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**The Sources of Business Cycle Fluctuations  
in the Philippines**

*by*

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## **ABSTRACT**

The objective of the paper is to estimate a structural model of the Philippine economy using vector autoregression (VAR) methodology. The structural model being estimated is a traditional Keynesian AS-AD model of macroeconomic fluctuations. This model predicts that in the short-run, transitory shocks (in the structural VAR model), interpreted as aggregate demand shocks, move output and prices in the same direction and are neutral with respect to output in the long-run, but affect prices. On the other hand, permanent shocks, interpreted as aggregate supply shocks, raise output and lower prices in the short- and long-run. A reduced form bivariate VAR (in output and prices) for the Philippines is estimated, and inversion of the estimated VAR yields a decomposition of output and prices into a moving average of orthogonal output and price shocks. Since this is a reduced-form model, no structural interpretation can be given to the estimates. Restrictions based on theory are imposed, and the resulting impulse response functions and variance decompositions are analyzed within the context of a structural AS-AD model. Impulse-response functions and variance decompositions reveal that output is mostly driven by supply (permanent) shocks, while prices are mostly driven by demand (temporary) shocks. The results appear to be consistent with a relatively steep short-run aggregate supply curve and therefore with rapid price adjustment and an absence of price and/or wage rigidities.

## 1. Introduction

Over the last decade, a large body of literature has been devoted to identifying the macroeconomic impacts of aggregate supply (AS) and aggregate demand (AD) disturbances. The disturbances interpreted as AS and AD shocks are normally the result of imposing the appropriate identifying restrictions on linear combinations of reduced form coefficient estimates from a bivariate vector autoregression (VAR), to make them conform to a structural model of the economy. The structural model on which the restrictions are based is the standard textbook model of aggregate supply and aggregate demand. In this standard model of the macroeconomy, AS shocks have both short- and long-run effects on output. In the VAR literature, therefore, shocks to the AS curve are associated with *permanent* shocks. On the other hand, while AD shocks have short-run effects, they are neutral with respect to output in the long-run. Thus, AD shocks are interpreted as *temporary* or *transitory* shocks within the context of a VAR. Long-run neutrality of AD shocks is imposed by setting the sums of linear combinations of some of the coefficients in a VAR (usually the long-run multipliers of output shocks) equal to zero. Blanchard and Quah (1989, BQ) wrote the seminal paper that identified structural shocks in this manner. They estimated a bivariate VAR using GDP and unemployment data.

Since the BQ paper, there has been a growing tradition of papers using the same long-run structural identification method. In a bivariate structural VAR identified using the BQ method, the key is to identify the proper recursive ordering of the two variables, so that the first variable is not affected in the long-run by one of the structural shocks extracted from the VAR estimates.<sup>1</sup> The BQ method has also been extended to apply to systems of greater than two variables.

A number of authors have attempted to improve on or modify BQ's simple bivariate VAR model of macroeconomic fluctuations. Gamber and Joutz (1993) substituted industrial output data for GDP and found essentially the same qualitative results. The model of Bayoumi (1992), and Bayoumi and Eichengreen (1993, 1994, referred to as the BE model in this paper) is perhaps the best-known adaptation of the BQ method. Bayoumi and Eichengreen substituted the price level for unemployment data, creating a more straightforward interpretation of their VAR results by linking the structure of the VAR to the standard AS-AD model. Because the objective of their work was to address the question of whether countries experience symmetrical responses to AS and AD shocks, their work has been used primarily to ascertain how well subsets of countries in the world are suited for economic integration. The idea is that integration and the concomitant sacrifice of monetary autonomy would be less costly if countries forming an economic union responded *ex ante* in a similar fashion to AS and AD shocks. Other authors using the BE model to study the feasibility of economic integration included Whitt (1995, for the European Union). Keating and Nye (1996, 1997) used the BE model to compare the effects of permanent and transitory shocks in pre- and post- World War I periods among the G7 countries.

Except for the studies of Bayoumi and Eichengreen, most of the studies using the BQ method to analyze AS and AD shocks have covered industrialized economies. Data constraints appear to be the reason why there is a dearth of research in this regard for developing countries. Indeed, Bayoumi and Eichengreen use only annual data, and do not dwell on the qualitative properties of the impulse response functions for the developing

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<sup>1</sup> That is, the second structural shock is neutral with respect to the first variable in a bivariate VAR.



countries in their sample. This study seeks to examine impulse response functions and variance decompositions for a long-run structural VAR model of the Philippines using the same bivariate VAR setup as Bayoumi and Eichengreen, but using more disaggregated time series data. In this paper, quarterly price and income data is used for a bivariate structural VAR of the Philippines.

This paper is structured as follows: Part II is a review of the theory of aggregate supply and aggregate demand, Part III presents the econometrics behind long-run structural VARs, Parts IV and V analyze the estimation results, including the impulse-response functions and variance decompositions. The last part presents the conclusion from this exercise.

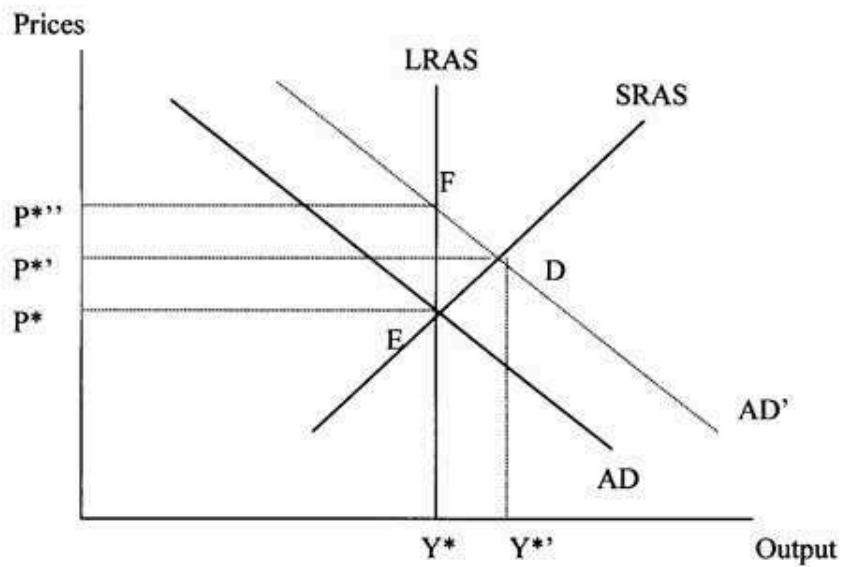
## **II. Aggregate Supply and Aggregate Demand: A Review of Theory**

In the standard textbook aggregate supply-aggregate demand (AS-AD) model, there are two variables: income (on the x-axis) and prices (on the y-axis). The AS curve describes for each given price level, the quantity of output firms are willing to supply. The AD curve shows combinations of the price level and level of output at which the goods and money markets are simultaneously in equilibrium. The AD curve is the total demand of goods and services used for consumption, investment, government purchases, as well as net goods to be exported abroad. The AD curve is downward-sloping, reflecting the fact that a lowering of the price level raises real money balances, leading to an increase in the demand for goods and services. The AD curve is drawn for a given level of foreign prices, a given nominal money supply, given fiscal policy and an exchange rate that is fixed. Changes in these variables will cause the AD curve to shift.

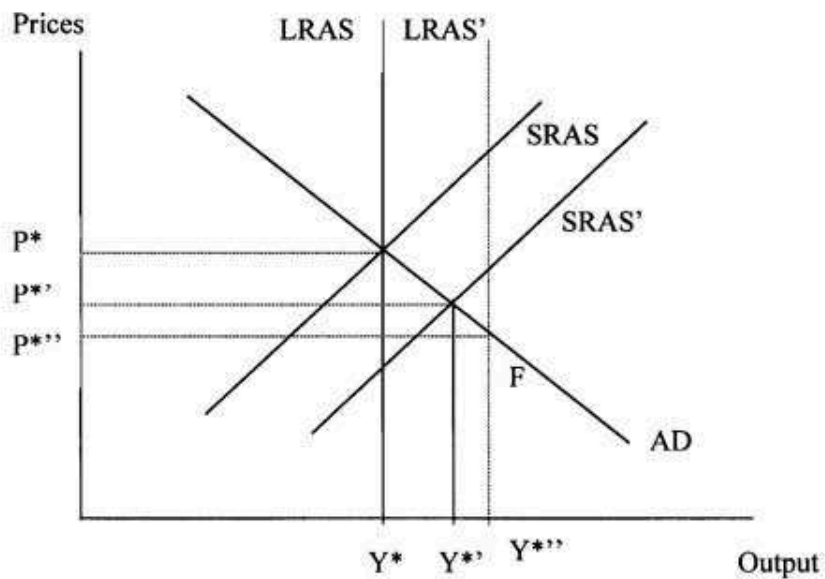
The AS-AD model predicts that exogenous changes in aggregate demand for a given AS curve move income and prices in the same direction (see **Figure 1**). A shock shifts the AD curve from AD to AD'. The economy moves from the initial equilibrium point at pE to the short-run equilibrium point at F. Output shifts upward as  $Y^*$  moves to  $Y^{*'}$ , prices move upward from  $P^*$  to  $P^{*'}$ . But that is not the end of the story. In the long-run, the AS curve rotates counter-clockwise and becomes vertical. Eventually, the economy moves from the short-run equilibrium at D to the long-run equilibrium point at F. Thus, output falls back to its initial level in equilibrium, and the price level rises to  $P^{***}$ .

The short-run aggregate supply (SRAS) curve is either horizontal or upward-sloping and reflects the adjustment mechanism dependent upon the relationship between unemployment, wages and prices. The idea behind a horizontal SRAS curve is that because there is unemployment, firms can obtain as much labor as they want at the current wage. Their average costs of production therefore are assumed not to change as their output levels change. Thus, firms are willing to supply as much output as is demanded at the existing price level because by doing so, profits increase. If this is the case, the price level does not depend on GDP. Price increases (inflation) are associated with shifts in the SRAS curve to the northwest. If the SRAS is upward-sloping, this suggests that as the economy approaches full employment, wages are bid up, so that average costs of production rise. Since output prices are assumed to be based on markups over cost, output prices rise. Increases in the price level can induce firms to increase production capacity, raising profits. In the long-run, however,

**Figure 1: The impact of an AD shock on output and prices**



**Figure 2: The impact of an AS shock on output and prices**





this will only be true up to a level of output consistent with full employment of labor (the natural level of output, or potential GDP).<sup>2</sup>

As a result of tightening in the labor market, firms supply increasingly smaller increments of output as the price level increases. Over time therefore, the long-run aggregate supply (LRAS) curve will be vertical, intersecting the horizontal axis at the level of potential GDP, indicating that the same amount of output will be supplied regardless of the price level. The vertical LRAS curve is based on the assumption that the labor market will be in equilibrium with full employment of the labor force.<sup>3</sup> Potential output grows over time as the economy accumulates resources and as technology improves. Changes in potential output do not depend on the price level. **The long-run implication is that aggregate demand disturbances, such as movements in the money supply have no long-run real impact on output, only on prices.** AD shocks move prices in the same direction without changing output in the long-run (see **Figure 1**).

The impact of an AS shock (Figure 2) is to lower prices and raise output in the short run. The economy moves from the initial equilibrium point E to the short-run equilibrium point D, and output moves from  $Y^*$  to  $Y^{**}$ , while prices move from  $P^*$  to  $P^{**}$ . Over time, the aggregate supply curve becomes vertical, and the economy moves from D to the long-run equilibrium point at F. Prices fall further, while income rises further.

**Table 1** summarizes the expected impact on output and prices of shocks. This table later serves as a guide, as it predicts what the shapes of the impulse-response functions from the VAR should resemble.

**Table 1: Shocks in the AS-AD model of macroeconomic fluctuations**

Shock	Short-run	Long-run
<b>AD shocks</b>	Move output and prices in the same direction	Move prices in the same direction as output stays the same
<b>AS shocks</b>	Move output and prices in opposite directions	Move output and prices in opposite directions

The standard AS-AD model interprets aggregate demand shocks as emanating from autonomous changes in the money supply, government spending, investment and consumption, while aggregate supply shocks emanate from changes in productivity, wages and oil prices. In a developing country such as the Philippines, it is thought that supply shocks come predominantly from changes in the weather, which are known to have significant and variable impacts on agricultural output. Shocks to the foreign exchange rate and to the price of oil also have potentially significant supply-side effects. In this paper, I make no attempt to further disaggregate the individual shocks.

<sup>2</sup> There is some frictional unemployment associated with full employment level of employment and potential output. This is called the natural rate of unemployment, which arises from normal labor market frictions even when the market is in equilibrium.

<sup>3</sup> Determining the speed at which prices adjust – how long it takes for the AS curve to rotate from horizontal or upward-sloping to vertical – is one of the objectives of this research paper.

### III. The Econometrics of Long-Run Structural VARs

BQ's study was primarily motivated by one objective: to employ a new econometric technique to extract long-run structural relationships from the VAR coefficients and to use this to test a theory of short- and long-run macroeconomic fluctuations. Their modeling technique could accommodate any short-run model because the short-run behavior of the variables left to be freely determined by the data. Although VARs at the time had been used extensively to study relationships among macroeconomic variables, *the only way* identification could be achieved was through the assumption that the variables in the model were contemporaneously related. This meant that even though recursive and non-recursive techniques could be used to extract structural relationships among the variables,<sup>4</sup> these relationships could not be construed as long-run in nature, even if the theory supposedly modeled by the VAR suggested that long-run relationships existed among the variables. To many macroeconomists, therefore, attributing long-run structural interpretations to VAR estimates represented a serious misrepresentation by leading VAR advocates. The BQ method addressed this issue by enabling researchers to extract long-run relationships from the data. What follows is an illustration of the BQ method, with emphasis on the adaptation by Bayoumi and Eichengreen (BE).

#### a. Long-run Structural VARs

Consider an  $n \times 1$  vector of variables,  $y_t$  ( $n = 1, \dots, i$ ). A vector autoregression (VAR) is a vector of variables,  $y_t$ , regressed on time lags of itself:  $y_{t-1}, y_{t-2}, \dots, y_{t-p}$ , where  $p$  is the number of periods. In matrix notation, this is expressed as:

$$y_t = A(L)y_{t-1} + \varepsilon_t \quad (1)$$

where

$$A(L) = A_0 + A_1L + A_2L^2 + \dots + A_pL^p$$

where  $A(L)$  is an  $n \times n$  matrix polynomial in  $L$ , the lag operator,  $L = 0, 1, 2, \dots, p$ . Equation (1) is usually called an *unrestricted VAR*.<sup>5</sup> In BE, the vector  $y_t$  is comprised of just two variables, the first difference of the log of income (GDP) and the first difference of the log of prices (P).  $\varepsilon_t$  is a vector comprised of a shock to income,  $\varepsilon_{GDP}$ , and a shock to prices  $\varepsilon_P$ . We call these reduced form shocks, because they have no structural interpretation at this point.

Suppose we add a constant term,  $\mu$ , then we have:

$$y_t = \mu + A_1y_{t-1} + \dots + A_py_{t-p} + \varepsilon_t \quad (2)$$

where

$\varepsilon_t$  is white noise and  $\text{cov}(\varepsilon_t) = \Omega$

<sup>4</sup> Sims' (1980) seminal paper assumed that the variables in a VAR would be recursively related.

<sup>5</sup> Why we need to distinguish between unrestricted and restricted VARs will be clear later.



For example, a VAR(2) of a 2 x 1 vector. Let  $y_t = [x_t, z_t]'$ . It follows that

$$\begin{bmatrix} x_t \\ z_t \end{bmatrix} = \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \end{bmatrix} + \begin{bmatrix} A_{1,11} & A_{1,12} \\ A_{1,21} & A_{1,22} \end{bmatrix} \begin{bmatrix} x_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} A_{2,11} & A_{2,12} \\ A_{2,21} & A_{2,22} \end{bmatrix} \begin{bmatrix} x_{t-2} \\ z_{t-2} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad (3)$$

Note that the VAR form in equation (3) is really  $y_t$  regressed on a series of predetermined variables (realizations of itself that are determined before time  $t$ , hence the term predetermined). Therefore, the VAR form in (3) can be interpreted as a reduced form of a system with  $n (= 2)$  endogenous variables,  $x_t$  and  $z_t$ . In BE,  $x$  is the first difference in the log of real GDP, while  $z$  is the first difference in the log of the price level. The appropriate number of lags to use will depend on the Akaike information criterion (more on this later). Equation (3) is estimated, and the coefficient matrices become the basis for the succeeding structural analysis.

Equation (1) implies that

$$\begin{aligned} [I - A(L)L]y_t &= \varepsilon_t \\ y_t &= [I - A(L)L]^{-1} \varepsilon_t \end{aligned} \quad (4)$$

where the last equation above is the impulse-response function, or VMA form of the VAR, relating the vector of endogenous variables to the reduced-form shocks. From (4), note that  $y_t$  is a linear combination of the reduced form shocks.

Let

$$C(L) = [I - A(L)L]^{-1}, \text{ so that}$$

$$y_t = C(L)\varepsilon_t$$

$$y_t = \varepsilon_t + C_1\varepsilon_{t-1} + C_2\varepsilon_{t-2} + C_3\varepsilon_{t-3} + \dots \quad (5)$$

which is simply a reformulation of equation (4). In order to create a structural interpretation of the model, introduce an  $n \times n$  matrix  $F$ , which expresses the vector of reduced form shocks in terms of a vector of (more) structural shocks  $u_t$ :

$$\begin{aligned} F\varepsilon_t &= u_t \\ \varepsilon_t &= F^{-1}u_t \end{aligned} \quad (6)$$



The structural shocks are a linear combination of the reduced form shocks. What follows next is the BQ method for recovering the structural shocks.

Using (5) and (6), we can write the VMA or impulse response function for reduced form shocks in terms of the structural shocks  $u_t$ :

$$y_t = F^{-1}u_t + C_1F^{-1}u_{t-1} + C_2F^{-1}u_{t-2} + C_3F^{-1}u_{t-3} + \dots$$

$$y_t = C(L)F^{-1}u_t \quad (7)$$

If  $(L = 1)$  in (7), then the matrix  $C(1)F^{-1}$  contains the long multipliers of the structural model. The long-run response of  $y$  to  $u$  is captured by the sum of the coefficients of  $u$ :

$$\begin{aligned} \lim_{s \rightarrow \infty} \frac{\partial y_{t+s}}{\partial u_t'} &= \lim_{s \rightarrow \infty} C_s F^{-1} \\ &= C(1)F^{-1} \end{aligned} \quad (8)$$

where  $C(1) = \sum_{j=0}^{\infty} C_s$ . Note that  $C(1)$  is just the sum of the long-run multipliers in the reduced form VAR (so, it is deterministic). However, since we still don't know the precise form of  $F$ , the long-run response is not yet identified. The idea underlying structural VAR analysis is to impose enough identifying restrictions to ensure that the structural shocks are uncorrelated with one another, so that impulse-response functions may be given a proper structural interpretation.

There must be  $(n(n-1)/2)$  restrictions imposed on these long-run responses to get the needed  $n^2$  restrictions for exact-identification of all elements in  $F$ . In order to do this, we note that since

$$\varepsilon_t = F^{-1}u_t$$

It follows that

$$EC(1)F^{-1}u_t u_t'(F^{-1})'C(1)' = EC(1)\varepsilon_t \varepsilon_t' C(1)' \quad (9)$$

$$C(1)F^{-1}D(F^{-1})C(1)' = C(1)\Omega C(1)'$$

$$C(1)F^{-1}(F^{-1})C(1)' = C(1)\Omega C(1)' \quad (10)$$

We can thus apply the Cholesky decomposition to the RHS of (9) (the RHS of (9) and (10) are known from the estimation of the reduced form VAR) to obtain the lower triangular matrix  $\Lambda$ , an  $n \times n$  matrix containing the long-run responses of the elements of  $y$  to the structural shocks (i.e.,  $\Lambda$  is a linear combination of the long-run multipliers):

$$\Lambda = C(1)F^{-1} \quad (11)$$

The long-run neutrality restriction that the upper right hand element of  $\Lambda$  equals zero imposes one restriction on the elements of  $F$  (i.e., that the sum of the terms in the upper right hand element of the RHS of (11) equals zero). This restriction is just one equation that will help pin down one of the elements of  $F$ . The other three restrictions (equations) are provided by the fact that  $F^{-1}(F^{-1})' = \Omega$  (since  $\Omega$  is symmetric). This yields three equations, so that the system to be solved has four equations in four unknowns (an exactly-identified system). Obtaining a solution for  $F$  allows us to recover the structural shocks using (6). Note that the long-run structural VAR allow the data to determine short-run dynamics, because only long-run restrictions are imposed.

Illustration: (Imposing long-run restrictions in the  $n = 2$  case a la BE)

Recall that

$$\begin{aligned} y_t &= C(L)F^{-1}u_t \\ &= (I + C_1L + C_2L^2 + C_3L^3 + \dots)F^{-1}u_t \end{aligned} \quad (12)$$

Setting  $L = 1$  in (12) yields the long-run coefficients of the structural shocks,  $C(1)F^{-1}$

$$(I + C_1 + C_2 + C_3 + \dots)F^{-1}u_t \quad (13)$$

Since we know the  $y$  and  $C$  matrices, we need only to determine  $F$  to recover the structural shocks in the  $u$  vector. This is done by applying the Cholesky decomposition to  $C(1)C(1)'$ .

This allows us to recover

$$\Lambda = C(1)F^{-1}$$

$$\begin{bmatrix} \text{unrestricted} & 0 \\ \text{unrestricted} & \text{unrestricted} \end{bmatrix} = (I + C_1 + C_2 + C_3 + \dots)F^{-1} \quad (14)$$

Since  $C(L) = [I - A(L)L]^{-1}$  and  $C(1) = [I - A(1)]^{-1}$  we have an alternative way of interpreting (14) using the coefficient matrices of the reduced form VAR:<sup>6</sup>

<sup>6</sup> See still another alternative derivation of the restrictions in the Appendix.

$$\begin{aligned}
\Lambda &= (I + A^1 + A^2 + A^3 + \dots) \begin{bmatrix} F_{11} & F_{12} \\ F_{21} & F_{22} \end{bmatrix}^{-1} \\
&= (I - A)^{-1} \begin{bmatrix} F_{11} & F_{12} \\ F_{21} & F_{22} \end{bmatrix}^{-1} \\
\begin{bmatrix} \Lambda_{11} & \Lambda_{12} \\ \Lambda_{21} & \Lambda_{22} \end{bmatrix} &= \begin{bmatrix} 1 - A_{11} & -A_{12} \\ -A_{21} & 1 - A_{22} \end{bmatrix}^{-1} \begin{bmatrix} F_{11} & F_{12} \\ F_{21} & F_{22} \end{bmatrix}^{-1} \\
\begin{bmatrix} \text{unrestricted} & 0 \\ \text{unrestricted} & \text{unrestricted} \end{bmatrix} &= \begin{bmatrix} 1 - A_{11} & -A_{12} \\ -A_{21} & 1 - A_{22} \end{bmatrix}^{-1} \begin{bmatrix} F_{11} & F_{12} \\ F_{21} & F_{22} \end{bmatrix}^{-1} \quad (15)
\end{aligned}$$

What is the interpretation of the series of equations in (15) in the context of the AS-AD model of BE? In order to identify the BE model, one restriction is needed. Consistent with the traditional model of macroeconomic fluctuations, the restriction imposed is that in the long-run, the accumulated effect of one of the shocks on output is zero. This imposes the lone identifying restriction required for a recursive and exactly-identified model. Thus,  $\Lambda_{11}$ ,  $\Lambda_{21}$ , and  $\Lambda_{22}$  are unrestricted, but because of the Cholesky decomposition,  $\Lambda_{12}$  is restricted to equal zero and  $\Lambda$  becomes lower triangular. Since  $\Lambda$  is lower triangular, and since  $y_t$  is related to  $u_t$  by (7), it follows that the long-run response of  $y_t$  to the first element in the vector  $u_t$  is zero. Therefore, in the bivariate VARs of Blanchard and Quah and Bayoumi and Eichengreen, the first element in the vector  $u_t$  is identified as the structural demand shock,  $u_{dt}$ , and  $u_t = [u_{dt}, u_{st}]'$ .

The resulting estimates can therefore be given a structural interpretation. Those shocks whose accumulated effect on output is zero are interpreted as aggregate demand shocks, while those shocks whose effect on output and prices are freely estimated are interpreted as aggregate supply shocks. Given the estimates of the structural model, impulse-response functions and forecast error variance decompositions will be examined to see whether the behavior of the data is consistent with the traditional model of macroeconomic fluctuations.

It is now clear that identification and estimation of the elements in the  $F$  matrix holds the key to the structural VAR exercise. When special routines written in RATS and TSP for estimating  $F$  recover this matrix, they then proceed to input  $F$  into the "structural" form of the VMA/impulse-response function (equation 7) and the forecast error variance.

Variance decompositions allocate each variable's forecast error variance to the individual shocks. If  $E_{t-j} y_t$  is the expected value of  $y_t$  based on all information available at time  $t - j$ , the forecast error is  $y_t - E_{t-j} y_t$ . The variance-covariance matrix for the total forecast error is:



$$E(y_t - E_{t-j}y_t)(y_{t+s} - E_{t-j}y_t)' = F^{-1}D(F^{-1})' + C_1F^{-1}D(F^{-1})'C_1' + \dots + C_{s-1}F^{-1}D(F^{-1})'C_{s-1}' \quad (16)$$

(note that  $C_0 = I$ ). If the index for the number of lags is  $k = 1, \dots, s-1$ , the index for the number of shocks is  $q = 1, \dots, i$  and the index for the number of variables is  $n = 1, \dots, i$ , then the forecast error variance for the  $q^{\text{th}}$  shock to the  $n^{\text{th}}$  variable is comprised of the diagonal elements in each of the matrix components of the sum in (16). If  $C_{knq}$  is the  $(n, q)$  element, and  $D_q$  is the variance of the  $q^{\text{th}}$  shock in each of the  $s$  matrices adding up to the sum in (16), the  $j$ -steps ahead forecast variance of the  $n^{\text{th}}$  variable is:

$$E(y_{n,t} - E_{t-j}y_{n,t})^2 = \sum_{k=0}^{s-1} \sum_{q=1}^i [C_{knq}F^{-1}D_q(F^{-1})'C_{knq}'] \quad (17)$$

The variance decomposition function (VDF) writes the  $j$ -steps ahead percentage of forecast error variance for variable  $n$  that can be attributed to the  $q^{\text{th}}$  shock (Keating, 1992):

$$VDF(n, q, j) = \left( \frac{\sum_{k=0}^{s-1} C_{knq}F^{-1}D_q(F^{-1})'C_{knq}'}{\sum_{k=0}^{s-1} \sum_{q=1}^i [C_{knq}F^{-1}D_q(F^{-1})'C_{knq}']} \right) \times 100 \quad (18)$$

Since there are necessarily differences between the coefficients of the structural shocks and reduced form shocks, it follows that the impulse-response patterns generated by (7) will differ significantly from that of (5). The same will be true for the structural and reduced forms of the forecast error variances.

#### **b. Expected VAR Results Based on Predictions of the Traditional Theory of Macroeconomic Fluctuations**

The restrictions in the Blanchard and Quah, as well as Bayoumi and Eichengreen studies are based on fundamental results from the standard aggregate demand-aggregate supply (AD-AS) model. The key restriction is based on the result that in the long-run, only disturbances to the AS curve would have any long-run effects on output. AD disturbances would therefore have only temporary, or short-run effects on output (because in the long-run, the AS curve is vertical). Imposition of the key identifying restriction should ensure that the resulting structural shocks are uncorrelated, allowing a structural interpretation of the impulse-response functions. Bayoumi and Eichengreen modify the BQ model by substituting the price level for unemployment, thereby facilitating the interpretation of the results as coming from an AS-AD model of the economy.

**Table 2: Traditional Theory of Macroeconomic Fluctuations and its Implications for the Shape of the Structural Impulse-Response Functions**

Type of Shock	Short-run		Long-run	
AD shocks	Move output and prices in the same direction		Move prices in the same direction as output stays the same	
	Implications for impulse-response function of:		Implications for impulse-response function of:	
	Output to positive AD shock	Prices to positive AD shock	Output to positive AD shock	Prices to positive AD shock
	Increase	Increase	No change	Increase
AS shocks	Move output and prices in opposite directions		Move output and prices in opposite directions	
	Implications for impulse-response function of:		Implications for impulse-response function of:	
	Output to positive AS shock	Prices to positive AS shock	Output to positive AS shock	Prices to positive AS shock
	Increase	Decrease	Increase	Decrease

Analyzing differences in the responses of output and prices to different structural shocks is the primary motivation for this study. This paper applies the Bayoumi and Eichengreen model in order to analyze the impact of AS-AD disturbances in the Philippines. This study differs from other cross-country VAR studies that include the Philippines in that:

- quarterly, instead of annual data is used, so that the data used is more temporally disaggregated; and
- the impulse response functions and variance decompositions are analyzed.

For the Philippines, AS shocks are interpreted to be those shocks that induce firms to change the level of output and services supplied, and these include climatic disturbances, movements in the exchange rate, productivity changes, oil price changes, and others. A one standard deviation innovation to AS that generates impulse responses is interpreted as a shock that would tend to increase aggregate output supplied by firms, such as good weather, a fall in oil prices, increased productivity, etc. AD shocks are identified as (mostly) autonomous money supply shocks, but they also include autonomous changes in government spending.

To summarize, the objective of the paper is to estimate a structural model of the Philippine economy using vector autoregression (VAR) methodology. The structural model being estimated is a traditional Keynesian AS-AD model of macroeconomic fluctuations. This model predicts that in the short-run, transitory shocks, interpreted as aggregate demand



shocks, move output and prices in the same direction and are neutral with respect to output in the long-run, but affect prices. On the other hand, permanent shocks, interpreted as aggregate supply shocks, raise output and lower prices in the short- and long-run. A reduced form bivariate VAR is estimated, and inversion of the estimated VAR yields a decomposition of output and prices into a moving average of orthogonal output and price shocks. Since this is a reduced-form model, no structural interpretation can be given to the estimates. Restrictions based on theory are imposed, and the resulting impulse response functions and variance decompositions are analyzed within the context of a structural AS-AD model.

#### **IV. Impulse-Response Functions for the Philippines**

##### **a) Results for the Philippines**

Using quarterly data from 1983-2000, a bivariate VAR in the first difference of the log of real GDP and the first difference of the log of the GDP deflator was estimated. The appropriate number of lags (4 quarters) was chosen using the Akaike information criterion and the Schwarz-Bayes information criterion. Identifying restrictions based on equation (15) were imposed and the corresponding “structural” impulse-response functions (see **Figures 3 – 6**) and variance decompositions were generated. 90 percent confidence bands for the impulse-responses were calculated using the Monte Carlo approach of Runkle (1987), which performs bootstrapping; simulating the VAR model to generate distributions for the results.<sup>7</sup>

Now that the structural shocks have been identified, we are ready to provide a structural interpretation for the resulting impulse-response functions and variance decompositions. In **Figures 3 – 4**, graphs of impulse responses suggest that output has a hump-shaped response to permanent (AS) shocks. The graph of the response of output to permanent, or aggregate supply (AS) shocks shows that the initial impact of AS shocks to output is positive from the outset and peaks from the sixth to seventh quarters (almost two years after the shock). Thereafter, output settles permanently towards its steady state just before the 16<sup>th</sup> quarter. AS shocks also display much persistence: the response of output reaches a plateau after four years. The shape of the impulse response function is consistent with the textbook impact on output of an AS shock – an increase in aggregate supply raises output permanently in the short- and long-run.

Prices also have a hump-shaped response to permanent AS shocks. However, the response of prices is a mirror image of outputs'. The initial response of prices is negative, with the peak negative response occurring on the fourth and fifth quarters. The negative response moderates after that, and reaches a plateau after about the 13<sup>th</sup> quarter. The shape of the impulse response function is likewise consistent with the textbook impact on prices of an AS shock. Provided the aggregate demand curve is downward-sloping, a shock that moves the AS curve outward lowers prices permanently in the short- and long-run.

<sup>7</sup> The residuals of the estimated VAR are randomly sampled, and these are then used as shocks to the estimated VAR. After the synthetic series are generated, they are used to perform the same structural VAR analysis. After 2000 replications of the model, standard errors were calculated for the impulse responses.



Figure 3: Response of Output to Permanent (AS) Shock

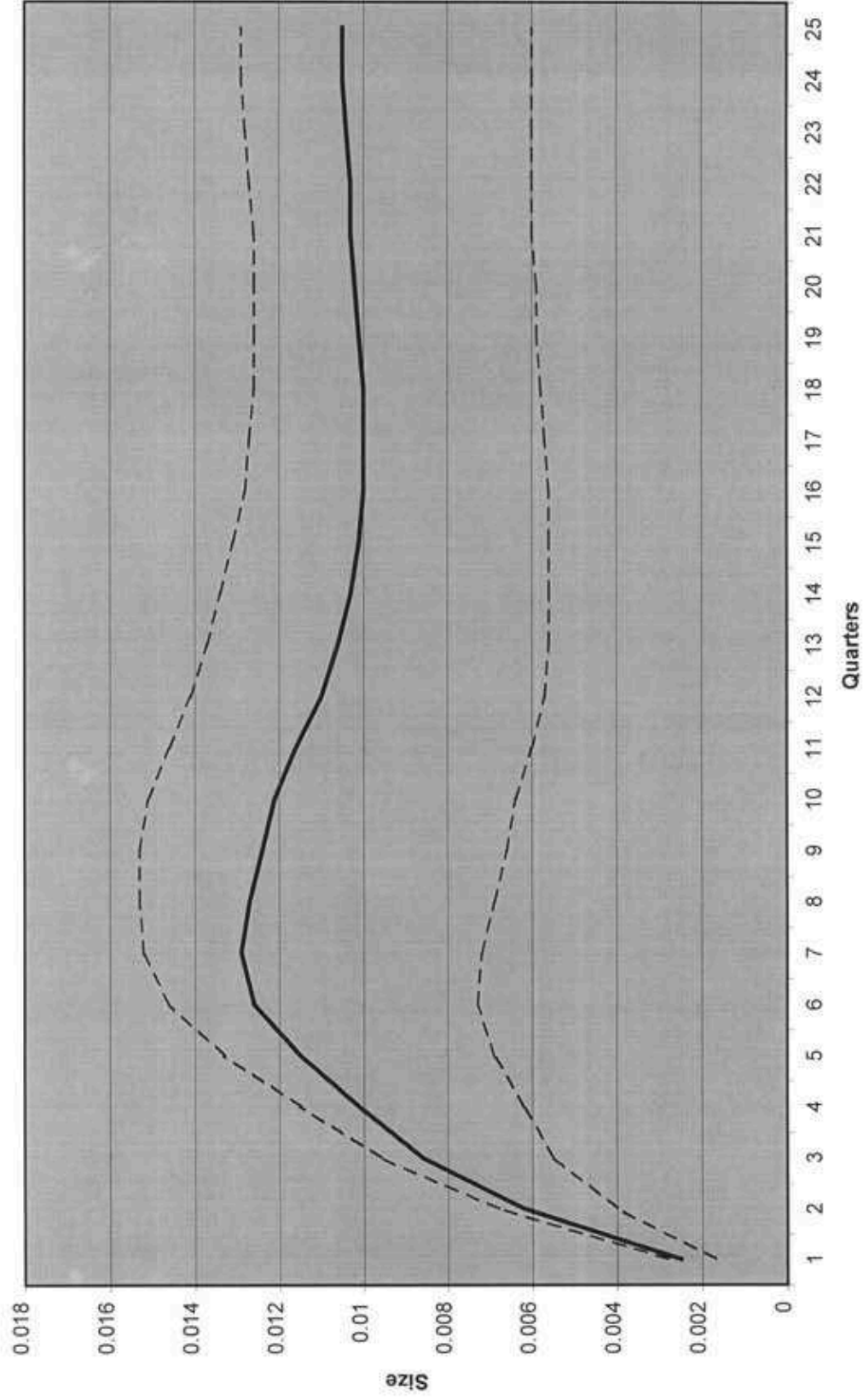


Figure 4: Response of Output to a Temporary (AD) Shock

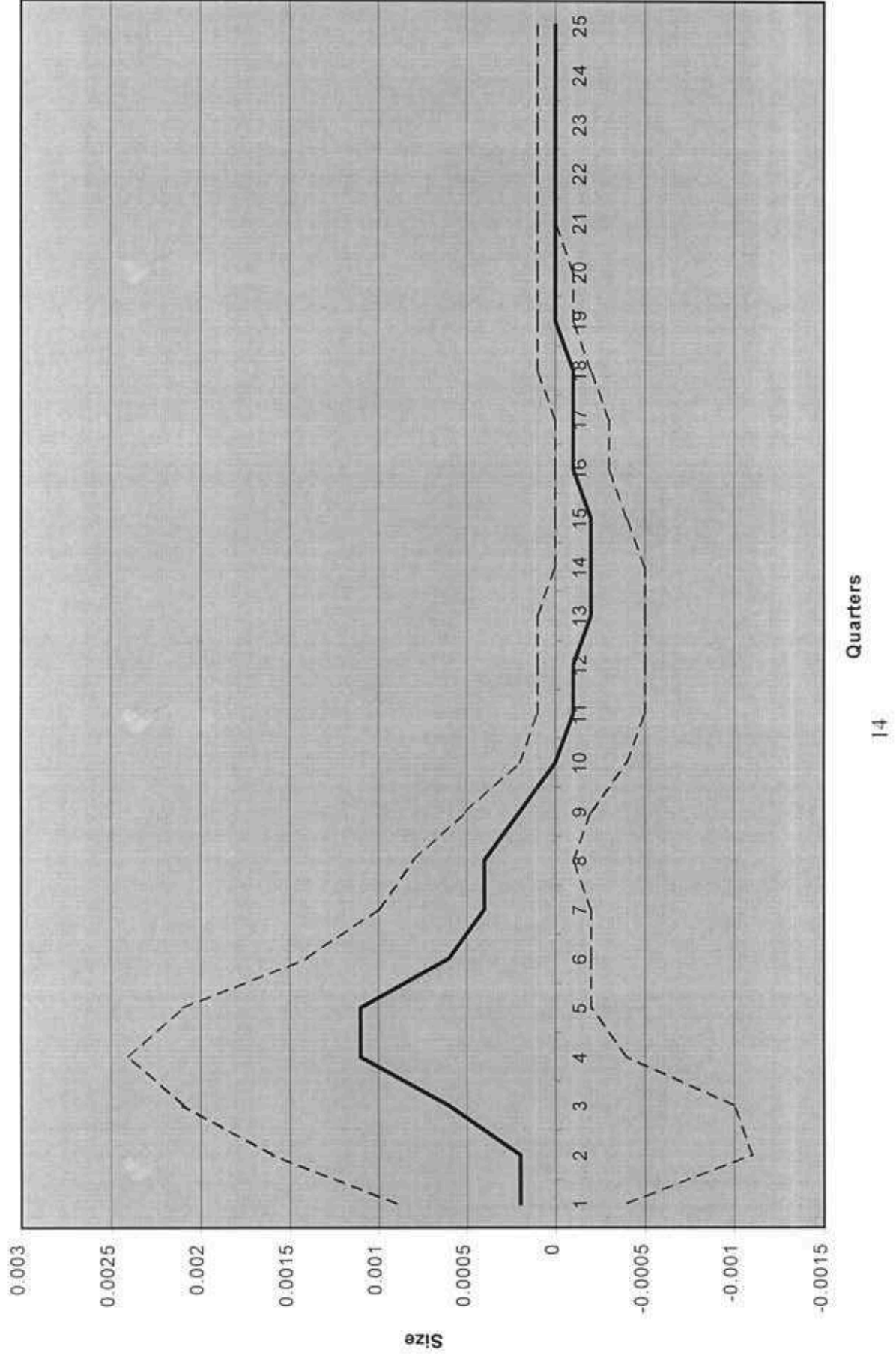


Figure 5: Response of Prices to a Permanent (AS) Shock

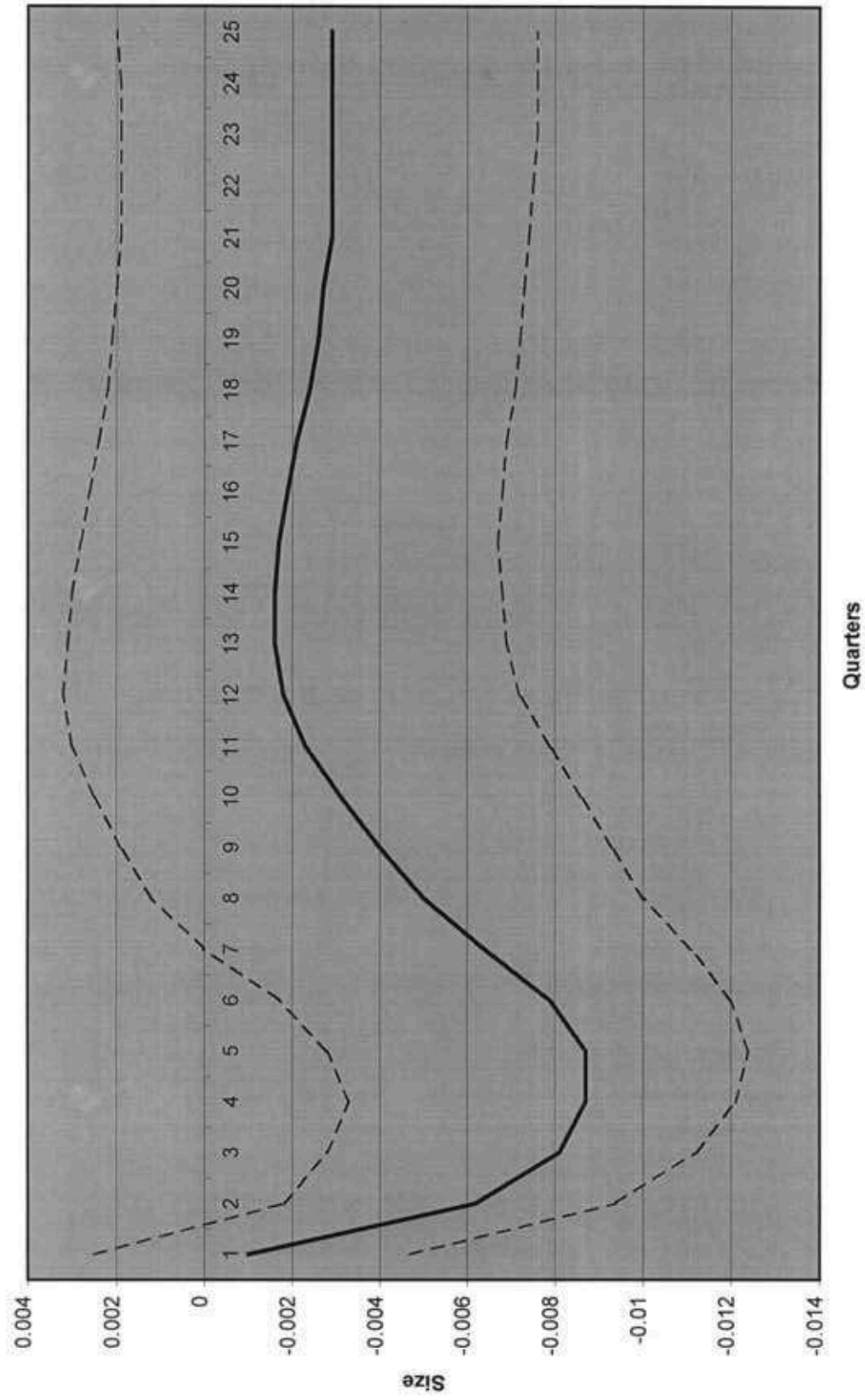
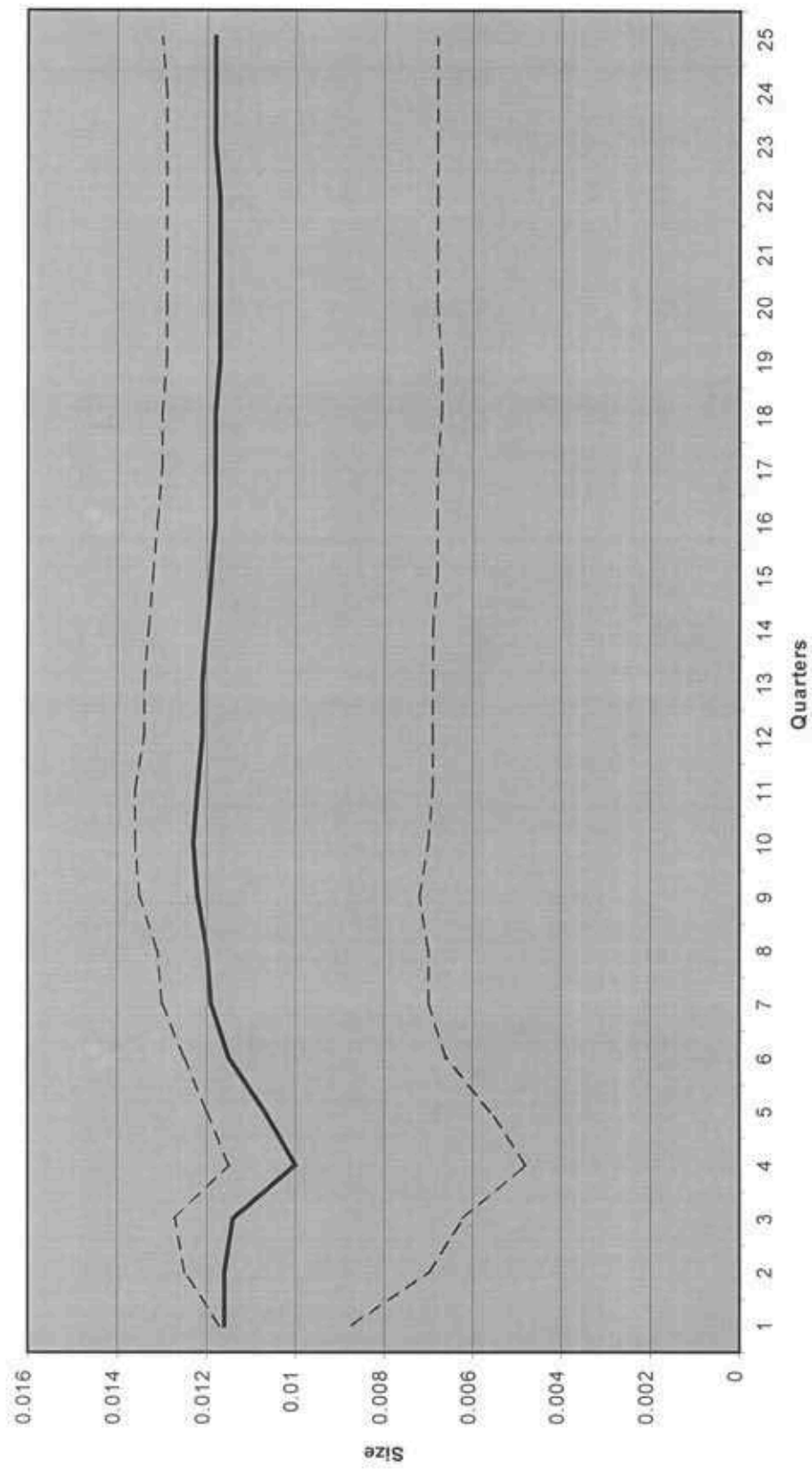




Figure 6: Response of Prices to a Temporary (AD) Shock



The impulse-responses of output and prices to AS shocks also allow us to trace out an implied AD curve. Because prices fall and output rises following an AS shock (that is uncorrelated with demand shocks), it follows that the AD curve is downward-sloping. The impulse response functions likewise shed light on the adjustment mechanism of output and prices to an AS shock. **Figures 3 and 4**, suggest the following interpretation: in response to a positive AS shock, the short-run AS curve shifts outward, raising output from  $Y$  to  $Y'$  and lowering prices from  $P$  to  $P'$ . In the long-run, wages and output adjust, and the output settles towards the (lower) level  $Y''$  and prices settle at the (higher) level  $P''$  determined by the vertical long-run AS (LRAS) curve.

In **Figures 5 – 6**, graphs of impulse responses suggest that output also has a hump-shaped response to temporary (AD) shocks. The graph of the response of output to temporary shocks shows that the initial impact of AD shocks to output is positive at the outset and peaks from the fourth to fifth quarters (about one year after the shock). Thereafter, the response of output becomes slightly negative, and settles permanently towards its steady state (zero) just before the 19<sup>th</sup> quarter (the fifth year). AD shocks do not display much persistence: the response of output reaches zero (or close to zero) after ten quarters years. The shape of the impulse response function is consistent with the textbook impact on output of an AD shock. In the short-run, a shock to AD raises output in the short-run. However, in the long-run, the effect disappears as the AS curve rotates toward the LRAS. There is one qualification to our results, however: the bootstrapping exercises reveal that the 90 percent confidence bounds for the impulse-responses yield very wide error bands. In fact, for the first 20 quarters, they include positive *as well as* negative values. Thus, these results are not as conclusive as those for the AS shocks derived earlier.

The graph of the response of prices to temporary (AD) shocks yields more definitive results. Consistent with the textbook impact of an AD shock, the graph of the impulse response of prices indicates that temporary shocks have a strong and very persistent positive effect on prices. Because the estimated response of prices is rather flat (except for a slight downward blip in the fourth quarter), this suggests that the short- and long-run effects of an AD shock are roughly equal in size. The upper and lower error bands for the responses suggest that these results are robust, because they all lie in the positive quadrant.

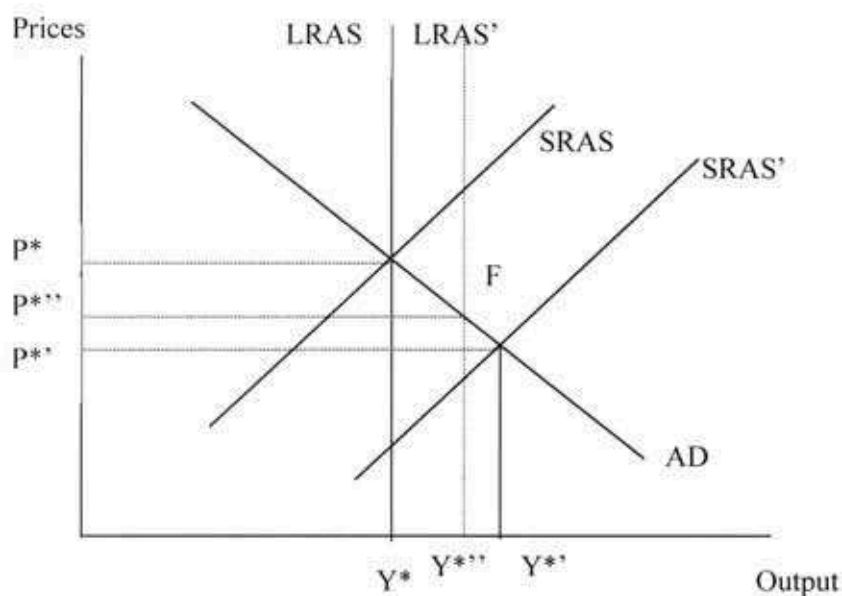
The shapes of the impulse-responses of output and prices to an AS shock in **Figures 3 and 5** reveal important information about the LRAS curve and the economy's long-run adjustment. Because the response of output to an AS shock is not monotonically increasing, and the response of prices to an AS shock is not monotonically decreasing in the long-run, it appears that in the long-run, the rotation of the aggregate supply curve leaves the magnitude of the increase in output and the fall in prices smaller in proportion to their short-run equilibrium values. This is consistent with the depiction of the Philippine economy's transitional dynamics in **Figure 7**. Unlike **Figure 2**, the long-run equilibrium output and price are lower than their short-run equilibrium values.

#### **b) Comparing The Philippines' Results with Industrialized Countries**

Estimates from Blanchard and Quah (1989), and Blanchard (1989) suggest that in the United States, the traditional view of macroeconomic fluctuations is supported by the data (i.e., the impulse response functions are consistent with the shapes suggested in **Table 2**. The same structural VAR restrictions applied to data from other industrialized countries yields

similar qualitative responses Keating and Nye (1996, 1997). The symmetry among these responses suggests that AS and AD shocks are structurally similar in developed countries. In these countries, AS shocks are interpreted to be mostly productivity shocks, while AD shocks are interpreted to be mostly monetary in nature. However, the nature of AS and AD shocks in non-developed countries could be different. For example, rather than being primarily productivity-driven, AS shocks could be primarily driven by climate or weather-related variables in a developing country, where agriculture accounts for a larger proportion of output. By comparing impulse responses for the Philippines with those of developed countries, we can determine whether the responses of output and prices to AS and AD shocks could be qualitatively different.

**Figure 7: Implied transitional dynamics of Philippine output and prices in response to an AS shock**



For ten developed countries, Keating and Nye (1998) examined the qualitative responses of output and prices to permanent and transitory shocks, identified using the BQ method. In general, they found similar responses across their sample. The general characteristics of the qualitative responses are described in general, and compared against the responses in The Philippines in **Table 3**.

There are several qualitative similarities and differences between the impulse-responses:

- 1) Both AS shocks to industrialized country output and Philippine output display persistence, but the positive impact of AS shocks on industrialized country output is stronger than impact of AS shocks on Philippine output. Output response is monotonically increasing over time in the industrialized countries, but the positive response of output to AS shocks peaks after just 7 quarters in the Philippines. Thereafter, the response falls slightly then becomes flat. This means that the while the transitional



dynamics of the Philippine economy resembles **Figure 7**, the dynamics in industrialized countries resembles **Figure 2**.

- 2) The evidence that AD shocks raise output is not as strong in the Philippines as in industrialized countries.
- 3) The response of prices to both AS and AD shocks is qualitatively similar.

**Table 3: Impulse-Response Functions from Long-Run VARs: Industrialized Countries vs. The Philippines**

Characteristics of the impulse-response	Response of output to permanent (AS) shock	Response of output to temporary (AD) shock	Response of prices to permanent (AS) shock	Response of prices to temporary (AD) shock
Shape of impulse response function for industrialized countries	Positive and rising over time	Positive and falling over time; peak impact on initial period	Negative and falling over time	Positive and rising over time
Persistence of the effects of the shock for industrialized countries	Positive response persists more than ten years after the shock	Strong positive response persists one or more years after the shock only for the US, UK, Italy, Germany, France and Canada.	Negative response persists at least one year after the shock for all countries but Canada	Strongly positive response persists for ten or more years except for all countries except Italy.
Philippines	Positive and plateaus over time; peak impact is on 7 <sup>th</sup> quarter; the magnitude of the positive impact slightly falls thereafter	Estimated coefficients suggest positive initial response with strongest impact felt from the 4 <sup>th</sup> to 5 <sup>th</sup> quarters after the shock; however, 90% error bounds fail to exclude negative responses	Negative and plateaus over time; peak impact is on 4 <sup>th</sup> to 5 <sup>th</sup> quarters; the magnitude of the negative impact slightly falls thereafter	Positive and plateaus over time; peak impact is from the start of the 9 <sup>th</sup> quarter onwards

Source: Keating and Nye (1998) for the second and third rows.

Thus, the most important qualitative differences lie in the response of output to AS and AD shocks. What needs to be analyzed is why the transitional dynamics of output and prices in response to an AS shock differs in the Philippines, compared to industrialized countries. Perhaps this dichotomy reflects the differences between productivity growth, the primary source of AS shocks in industrialized countries, and climate and changes in the exchange rate, the primary sources of AS shocks in the Philippines. It appears that AS shocks in the Philippines lead to some “overshooting” of long-run equilibrium output and prices.

## V. Forecast Error Variance Decompositions

The  $j$  quarters-ahead forecast error in output is the difference between its actual value and its forecast as of  $j$  quarters earlier (derived from **equations 16 – 18**). As in Blanchard and Quah, the forecast error is due to both unanticipated demand and supply disturbances in the last  $j$  quarters. The shaded areas in the third column of **Table 4** represent interpretations by Keating and Nye (1998) of the results from general short horizon (one year) variance decompositions from long-run VARs using post-World War II data from industrialized countries. *Keating and Nye suggest that cross-country differences in the short-horizon variance decompositions result from differences in the slopes of their short-run AS curves.*

**Table 4: Short-Horizon (One Year) Variance Decompositions from Long-Run VARs**

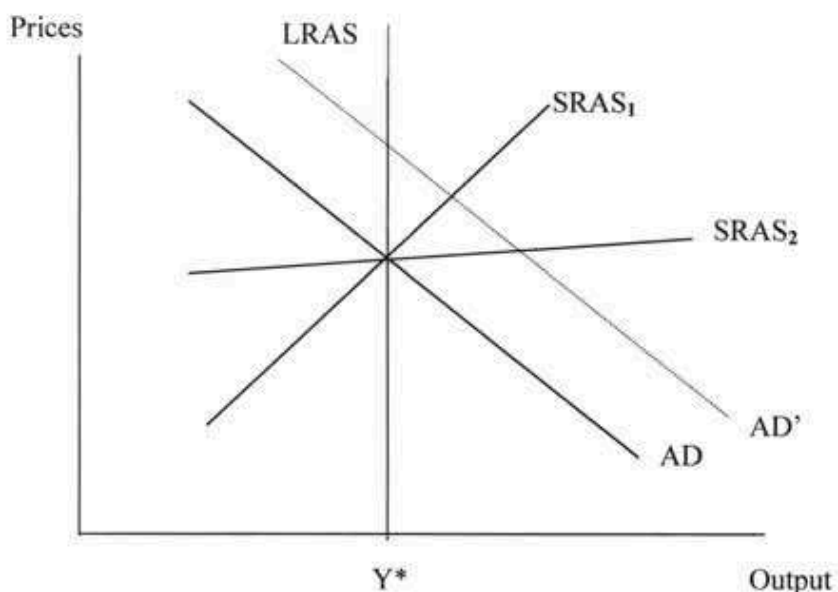
Variance in output shocks explained primarily by shocks to	Variance in price shocks explained primarily by shocks to	Implication
AS	AD	Relatively steep AS curve
AS	AS	No conclusions can be drawn about the slopes of the AS or AD curves. Most important shocks affecting the economy are supply-side shocks
AD	AS	Relatively flat AS curve
AD	AD	No conclusions can be drawn about the slopes of the AS or AD curves. Most important shocks affecting the economy are demand-side shocks

Source: Shaded areas represent the interpretations of Keating and Nye (1998). Other areas represent the author's interpretations.

The impact of a steeper short-run AS curve is illustrated in **Figure 8**. For a given AD shock, the country with a steeper short-run AS curve ( $SRAS_1$ ) will experience a smaller increase in short-run equilibrium output and a larger increase in short-run equilibrium price level. This makes it more likely that the short-horizon variance in output and prices will be explained by AS and AD shocks, respectively.

Variance decompositions from the Philippine structural VAR are presented in **Tables 4 – 5**. The variance decompositions present dramatic evidence about macroeconomic fluctuations in the Philippines.

**Figure 8: Effect of different short-run AS curves (Keating and Nye, 1998)**



**Table 4: Variance Decomposition of Output**

Step-ahead horizon (j quarters)	forecast	Percentage of forecast error of output due to AS shocks	Percentage of forecast error of output due to AD shocks
0		0.9909	0.0092
1		0.9969	0.0031
2		0.9923	0.0077
3		0.9826	0.0174
4 (1 year)		0.9836	0.0164
5		0.9785	0.0215
6		0.9772	0.0229
7		0.9771	0.0229
8 (2 years)		0.9762	0.0238
9		0.9746	0.0255
10		0.9745	0.0255
11		0.9748	0.0253
12 (3 years)		0.9748	0.0252
13		0.9748	0.0252
14		0.9749	0.0252
15		0.9748	0.0252
16 (4 years)		0.9747	0.0253
17		0.9747	0.0253
18		0.9747	0.0253
19		0.9747	0.0253
20 (5 years)		0.9747	0.0253
21		0.9747	0.0253
22		0.9747	0.0253
23		0.9747	0.0253
24 (6 years)		0.9747	0.0253



The second and third columns in **Table 4** contain the proportion of the mean square error (MSE) of the  $j$ -steps ahead forecast of output that is attributed to output and price level shocks, respectively. Note that shocks in aggregate supply explain virtually all of the forecast error variance in output, suggesting that *changes in output are driven mostly by supply side shocks*. The second and third columns in **Table 5** contain the proportion of the mean square error (MSE) of the  $j$ -steps ahead forecast of prices that is attributed to output and price level shocks, respectively. Note that shocks in aggregate demand explain virtually all of the forecast error variance in prices, suggesting that *changes in prices are driven mostly by demand side shocks*.

The variance decompositions also suggest that the Philippines belongs to the first category in **Table 4**. If this is so, then the country should have a relatively steep short-run AS curve. This is very much consistent with the earlier interpretation of the structural impulse-response functions.

**Table 5: Variance Decomposition of Prices**

Step-ahead forecast horizon (j quarters)	Percentage of forecast error of prices due to AS	Percentage of forecast error of prices due to AD
0	0.0076	0.9924
1	0.1700	0.8301
2	0.1879	0.8121
3	0.1878	0.8122
4 (1 year)	0.1873	0.8127
5	0.1890	0.8110
6	0.1994	0.8006
7	0.2086	0.7914
8 (2 years)	0.2131	0.7869
9	0.2165	0.7835
10	0.2196	0.7804
11	0.2207	0.7793
12 (3 years)	0.2208	0.7792
13	0.2208	0.7792
14	0.2208	0.7792
15	0.2210	0.7790
16 (4 years)	0.2213	0.7787
17	0.2215	0.7785
18	0.2217	0.7783
19	0.2218	0.7782
20 (5 years)	0.2219	0.7782
21	0.2219	0.7781
22	0.2219	0.7781
23	0.2219	0.7781
24 (6 years)	0.2219	0.7781

How are these results interpreted? First, since price level changes are driven mostly by demand side shocks, even at very short horizons, it appears that (even) the short-run AS curve is very steep. Interpreted within the context of the economy's adjustment mechanism, this suggests that the price adjustment mechanism in the Philippine economy is fairly rapid. What could be the reason for rapid price adjustment in the economy? There could be an absence of nominal price and/or wage rigidities, a scenario more consistent with neoclassical explanations of the macroeconomy than with neo-Keynesian theories. Given that Philippine output appears to be neutral with respect to AD shocks (or at least, given that the response of output to AD shocks is very uncertain), it appears that there is very little room for government stabilization policy to work, even in the short-run. Since the AS curve is steep or vertical, demand-side interventions lead mostly to short- and long-run increases or reductions in prices without corresponding changes in output. The uncertainty with respect to the impact of demand shocks is consistent with the earlier findings with respect to the impulse-response function of output with respect to demand shocks.

## **VI. Conclusion**

The results of the structural VAR exercise for the Philippines suggest that the Philippines has both a relatively steep short-run AS curve. This is consistent with rapid price adjustment in the macroeconomy. A more in-depth empirical analysis of the data may be performed to determine whether or not rapid price adjustment is more due to the absence of only wage or only price rigidities (or the absence of both). At any rate, the results also do not bode well for the efficacy of government stabilization policy. If the results are correct and the standard AS-AD model in fact captures the structure of the Philippine economy correctly, perhaps this explains why government economic intervention has been so ineffective for so long in raising output.

Several findings in the paper require further analysis. One is the "overshooting" by output and prices from their long-run equilibrium values in response to an AS shock. The other is why the response of output to AD shocks is so uncertain. Succeeding studies, perhaps in expanding this basic VAR to include more variables, could shed more light on these issues. Another direction this study will be extended is in conducting this study for a wider subset of developing countries, to see if any empirical regularities regarding the AS curve will be discovered.

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## Appendix

The imposition of long-run identifying restrictions on a VAR implies that  $L$  should be set equal to 1 in equations (4) and (5). In more compact notation, this means that:

$$y_t = [I - A(1)]^{-1} F^{-1} u_t$$

where we let

$$\theta(1) = [I - A(1)]^{-1} F^{-1} \quad \text{so that} \quad y_t = \theta(1) u_t \quad (A.1)$$

From this last equation, it follows that

$$\begin{aligned} [I - A(1)]^{-1} E(F^{-1} u_t u_t' F^{-1}) [I - A(1)]^{-1'} &= [I - A(1)]^{-1} F^{-1} D F^{-1'} [I - A(1)]^{-1'} \\ &= \theta(1) u_t u_t' \theta(1)' \end{aligned}$$

so that since  $\varepsilon_t = F^{-1} u_t$  and  $\text{cov}(\varepsilon_t) = \Omega$ , we get the link between the reduced form VAR and the structural VAR

$$[I - A(1)]^{-1} \Omega [I - A(1)]^{-1'} = \theta(1) D \theta(1)' \quad (A.2)$$

Where the LHS of this last equation comes from the reduced form VAR estimates and the RHS contains the structural long-run responses of the elements of  $y$  to the elements of  $u$ ,  $\theta(1)$ .  $\theta(1)$  may be extracted from the LHS of (A.2) using the Cholesky decomposition. Imposing the restriction  $D = I$  means that the Cholesky decomposition may be applied to the LHS of (A.2) to obtain the lower triangular matrix of long-run responses to the structural shocks,  $\theta(1)$ , such that the LHS of (A.2) =  $\theta(1)\theta(1)'$ . In this case, since  $\theta(1)$  has a recursive structure, with the first variable affected only by lags of itself and not affected in the long-run by the other variables, the second variable affected in the long-run by its own lags and lags of the first, but not the others, and so on and so forth.