JAMES PEERY COVER
WALTER ENDERS
C. JAMES HUENG

Using the Aggregate Demand-Aggregate Supply Model to Identify Structural Demand-Side and Supply-Side Shocks: Results Using a Bivariate VAR

This paper uses the short-run restrictions implied by a simple aggregate demand-aggregate supply model as an aid in identifying structural shocks. Combined with the Blanchard–Quah restriction, it allows estimation of the slope of the aggregate supply curve, the variances of structural demand and supply shocks, and the extent to which structural demand and supply shocks are correlated. This paper finds that demand and supply shocks are highly correlated and that demand shocks possibly can account for as much as 82% of the long-run forecast error variance of real U.S. GDP.

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Vector autoregression (VAR) analysis has been a popular tool for analyzing the dynamic properties of economic systems since Sims's (1980) influential work. Research on the relationship between VARs and structural econometric models has made possible the identification of unobservable structural shocks and an examination of the dynamic effects of these shocks on observable data. For example, Blanchard and Quah (B-Q) (1989) use a bivariate VAR of real output growth and the unemployment rate to decompose real output into its temporary and permanent components. Similarly, Spencer (1996) applies the B-Q identification

James Peery Cover *is a Professor of Economics, University of Alabama (E-mail:* jcover@cba.ua.edu). Walter Enders *is the Lee Bidgood Professor of Economics, University of Alabama (E-mail:* wenders@cba.ua.edu). C. James Hueng *is an Assistant Professor of Economics, Western Michigan University (E-mail:* James.Hueng@wmich.edu).

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strategy to a bivariate VAR of output and the price level. One critical identifying assumption in the B-Q methodology is that one shock has no long-run effect on real output. In a bivariate system, it is natural to assume that this shock is an aggregate demand (AD) shock, while the other shock is an aggregate supply (AS) shock.[1]

The other critical identifying assumption in the B-Q methodology is that the variance-covariance matrix of structural shocks is diagonal. In a bivariate framework guided by an aggregate demand and aggregate supply (AD–AS) model, this is equivalent to assuming that the AD and AS shocks are uncorrelated. This paper departs from the standard B-Q methodology by pointing out that there are sound economic reasons for presuming that structural AD and AS shocks are correlated. As such, an alternative set of identification restrictions is required. We propose to use the complete set of restrictions from a simple AD-AS model in order to achieve full identification of the structural parameters of a VAR. Our alternative decomposition allows us to present an estimate of the slope of the AS curve (that is, a measure of the short-run output-inflation tradeoff), estimates of the variances of the structural supply and demand shocks, and an estimate of their covariance. We find that the AS curve is flat enough for the structural demand shock to have important short-run effects on output. We also find that the correlation between the structural demand and supply shocks is positive and high enough for most of the variation in real output (54% in the long run and 70% in the short run) to be attributed to simultaneous shifts of the AD and AS curves.

The paper is organized as follows. Section 1 reviews the standard B-Q methodology and places special emphasis on the conditions necessary for the exact identification of the structural AD and AS shocks. Section 2 presents a basic AD-AS model and shows that it implies a set of identification restrictions that are sufficient to replace all the constraints normally placed on the covariance matrix of structural shocks. Sections 3 and 4 use U.S. data for the 1954Q1–2001Q4 sample period and compare the results obtained from a standard B-Q decomposition to those obtained from our decomposition. Section 5 offers a summary and some conclusions.

1. STRUCTURAL VARs WITH THE BLANCHARD–QUAH RESTRICTION

Let y_t and p_t, respectively, represent measures of output and the price level, which have been differenced sufficiently to achieve stationarity. Now consider the following bivariate VAR in which e_{yt} and e_{pt}, respectively, are the random disturbances in the output and price level equations and the $a_{ij}(L)$ are polynomials of order n in the lag operator, L, or $a_{ij}(L) = \Sigma_{k=1}^{n} a_{ij}(k)\mathrm{L}^k$:

1. Studies that use a larger dimension VAR often impose more restrictions on the long-run or short-run effects of selected shocks. For example, using an IS-LM-Phillips Curve framework, Galí (1992) distinguishes the supply shock from IS-curve shocks and from LM-curve shocks by assuming that each of these latter shocks has no long-run effect on output.

$$\begin{bmatrix} y_t \\ p_t \end{bmatrix} = \begin{bmatrix} y_0 \\ p_0 \end{bmatrix} + \begin{bmatrix} a_{11}(L) & a_{12}(L) \\ a_{21}(L) & a_{22}(L) \end{bmatrix} \begin{bmatrix} y_t \\ p_t \end{bmatrix} + \begin{bmatrix} e_{yt} \\ e_{pt} \end{bmatrix}. \tag{1}$$

Assume that the residuals e_{yt} and e_{pt} are composed of the two underlying structural shocks responsible for variations in y_t and p_t, or

$$\begin{bmatrix} e_{yt} \\ e_{pt} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \cdot \begin{bmatrix} \varepsilon_t \\ \eta_t \end{bmatrix}, \tag{2}$$

where ε_t is the AS shock and η_t is the AD shock. Equation (2) implies

$$\begin{bmatrix} \text{var}(e_{yt}) & \text{cov}(e_{yt}e_{pt}) \\ \text{cov}(e_{yt}e_{pt}) & \text{var}(e_{pt}) \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \cdot \begin{bmatrix} \sigma_\varepsilon^2 & \sigma_{\varepsilon\eta} \\ \sigma_{\varepsilon\eta} & \sigma_\eta^2 \end{bmatrix} \cdot \begin{bmatrix} c_{11} & c_{21} \\ c_{12} & c_{22} \end{bmatrix}. \tag{3}$$

If it is assumed that $\sigma_\varepsilon^2 = 1$, $\sigma_\eta^2 = 1$, $\sigma_{\varepsilon\eta} = 0$ and

$$c_{12}[1 - a_{22}(1)] + c_{22}a_{12}(1) = 0, \tag{4}$$

then the values of the c_{ij} and the time paths of the structural shocks $\{\varepsilon_t\}$ and $\{\eta_t\}$ can be determined from estimation of the VAR. Blanchard and Quah (1989) show that Equation (4) is a "long-run neutrality" restriction guaranteeing that the AD shock, η_t, has no permanent effect on output.

There are at least two reasons to be concerned about the above restrictions. The first is that the AD shock is assumed to have no long-run effect on output and to be orthogonal to all past values of itself and to current and past values of the AS shock. Hence, it is not surprising that papers using the B-Q methodology often find that AD shocks play only a small role in explaining fluctuations in real economic activity. The shocks identified in this way may not bear any reasonable relationship to actual shifts in AD and AS curves because such shifts are likely to be correlated. Clearly, the assumption that AD and AS shocks are uncorrelated is implausible if the monetary or fiscal authority acts in regard to the current or past state of economic activity.[2] Similarly, shifts in AS may result from AD shocks. In an intertemporal optimizing model, a temporary increase in demand will lead to a positive supply response as agents react to a temporary increase in real wages. New Keynesian models also suggest reasons to believe that AD and AS shocks are correlated as some firms increase output (rather than price) in response to a positive demand shock.[3] The decomposition presented below allows for the two shocks to be correlated and for the effects of the 'pure' AD and AS innovations to be estimated.

The second reason to be concerned about the B-Q restrictions is a statistical issue argued by Waggoner and Zha (2003). In the bivariate VAR represented by Equation (3), there are actually four solutions for the values of the c_{ij}. The B-Q restrictions produce a system of quadratic equations so that the signs of the c_{ij} are not identified.

2. See, for example, Clarida, Galí, and Gertler (1999, p. 1674) and Cover and Pecorino (2003).

3. See, for example, Romer (2001, pp. 304–310) and Ball, Mankiw, and Romer (1988, pp. 13–19) who present models in which firms change output rather than price in response to demand shocks because of real rigidity.

Therefore, additional restrictions on the signs of the c_{ij} are needed. As a result of the additional restrictions, Waggoner and Zha (2003) argue that a normalization can have important effects on statistical inference. In particular, the choice of the c_{ij} can have profound effects on the shape of the likelihood function and thus confidence intervals for the impulse responses.

Our decomposition is designed to address these problems. In particular, we do not need to restrict the value of $\sigma_{\varepsilon\eta}$ in order to obtain the identified demand and supply shocks. As we show below, the estimated value of $\sigma_{\varepsilon\eta}$ for the United States is equal to 0.576. Moreover, instead of normalizing the variance–covariance matrix of the structural shocks to an identity matrix, we use the normalizations usually suggested by an AD-AS model: a one-unit demand shock shifts AD by one unit and a one-unit supply shock shifts AS by one unit. The impulse responses and variance decompositions attained by using our decomposition can be quite different from those of the B-Q decomposition. However, our main result only adds to the notion that structural decompositions are not robust to structural identifying assumptions. We deem it important that the results of our decomposition are contrary to the prevailing view that supply shocks account for the preponderance of the long-run forecast error variance of real output. Allowing for a nonzero correlation between shifts in supply and demand, we show that demand shocks can account for more than 82% of the long-run forecast error variance of output. This finding is consistent with the argument by West (1988) that demand shocks may account for a large share of output fluctuations at long horizons. It is, however, in stark contrast to the findings of those who force the correlations of shocks to be zero. Galí (1992), for example, finds that more than 80% of output variability can be attributed to supply shocks.

2. IDENTIFICATION OF AN AD-AS MODEL

Consider the following simple AD-AS model:

$$y_t^s = {}_{t-1}y_t + \alpha(p_t - {}_{t-1}p_t) + \varepsilon_t, \alpha > 0\,, \tag{5}$$

$$(y_t + p_t)^d = {}_{t-1}(y_t + p_t)^d + \eta_t\,, \tag{6}$$

$$y_t^d = y_t^s\,, \tag{7}$$

where y_t and p_t, respectively, are the logarithms of output and the price level during period t; ${}_{t-1}y_t$ and ${}_{t-1}p_t$ are their expected values given information available at the end of period $t - 1$; the superscripts s and d represent supply and demand; while ε_t and η_t, respectively, denote the serially uncorrelated structural AS and AD shocks. Equation (5) is a Lucas (1972) AS curve in which output increases in response to unexpected increases in the price level and positive realizations of the AS shock ε_t. Equation (6) is the AD relationship; nominal aggregate demand equals its expected value plus a random demand disturbance, η_t.

Although Equations (5)–(7) represent an overly simplified model of the aggregate economy, our goal is to suggest that a plausible macroeconomic model is consistent with the notion that demand shocks can play a predominant role in real GDP fluctuations. The essential feature of the model is the absence of a restriction forcing the demand and supply shocks to be contemporaneously uncorrelated. In an unpublished appendix (available on request), we report similar findings within a New Keynesian framework.

It is instructive to compare the four identifying restrictions embedded within our AD-AS model to those of Blanchard and Quah. Our normalization restrictions are that an ε_t shock has a one-unit effect on y_t^s and an η_t shock has a one-unit effect on y_t^d. Finally, Equation (6) implies that the slope of the AD curve is unity. To show how these restrictions exactly identify the system, solve Equations (5)–(7) for output and the price level. If it is assumed that ${}_{t-1}y_t$ and ${}_{t-1}p_t$ are equal to linear combinations of their past observed values, the result can be written in a form similar to Equation (1), which yields:

$$\begin{bmatrix} e_{yt} \\ e_{pt} \end{bmatrix} = \begin{bmatrix} \dfrac{1}{1+\alpha} & \dfrac{\alpha}{1+\alpha} \\ \dfrac{-1}{1+\alpha} & \dfrac{1}{1+\alpha} \end{bmatrix} \cdot \begin{bmatrix} \varepsilon_t \\ \eta_t \end{bmatrix} \tag{8}$$

so that

$$\begin{bmatrix} \text{var}(e_y) & \text{cov}(e_y,e_p) \\ \text{cov}(e_y,e_p) & \text{var}(e_p) \end{bmatrix} = \begin{bmatrix} \dfrac{1}{1+\alpha} & \dfrac{\alpha}{1+\alpha} \\ \dfrac{-1}{1+\alpha} & \dfrac{1}{1+\alpha} \end{bmatrix} \cdot \begin{bmatrix} \sigma_\varepsilon^2 & \sigma_{\varepsilon\eta} \\ \sigma_{\varepsilon\eta} & \sigma_\eta^2 \end{bmatrix} \cdot \begin{bmatrix} \dfrac{1}{1+\alpha} & \dfrac{-1}{1+\alpha} \\ \dfrac{\alpha}{1+\alpha} & \dfrac{1}{1+\alpha} \end{bmatrix} . \tag{9}$$

The assumption that the structural AD shock, η_t, has no long-run effect on output now implies that

$$\alpha = -a_{12}(1)/[1 - a_{22}(1)] , \tag{10}$$

which yields an estimate of α, the slope of the AS curve. Once the estimate of α is obtained, Equation (9) can be used to solve for σ_ε^2, σ_η^2, and $\sigma_{\varepsilon\eta}$. Thus, the system is exactly identified.

Due to the additional constraints introduced by employing an AD-AS model, it is not necessary to assume that structural shocks are mutually uncorrelated in order to identify the structural demand and supply shocks. However, in order to obtain the variance decompositions and impulse responses, it is necessary to identify orthogonal structural shocks. In Section 4, this is done by implementing the two possible recursive orderings traditionally used in a Choleski decomposition. The first ordering assumes that supply shocks are causally prior to demand shocks and the second ordering assumes that demand shocks are causally prior to supply shocks.

The assumption that causality runs from the supply shock to the demand shock can be implemented by assuming that unexpected AD equals a pure AD shock, ν_t, plus an unexpected change in AD that is induced by the AS shock, $\rho\varepsilon_t$, or $\eta_t = \rho\varepsilon_t + \nu_t$. There are at least two motivations for such an assumption. The first comes from the life-cycle/permanent income hypothesis (LC/PIH). According to the LC/PIH, if a particular shock to AS has only a temporary effect on output, it has very little effect on the present value of expected future income and therefore has only a little, if any, effect on current AD. However, if a particular shock to AS has a permanent effect on output, then the present value of future income increases by enough for current demand to increase by an amount approximately equal to the increase in output supplied. The value of ρ therefore depends upon how the time series of structural supply shocks is divided between permanent and temporary shocks.[4]

The second motivation for allowing causality to run from the supply shock to the demand shock is the possibility that the monetary authority is attempting to stabilize the price level or the rate of inflation. If there is a positive AS shock, then in order to prevent the price level from declining, the monetary authority must increase AD. This causes unexpected changes in AD to be positively correlated with unexpected changes in AS.

The assumption that causality runs from the demand shock to the supply shock can be implemented by assuming that unexpected AS equals a pure AS shock, δ_t, plus an unexpected change in AS that is induced by the AD shock, $\gamma\eta_t$, or $\varepsilon_t = \gamma\eta_t + \delta_t$. All the motivations for this assumption are Keynesian. For example, if there is real rigidity in the economy, then some firms do not adjust price in response to unexpected changes in demand; rather, they simply supply the additional output demanded. The value of γ depends upon the share of firms in the economy that do not change their current price in response to an unexpected change in AD.

3. ESTIMATION RESULTS FOR THE STANDARD B-Q MODEL

Data on real GDP and the GDP deflator for the period 1954Q1–2001Q4 were obtained from the United States Department of Commerce. Standard Dickey-Fuller tests of the logarithms of real GDP and the GDP deflator indicated that real GDP was difference stationary, while the GDP deflator had to be differenced twice to become stationary. Hence, the variables employed in the VAR are the log-first difference of real GDP and the log-second difference of the GDP deflator. The log

4. See, for example, McCallum (1989) and McCallum and Nelson (1999) for derivations that show that current AD depends upon expected future output. Galí (1992) takes this possibility into account by including the AS shock in both the IS curve and the AS curve.

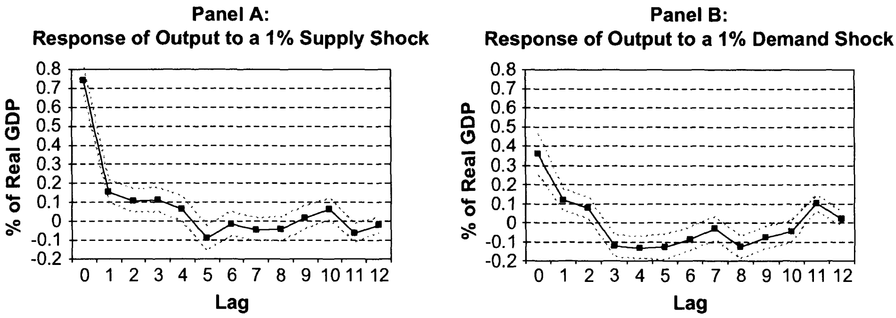

FIG. 1. Output Responses with the B-Q Restrictions

likelihood ratio test, modified for small samples, used in Sims (1980) indicated that the optimal lag length is 10.

The solid lines in Figures 1 and 2 are the impulse response functions for the structural AS and AD shocks as identified by the standard B-Q set of identifying restrictions.[5] The dashed lines denote upper and lower one-standard deviation bands. From Figure 1A, notice that a 1% supply shock causes output to increase by about 0.75%, while in Figure 1B a 1% demand shock causes output to increase by only about 0.35%. The effects of both shocks decline very rapidly.

The variance decompositions presented in Table 1 show that about 80% of the short-run variation in output and 72% of the long-run variation in output in the United States has been the result of the structural supply shock. The percentages are approximately reversed for the variation in inflation, with the demand shock accounting for 75% of the short-run variation and nearly 70% of the long-run variation in inflation.

What might one conclude from these results for the standard B-Q model? One possible conclusion is that demand shocks have been the primary source of variations in inflation, while supply shocks have been the primary source of variations in output. Although this conclusion may be sound, it hinges on the assumption that the structural shocks are contemporaneously uncorrelated. If the structural shocks are correlated, both the response of output to the supply shock and the importance of supply shocks in explaining the variance of output could be the result of AD shifting at the same time as AS. In particular, the next section shows that the variance decomposition obtained from this model is identical to that obtained from an AD-AS model in which demand and supply shocks are correlated such that supply shocks are causally prior to demand shocks. If instead it is assumed that supply shocks do not affect AD, then most of the variation in output (in both the short and long runs) will be the result of the structural demand shocks.

5. There are four real solutions with different signs for the c_{ij} solved from Equations (3) and (4). As discussed in Taylor (2003), we pick the one that implies a positive long-run effect of demand shocks on price and a positive long-run effect of supply shocks on output.

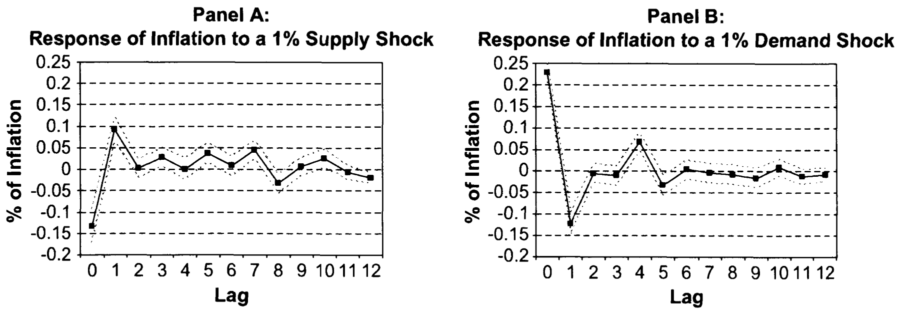

FIG. 2. Inflation Responses with the B-Q Restrictions

4. ESTIMATION AND IDENTIFICATION OF OUR AD-AS MODEL

The first row of Table 2 presents the estimates of the structural parameters (along with their bootstrapped 95% confidence intervals) obtained by using the restrictions of our AD-AS model. The point estimate of α, the slope of the AS curve, is 1.56. From Equation (8), the immediate effect of a 1% supply shock on output is $1/(1 + \alpha) = 0.39$. The effect of the structural demand shock on output is $\alpha/(1 + \alpha) = 0.61$. Hence, the point estimate of the output-inflation tradeoff parameter implies that the immediate effect on output of a structural demand shock is larger than that of an equal-sized structural supply shock. The variance of each structural shock is less than unity (i.e., $\sigma_\varepsilon^2 = 0.90$ and $\sigma_\eta^2 = 0.72$). More importantly, the covariance between the shocks is 0.58; thus, the AD and AS curves tend to shift together.

In order to obtain impulse response functions and variance decompositions, it is necessary to use orthogonal shocks to avoid any ambiguity regarding the type of shock under examination. Since $E\varepsilon_t\eta_t \neq 0$, it is necessary to make an assumption concerning the source of the correlation between the shocks. Although there are an infinite number of possibilities, each one can be represented by a combination of two extreme possibilities—the two recursive orderings discussed in Section 2, above.

The first recursive ordering is that the supply shock is causally prior to demand. It is straightforward to show that this yields an AD-AS model identical to the standard B-Q model discussed in Section 3. This recursive ordering is represented by:

$$\eta_t = \rho\varepsilon_t + \nu_t . \tag{11}$$

If Equation (11) is substituted into Equations (8) and (9), the result is:

$$\begin{bmatrix} \mathrm{var}(e_y) & \mathrm{cov}(e_y,e_p) \\ \mathrm{cov}(e_y,e_p) & \mathrm{var}(e_p) \end{bmatrix} = \begin{bmatrix} \dfrac{1}{1+\alpha} & \dfrac{\alpha}{1+\alpha} \\ \dfrac{-1}{1+\alpha} & \dfrac{1}{1+\alpha} \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 \\ \rho & 1 \end{bmatrix} \cdot \begin{bmatrix} \sigma_\varepsilon^2 & 0 \\ 0 & \sigma_\nu^2 \end{bmatrix} \cdot \begin{bmatrix} 1 & \rho \\ 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} \dfrac{1}{1+\alpha} & \dfrac{-1}{1+\alpha} \\ \dfrac{\alpha}{1+\alpha} & \dfrac{1}{1+\alpha} \end{bmatrix}, \tag{12}$$

TABLE 1

VARIANCE DECOMPOSITION FOR STANDARD MODEL (AND AD-AS MODEL WITH CAUSALITY FROM SUPPLY TO DEMAND)

	Variation in Output due to		Variation in Inflation due to	
Horizon (Quarters)	Supply Shock	Demand Shock	Supply Shock	Demand Shock
1	0.810	0.190	0.248	0.752
2	0.801	0.199	0.277	0.723
3	0.797	0.203	0.277	0.723
4	0.785	0.215	0.283	0.717
5	0.769	0.231	0.270	0.730
6	0.756	0.244	0.277	0.723
7	0.749	0.251	0.277	0.723
8	0.749	0.251	0.292	0.708
9	0.734	0.266	0.299	0.701
10	0.729	0.271	0.299	0.701
11	0.728	0.272	0.303	0.697
12	0.721	0.279	0.303	0.697
13	0.720	0.280	0.305	0.695
14	0.721	0.279	0.305	0.695
15	0.722	0.278	0.305	0.695
16	0.724	0.276	0.306	0.694

where σ_ε^2 continues to be the variance of the total structural supply shock and σ_v^2 is the variance of the independent structural demand shock. The B-Q constraint is not affected by this orthogonalization and is still given by Equation (10).

It can be shown that Equation (12) implies

$$\begin{bmatrix} \mathrm{var}(e_y) & \mathrm{cov}(e_y,e_p) \\ \mathrm{cov}(e_y,e_p) & \mathrm{var}(e_p) \end{bmatrix} = \begin{bmatrix} \frac{1+\alpha\rho}{1+\alpha}\sigma_\varepsilon & \frac{\alpha}{1+\alpha}\sigma_v \\ \frac{-(1-\rho)}{1+\alpha}\sigma_\varepsilon & \frac{1}{1+\alpha}\sigma_v \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} \frac{1+\alpha\rho}{1+\alpha}\sigma_\varepsilon & \frac{\alpha}{1+\alpha}\sigma_v \\ \frac{-(1-\rho)}{1+\alpha}\sigma_\varepsilon & \frac{1}{1+\alpha}\sigma_v \end{bmatrix}. \tag{13}$$

This expression is identical to Equation (3) under the identifying assumptions of the standard model if we assume that

$$\begin{bmatrix} \frac{1+\alpha\rho}{1+\alpha}\sigma_\varepsilon & \frac{\alpha}{1+\alpha}\sigma_v \\ \frac{-(1-\rho)}{1+\alpha}\sigma_\varepsilon & \frac{1}{1+\alpha}\sigma_v \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}. \tag{14}$$

In addition, substituting Equation (14) into the long-run neutrality restriction Equation (4) in the standard B-Q model yields exactly Equation (10)–the long-run neutrality restriction in our AD-AS model with the supply shock causally prior

TABLE 2

POINT ESTIMATES OF STRUCTURAL PARAMETERS OF AD-AS MODEL 1956:3–2001:4

Model Name	α	σ^2_ε	$\sigma_{\varepsilon\eta}$	σ^2_η	σ^2_ν	ρ	σ^2_δ	γ
(1) Basic AD-AS	1.559 (0.449, 3.019)	0.896 (0.546, 1.316)	0.576 (0.350, 0.673)	0.716 (0.470, 0.818)	—	—	—	—
(2) Causality from Supply to Demand	1.559 (0.449, 3.019)	0.896 (0.546, 1.316)	—		0.346 (0.118, 0.504)	0.643 (0.334, 0.922)	—	—
(3) Causality from Demand to Supply	1.559 (0.449, 3.019)	—	—	0.716 (0.470, 0.818)	—	—	0.433 (0.116, 0.952)	0.804 (0.616, 0.948)

NOTES: The numbers in parenthesis are 95% confidence intervals from bootstrapping. α = sensitivity of AS to an unexpected change in inflation. σ^2_ε = variance of total structural shock to AS. $\sigma_{\varepsilon\eta}$ =covariance between total structural shocks to AS and AD. σ^2_η = variance of total structural shock to AD. σ^2_ν = variance of independent structural shock to AD. ρ = effect of shock to AS on total shock to AD if causality runs from supply shock to demand shock. σ^2_δ = variance of independent structural shock to AS. γ = effect of shock to AD on total shock to AS if causality runs from demand shock to supply shock.

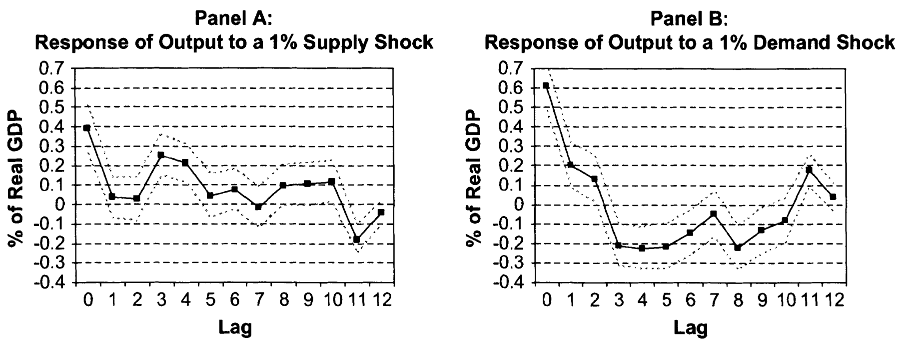

FIG. 3. Output Response in the AD-AS Model

to the demand shock. Therefore, the two models are identical. As a result, the standard B-Q model forces all the variations in output resulting from common shifts in the AD and AS curves to be attributed to the structural supply shock.

The parameter estimates obtained from employing Equation (12) are presented in the second row of Table 2. The values of α and σ_ε^2 are the same as those in the basic model. The estimate of the variance of the independent demand shock, $\sigma_v^2 = 0.35$, is slightly less than one-half of the variance of the total demand shock, σ_η^2, reported in the first row. Hence, if we use this ordering, slightly more than one-half of the variation in unexpected AD is the result of shifts in the AD curve induced by structural shocks to AS. The estimate of ρ is 0.64, implying that a 1% structural supply shock not only shifts the AS curve 1% to the right but also shifts the AD curve 0.64% to the right.

We do not depict the impulse response functions for this case because they are simply proportional to those shown in Figures 1 and 2. The shapes are identical since a decomposition using Equation (12) is identical to that using the standard B-Q restrictions. The scale changes since the standard deviations of the shocks are below unity. Moreover, the variance decompositions obtained from Equation (12) are identical to those reported in Table 1.

The other recursive ordering assumes that the demand shock is causally prior to the supply shock. This case is represented by

$$\varepsilon_t = \gamma\eta_t + \delta_t . \tag{15}$$

If Equation (15) is substituted into Equations (8) and (9), the result is

$$\begin{bmatrix} \mathrm{var}(e_y) & \mathrm{cov}(e_y,e_p) \\ \mathrm{cov}(e_y,e_p) & \mathrm{var}(e_p) \end{bmatrix} = \begin{bmatrix} \dfrac{1}{1+\alpha} & \dfrac{\alpha}{1+\alpha} \\ \dfrac{-1}{1+\alpha} & \dfrac{1}{1+\alpha} \end{bmatrix} \begin{bmatrix} 1 & \gamma \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \sigma_\delta^2 & 0 \\ 0 & \sigma_\eta^2 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 \\ \gamma & 1 \end{bmatrix} \begin{bmatrix} \dfrac{1}{1+\alpha} & \dfrac{-1}{1+\alpha} \\ \dfrac{\alpha}{1+\alpha} & \dfrac{1}{1+\alpha} \end{bmatrix} , \tag{16}$$

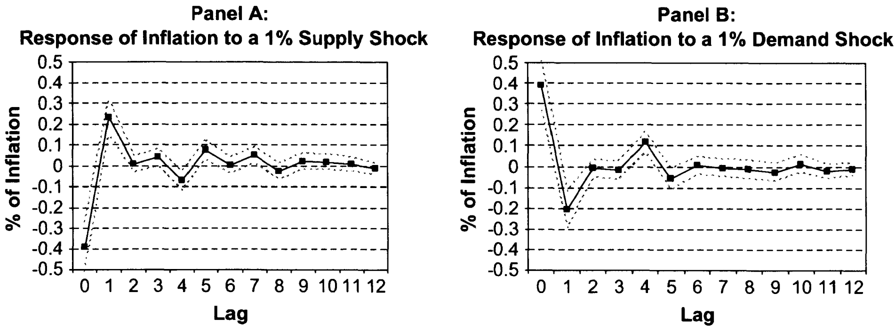

FIG. 4. Inflation Response in the AD-AS Model

where σ_η^2 continues to be the variance of the total structural demand shock and σ_δ^2 is the variance of the independent structural supply shock.

The third row of Table 2 presents the results obtained using Equation (16). The values of α and σ_η^2 are the same as those in the basic model because here the long-run neutrality condition is the assumption that any shift in the AD curve, given no shift in AS, has no long-run effect on output. The estimate of the variance of the independent supply shock, $\sigma_\delta^2 = 0.43$, is slightly less than one-half of the variance of the total supply shock, σ_ε^2, reported in the first row. Therefore, with this orthogonalization, slightly more than one-half of the variation in unexpected AS is the result of shifts in the curve induced by structural shocks to AD. The estimated value of γ is 0.80, implying that a 1% demand shock not only causes the AD curve to shift by 1% of GDP, but also causes the AS curve to shift by 0.80% of GDP.

Figures 3 and 4 present the impulse response functions obtained from this orthogonalization. Comparing these responses to those shown in Figures 1 and 2, a 1% demand shock here induces a relatively larger response of output and a relatively smaller response of inflation. This result is obtained because a 1% structural demand shock shifts the AD curve by 1% and the AS curve by γ%. Hence, the immediate effect of a 1% structural demand shock is to cause output to increase by slightly more than 0.9%, while there is almost no effect on inflation. In contrast, supply shocks have relatively small effects on output since they have no contemporaneous effect on demand.

The variance decompositions with this orthogonalization are reported in Table 3. About 90% of the short-run variation in output and nearly 83% of the long-run variation in output is the result of the structural demand shock. Over 90% of the variation in inflation is the result of the structural supply shock.

5. SUMMARY AND CONCLUSIONS

This paper uses an AD-AS model to identify a structural VAR and compares this identification to that obtained from the standard Blanchard–Quah decomposition.

TABLE 3
VARIANCE DECOMPOSITION FOR AD-AS MODEL WITH CAUSALITY FROM DEMAND TO SUPPLY SHOCK

	Variation in Output due to		Variation in Inflation due to	
Horizon (Quarters)	Supply Shock	Demand Shock	Supply Shock	Demand Shock
1	0.098	0.902	0.940	0.060
2	0.093	0.907	0.952	0.048
3	0.091	0.909	0.952	0.048
4	0.125	0.875	0.950	0.050
5	0.146	0.854	0.929	0.071
6	0.143	0.857	0.931	0.069
7	0.144	0.856	0.930	0.070
8	0.144	0.856	0.923	0.077
9	0.146	0.854	0.916	0.084
10	0.150	0.850	0.915	0.085
11	0.156	0.844	0.910	0.090
12	0.170	0.830	0.909	0.091
13	0.171	0.829	0.906	0.094
14	0.172	0.828	0.906	0.094
15	0.172	0.828	0.906	0.094
16	0.175	0.825	0.904	0.096

Our decomposition imposes the "natural" normalizations that a demand shock has a one-unit effect on AD and a supply shock has a one-unit effect on AS. Moreover, the procedure has the advantage that it does not force the correlation between demand and supply shocks to be zero. As such, we are able to estimate the correlation between unexpected shifts in the AD and AS curves as well as obtain a point estimate of the slope of the short-run AS curve.

We find that the AS curve is flat enough for demand shocks to have an important short-run effect on output. Even if it is assumed that all the correlation between the structural demand and supply shocks is the result of one-way causality from supply to demand, a 1% demand shock continues to cause output to increase by 0.61%—only slightly lower than the 0.78% increase in output caused by a 1% supply shock (including its induced shift of AD).

Perhaps, the most important finding is the high correlation between demand and supply shocks. This paper shows that assumptions about the source of this correlation affect variance decompositions and impulse response functions. For example, we prove that a causal ordering in which structural supply shocks shift the demand curve is mathematically equivalent to the standard B-Q model (up to a scalar). In this case, the structural demand shock accounts for 28% of the long-run variation in output. On the other hand, if the ordering is such that causality runs from demand to supply, then the structural supply shock (which in this case is an independent structural supply shock) accounts for only 18% of the variation in output. Therefore, demand shocks are capable of accounting for a large share of the long-run variation in output, as suggested by the model in West (1988).

This paper explicitly considers only the two simplest explanations for the contemporaneous correlation between the structural AD and AS shocks. Even though each of these two possibilities is rather extreme—it is most likely that causality is bidirectional, that is demand shocks affect supply shocks and vice versa—they demonstrate that assumptions about the correlation between structural shocks have important effects on VAR results. Since it is not possible to determine the reason why the curves shift together without placing additional restrictions on the data, without further evidence it is not possible to claim that demand shocks play a limited role in real output variability.

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