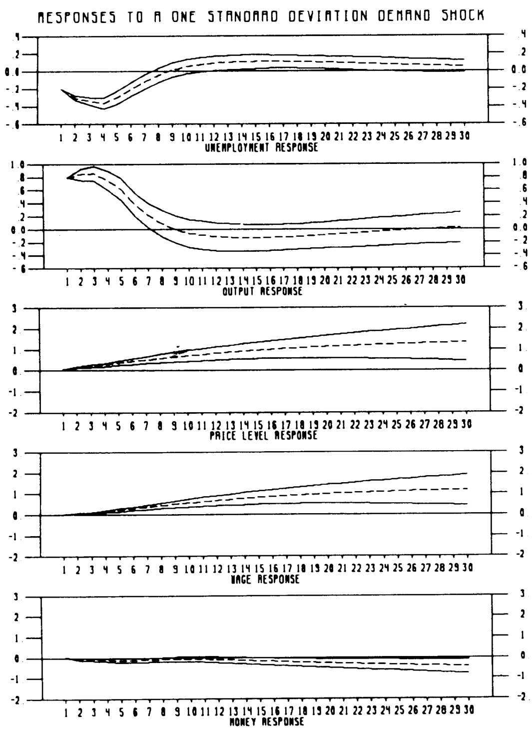

FIGURE 1a. RESPONSES TO A ONE-STANDARD DEVIATION DEMAND SHOCK

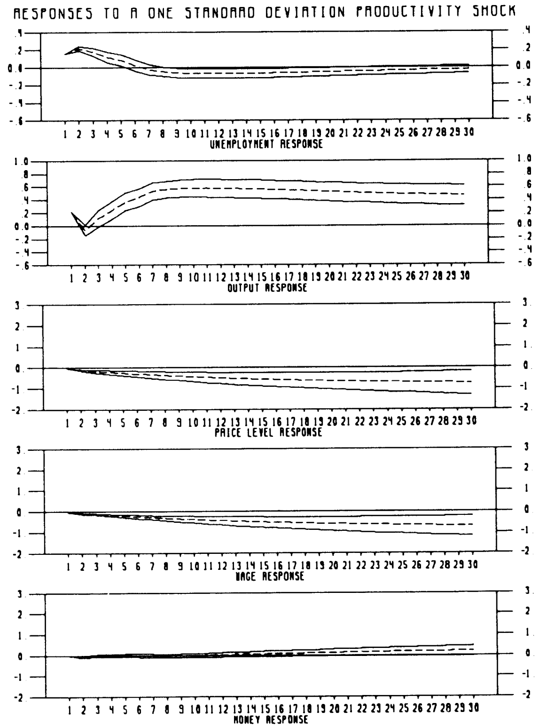

FIGURE 1b. RESPONSES TO A ONE-STANDARD DEVIATION PRODUCTIVITY SHOCK

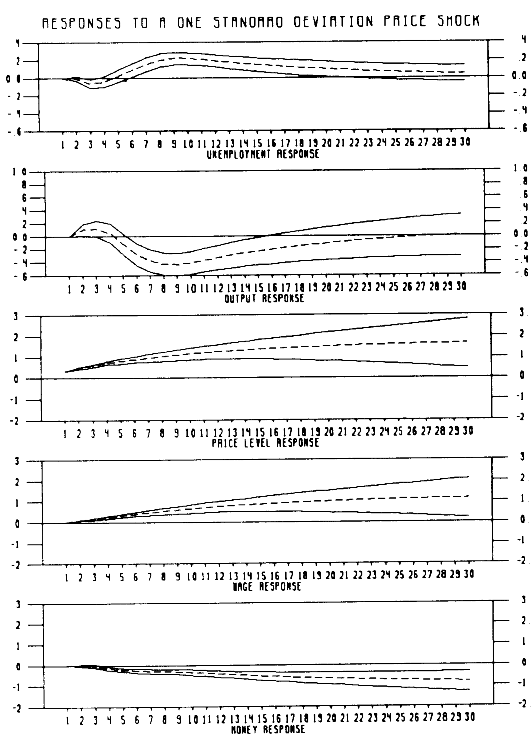

FIGURE 1c. RESPONSES TO A ONE-STANDARD DEVIATION PRICE SHOCK

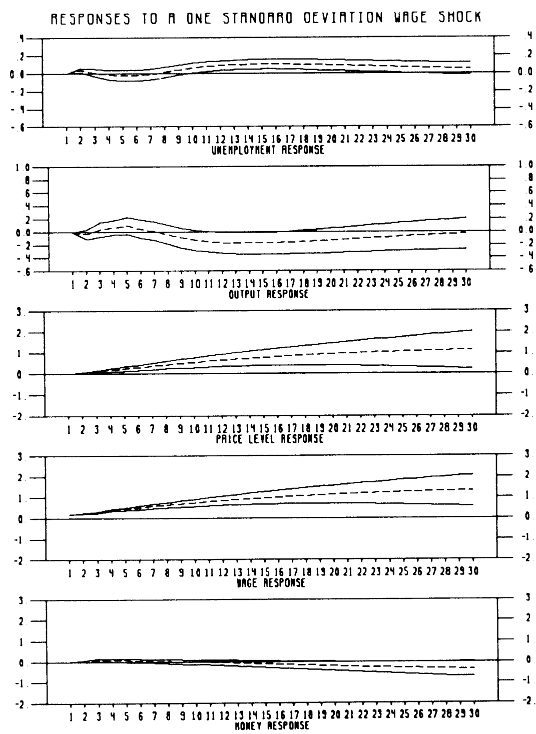

FIGURE 1d. RESPONSES TO A ONE-STANDARD DEVIATION WAGE SHOCK

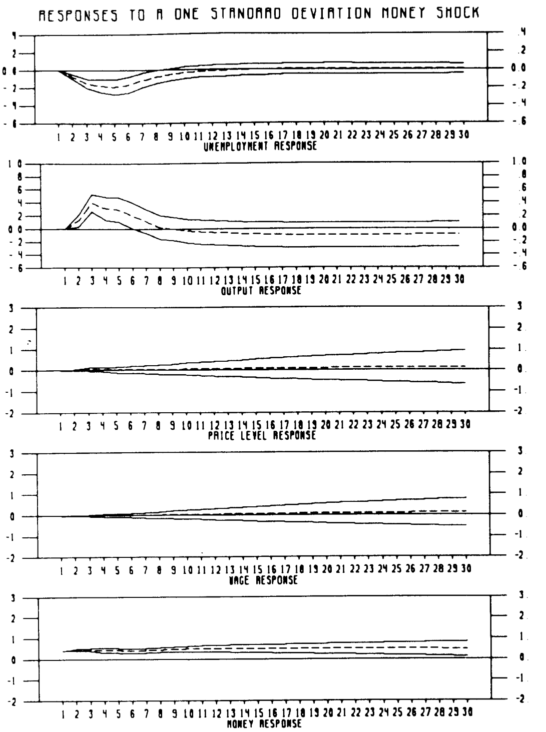

FIGURE 1e. RESPONSES TO A ONE-STANDARD DEVIATION MONEY SHOCK

can be traced to the strong negative and significant estimated effect of lagged unemployment on aggregate demand: a positive supply shock increases contemporaneous unemployment given output and leads, *ceteris paribus*, to a decrease in output next period. This decrease in output from the first to the second quarter in Figure 1b is highly significant, and robust within the set of alternative identification restrictions considered in this paper. In particular, increasing the assumed effect of productivity innovations on aggregate demand still leads to a decrease in output from the first to the second quarter, although output may remain above its preshock level. I return to this issue in the concluding section.

The other three impulse responses are given in Figures 1c to 1e. They contain both predicted and puzzling features. I discuss them briefly.

Positive *price* and *wage* innovations, which stand for such factors as omitted input prices, increases in markups, stronger union bargains, tend to increase unemployment in the medium run, which is what the Keynesian model would lead one to expect; both also increase output in the short run, which is more surprising, although the effect is not significant. Price innovations lead to a long-run decrease in real wages, wage innovations to a long-run increase in real wages. Unemployment is still higher after 6 years, although not significantly so.

Positive money innovations increase output for 8 quarters. A one-standard deviation innovation in money, which increases nominal money by 0.4 percent roughly permanently, increases output by up to 0.4 percent after 3 quarters. The increase in money never leads to a proportional increase in nominal prices and nominal wages—although the confidence bands are so large that full adjustment cannot be rejected. This is surprising if the innovations reflect money supply innovations. To the extent that positive innovations in money reflect also money demand innovations, one would not expect prices to increase proportionately. Making further progress requires including interest rates and identifying money supply and money demand innovations separately.[12]

C. *Robustness*

How robust are the major conclusions to identification assumptions and to treatment of time trend and stationarity?

As indicated earlier, within the set of identification restrictions considered in this paper, only the coefficient giving the contemporaneous effect of supply innovations on aggregate demand has an important effect on the results. Doubling this coefficient, c, which implies that the one-quarter ahead variance of output is due in equal proportions to e_d and e_Θ, leads to a dynamic response of output to supply innovations which has

[12] This remark applies obviously to much of the empirical work on the relation between money and income. Gali (1988) includes an interest rate and deals explicitly with this identification problem. He concludes that prices increase roughly proportionately to money supply shocks.

roughly the same size in the short and the long-run. Put another way, the value of c does not affect the estimated long-run effect of supply innovations on output. Variations in c do not substantially affect the dynamic effects of demand and other innovations.

Eliminating all time trends has an important effect on the estimated dynamic effects of demand innovations. Demand innovations now have a long-run effect on output: a one-standard deviation innovation increases output by 0.8 percent in the current quarter. The effect increases to 1.1 percent 4 quarters later, and decreases back to 0.8 percent in the long run. The effects of productivity innovations are similar to those of the benchmark case. Thus, removing time trends altogether makes an important difference; as I argued earlier however, not allowing for a time trend does not allow the data to explain the slowdown in output growth, or the steady increase in unemployment over the period. Allowing only for a post-73 dummy for output growth and for a time trend for unemployment leads to estimated effects of supply and demand innovations similar to the benchmark case.

V. Comparison with Other Studies

This paper is only one of a series of recent decompositions of aggregate fluctuations in the postwar United States. It is probably my responsibility to indicate how the results relate to others and provide guesses as to why they may differ. I now provide such a brief comparison, focusing on variance decompositions rather than on the shape of impulse responses.

Table 5 gives variance decompositions from six recent studies.[13] All of those, except for the second one, which is based on the Fair model, are based on a just-identified interpretation of a reduced form. It is apparent that results differ substantially, in particular in the contribution of supply and demand shocks to short-run and long-run fluctuations in output. I believe that these differences come mostly from differences in the statistical treatment of trends:

The first two decompositions come from models where trend growth is modeled as largely deterministic. In the first, growth is entirely captured by exponential time trends. In the second—which comes from a structural model estimated using standard exclusion restrictions—underlying total factor productivity growth is deterministic while capital accumulation is endogenous. By assumption therefore, supply shocks have little or no long-run effect and, in both, movements around trend turn out to be explained mostly by movements in demand.[14]

The next four decompositions have two common characteristics. First they allow for a stochastic trend in output. Second, they achieve identification by using, in part, long-run identification restrictions: in particular they all impose that demand shocks have no long-run effect on output, so that the contribution of demand shocks to the variance of output goes to zero in the long run. There is still a wide range of estimates of the contribution of demand shocks to short-run fluctuations. I believe that the main source of those differences lies in the statistical treatment of the slowdown in growth since 1970:

Recall from the previous section that, when no allowance is made for this slowdown, when the system is estimated without deterministic trends, demand shocks are estimated to have substantial long-run effects. In that case, a decomposition which *defines* demand shocks as those shocks which have no long-run effect will lead to a small esti-

[13]This is not the place for a survey, and the reader should go to the original studies for the exact definitions of shocks, details of estimation, and identification. Other studies using a similar methodology and not included here are Taylor (1986), Bernanke (1986), George Evans (1988), and Jun (1988).

[14]Sims (1980) also does estimation in levels with deterministic time trends. He does not interpret his shocks. If a structural interpretation is given to his recursive ordering, his results are roughly consistent with those of Ray Fair and Blanchard and Watson. Money and demand innovations account for 28 percent and 15 percent of the 33 quarters ahead variance of output respectively. Supply innovations, movements in unemployment given output, account for 33 percent.

TABLE 5—OUTPUT VARIANCE DECOMPOSITIONS; RESULTS FROM OTHER STUDIES

Blanchard-Watson Quarters	Demand				Supply
	Fiscal	Money	Autonomous	(Total)	
1	0.03	0.04	0.74	0.81	0.19
4	0.15	0.16	0.54	0.84	0.16
20	0.27	0.17	0.37	0.80	0.20

Fair Quarters	Demand				Supply
	Fiscal	Money	Autonomous	(Total)	
1	0.10	0.01	0.88	0.99	0.02
4	0.11	0.08	0.70	0.89	0.05
8	0.20	0.12	0.53	0.85	0.07

Blanchard-Quah I Quarters	Demand	Supply
1	0.99	0.01
4	0.97	0.03
40	0.40	0.60
Blanchard-Quah II Quarters	Demand	Supply
1	0.45	0.55
4	0.39	0.61
40	0.05	0.95

Gali Quarters	Demand				Supply
	M supply	*M* demand	Autonomous	(Total)	
1	0.00	0.00	0.31	0.31	0.69
5	0.12	0.02	0.17	0.31	0.69
20	0.08	0.03	0.04	0.15	0.84

Shapiro-Watson Quarters	Demand	Supply		
		Labor Supply	Productivity	Oil
1	0.28	0.45	0.25	0.00
4	0.28	0.48	0.22	0.01
20	0.12	0.40	0.36	0.10

Sources: Blanchard and Watson, 1986, Table 2-3; Fair, 1988, Table 1; money: money demand and supply shocks; Blanchard and Quah, 1989, Table 2, Table 2c; Gali, 1988, Table 4; Shapiro and Watson, Table 2.

mated role of demand shocks at all frequencies. This hypothesis is consistent with the two sets of results from Blanchard and Quah.[15] The first, which allows for a change in the average growth rate post-1973, yields results very similar to those presented in this paper. The second, which does not allow for such a change, yields a smaller short-run effect of demand shocks. I guess that a similar explanation applies to the results obtained by both Gali and Shapiro and Watson.

To the extent that my guess is correct, this suggests that the treatment of time trends plays a central role in variance decompositions. While the treatment of the slowdown in growth by either a dummy shift or a linear time trend for growth is too rough, I believe that the assumptions used here, namely the joint assumptions that output growth is stochastic and has declined on average since the early 1970s, are the most plausible set of assumptions to use.

VI. Conclusions

This paper has asked whether the traditional interpretation of fluctuations was consistent with the joint behavior of output, unemployment, prices, wages, and money. The answer is largely but not entirely positive:

One can interpret observed fluctuations in the major macroeconomic variables as the result of demand, money, labor supply and productivity, price- and wage-setting shocks. Demand shocks explain most of the short-run fluctuations in output and positive demand shocks are associated with increases in nominal prices and wages. Supply shocks dominate the medium and the long run, and are associated with decreases in nominal prices and wages.

I find however one aspect of the data, namely the joint dynamics of unemployment and output, hard to reconcile with the traditional interpretation. Unemployment strongly Granger-causes output, in either bivariate or multivariate systems, a statistical relation which is not easily explained in the class of structural models associated with the traditional interpretation. These joint dynamics imply a puzzling description of the short-run effects of shocks identified as supply shocks. This leads me to temper my assessment of success and to entertain the possibility that this interpretation of their data is misleading in some important way; an explanation of this aspect of the joint dynamics is a clear item for future research.

[15]Given the publication of Blanchard and Quah (1989) and this paper in the same journal, a note on product differentiation is needed here. The focus of Blanchard and Quah is both on the use of long-run restrictions as a source of identification and on the relative importance of demand and supply shocks for movements in quantities. The present paper does not use long-run restrictions for identification, and focuses on the joint behavior of prices and quantities.

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