IDENTIFYING AGGREGATE SUPPLY AND DEMAND SHOCKS IN SOUTH AFRICA

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Abstract

This paper uses a structural VAR methodology to identify aggregate demand and supply shocks to real output for the South African economy. Demand shocks, in turn, are separated into fiscal and monetary shocks. The model is estimated with quarterly data over two overlapping samples: 1960Q2-2006Q4 and 1983Q4-2006Q4. The identified (structural) shocks were used in a historical decomposition to split output into a measure of potential output (resulting from the evolution of supply shocks) and a measure of the business cycle (the gap between actual and potential output). This measure of potential output suggests a significant decline relative to trend in the years prior to the political transition of 1994 and a swift reversal thereafter. The paper presents evidence from three sources to support its identification of aggregate supply and demand shocks. These sources are the following: theory consistent impulse response functions; a close match between the implied measure of the business cycle and independent information about the South African business cycle; and a demonstration of the close match between the identified series of aggregate supply shocks and important historical events in the decades prior to and following 1994 that have been identified by economic historians as important shocks to the South African economy.

JEL Codes: C25; C41; E32

Key words: South Africa, aggregate supply, aggregate demand, monetary policy, fiscal policy, potential output, long-run restrictions

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This paper offers a decomposition of output fluctuations into aggregate demand and aggregate supply shocks in South Africa for the period since the early 1960s. Theoretically motivated long-run restrictions are used to identify these shocks in a three-variable vector-autoregressive (VAR) model. The aggregate demand shocks, assumed to be transitory in nature, provide a new measure of the business cycle, whereas the cumulative aggregate supply shocks, assumed to have a long lasting effect on output, provide a novel estimate of potential output.

The research is motivated by the South African government's ongoing attempts to identify constraints to economic growth with the goal of raising the sustainable rate of growth of the economy and employment creation. As such, it contributes to the literature on quantifying measures of both potential GDP and, by implication, to studies of the business cycle in South Africa. The overlapping interests of researchers in potential GDP and the business cycle are evident from the attention given to potentially pro-cyclical macroeconomic policy in the Harvard-based Center for International Development's (CID) project to study opportunities for accelerated growth in South Africa (Frankel, Smit and Sturzenegger, 2007).

The first section of the paper is a brief introduction to the South African literature on measuring potential GDP. This is followed by an exposition of the structural VAR method used to identify the various shocks to output. Section three describes the data used and section four follows with the empirical results.

1. LITERATURE

With the notable exception of De Jager and Smal (1984), the empirical literature on potential GDP in South Africa is fairly recent. Many of these studies compare different methods making it difficult to classify the South African literature according to method, as is done in many of the international surveys, for example, DuPasquier, Guay and St-Amant (1999).

The focus of the literature has, however, been on contrasting univariate statistical techniques, notably the Hodrick-Prescott (HP) filter, with structural production function methods[2]. Production function models in this literature generally rely on a Cobb-Douglas functional form (though Smit and Burrows (2002) also estimate a CES functional form). It is expected that the univariate statistical filters will generate potential GDP growth rates close to the observed experience for a given period, but it is striking that the production function models yield very similar estimates of potential GDP.

While the comparative studies have indicated considerable agreement across methods in the estimates of potential GDP for given historical intervals in South Africa, the empirical macroeconomic literature that uses potential GDP to generate output gaps has, predominantly used the Hodrick-Prescott filter to identify potential GDP. Examples of these include: Kaseeram, Nicola and Mainardi (2004), Burger and Marinkov (2006), Geldenhuys and Marinkov (2006), Woglom (2005), Knedlik (2006),

2 Examples include: Smit and Burrows (2002), Arora and Bhundia (2003), Du Toit and Moolman (2003), Akinboade (2005), and Du Toit, Van Eyden and Ground (2006)

and Fedderke and Schaling (2005).

2. IDENTIFYING AGGREGATE SUPPLY AND DEMAND SHOCKS: AN SVAR ANALYSIS

The influential literature, starting with Shapiro and Watson (1988) and Blanchard and Quah (1989), uses long-run restrictions based on neutrality properties in the theory of macroeconomic dynamics to identify permanent and transitory shocks to real output. While Blanchard and Quah (1989) interpreted the permanent shocks as aggregate supply shocks and the transitory shocks as aggregate demand shocks, the technique has since become widely used to generate joint estimates of potential GDP (the cumulative aggregate supply shock) and a measure of business cycle fluctuations relative to GDP (the cumulative aggregate demand shock) (DuPasquier et al., 1999).

Blanchard and Quah (1989) identified these shocks in a bivariate vector-autoregressive (VAR) model assumed to have one unit root (in real GDP) and a covariance stationary variable (the rate of unemployment). This model can be extended in various directions by adding more variables with unit roots and/or by expanding the model with covariance stationary variables. The early example of King, Plosser, Stock and Watson (1991) used both these extensions, while Galí (1992) and Clarida and Galí (1994) decomposed the demand shock into several components and kept one aggregate supply shock with a unit root. This paper follows Clarida and Galí's (1994) three-variable model by explicitly combining real GDP with two demand shocks, one interpreted as a fiscal policy shock and the other as a monetary policy shock.

The technical exposition follows Clarida and Galí (1994), and starts with the proposition that the three variables (the first difference of real GDP, the fiscal policy measure, and the monetary policy measure) are jointly determined by a simultaneous equation system which can be represented by a covariance stationary MA representation such as equation 1,

$$x_t = C(L)e_t$$

where (1)

$$x_t = \begin{bmatrix} \Delta y_t \\ g_t \\ r_t \end{bmatrix}, \; e_t = \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix}$$

where {y_t, g_t, r_t} refers to (log) real GDP, the fiscal policy measure, and the real interest rate respectively and {ε_t} are the structural shocks identified with each of these variables. But this system (equation 1) is not observable and cannot be estimated. Instead we can estimate a reduced form VAR with the MA representation shown in equation 2:

$$x_t = R(L)u_t$$

where (2)

$$u_t = \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \end{bmatrix}$$

where {u_t} are the reduced form disturbances. The variance covariance matrix is given in equation 3:

$$\Sigma = Eu_t u_t^{'} \quad (3)$$

Assume that a non-singular matrix S exists such that $u_t = S\varepsilon_t$. which implies that C(L) = R(L)S. Keep in mind that by construction R(0)=I, which means that C(0)=S.

After normalising the elements of $\{\varepsilon_t\}$ so that their variance covariance is the identity matrix, it follows that equation 3 can be written as:

$$\Sigma = E(uu') = E(See'S') = SS' = C_0 C_0' \qquad (4)$$

where C_0 is the (3×3) matrix of contemporaneous structural relationships. Because equation 4 provides only six independent equations, three additional restrictions are required in order to estimate the full matrix and identify the nine elements of C_0. Once this matrix has been computed, identification of the structural shocks $\{\varepsilon_t\}$ follows directly from inverting the relationship $u= C_0\varepsilon_t$. The structural representation obtains from inverting C(L) = R(L) C_0.

Where do these three additional restrictions, to orthogonalise the system, come from? It was Blanchard and Quah's (1989) suggestion, that restrictions on the long-run relationship between the three variables might complete the identification scheme. In their case it required only one long-run restriction, viz. a neutrality condition that the demand shock would not affect real output in the long run. However, in the three-variable model used here, we require three additional restrictions to identify the structural shocks and the dynamics of the structural system C(L).

Define C(1) as $C_0 + C_1 + C_2 + \ldots$ and use this to define three additional restrictions.

The first two of these long-run restrictions require that fiscal and monetary policy shocks have no long-run effects on real GDP, as expressed in equation 5:

$$C_{12}(1) = C_{13}(1) = 0 \tag{5}$$

Finally, the long-run effect of monetary policy on the stance of fiscal policy is also restricted to zero as expressed in equation 6:

$$C_{23}(1) = 0 \tag{6}$$

This last restriction implies that monetary shocks (that affect the real interest rate) do not have long-run effects on the level of government consumption relative to GDP, the variable we will use to measure fiscal policy. This, of course, requires strong assumptions on the preferences for public goods to be true.

These restrictions create a lower-triangular matrix C(1), which is sufficient to recover the dynamics of the structural system, C_1, C_2, … as well as the structural shocks (Clarida and Galí, 1994).

Blanchard and Quah (1989) were cautious in interpreting the resulting identified shocks as aggregate supply and demand shocks. The long-run neutrality condition is not generally sufficient to identify demand shocks, since demand shocks might (under certain conditions) have a long-run impact on output, while aggregate supply shocks may also impact at business cycle frequencies or be short-lived. At best their identification scheme was "nearly correct" (Blanchard and Quah, 1989: 659), and the extent to which it was correct is an empirical matter.

To investigate the plausibility of the identification scheme on the model posed here for South African data, we consider the same output as Blanchard and Quah, viz. impulse response functions and a variance decomposition analysis, a historical decomposition of the output effects of the structural shocks, and a comparison of this historical decomposition with independent information about the business cycle and factors affecting aggregate supply in South Africa.

3. DATA

The data are seasonally adjusted quarterly time series, starting in the second quarter of 1960 and ending in the fourth quarter of 2006[3]. Table 1 shows the variables used in the model and Figures 1 to 3 plot the three main variables. The reduced form VAR was estimated with four lags.

Table 1 about here

Figure 1 about here

As a further robustness check, the estimation and identification were implemented on the entire sample starting in the second quarter of 1960 and on a sub-sample starting in the fourth quarter of 1983. This check was carried out for two reasons. Firstly, the important evolution of the monetary policy regime in South Africa during the early eighties when quantitative controls were largely abandoned in favour of market-based

[3] The data for the fourth quarter are an estimate.

instruments, as was recommended by the De Kock Commission (1985). Secondly, as can be seen in Figure 2, there is some doubt over the covariance stationarity[4] of the fiscal policy proxy over the longer sample, a problem which is less serious in the shorter sample (the unit root tests are reported in Appendix A).

Figure 2 about here

Figure 3 about here

As a proxy for the stance of fiscal policy we use government consumption, rather than the deficit. Many other measures of the stance of fiscal policy, such as the budget balance, are jointly determined with the economic cycle and are inappropriate for the purpose at hand. Since government revenue accounts for a large portion of the joint endogeneity between the budget balance and the economic cycle, a useful proxy of the fiscal stance for purposes of judging the cyclicality of fiscal policy is the ratio of government expenditure to GDP. This is also the measure used by Fatás and Mihov (2003) to investigate the potentially destabilising role of fiscal policy in a large cross-country study.

As a proxy for monetary policy we use the real interest rate. Alternative estimations

[4] Ideally all the variables in the estimated model should be covariance stationary, which implies that they must not have stochastic trends. Augmented Dickey-Fuller tests were used to test for the presence of unit roots and are reported in Appendix A.

using the inflation rate itself were done, delivering comparable results which are available upon request.

4. RESULTS

This section reports impulse responses and historical decompositions to support the plausibility of the identified supply and demand shocks proposed here.

4.1 Innovation accounting

Innovation accounting entails considering the impulse responses and variance decomposition of structural VAR models. The first task is to inspect the impulse response functions of the identified shocks to determine whether they match theoretical priors concerning the direction and magnitude of impact. Figure 4 below shows the impulse responses of real GDP for each of the identified shocks and for both the longer and shorter sample models.

Figure 4 about here

The impulse responses in Figure 4 are consistent with theoretical priors. The supply shock has a permanent impact on real GDP, while the two components of aggregate demand have, by construction, only transitory impacts. A positive fiscal shock has a temporary expansionary impact on real GDP and a positive shock to the real interest rate has a temporary contractionary impact on real output. The fiscal effect is stronger in the longer sample, though that should be interpreted cautiously given the potential non-stationarity of the fiscal proxy over that sample.

The variance decomposition of real GDP shows the proportion of the variance of real GDP which can be accounted for by the three identified shocks over various horizons. Table 2 contains the variance decomposition for real GDP, from which two deductions follow. Firstly, the long-run development of real GDP is dominated by the history of supply shocks. Secondly, over the short to medium term, fiscal shocks dominate monetary shocks in their impact on real GDP, but only in the model estimated on the longer sample. In the post-1983 sample the relative importance of monetary and fiscal policy shocks are reversed.

Figure 5 about here

This difference between the variance decompositions of the shorter and longer sample models might be due to the changing average size and variability of the three structural shocks over the sample period. Figure 5 uses box plots by decade to show how the distribution of these shocks has changed over time. The monetary policy shocks have become more dispersed since the 1960s, while the opposite seems to have happened with the GDP growth and fiscal policy shocks. A model estimated over the entire sample period therefore combines two very different periods (with a pivotal point around 1980) in the monetary history of South Africa. This stylised observation can be sensibly connected with the reforms of the monetary policy regime introduced by the De Kock commission and implemented in the course of the early to middle 1980s.

Figure 6 shows the impulse responses of the real interest rate relative to the three identified shocks for both samples. A positive supply shock raises the real interest rate temporarily in both samples. This is expected from the transitory disinflationary impact of a positive supply shock. A positive fiscal shock lowers the real interest rate temporarily, notably in the model estimated on the shorter sample, which suggests that over that sample a fiscal stimulus meets with accommodating monetary policy.

Figure 6 about here

Figure 7 shows the impulse response functions for government expenditure relative to the three identified shocks for both samples. The reaction of the fiscal proxy to a supply shock in both samples suggests that GDP responds faster to a positive supply shock than government expenditure. At least in the model estimated on the shorter sample, government expenditure catches up with GDP over the medium term. The positive response of a fiscal shock to a rise in the real interest rate might suggest a counteracting fiscal response to a monetary policy shock, but even at its maximum, the effect is very small and is not of great practical interest.

Figure 7 about here

4.2 Historical decomposition

The moving average representation of the structural system, i.e. equation 1, can be used to decompose the historical real GDP series into paths attributable to each of the identified shocks. For example, the structural VAR can be used to plot the evolution of real GDP under the assumption that both demand shocks are zero, to yield a measure of supply shocks to GDP which, aggregated over time and added to any non-stationary drift, may construct an estimate of potential GDP. Similar historical decompositions can be used to plot the contribution of the two demand shocks to the time path of GDP and jointly they will yield a measure of the business cycle. Figure 8 shows the historical decomposition of real GDP into components due to supply shocks, fiscal shocks, and monetary shocks[5].

Figure 8 about here

The major difference between the historical decompositions for the short and longer sample models lies in the much larger contribution of fiscal shocks to GDP in the longer sample. For example, fiscal policy has contributed positively to real GDP since about 2000 on both estimates, but much more powerfully so in the model estimated on the longer sample. However, in both models the supply shocks dominate fluctuations in real GDP.

The patterns of the cumulated supply shocks are not identical in the two models but show remarkable similarity, with both recording continued negative supply shocks from the mid-eighties through 1994, after which positive supply shocks moved actual and potential real GDP up. Figure 9 shows the estimated potential GDP for the shorter and longer samples yielded by this decomposition.

[5] The series for the potential output and business cycle measures are presented in Appendix B.

Figure 9 about here

The longer sample yields an opportunity to quantify the cumulative loss in aggregate supply suffered by the South African economy in the twilight of apartheid. The top graph in figure 9 shows that the generally positive supply shocks of the sixties were reversed from 1973 onwards. Adverse international events, notably the first oil shock, but also the collapse of the Portuguese colonies (Mozambique and Angola) which created hostile states on the borders of South Africa, signalled the start of two decades of adverse supply shocks. Domestic unrest in 1976 and again in the mid-1980s, the debt standstill in 1985, and the final unravelling of the National Party's grip on political power were all along the path of declining potential GDP, most likely fuelled by significant human and capital flight.

Figure 10 matches important international events, political developments, policy decisions, and economic shocks to the cumulative supply shocks as identified by the longer sample model. On this measurement potential GDP declined by a cumulative 30% relative to trend between the mid-seventies and the mid-nineties. In this way the decomposition provides a unique quantification of the costs of maintaining apartheid since the seventies, in a time of adverse international shocks. It yields a plausible pattern and magnitude, given historical accounts of the economic costs of apartheid by Moll (1991) and Feinstein (2005), for example.

Figure 10 about here

The new measure of potential GDP also shows a marked rise in potential GDP since 1994, starting almost immediately after the political transition. While the pattern differs for the models estimated on the longer and shorter samples (the longer sample model shows a sharper bounce in potential GDP immediately after the political transition which flattens out after 2000, while the shorter sample model shows a slower initial response for potential GDP but an acceleration after 2000), both imply that potential GDP has lately been growing at a healthy rate, though well short of the goals set by the South African government. Table 3 shows the growth rate of potential GDP for the two models calculated over different sub-samples of the post-1994 era. The estimates in Table 3 suggest a range of 2.5% to 4.4% for the growth rate of potential GDP, while 3.5% would be a likely point estimate (Frankel et al., 2007: 14).

Table 3 about here

In addition to examining the plausibility of the identified supply shocks, one might also examine the plausibility of the identified demand shocks through comparison with independent information on the South African business cycle. Following Blanchard and Quah (1989), we compare the cumulative aggregate demand shock with the turning points of the South African business cycle as identified by (i) the dating committee of the SARB, and (ii) the turning points identified by Du Plessis (2006) using a non-parametric dating algorithm applied to real GDP. Figure 11 shows the phases of the business cycle defined with these two methods and the new measure of aggregate demand is superimposed onto it

The measure of aggregate demand identified with the long-run restrictions matches the periods of relative expansion and relative contraction in the South African economy surprisingly well. This is particularly the case where the comparison is made with Du Plessis' (2006) alternative turning points, which, he has argued, capture the periods of relative contraction and expansion in the South African GDP more accurately than the official turning points.

The only real anomaly in the comparison is the apparent positive demand shock during the contraction following the peak of June 1984. Du Plessis and Smit (2007) examined the circumstances of this contraction and found that it was the only post-1980 contraction in South Africa during which the monetary authorities provided a cumulatively large nominal and particularly real reduction in their policy interest rate. Not all downswings are due to demand shocks (in this case the demand shock from monetary policy was notably positive) and in this case the downswing is largely explained by a sharp negative supply shock as identified (see Figure 10). The model as presented here, is not sensitive enough to identify the precise nature of that supply shock, but Frankel, Smit and Sturzenegger (2007: 11) highlight two developments that were particularly adverse in 1984 and would have ended in the supply shock as identified here, i.e. a precipitous decline in public investment and depressed terms of trade.

Apart form this period, the new business cycle measure matches existing evidence closely. Following Blanchard and Quah (1989: 665), we interpret this close match between the business cycle measure, generated by the identified demand shocks, and independent business cycle information as suggestive of the plausibility of the identified demand shocks.

5. CONCLUSION

This paper applies a structural VAR method to identify aggregate supply and demand shocks for the South African economy since the 1960s. The impulse responses suggest that the identified structural shocks and system dynamics are theory consistent. Further, the identified aggregate supply shock is used to yield a new measure of potential GDP and of the business cycle. The new measure of potential GDP suggests that the South African economy suffered a 30% relative decline in potential GDP between the mid-seventies and mid-nineties as the internal and external costs of apartheid rose at a time of disruption in the world economy. It also suggests that the present trajectory potential GDP is growing by about 2.5% to 4.4% per year with a likely value of around 3.5%. This order of magnitude compares favourably with some of the more recent calculations in the literature such as Du Toit, Van Eyden and Ground (2006).

The identified demand shock was also used to create a new measure of the South African business cycle, which matched independent information about the business cycle. The plausible history of the new measures for the business cycle and potential GDP support the method of identification used here.

Table 1 Data

Variable	Calculation	Source
Δy_t	First difference of the log of real GDP	SARB, RB6006D
g_t	Ratio of government consumption to GDP	SARB, RB6008D, RB6006D
r_t	Real interest rate calculated using monthly data and a within-quarter formula[6]	SARB, Discount rate and CPI index, RB 7032N

[6] For each quarter the real interest rate was calculated using monthly data and the following formula where m_t means the second month of the quarter:

$$Avg(i_{mt-1}, i_{mt}, i_{mt+1}) - \left\{ \left[\ln\left(\frac{CPI_{mt} + CPI_{mt+1}}{2} \right) - \ln\left(\frac{CPI_{mt} + CPI_{mt-1}}{2} \right) \right]^{12} - 1 \right\}$$

Table 2 Variance decomposition of real GDP

Quarter Nº	Variance Decomposition of GDP Supply Shock	Fiscal Shock	Monetary Shock
1	69.0%	28.3%	2.6%
2	67.6%	31.4%	1.0%
3	58.6%	37.0%	4.4%
4	62.2%	35.2%	2.6%
5	64.0%	33.3%	2.7%
6	63.4%	33.6%	2.9%
7	68.3%	29.9%	1.8%
8	70.0%	28.1%	1.9%
9	72.0%	26.5%	1.5%
10	74.7%	24.2%	1.2%
11	75.9%	23.0%	1.1%
12	77.6%	21.6%	0.9%
13	78.9%	20.3%	0.8%
14	80.1%	19.3%	0.7%
15	81.3%	18.1%	0.6%
20	85.9%	13.7%	0.3%
30	91.6%	8.2%	0.1%
50	96.6%	3.4%	0.0%
75	98.7%	1.3%	0.0%
100	99.5%	0.5%	0.0%

Longer sample (1960+)

Quarter Nº	Variance Decomposition of GDP Supply Shock	Fiscal Shock	Monetary Shock
1	88.7%	1.0%	10.3%
2	86.0%	5.1%	8.9%
3	82.4%	3.0%	14.6%
4	88.2%	3.7%	8.1%
5	88.3%	3.3%	8.4%
6	90.9%	2.4%	6.7%
7	93.5%	1.5%	5.0%
8	94.7%	1.2%	4.1%
9	96.1%	0.6%	3.3%
10	97.3%	0.4%	2.3%
11	97.8%	0.2%	2.0%
12	98.4%	0.1%	1.5%
13	98.8%	0.0%	1.2%
14	99.0%	0.0%	1.0%
15	99.2%	0.0%	0.8%
20	99.7%	0.0%	0.2%
30	99.9%	0.0%	0.0%
50	100.0%	0.0%	0.0%
75	100.0%	0.0%	0.0%
100	100.0%	0.0%	0.0%

Shorter sample (1983+)

Table 3 Growth rate of potential GDP during different sub-samples

	Longer sample (1960+)	Shorter sample (1983+)
1994Q1 to present	3.13%	3.32%
1996Q1 to present	2.74%	3.34%
1998Q1 to present	2.82%	3.42%
2000Q1 to present	2.56%	3.58%
2002Q1 to present	2.62%	4.17%
2004Q1 to present	2.9%	4.4%

Figure 1 First difference of logged real GDP

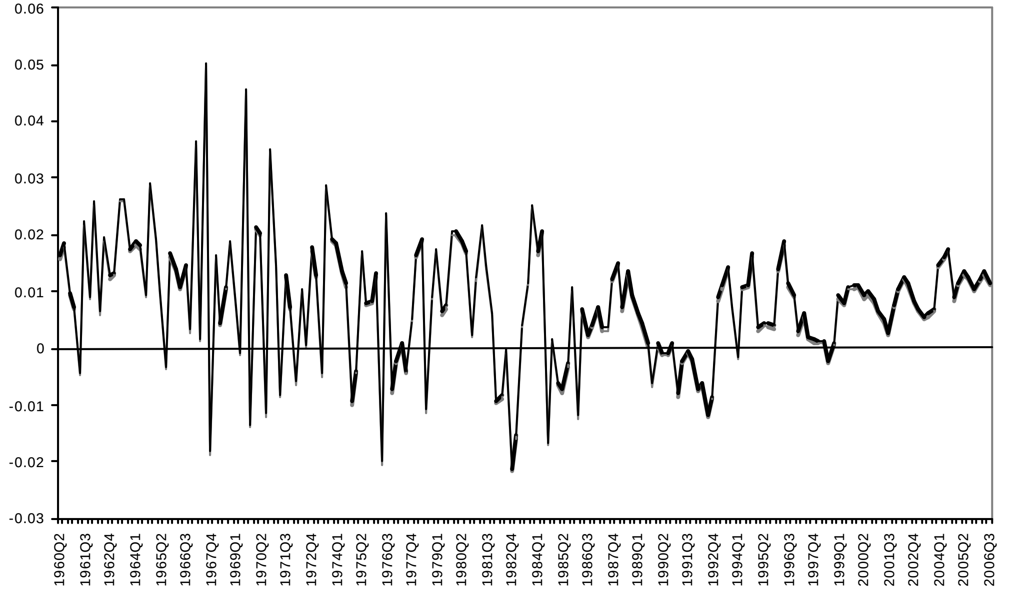


Figure 2 Ratio of government expenditure to GDP

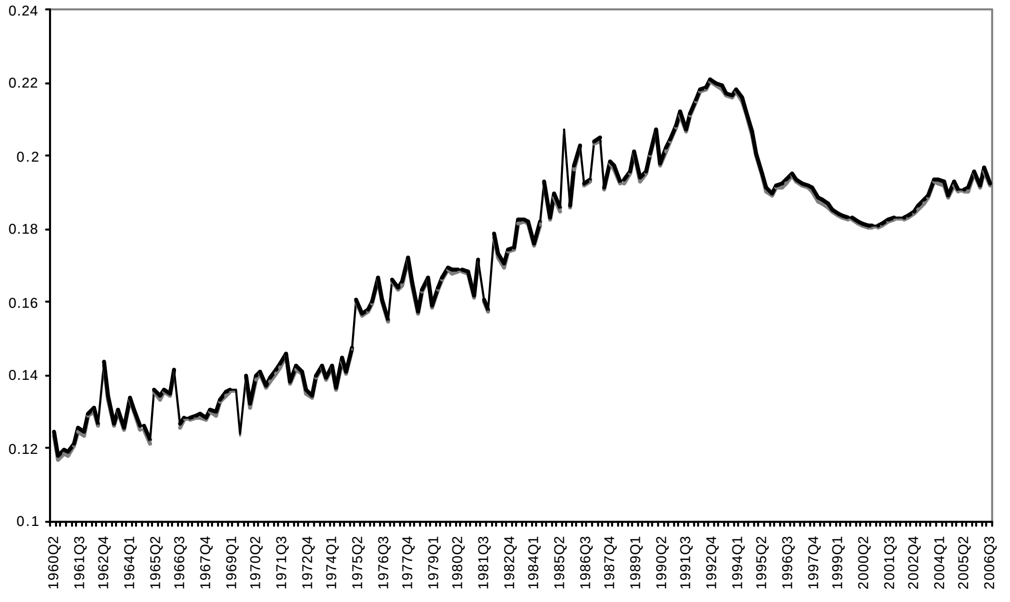


Figure 3 Real interest rate

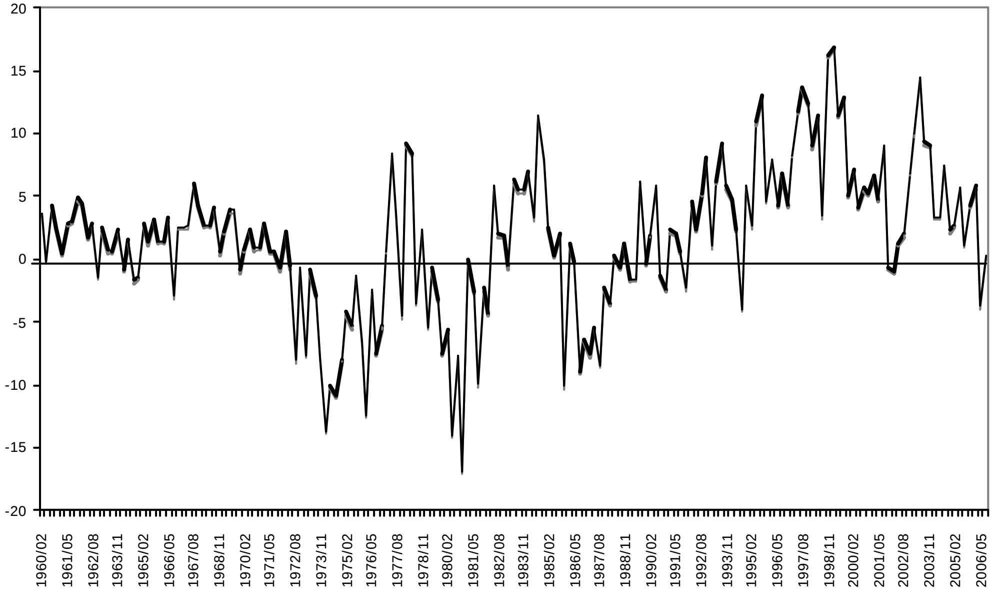
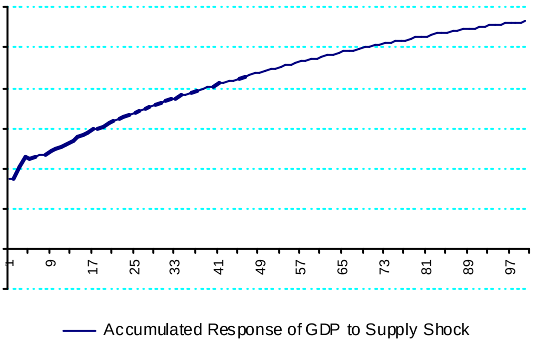
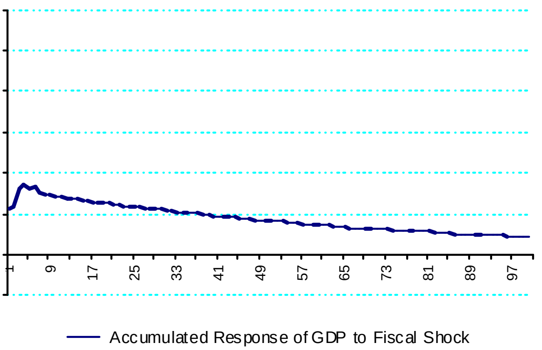
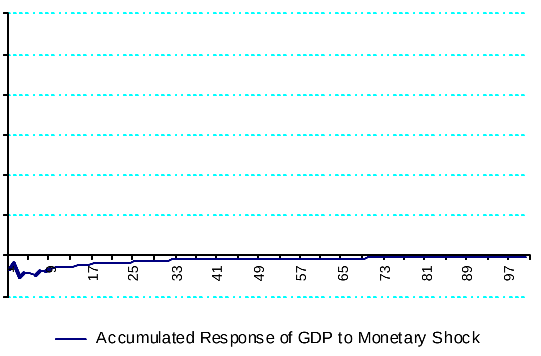


Figure 4 Impulse response of real GDP for each of the identified shocks

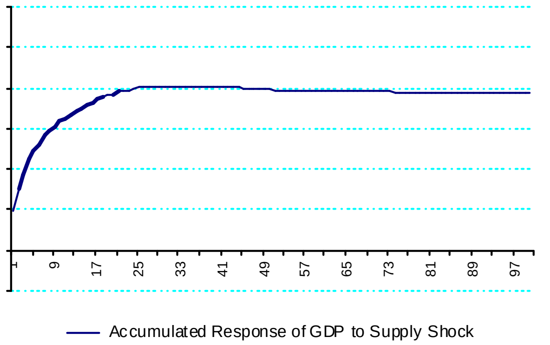
Longer sample (1960+)

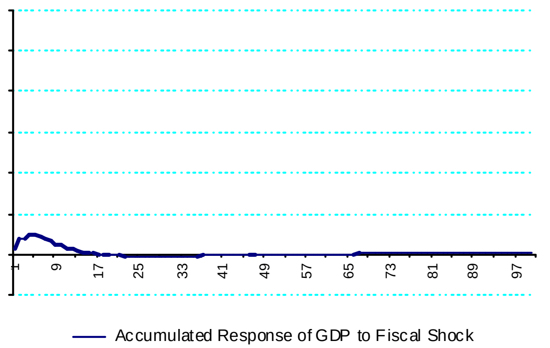






Shorter sample (1983+)





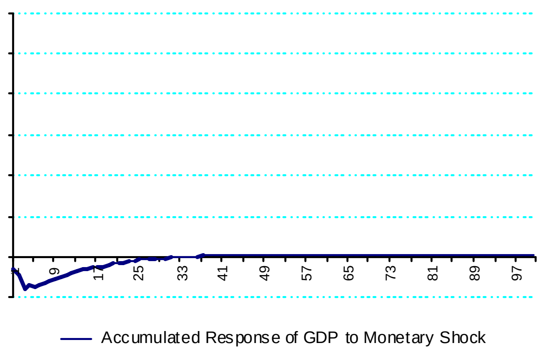


Figure 5 Box plot of structural shocks to the three variables by decade

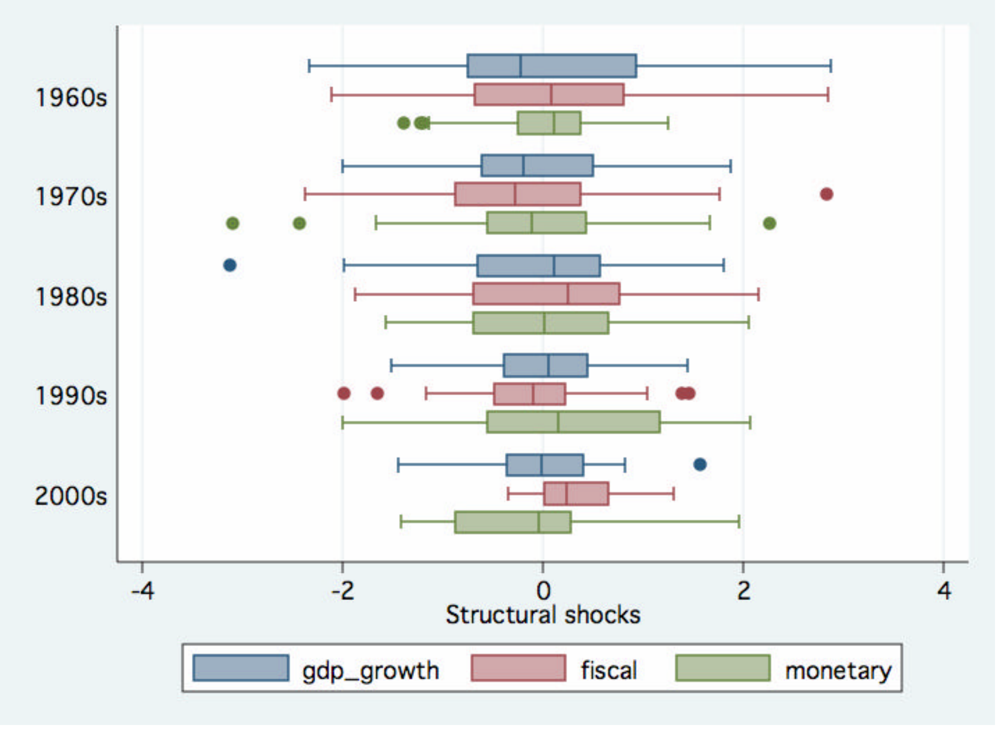


Figure 6   Impulse response of the real interest rate for each of the identified shocks

Longer sample (1960+)

Shorter sample (1983+)

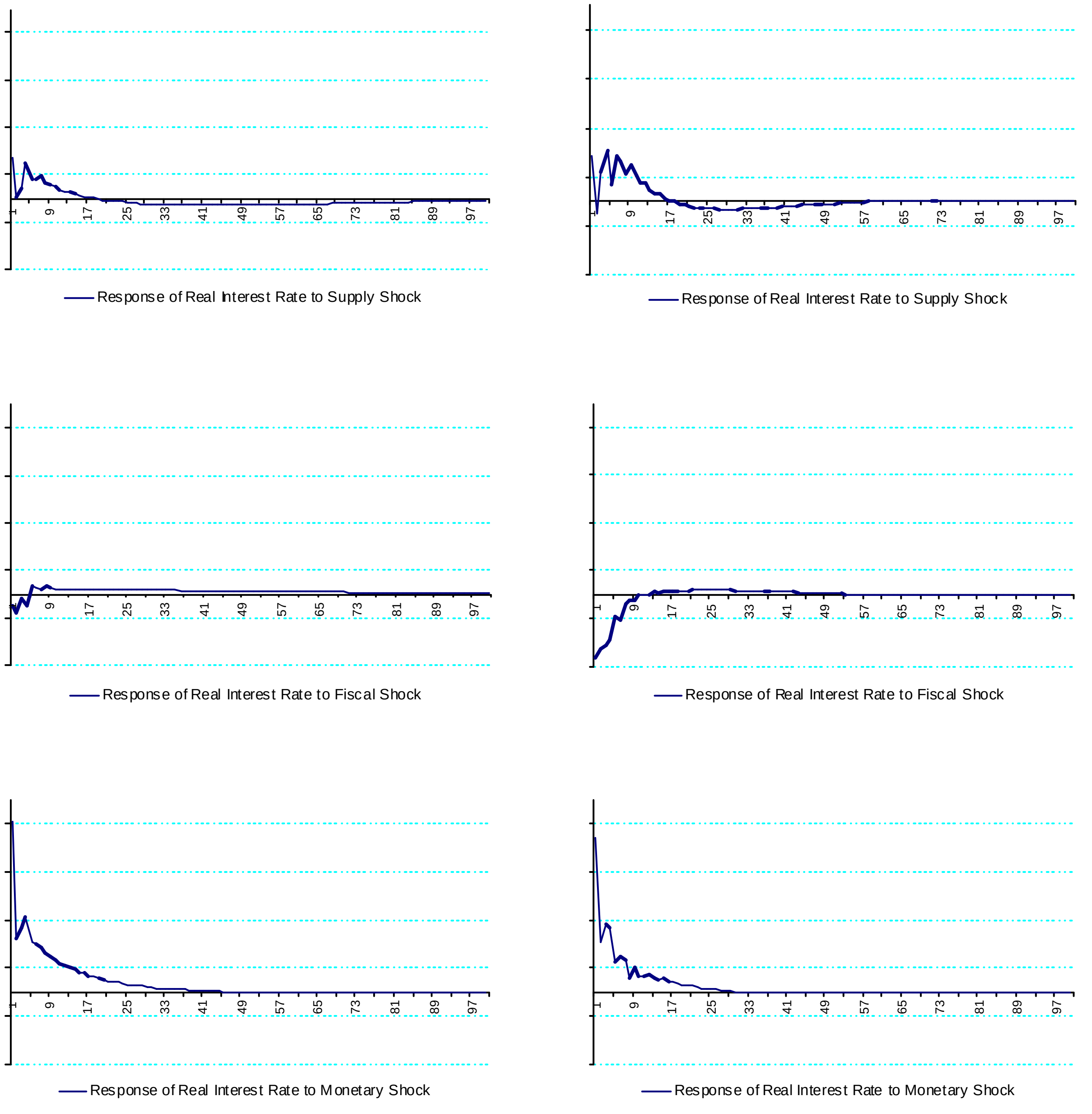


Figure 7 Impulse response of government consumption to real GDP for each of the identified shocks

Longer sample (1960+) Shorter sample (1983+)

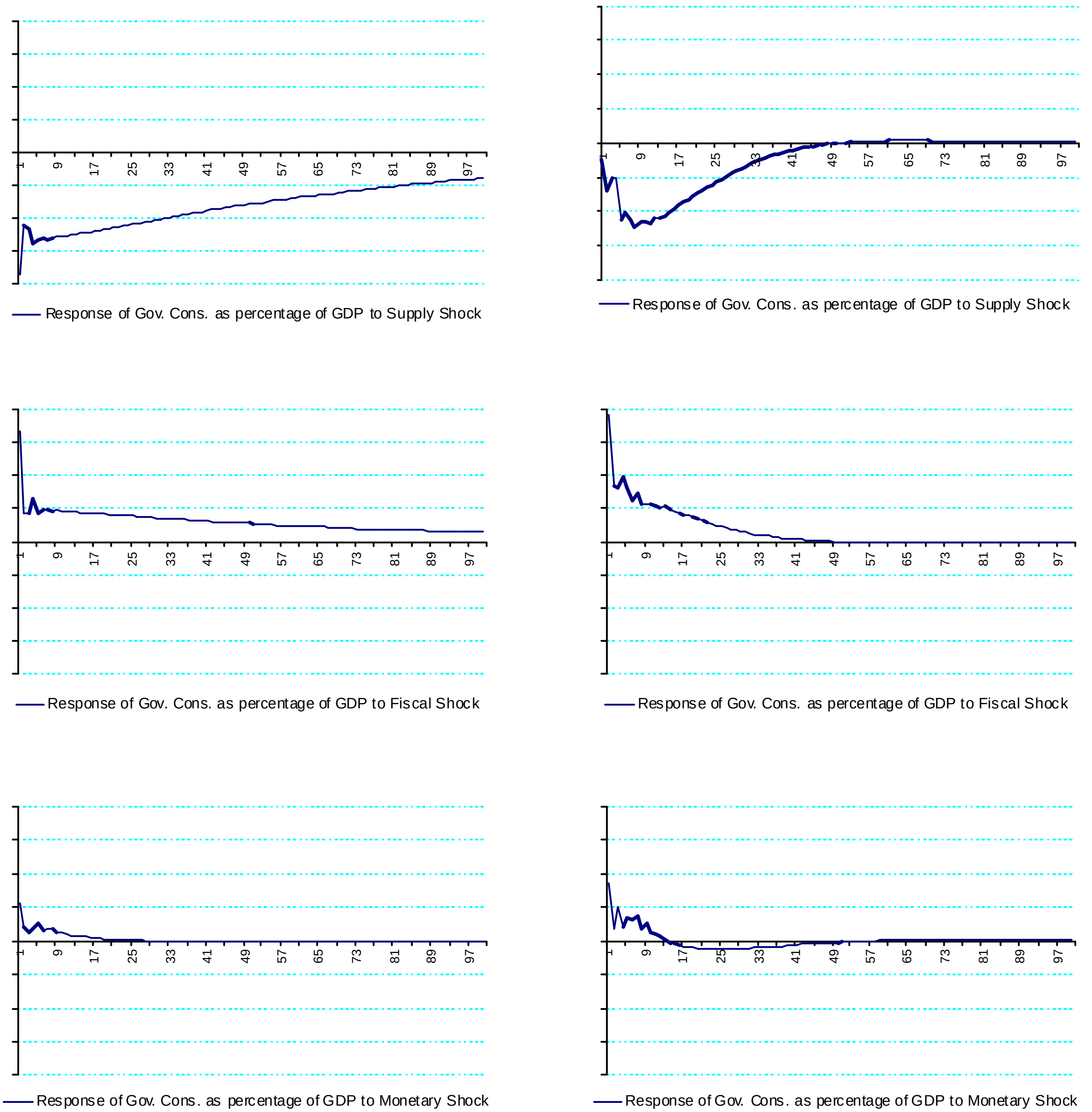
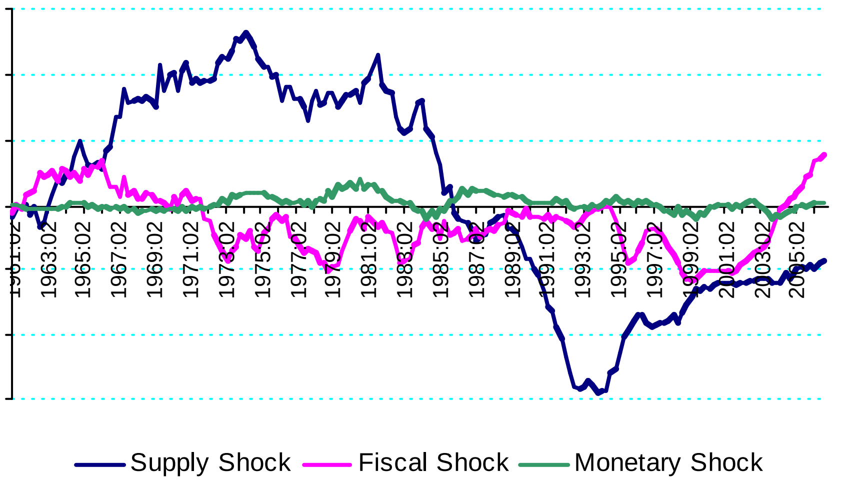


Figure 8 Historical decomposition of real GDP

Longer sample (1960+)



Shorter sample (1983+)

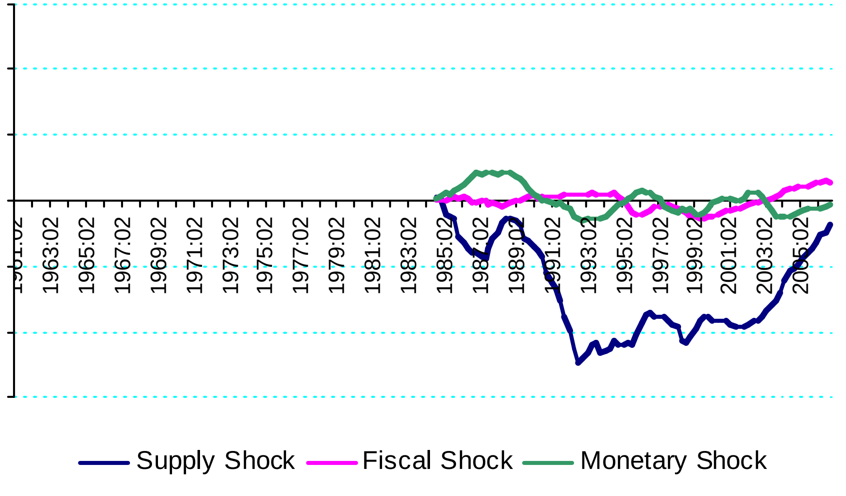
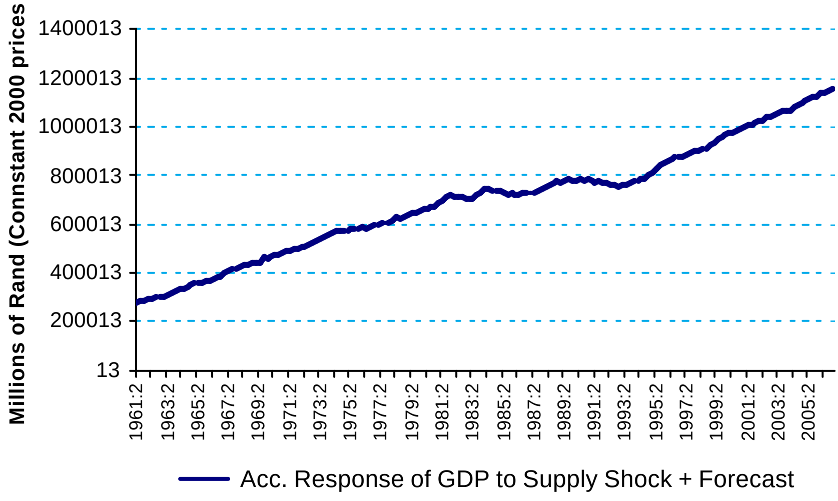


Figure 9 *New measure of aggregate supply*

Longer sample (1960+)



Shorter sample (1983+)

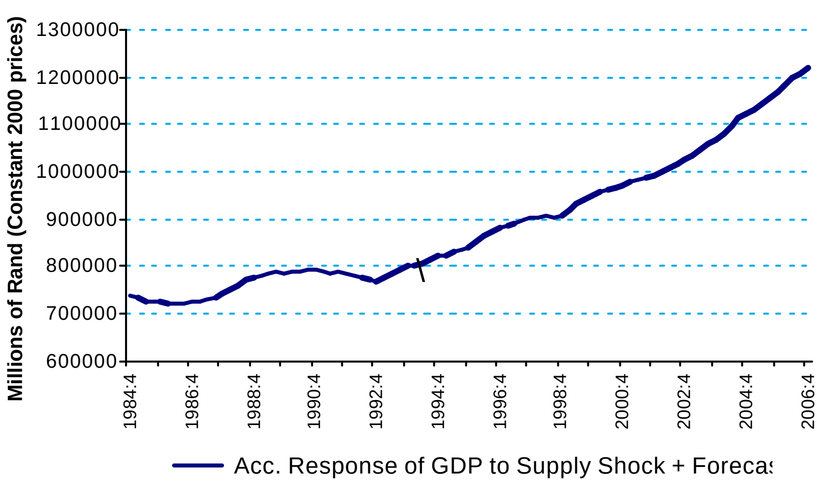


Figure 10 Events associated with supply shocks to the South African economy

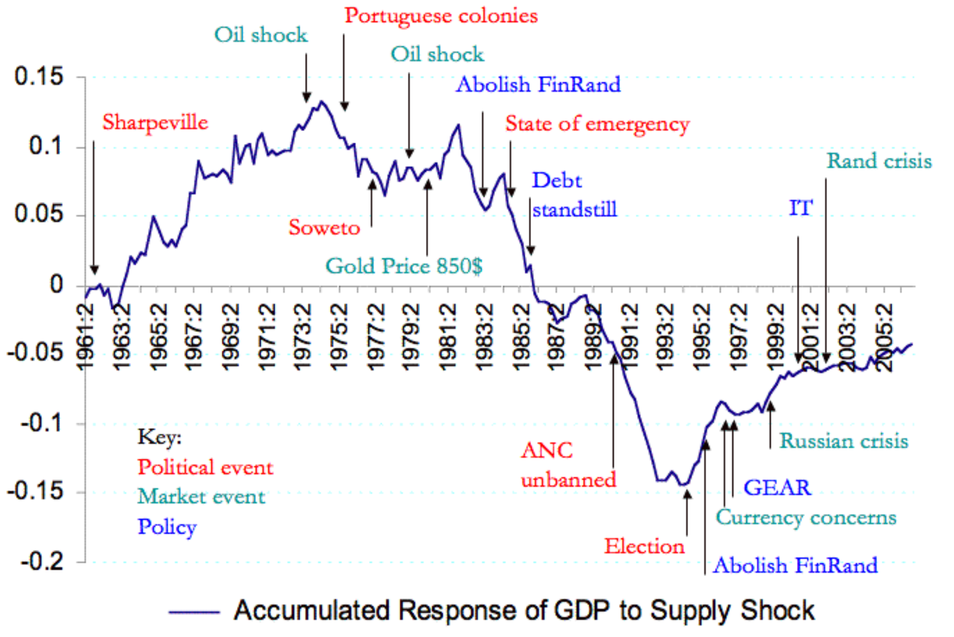
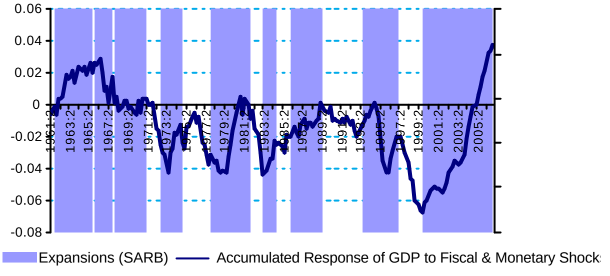
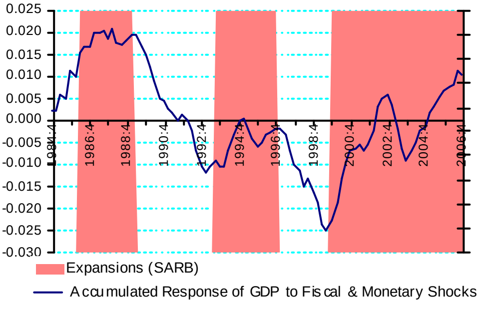


Figure 11   New measure of aggregate demand

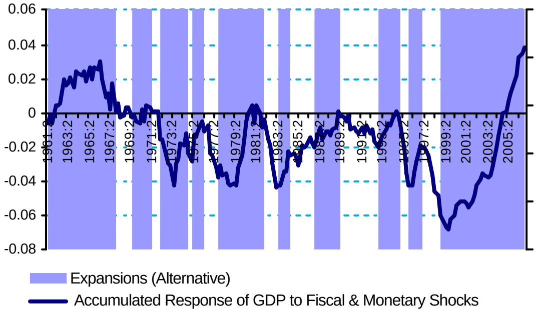
Longer sample (1960+)



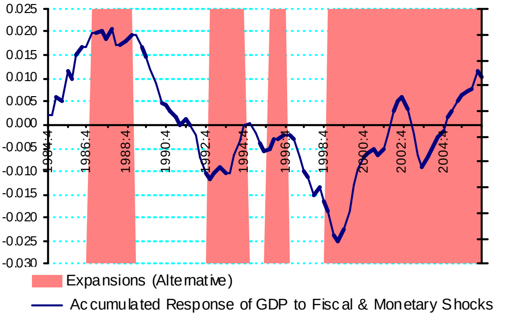
Shorter sample (1983+)



Longer sample (1960+)



Shorter sample (1983+)



APPENDIX A

Augmented Dickey-Fuller tests were used to test the null hypothesis of a unit root in the series used here, the results of which are reported in Table 2. There is no evidence of unit roots either in the real GDP differenced series or in the series for real interest rates, but it is not possible to reject the hypothesis of a unit root for the fiscal policy proxy. This raises a concern over the stability of the VAR. Of course, there may be concern over the low power of unit root tests, and thus for a variable such as government expenditure over GDP, it is unlikely to drift forever away from a reasonably stable value. However, to determine how serious this may be, we computed the eigenvalues of the SVAR system. We found that all the eigenvalues lie within the unit circle, and therefore there does not seem to be a risk of VAR instability, despite the unit root test results.

Table 2 Unit root tests

Variable	Sample	ADF critical values		
		No. deterministic components	Constant	Constant and trend
Δy_t	1960+	-2.691***	-4.656**	-5.007***
Δy_t	1984+	-2.155**	-3.499**	-4.339***
g_t	1960+	1.319	-1.605	-1.251
g_t	1984+	0.101	-1.856	-2.082
r_t	1960+	-3.348***	-3.874***	-4.438***
r_t	1984+	-2.453**	-3.336**	-4.313***

The Augmented Dickey-Fuller statistics were estimated with four lags.

*** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level

APPENDIX B

The following table shows the historical decomposition of the South African real GDP for both versions of the SVAR estimated here. Table B.1 shows real GDP, the implied measure of potential GDP and the implied business cycle measure for the model estimated over the longer sample, while table B.2 shows the same for the model estimated over the shorter sample.

Table B.1 Historical decomposition of real GDP, 1960+ model

Date	Real GDP	Potential GDP	Output Gap	Date	Real GDP	Potential GDP	Output Gap
1961Q1	280645			1984Q1	712,246	707,749	4,497
1961Q2	279418	283167	-3749	1984Q2	727,042	714,400	12,642
1961Q3	285659	283449	2210	1984Q3	714,992	728,019	-13,027
1961Q4	288256	290732	-2476	1984Q4	716,097	714,684	1,413
1962Q1	295712	292920	2792	1985Q1	711,831	714,610	-2,779
1962Q2	297606	299595	-1989	1985Q2	706,655	708,350	-1,695
1962Q3	303416	302913	503	1985Q3	704,790	706,933	-2,143
1962Q4	307302	306557	745	1985Q4	712,326	705,216	7,110
1963Q1	311367	311769	-402	1986Q1	703,840	708,664	-4,824
1963Q2	319600	317527	2073	1986Q2	708,699	706,771	1,928
1963Q3	328035	325041	2994	1986Q3	710,294	706,866	3,428
1963Q4	333815	334466	-651	1986Q4	713,276	712,693	583
1964Q1	340068	337771	2297	1987Q1	718,464	715,712	2,752
1964Q2	346223	345497	726	1987Q2	721,026	718,399	2,627
1964Q3	349476	350386	-910	1987Q3	723,657	725,103	-1,446
1964Q4	359695	355056	4639	1987Q4	732,541	728,796	3,745
1965Q1	366616	367366	-750	1988Q1	743,550	739,377	4,173
1965Q2	370162	370889	-727	1988Q2	748,830	749,396	-566
1965Q3	368994	374783	-5789	1988Q3	758,901	752,597	6,304
1965Q4	375131	373424	1707	1988Q4	766,027	763,268	2,759
1966Q1	380399	380678	-279	1989Q1	770,771	766,328	4,443
1966Q2	384539	385573	-1034	1989Q2	774,115	772,109	2,006
1966Q3	390204	389833	371	1989Q3	774,737	779,949	-5,212
1966Q4	391488	396036	-4548	1989Q4	769,943	775,540	-5,597
1967Q1	405721	399068	6653	1990Q1	770,559	769,851	708
1967Q2	406366	411623	-5257	1990Q2	769,923	777,447	-7,524
1967Q3	426799	414815	11984	1990Q3	769,276	770,191	-915
1967Q4	419050	433949	-14899	1990Q4	769,990	768,754	1,236
1968Q1	425930	424204	1726	1991Q1	763,866	771,276	-7,410
1968Q2	427818	432497	-4679	1991Q2	762,142	762,986	-844
1968Q3	432436	433126	-690	1991Q3	761,846	762,718	-872
1968Q4	440612	438117	2495	1991Q4	760,536	757,442	3,094
1969Q1	443778	445886	-2108	1992Q1	755,206	763,368	-8,162
1969Q2	443404	448967	-5563	1992Q2	750,574	755,680	-5,106
1969Q3	463653	453410	10243	1992Q3	741,884	751,311	-9,427
1969Q4	457395	466872	-9477	1992Q4	735,580	745,938	-10,358
1970Q1	467240	463084	4156	1993Q1	742,097	736,393	5,704
1970Q2	476774	474001	2773	1993Q2	750,237	741,863	8,374
1970Q3	471270	480793	-9523	1993Q3	761,036	757,883	3,153

1970Q4	487852	478221	9631	1993Q4	766,675	764,697	1,978
1971Q1	495078	495523	-445	1994Q1	765,582	768,591	-3,009
1971Q2	491042	495761	-4719	1994Q2	773,888	770,962	2,926
1971Q3	497438	495875	1563	1994Q3	782,592	772,707	9,885
1971Q4	501,014	502,783	-1,769	1994Q4	795,654	791,452	4,202
1972Q1	498,060	507,077	-9,017	1995Q1	798,528	801,723	-3,195
1972Q2	503,271	502,753	518	1995Q2	802,074	807,016	-4,942
1972Q3	503,582	505,273	-1,691	1995Q3	805,536	815,626	-10,090
1972Q4	512,500	509,763	2,737	1995Q4	808,715	810,934	-2,219
1973Q1	519,110	515,558	3,552	1996Q1	820,063	816,103	3,960
1973Q2	516,801	524,457	-7,656	1996Q2	835,424	827,319	8,105
1973Q3	531,747	523,353	8,394	1996Q3	844,904	841,808	3,096
1973Q4	541,990	536,596	5,394	1996Q4	852,917	848,159	4,758
1974Q1	552,117	546,061	6,056	1997Q1	855,368	859,269	-3,901
1974Q2	559,706	557,263	2,443	1997Q2	860,600	864,740	-4,140
1974Q3	566,045	561,454	4,591	1997Q3	862,397	869,707	-7,310
1974Q4	560,702	569,544	-8,842	1997Q4	863,699	871,166	-7,467
1975Q1	558,456	565,891	-7,435	1998Q1	864,791	871,465	-6,674
1975Q2	568,083	560,360	7,723	1998Q2	866,014	872,349	-6,335
1975Q3	572,631	572,873	-242	1998Q3	864,116	859,779	4,337
1975Q4	577,353	576,964	389	1998Q4	864,951	873,521	-8,570
1976Q1	584,941	580,970	3,971	1999Q1	872,905	879,230	-6,325
1976Q2	573,271	585,180	-11,909	1999Q2	879,852	883,014	-3,162
1976Q3	586,910	578,782	8,128	1999Q3	889,461	894,597	-5,136
1976Q4	582,621	592,304	-9,683	1999Q4	899,242	895,557	3,685
1977Q1	581,348	584,227	-2,879	2000Q1	909,357	906,289	3,068
1977Q2	581,907	584,011	-2,104	2000Q2	917,724	913,835	3,889
1977Q3	579,661	585,840	-6,179	2000Q3	926,813	924,461	2,352
1977Q4	582,638	578,689	3,949	2000Q4	934,698	935,643	-945
1978Q1	592,219	591,355	864	2001Q1	940,768	942,358	-1,590
1978Q2	603,664	598,298	5,366	2001Q2	945,471	949,205	-3,734
1978Q3	597,170	599,191	-2,021	2001Q3	947,982	958,571	-10,589
1978Q4	602,605	602,585	20	2001Q4	955,271	953,068	2,203
1979Q1	613,153	607,610	5,543	2002Q1	965,346	956,339	9,007
1979Q2	617,114	618,077	-963	2002Q2	977,594	968,088	9,506
1979Q3	621,720	615,392	6,328	2002Q3	988,659	981,114	7,545
1979Q4	634,479	625,926	8,553	2002Q4	996,885	993,695	3,190
1980Q1	647,514	644,735	2,779	2003Q1	1,003,734	1,009,525	-5,791
1980Q2	659,823	649,345	10,478	2003Q2	1,009,319	1,019,042	-9,723
1980Q3	671,120	665,270	5,850	2003Q3	1,015,432	1,021,499	-6,067
1980Q4	672,628	669,836	2,792	2003Q4	1,022,567	1,028,894	-6,327
1981Q1	680,982	684,229	-3,247	2004Q1	1,037,622	1,029,023	8,599
1981Q2	695,854	689,418	6,436	2004Q2	1,054,288	1,046,140	8,148
1981Q3	705,981	696,186	9,795	2004Q3	1,072,821	1,068,462	4,359
1981Q4	710,386	714,617	-4,231	2004Q4	1,082,341	1,077,836	4,505
1982Q1	703,805	712,172	-8,367	2005Q1	1,094,907	1,093,412	1,495
1982Q2	697,932	706,267	-8,335	2005Q2	1,109,662	1,107,209	2,453
1982Q3	697,754	704,000	-6,246	2005Q3	1,123,529	1,115,994	7,535
1982Q4	683,003	697,937	-14,934	2005Q4	1,135,402	1,134,710	692
1983Q1	672,461	684,804	-12,343	2006Q1	1,149,336	1,148,473	863
1983Q2	675,253	676,992	-1,739	2006Q2	1,164,856	1,153,124	11,732
1983Q3	683,038	679,034	4,004	2006Q3	1,178,196	1,172,574	5,622
1983Q4	700,362	689,333	11,029				

Table B.2 Historical decomposition of real GDP, 1983+ model

Date	Real GDP	Potential GDP	Output Gap	Date	Real GDP	Potential GDP	Output Gap
1984Q3	714,992			1995Q4	808,715	812,648	-3,933
1984Q4	716,097	715,862	235	1996Q1	820,063	819,265	798
1985Q1	711,831	711,712	119	1996Q2	835,424	831,189	4,235
1985Q2	706,655	707,126	-471	1996Q3	844,904	844,840	64
1985Q3	704,790	703,934	856	1996Q4	852,917	852,027	890
1985Q4	712,326	712,971	-645	1997Q1	855,368	857,167	-1,799
1986Q1	703,840	707,721	-3,881	1997Q2	860,600	862,011	-1,411
1986Q2	708,699	706,500	2,199	1997Q3	862,397	867,317	-4,920
1986Q3	710,294	712,618	-2,324	1997Q4	863,699	869,058	-5,359
1986Q4	713,276	715,099	-1,823	1998Q1	864,791	868,182	-3,391
1987Q1	718,464	716,748	1,716	1998Q2	866,014	869,456	-3,442
1987Q2	721,026	722,329	-1,303	1998Q3	864,116	864,621	-505
1987Q3	723,657	727,253	-3,596	1998Q4	864,951	867,599	-2,648
1987Q4	732,541	733,319	-778	1999Q1	872,905	871,124	1,781
1988Q1	743,550	741,232	2,318	1999Q2	879,852	881,271	-1,419
1988Q2	748,830	749,096	-266	1999Q3	889,461	887,406	2,055
1988Q3	758,901	758,177	724	1999Q4	899,242	895,363	3,879
1988Q4	766,027	762,934	3,093	2000Q1	909,357	902,938	6,419
1989Q1	770,771	768,964	1,807	2000Q2	917,724	913,121	4,603
1989Q2	774,115	772,880	1,235	2000Q3	926,813	924,856	1,957
1989Q3	774,737	772,693	2,044	2000Q4	934,698	932,912	1,786
1989Q4	769,943	769,680	263	2001Q1	940,768	940,219	549
1990Q1	770,559	766,905	3,654	2001Q2	945,471	943,960	1,511
1990Q2	769,923	770,718	-795	2001Q3	947,982	949,437	-1,455
1990Q3	769,276	771,874	-2,598	2001Q4	955,271	953,100	2,171
1990Q4	769,990	768,419	1,571	2002Q1	965,346	964,053	1,293
1991Q1	763,866	762,680	1,186	2002Q2	977,594	976,058	1,536
1991Q2	762,142	758,672	3,470	2002Q3	988,659	990,264	-1,605
1991Q3	761,846	760,235	1,611	2002Q4	996,885	1,000,712	-3,827
1991Q4	760,536	759,002	1,534	2003Q1	1,003,734	1,006,929	-3,195
1992Q1	755,206	758,851	-3,645	2003Q2	1,009,319	1,015,263	-5,944
1992Q2	750,574	752,041	-1,467	2003Q3	1,015,432	1,018,659	-3,227
1992Q3	741,884	745,823	-3,939	2003Q4	1,022,567	1,022,961	-394
1992Q4	735,580	737,725	-2,145	2004Q1	1,037,622	1,033,262	4,360
1993Q1	742,097	738,799	3,298	2004Q2	1,054,288	1,049,575	4,713
1993Q2	750,237	743,953	6,284	2004Q3	1,072,821	1,069,526	3,295
1993Q3	761,036	758,532	2,504	2004Q4	1,082,341	1,080,983	1,358
1993Q4	766,675	766,010	665	2005Q1	1,094,907	1,093,305	1,602
1994Q1	765,582	767,155	-1,573	2005Q2	1,109,662	1,107,435	2,227
1994Q2	773,888	773,555	333	2005Q3	1,123,529	1,120,809	2,720
1994Q3	782,592	781,234	1,358	2005Q4	1,135,402	1,133,819	1,583
1994Q4	795,654	795,213	441	2006Q1	1,149,336	1,150,461	-1,125
1995Q1	798,528	801,598	-3,070	2006Q2	1,164,856	1,162,177	2,679
1995Q2	802,074	807,906	-5,832	2006Q3	1,178,196	1,176,693	1,503
1995Q3	805,536	810,112	-4,576				

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