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Identifying Long run Supply Curve of India♣

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Abstract

Identifications of a vertical then a horizontal supply curve are successively imposed on Indian time series inflation and industrial output growth data in a two-equation Structural Vector Autoregression (SVAR) model. The results provide an indirect test of the identifications. A high elasticity of long run supply cannot be ruled out, because supply shocks have a large impact on inflation and demand has a large and persistent effect on output levels. But supply is subject to frequent shocks. Estimated structural shocks capture historical recessions and turning points well. Pro-cyclical policy induced demand shocks aggravated negative supply shocks or failed to take full advantage of positive supply side developments.

Key words: Horizontal and vertical supply curves, demand and supply shocks, Structural VAR, identification, historical decomposition.

JEL Classification: C32, E31, E32

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1. Introduction

Macroeconomic price and output series result from a combination of deterministic causal factors and shocks. If they have a unit root, it implies that shocks have long-run effects on the variables. Considering the simplest aggregate demand, aggregate supply model as generating the price and output series, these shocks can be understood as shifting the two curves, and can be broadly classified into demand and supply shocks.

A Structural Vector Autoregression (SVAR) representation of a time series of price and output can be used to decompose the share of the changes originating from demand and supply shocks respectively. But in a dynamic simultaneous equation system, some identifying restrictions are required to identify structural shocks. It is also necessary to assume that the two aggregate shocks represent the average dynamic effects of potentially many underlying shocks. The averaging process is valid insofar as demand and supply are conceptually distinct categories. The aggregate demand and supply curves that survive in all macroeconomic textbooks demonstrate the viability of these conceptual categories. Moreover, small models have an advantage especially when we want, as in this paper, to systematically compare the effects of two polar identifications. Large size VAR models quickly run into the curse of dimensionality because of the large number of lags involved.

In the literature (Blanchard and Quah, 1989, Quah and Vahey, 1995), it is common to impose the identifying restriction that the aggregate supply curve is vertical in the long run. Then aggregate demand shocks have no long-run effect on output. This is the output neutrality assumption. If the economy is at full employment in the long run, a rise in demand due to monetary or fiscal policy cannot raise output but contributes only to a price rise. This mainstream macroeconomic convention may be a valid long-run approximation for a mature economy that is near full-employment.

Even so, there is an established literature that allows demand to have long-run effects either through multiple equilibria (Farmer, 1999) or through hysterisis effects (Blanchard and Summer, 1987). Mankiw and Romer (1991) have a collection of articles on these issues.

A labor surplus country such as India cannot be regarded as being anywhere near full employment. There tend to be short-term supply shocks which if relieved allow an expansion of employment at a constant real wage, or one that rises with productivity. Therefore, an elastic long-term supply curve may be a valid identification for such a country until it reaches full maturity and absorption of its labor surplus. Globalization and more foreign inflows have relaxed the foreign exchange constraint, which used to be one of the major bottlenecks.

In this paper we estimate two alternative extreme decompositions of structural shocks for the Indian economy, and test, which is more appropriate. The decomposition gives us the relative size and effect of demand and supply shocks on inflation and output. First, the restriction is imposed that demand shocks can have no long run effect on output.

The second identification restriction tested for the dynamic structural VAR is that demand shocks have no long run effect on inflation. Comparing the relative size of demand and supply shocks under such identification, with the earlier one, yields useful insights.

The results serve as an indirect test of the two identifications. They imply that high long run supply elasticity cannot be ruled out for the Indian economy. The relative size of supply shocks are larger than that warranted by a vertical long-run supply. Their size also exceeds that found in similar decompositions estimated in developed countries.

Results on the historical relative contribution of demand and supply shocks to inflation and industrial output growth illustrate the impact of oil shocks and the interaction of macroeconomic policy with structural adjustment that was a part of the ongoing reform process during the nineties. Macroeconomic policy would be part of demand shock while structural reform would add to supply shocks.

The results also contribute to the debate about the conditions under which demand can have long-run effects.

This paper has been organized in the following manner. Section 2 explains the identification problem in an SVAR model. The information about data and methodology has also been presented in this section. Section 3 discusses the results and Section 4 analyzes the demand and supply components of output growth and inflation. The conclusion is in Section 5.

2. Identifying the SVAR

Consider a VAR (p) model, which can be expressed as follows:

$$Z_t = \alpha + A_1 Z_{t-1} + A_2 Z_{t-2} + ... + A_p Z_{t-p} + e_t \qquad (1)$$

$$\left(1 - L - L^2 - L^p\right) Z_t = \alpha + e_t$$

$$A(L) Z_t = \alpha + e_t, \qquad e_t \sim N(0, \Omega)$$

where Z_t is a covariance stationary vector, $A(L)$ is the matrix of lag operators, α is an intercept vector and e_t is an error vector. The Wold (moving average) representation of Equation 1 would be

$$Z_t = C(L) e_t \qquad (2)$$

where $C(L) = A(L)^{-1}$ and $C_0 = I$. In this representation, the elements of e_t are contemporaneously correlated.

Now suppose that the behaviour of Z_t is governed by independent structural shocks (innovations) ε_t, which are orthogonal to each other. These have to be identified in order to estimate the movement of the components of Z_t with respect to the individual shocks. Suppose that the Wold representation with the structural shocks takes the following form:

$$Z_t = D(L)\,\varepsilon_t; \qquad \text{where } \varepsilon_t \sim N(0, I) \tag{3}$$

We follow the BQ (Blanchard and Quah, 1989) SVAR approach[1] to identify the structural innovations or components of ε_t. BQ make use of long run restrictions. From Equation 2 and Equation 3,

$$e_t = D_0\varepsilon_t \quad \text{and} \quad C_j D_0 = D_j \tag{4}$$

$$C(L)D_0 = D(L) \tag{5}$$

$$\Omega = D_0 D_0' \qquad \text{Since Var}(\varepsilon)=\text{I} \tag{6}$$

After obtaining the D_0 matrix it can be used to identify ε_t with the help of e_t.

In a bi-variate model, D_0 consists of four elements, which necessitates four restrictions for identification. The symmetry of the matrix Ω = Var(e_t) and the normalization conditions impose three restrictions. Therefore, we need only one more restriction to identify D_0. If, following BQ, we impose a long run restriction; the structural innovations can be identified. In our bi-variate model, the long run expression of Equation 3 can be written as:

$$\begin{pmatrix} \Delta z_{1t} \\ \Delta z_{2t} \end{pmatrix} = \begin{pmatrix} D_{11}(1) & D_{12}(1) \\ D_{21}(1) & D_{22}(1) \end{pmatrix} \begin{pmatrix} \varepsilon^1 \\ \varepsilon^2 \end{pmatrix} \tag{7}$$

where $D(1) = \sum_{j=0}^{\infty} D_j$ is the long run matrix of *D(L)*. With a long-run restriction $D_{12}(1) = 0$, *D(1)* will be a lower triangular matrix. From Equation 4, $C(1)D_0 = D(1)$. With Equation 5,

$$\begin{aligned} C(1)D_0 D_0' C(1)' &= D(1)D(1)' \\ C(1)\Omega C(1)' &= D(1)D(1)' \end{aligned} \tag{8}$$

Given the estimates of Ω and *C(1), D(1)* will be the unique lower triangular Choleski factor of $C(1)\Omega C(1)'$, since *D(1)* is lower triangular. The structural shocks can now be easily computed by using $D_0 = C(1)^{-1}M$; where M is the lower triangular Choleski decomposition of Equation 7. The structural shocks are obtained from D_0 and e_t using the relation $e_t = D_0\varepsilon_t$, where e_t is the residual from estimating the reduced form VAR, i.e., Equation1.

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[1] Please see Bjornland (2001), Giannini (2004) and Enders (2004) for applications and further developments of the approach.

In the present context, Z comprises change in the logarithm of output and inflation, y and Δp. Their behaviour is governed by two kinds of structural innovations, that is, supply shocks and demand shocks. We estimate two separate SVAR models with these two variables, by altering their order. Supply shocks are ε^1 and demand shocks ε^2 respectively.

In our analysis the first model is the vertical supply curve (VSC) model, $Z_t = (y \quad \Delta p)$. The assumption that demand shocks have no impact on y in the long run, gives us a vertical long run supply curve. This corresponds to long run neutrality assumption where demand inflation does not raise output in the long run. This model is equivalent to long run vertical Phillips curve or Lucas supply curve. The long-run restriction makes $D_{12}(1)=0$, so that $D(1)$ is a lower triangular matrix.

Once the structural shocks and the sequence of D_0s are estimated, the long -run effect of supply shocks on output is given by $\sum_{j=0}^{\infty} D_{11}(j)\varepsilon^1(t-j)$, while the long-run effect of demand on output is zero. Inflation is decomposed as the sum of supply and demand shocks respectively as $\Delta p = \sum_{j=0}^{\infty} D_{21}(j)\varepsilon^1(t-j) + \sum_{j=0}^{\infty} D_{22}(j)\varepsilon^2(t-j)$.

The second model is called the horizontal supply curve (HSC) model. Here $Z_t = (\Delta p \quad y)$. Here, we assume demand shocks to have no impact on inflation in the long run. Therefore, this provides a horizontal long run supply curve. The long-run restriction again makes $D_{12}(1) = 0$, so that $D(1)$ is a lower triangular matrix, but because of the change in order of the variables it now implies a horizontal supply curve. In both the models, however, the order of the structural shocks remains the same.

Again, once the structural shocks and the sequence of D_0s are estimated, the long run effect of supply shocks on inflation is given by $\sum_{j=0}^{\infty} D_{11}(j)\varepsilon^2(t-j)$, while the long run effect of demand on inflation is zero. Output is decomposed as due to the sum of supply and demand shocks respectively as

$$y = \sum_{j=0}^{\infty} D_{21}(j)\varepsilon^1(t-j) + \sum_{j=0}^{\infty} D_{22}(j)\varepsilon^2(t-j)$$

These decompositions are presented and discussed in Section 4. Note that in both the models shock 1 and shock 2 refer to supply shocks and demand shocks respectively.

2.1 Tests of Identification

In both the models, there is no restriction on the length of horizon for the long run impact to be neutralized. This is estimated and can be observed through the impulse response functions, which are indicators of the validity of the identifications.

That demand should not affect output in the long run is imposed by the vertical supply curve (VSC) identification. But testable implications are that (i) the impact of demand on output should peter out by the medium-run (ii) supply shocks should have little sustained impact on measured inflation, (iii) demand shocks should account for the major part of measured inflation, (iv) only supply shocks should affect long run output levels. Since these restrictions are not imposed as identifying conditions, they serve as tests. Different results would shed doubt on the identification procedure.

Similarly, the horizontal supply curve (HSC) is imposed only for the long-horizon. A short-term output expansion may lead to a rise in inflation, which falls only when short-term bottlenecks are removed. The HSC does not restrict how quickly the effect of demand shocks on inflation falls. Therefore the speed of inflation-response to demand shocks serves as a test of the identification imposed.

That demand should not effect inflation in the long run is imposed by the HSC identification. But testable implications are that (i) that the impact of demand on inflation should peter out by the medium-run and demand shocks should have little sustained impact on inflation (ii) supply shocks should account for the major part of measured inflation (iii) demand shocks should have a sustained impact on output levels (iv) supply shocks would require accommodating demand to affect output. If the results differ it would shed doubt on the horizontal long-run supply curve used as the identification procedure.

Although the assumption is made that the two disturbances are uncorrelated or orthogonal to each other at all leads and lags, policy causing one type of shock can still react to another shock. Even if orthogonality breaks down at specific points, as long as there is no systematic correlation, the procedure is valid.

2.2 Data and Methodology

We have used monthly data for WPI and IIP (proxy for real output) from international Financial Statistics-CD-ROM (column 63 and 66 respectively), published by the International Monetary Fund. Our dataset covers a time span from January 1971 to July 2004, giving 403 observations. Note that the base year for these two series is 2000. *p* and *iip* are the wholesale price index (WPI) and index of industrial production (IIP) in logarithmic terms. The standard unit root tests - Augmented Dickey Fuller (ADF) and Phillips Perron (PP) - have been performed for the above two series, i.e., *p* and *iip*, both with trend and without trend. The results of unit root tests for all the series are reported in Table 1.

Table 1: Tests for Unit Roots

Variables	ADF (at 4 lags)		Phillips-Perron		Remarks
	No Trend	Trend	No Trend	Trend	
Ln(WPI)	-1.79	-2.24	-1.73	-2.02	I(1)
Ln(IIP)	-0.41	-6.59	-0.38	-10.2	I(0)*
Inflation	-8.50	-8.64	-12.8	-10.9	I(0)

1. The tabulated value at 5% level of significance is –3.42.
2. Ln(IIP) has been reported as I(0)* , but it is non-stationary due to presence of trend component.

From Table 1, it is clear that *p* is integrated of order one. The IIP series, however, does not have a unit root. It is non-stationary because of a trend component.

Therefore, we use the first difference of *p* and detrended *iip* (we define it as real output *y*) in our SVAR estimation.[2]

3. Results

The results are presented first for the VSC and then the HSC. Impulse response functions of *p* and *y* to supply and demand shocks (figures 1 and 3) are followed by charts (figures 2 and 4) and tables (2 and 3) of the forecast error decompositions.[3]

The *k* month-ahead forecast error in output is defined as the difference between the actual value of output and its forecast as of *k* months earlier. This forecast error is due to both unanticipated demand and supply shocks in the last k months. The horizontal axis gives months and the vertical axis gives the effects in percentage. The figure for output at horizon *k*, (k = 1, 2, …., 48) gives the percentage of variance of the *k* month-ahead forecast error due to demand and supply shocks respectively, which add up to 100. Figures 2 and 4 give the FEVD for inflation, output growth and output levels.

These forecast error variance decompositions (FEVD) have been presented in tables 2 and 3 also. The major impact of a shock is over within 24 months but small variations continue beyond. The standard error bands show satisfactory precision except for longer-run output level response. The graphs illustrate the tables to which we largely confine our interpretations.

3.1 Vertical Supply Curve (VSC) Model

Impulse response functions (IRF) of the VSC model are given in Figure 1. Supply shocks have an immediate negative impact on inflation (Δp), which rises in few

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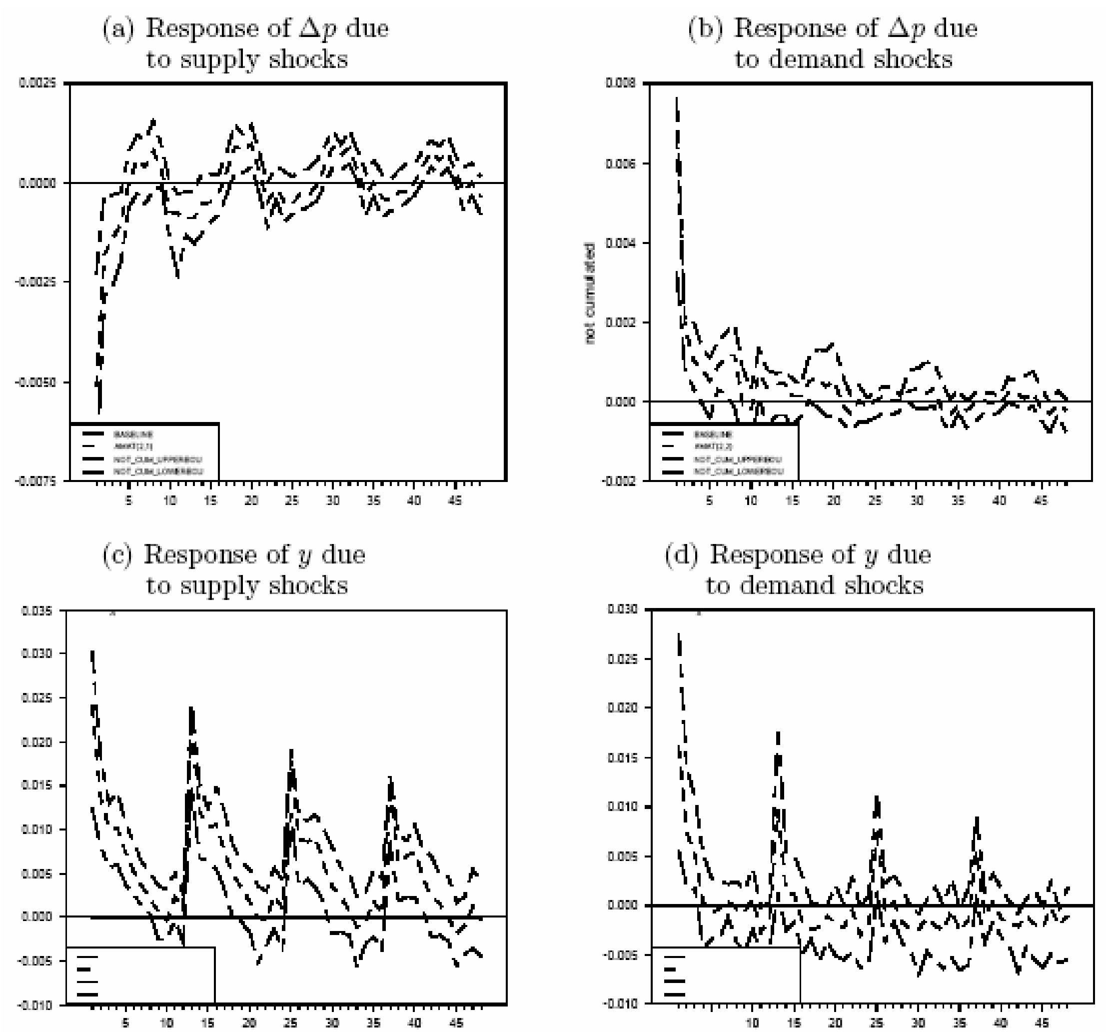
[2] Note that Blanchard and Quah's (1989) decomposition technique requires the vector of variables to be covariance stationary.

[3] The estimation is done with RATS software, using a module developed by Lack and Lenz (1999).

months and fluctuates before getting neutralized. However, demand shocks push Δp up in the first month. Then Δp falls back and it takes relatively longer time to get neutralized. The IRF of supply and demand shocks on inflation are given in panel (a) and (b) in Figure 1.

Looking at the panel (c) and (d) of Figure 1 (which give the IRF of y due to supply shocks and demand shocks respectively), it is clear that supply shocks have a permanent positive impact on real output, whereas demand shocks are found to have no impact in the medium to long run.

Figure 1: Impulse Response Functions in VSC Model



The FEVD of the VSC model have been presented in Figure 2 and Table 2 below. What do the results imply for our indirect tests of the identification procedure? The FEVD shows that although the effect of demand shocks on output does fall after one year, it is quite substantial in the one year (31.05 in the first month compared to 0.1 in Quah and Vahey (1995)). Therefore the vertical supply curve is not well supported. The rate of decay slows and remains at 17.51 at 48 months. Demand has persistent effects on output and output neutrality may be only approximate even at longer-run horizons.

Figure 2 (a): FEVD of Inflation in VSC Model

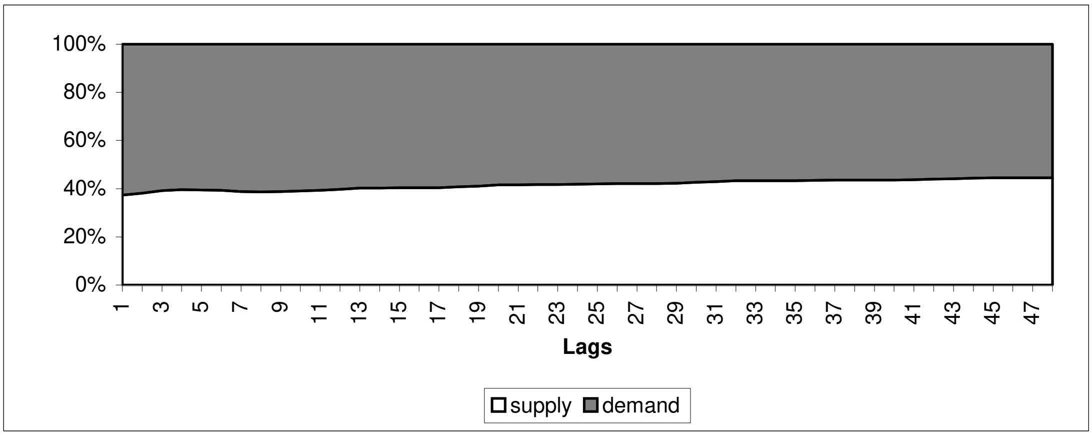
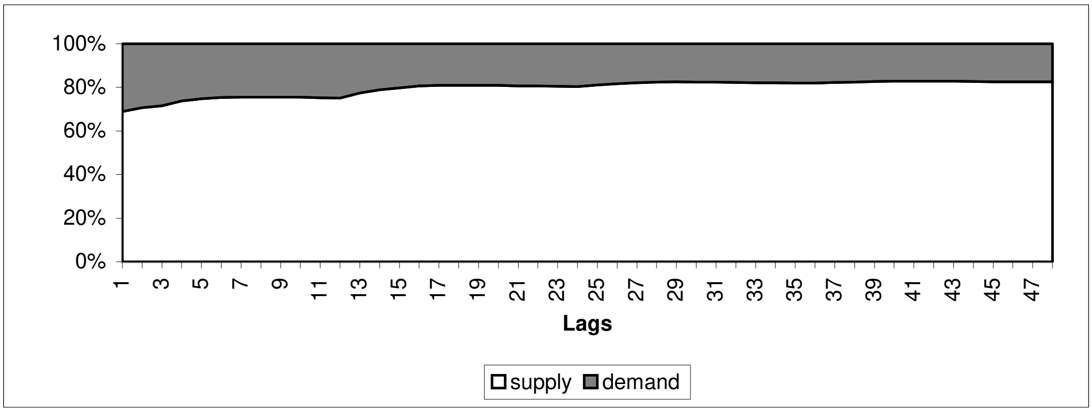


Figure 2 (b): FEVD of Real Output in VSC Model



The VSC as an identification procedure is dubious also since supply shocks have a sustained large impact on inflation (44.46 at 48 months compared to 7.3 in a mature economy (Quah and Vahey 1995)). Demand accounts for only 55 percent of the variance in the 48 months forecast error in inflation. Supply shocks do have a sustained impact on output levels accounting for 69 percent at the one-month horizon and going up to 98 percent by 82 months.

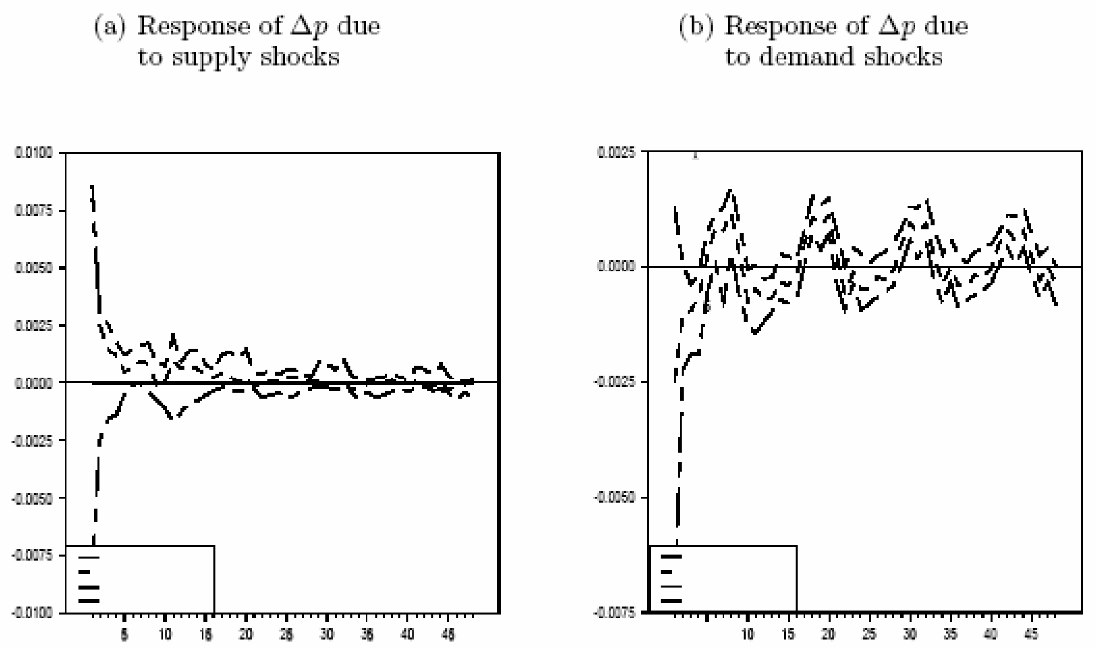
Table 2: FEVD in VSC Model

Months	Real Output		Inflation	
	Supply	Demand	Supply	Demand
1	68.95	31.05	37.34	62.66
2	70.64	29.36	38.15	61.85
3	71.59	28.41	39.14	60.86
4	73.81	26.19	39.57	60.43
12	75.13	24.87	39.73	60.27
24	80.32	19.68	41.82	58.18
36	81.92	18.08	43.38	56.62
48	82.49	17.51	44.46	55.54

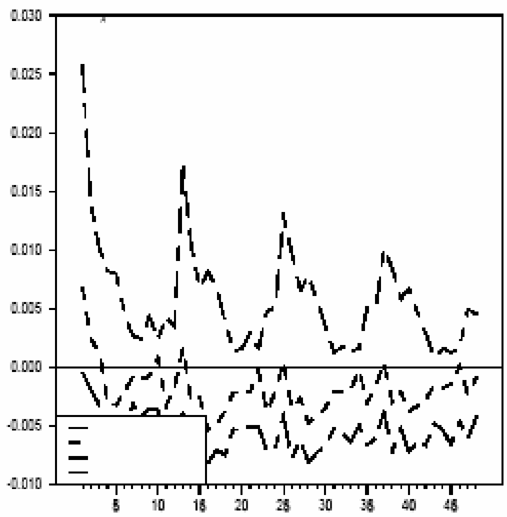
3.2 Horizontal Supply Curve (HSC) Model

Figure 3 presents the IRF of the HSC model. From panel (a) and (b) of Figure 3, it is clear that supply shocks raise inflation on impact, which falls back. However, the impact of demand shocks is more cyclic, taking a longer time to be neutralized.

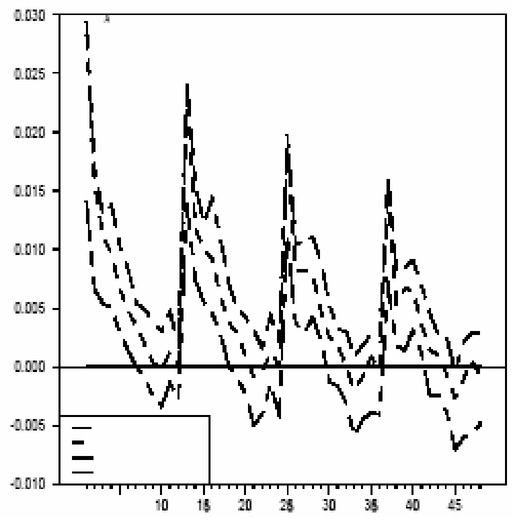
Figure 3: Impulse Response Functions of HSC Model



(c) Response of y due to supply shocks



(d) Response of y due to demand shocks



Panel (c) and (d) presents the IRF of *y* with respect to supply shocks and demand shocks respectively. Demand shocks raise *y* in the first month and get neutralized through fluctuations. Supply shocks also show the same pattern.

Real output declines due to supply shocks, although the estimation is not precise. Demand shocks raise *y* in the first month and then *y* moves slowly towards a stable positive value. In the case of the HSC the adjustment of inflation to demand shocks is faster with an effect of only about 10 percent up to three months, but after that it rises gradually to about 23 percent by the 48th month. This implies that an elastic-long-run supply curve cannot be ruled out.

Moreover, demand shocks have little sustained impact on inflation. Supply shocks account for almost the entire FEVD of measured inflation at short horizons and stay at 77 percent at 48 months. Demand shocks have a persistent impact on output levels. An initial impact of 5.5 percent rises to above 15 percent by 48 months.

In both identifications the impact of supply shocks dominates but demand has a persistent effect. The size of the supply shocks rises under the HSC. At long horizons supply shocks account for the major part of output levels in both, as must be the case, but demand has a sustained and substantial effect. The dominance of supply gives more support to the HSC identification.

Figure 4 (a): FEVD of Inflation in HSC Model

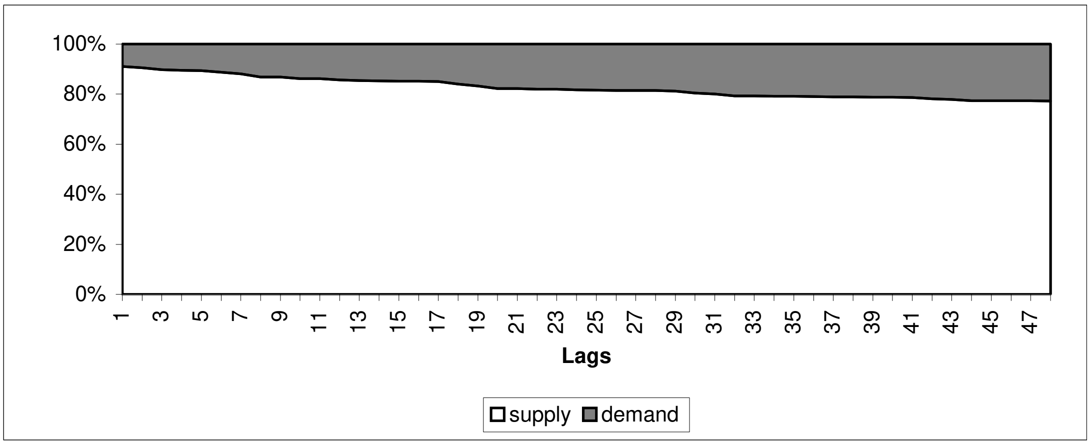


Figure 4 (b): FEVD of Real Output in HSC Model

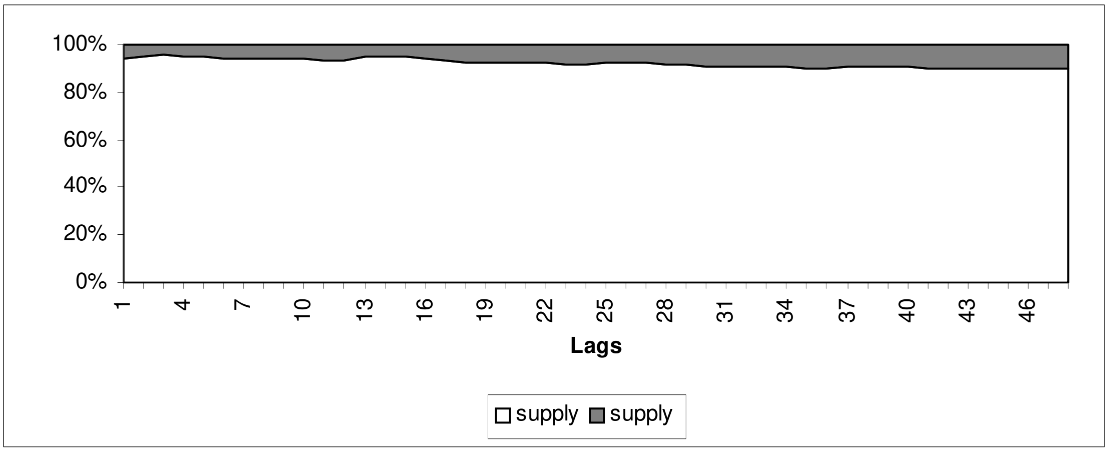


Table 3: FEVD in HSC Model

Months	Real Output		Inflation	
	Supply	demand	Supply	Demand
1	94.49	5.51	91.07	8.93
2	95.21	4.79	90.55	9.45
3	95.57	4.43	89.79	10.21
4	95.16	4.84	89.46	10.54
12	93.30	6.70	85.73	14.27
24	91.44	8.56	81.73	18.27
36	90.26	9.74	79.05	20.95
48	89.75	10.25	77.25	22.75

While reality probably lies somewhere in the middle of our two extreme identifying assumptions, the results suggest that on the whole the long-run supply curve is highly elastic for the Indian economy, so that the HSC needs to be kept in mind in designing macroeconomic policy for the economy. It has the implication that macroeconomic policies that maintain demand and counter the effects of supply shocks on inflation would yield better results.

4. Historical size and effects of demand and supply shocks

The Figures (5 and 6) show the contribution of structural demand and supply shocks to annual inflation and IIP output growth across the two identification schemes.[4] The effect of demand on output shown in Figure 5 (a) is calculated as a residual, subtracting the structural supply shock from y. Similarly, the effect of demand on inflation under the HSC is a residual [Figure 6 (b)].

Although their relative size varies, the structure of demand and supply shocks is similar across the two identifications, implying that the distinction between demand and supply shocks and their estimation is robust. Turning points are well captured and the estimated shocks match historic events such as oil price hikes and industrial recessions well.

Supply shocks dominate, but demand shocks, which include policy responses, seem to have played a pro-cyclical role. Thus inflation was higher than it need have been under negative supply shocks and growth lower than potential under positive supply shocks. The oil shocks show up as sharp supply shocks in the seventies. But demand also fluctuated pro-cyclically and aggravated adverse output and inflation

[4] The shocks are derived using monthly variables and then aggregated by addition. Since the variables are in logarithms this gives an approximation to the annual series. The monthly results are available on request.

effects. The macro stabilization adopted in the early nineties shows up as sharp negative demand shocks. The 1997 recession in industrial output, following the high growth period, is clearly due to a sharp negative demand shock while supply remained positive. This is the period when real interest rates were raised drastically in response to rupee fluctuations. During the nineties, structural adjustment took the form of benign positive supply shocks but demand was low and prevented higher growth from setting in. Policy could not translate the increased potential into actual output growth.

Inflation was also dominated by supply shocks, especially in the HSC but residual (demand) shocks contributed to raising inflation. This is particularly clear in the decade of the nineties where structural demand shocks on output peaked in the mid-nineties in the VSC [Figure 6 (a)] but fluctuations and fall in output demand were accompanied by residual shocks that kept inflation high. The HSC shows that the residual demand category kept inflation from fully benefiting from supply improvements. The historical inflation series lies between the largely negative supply shocks and positive demand. But since demand shocks on output were negative in this period low output demand seems to have translated into higher inflation, implying some counter-cyclical mark-ups or cost factors. The structure of demand and supply shifts seems to have been such as to generate a negative association between inflation and output. The seventies had the highest rates of inflation, due to the oil price induced steep fluctuations in both demand and supply.

The results demonstrate downward inflexibility of the price level. Inflation is pulled sharply up by positive supply shocks and brought down by negative, but inflation rarely falls below zero, and on the rare occasions it does become negative it is by miniscule amounts.

Figure 5 (a): Real Output and its components in VSC model

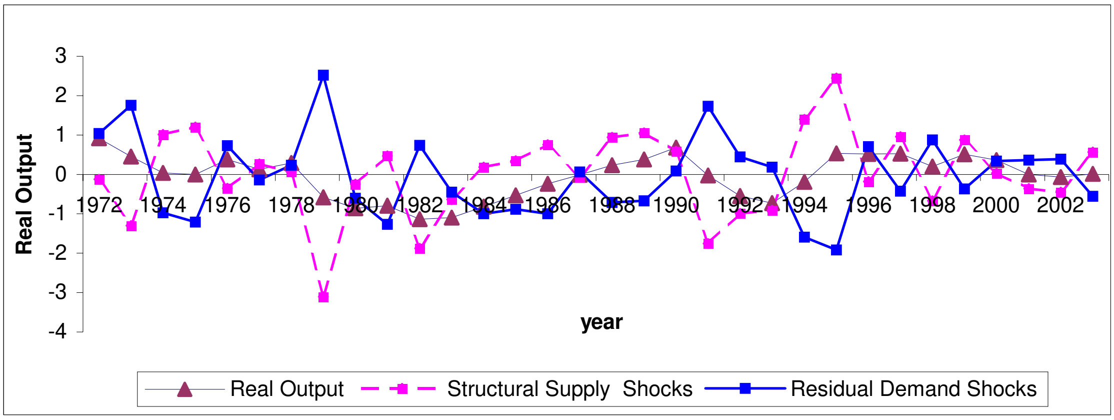


Figure 5 (b): Inflation and its components in VSC model

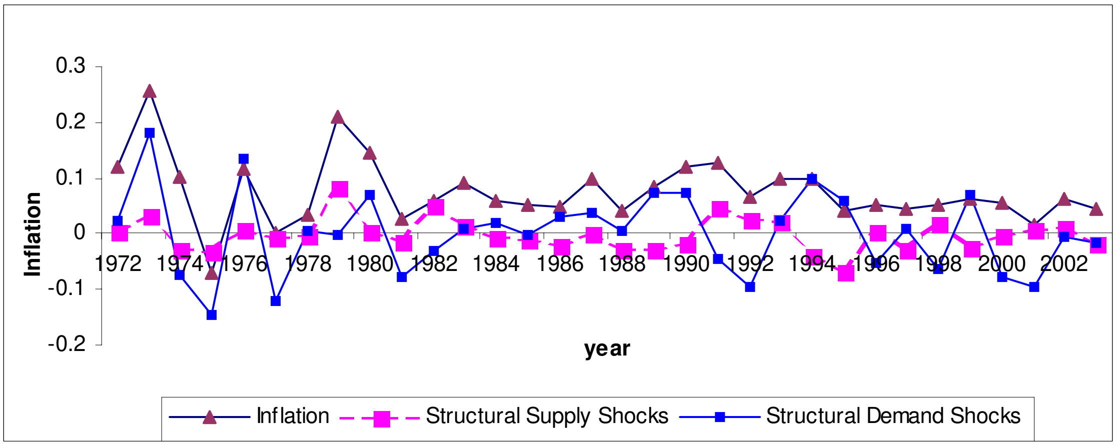


Figure 6 (a): Real Output and its components in HSC model

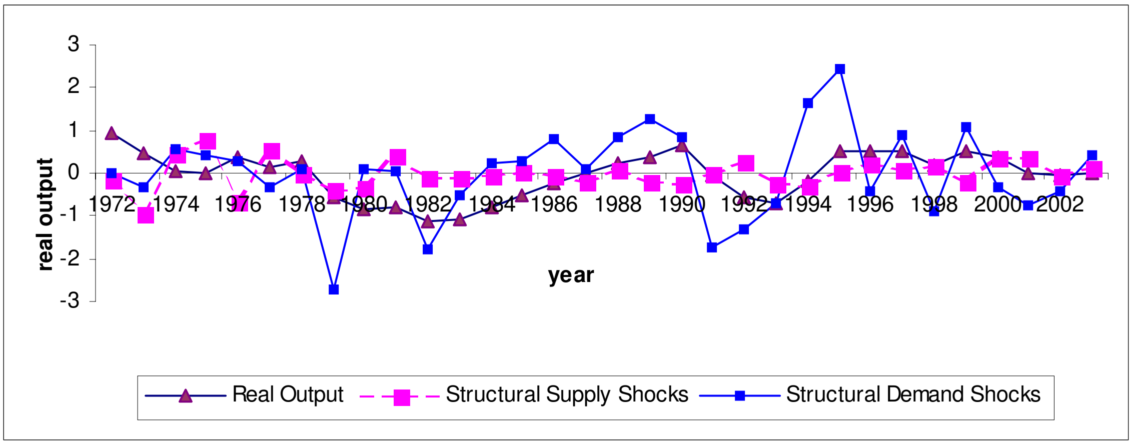
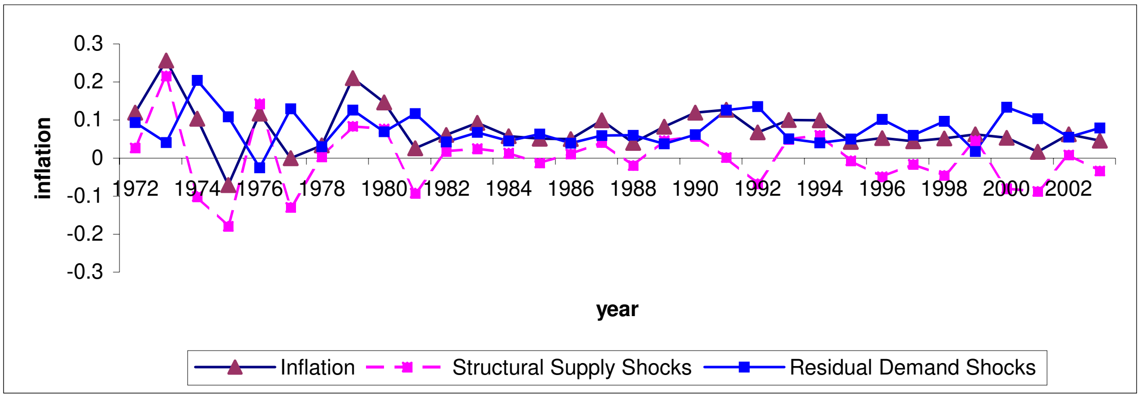


Figure 6 (b): Inflation and its components in HSC model



5. Conclusion

In a two equation Structural Vector Autoregression (SVAR) identifications of a vertical and then a horizontal supply curve are successively imposed on Indian time series inflation and industrial output data. Because supply shocks have large impact on inflation and demand has a persistent effect on output, on balance the evidence favours a high elasticity of long-run supply, but with frequent shocks and shifts of the supply curve.

The structural demand and supply shocks estimated capture historical recessions and turning points well. Policy affects both supply and demand shocks but macroeconomic policy affects demand. The demand shocks seem to have aggravated negative supply shocks or failed to take full advantage of positive supply side developments.

In the more open economy of the nineties interest and exchange rate policy had a rising impact. An extended SVAR, which brings in these variables, may be able to further refine our understanding of macroeconomic policy impact. Our analysis is also restricted by the use of the IIP series as a proxy for output. Monthly output series are not yet available in India. Estimation of a time varying trend for output would also improve the results.

References

Bjornland H. C. (2001), 'Identifying Domestic and Imported Core Inflation', *Applied Economics*, Vol. 33, pp. 1819-1831.

Blanchard O. J. and D. Quah (1989), 'Dynamic Effects of Aggregate Demand and Supply Disturbances', *American Economic Review*, Vol. 79 (4), pp. 655-671.

Blanchard O. J. and L.H. Summers (1987), 'Hysterisis in Unemployment', *European Economic Review*, Vol. 31, pp. 288-295.

Enders, Walter (2004), '*Applied Econometric Time Series*', John Wiley and Sons, Second Edition.

Farmer, R. (1999), *The Macroeconomics of Self-Fulfilling Prophecies*, Cambridge, MA: MIT Press, Second Edition.

Giannini C. (1992), 'Topics in Structural VAR Econometrics', *Lecture Notes in Economics and Mathematical Systems*, Springer Verlag.

Lack, C. and C., Lenz (1999), A Program for the Identification of Structural VAR Models, *http://www.unibas.characteristic/wwz/makro/svar*

Mankiw, G. and D. Romer (eds.) (1991), *New Keynesian Economics: Coordination Failures and Real Rigidities*, Cambridge, MA: NBER/MIT Press.

Quah D. (1995) 'Misinterpreting Dynamic Effects of Aggregate Demand and Supply Disturbances', *Economic Letters*, Vol. 49, pp. 247-250.

Quah, D. and S. P. Vahey (1995), 'Measuring Core Inflation', *Economic Journal* Vol. 105 (432), PP. 1031-1044.