CHAPTER 6

GROWTH DETERMINANTS IN SOUTH AFRICA

The only cure for the shortcomings of econometrics is more and better econometrics.
Pesaran as quoted in Blaug (1992:246:1)

6.1 INTRODUCTION

Chapter 5 discussed a number of growth determinants often used in cross-country growth analyses. These cross-country tests show that certain variables make statistically significantly contributions to growth, while the signs of the coefficients indicate whether such contributions are negative or positive. The value of the coefficient indicates the importance of the variable's contribution to growth, but does not necessarily prove causality.

In this chapter, empirical time-series tools are used to determine the validity of the assumptions of causal relationships between some of these growth determinants and economic growth in South Africa. The analysis is conducted according to five broad categories, namely openness variables, investment variables, sectoral variables, human capital and institutional variables, and technology and productivity variables.

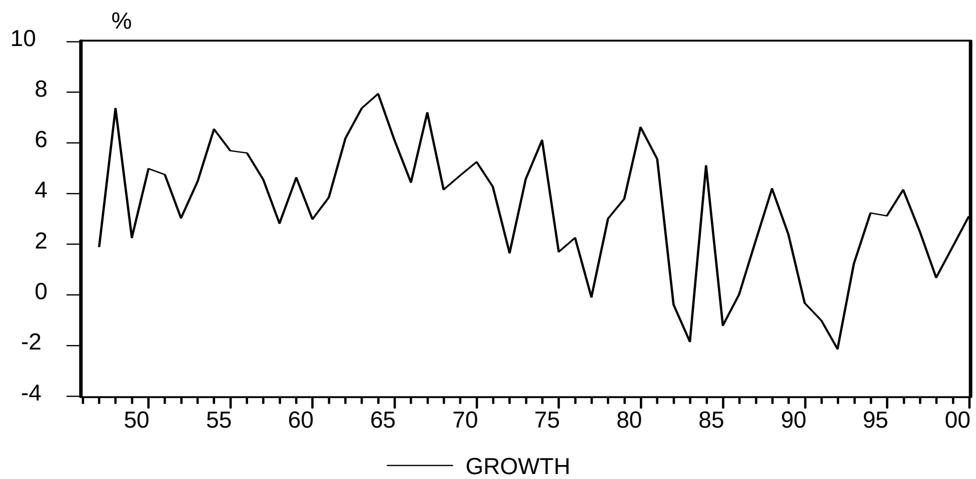
This chapter starts with a discussion of the data series used, the sources and construction thereof, and the univariate characteristics of the data. The empirical methodology is set out in section 6.3, followed by the empirical results in section 6.4. A number of conclusions are drawn in section 6.5.

This is done in the spirit of the recommendations of Thomas Mayer (1980:18) who urged that "most applied econometrics should seek to replicate previous results using a different data set and by doing this to rely increasingly on the weight of many pieces of evidence, rather than a single crucial experiment." In addition, the Socratic approach of deductive thinking remains crucial for the interpretation of the results of empirical tests by researchers.

However, before any growth empirics are analysed, the South African growth performance is revisited. Figure 6.1 demonstrates that growth rates in the South African economy accelerated during the period 1946 to the late 1960s, but declined sharply in subsequent periods. The average growth rate measured 3.42 per cent for the whole period from 1946 to 2000. When considering the period 1960 to 2000, the growth is lower at 3.07. The average growth rate, however, is substantially lower at 2.29 per cent for the period from 1970 to 2000.

Since the growth rates in the last two decades were lower than the population growth (see table 4.3), this implies that the average living standard (as measured by the GDP per capita) of South Africa declined during this period – the average GDP per capita growth for the 1980s and 1990s measured -0.2 per cent and -0.77 per cent respectively.

Figure 6.1: Real economic growth in GDP at market prices, 1946 to 2000



Source: SARB Quarterly Bulletin, various issues

6.2 THE DATA

The sources and construction of the data series used to empirically test and estimate the hypothetical causalities, set out in section 6.4, are discussed in this section, as well as the ways in which the univariate and bivariate characteristics of the data are analysed in subsequent sections.

6.2.1 Sources of data and calculations

Table 6.1 contains a list of the variables employed in subsequent sections containing empirical results. The dependent variable in all instances was the growth rate in GDP at market prices (at constant 1995 prices).

Variables expressed in levels and differences are more difficult to assess, while growth rates are easier to interpret because the analyst can state that growth in the variable should exceed the growth in the GDP or a desired growth in GDP when it makes a positive contribution to growth. Also, that the variable should not exceed the rate of growth in GDP when it is essential for the economic system but has a negative effect on growth.

When the variable is expressed as a ratio of GDP, it has the additional advantage of possible international comparison. A number of variables are therefore expressed as ratios of GDP, or as growth rates, and by exception, in terms of first or second differences, should a variable prove to be nonstationary.

The majority of the data series was obtained from the SARB Quarterly Bulletin. A number of series, such as the human capital series were obtained from Statistics South Africa, while data on productivity were obtained from the National Productivity Institute and data on crime incidents from the SA Police Force.

Table 6.1: List of variables

Series	Description
CAP_GR	Growth in fixed capital stock, at constant 1995 prices
CRIME	Crime incidence
CRIME_GR	Growth rate in crime
CRIME95	Crime incidence index 1995=100
ED_ST10_POP_GR	Number of matric enrolments as a percentage of the total population
G_ED	Government spending on education, deflated by the CPI
G_ED_PERC	Government spending on education as a percentage of total government expenditure
G_GDP	General government expenditure as a percentage of GDP, at constant 1995 prices
G_GDP_GR	Growth in general government expenditure as a percentage of GDP at constant 1995 prices
G_DE_GDP	General government expenditure, less defence and education expenditures, as a percentage of GDP, at constant 1995 prices
G_DE_GDP_GR	Growth in general government expenditure, less defence and education expenditures as a percentage of GDP, at constant 1995 prices
GROWTH	Growth in GDP at market prices at constant 1995 prices
GVA_AGR_GDP	Ratio of gross value added of the agriculture sector to GDP at constant 1995 prices
GVA_AGR_GR	Growth in gross value added of the agricultural sector, at constant 1995 prices
GVA_MAN_GDP	Ratio of gross value added of the manufacturing sector to GDP, at constant 1995 prices
GVA_MAN_GR	Growth in gross value added of the manufacturing sector, at constant 1995 prices
GVA_MIN_GDP	Ratio of gross value added of the mining sector to GDP, at constant 1995 prices

Table 6.1: List of variables (continued)

GVA_MIN_GR	Growth in gross value added of the mining sector, at constant 1995 prices
GVA_RES_GDP	Ratio of gross value added of residual sector to GDP, at constant 1995 prices
GVA_RES_GROWTH	Growth in gross value added of the residual sector, at constant 1995 prices (RES=GDP-GVA_AGR-GVA_MIN-GVA_MAN)
I_GDP	Gross fixed capital formation to GDP %, all at constant 1995 prices
I_GROWTH	Growth in gross fixed capital formation, at constant 1995 prices
I_MAEQ_RAT	Gross fixed capital formation (investment) in machinery and other equipment as a percentage of gross fixed capital formation (total), at constant 1995 prices
I_MAEQ_RAT_D	Gross fixed capital formation (investment) in machinery and other equipment as a percentage of gross fixed capital formation (total), at constant 1995 prices, first difference
I_TRCO_RAT	Gross fixed capital formation (investment) in transport and communication as a percentage of gross fixed capital formation (total) at constant 1995 prices
OPEN_AVE_XZ	Openness of the economy to international trade, measured by the average of the ratios of exports to GDP and imports to GDE, at constant 1995 prices
OPEN_SUM_XZ	Openness of the economy to international trade, measured as exports plus imports to GDP %, at constant 1995 prices
PTGR_CAP_AGR	Growth in capital productivity – agriculture
PTGR_CAP_MAN	Growth in capital productivity - manufacturing
PTGR_CAP_MIN	Growth in capital productivity – mining
PTGR_CAP_PR_EC	Growth in capital productivity - private economy

Table 6.1: List of variables (continued)

PTGR_LAB_AGR	Growth in labour productivity - agriculture
PTGR_LAB_MAN	Growth in labour productivity - manufacturing
PTGR_LAB_MIN	Growth in labour productivity - mining
PTGR_LAB_PR_EC	Growth in labour productivity - private economy
PTGR_MFP_AGR	Growth in multifactor productivity growth - agriculture
PTGR_MFP_MAN	Growth in multifactor productivity growth - manufacturing
PTGR_MFP_MIN	Growth in multifactor productivity growth - mining
PTGR_MFP_PR_EC	Growth in multifactor productivity growth - private economy
PTGR_ULC_AGR	Growth in unit labour cost – agriculture
PTGR_ULC_MAN	Growth in unit labour cost – manufacturing
PTGR_ULC_MIN	Growth in unit labour cost – mining
PTGR_ULC_EC	Growth in unit labour cost – private economy
X_GDP	Exports as a percentage of GDP
X_MAN_GDP	Exports of manufactures as a percentage of GDP at current prices

6.3 EMPIRICAL METHODOLOGY

This section contains a discussion of the econometric tools used in the analysis of growth empirics for South Africa, while section 6.4 contains the empirical results. It presents the determination of potential relationships and empirical causalities between certain stationary economic variables and the economic growth rate over time, of which the underlying data-generating process is also stationary (see appendix A for a list of unit root test results).

The same strategy was broadly followed for each variable analysed, namely to first present the data by means of a simple scatter graph with a fitted regression line of the potential explanatory variable and the economic growth rate – often already a most insightful analysis. A correlation matrix containing simple correlation coefficients supplements this. To proceed beyond the contemporaneous effects and in an attempt to establish causality – and in cases where it is found to exist, its direction – a Granger causality test was performed. The first step in establishing causality would be to select the proper lag order for each series. In each case, the lag order was selected by specifying an AR model with a maximum of six lags[1] for each variable. Then t-statistics (or p-values) on the last lag were considered and lags dropped until the final lag was significant. A vector autoregression (VAR) model was subsequently fitted to establish the significance of the relationships. If significant, the tools of variance decomposition and impulse response functions were used to throw more light on the relationship.

6.3.1 Order of integration

In analysing the univariate characteristics of the data, the Augmented Dickey-Fuller (ADF) test was employed to establish the order of integration of the data series. The testing strategy, as suggested by Dolado *et al.* (1990:253-262) and applied by Sturm and De Haan (1995:69), was used.

The number of lags used in the estimated equations was determined in a similar way to that suggested by Perron (1989:1384), namely starting with eight lags and testing downwards, until the last lag is significant or there are no lags left. In addition, graphing the data series in levels as well as their first and second differences and looking at autocorrelation functions (correlograms) and spectrum analysis, proved to be helpful when ADF-test results were inconclusive.

The respective tables reporting on the outcomes of the ADF-tests for the relevant data series employed in estimations, are included in appendix A and follow the convention set out below. The series that were tested are listed in the first column. The second column reports the sample period, and the third column whether a trend and a constant (Trend), only a constant (Constant), or neither one (None) is included. In the fourth column, the number of lags included in the test regression is reported. The next column shows the ADF t-statistic, called τ_τ when a trend and a constant are included, τ_μ when only a

[1] Said and Dickey (1984), have shown that an unknown ARIMA(p,1,q) can be well approximated by an ARIMA(n,1,0) where $n \leq int[T^{1/3}]$ with T the number of observations.

constant is included, and τ when neither is included. The last column reports the F statistic, Φ_3 (Φ_1), testing whether the trend (constant) is significant under the null hypothesis of no unit root.

The question of causality and its direction, may best be answered with the Granger causality test. The results are reported in the respective tables in each section. Data series from 1946 to 2000 were generally used. The order of the Granger causality test first has to be determined. This can be done either through an AR specification on the individual time series, starting by including a sufficient number of lags, and omitting statistically insignificant last lags, in order to render the residual of the test regression white noise. Alternatively, the Akaike and Schwarz information criteria on the underlying vector autoregression (VAR) model with different lag orders can be used.

To further investigate the dynamics of the system, the vector autoregression (VAR) model is estimated. The general VAR specification can be written as:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 X_{t-1} + \beta_4 X_{t-2} + \beta_5 Z_{t-1} + \beta_6 Z_{t-2} + \ldots + \varepsilon_t.$$

The tables in the various sections report the results of the VAR with the lag order determined by testing the relevant AR specification for individual series. What is important in these tables is the first column of results with growth as the dependent variable. When the slope coefficients are significant and carry the correct sign, this is a good indication that the variable contributes to growth.

Sims (1980, 1982) introduced a different test for causality, or future impact, based on the variance decomposition of a variable's forecast error variance. The decompositions show the proportion of forecast error variance for each variable that is attributable to its own innovations and those of others. Thus relationships between variables may be evaluated in terms of degree of causality. Where the VAR results indicated positive contributions to growth, the strength of the causality was usually further investigated with the Sims variance decomposition test.

Finally, impulse response functions for the two-variable system are examined in order to throw light upon the dynamics of the relationship. Impulse responses summarise the short-run and long-run effects of various shocks to the system and are displayed in groups of four graphs.

The first of the four graphs proves that economic growth is responsive to shocks to itself, while in the second graph, innovations in the tested explanatory variable serve as a stimulus for higher growth in most of the tested variables (one exception being government spending). Convergence back to the long-run growth level is shown in these graphs after innovations in the independent variable.

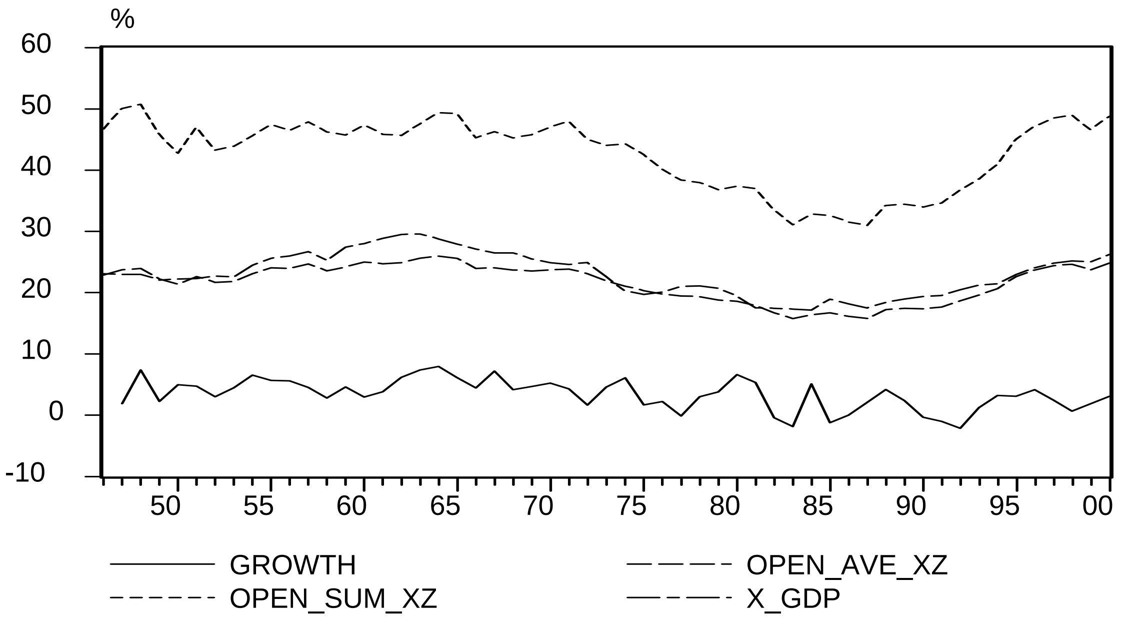
6.4 EMPIRICAL RESULTS

The analysis is categorised in five broad groups, namely openness variables, investment variables, sectoral contribution variables, human capital and institutional variables, and technology or productivity variables.

6.4.1 Openness to international trade and investment

This section investigates the implications for growth in South Africa from a number of variables measuring openness to foreign trade that are often used in international growth studies to investigate the effect of these variables on growth. Different measures of the openness of the South African economy to international trade are used. Firstly, it is derived as (X+Z)/GDP*100; with X and Z representing exports (of goods and services) and imports (of goods and services) respectively. According to Mohr et al (1995:93), a more accurate way of determining openness would be ((X/GDP)+(Z/GDE))/2. In addition, the ratio of exports to GDP and manufacturing exports to GDP, expressed as a percentage, is tested (see section 5.2.17 on p114 and Edwards (1993:9-11) on p115).

Figure 6.2: Openness to international trade variables and economic growth



It is evident from figure 6.2 that there seems to be a coherent movement between all measurements for the openness of the economy and economic growth. Figure 6.2 (above) and table 6.2 confirms this because they show positive correlations ranging from 0.51 to 0.56 between openness variables and economic growth.

Figure 6.3: Simple scatter graphs of growth versus openness variables

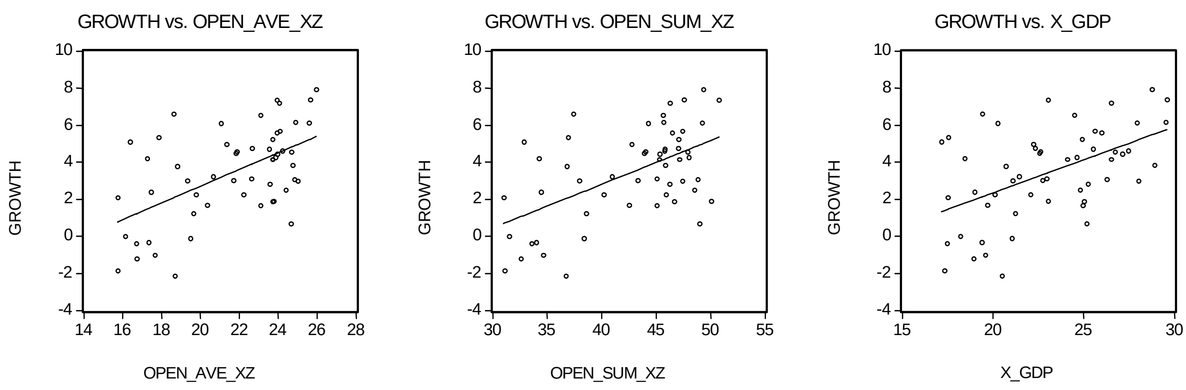


Table 6.2: Correlation matrix for GROWTH, OPEN_SUM_XZ, OPEN_AVE_XZ and X_GDP

	GROWTH	OPEN_SUM_XZ	OPEN_AVE_XZ	X_GDP
GROWTH	1.000	0.555	0.559	0.512
OPEN_SUM_XZ	0.555	1.000	0.972	0.839
OPEN_AVE_XZ	0.559	0.972	1.000	0.942
X_GDP	0.512	0.839	0.942	1.000

The question of causality and its direction is best answered by a test for Granger causality. The first step in establishing causality would be to select the proper lag order for each series. The results are reported in table 6.3. The sample period is 1946 to 2000.

Table 6.3: Test results of the lag order of openness variables

	Lag order	p-value	AIC	SIC
GROWTH	1	0.0005	4.482	4.482
OPEN_AVE_XZ	2	0.0327	2.474	2.474
OPEN_SUM_XZ	1	0.0000	4.312	4.312
X_GDP	1	0.0179	2.759	2.759
X_MAN_GDP	3	0.0322	2.292	2.466

Results describe p-values on the last lag as well as Akaike and Schwarz selection criteria results for the final model. The lag orders are subsequently used in Granger causality tests. The results are provided in table 6.4.

Table 6.4: Pairwise Granger causality tests for openness and economic growth, 1946 to 2000

Null hypothesis:	Lag order	Obs	F-stat	Probability
OPEN_AVE_XZ does not Granger Cause GROWTH	2	52	5.52	0.0070***
GROWTH does not Granger Cause OPEN_AVE_XZ			5.06	0.0102**
OPEN_SUM_XZ does not Granger Cause GROWTH	1	53	4.94	0.0308**
GROWTH does not Granger Cause OPEN_SUM_XZ			0.00	0.9342
X_GDP does not Granger Cause GROWTH	1	53	12.90	0.0008***
GROWTH does not Granger Cause X_GDP			0.75	0.3915
X_MAN_GDP does not Granger Cause GROWTH	3	37	2.37	0.0907*
GROWTH does not Granger Cause X_MAN_GDP			0.61	0.6134

Note: ***/**/* indicate rejection of the hypothesis at the 1/5/10 per cent level of significance.

All measures of openness are indicative of a causal relationship running from openness to economic growth. In the case where openness is measured as the sum of exports and imports as a percentage of GDP, there is indication of bidirectional causality.

To further investigate the dynamics of the system, the vector autoregression (VAR) model is estimated. Table 6.5 reports the results of the VAR with lag order 1 for the relationship between growth and openness according to the measure of imports plus exports as a percentage of GDP. What is important is the first column of results with growth as the dependent variable. Both slope coefficients are significant and carry the correct sign. Results for other measures are in accordance and therefore not reported.

Table 6.5: Vector autoregression model estimating the effect of openness, measured by the sum of exports and imports, on economic growth

Sample (adjusted): 1948-2000
Included observations: 53 after adjusting endpoints
t-statistics in parentheses

	GROWTH	OPEN_SUM_XZ
GROWTH(-1)	0.2777	-0.0113
	(1.922)	(-0.083)
OPEN_SUM_XZ(-1)	0.1381	0.9370
	(2.223)	(15.979)
C	-3.3692	2.6936
	(-1.396)	(1.1824)
R-squared	0.2828	0.8815
Adj R-squared	0.2541	0.8767
Sum sq resides	231.58	206.28
SE equation	2.1521	2.0311
F-statistic	9.8591	186.03
Log likelihood	-114.28	-111.21
Akaike IC	4.4257	4.3100
Schwarz IC	4.5372	4.4215

Statistical significance exists to support the theoretical positive impact of openness on the economic growth rate. Economic growth is also impacted by its first lag. The positive sign shows a positive momentum to economic growth.

The strength of the causality was further investigated with the Sims variance decomposition test. Table 6.6 contains the results from this analysis for a 10 year period for the measurement of openness as the sum of exports and imports as a percentage of GDP.

Table 6.6: Variance decomposition of growth due to innovations in openness

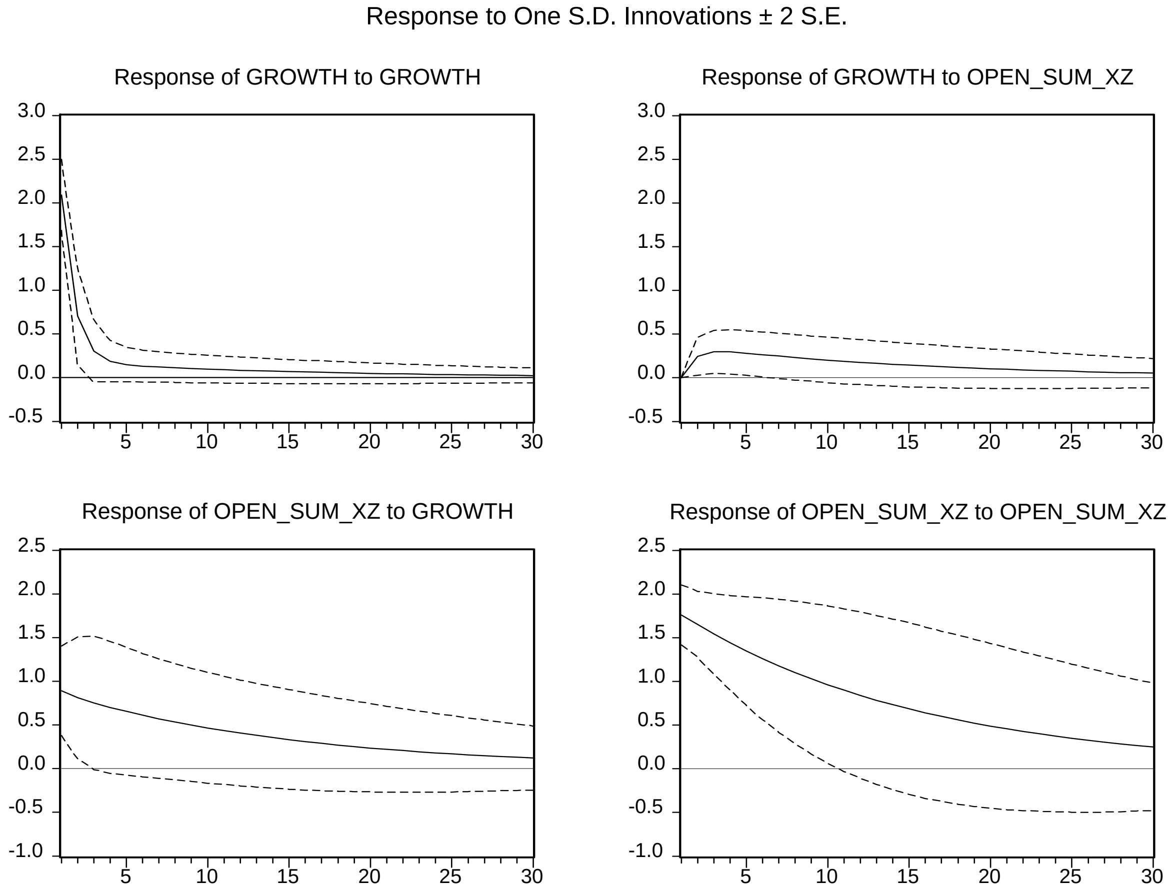
Period	SE	GROWTH	OPEN_SUM_XZ
1	2.090	100.000	0.000
2	2.218	98.799	1.200
3	2.259	97.134	2.865
4	2.286	95.536	4.463
5	2.308	94.138	5.861
6	2.327	92.944	7.055
7	2.343	91.928	8.071
8	2.357	91.061	8.938
9	2.369	90.321	9.678
10	2.380	89.687	10.312

For the period under consideration, innovations in openness explain a relatively small portion, but with an increasing long-run significance (up to 10 per cent), of the forecast error variance of the economic growth rate directly, and thus support results obtained from Granger causality tests.

Finally, impulse response functions for the two-variable system are examined in order to throw light upon the dynamics of the relationship. Impulse responses summarise the short-run and long-run effects of various shocks to the system and are displayed in figure 6.4.

The first of the four graphs in figure 6.4 proves that economic growth is responsive to shocks to itself, while in the second graph, increases in the openness of the economy to international trade and investment serves as a stimulus for higher growth. This positive impact is sustained, and after 30 periods the relationship is still above the long-run level. Convergence back to the long-run growth level therefore takes place more than 30 periods after innovations in openness.

Figure 6.4: Impulse response functions of economic growth due to innovations in openness



The conclusion that can be drawn from the above analysis of the relationship between openness of the economy to international trade and investment is that barriers to openness must be limited in the form of import tariffs and quotas, and exports must be promoted since export-led growth in line with the new growth theories remains important for the future. For obvious reasons, however, imports of productive capital goods are needed more than imports of nonproductive luxury goods in order to revive the economy. Export promotion should concentrate on manufactured goods rather than primary products in the long run, a skilled workforce may contribute to higher competitiveness in the export of manufactured goods.

To complete the analysis on openness and its impact on economic growth, the share of manufactured exports in GDP is analysed. The share of manufactured exports in GDP is stationary in levels, and according to table 6.4, the ratio of manufactured exports in GDP Granger causes economic growth.

Since the prerequisites of stationarity of the series allow it, a vector autoregression model with lag order 3 is fitted to establish the significance of the relationship.

Table 6.7: Vector autoregression model estimating the effect of the ratio of manufacturing exports to GDP on economic growth

Sample(adjusted): 1960-1996
Included observations: 37 after adjusting endpoints
t-statistics in parentheses

	GROWTH	X_MAN_GDP
GROWTH(-1)	0.4888	0.0071
	(2.960)	(0.132)
GROWTH(-2)	-0.0049	-0.0419
	(-0.026)	(-0.698)
GROWTH(-3)	0.1184	-0.0336
	(0.710)	(-0.623)
X_MAN_GDP(-1)	0.0491	0.8067
	(0.093)	(4.726)
X_MAN_GDP(-2)	0.9122	-0.0755
	(1.324)	(-0.338)
X_MAN_GDP(-3)	-1.2558	-0.3533
	(-2.403)	(-2.087)
C	3.5573	5.0909
	(0.977)	(4.319)
R-squared	0.4127	0.6389
Adj R-squared	0.2952	0.5666
Sum sq resides	155.0516	16.281
SE equation	2.2734	0.7366
F-statistic	3.5135	8.8465
Log likelihood	-79.0082	-37.314
Akaike IC	4.6490	2.3953
Schwarz IC	4.9538	2.7001

According to the above result, in addition to the first lag of growth itself, the only other significant independent variable was the third lag of the manufactured exports to GDP ratio, which carries a negative sign. This either insignificant or negative relationship between manufactured exports and economic growth is confirmed by the fact that the simple correlation coefficient between these two variables is -0.052. This may be indicative that manufacturing exports did not really contribute to economic growth in the past, contrary to the experience of the fast-growing East Asian countries. This could be an indication that the largely primary exports of the past (Dutch disease effect) and the sanctions campaign of the late 20th century detracted from manufacturing export growth and that potential additional sources of growth can be induced with a policy regime conducive to manufacturing rather than primary exports.

In the light of the above results, the tools of variance decomposition and impulse response functions are not all that useful, and are therefore not explored any further.

6.4.2 Investment and selected constituent parts as stimuli to economic growth

This section deals with the validity of the notion that investment is a stimulus to growth. From the early growth models of Harrod (1959:295) and Domar (1947:282), the neoclassical theory (Solow 1957:312), the growth accounting work of Denison (1967:159, 194) and the endogenous growth theory (Romer 1990b:S89), investment featured prominently in one of its various forms. More recent research also focused on this variable. Levine and Renelt (1992:959) used the extreme bounds test and found the share of capital investment to GDP to be the only robust growth variable (see section 5.2.5 on p102).

Other researchers subsequently felt that the extreme bounds criteria were too stringent which resulted in the conclusion that nothing is robust. Sala-i-Martin (1997:17) devised new criteria for significant growth-inducing variables, which widened the scope for robust variables and also included, *inter alia,* equipment investment and non-equipment investment. De Long and Summers

(1991:449) justified the exclusion of the transportation investment component, because it "reflects differences in the 'need' for transportation caused by differences in urbanization and population density".

In South Africa where large portions of the production facilities are located far from the coast, a lack of transport infrastructure investment could impede growth (see section 5.2.7 on p106). It was therefore decided to test for such a possibility (I_TRCO_RAT, representing the portion of capital formation of transport, storage and communication in total gross fixed capital formation). In line with other international studies, the following representative set of variables was also tested: the ratio of gross fixed capital formation to GDP (I_GDP), growth in gross fixed capital formation (I_GROWTH), investment in manufacturing and other equipment as ratio of total gross fixed capital formation (I_MAEQ_RAT). Since this variable is not stationary, the first difference thereof was also subjected to the tests of Granger causality, that is, testing the hypothesis that the change in the ratio would contribute towards growth.

The logic for choosing the machinery and equipment part of total investment as a possible source of growth lies in the new technology that is inevitably incorporated into new machinery and equipment. The new growth theory stresses the importance of technology as a pivotal factor in endogenous growth. Romer (1994:21) stressed that the best way for a developing country to accelerate its growth would be to find the best institutional arrangements for gaining access to the knowledge that already exists in the world. Keller (1997:1) estimated that as much as 20 per cent of growth can be attributed to foreign R&D investments in developed countries, and he conjectures that "this effect could be higher for less industrialised countries importing from OECD countries."

A discussion of the empirical results follows. Firstly, simple correlations between the selected investment variables and economic growth are reported in table 6.8. Of these, a significant positive relationship exists between investment growth and economic growth, with a simple correlation coefficient of 0.51. Investment in transport, storage and communication displayed only a weak positive relationship with economic growth, while the ratio of investment in machinery and other equipment displayed a rather strong negative relationship with economic growth, with a simple correlation coefficient of –0.43. The reason for that is that this type of investment increased from around 20 per cent of total capital formation in the 1950s to more than 50 per cent in the 1990s, and could therefore be considered a growth inhibitor.

This is in contradiction with *a priori* expectations since equipment investment was found to be a significant growth contributor by both De Long and Summers (1991:485), and subsequently confirmed by Sala-i-Martin (1997:17). Since the above-mentioned variable is not stationary in levels, the first difference was also analysed, that is, the change in the ratio. However it bears no significant relationship to economic growth.

Table 6.8 Correlation matrix for GROWTH, I_GDP, I_GROWTH, I_TRCO_RAT and I_MAEQ_RAT

	GROWTH	I_GDP	I_GROWTH	I_TRCO_RAT	I_MAEQ_RAT
GROWTH	1.000	-0.045	0.512	0.119	-0.429
I_GDP	-0.045	1.000	0.145	0.314	-0.068
I_GROWTH	0.512	0.145	1.000	0.102	-0.159
I_TRCO_RAT	0.119	0.314	0.102	1.000	-0.352
I_MAEQ_RAT	-0.429	-0.068	-0.159	-0.352	1.000
I_MAEQ_RAT_D	0.007	-0.061	0.294	-0.055	0.486

Analysing the above results further, the proper lag length was selected with the aid of an AR model on individual series. These results are reported in table 6.9.

Table 6.9: Testing for the lag order of investment variables

	Lag order	p-value	Akaike	Schwarz
GROWTH	1	0.0005	4.482	4.482
I_GDP	3	0.0126	2.971	3.123
I_GROWTH	1	0.0005	6.680	6.794
I_TRCO_RAT	1	0.0000	-4.762	-4.688
I_MAEQ_RAT	1	0.0000	-5.496	-5.422
I_MAEQ_RAT_D	1	0.0820	-5.486	-5.412

Given the above lag orders, Granger causality tests were performed on the data, and the results reported in table 6.10. A bidirectional relationship seems to exist between investment and growth, except for the investment in transport and communication variable, where the Granger causality test suggests an inverse causality. (Although the test was performed for the variable measuring investment in machinery and other equipment and its first difference, less value should be attached to it, given the negative and almost zero correlation coefficients reported in table 6.8.)

Barro and Sala–i–Martin (1995:433) refer to the possible reverse relation between growth prospects and investment by observing that: "... much of the positive estimated effect of the investment ratio on growth in typical cross-country regressions reflects the reverse relation between growth prospects and investment". Investment appears to lead to higher growth, but growth prospects also play a role in the level and increase in investment.

Table 6.10: Pairwise Granger causality tests for investment and economic growth, 1946 to 2000

Null hypothesis:	Lag order	Obs	F-stat	Probability
I_GDP does not Granger Cause GROWTH	3	50	3.40	0.03**
GROWTH does not Granger Cause I_GDP			4.71	0.007***
I_GROWTH does not Granger Cause GROWTH	1	52	2.50	0.08*
GROWTH does not Granger Cause I_GROWTH			3.65	0.02**
I_TRCO_RAT does not Granger Cause GROWTH	1	52	1.56	0.21
GROWTH does not Granger Cause I_TRCO_RAT			5.98	0.02**
I_MAEQ_RAT does not Granger Cause GROWTH	1	52	7.56	0.008***
GROWTH does not Granger Cause I_MAEQ_RAT			1.96	0.17
I_MAEQ_RAT_D does not Granger Cause GROWTH	1	52	0.34	0.56
GROWTH does not Granger Cause I_MAEQ_RAT_D			6.25	0.02**

Note: ***/**/* indicate rejection of the hypothesis at the 1/5/10 per cent level of significance.

The inverse relationship between investment in transport and communication seems to reveal that public sector participation through the South African railways and harbour projects and the large investment of ESKOM could have reflected the result of the need for such infrastructure because of the remoteness of the large PWV industrial area from the main harbours, but did not really contribute to growth. This finding is thus in line with that of De Long and Summers (1991:449) who justified the exclusion of the transportation investment component because it “reflects differences in the ‘need’ for transportation caused by differences in urbanization and population density”.

Table 6.11 reports the results of the VAR with lag order 1 for the relationship between growth and investment growth.

Table 6.11: Vector autoregression model estimating the effect of investment growth on economic growth, and *vice versa*

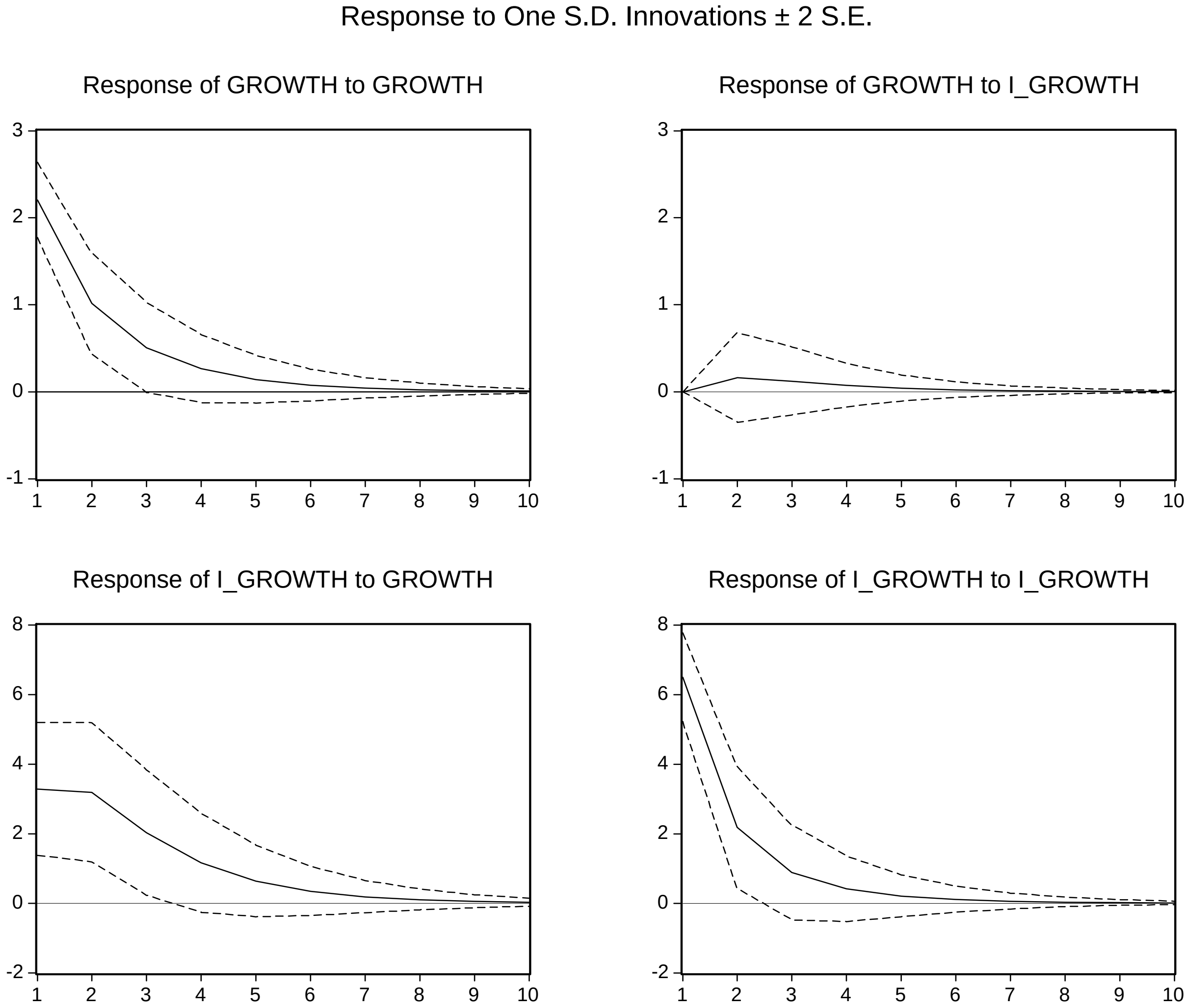
Sample(adjusted): 1948 2000
Included observations: 53 after adjusting endpoints
t-statistics in parentheses

	GROWTH	I_GROWTH
GROWTH(-1)	0.4221 (2.886)	0.9465 (1.958)
I_GROWTH(-1)	0.0247 (0.608)	0.3351 (2.489)
C	1.8747 (3.445)	-0.9210 (-0.512)
R-squared	0.2220	0.2893
Adj R-squared	0.1902	0.2603
Sum sq resides	252.71	2758.7
SE equation	2.2710	7.5033
F-statistic	6.9929	9.9767
Log likelihood	-114.89	-177.03
Akaike IC	4.5342	6.9245
Schwarz IC	4.6468	7.0371

The bidirectional causality is evident from the result with the causality running from economic growth to investment growth containing a statistically significant coefficient on the lagged economic growth variable. In the case of economic growth as a dependent variable, the coefficient on the lagged investment variable is statistically insignificant, but positive.

The strength of the effect is also noticeable from the impulse response functions reported in figure 6.5. According to this result, an innovation in investment growth seems to have a relatively smaller effect on economic growth, than the other way round, namely that stimuli to economic growth will lead to higher investment demand and consequently higher rates of investment.

Figure 6.5: Impulse response functions of economic growth due to innovations in investment growth



The conclusion of this section on investment and economic growth is that the investment to GDP ratio had a negative (-0.05) correlation with growth, while the first difference of this ratio had a positive and impressively stronger (0.31) correlation with growth. Contrary to the findings of Levine and Renelt (1992:959), who used the extreme bounds test and found that the share of capital investment to GDP was the only robust growth variable, this analysis for South Africa shows that the effect of investment variables on economic growth in South Africa was rather disappointing because its influence on growth was statistically insignificant.

However, the reverse influence of growth on investment was statistically significant and positive, in line with the finding of King and Levine (1994:259) who came to a similar conclusion as the one tested in this study and advised that the role of investment and physical capital accumulation in economic growth and development should be revised. They concluded that the modern version of capital fundamentalism describing capital and investment as the primary determinants of economic development and long-run growth should be scaled down. They proposed that the relationship should be viewed as a part of the process of economic development and growth and not as the primary connecting source. The new view should be the guide to research and policy advice.

The findings of the current study and the one quoted above are in line with those of Easterly and Levine (2000:17) who conclude that "... evidence suggests that physical and human capital accumulation do not cause faster growth". A study by Blomstrom, Lipsey and Zejan (1996:275), show that "simple causality tests suggest that growth induces subsequent capital formation more than capital formation induces subsequent growth." Injections of capital do not seem to be the driving force of future growth. Easterly and Levine (2000:4), found evidence which "suggests that creating the conditions for productive capital accumulation is more important than capital accumulation *per se* and that policymakers should focus more on policies that encourage total factor productivity growth". Section 6.4.7, specifically 6.4.7.1 to 6.4.7.5, confirms this finding for South Africa.

6.4.3 Government spending

In this section, different measures of government spending are used: firstly, the ratio of government spending to GDP used by Gwartney *et al* (1998:4), as well as the ratio of government spending less spending on education and defence to the GDP. The second variable is what Barro (1997:26) terms “nonproductive” spending. In both instances, the growth rates in these variables are also analysed (see section 5.2.3 on page 99).

Figure 6.6: Simple scatter graphs of growth versus government spending variables

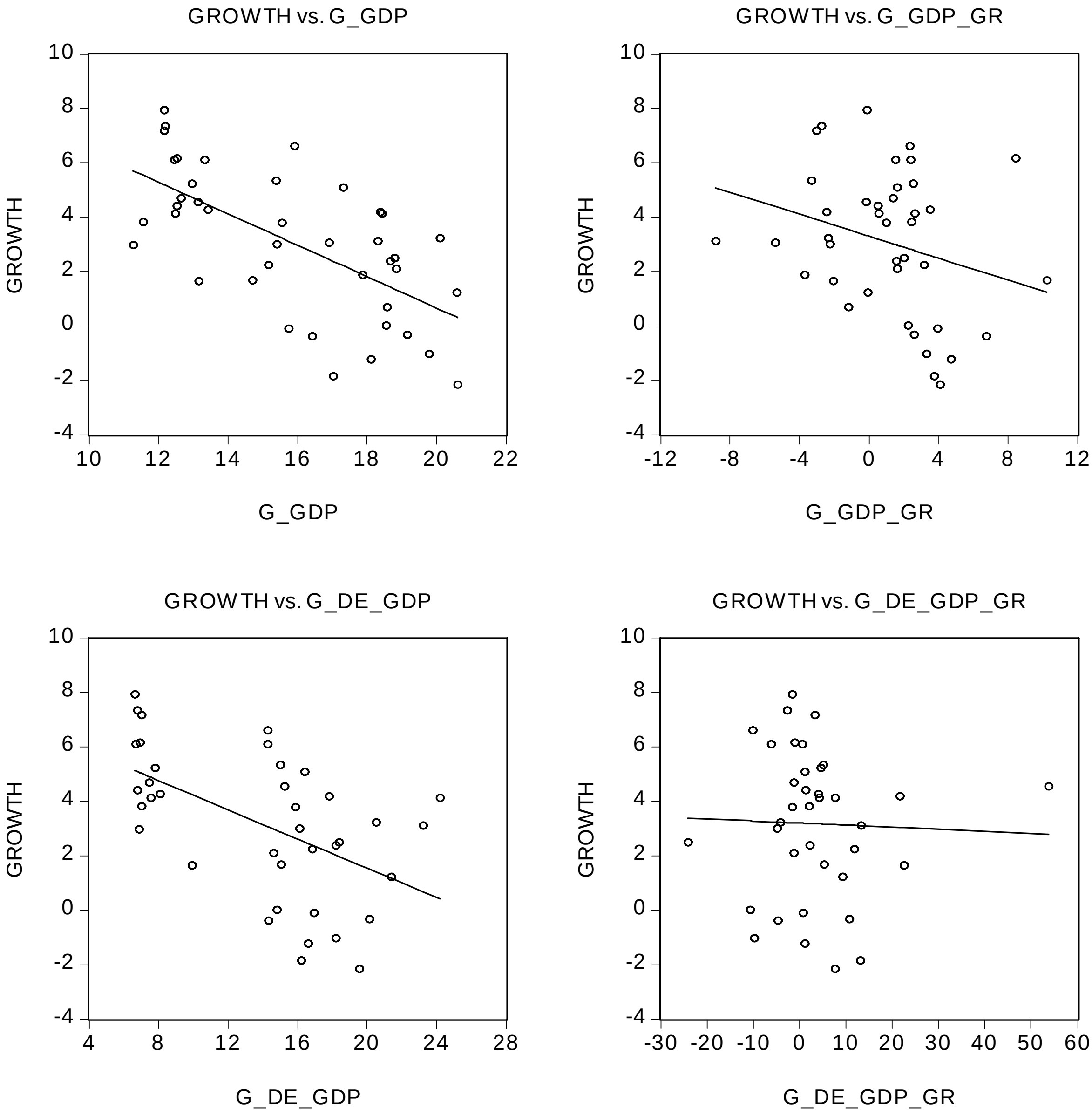


Table 6.12: Correlation matrix for growth, G_GDP G_GDP_GR, G_ED_GDP and G_ED_GDP_GR

	GROWTH	G_GDP	G_GDP_GR	G_ED_GDP	G_ED_GDP_GR
GROWTH	1.000	-0.641	-0.275	-0.535	-0.034
G_GDP	-0.641	1.000	-0.097	0.885	-0.134
G_GDP_GROWTH	-0.275	-0.097	1.000	-0.145	-0.207
G_ED_GDP	-0.535	0.885	-0.145	1.000	0.071
G_ED_GDP_GR	-0.034	-0.134	-0.207	0.071	1.000

In all cases a negative relationship exists between government spending variables and the economic growth rate. The ratios of government spending to GDP are better (although negatively) correlated with growth if compared to the growth rates in these ratios. In order to establish causality, the lag order for each individual series should first be determined. These results are reported in Table 6.13.

Table 6.13: Testing for the lag order of government spending variables

	Lag order	p-value	AIC	SIC
GROWTH	1	0.0005	4.482	4.482
G_GDP	1	0.0000	1.763	1.848
G_GDP_GROW	0	-	-	-
G_ED_GDP	1	0.0000	3.994	4.081
G_ED_GDP_G	0	-	-	-

The results describe p-values on the last lag as well as Akaike and Schwarz selection criteria results for the final model. Two variables, namely G_GDP_GR and G_ED_GDP_GR, do not necessitate the inclusion of any lags to render the series white noise. A lag order of one would therefore be used for analyses of government spending variables. Results of Granger causality tests are provided in table 6.14.

Table 6.14: Testing for Granger causality of government spending variables

Null hypothesis:	Lag order	Obs	F-stat	Probability
G_GDP does not Granger Cause GROWTH	1	40	6.33	0.0163**
GROWTH does not Granger Cause G_GDP			0.79	0.3772
G_GDP_GROWTH does not Granger Cause GROWTH	1	39	0.09	0.7660
GROWTH does not Granger Cause G_GDP_GR			0.97	0.3550
G_ED_GDP does not Granger Cause GROWTH	1	37	4.79	0.0355**
GROWTH does not Granger Cause G_ED_GDP			2.59	0.1167
G_ED_GDP does not Granger Cause GROWTH	1	36	1.08	0.3067
GROWTH does not Granger Cause G_ED_GDP			0.24	0.6269

Note: ***/**/* indicate rejection of the hypothesis at the 1/5/10 per cent level of significance.

For two of the measured variables, the Granger causality tests suggest the causality exists, running from government spending to growth. Thus an increase in government spending, especially nonproductive spending, might lead to a decrease in economic growth. Both the VAR models are presented in tables 6.15 and 6.16. In both cases, using government spending to explain growth, coefficients are negative and statistically significant. Comparing the impulse response functions, presented in figure 6.7, on can deduce that the negative effect of nonproductive spending on growth is higher than that of total government spending. This is also a long-run effect, since after 20 periods the growth level is still below the original long-run path.

Table 6.15: Vector autoregression model estimating the effect of government spending as a ratio of GDP on economic growth and *visa versa*

Sample(adjusted): 1961-2000
Included observations: 40 after adjusting endpoints
t-statistics in parentheses

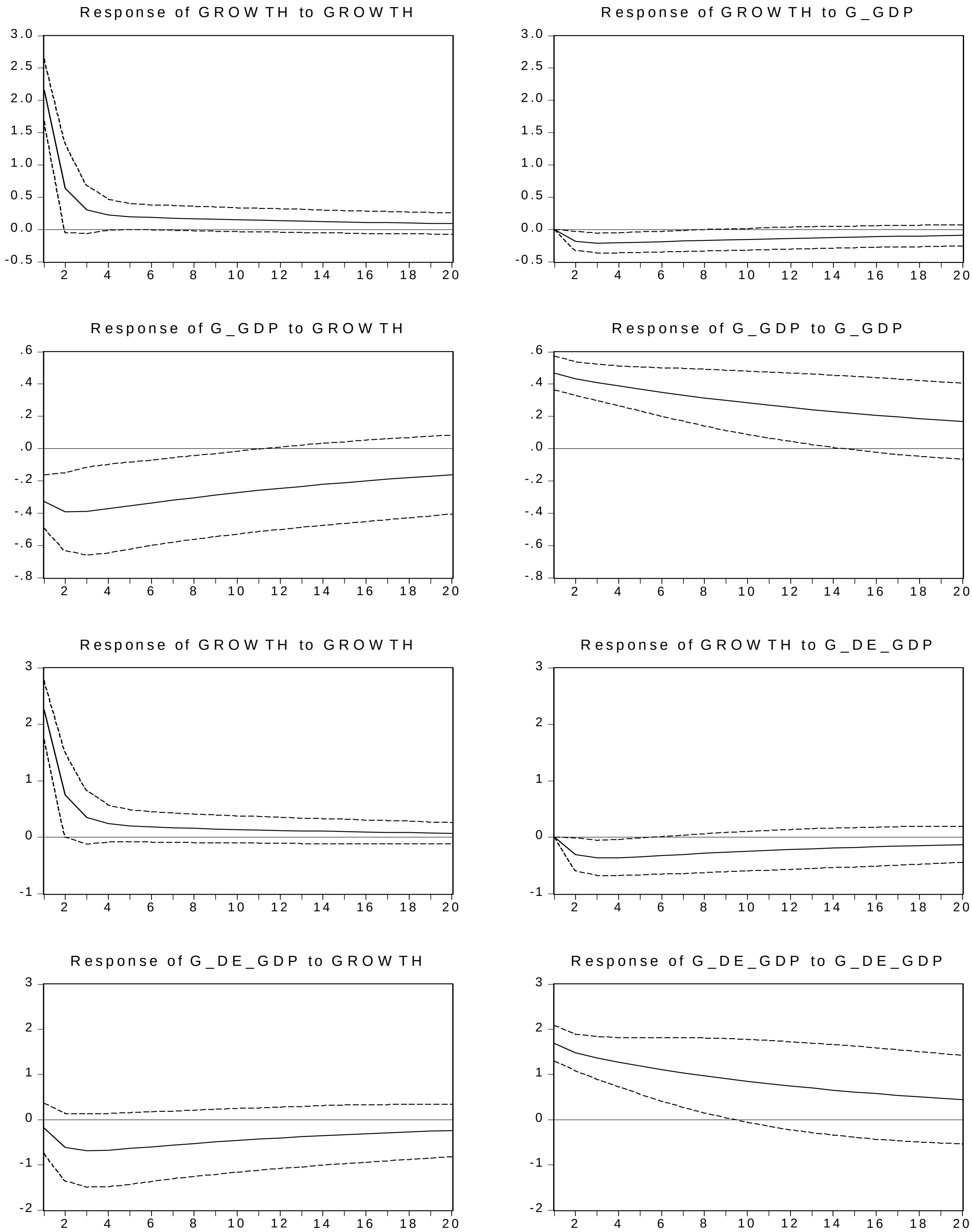
	GROWTH	G_GDP
GROWTH(-1)	0.2367	-0.0403
	(1.390)	(-0.893)
G_GDP(-1)	-0.3871	0.9272
	(-2.516)	(22.71)
C	8.4642	1.4144
	(3.006)	(1.894)
R-squared	0.3699	0.9615
Adj R-squared	0.3359	0.9594
Sum sq resides	172.06	12.103
SE equation	2.1564	0.5719
F-statistic	10.863	462.31
Log likelihood	-85.937	-32.849
Akaike IC	4.4468	1.7924
Schwarz IC	4.5735	1.9191

Table 6.16: Vector autoregression model estimating the effect of government spending, less defence and education spending, as a ratio of GDP on economic growth and *vice versa*

Sample(adjusted): 1961-2000
Included observations: 40 after adjusting endpoints
t-statistics in parentheses

	GROWTH	G_DE_GDP
GROWTH(-1)	0.3180 (1.943)	-0.1987 (-1.609)
G_DE_GDP(-1)	-0.1813 (-2.190)	0.8779 (14.05)
C	4.6704 (3.040)	2.6322 (2.271)
R-squared	0.3509	0.9023
Adj R-squared	0.3127	0.8966
Sum sq resides	172.36	98.050
SE equation	2.2515	1.6981
F-statistic	9.1929	157.11
Log likelihood	-80.966	-70.530
Akaike IC	4.5387	3.9746
Schwarz IC	4.6693	4.1052

Figure 6.7: Impulse response functions of economic growth due to innovations in government spending as a ratio of GDP (G_GDP) and innovations in government spending, excluding spending on defence and education as a ratio of GDP (G_DE_GDP).



6.4.4 The ratios of gross value added in agriculture, mining, manufacturing and the remaining residual (construction, electricity, retail, wholesale, etc) to GDP and its respective relationships with economic growth

The focus of this section is on a group of variables consisting of the ratios of gross value added to GDP. Sachs and Warner (1995:42,43) used the share of agriculture as a percentage of the GDP and also the gross value added of manufacturing as a percentage of GDP. Sala-i-Martin (1997:17) and Hall and Jones (1996:9) used the gross value added of mining as a percentage of GDP in their analyses. This section throws light on the growth empirics of these sector contributions. To complete the analyses, the gross value added of the remaining sectors combined expressed as a percentage of GDP is termed the residual sector in this study (see section 5.2.8 on page 107).

The contribution of the agricultural sector to GDP was the highest in 1947 and 1948 when it was 7.2 percent and the lowest in 1983 when it was only 3.2 per cent. The relative contribution of the sector declined. The average year-on-year growth rate of gross value added for the agricultural sector for the period 1960 to 2000, namely 2.8 per cent, is lower than the average real economic growth rate of 3.4 per cent for the period. This phenomenon may be regarded as an impeding effect on total GDP growth. The contribution of the agricultural sector at constant 1995 prices increased from the initial R6.4 billion in 1946 to over R24 billion in 2000, which is almost a fourfold increase. Table 6.18 shows a simple correlation coefficient of 0.42 between growth and agriculture to GDP ratio.

The growth rate of the agriculture gross value added series shows wide variations over time, ranging between –27 per cent and +30 per cent. These variations are the result of unpredictable weather conditions exacerbated by the wide range of agricultural land, which varies from semi-arid to sub-tropical.

The contribution of the mining industry to GDP increased from just over 13 per cent in the late 1040s to reach its pinnacle of 16.2 per cent in 1962. Thereafter it declined steadily to 8.5 per cent of GDP in 1975. The mining contribution then increased marginally with the freeing of the gold price, making possible the mining of lower grade ore, and also as a result of the exploitation of new minerals such as chrome and platinum. The declining trend nevertheless resumed and the contribution of this sector was at an all-time low of 5.5 per cent of GDP in 2000. These shrinkages of the contribution of the mining sector as a percentage of GDP are an indication of lower growth in the mining sector, which reduced the economic growth stimulus stemming from this sector – the average year-on-year growth for the mining sector was only 0.6 per cent for the period 1960 to 2000 (see section 5.2.10 on page 108).

The contributions of mining to GDP in constant prices are more stable than the current price contributions because wide swings in the price of gold increased the current price contribution between 1970 and 1990. The gold price soared from $35 an ounce in 1970 to reach its highest ever level of $613 (average) in 1980. Thereafter it dwindled to below $300 in 1998, and further to below $280 in 2000. The ratio of mining to GDP (constant prices) is positively correlated to economic growth with a coefficient of 0.58 (table 6.18).

The share of manufacturing to GDP rose steadily over the decades from about 10 per cent in the 1940s to its highest contribution of 21.3 per cent in 1981, where after it stabilised on just over 20 per cent for the whole of the 1980s. In the 1990s it declined steadily to just over 18 per cent by 2000 (see section 5.2.11 on page 108).

The figures on the manufacturing to GDP ratio against the growth of the economy shows that as the contribution to GDP from the manufacturing sector increased, the growth in real GDP remained around an average of about 4 per cent per annum. The real GDP growth rate decreased to about 2 per cent or half of its former average when manufacturing growth declined, causing the manufacturing sector contribution to stabilise at first, and subsequently to decline. Figure 6.8 depicts the two growth rates (manufacturing and GDP) over time and shows a remarkable tandem movement. The simple correlation coefficient of this variable to GDP is a high 0.86 as reported in table 6.18.

The graph depicting the contribution of the residual group to GDP and growth show an almost perfect mirror image. When this ratio declined between the 1940s and the 1960s, the GDP growth rate increased, and when this ratio rose from the late 1960s to the present, the GDP growth rate recorded a declining trend.

The figure representing the growth of GDP and the growth of the residual group reveals a remarkable similarity, which is partly the result of the large share of this group in total GDP. The correlation coefficient (0.98) between the GDP growth rate and the residual series growth rate is high, while the correlation between the share of the residual group and the GDP growth rate is negative at -0.51, implying that the growth rate declines with an increasing share of the residual group.

Table 6.17 confirms that the agriculture and mining sectors, on average, grew at a slower rate than the total economy, while the manufacturing and service sectors grew at a faster rate. As such, these are therefore important variables in determining the growth rate of the country.

Table 6.17: Average growth rates and spread of growth for agriculture, mining, manufacturing and residual sectors, 1960 to 2000

GROWTH	Agriculture	Mining	Manufacturing	Residual	Total economy
Mean	2.8	0.6	4.1	3.2	3.1
Maximum	30.4	7.9	15.8	6.9	7.9
Minimum	-27.3	-7.9	-5.2	-1.2	-2.1

Figure 6.8: Main sector contributions to GDP and main sectoral growth rates and its respective relationships to economic growth

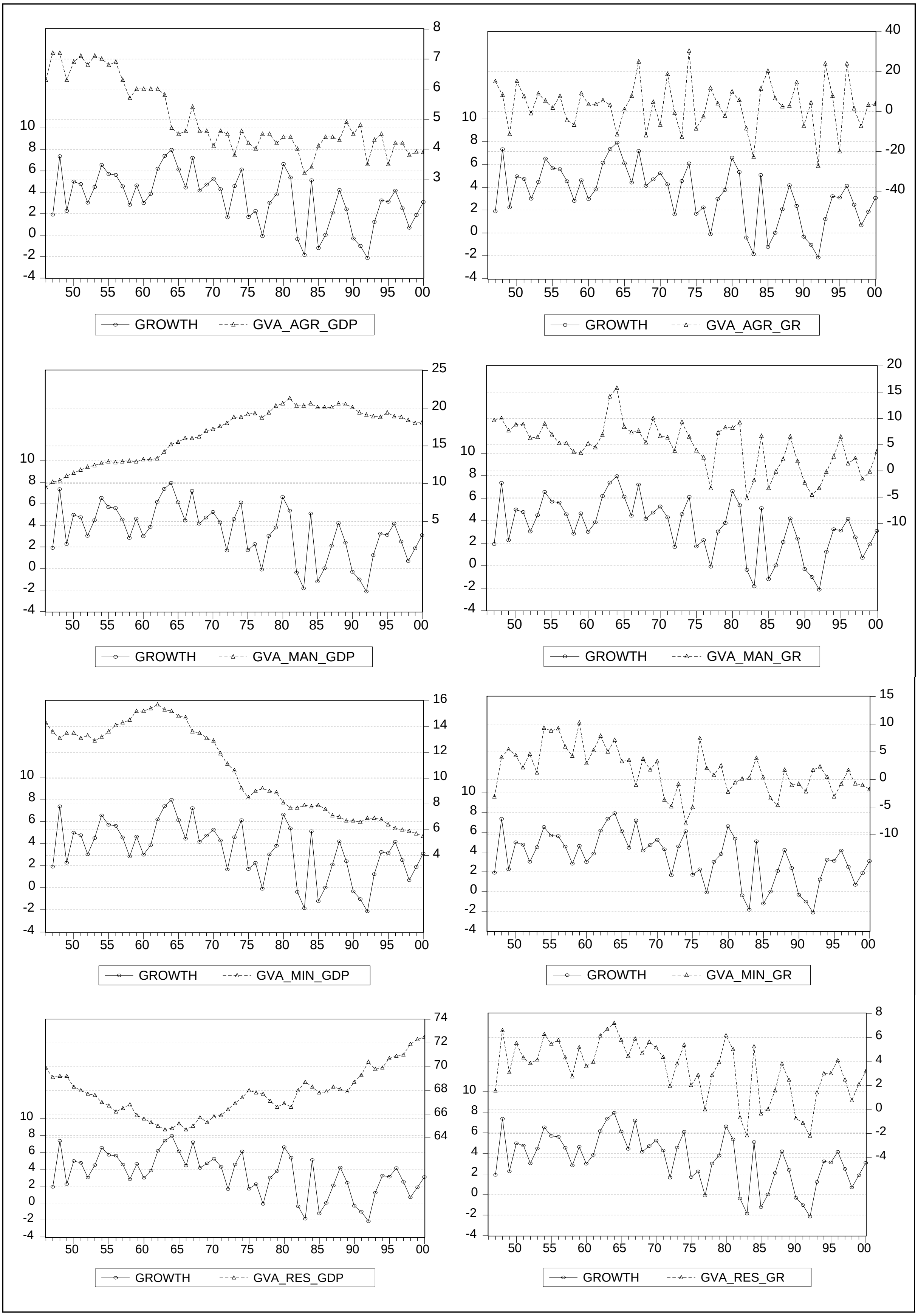


Table 6.18: Simple correlation coefficients for the contributions to GDP and growth rates of agriculture, mining, manufacturing and the residual sector and economic growth, 1946 to 2000

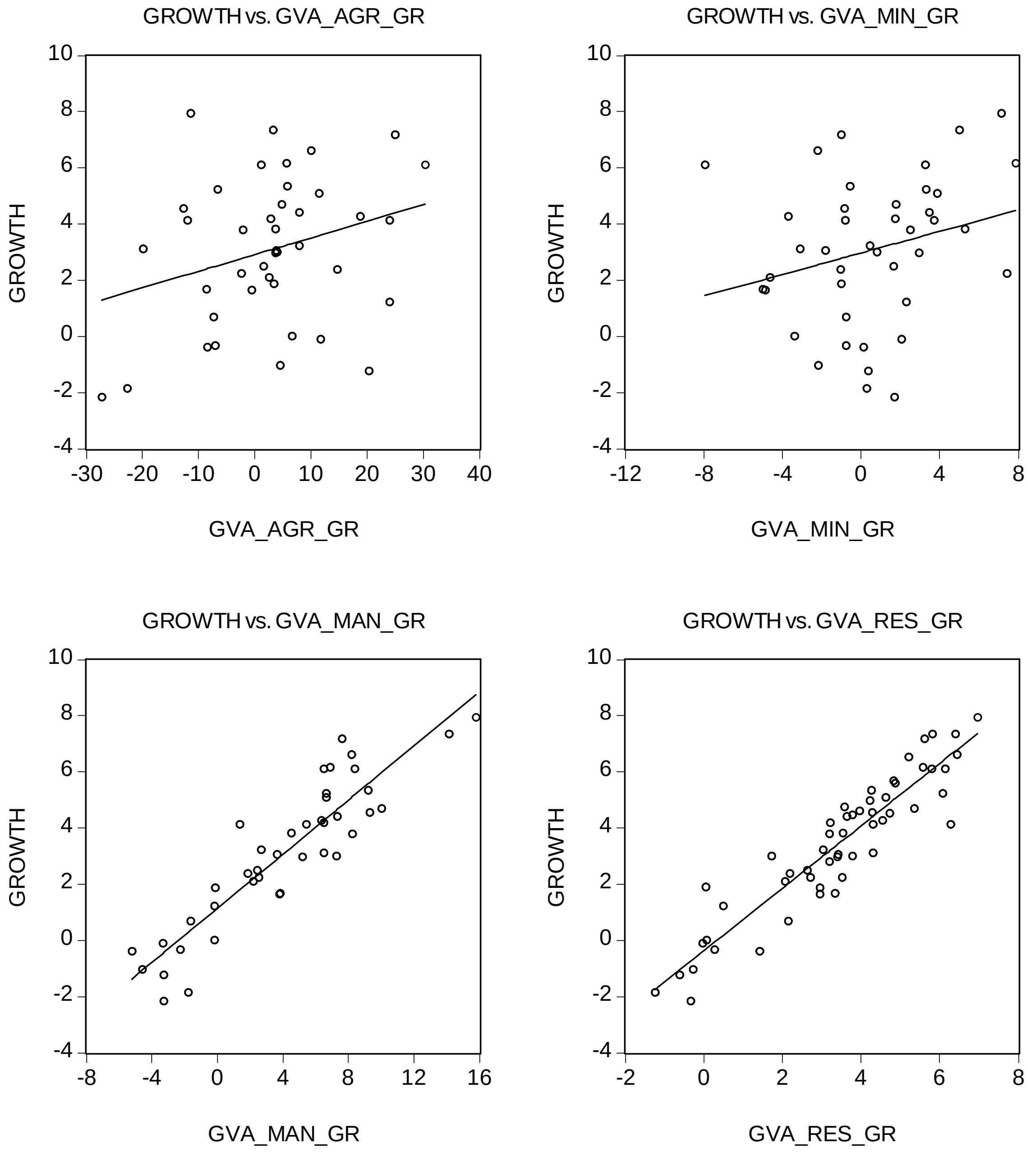
Variable	Correlation coefficient
GVA_AGR_GDP	0.424
GVA_MIN_GDP	0.576
GVA_MAN_GDP	-0.435
GVA_RES_GDP	-0.513
GVA_AGR_GROWTH	0.299
GVA_MIN_GROWTH	0.368
GVA_MAN_GROWTH	0.861
GVA_RES_GROWTH	0.983

The simple correlation coefficients for the growth rates of the agriculture and mining sectors are lower than for their shares in GDP respectively. For the manufacturing and service (residual) sectors, the correlations to growth for the growth rates of the sectors are more pronounced than for their shares in GDP. The shares to GDP of the latter sectors show negative correlations to growth, the result of a substantial increase in both of these sectors' contributions to GDP, while the long-run growth trend is rather flat to slightly negative, as indicated in figure 6.8. The data clustering in figure 6.9 confirms these observations.

The simple correlation coefficient of the residual sector ratio to GDP growth is - 0.51 indicating that if the sector increases relative to other sectors, the economic growth rate can be expected to decline. Because of the size of this sector it is not surprising that the correlation of its growth to economic growth was remarkably high at 0.98, which is indicated by the scatter graph in which the individual points are concentrated around the fitted line.

Since only the growth rates of the gross value added series are stationary and the gross value added expressed as a percentage of GDP are not, only the first mentioned variables will be analysed further, applying econometric tools applicable to stationary time series.

Figure 6.9: Simple scatter graphs of growth in different sectors and real economic growth rate



In the case of the manufacturing sector and the tertiary sectors, the growth rates shows closer correlations to growth, indicating the importance of the size of these sectors in a more mature economy.

The next section addresses the lines of causality between this group of variables and growth, firstly determining the proper lag order for this set of variables.

Table 6.19: Testing for the lag order of gross value added variables

	Lag order	p-value	AIC	SIC
GROWTH	1	0.0005	4.482	4.482
GVA_AGR_GR	2	0.0150	2.816	7.944
GVA_MIN_GR	1	0.0072	5.249	5.333
GVA_MAN_GR	1	0.0005	5.800	5.800
GVA_RES_GR	1	0.0001	4.012	4.087

The table gives p-values on the last lag as well as Akaike and Schwarz selection criteria results for the final model. The lag orders are subsequently used in Granger causality tests. These results are provided in Table 6.20.

Table 6.20: Pairwise Granger causality tests for gross value added growth rates in different sectors of the economy and economic growth, 1960 to 2000

Null hypothesis:	Lag order	Obs	F-stat	Probability
GVA_AGR_GR does not Granger Cause GROWTH	2	39	2.43	0.1029
GROWTH does not Granger Cause GVA_AGR_GR			1.01	0.3744
GVA_MIN_GR does not Granger Cause GROWTH	1	40	1.68	0.2022
GROWTH does not Granger Cause GVA_MIN_GR			0.00	0.9527
GVA_MAN_GR does not Granger Cause GROWTH	1	40	7.52	0.0094***
GROWTH does not Granger Cause GVA_MAN_GR			0.00	0.9740
GVA_RES_GR does not Granger Cause GROWTH	1	40	0.73	0.3984
GROWTH does not Granger Cause GVA_RES_GR			4.89	0.0315**

Note: ***/**/* indicate rejection of the hypothesis at the 1/5/10 per cent level of significance.

The most important sector for growth seems to be the manufacturing sector, firstly because it displays direct and highly significant Granger causality from manufacturing sector growth to economic growth. Stimulation of growth in this sector would therefore have job creation spin-offs in the rest of the economy as well. The growth in this sector could be further enhanced if growth in manufacturing exports could also be stimulated. The effect of manufacturing export growth on economic growth is illustrated by the fast-growing East Asian economies and China.

However, a reverse causality seems to exist between growth in the service sectors and economic growth in general. A significant reason for this could be the large share of public corporations or state institutions that are included in the services sector, such as rail transport and harbours, post and telecommunications, which are virtually state monopolies and therefore in most cases lack the pressure of competition. This is compounded by the notorious difficulty of measuring productivity in service sectors, and if productivity is not measured, there is no way of showing that it is high or low or improving or deteriorating. Although some of the public corporations have been privatised, the largest part of their data reflects the performance of their previous status as public institutions.

To further investigate the dynamics of the system, the vector autoregression (VAR) model for the manufacturing sector is estimated. Table 6.21 reports the results of the VAR with lag order 1 for the relationship between growth and the growth in gross value added in the manufacturing sector. What is important is the first column of results with growth as dependent variable. The coefficient for manufacturing is significant and carries the correct sign.

Table 6.21: Vector autoregression model estimating the effect of growth in the manufacturing sector on real economic growth

Sample(adjusted): 1961-2000
Included observations: 40 after adjusting endpoints
t-statistics in parentheses

	GROWTH	GVA_MAN_GROWTH
GROWTH(-1)	-0.2527	0.0205
	(-1.822)	(0.032)
GVA_MAN_GROWTH(-1)	0.4472	0.5151
	(2.741)	(1.544)
C	2.0552	1.8527
	(3.687)	(1.625)
R-squared	0.3867	0.2760
Adj R-squared	0.3535	0.2369
Sum sq resides	167.48	700.38
SE equation	2.1275	4.3507
F-statistic	11.666	7.0551
Log likelihood	-85.398	-114.01
Akaike IC	4.4199	5.8506
Schwarz IC	4.5465	5.9772

Statistical significance exists to support the theoretical positive impact of growth in the manufacturing sector on the economic growth rate. The strength of the causality is further investigated with the Sims variance decomposition test. Table 6.22 contains the results from this analysis for a 10-year period for manufacturing growth.

Table 6.22: Variance decomposition of growth due to innovations in growth in the manufacturing sector

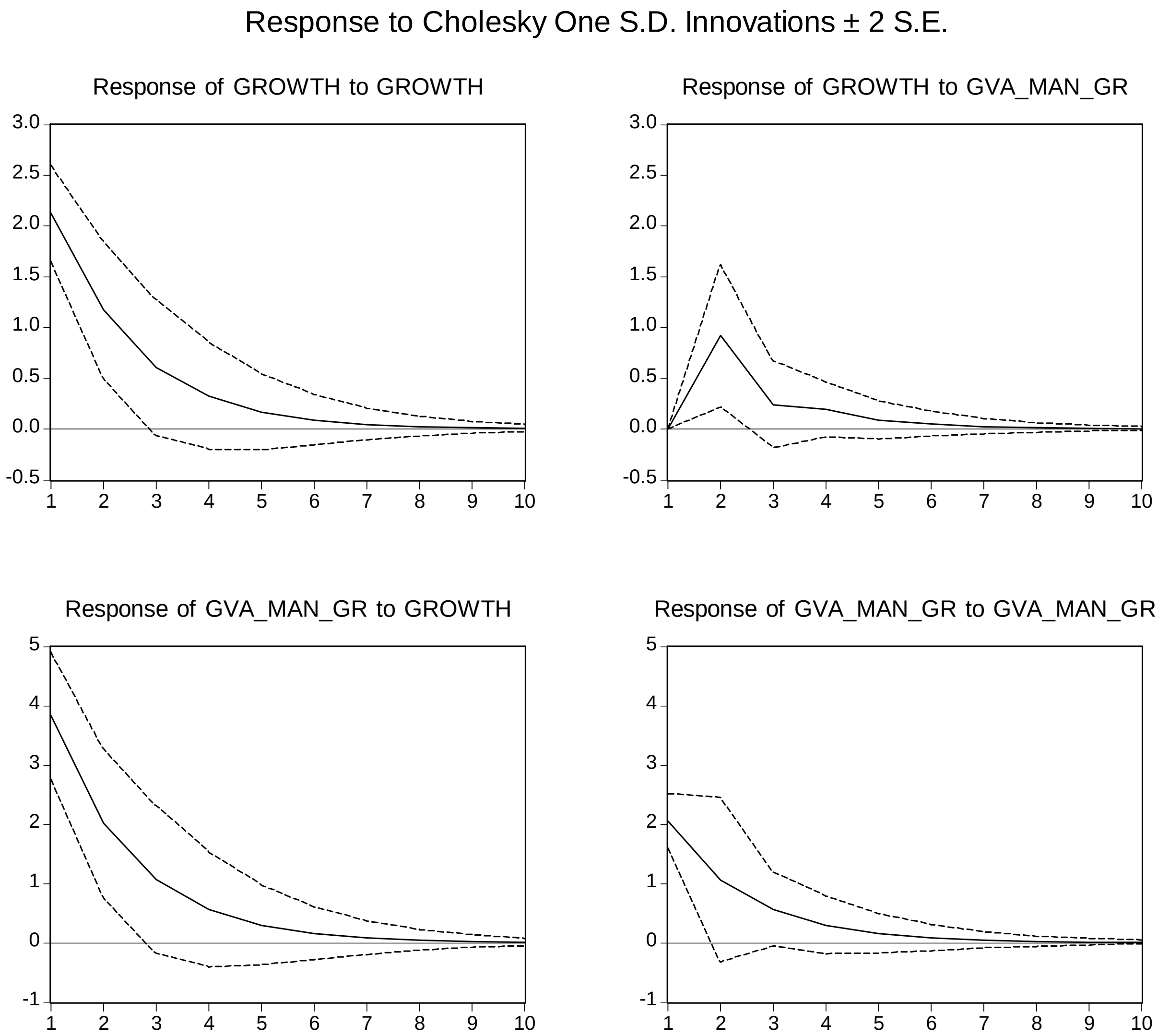
Period	SE	GROWTH	GVA_MAN_GROWT
1	2.127	100.000	0.0000
2	2.599	87.499	12.500
3	2.679	87.429	12.570
4	2.706	87.170	12.829
5	2.712	87.137	12.862
6	2.714	87.123	12.876
7	2.715	87.120	12.879
8	2.715	87.119	12.880
9	2.715	87.119	12.880
10	2.715	87.118	12.881

For the period under consideration, innovations in manufacturing growth explain a relatively small portion, but with a stable long-run significance (up to 12.9 per cent), of the forecast error variance of the economic growth rate directly, and thus support the results obtained from Granger causality tests.

Finally, impulse response functions for the two-variable system are examined in order to throw light upon the dynamics of the relationship. Impulse responses summarise the short-run and long-run effects of various shocks to the system and are depicted in figure 6.10.

The first of the four graphs proves that economic growth is responsive to shocks to itself, while in the second graph, increases in the growth in the manufacturing sector serve as a stimulus for higher growth. This positive impact is sustained and convergence back to the long-run growth level takes place seven to eight years after innovations in manufacturing growth. Of particular significance is that manufacturing growth feeds on it self while simultaneously contributing to long-term economic growth. The last-mentioned feedback effect is confirmed by the fourth graph of the series.

Figure 6.10: Impulse response functions of economic growth due to innovations in manufacturing growth



The same analysis for agricultural and mining indicates a relatively small positive response in economic growth due to innovations in growth in these sectors. Policy should therefore be directed towards developing manufacturing in general for local as well as global consumption and service sectors such as trade and transport. The privatisation of state monopolies in electricity, transport and communication sectors should be expedited, in the process guaranteeing that competition, especially foreign competition, is ensured. Export promotion could facilitate this and has indeed been emphasised in the analysis of the openness of the economy, as indicated in section 6.4.1.

6.4.5 Crime

Crime incidents in South Africa escalated from the late 1980s into the 1990s with a slight respite during 1996 to 1997. The increases resumed after 1997. Both the crime index and the growth rate in crime are as logic anticipates, that is, negatively correlated to economic growth. Figure 6.11 depicts the economic growth rate, the crime index and the percentage growth in crime (see section 5.2.9 on page 108).

The simple correlation coefficient of -0.06 for crime incidents levels is rather weak. A substantially higher negative correlation between the crime growth rate and economic growth of -0.47 is shown in table 6.23. This is also evident from figure 6.12. The public and media opinion that the increase in crime has negative effects on sentiment in general, and investor confidence, the fact that crime is also responsible for the so-called “brain-drain”, and ultimately, stunts economic growth, seems to be confirmed by this test.

Figure 6.11: Economic growth, crime index and the growth rate in crime incidents

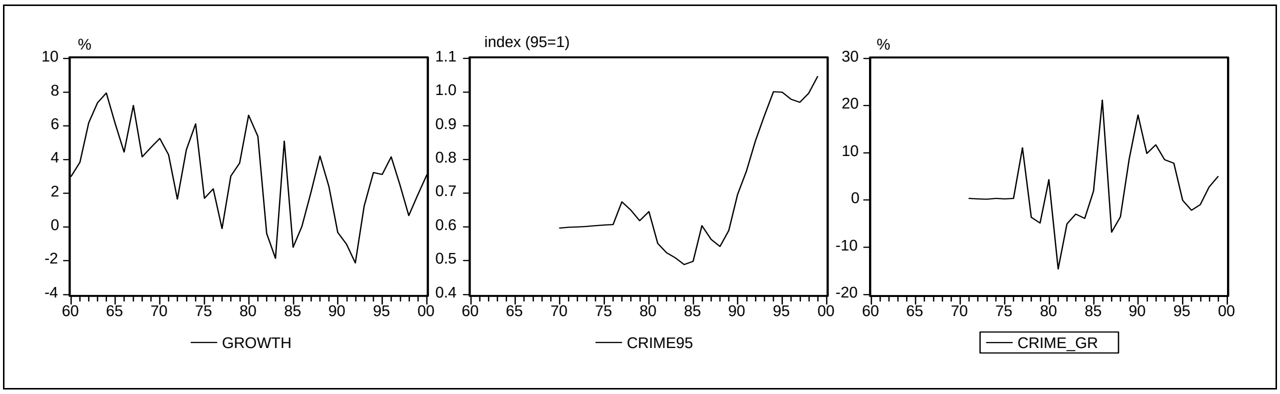
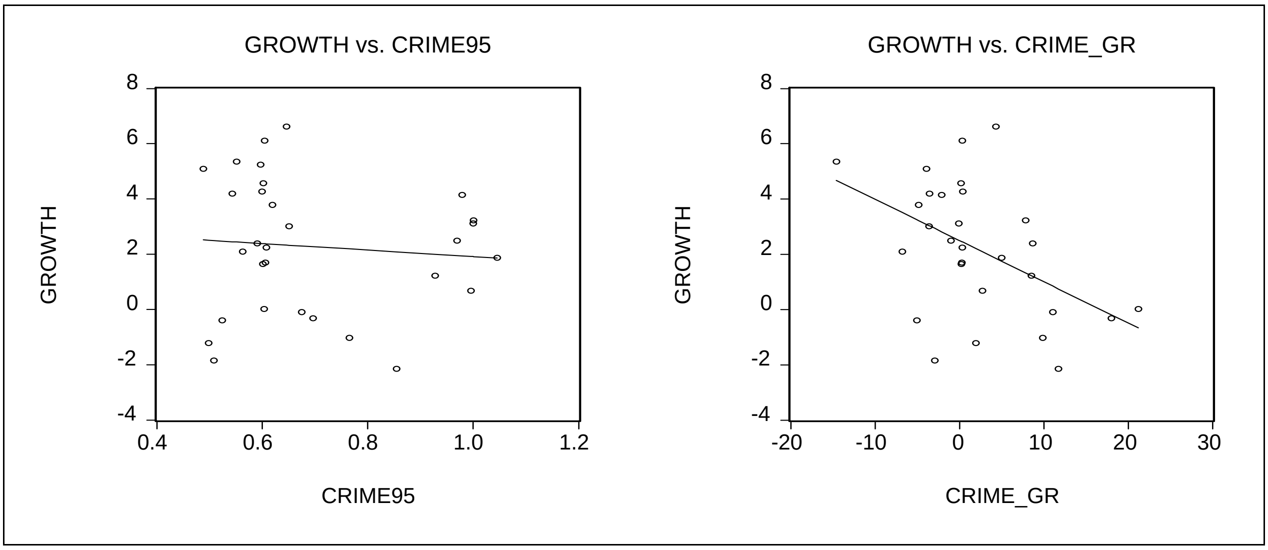


Table 6.23: Correlation matrix for growth, crime incidents and growth in crime incidents

	GROWTH	CRIME95	CRIME_GR
GROWTH	1.000000	-0.064497	-0.473544
CRIME95	-0.064497	1.000000	0.277744
CRIME_GROWTH	-0.473544	0.277744	1.000000

Figure 6.12: Simple scatter graphs of growth verses crime variables



The question of causality and the direction thereof is investigated in this section. The proper lag length is selected with the aid of an AR model on individual series. The proper lag order in this case is 1, since specifying an AR model for growth rendered only one lag significant. This is also the case for CRIME95, while for CRIME_GR no lags are needed to ensure that the series is white noise. The data series from 1960 to 2000 were used. Results for pairwise Granger causality tests are provided in table 6.24.

Table 6.24: Pairwise Granger causality tests for crime, 1960 to 1999

Null Hypothesis:	Lag order	Obs	F-stat	Probability
CRIME95 does not Granger Cause GROWTH	1	29	0.24	0.6258
GROWTH does not Granger Cause CRIME95			5.64	0.0251**
CRIME_GR does not Granger Cause GROWTH	1	28	0.02	0.8958
GROWTH does not Granger Cause CRIME_GR			2.64	0.1175

Note: ***/**/* indicate rejection of the hypothesis at the 1/5/10 per cent level of significance.

According to table 6.24, there is no evidence to suggest that crime Granger causes a lack of growth. The opposite seems to hold true, namely that a lack of growth and the concomitant absolute and relative poverty levels are conducive to criminal activities.

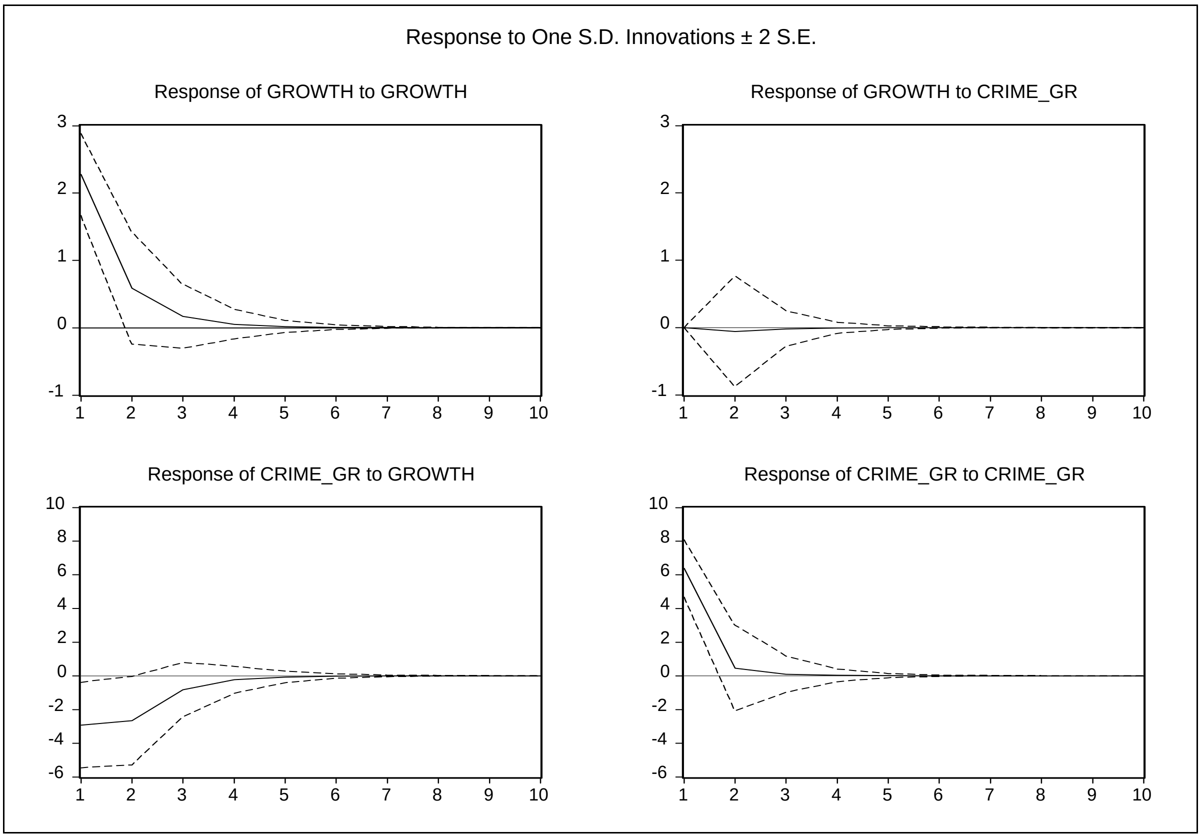
Based on the VAR model with lag order 1 for the relationship between growth and the growth rate in crime incidents, innovations in crime serve to directly explain a very small portion of decline in the economic growth rate. We know, however, that it impacts negatively on variables such as investor confidence and is in itself a difficult concept to measure, but can be sensed indirectly from variables such as gross capital formation, direct foreign investment, and the like. Unfortunately, political issues such as sanctions and disinvestments are also reflected in the time trend of capital formation, making it difficult to isolate the effect of crime on variables such as capital formation and economic growth.

Table 6.25: Variance decomposition of growth due to innovations in crime

Period	SE	GROWTH	CRIME_GR
1	2.273	100.000	0.000
2	2.348	99.940	0.059
3	2.355	99.934	0.065
4	2.355	99.933	0.066
5	2.355	99.933	0.066
6	2.355	99.933	0.066
7	2.355	99.933	0.066
8	2.355	99.933	0.066
9	2.355	99.933	0.066
10	2.355	99.933	0.066

Impulse response functions for the two-variable system demonstrate the dynamics of the relationship. Impulse responses summarise the short-run and long-run effects of various shocks to the system and are displayed in figure 6.13.

Figure 6.13: Impulse response functions of economic growth due to innovations in crime incidents



The first of the four graphs proves that economic growth is responsive to shocks to itself, while in the second graph, increases in the growth rate of crime incidents serve as a negative shock to higher growth. This negative impact, however, dies out quite quickly – convergence back to the long-run growth level takes place after only about four periods. This may be good news in the sense that an improvement in the safety and security setup may soon lead to a situation that is more conducive to economic growth.

6.4.6 Capital stock

In this section, the two state (or stock) variables referred to in empirical growth analysis, namely measures of physical capital and human capital stock, are analysed.

As a measure of physical capital stock, we analysed the growth in real capital stock taken from the national accounts (CAP_GR). This yielded a positive correlation with economic growth of 0.49.

Theoretically speaking, the measurement of human capital should cover the range of investments made in formal and informal education, on-the-job training and health. Proxies for these include enrolment rates, adult literacy rates and health indicators. The trend has been to develop education stock estimates based on the mean school years of education per working person in the economy. Continuous time series data of this nature, however, are not readily available for South Africa.

One quantitative measure that was examined was the number of matric enrolments as a percentage of the total population (ED10_POP_GR). Government spending on education represents a qualitative measure. Two variables were employed, namely government spending on education (G_ED) and government spending on education measured as a percentage of total government spending (G_ED_PERC) (see section 5.2.13-16 on pp111-114).

It is evident from figure 6.14 that there seems to be a positive relationship between economic growth and measures of growth in physical as well as human capital stock. The correlation between growth and growth in physical capital stock, however, is stronger than between growth and human capital stock, using the measures for human capital stock as described above. Table 6.31 which contains simple correlation coefficients, confirms this, with positive correlations only ranging from 0.07 to 0.16 between human capital variables and economic growth, while the correlation between growth in physical capital stock and economic growth is 0.49.

Figure 6.14: Simple scatter graphs of growth versus capital stock variables

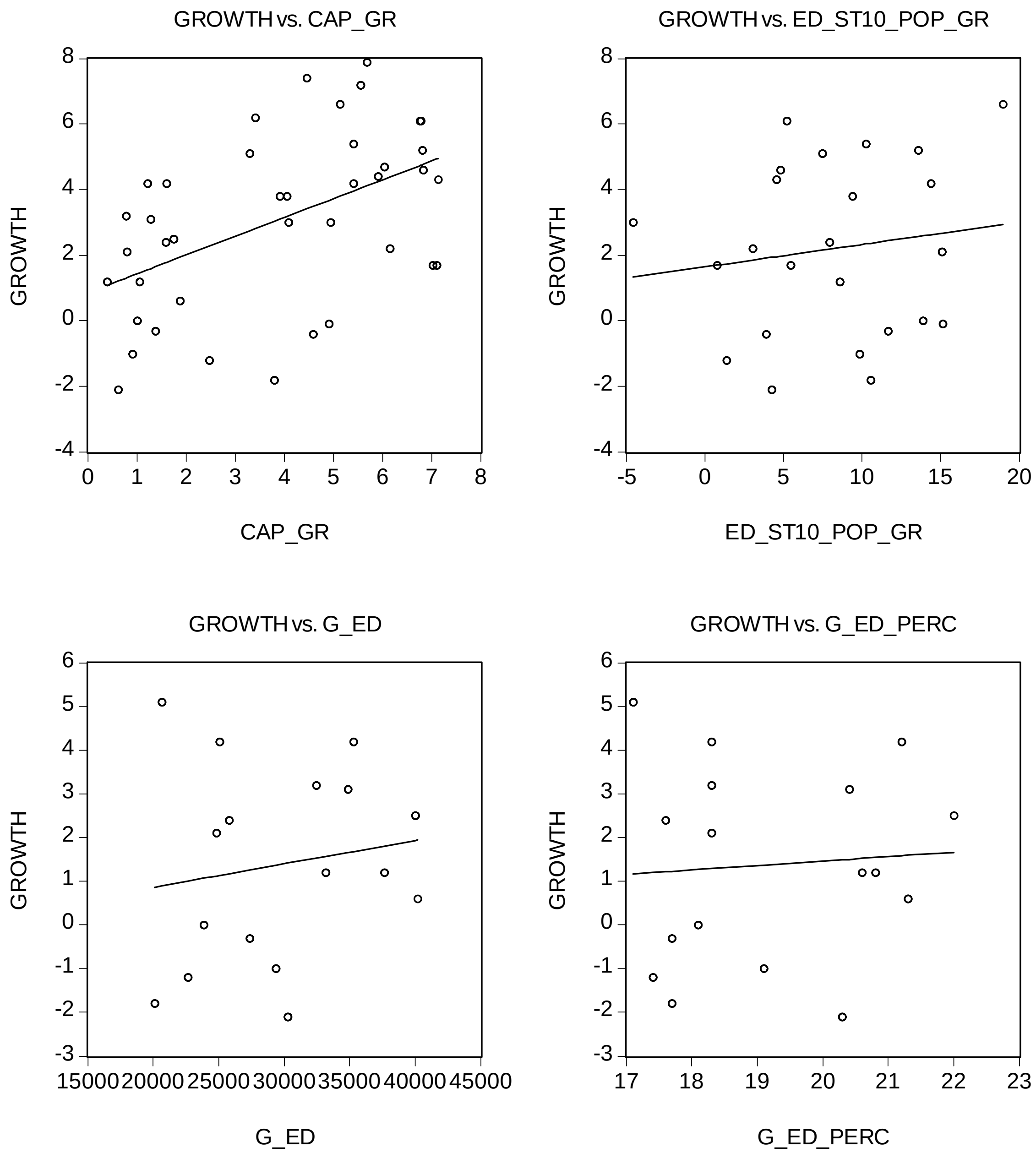


Table 6.26: Correlation matrix for GROWTH, CAP_GR, ED_ST10_POP_GR, G_ED and G_ED_PERC

	GROWTH	CAP_GR	ED_ST10_POP_GR	G_ED	G_ED_PERC
GROWTH	1.000	0.493	0.143	0.157	0.074
CAP_GROWTH	0.493	1.000	-0.277	-0.429	-0.366
ED_ST10_POP_GR	0.143	-0.277	1.000	-0.075	-0.090
G_ED	0.157	-0.429	-0.075	1.000	0.905
G_ED_PERC	0.074	-0.366	-0.090	0.905	1.000

The question of causality, and the direction thereof, is answered by a test for Granger causality. The first step in establishing causality would be to select the proper lag order for each series. The results are reported in table 6.27. The sample period varies, from 1960 to 2000 for CAP_GR and ED_ST10_POP_GR to only 1983 to 2000 for G_ED and G_ED_PERC.

Table 6.27: Testing for the lag order of physical and human capital stock variables

	Lag order	p-value	AIC	SIC
GROWTH	1	0.0005	4.482	4.482
CAP_GROWTH	3	0.0028	1.696	1.870
ED_ST10_POP	3	0.0803	5.722	6.531
G_ED	1	0.0000	17.685	17.783
G_ED_PERC	1	0.0002	2.286	3.084

Results describe p-values on the last lag as well as Akaike and Schwarz selection criteria results for the final model. The lag orders are subsequently used in Granger causality tests. The results are provided in table 6.28.

Table 6.28: Pairwise Granger causality tests for human and physical capital stock and economic growth, 1960 to 2000

Null hypothesis:	Lag order	Obs	F-stat	Probability
CAP_GR does not Granger Cause GROWTH	3	37	2.69	0.0636*
GROWTH does not Granger Cause CAP_GR			2.91	0.0506*
ED_ST10_POP_GR does not Granger Cause GROWTH	3	37	2.66	0.0719*
GROWTH does not Granger Cause ED_ST10_POP_GR			0.88	0.4612
G_ED does not Granger Cause GROWTH	1	16	0.66	0.8856
GROWTH does not Granger Cause G_ED			0.02	0.4288
G_ED_PERC does not Granger Cause GROWTH	1	16	0.39	0.5427
GROWTH does not Granger Cause G_ED_PERC			0.01	0.9301

Note: ***/**/* indicate rejection of the hypothesis at the 1/5/10 per cent level of significance.

The Granger causality tests suggest that a bidirectional causality exists between growth in capital stock and economic growth. This result is in line with the results obtained for growth in fixed investment and economic growth. The same holds true for the quantitative proxy for human capital. For the two proxies for qualitative measures of human capital, we fail to establish causality, possibly because of the very low correlation between these series and economic growth.

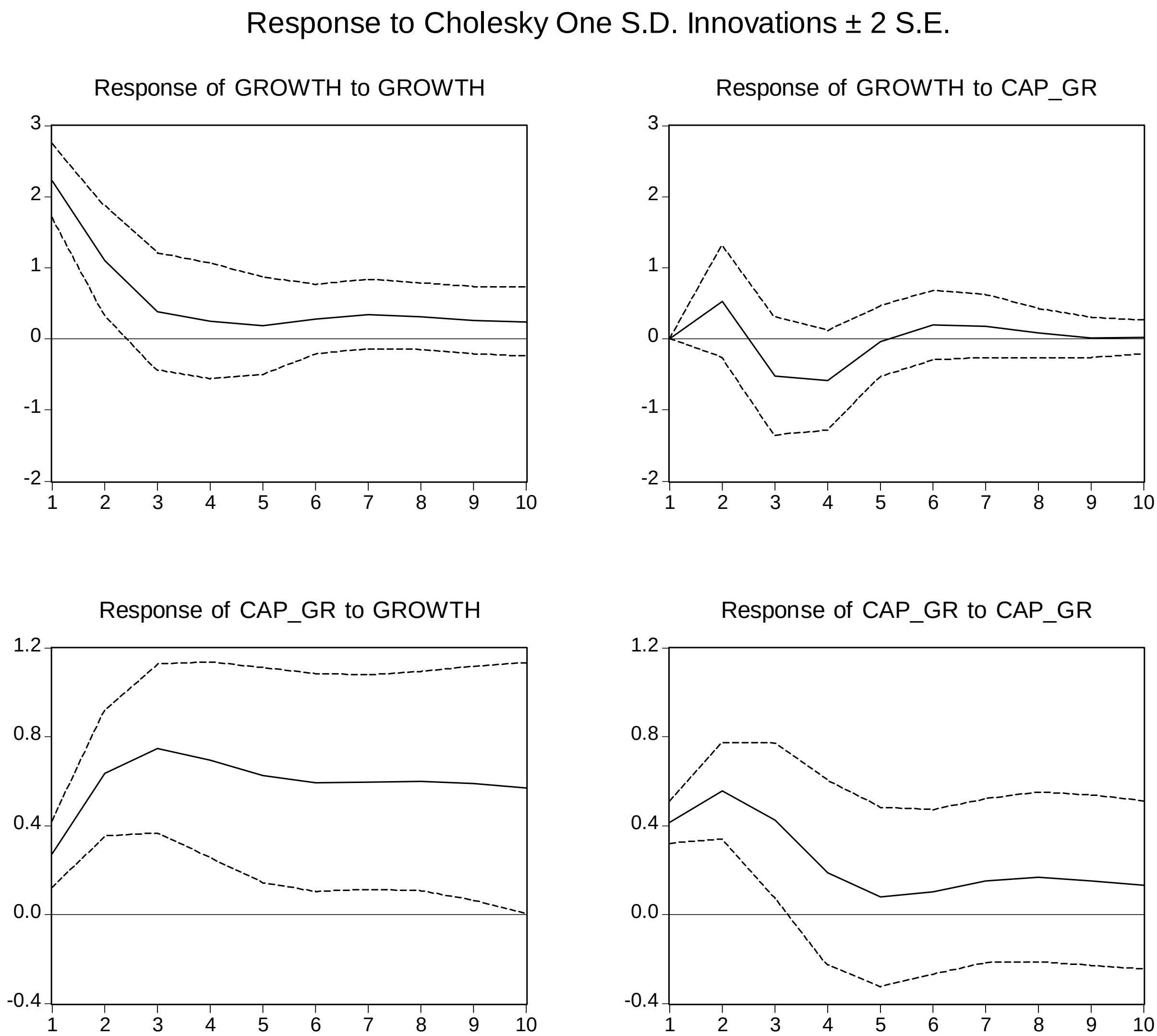
To further investigate the dynamics of the system, the vector autoregression (VAR) model is estimated for the growth in physical capital stock and economic growth. Table 6.29 reports the results of the VAR with lag order 3. As is often the case with a VAR with lag order higher than 1, one of the coefficients of the lagged explanatory variable has a negative sign. The coefficient of the second and third lags of growth in capital stock is significant. The statistical insignificance of the first lag may be explained by the time lag necessary between the outlay for the acquirement of new capital equipment and the positive contribution to economic growth.

Table 6.29: Pairwise Granger causality tests for human and physical capital stock and economic growth, 1960 to 2000

Sample(adjusted): 1963-2000 Included observations: 38 after adjusting endpoints t-statistics in parentheses		
	GROWTH	CAP_GR
GROWTH(-1)	0.3417 (1.693)	0.1207 (2.688)
GROWTH(-2)	0.0564 (0.257)	0.0071 (0.146)
GROWTH(-3)	0.2945 (1.469)	0.0450 (1.008)
CAP_GR(-1)	1.2604 (1.331)	1.3438 (6.379)
CAP_GR(-2)	-3.3826 (-2.402)	-0.9375 (-2.992)
CAP_GR(-3)	2.2088 (2.780)	0.4867 (2.752)
C	0.3172 (0.373)	-0.2044 (-1.080)
R-squared	0.4356	0.9633
Adj R-squared	0.3228	0.9560
Sum sq resides	148.79	7.3712
SE equation	2.2270	0.4956
F-statistic	3.8601	131.51
Log likelihood	-78.246	-22.653
Akaike IC	4.6079	1.6029
Schwarz IC	4.9126	1.9076

Statistical significance exists to support the overall theoretical positive impact of the growth in capital stock on the economic growth rate. This is evident from the impulse response functions depicted in figure 6.15. The initial effect of a positive innovation in capital stock on economic growth is positive, followed by a slight negative effect, which turns into a positive effect again by period 5. This positive effect lasts until period 9 or 10, after which the system returns to its original long-run growth level.

Figure 6.15: Impulse response functions of economic growth due to innovations in growth in physical capital stock



6.4.7 Productivity

To augment the variables on human capital, a number of productivity variables were tested, which will simultaneously also serve to indicate the role that technology played in the past growth performance of South Africa.

Various authors have referred to the importance of the contribution of productivity growth to economic growth, notably Solow (1957) who referred to it as the "measure of our ignorance". This later became known as the Solow residual. Denison (1962) used this theoretical model to establish his growth accounting techniques, which he used in his well-known book *Why growth rates differ* (Denison 1967:9, 282, 233), to apportion economic growth to various sources like "contribution of inputs", "advances in knowledge" such as education, "economies of scale" and "output per unit of input" (productivity).

In this section, the relationships of various productivity measures to growth are examined. Productivity growth measures include capital productivity, labour productivity and multifactor productivity. Unit labour cost represents a measure for competitiveness. Sectoral analyses cover the agricultural, mining and manufacturing sectors, as well as the so-called "private economy" - the most aggregate productivity measure (GDP by kind of economic activity less community, social and personal services, where the latter include government services). More in-depth sectoral analysis includes the following: labour and multifactor productivity in the manufacturing sector, capital and multifactor productivity in the mining sector and unit labour costs for the manufacturing sector.

Figure 6.16 contains a graphical representation of economic growth *vis*-à-*vis* a wide spectrum of productivity growth rates (see section 5.2.21 on page 120).

Figure 6.16: Graphical representation of economic growth against growth rates of productivity and unit labour costs, 1960-2000

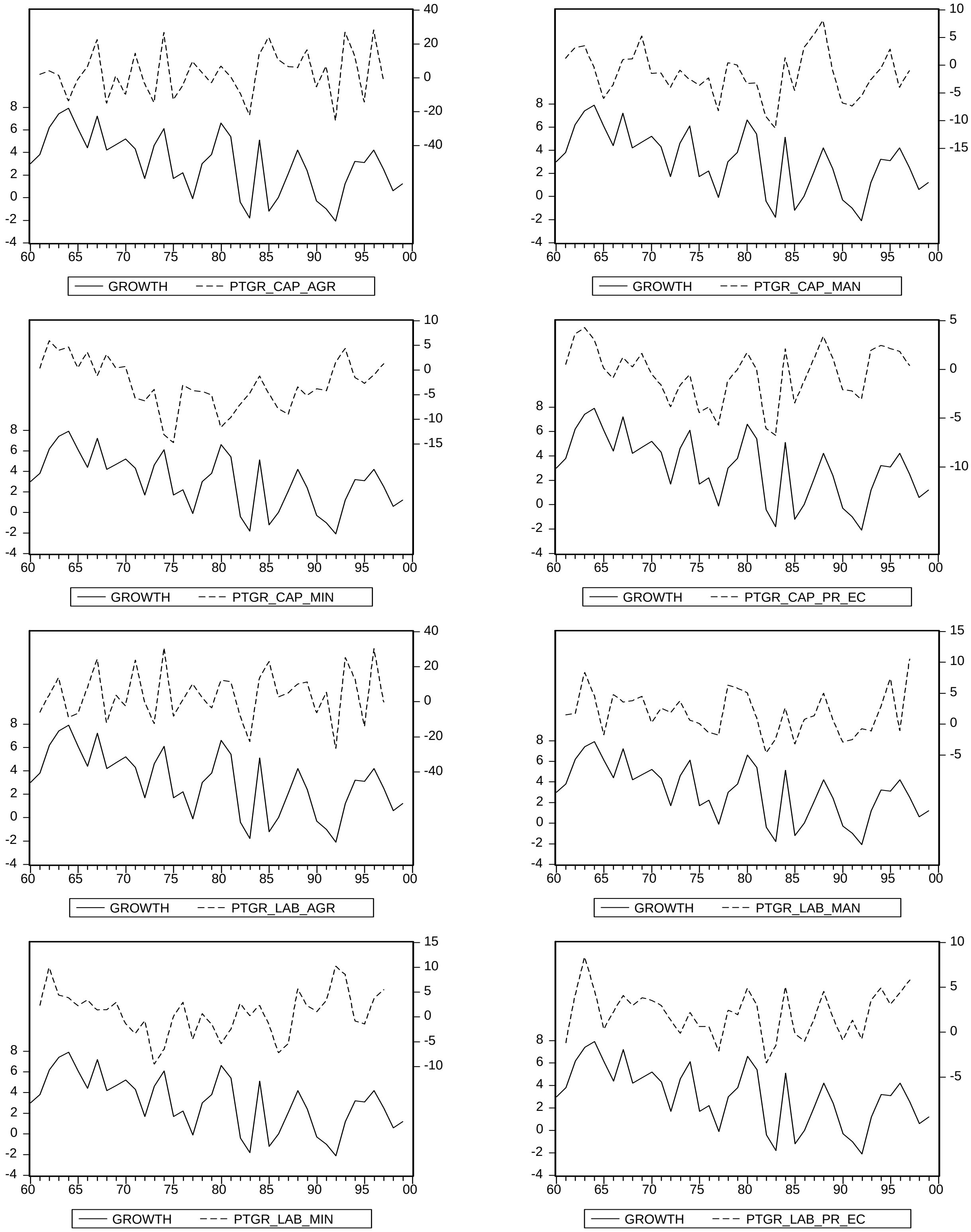
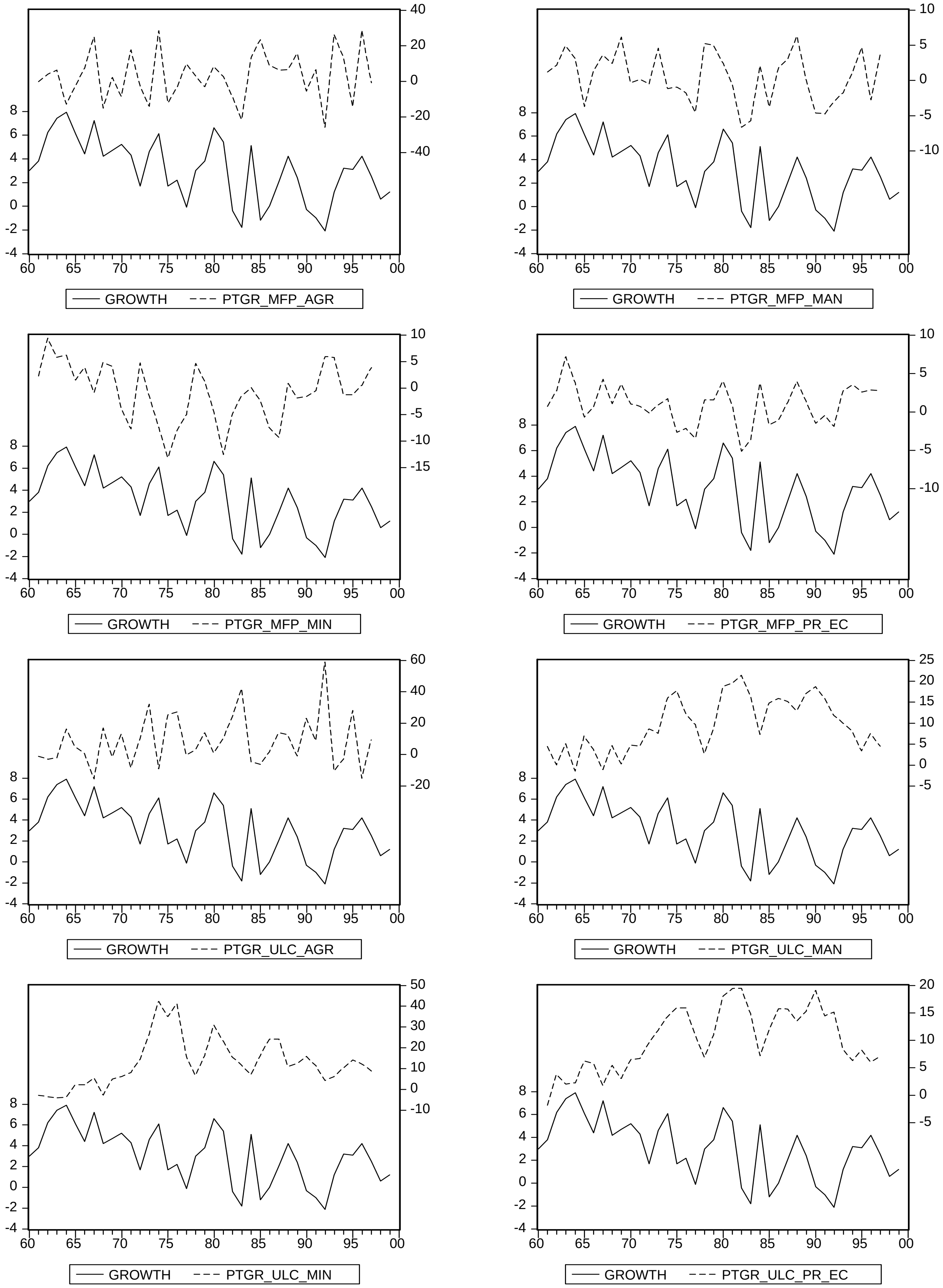
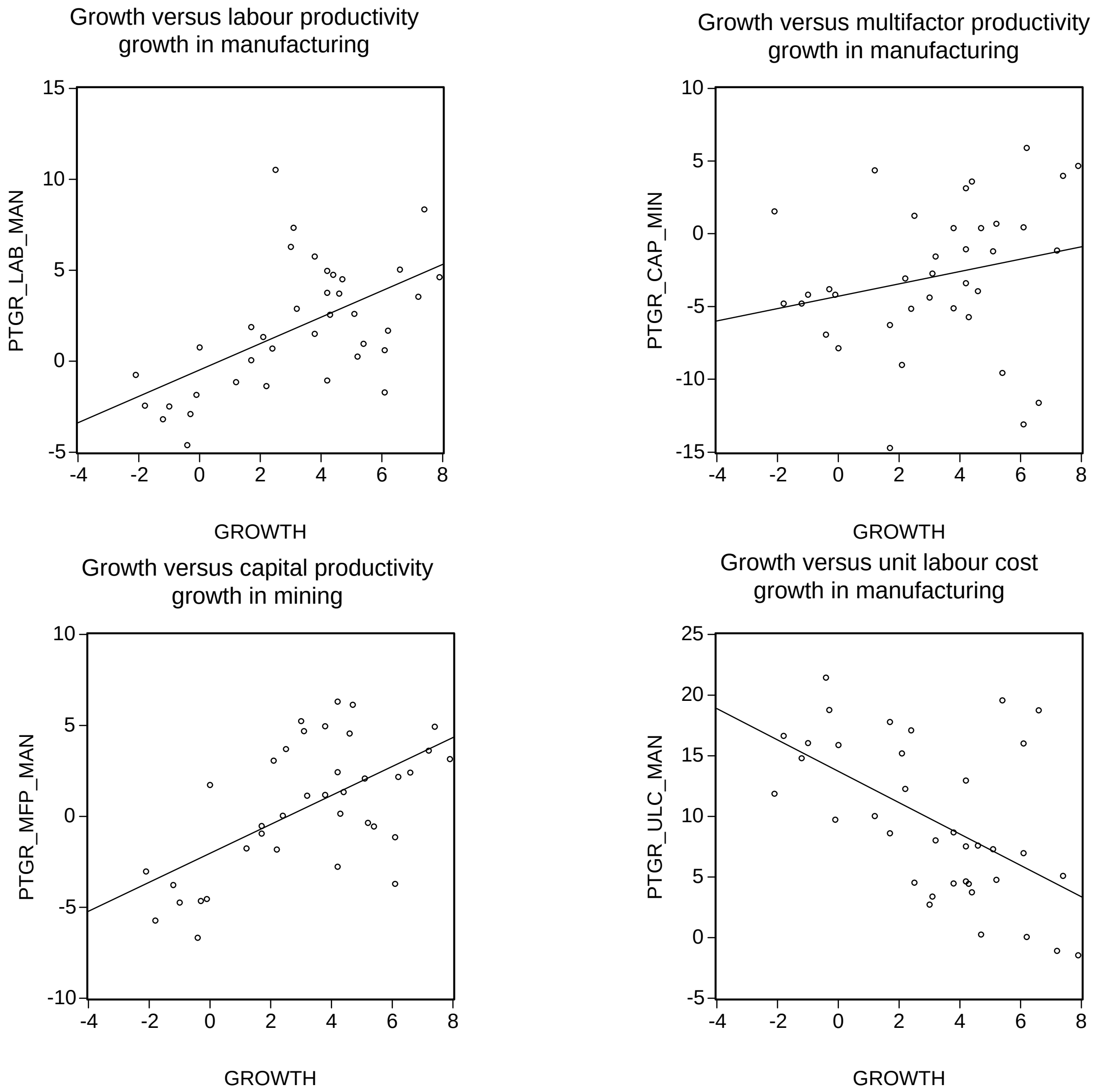


Figure 6.16: Graphical representation of economic growth against growth rates of productivity and unit labour costs, 1960-2000 (continued)



The graphs in figure 6.16 show the expected close relationship between growth and productivity growth variables as well as the contra-tendencies for the graphs depicting growth against unit labour cost growth rates.

Figure 6.17: Simple scatter graphs of growth versus a selection of productivity growth variables



Positive relationships between growth and selected productivity variables are evident from figure 6.17 above. This is confirmed by the information in table 6.30 which reports simple correlation coefficients for a broader spectrum of productivity variables.

Table 6.30: Simple correlation coefficients between productivity variables and economic growth, 1960 to 2000

Variable	Correlation coefficient
PTGR_CAP_AGR	0.173
PTGR_CAP_MAN	0.516
PRGR_CAP_MIN	0.231
PTGR_CAP_PREC	0.714
PTGR_LAB_AGR	0.309
PTGR_LAB_MAN	0.564
PRGR_LAB_MIN	-0.036
PTGR_LAB_PREC	0.696
PTGR_MFP_AGR	0.213
PTGR_MFP_MAN	0.606
PRGR_MFP_MIN	0.163
PTGR_MFP_PREC	0.747
PTGR_ULC_AGR	-0.444
PTGR_ULC_MAN	-0.546
PRGR_ULC_MIN	-0.198
PTGR_ULC_PREC	-0.538

The correlations given in table 6.30 reveal that the manufacturing sector correlations are more pronounced than those of the mining industry, while those of the private economy in turn exceed manufacturing productivity correlations. As can be expected, unit labour cost series are negatively correlated with growth.

The question of causality, and the direction thereof, is answered by a test for Granger causality, and the proper lag order for each series is determined by fitting a simple AR model to the series. The results are reported in tables 6.31 and 6.32. The sample period is 1960 to 2000.

Table 6.31: The lag order of productivity growth variables

	Lag order	p-value	AIC	SIC
GROWTH	1	0.0005	4.482	4.482
PTGR_CAP_AGR	1	0.0946	8.093	8.182
PTGR_CAP_MAN	1	0.0191	5.664	5.361
PTGR_CAP_MIN	1	0.0000	8.098	8.185
PRGR_CAP_PREC	1	0.0039	4.756	4.844
PTGR_LAB_AGR	2	0.0078	7.944	8.077
PTGR_LAB_MAN	1	0.0000	5.222	5.340
PRGR_LAB_MIN	1	0.0050	5.709	5.797
PRGR_LAB_PREC	2	0.0466	4.611	4.744
PTGR_MFP_AGR	2	0.0975	8.095	8.228
PTGR_MFP_MAN	1	0.0000	5.273	5.360
PRGR_MFP_MIN	1	0.0016	6.047	6.135
PTGR_MFP_PREC	1	0.0605	4.769	4.857
PTGR_ULC_AGR	0	-	-	-
PTGR_ULC_MAN	1	0.0000	5.961	6.049
PRGR_ULC_MIN	1	0.0000	6.974	7.061
PTGR_ULC_PREC	1	0.0000	5.287	5.375

Table 6.31 describes p-values on the last lag as well as Akaike and Schwarz selection criteria results for the final model. The results in table 6.31 show that in most cases one lag will be sufficient to render the residual white noise and these lags will subsequently be used in Granger causality tests. The results are provided in table 6.32.

Table 6.32: Pairwise Granger causality tests for productivity growth variables and economic growth, 1960 to 2000

Null hypothesis	Lag order	Obs	F-stat	Probability
PTGR_CAP_AGR does not Granger Cause GROWTH	1	36	4.39	0.0438**
GROWTH does not Granger Cause PTGR_CAP_AGR			0.14	0.7089
PTGR_CAP_MAN does not Granger Cause GROWTH	1	36	0.65	0.4237
GROWTH does not Granger Cause PTGR_CAP_MAN			2.84	0.1009
PTGR_CAP_MIN does not Granger Cause GROWTH	1	36	4.42	0.0433**
GROWTH does not Granger Cause PTGR_CAP_MIN			0.73	0.3983
PTGR_CAP_PREC does not Granger Cause GROWTH	1	36	0.01	0.9338
GROWTH does not Granger Cause PTGR_CAP_PREC				0.0237**
PTGR_LAB_AGR does not Granger Cause GROWTH	2	35	2.71	0.0831*
GROWTH does not Granger Cause PTGR_LAB_AGR			1.33	0.2792
PTGR_LAB_MAN does not Granger Cause GROWTH	1	36	8.32	0.0068***
GROWTH does not Granger Cause PTGR_LAB_MAN			0.23	0.6325
PTGR_LAB_MIN does not Granger Cause GROWTH	1	36	0.02	0.8953
GROWTH does not Granger Cause PTGR_LAB_MIN			0.00	0.9540
PTGR_LAB_PREC does not Granger Cause GROWTH	2	35	0.71	0.4979
GROWTH does not Granger Cause PTGR_CAP_PREC			0.07	0.9313
PTGR_MFP_AGR does not Granger Cause GROWTH	1	36	4.48	0.0417**
GROWTH does not Granger Cause PTGR_MFP_AGR			0.00	0.9661
PTGR_MFP_MAN does not Granger Cause GROWTH	1	36	5.03	0.0317**
GROWTH does not Granger Cause PTGR_MFP_MAN			0.48	0.4891
PTGR_MFP_MIN does not Granger Cause GROWTH	1	36	9.08	0.0049***
GROWTH does not Granger Cause PTGR_MFP_MIN			0.58	0.4509

Table 6.32: Pairwise Granger causality tests for productivity growth variables and economic growth, 1960 to 2000 (continued)

PTGR_MFP_PREC does not Granger Cause GROWTH	1	36	0.28	0.5957
GROWTH does not Granger Cause PTGR_MFP_PREC			2.11	0.1551
PTGR_ULC_AGR does not Granger Cause GROWTH	1	36	1.33	0.2566
GROWTH does not Granger Cause PTGR_ULC_AGR			2.69	0.1102
PTGR_ULC_MAN does not Granger Cause GROWTH	1	36	9.87	0.0035***
GROWTH does not Granger Cause PTGR_ULC_MAN			3.95	0.0551*
PTGR_ULC_MIN does not Granger Cause GROWTH	1	36	4.04	0.0526*
GROWTH does not Granger Cause PTGR_ULC_MIN			0.00	0.9697
PTGR_ULC_PREC does not Granger Cause GROWTH	1	36	9.05	0.0050***
GROWTH does not Granger Cause PTGR_ULC_PREC			4.39	0.0439**

Note: ***/**/* indicate rejection of the hypothesis at the 1/5/10 per cent level of significance.

The results in table 6.32 above show that growth in *capital* productivity in both the agriculture and mining sector Granger causes growth, but that this is not the case in the manufacturing sector. A reverse causality seems to exist for the private economy. Granger causalities are also shown to exist between growth in *labour* productivity and economic growth in the agriculture and manufacturing sectors. Increases in *multifactor* productivity in the agriculture, mining and manufacturing sectors, Granger causes economic growth within these sectors. Lastly, it can be deduced from table 6.32 that *unit labour cost growth* will detract from growth in the mining sector, while a bi-directional Granger causality exists between unit labour cost growth and economic growth for the manufacturing sector and the combined private economy – that is, that higher growth may stimulate these sectors sufficiently to reduce unit labour costs.

Table 6.33 provides a summary of the Granger causalities, which is useful for interpretation purposes.

Table 6.33: Summary of Granger causality tests for relationships between productivity and economic growth

Productivity	Sector			
	Agriculture	Manufacturing	Mining	Private Economy
Capital	Causality		Causality	Causality
Labour	Causality	Causality		
Multifactor	Causality	Causality	Causality	
ULC		Bidirectional Causality	Causality	Bidirectional Causality

Given the importance of the manufacturing sector in most economies, and the fast-growing Asian economies in particular, and in view of its relatively large contribution to total GDP in most economies as well as in South Africa, it would appear that manufacturing sector productivity might give valuable insights into the country's growth potential. Furthermore, in the light of the importance of labour in the South African economy, stemming from its political influence in the governing tripartite alliance, the relationship between labour productivity in the manufacturing sector, and multifactor productivity for the manufacturing sector are further investigated. To balance these effects, it is also of interest to investigate the effects of unit labour cost growth on growth in the economy. The last section investigates the effects of unit labour cost increases in the manufacturing sector on growth. The Granger causalities running from labour productivity and unit labour cost to growth shown above, seem to indicate important relationships between these variables and economic growth, and they therefore merit further investigation. Capital productivity and multifactor productivity for mining are also included in this analysis, given the important influence of the mining sector on economic growth in South Africa's early growth path.

Vector autoregression (VAR) models for the above-mentioned cases are presented in tables 6.34, 6.36, 6.38 and 6.40 respectively. In all instances, the productivity and unit labour cost coefficients in the models with growth as dependent variable are of the correct sign and statistically significant.

6.4.7.1 *Labour productivity growth in the manufacturing sector*

Table 6.34 reports the results of the VAR with lag order 1 for the relationship between growth and the growth rate in labour productivity in the manufacturing sector.

Table 6.34: Vector autoregression model estimating the effect of growth in labour productivity in manufacturing on economic growth

Sample(adjusted): 1962-1997
Included observations: 36 after adjusting endpoints
t-statistics in parentheses

	GROWTH	PTGR_LAB_MAN
GROWTH(-1)	0.1869	0.1418
	(1.071)	(0.493)
PTGR_LAB_MAN(-1)	0.4324	0.1077
	(2.289)	(0.4376)
C	1.8814	1.2034
	(3.281)	(1.2752)
R-squared	0.4108	0.0355
Adj R-squared	0.3751	-0.0228
Sum sq resides	155.57	421.50
SE equation	2.1712	3.5739
F-statistic	11.505	0.6087
Log likelihood	-77.426	-95.367
Akaike IC	4.4681	5.4648
Schwarz IC	4.6000	5.5968

The first column of results in table 6.34, with growth as the dependent variable, shows that the coefficient for labour productivity growth in manufacturing is significant and carries the correct sign. Labour productivity therefore makes an important contribution to growth.

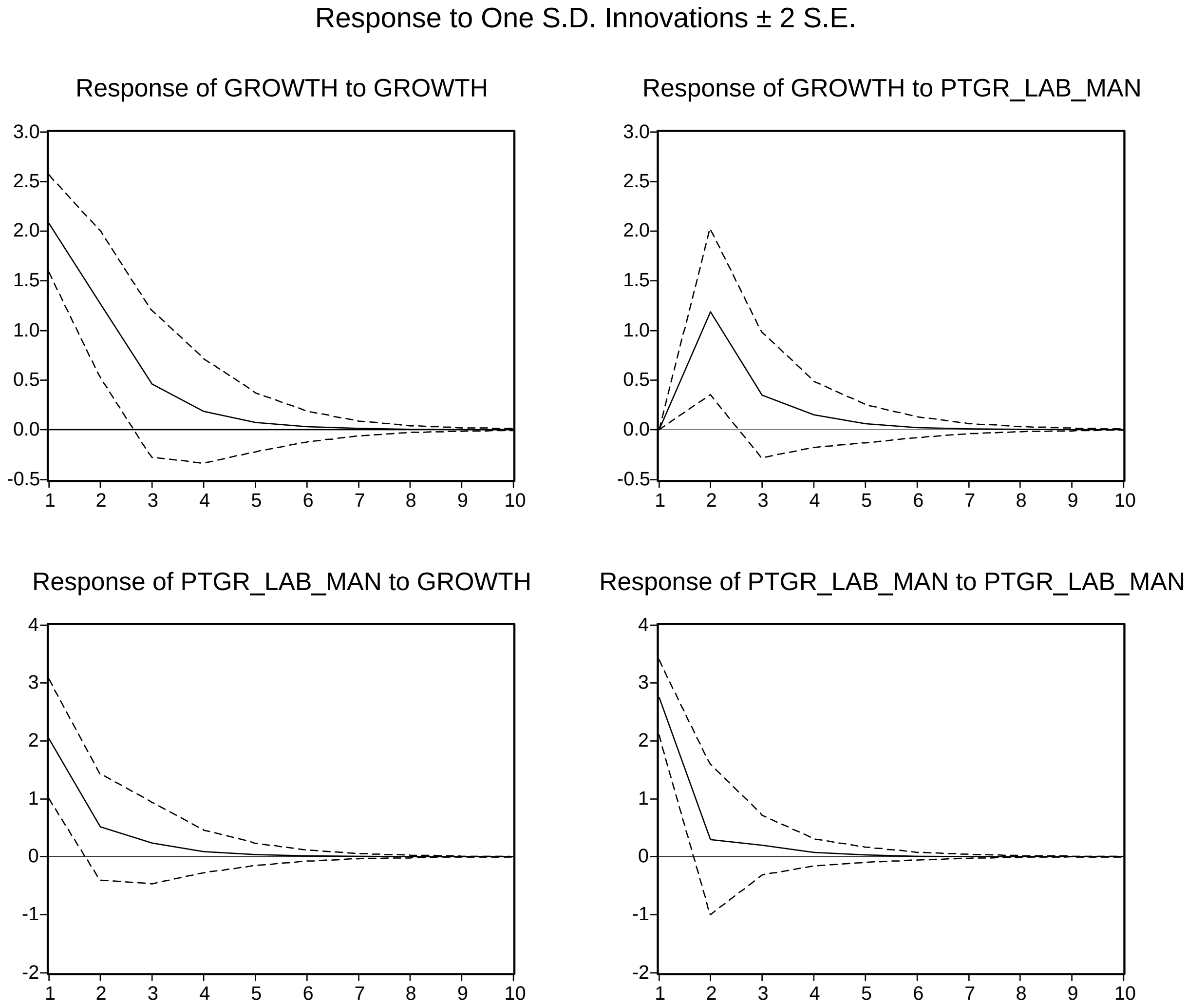
The strength of the causality was further investigated with the Sims variance decomposition test.

Table 6.35: Variance decomposition of growth due to innovations in labour productivity growth in the manufacturing sector

Period	SE	GROWTH	PTGR_LAB_MAN
1	2.078	100.00	0.000
2	2.710	80.753	19.246
3	2.771	79.992	20.007
4	2.781	79.843	20.156
5	2.783	79.821	20.178
6	2.783	79.818	20.181
7	2.783	79.817	20.182
8	2.783	79.817	20.182
9	2.783	79.817	20.182
10	2.783	79.817	20.182

For the period under consideration, innovations in labour productivity growth in manufacturing explain an important portion of growth, with a sustained long-run significance (of just more than 20 per cent), of the forecast error variance of the economic growth rate directly, and thus support results obtained from Granger causality tests.

Figure 6.18: Impulse response functions of economic growth due to innovations in labour productivity growth in manufacturing



The second graph shows that increases in the growth in labour productivity of the manufacturing sector serve as a stimulus for higher growth. This positive impact of just more than 1 per cent takes place in the second period and is sustained, although at lower levels, for just more than five periods, during which the relationship remain above the long-run level. Convergence back to the long-run growth level takes place about six periods after innovations in the growth in labour productivity of the manufacturing sector.

6.4.7.2 Multifactor productivity growth in the manufacturing sector

Growth in multifactor productivity gives another dimension to the impact of technology on growth as the physical content of the use of more capital and more labour is neutralised by the formula:

(multifactor productivity=(output index/(weighted labour input index plus weighted capital input index))

It therefore leaves a residual that mainly incorporates changes in human knowledge and technology embodied largely in capital equipment used in the manufacturing sector.

Table 6.36: Vector autoregression model estimating the effect of growth in multifactor productivity in manufacturing on economic growth

Sample(adjusted): 1962-1997.
Included observations: 36 after adjusting endpoints
t-statistics in parentheses

	GROWTH	PTGR_MFP_MAN
GROWTH(-1)	0.2645	-0.1941
	(1.489)	(-0.689)
PTGR_MFP_MAN(-1)	0.3060	0.3378
	(2.243)	(1.563)
C	2.1935	0.9541
	(3.346)	(0.918)
R-squared	0.3592	0.0722
Adj R-squared	0.3204	0.0160
Sum sq resides	169.17	424.43
SE equation	2.264	3.5863
F-statistic	9.2529	1.2851
Log likelihood	-78.935	-95.491
Akaike IC	4.5519	5.4717
Schwarz IC	4.6839	5.6037

Table 6.36 reports the results of the VAR with lag order 1 for the relationship between growth and the growth in multifactor productivity in the manufacturing sector. The important first column of results with growth as the dependent variable shows that the coefficient for multifactor productivity growth in manufacturing is significant at the 1 per cent level and carries the correct sign. Human and capital-embodied technology in the manufacturing sector therefore played a significant part in the overall growth of the economy.

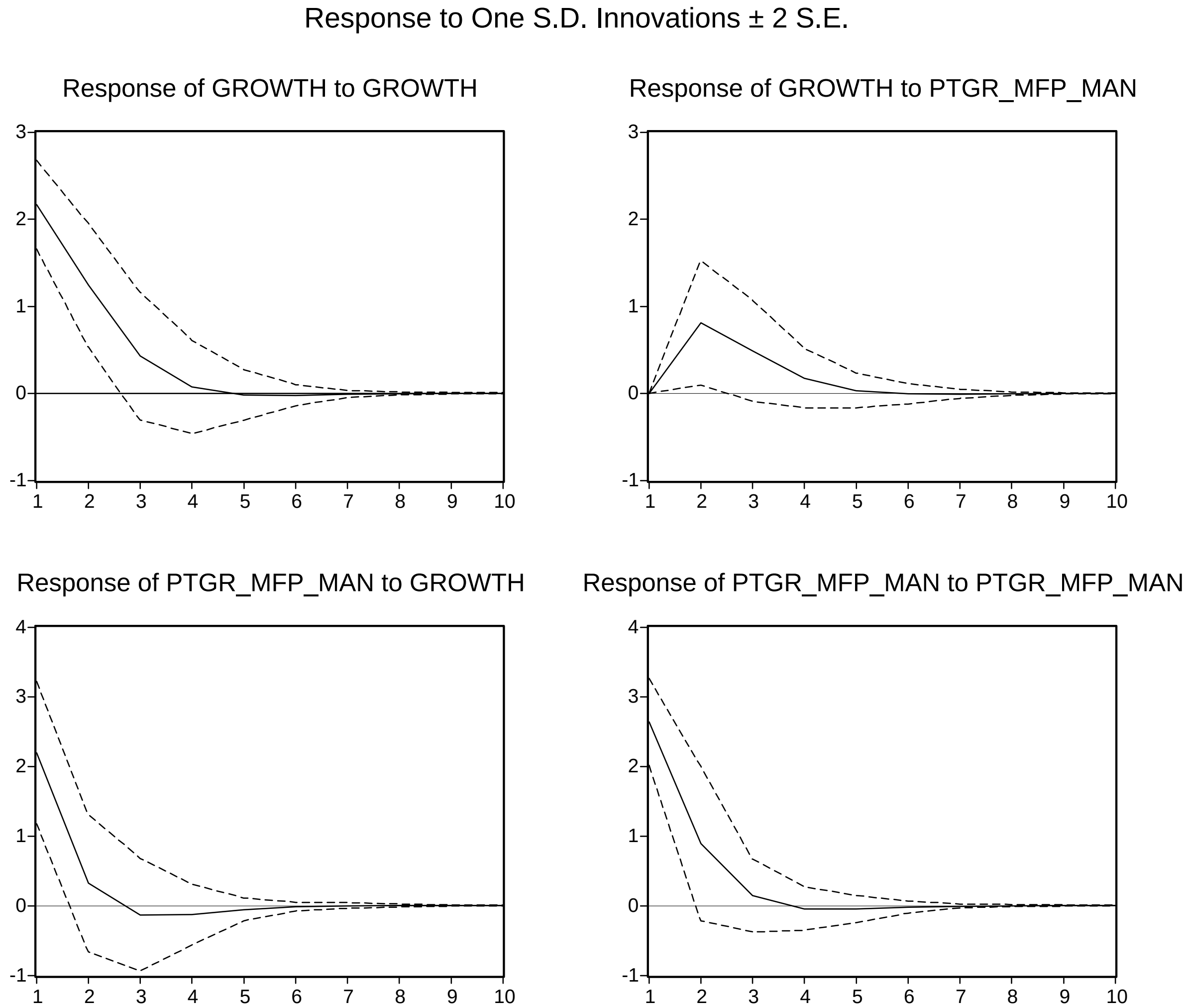
Table 6.37: Variance decomposition of growth due to innovations in growth in the multifactor productivity in the manufacturing sector

Period	SE	GROWTH	PTGR_LAB_MAN
1	2.167	100.00	0.000
2	2.627	90.547	9.452
3	2.705	87.855	12.144
4	2.712	87.507	12.492
5	2.712	87.496	12.503
6	2.712	87.496	12.503
7	2.712	87.495	12.504
8	2.712	87.495	12.504
9	2.712	87.495	12.504
10	2.712	87.495	12.504

For the period under consideration, innovations in multifactor productivity growth in manufacturing explain a relatively small portion, but with a stable long-run significance (up to 12.5 per cent), of the forecast error variance of the economic growth rate directly, and thus support the results obtained from Granger causality tests.

In testing the likely development over time of the relationship, impulse response functions for the two-variable system are examined in figure 6.19 to throw light upon the dynamics of the relationship.

Figure 6.19: Impulse response functions of economic growth due to innovations in multifactor productivity growth in manufacturing



The second graph in figure 6.19 shows that multifactor productivity growth in manufacturing had a rather modest (less than 1 per cent) effect on growth. This positive effect lasts for about five periods, after which the system returns to its original long-run growth level.

6.4.7.3 *Capital productivity growth in the mining sector*

Recognising the vulnerability of the mining sector to developments in the international arena and its dependency on capital productivity enhancements to remain internationally competitive, this section proceeds with an analysis of the effect of capital productivity growth in the mining industry on economic growth. The relationship between capital productivity growth and economic growth is captured in the vector autoregression (VAR) model reported in table 6.38, while the magnitude of the effect of an innovation in capital productivity in the mining sector on economic growth is evident in figure 6.20.

Table 6.38: Vector autoregression model estimating the effect of growth in capital productivity in mining on economic growth

Sample(adjusted): 1962-1997
Included observations: 36 after adjusting endpoints
t-statistics in parentheses

	GROWTH	PTGR_CAP_MIN
GROWTH(-1)	0.4389	-0.2063
	(3.032)	(-0.847)
PTGR_CAP_MIN(-1)	0.1665	0.6896
	(2.096)	(5.155)
C	2.2669	-0.2655
	(3.300)	(-0.229)
R-squared	0.3484	0.4476
Adj R-squared	0.3089	0.4141
Sum sq resides	172.04	487.56
SE equation	2.2833	3.8437
F-statistic	8.8232	13.370
Log likelihood	-79.238	-97.987
Akaike IC	4.5687	5.6104
Schwarz IC	4.7007	5.7424

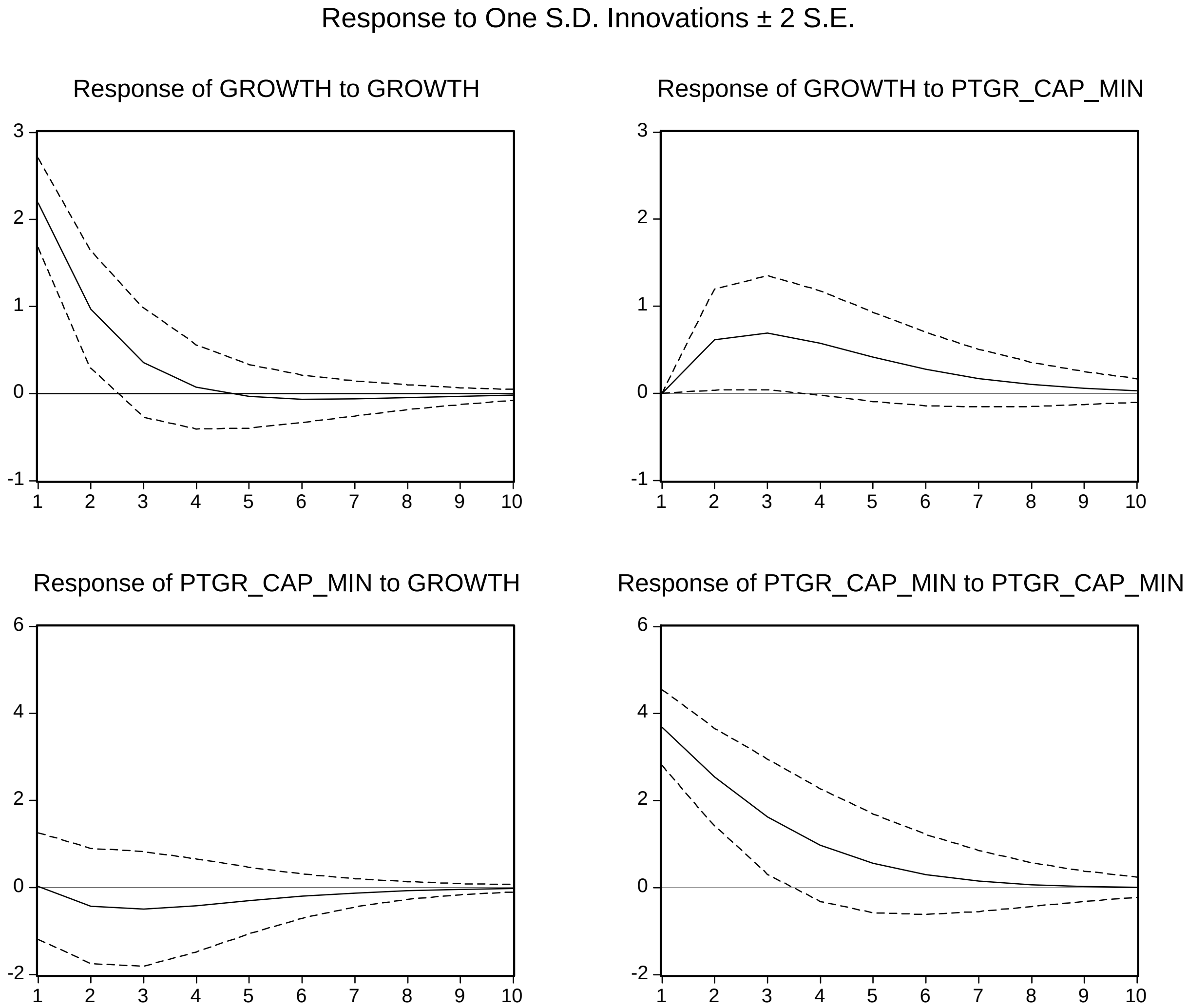
Table 6.38 reports the results of the VAR with lag order 1. The first lag is significant and positive indicating a positive effect on economic growth from innovations in capital productivity growth in the mining sector. Growth and capital productivity growth are also influenced by their first lags respectively.

Table 6.39: Variance decomposition of growth due to innovations in capital productivity growth in the mining sector

Period	SE	GROWTH	PTGR_LAB_MAN
1	2.186	100.00	0.000
2	2.466	93.820	6.173
3	2.586	87.226	12.771
4	2.650	83.142	16.857
5	2.682	81.158	18.841
6	2.697	80.328	19.671
7	2.703	80.021	19.978
8	2.705	79.920	20.079
9	2.706	79.890	20.109
10	2.706	79.882	20.117

For the 10-year period, innovations in capital productivity growth in mining explain a relatively small initial portion, but with an accelerating stable long-run significance (up to 20 per cent), of the forecast error variance of the economic growth rate directly, and thus support the results obtained from Granger causality tests.

Figure 6.20: Impulse response functions of economic growth due to innovations in capital productivity growth in mining



The initial effect of a positive innovation in capital productivity growth in the mining sector on economic growth is zero (shown in the second graph above). This is followed by a positive effect of about 0.5 per cent in the second period, which increases slightly in the third period and then gradually decreases over time, to its original long-run growth level by the 10th period. The impacts of the first lags of growth and of capital productivity growth in mining on itself respectively, mentioned above, are confirmed by the positive contributions depicted in graphs 1 and 4 above.

6.4.7.4 *Multifactor productivity growth in the mining sector*

Since capital productivity in the mining sector contributes significantly to growth, it will be interesting to determine whether pressures of international competition will secure a similar result for multifactor productivity in this sector. The relationship between multifactor productivity and growth is captured in the vector autoregression (VAR) model reported in table 6.40, while the extent of the effect of an innovation in multifactor productivity in the mining sector on economic growth is evident in figure 6.21.

Table 6.40: Vector autoregression model estimating the effect of growth in multifactor productivity in mining on economic growth

Sample(adjusted): 1962-1997 Included observations: 36 after adjusting endpoints t-statistics in parentheses		
	GROWTH	PTGR_MFP_MIN
GROWTH(-1)	0.4420 (3.286)	-0.2287 (-0.750)
PTGR_MFP_MIN(-1)	0.2019 (3.010)	0.5289 (3.481)
C	1.9417 (3.393)	0.3218 (0.248)
R-squared	0.4207	0.2689
Adj R-squared	0.3856	0.2246
Sum sq resides	152.94	784.62
SE equation	2.1528	4.8761
F-statistic	11.985	6.0713
Log likelihood	-77.120	-106.55
Akaike IC	4.4511	6.0862
Schwarz IC	4.5830	6.2181

Table 6.40 reports the results of the VAR with lag order 1 for the relationship between growth and the growth in multifactor productivity in the mining sector. Of significance is the first column of results with growth as the dependent

variable. The coefficient for the multifactor productivity in the mining sector is significant and has a positive sign indicating a positive impact on economic growth. The strength of the relationship is further supported by the significant first lag of growth on itself as well as the first lag of multifactor productivity in the mining sector on itself.

Table 6.41: Variance decomposition of growth due to innovations in growth in multifactor productivity in the mining sector

Period	SE	GROWTH	PTGR_MFP_MIN
1	2.061	100.00	0.000
2	2.424	84.914	15.085
3	2.604	74.594	25.405
4	2.677	70.541	29.458
5	2.701	69.372	30.627
6	2.707	69.131	30.868
7	2.708	69.102	30.897
8	2.708	69.103	30.896
9	2.708	69.103	30.896
10	2.708	69.103	30.896

Table 6.41 shows that for the 10-year period, innovations in multifactor productivity growth in the mining sector, explain an initial modest portion of 15 per cent for the second period, but with an accelerating and impressively stronger and stable long-run significance (up to 30.8 per cent by the 10th period), of the forecast error variance of the economic growth rate directly, and thus support the results obtained from Granger causality tests.

Figure 6.21: Impulse response functions of economic growth due to innovations in multifactor productivity growth in the mining sector

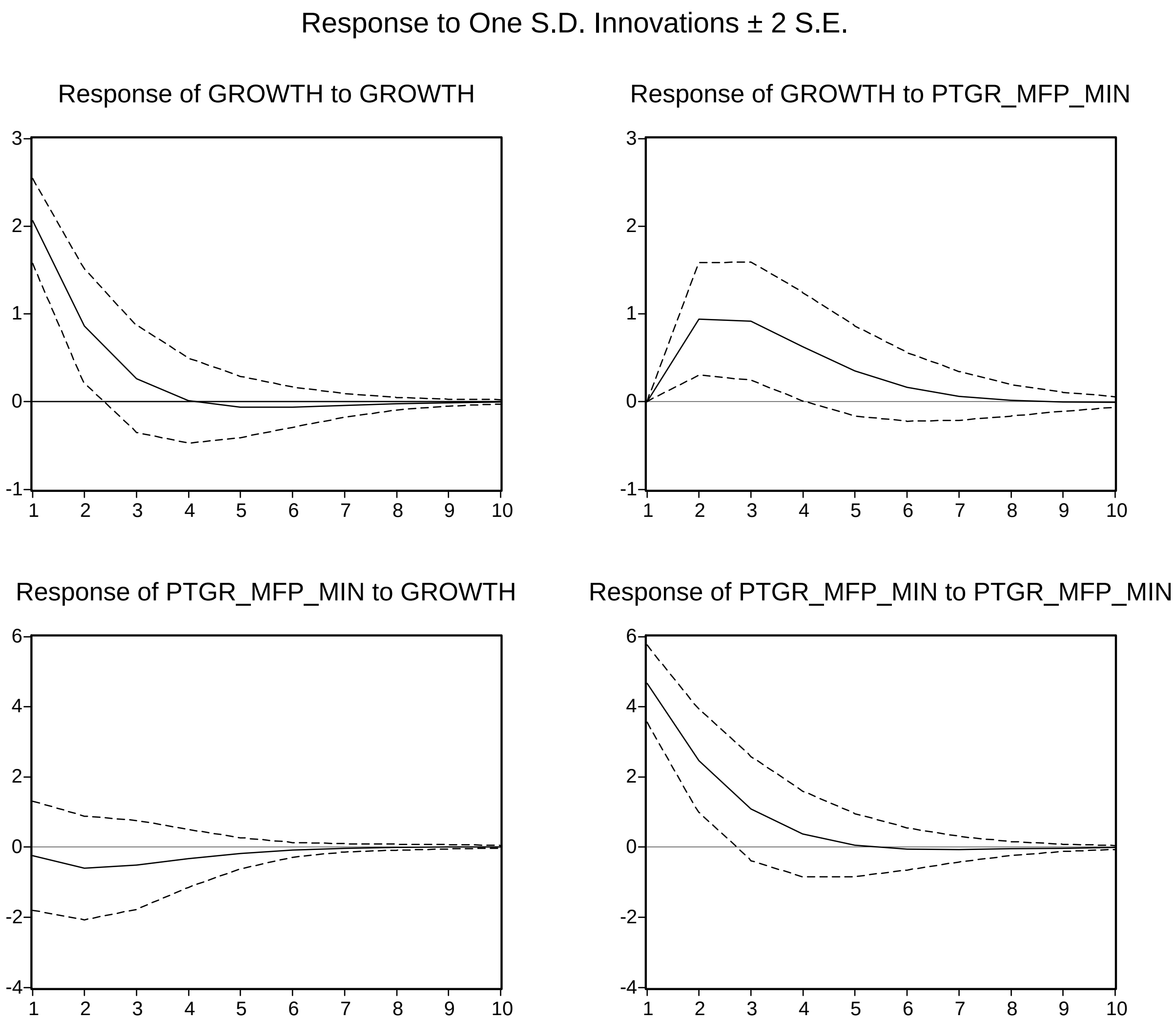


Figure 6.21 depicts the short-run and long-run effects of various shocks to the system and shows no immediate effect on growth from innovations in growth of mining multifactor productivity shocks. However, it predicts a 1 per cent effect by the next period, which subsides in the second period and gradually fades away to its long-run trend by the seventh period. The first and fourth graphs give indications of the positive and statistically significant effect of the impacts on these variables by their respective first lags.

The analyses of the effects of various productivity growth rates on growth reaffirm the importance of the contribution of all types of productivity increases to growth, and verify the role that growth accounting suggested in this respect.

6.4.7.5 *Unit labour cost in the manufacturing sector*

To conclude this chapter, this final section examines the effect of unit labour cost in the manufacturing sector on economic growth. Intuitive responses tend to lead one to expect that there would be a negative effect on economic growth stemming from higher unit labour costs. This, off course, overlooks the purchasing power stimulus that higher incomes will have on demand, and ultimately on future growth. The bidirectional Granger-causalities reported in table 6.33 confirm this notion.

Table 6.42: Vector autoregression model estimating the effect growth in unit labour cost in the manufacturing sector has on economic growth

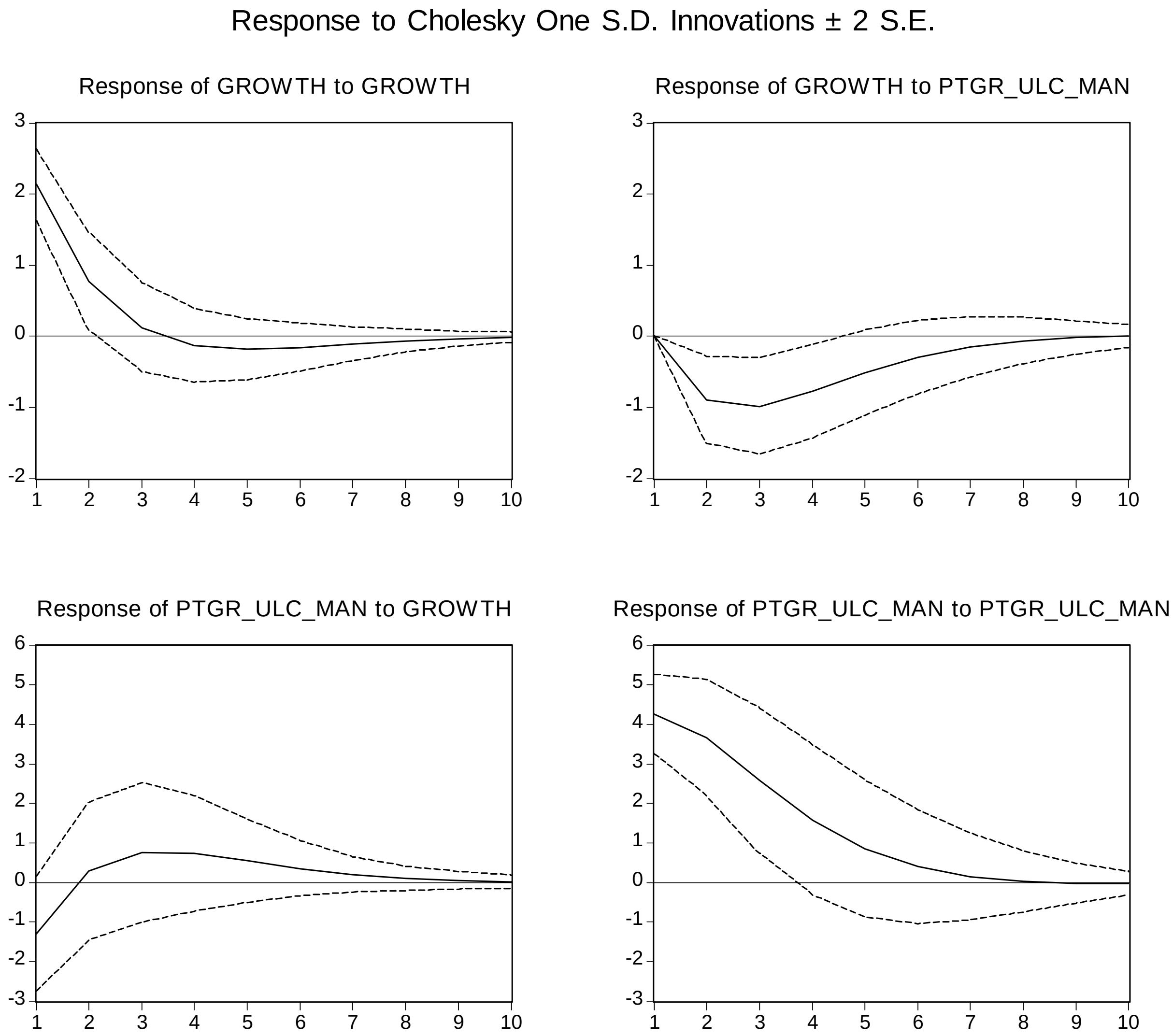
Sample(adjusted): 1962-1997
Included observations: 36 after adjusting endpoints
t-statistics in parentheses

	GROWTH	PTGR_ULC_MAN
GROWTH(-1)	0.2345	0.6673
	(1.487)	(1.994)
PTGR_ULC_MAN(-1)	-0.2119	0.8623
	(-3.151)	(6.163)
C	4.4646	-0.7618
	(4.123)	(-0.337)
R-squared	0.4324	0.5538
Adj R-squared	0.3980	0.5268
Sum sq resides	149.86	653.09
SE equation	2.1310	4.4486
F-statistic	12.571	20.486
Log likelihood	-76.753	-103.24
Akaike AIC	4.4307	5.9027
Schwarz SC	4.5627	6.0347

The vector autoegression results given in table 6.42 confirm the notion that increases in unit labour costs detract from economic growth. The expected negative sign of the sizeable unit labour cost coefficient and its statistical significance confirm the expected negative effect on growth.

The expected reverse effect indicated by the Granger causality of growth to higher unit labour cost is also confirmed by the positive sign and the statistically significant coefficient of growth to unit labour cost in the manufacturing sector, and also by the statistically significant and positive lagged effect of unit labour cost on itself, indicating that unit labour cost increases have a built-in self-perpetuating mechanism.

Figure 6.22: Impulse response functions of economic growth due to innovations in unit labour costs in the manufacturing sector



The impulse response graphs show the bidirectional causalities suggested by the Granger causality tests. The second graph in the series shows a negative effect of unit labour cost on growth of about 0.8 per cent by the second period, which increases to 1 per cent by the third period and gradually fades away to its long-run level by the ninth period. The third graph displays the opposite effect of growth on unit labour costs. The initial reducing effect on unit labour cost possibly represents positive scale effects of higher demand from higher wages on growth which is summarily overtaken by cost-push factors which then dampen further growth. The cost-raising effects reduce more slowly and only converge to its original long-run trend by the ninth period.

Table 6.43: Variance decomposition of growth due to innovations in growth in unit labour cost in the manufacturing sector and *vice versa*

Variance decomposition of GROWTH:			
Period	SE	GROWTH	PTGR_ULC_MAN
1	2.040	100.00	0.0000
2	2.335	86.421	13.578
3	2.521	74.335	25.664
4	2.631	68.480	31.519
5	2.682	66.313	33.686
6	2.702	65.673	34.326
7	2.708	65.534	34.465
8	2.709	65.518	34.481
9	2.710	65.520	34.479
10	2.710	65.522	34.477
Variance decomposition of PTGR_ULC_MAN:			
Period	SE	GROWTH	PTGR_ULC_MAN
1	4.259	8.494	91.505
2	5.528	5.286	94.717
3	6.095	5.743	94.256
4	6.316	6.569	93.430
5	6.389	7.083	92.916
6	6.409	7.308	92.691
7	6.413	7.384	92.615
8	6.414	7.403	92.596
9	6.414	7.406	92.593
10	6.414	7.406	92.593

Table 6.43 shows that for the 10-year period, innovations in unit labour cost growth in the manufacturing sector rises from an initial zero effect on growth to a modest 13 per cent depressing effect for the second period. However, sharply

accelerating to 34 per cent by the sixth period, after where it stabilises in the long-run and thus supports results obtained from Granger causality tests.

Of further interest is the lower part of table 6.43 which indicates the decomposition of unit labour cost increases stemming from growth and from itself. The third column shows a modest 8.5 per cent stimulus on unit labour cost from growth in the first period supporting similar evidence from the impulse response graphs. It reduces sharply to 5.2 per cent in the second period and gradually edge up to its long-run level of 7.4 per cent by the eighth period, supporting the initial growth scale effect hypothesis mentioned earlier and the effects from the additional lagged response from itself as well as from the lagged growth response.

6.5 SUMMARY AND CONCLUSIONS

The plethora of research papers on economic growth, using cross-country analyses indicates which growth inducing factors are statistically significant contributors to growth. The latter factors, for which time series are available in South Africa, have been used to determine which of them caused growth in South Africa. This summary provides a brief overview of the results of this research.

The openness variables are all indicative of a causal relationship using Granger causality tests, and the causalities run from openness to economic growth. In the case where openness is measured as the sum of exports and imports as a percentage of GDP, there is an indication of bidirectional causality.

The results suggest that barriers to openness such as import tariffs and quotas must be limited and exports must be promoted since export-led growth in line with the new growth theories remains vital for the future. For obvious reasons, however, imports of productive capital goods are needed more than imports of nonproductive luxury goods to revive the economy. Export promotion should concentrate on manufactured goods rather than primary products. Also, in the long run, a skilled workforce may contribute to higher competitiveness in the export of manufactured goods.

The relationship between economic growth and investment growth, as well the investment-gdp ratio, displayed a bidirectional causality. Causality was also established, running from investment in machinery and other equipment to economic growth. A reverse causality between investment in transport and communication and economic growth also seems to exist. The relationship between growth and investment should thus be viewed as a part of the process of economic development and growth and not as the primary connecting source.

Although injections of capital are important, it does not seem to be the sole driving force of future growth. Creating the conditions for productive capital accumulation is more important than capital accumulation *per se* and policy makers should focus more on policies that encourage total factor productivity growth, as shown in the sections on productivity growth in this study (see section 6.4.7 on p176, specifically 6.4.7.1 on p185 and 6.4.7.5 on p197).

The effects on growth of the ratio of government spending to GDP, as well as the ratio of government spending less spending on education and defence to the GDP or so-called "nonproductive" spending and the growth rates in these variables were also analysed. Granger causality tests conducted on these variables, show causality from government spending to growth. Using this evidence in tandem with VAR models for both variables (tables 6.15 and 6.16) show that in both cases, coefficients are negative and statistically significant, implying that excessive government spending detracts from growth. The negative effect of nonproductive spending on growth is higher than that of productive government spending (fig 6.7). This is a long-run effect, since after 20 periods the growth level is still below the original long-run path. These findings imply that benign government spending, mainly on domestic defence and personal safety and security as well as education, should constitute almost the entire budget and that other government activities falling outside of this group should be privatised.

Internationally, rapid rates of growth are almost invariably associated with the rapid rate of growth of the secondary sector, mainly the manufacturing sector.

The influence on growth of various variables defined in terms of the main sectors was investigated.

Results show that there is statistical significance to support the theoretical positive impact of growth in the manufacturing sector on the economic growth rate. Of particular significance is that the manufacturing growth feeds on itself, while simultaneously contributing to long-term economic growth. It would therefore appear that the manufacturing sector is a formidable engine to drive economic growth. The same analysis for agricultural and mining indicates a relatively small positive response in economic growth because of innovations in growth in these sectors.

Policy should therefore be directed towards creating an environment conducive to developing manufacturing in general for local as well as global consumption and its downstream service sectors such as trade and transport. The privatisation of state monopolies in the electricity, transport and communication sectors should be expedited, in the process ensuring competition, especially foreign competition.

Export promotion could facilitate sectoral growth and has indeed been emphasised in the analysis of the openness of the economy, as set out in section 6.4.1.

South Africa's high crime rate is has a further negative effect on economic growth. Impulse response graphs show that economic growth is responsive to increases in the growth rate of **crime** incidents, which serves as a negative shock to higher growth. This negative impact, however, dies out relatively quickly as the convergence back to the long-run growth level takes place after only about four periods. This implies that an improvement in the safety and security setup may soon lead to a situation more conducive to economic growth.

The two state (or stock) variables, namely measures of physical capital and human capital stock, were also analysed. The Granger causality tests suggest that a bidirectional causality exists between growth in capital stock and economic growth. This result is in line with the results obtained for growth in fixed investment and economic growth. The same holds true for the quantitative proxy for human capital. For the two proxies for qualitative measures of human capital, causality was not established, possibly because of below par education standards, low availability or poor education quality in the past.

Statistical significance exists to support the overall theoretical positive impact of the growth in capital stock on the economic growth rate. This is evident from the impulse response functions showing that the initial effect of a positive innovation in capital stock on economic growth is also positive.

To augment the variables on human capital, a number of productivity variables were tested, which will simultaneously also serve to indicate the role that technology played in the past growth performance of South Africa. Results show that innovations in labour productivity growth in manufacturing were a statistically significant contributor to economic growth and to explain an important portion of growth, with a sustained long-run significance.

Multifactor productivity in manufacturing also made a statistically significant contribution to economic growth. Simulated innovations explaining an initial 9 per cent portion, increasing to more than 12 per cent by the third period and thus supports results obtained from Granger causality tests.

Innovations in capital productivity growth in mining explain a relatively small initial portion, but accelerating to 20 per cent of the forecast error variance of the economic growth rate and thus support results from Granger causality tests. Innovations in multifactor productivity growth in the mining sector explain an initially modest 15 per cent accelerating to 30.8 per cent in the 10th period and thus support results obtained from Granger causality tests.

The analyses of the effects of various productivity growth rates on growth reaffirm the importance of the contribution of all types of productivity increases to growth, and verify the role that growth accounting suggested in this respect. It also suggests that multifactor productivity growth and labour productivity growth in manufacturing in particular, are strong growth stimulants. Policy options that will stimulate productivity growth in manufacturing and induce exports of manufactures should be carefully chosen and constantly honed in consultation with private sector institutions. Policies used by the high performing Asian economies that pursued rapid industrialisation could be of particular importance in this respect.

Innovations in unit labour cost growth in the manufacturing sector, initially have a zero effect on growth which increases to 13 per cent depressing effect on growth for the second period, but with a sharply accelerating influence of more than 34 per cent from the sixth to the 10th period. The bidirectional influences of unit labour cost must be carefully examined and strategically managed because excessive increases could compromise international competitiveness while excluding the large unemployed labour contingent. Instead, the focus should rather be on the bidirectional initial effect, which could be enhanced by the employment of the unemployed rather than higher increases for current job incumbents. The initial effect of the purchasing power of the newly employed on manufacturing itself seems to be greater because of the statistically significant bidirectional influences and lagged positive contributions of productivity growth on itself, and by implication, the negative effects of unit labour cost increases by its significant first lag.