An Econometric Analysis of Aspects of Economic Growth in South Africa

by

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Contents

Abstract

This thesis investigates aspects of economic growth of South Africa using data covering the first quarter of 1990 to the second quarter 2010 period, using methods, theories and applications from the field of statistics, econometrics, and economics. Going by current trend in the literature, the principal focus is on endogenous growth theory and the new economic variables based on the literature.

A review of the literature is first presented, followed by presentation of an overview of the related theories. Next, the thesis discusses of the relevant analytical methods required for the analysis of the data. Then, using these analytical methods, thorough analyses that seek to address the study aims and objectives were performed to examine the relationships of South Africa's economic growth with other key economic determinants. The path of economic growth is also assessed along with future forecasts for economic growth. Using the results, conclusions are drawn about the economic growth with the other key economic determinants. Policy implications as informed by the findings are also presented.

Chapter 1

Introduction

1.1 Background

Economic growth leads to greater economic prosperity and emancipation. Positive economic growth increases the overall lives of the people. People are better able to provide for their needs and fulfill their aspirations and wishes through sustained economic growth. Positive economic growth of a country is empirically linked to higher overall levels of human happiness and betterment (Wright, 2000). Due to the lack of economic growth, several sub-Saharan economies are not able to provide for the well-being of their citizens. Economic failure of a country serves a recipe for social upheaval, as well as a source for frequent and ugly triggers of intra and interstate conflicts. Many of the conflicts currently going on in some sub-Saharan countries have occurred as a result of economic and political deficiencies.

In the most recent literature, focus by many development economists and financial statisticians has been on accelerated economic growth. Economic growth, rather than short-run macroeconomic policy, continues to be the dominant concern in existing texts on development economics. The rapid decline in economic growth of most of the sub-Saharan countries has resulted in a continual decline in the per capita income of these countries. This has led in a closer scrutiny into the economic structure to examine factors that determine the economic growth of these countries. The relationship between exports and a number of macroeconomic variables has been fully analyzed by a large number of empirical studies. Some studies support the existence of a causal relationship between economic growth and some of the variables. On the other hand some fail to support such relationships. For medium-size economies such as South Africa, timely empirical evidence on the contribution of such macroeconomic variables to economic growth is crucial for the formulation of policies consistent with the efficient use of the country's limited resources.

In this study, the researcher examines the role of some macroeconomic variables on the economic growth of South African over the period first period of 1990 to the second quarter of 2010.They shall henceforth be denoted by 1990Q1-2010Q2 The study evaluates and discusses the empirics of economic growth in South Africa.

1.2 Importance of Studying Economic Growth

Economic growth adds global level that has long been under meticulous study. It is also important to evaluate economic growth to every country. Through studying the sources and causes of economic growth, economists, social scientists, governments and policymakers can embark on the proper strides to economic development. Even though economic growth theory has been studied a great deal, much is still not known or fully understood. Growth theories and strategies change and/or are reversed quite frequently. Failures to understand the causes of economic growth and economic development have caused massive political, economic, and social upheavals in large parts of the world. In the quest by governments to improve the lives and the well-being of humanity, studying the dynamics of economic growth of a country is a challenging and worthy area of research.

1.3 South Africa as Economic Powerhouse of Africa

South Africa is among the most advanced economies on the African continent. The relatively large economic size of the country and its growing influence on other African economies makes South Africa an economic giant within the continent Africa. In 2003, South Africa recorded a GDP equivalent to 33 percent of whole of the Africa's GDP (on the basis of PPP) and nearly 38 percent of African nominal GDP at market exchange rates (South African Reserve Bank, 2005). On the basis of financial linkages, South Africa's direct and portfolio investment over the period 1998-2002 was, on average, about 5% of GDP in other African countries. Over the period 1994-2002, the average external trade share of South Africa in the rest of Africa's went up to three times its 1970-93 average. As a percent of GDP, the rest of Africa's trade with South Africa the same period increased to four times its 1970-93 average level.

During the mid-1980s to the early 1990s, the South African economy had stagnated despite its high level of industrialization. The stagnation was due to the constraints created by the practice of apartheid system of government which prevented the country from fully mobilizing its resources, both human and natural. The apartheid system of government hampered its effective participation in the international economy due to the imposition of a number of sanctions. Since the ending of Apartheid in the early 1990s, South Africa has experienced strong economic growth. A profound restructuring of the economy has paid off in the form of macro-economic stability, booming exports and improved productivity in both capital and labour. In 2002 alone, South Africa's manufacturing sector grew by 5.4%, the fastest increase since 1995 (South African Reserve Bank, 2005). Low inflation, interest rates, as well as personal income taxes have resulted in a high consumer spending. In 2007, the manufacturing sector went up by about 40% over the 1995 figure (South African Reserve Bank, 2005).

The South African economy grew by about 1.9% in 2003, as compared with 3.6% growth in the previous year. The second quarter of 2003 witnessed just a 0.5% growth in real GDP but rose to about 1.0% in the third quarter. South Africa's real GDP grew by about 4.5% in 2004, the fastest rate since 1984, while the provisional figure for 2005 stood at about 5.1% (South Africa Reserve Bank, 2006). In 2006, growth is expected to be moderately lower than that achieved preceding year following the 4.2% measured in the first quarter of 2006 (South African Reserve Bank, 2006). As of the year 2005, the Gross National Income (GNI) of South Africa had reached at current US$165.3 billion with a per capita of current US$3,630 (South African Reserve Bank, 2006).

1.4 Problem Definition

Although economic activities are an important source of foreign exchange earnings and that such activities generate considerable employment in South Africa, there is no recent empirical evidence assessing the impacts of the dynamics of such activities on economic growth in South Africa. Furthermore, even though there seems to be an agreement that economic activities benefit economic growth, recent empirical evidence supporting this development strategy is lacking.

1.5 Study Rationale

As remarked in Njikam (2003), most African countries recorded a slow or negative growth in per capita GDP during the period 1980-1990. This led to worsening balance of payments, debt and financial crises. In the past few years before 2010, however, the South African economy recorded an average annual growth of about 2.5%, which, in per capita terms, suggested that growth had slowed down dramatically. South African authorities were not worried simply because, by comparing the performance of the country's economic growth with that of the developed world, South Africa was seen to be doing fairly well. The year 2002 bears reference when economic growth in the developed world was sluggish against South Africa's positive growth from 2.3% to 3.6% and again the 2.2% growth for 2003 (South African Reserve Bank, 2005).

Naturally one would wonder why the authorities charged with the task of putting the economy on a positive growth path were content with such economic growth performance knowing that the country's per capita income was much lower than that of most of the developed world. As a middle-income country, South Africa's economic capos should rather be encouraged to work harder to make sure that, in the long term, the country's per capita output and income converge towards those of the developed world. How current situation is fairing is interesting question that serves as the main source of motivation for this study.

1.6 Research Objectives

The general objective of this thesis is to postulate macroeconometric models of the South African economy that would serve three main purposes - economic analysis, policy simulations and short term forecasting. The specific objectives are:

- To test the export-led growth hypothesis for South Africa.
- To examine the long-run and short run relationships of economic growth with exports and imports.
- To investigate the causal relationship between government expenditure and economic growth along with money stock.
- To decompose economic growth of South Africa into long-run trend and cyclical component to assess the future path of economic growth in South Africa.
- To identify the impact of macroeconomic shocks on the economic growth of South Africa.
- To forecast the future economic growth of South Africa.
- To give the economic policy recommendations

1.7 Significance of the Study

In the context of the South African economy, it is also the expectation of the researcher that the study brings more insights into the debate that trade openness enhances economic growth. It is the expectation of the researcher that findings from this study will go a long way to contribute to the work so far done in relation to the performance of the South African economy in general.

1.8 Structure of the Study

The mini-dissertation is structured in the following way. Chapter 2 presents a review of the literature related to the study. Different findings related to the topic being studied are reviewed briefly, paying particular attention to literature on economic growth. The chapter also gives an overview of some major economic models that have wide-ranging implications for the economic status of a country. These include the Harrod-Domar Model (HDM), the Solow Growth Model (SGM), and the New Growth Theory.

Chapter 3 focuses on the data used in the study and analytical techniques that underpin the realization of the research objectives. This chapter attempts to collect all theoretical considerations of previous empirical works that are important to build the empirical models applied in the study. The chapter also performs an exploratory analysis of the variables of the study. Empirical analyses and discussion of results are dealt with in Chapter 4. Chapter 5 presents a summary of the findings as well as recommendations based on the findings from the study.

Chapter 2

Review of the Related Literature and Theories

2.1 Introduction

This chapter presents the review of the related literature and core theories related to economic growth with special emphasis on the variables used in this current study – exports of goods and services, imports of goods and services, money stock (M2), government expenditure, gross fixed capital formation, and gross domestic product (GDP).

2.2 Overview of Economic Growth Relationships

This section presents an overview of the relationships of some selected economic variables with economic growth, often proxied by gross domestic product (GDP). Economic growth relationships of such variables as exports, imports, money stock, government expenditure, and gross fixed capital formation are particularly reviewed.

2.2.1 Exports and Economic Growth

Exports are goods and services that are produced domestically and sold to buyers in another country with the intention of uniting them to the mass of things belonging to a foreign country. A vast empirical literature exists that explores the relationship between exports and economic growth. Export-led growth is an economic strategy used by some developing countries. This strategy seeks to find a niche in the world economy for a certain type of export. Industries producing this export may receive governmental subsidies and better access to the local markets. By implementing this strategy, countries hope to gain enough hard currency to import commodities manufactured more cheaply somewhere else.

Export-led growth is important for mainly two reasons. Firstly, it creates profit, allowing a country to balance its finances, as well as surpass their debts as long as the facilities and materials for the export exist. Secondly, much more debatable reason is that increased export growth can trigger greater productivity, thus creating more exports in an upward spiral cycle. The export-led growth (ELG) hypothesis implies that an expanding export sector is a significant determinant of the long-run economic growth of an economy. However, debate over this issue still continues with conflicting results, and it is further fuelled by the unprecedented success stories of the East Asian countries. Export activities are said to stimulate economic growth in a number of ways, through production and demand linkages, economies of scale due to larger international markets, further efficiency, adoption of advanced technologies embodied in foreign-produced capital goods, learning effects and improvement of human resources, and increase productivity through specialization (Were et al, 2002). ELG is said to be an economic development strategy in which export expansion plays a central role in a country's economic growth. Although practical evidence in support of ELG may not be universal, it is widely acknowledged that carefully managed openness to trade through an ELG can be a mechanism for achieving rapid growth (Giles and Williams, 2000). The relationship between exports and economic growth, however, has for a long time remained a subject of debate among economists. Lessons from the identified successes of ELG may be used/applied in the South African economy.

Being a component of GDP, exports contribute directly to national income growth. However, there are a number of reasons why the impact of exports should be greater than the pure volume change. Indirect growth promoting effects may occur due to economies of scale, increased capacity utilization, productivity gains, greater product variety and so on. Furthermore, greater exposure to the world market may induce competitive pressures that lead to technological upgrading, efficiency gains in production as well as in management procedures, etc. All these trade related aspects are not new and have been put forward in the literature more than two decades ago (Feder, 1983; Bhagwati and Srinivasan, 1978; Krueger, 1980). More recent contributions put special emphasis on the role of trade in spurring innovation and facilitating the international transmission of knowledge and technology (Grossman and Helpman, 1991). Thus, the qualitative distinction between the export sector and domestic production with respect to its influence on the path and prospects of economic development is well founded in the theoretical literature.

Several influential researchers including Feder, (1983), Kavonssi, (1984), Ram (1987), and Baldwin and Forslid (1996) studied the relationship between export and economic growth within the neoclassical framework. These studies concluded in support of the ELG. Studies on role of exports in economic growth, also supported by neoclassical view were in support of the ELG hypothesis. However, these were sensitive to the choice of sample and estimating techniques. Generally, the early ELG framework did not provide insights into the direction of the relationship, but merely measured the association between exports and economic growth, hence casting doubt on the results obtained.

The most recent empirical time series estimations have tended to focus attention on the direction or causality between exports and economic growth using granger causality tests (Abdulai and Jaquet, 2002; Sharma and Panagiotidis, 2004; and Abou-Stait, 2005). However, the empirical evidence based on these tests has tended to give mixed and often contradictory results. Findings of the few studies on Zambia were mixed, with others finding support for ELG hypothesis (Amirkhalkhali and Dar, 1995; Dodaro, 1993; Riezman et al., 1996), while others did not support ELG (Love, 1994; Pomponio, 1996). Onafowora et al., (1996) found bidirectional causality between export and economic growth. On the other hand, Njikam, (2003) found that exports have a negative influence on economic growth in the long run in Zambia.

The empirical literature on tests of the hypothesis that exports stimulate growth is equally extensive. Most authors include either export growth (Balassa, 1984; Jung and Marshall, 1985) or a measure of openness (Greenaway and Sapsford, 1994; Sala-i-Martin, 1997) in an empirical growth model and find a significant positive relationship, although some are cautious when assigning the direction of causality (Jung and Marshall, 1985). The studies cited above do not explicitly investigate indirect effects from trade on growth. Feder (1983) is believed to be the first to explicitly describe such indirect effects and develop an analytical framework that allows testing for productivity differentials and externalities between the export and the non-export sector.

On the other hand, the impact of exports or trade composition on growth has been researched considerably less than the relationship between exports or trade and growth in general. Fosu (1990) studied the effect of manufacturing exports on growth for developing countries as compared to primary sector exports, and concluded that there is a differential positive impact by the manufacturing export sector. Greenaway et al. (1999) studied the growth effect of disaggregated exports. In Greenaway et al (1999), certain industries are identified as having a special importance for developing countries' growth performance. Amable (2000), Laursen (2000), and Peneder (2002) investigated the effect of trade specialization (in relation to all other countries) in specific industries. These studies found evidence for an impact of trade specialization on growth. Amable (2000) identified specialization as such to be growth enhancing, but especially specialization in electronics. Laursen (2000) arrived at similar results, reporting that specialization in fast growing sectors (which correspond in general to high-tech sectors) is related to GDP. Peneder (2002) found that specialization in services represents a burden to future growth whereas exports of technology driven and high skill intensive industries have positive effects on aggregate growth. The last two contributions refer to OECD countries while Greenaway et al. (1999) restrict their analysis to developing countries. The coverage of present analysis is similar to the study by Amable (2000). We also adopt a global view and include a large set of industrialized and semi-industrialized countries.

Darrat (1986) worked on four Asian countries and found no evidence of unidirectional causality from exports to economic growth in all the four economies. In the case of Taiwan, however, the study detected unidirectional causality from economic growth to export growth. Erfani (1999) examined the causal relationship between economic performance and exports over the period of 1965 to 1995 for several developing countries in Asia and Latin America. The result showed the significant positive relationship between export and economic growth. This study also provides the evidence about the hypothesis that exports lead to higher output. Vohra (2001) showed the relationship between the export and growth in India, Pakistan, the Philippines, Malaysia and Thailand for 1973 to 1993. The empirical results indicated that when a country has achieved some level of economic development, then the exports have a positive and significant impact on economic growth. The study also showed the importance of liberal market policies by pursuing export expansion strategies and by attracting foreign investments. Subasat (2002) investigated the empirical linkages between exports and economic growth. The analysis suggested the more export oriented countries, such as middle-income countries grow faster than the relatively less export oriented countries .The study also showed that export promotion does not have any significant impact on economic growth for low and high income countries.

Balaguer (2002) examined the hypothesis of export-led growth from the Spanish trade liberalization process initiated four decades ago, for 1961 to 2000. Both the export expansion and the progression from exports to manufactured and semi-manufactured export are considered for this purpose. It is proved that the structural transformation in export composition has become a key factor for Spain's economic development along with the relationship between export and real output. Amavilah (2003) determined the role of exports in economic growth by analyzing Namibia's data from 1968 to 1992. Results explained the general importance of exports, but found no discernible sign of accelerated growth because of exports. Lin (2003) stated that 10% increase in exports caused 1% increase in GDP in the 1990s in China on the basis of new proposed estimation method, when both direct and indirect contributions were considered.

Shirazi (2004) studied the short run and long run relationship among real export, real import and economic growth on the basis of co-integration and multivariate Granger causality developed by Toda and Yamamoto (1995) for the period 1960 to 2003. That study showed a long-run relationship among import, export and economic growth and found unidirectional causality from export to output and did not find any significant causality between import and export. Mah (2005) studied the long-run causality between export and growth with the help of significance of error correction term. Tang (2006), stated that there is no long run relationship among export, real Gross Domestic product and imports. This study further showed no long-run and short-run causality between export expansion and economic growth in China on the basis of Granger causality while economic growth does Granger-cause imports in the short run. Jordaan (2007) analyzed the causality between exports and GDP of Namibia for the period 1970 to 2005.

The hypothesis of growth led by export was tested through Granger causality and cointegration. It tested whether there is uni-directional or bi-direction causality between export and GDP. The results revealed that exports Granger cause GDP and GDP per capita and suggested that the ELG strategy through various incentives has a positive influence on growth. Pazim (2009) tested the validity of ELG hypothesis in three countries by using panel data analysis. It is concluded that there is no significant relationship between the size on national income and amount of export for these countries on the basis of one-way random effect model. The panel unit root test shows that the process for both GDP and export at first difference is not stationary while the panel co-integration test indicates that there is no co-integration relationship between the export and economic growth for these countries. The benefits of the ELG strategy have led, not only to the adoption of this strategy by many countries, but also to a mushrooming of many studies to test the empirical validity of the hypothesis (Al-Yousif, 1997; Ghatak and Price 1997; Shan and Sun, 1998; Islam 1998). However, there are still questions as to whether the ELG strategy will also be beneficial to the small resource-based economies of Sub-Saharan Africa.

The causal relationship between exports and growth in developing economies has been of considerable interest among development economists because of its tremendous policy implications. Obviously, if it can be shown that export growth does not cause income growth but instead, a reverse causal relationship exist. Policy-makers would therefore not need to promote export expansion policies with the aim of achieving income growth. It may, instead, be necessary for policy-makers to concentrate their resources on the production of non-export goods and services, which could eventually cause growth in exports. Many empirical studies have attempted to test for the existence of a causal relationship between exports and economic growth. The results have been mixed. The existing empirical evidence ranges from support for the bidirectional causal relationship to one-way directional causal relationship, either from exports to economic growth or from economic growth to exports and to non-causal relationship between exports and economic growth (Ahmad and Kwan, 1991; Hutchinson and Singh, 1992; Oxley, 1993).

Many of the above mentioned empirical studies were conducted with the implicit assumption that the time-series data used were stationary in their levels and thus integrated of the order zero, I (0). But, it has recently been shown that many macroeconomic series are non-stationary in their levels and thus would lead to spurious results if the OLS technique is used. In testing for causality, many of the previous studies have incorporated arbitrary numbers of lags. But, the optimal number of lags can be determined by using a two-step procedure, which requires combining the Granger causality test with the Final Protection Error (Ahmad and Kwan, 1991; Hutchinson and Singh, 1992). Most of the empirical work support the export led economic growth hypothesis, there is no overall consensus on this issue. While some economists (Balassa, 1985; Chow, 1987; Fosu, 1990; Salvatore and Hatcher, 1991) seem to generally agree that exports benefit economic growth, others (Oxley, 1993; Yaghmaian, 1994; Ahmad and Harnhirum, 1995) did not find much support to the export led economic growth hypothesis.

Some empirical studies were conducted on the basis of inter-country cross-section data sets but there are large differences between economic and demographic structures of different countries. According to Ram (1987), even if the sample of countries chosen seems homogeneous, using cross-sectional analysis, it is hard to unveil the important parametric differences across countries. The statistical methodologies employed by researchers who used time series data have concentrated upon simple Granger-type tests assuming that data on variables are stationary. However, many macroeconomic time series are not stationary, contain unit roots and give rise to many econometric problems. The possibilities of spurious regression relationships among variables exist unless an appropriate statistical test of long run relationship takes into account important characteristics of time series data. The time series on the variables in the model should be tested for their long run relationship prior to testing for causality between them. Jung and Marshall conducted their study with time series data for 37 countries for the period of 1950-1981. They found evidence for exports promoting economic growth in only four countries. Oxley (1993) conducted his study only for

Portugal, using data from 1865 to 1985 and rejected exports led economic growth hypothesis but on the other hand found causality from income growth to export growth. Ahmad and Harnhirum (1995) used Asian countries data for the period of 1966 to 1990. The data did not generally support the exports growth link. Singapore is the only country where the authors found bidirectional causality between exports and economic growth.

2.2.2 Imports and Economic Growth

Imports are goods or services brought in from one country to another country in a legitimate fashion, typically for use in trade. They are goods and services that are brought in from another country for sale. Import goods or services are provided to domestic consumers by foreign producers. According to the general understanding of macroeconomics, import is often recognized as a leakage of revenue which will lead to unemployment rather than economic growth. Based on this assumption, the research on relationship between economic growth and foreign trade can be taken for the study of the relationship between growth and export to test the assumptions of export-led economic growth. Kwan and Cotsomitis (1991) and Kwan and Kwok (1995) took use of Granger causality test to study Chinese growth and foreign trade. They concluded conclusion that the output was an exogenous variable and there was a one-way causal relationship between the two. Lee added other variables, such as the trend of time, FDI and the lagging investment and so on, and concluded that export promoted economic growth by using ad-hoc model and regression analysis. However, he also found that the result was affected by regional differences. Kwan and Kwok (1995) also verified the assumption of export led economic growth using time-series data and regression analysis. He found that employment and output of manufacturing sector could promote export and economic growth. In the model of classical economics, if we took the statistics of population as labor force, export marked the leading role to economic growth, but it could not be reversed.

In these empirical studies, economists used ordinary least squares (OLS) to test these cross-regional or cross-section data, and the results generally support the promotion of export to growth. But its reliability is questionable: the results from OLS only showed the relevance between foreign trade and economic growth but could not explain the existence of a causal relationship between the two. Shen (1999) used Granger causality test and co-integration test to test the hypothesis of Chinese export-oriented economic growth by the data of export and GDP in china from 1977 to 1998. He found that there was a two-way causal relationship between the two, but no long term and stable relations.

The studies took only the output and export into account, but import weighed with the export - output association (Grossman and Helpman, 1991), so the impact of import on economic growth should not be ignored. The developed countries mainly have advantage in capital and technology, and China has advantages mainly in natural resources and labour. The major export products of China are agricultural products and low value-added products, and its import products are high-tech products. The import is an important means to break the bottleneck of economic development and promote economic growth. Meanwhile, imported products will encourage domestic enterprises to improve product quality and production efficiency, and promote the upgrading of traditional industrial structure. As a result, the research on the relationship of import and economic growth is necessary. Tong (1995) explored the relationship between economic growth and import, and recognized that import at different times contributed to economy differently, but on the whole, there was a positive correlation between import and economic growth. Li (1996) made an empirical analysis on economic growth model and pointed out that export boosted economic growth. Peng (1999) found that net exports had less relevance with economic growth. Chen (1999) viewed that export had a great role in promoting economic growth.

Yang (1999) made Chinese data into Balassa model and found that export had a positive correlation with economy. Liu (2001) started from the relevance of foreign trade and GDP growth rate and revealed that imports had a strong role in the promotion of national economy by analyzing the data of china from 1980 to 1998. He also explained why Chinese export had weak correlation with economy from the angle of export structure. Fan et al (2005) studied the relationship through Granger causality model and broad difference approach, using Chinese statistics from 1952 to 2003. The result showed that Chinese GDP and exports had a clear one-way causal relationship. Thus, the export was an important factor to promote Chinese economic growth.

The number of empirical studies on the relationship between imports and productivity is quite limited. Many studies focus exclusively on the relationship between exports and growth, and ignore the role of imports in growth. This is not surprising in the light of the central role of export-oriented industrialization in the East Asian miracle. However, the almost complete neglect of imports is still surprising since economic intuition and theory suggest that imports may serve as an important channel for technological transfer, productivity growth, and economic growth. Such neglect is also unfortunate because it helps to reinforce the deep-seated regional bias against imports. Increased imports of consumer products encourage domestic import-substituting firms to innovate and restructure themselves in order to compete with foreign rivals; therefore, imports enhance productive efficiency. Under perfect competition in the neoclassical model, an industry reduces factor usage in the short run when trade barriers are removed and the market is opened up to imports. In the long run, however, the industry becomes more productive and competitive, and expands its investments in new technology, resulting in a rightward shift of the industry supply curve (Haddad et al., 1996).

According to Tybout (2000), generally, the effect on productivity of opening the market depends on both market structure and institutional factors. Under imperfect competition, an import-substituting domestic market shrinks as imports increase, causing investment to fall and thereby productivity to eventually fall. Furthermore, higher future expected profits lead to more active research and development investment and innovation efforts. Imports of capital goods and intermediate goods that cannot be produced domestically enable domestic firms to diversify and specialize, further enhancing their productivity (Sjoeholm, 1999; Tybout, 2000). Furthermore, there are also theoretical grounds for both positive and negative causality from productivity to imports. Productivity growth triggers economic growth and increases income, which in turn stimulates imports. Sinha (1996) investigated the behaviour of Indian aggregate imports and argued that there was no empirical evidence in favour of the existence of any cointegrated relationship among the variables used in the aggregate import demand function. Muendler (2004) finds that in the Brazilian manufacturing sector, the competitive effects of imports on competition are large even though the effect of intermediate imports on labour productivity is small. The increased productivity in an import-substituting industry crowds out imports from the domestic market and thus has a negative impact. The only study to empirically examine the relationship for Korea does so only very briefly and focuses on Japan (Lawrence and Weinstein, 1999). Their main finding is that imports contributed to total factor productivity (TFP) growth for a panel data set of Japanese manufacturing industries, mainly through competition effects.

2.2.3 Monetary Base

The monetary base is the definitive money of a nation, meaning the State has no obligation to convert it on demand into some other form of money. The State defines the unit of account in base money, makes it legal tender for all debts, public and private, and requires that payments to the State be in base money. Monetary policy is the key macroeconomic tool employed by central banks in maintaining economic growth and price stability. Monetary policy is a cornerstone of macroeconomic policy, aimed at creating macroeconomic stability and economic growth. Monetary policy influences the level of economic activity through actions that influence the overall liquidity in the economy. Effective macroeconomic management presupposes a coordinated monetary policy framework with a clear division of responsibilities and instruments. The monetary financing of a high fiscal deficit and government borrowing at below market-determined interest rates significantly affect the effective functioning of monetary policy and lead ultimately to the build-up of inflationary pressure in the economy.

Support for the monetary base as the central bank's chief policy instrument gained momentum in the mid-1980s with the research findings of Meltzer (1984, 1987) and McCallum (1987, 1988). Both Meltzer and McCallum urged that the Fed adopted a rule to guide the movements of monetary base over time. McCallum (1988, 1993) provided empirical evidence to support his policy prescription for the United States and Japan. With regard to the U.S., McCallum (1988) claimed that his proposed rule would, if it had been in effect, have kept nominal GNP for the United States close to a smooth target growth path over the period 1954-88 despite the regulatory and financial turmoil that occurred during the latter part of that period. Critics such as Friedman (1988) are skeptical that simple base rules would substantially smooth fluctuations of nominal income around a target path. Arguments against adopting the base often center on the fact that currency has become an increasingly large component of the monetary base. In short, critics of base rules argue that the composition of the change in the monetary base matters, because the effect of changes in the base on nominal GNP will differ depending on the distribution of base money between currency and reserves.

The second argument invokes Gresham's Law: The Federal Reserve has always been willing to supply currency to meet whatever quantity is demanded, so that currency will not trade at a premium above its face value. The conjecture is that targeting the base is incongruent with elastic currency supply since the Fed controls only a portion of the base. Moreover, changes in currency may require offsetting movements in reserves. The pure theory of the demand for money assumes that the nominal supply of money is given and is varied at the discretion of the monetary authorities and government. Demand theory sets out to analyze the effects on general equilibrium of a change in the nominal quantity of money or a change in demand for money arising from an exogenous change in tastes. This also explicitly assumes that the monetary authorities and government can control the nominal quantity of money. In contrast to this view there is a school that sees the money supply responding to demand; it therefore concludes that there is no point in attempting to control the economy by monetary policy. Hence a theory of money, if it is to be consistent, requires that supply be determined independently of the money demand. If the theory is to be of use, it must allow that the central bank can control the quantity of money in the hands of the public (Johnson, 1971).

Basically, these functions are two types: Brunner (1961) and Brunner and Melzer (1963) consider money supply as a function of the monetary base, currency-deposit ratio, and reserve-deposit ratio. They contend that, with the monetary base given, the current rate of interest can have very little effect on the supply of money. In contrast, Teigen (1964), Goldfield (1966), Smith (1967), Hodigliani et al (1970), and Bhattacharya (1974) attach importance to the interest rates. The ability of banks to vary the level of excess and borrowed reserves they wish to hold provides an important reason for treating the supply of money as an endogenous variable. The interest responsiveness of excess and borrowed reserves implies a supply function of money that is similarly responsive. To allow for this dependence Telgen (1964) has estimated a relationship in which the money supply is made a function of certain financial parameters and of interest rates. Research work that clarify the understanding of the role of monetary base in economic growth will have policy implications and shape future policy-oriented research. Information about the impact of monetary base on economic growth will influence the priority that policy makers and advisors attach to reforming financial sector policies. Furthermore, convincing evidence that the monetary system influences long-run economic growth will advertise the urgent need for research on the political, legal, regulatory, and policy determinants of financial development. In contrast, if a sufficiently abundant quantity of research indicates that the operation of the financial sector merely responds to economic development, then this will almost certainly mitigate the intensity of research on the determinants and evolution of financial systems.

Studying the linkages between financial development and growth is a popular topic both systems foster growth as they produce ex ante information about possible investment; monitor investment and exert corporate governance after providing finance; facilitate the trading, diversification and management of risk; mobilize and pool savings; and ease the exchange of goods and services. The theoretical foundations of this relationship can be found in a handful of researchers including Fry (1989) and Mathieson (1980). Study by Bofinger (2001) stated that monetary variables need to show a close relationship to the final target of the price level and have to be controllable via the monetary policy instruments at the same time to be eligible to serve as intermediate target in the concept of monetary targeting. The main policy implication of these studies is that government restrictions on the banking system (such as interest rate ceilings, high reserve requirements and directed credit programmes) may have a detrimental effect on financial development and, therefore, reduce economic growth. Similar conclusions are also reached by the endogenous growth literature, which suggests that financial intermediation has a positive effect on steady-state growth (Bencivenga and Smith, 1991) and that government intervention in the financial system has a negative effect on the growth rate (King and Levine, 1993). Goldsmith (1969) provided the first cross-country empirical study documenting the existence of a link between finance and growth. A number of studies followed, mainly focusing on cross-country panel data and making use of several measures of financial development, as well as of different econometric techniques. These studies generally confirmed the existence of a strong positive link between the functioning of the financial system and growth (Levine 2005).

Rajan and Zingales (1998) and Demirguc-Kunt and Maksimovic (1998) used industry-level or firm-level data, across a broad cross-section of countries. They found that in countries with better functioning financial systems, industries that are naturally heavy users of external finance grow faster than industries that are not, and a larger proportion of firms grows at rates that cannot be self-financed, but require access to external financing. Other studies look at the finance-growth nexus using a variety of time-series techniques, such as Granger causality tests and vector autoregressive procedures. Like the panel studies, most of them also note a positive link between various measure of financial development and growth (Levine, 2005). These studies have been written to conceptualize how the development and structure of an economy's financial sector affect domestic savings, capital accumulation, technological innovation, and income growth, or vice versa; and to empirically test these linkages including identifying directions of the causality and their relative importance using cross-country; country-specific; and industry-, firm-, and project-level data. The studies on the monetary base and economic growth confirmed the strong positive relationship between the two variables.

2.2.4 Government Expenditure

Government expenditure or spending refers to government acquisition of goods and services for current use to directly satisfy individual or collective needs of the members of the community. Acquisition of goods and services is made through own production by the government (using the government's labour force, fixed assets and purchased goods and services for intermediate consumption or through purchases of goods and services from market producers. Government spending can be financed by taxes or government borrowing.

The relationship between economic growth and government spending, or more generally the size of the public sector, is an important subject of analysis and debate. A central question is whether or not public sector spending increases the long run steady state growth rate of the economy. The general view is that public expenditure, notably on physical infrastructure or human capital, can be growth-enhancing although the financing of such expenditures can be growth-retarding. Government activity may directly or indirectly increase total output through its interaction with the private sector. Lin (1994) used a sample of 62 countries (1960-85) and found that non-productive spending had no effect on growth in the advanced countries but a positive impact in LDCs. He outlined some important ways in which government can increase growth. These include provision of public goods and infrastructure, social services and targeted intervention (such as export subsidies). The nature of the impact of public expenditure on growth will depend on its form. Following Barro (1990), expenditure on investment and productive activities (in principle including State-owned production) should contribute positively to growth, whereas government consumption spending is anticipated to be growth-retarding. However, in empirical work it is difficult to determine which particular items of expenditure should be categorized as investment and which as consumption.

Numerous studies have been conducted but no consistent evidence found for a significant relationship between public spending and growth, in a positive or negative direction. Results and evidence differ by country and region, analytical method employed, and categorization of public expenditures. In a recent debate regarding the evidence for OECD countries, Folster and Henrekson (1999) argue that the relationship is negative whereas Agell et al. (1999) respond that it is not significant. Furthermore, there is no agreement regarding the direction of causality between public spending and economic growth, implying a potential endogeneity problem in regression analysis (Folster and Henrekson, 1999). According to Grier and Tullock (1989), the actual relationship between public spending and growth is not well understood and there is a need for more empirical research. Economic theory has shown how government spending may either be beneficial or detrimental to economic growth.

In traditional Keynesian macroeconomics, many kinds of public expenditures, even of a recurrent nature, can contribute positively to economic growth, through multiplier effects on aggregate demand. Expenditures are categorized as productive if they are included as arguments in private production functions and unproductive if they are not (Burro and Sala-I-Martin, 1992). This categorization implies that productive expenditures have a direct effect upon the rate of economic growth but unproductive expenditures have an indirect or no effect. The issue of which expenditure items should be categorized as productive or unproductive is debatable and may be difficult to define a priori. Studies using a sample of only advanced (mostly OECD) countries obtain negative results. For instance, Hansson and Henrekson (1994) find that government consumption spending is growth-retarding but spending on education impacts positively on growth. Kneller et al. (1998) found that for the years 1970 to 1995, productive spending has a positive impact, while non-productive spending has a negative impact on growth of OECD countries. Ram (1986), using a sample of 115 countries, found government expenditure to have significant positive externality effects on growth particularly in the developing countries (LDC) sample, but total government spending had a negative effect on growth. Other studies have investigated the impact of particular (functional) categories of public expenditure. Devarajan et al. (1993), used a sample of 14 OECD countries, found that spending on health, transport and communication have positive impacts while spending on education and defence did not have a positive impact.

In the majority of studies, total government spending appears to have a negative effect on growth (Alexander, 1990; Folster and Henrekson, 1999). Empirical evidence on the government spending-growth relationship is diverse, mostly based on cross-section studies that often include a sample of both advanced and developing countries. The main conclusion in most of these studies is that government consumption spending has a negative impact on growth (Easterly and Rebelo, 1993; Tanninen, 1999). Barro (1990) examined an endogenous growth model that suggests a possible relationship between the share of government spending in GDP and the growth rate of per capita real GDP. The key feature of Barro's model is the presence of constant returns to capital that broadly includes private capital and public services. To the extent that public services are considered an input to production, a possible linkage arises between the size of government and economic growth. Saez and Garcia (2006) studied the relationship between government expenditure and economic growth in the EU-15 countries. The results obtained based on regressions and panel techniques suggest that government spending is positively related with economic growth in the EU countries.

Hsieh and Lai (1994) examined the inter-temporal interactions among the growth rate in per capita real GDP, the share of government spending, and the ratio of private investment to GDP for the Group-of-Seven (G7) countries (Canada, France, Germany, Italy, Japan, the United Kingdom and the United States of America). They found no consistent evidence which government spending increases per capita output growth. There is also no consistent support for the negative argument. Ghali (1997) examined the relationship between government expenditure and economic growth in Saudi Arabia using the series of the growth rate in per capita real GDP and the share of government spending in GDP. He found no consistent evidence that government spending can increase Saudi Arabia's per capita output growth.

In a related study, Ramayandi (2003) investigated the impact of government size on economic growth using a sample of time series data on Indonesia based on the data from 1969 to 1999. He found consistent evidence that the share of government consumption spending decreases economic growth. Surprisingly, the share of government investment also shows negative effect on growth. For the case of a developing economy such as Turkey, the empirical studies on the relationship between the share of government spending in GDP and the economic growth have been extensively debated (Altay and Altın, 2008; Arısoy, 2005; Yılmaz and Kaya, 2005; Taban, 2010). Most of these studies have shown no evidence supporting Barro's view of the role of government spending in Turkey. For example, Altay and Altın (2008) found no causal link between the share of total government spending in GDP and economic growth for the period 1980 to 2005. Arısoy (2005) examined the relationship between economic growth and total government expenditure as well as its various components, such as consumption, investment and transfer spending as the ratio of GDP during the period 1950 to 2003. Although the results do not support the existence of any long run causal relationship between economic growth and total government expenditures, they do support the existence of long run relationship between economic growth and the disaggregated government expenditure variables, running from economic growth to disaggregated public expenditures. In a similar study, Uzay (2002) found that the share of total government spending to GDP reduced economic growth. Yılmaz and Kaya (2005) found no relationship between the growth rate of real per capita GDP and the share of government consumption spending. However, when the share of public investment was considered, they found a positive and statistically significant effect on growth. Recently, Taban (2010) investigate this issue empirically by using the data of the share of government consumption spending on goods and services in GDP. From his empirical exercise, he found no consistent evidence that there is a relationship between government consumption spending and economic growth in Turkey.

2.2.5 Gross Fixed Capital Formation

Government acquisition of goods and services intended to create future benefits, such as infrastructure investment or research spending, which usually is the largest part of the government gross capital formation. Fixed capital formation (often referred to as investment) plays a major role in economic growth and cyclical fluctuations. In a long term, investment increases the capacity of the economy to produce goods and services and thus leads to economic growth. Over the short-term, investment is an important and volatile component of aggregate demand. Investment is a flow variable, which is the rate of addition to the stock of capital which have accumulated in the past. Investment can be measured in gross or net terms. Gross investment is the sum of the additions to capital stock, while net investment is the sum of these additions minus any reductions in the capital stock, of which depreciation is the most important.

Theoretically, the gross capital formation affects the economic growth by increasing the physical capital stock in domestic economy directly (Plossner, 1992). Many empirical studies have emphasized in diversified role of private and public investments in growth process. The public investments on infrastructure, extent in which are proved to be complementary to the private investments, can increase the marginal product of the private capital, augmenting the growth rate of a domestic economy. Khan and Kumar (1997) supported that the effects of private and public investments on economic growth differ significantly, with private investment to be more productive than public one. Knight et al. (1993) and Nelson and Singh (1994) confirmed that public investments on infrastructure have an important positive effect on economic growth over the period 1980 to 1990. Easterly and Rebelo (1993) revealed that public investments on transportation and communications are positively correlated to economic growth, while there were negative effects of public investments of state-owned businesses on economic growth. The effect of foreign direct investment on economic growth is dependent on the level of technological advance of a host economy, the economic stability, the state investment policy and the degree of openness.

FDI inflows can affect capital formation because they are a source of financing and capital formation is one of the prime determinants of economic growth. Inward FDI may increase a host's country productivity and change its comparative advantage. If productivity growth were export biased then

FDI would affect both growth and exports. A host's country institutional characteristics such as its legal system, enforcement of property rights, could influence simultaneously the extent of FDI and inflows and capital formation in that country. Blomstoerm et al. (1994) found a unidirectional causal relationship between FDI inflows as a percentage of GDP and the growth of per capita GDP for all developed countries over the period 1960 to 1985. Zhang (1999) examines the causal relationship between foreign direct investment and economic growth with Granger causality analysis for 10 Asian countries. The results suggested that there is a unidirectional causality between foreign direct investment and economic growth with direction from FDI to GDP in Hong Kong, Japan, Singapore and Taiwan; a unidirectional causality between exports and economic growth with direction from economic growth to exports for Malaysia and Thailand, and a bilateral causal relationship between FDI and GDP for Kina and Indonesia. On the other hand there is no causality for Korea and Philippines. Borensztein et al. (1998) discussed the role of FDI as an important vehicle of economic growth only in the case that there is a sufficient absorptive capability in the host economy. This capability is dependent on the achievement of a minimum threshold of human capital. Moudatsou (2003) suggested that FDI inflows have a positive effect on economic growth in European Union countries both directly and indirectly through trade reinforcement over the period 1980 to 1996.

2.3 Overview of Related Economic Growth Theories

The interest in the study of economic growth has been central in classical political economy. Since its inception, growth models postulated by early authors attempted to generalize Keynes's principle of effective demand in the long run ignited an interest in economic growth theory. Following the publication of papers by Robert Solow and Nicholas Kaldor in the mid-1950s, economic growth theory became one of the central topics in classical political economy and continues to remain to date. In this chapter, the objective is to review three major economic models that have wide-ranging implications for the economic status of a country - the Harrod-Domar Model (HDM), the Solow Growth Model (SGM), and the New Growth Theory.

2.3.1 The Harrod-Domar Model

The Harrod-Domar model, developed by Roy F. Harrod and Evsey Domar in the late 1940s, follows a Keynesian framework that incorporates variables known to influence economic growth. The Harrod-Domar model was originally developed to help analyze the business cycle. However, it was later adapted to 'explain' economic growth. The model appeals to the following conclusions:

- Economic growth depends on the amount of labour and capital.
- Least Developed Countries (LDCs) often have an abundant supply of labour, it is a lack of physical capital that holds back economic growth and development.
- More physical capital generates economic growth.
- Net investment leads to more capital accumulation, which generates higher output and income.
- Higher income allows higher levels of saving.

The formulated on the two assumptions which are:

- The economy in question is closed to foreign capital flows and has no government sector; and
- The capital-output ratio, K_t/Y_t, is constant.

The Harrod-Domar model is simple. The fundamental equation underlying at time t is given by the relationship between national income or output (Y_t), consumption (C_t), and savings (S_t):

$$Y_t = C_t + S_t \tag{2.1}$$

Where national income (Y_t) relates to consumption (C_t) and investment (I_t) according to the following relationship:

$$Y_t = C_t + I_t \tag{2.2}$$

Equation (2.1) and (2.2) imply:

$$S_t = I_t . \tag{2.3}$$

Also, investment (I_t) can be used to increase a country's capital stock (K_t). The relationship between investment and capital stock, given the rate of depreciation (λ), is given by:

$$K_{t+1} = (1-\lambda)K_t + I_t . \tag{2.4}$$

In the absence of any depreciation, $\lambda = 0$, and so equation (2.4) becomes

$$K_{t+1} = K_t + I_t \qquad \text{or} \qquad K_{t+1} = K_t + S_t \tag{2.5}$$

Since savings rate (s) and capital-output ratio (ξ) relate to savings (S_t), output (Y_t) and capital stock (K_t), according to the following relations:

$$s = S_t / Y_t \qquad \text{or} \qquad S_t = s.Y_t \tag{2.6}$$

$$\text{and} \qquad \xi = K_t / Y_t \qquad \text{or} \qquad K_t = \xi.Y_t, \tag{2.7}$$

substituting equations into equation (2.5) yields:

$$\xi.Y_{t+1} = \xi.Y_t + s.Y_t$$

$$\Rightarrow \qquad \xi.Y_{t+1} - \xi.Y_t = s.Y_t \qquad \text{or} \qquad \frac{Y_{t+1} - Y_t}{Y_t} = \frac{s}{\xi}$$

$$\text{or} \qquad g = \frac{s}{\xi}, \tag{2.8}$$

where $g = (Y_{t+1} - Y_t)/Y_t$ is the growth rate. In the presence of depreciation (d), ξ is replaced by $(\xi - d)$, and so equation (2.8) becomes:

$$g = \frac{s}{\xi - d}. \tag{2.9}$$

Equations (2.8) and (2.9) mean that growth is accelerated when as savings rate, s, goes up and as capital-output ratio declines. The model suggests that the growth rate of an economy depends on both the level of saving and the productivity of investment (i.e. the capital output ratio). Thus, saving and capital output ratio are the two key variables in the Harrod-Domar model.

Implications and Important Features of the Harrod-Domar Model

The key to economic growth is to expand the level of investment both in terms of fixed capital and human capital. To do this policies are needed that encourage saving and/or generate technological advances which enable firms to produce more output with less capital i.e. lower their capital output ratio. There are two important features about the Harrod-Domar model.

i. Savings must be treated as a policy instrument (exogenous variable), when, it is, in fact, an endogenous variable, and

ii. The fact that the capital-output ratio is constant means that savings have a growth effect – i.e. an increase in savings increases investment by the same proportion. Thus, higher capital accumulation will accelerate output growth.

The Harrod-Domar Model and Its Inherent Problems

- Economic growth is a necessary but not sufficient condition for development. This means that economic growth and economic development are not the same.
- Practically it is difficult to stimulate the level of domestic savings particularly in the case of Least Developed Countries where incomes are low.
- Borrowing from overseas to fill the gap caused by insufficient savings causes debt repayment problems later.
- The law of diminishing returns would suggest that as investment increases the productivity of the capital will diminish and the capital to output ratio rise.

2.3.2 The Solow Growth Model

In 1956, economist Robert Solow of MIT developed a classic model of growth. The model, called the Solow Growth Model (SGM), is based on the law of diminishing returns to each factor of production, which suggests that, unlike in the Harrod-Domar Model, the capital-output ratio is not constant. In fact, the capital-output ratio tends to increase as per capita output increases. The SGM, which had implications for balanced growth and technology, can broadly be presented in two methods:

i. Using a Keynesian national income identity function along with the condition that net savings equal net investment (i.e., $S_t = I_t$).

ii. Using the Cobb-Douglas aggregate production function. Here, income is made to equal a Cobb-Douglas aggregate production function.

2.3.3 Using the Keynesian National Income Identity Function

Substituting equations (2.3) and (2.6) into equation (2.4) yields:

$$K_{t+1} = (1-\lambda)K_t + s.Y_t \, . \qquad (2.10)$$

Given the population at time t, P_t, and assuming that it grows at a constant rate, r, then:

$$P_{t+1} = (1+r).P_t$$

$$\text{or} \qquad P_t = \frac{P_{t+1}}{1+r} \, . \qquad (2.11)$$

Next, we use the per capita magnitudes $y_t = Y_t/P_t$, $k_t = K_t/P_t$ and $k_{t+1} = K_{t+1}/P_{t+1}$, and the fact that:

$$k_{t+1} = \frac{K_{t+1}}{P_{t+1}} = \frac{K_{t+1}}{(1+r).P_t}$$

$$\text{or} \qquad \frac{K_{t+1}}{P_t} = (1+r).k_{t+1} \, .$$

Then, dividing equation (2.10) by P_t:

$$\frac{K_{t+1}}{P_t} = (1-\lambda)\frac{K_t}{P_t} + s.\frac{Y_t}{P_t}$$

$$\Rightarrow \qquad (1+r)k_{t+1} = (1-\lambda)k_t + s.y_t \, . \qquad (2.12)$$

Equation (2.12) suggests that the higher per capita savings ($s.y_t$), the higher per capita capital stock, and the higher population growth, the lower per capita capital stock and the lower the per capita savings.

2.3.4 Using the Cobb-Douglas Production Function

The Cobb-Douglas Production Function could take several forms. Popular among them are the four basic forms:

- the capital-population ratio form;
- the capital-labor ratio form;

- the capital-output form; and
- the incorporation of technology.

Cobb-Douglas Production Function: The Capital-Population Ratio Form

In its simplest form, the Cobb-Douglass Production Function can be expressed as:

$$Y_t = A.K_t^{\alpha} P_t^{1-\alpha}, \tag{2.13}$$

where A is a constant and $0 < \alpha < 1$. The value of α is the contribution of capital to aggregate output (Y_t). A value of α near zero means that the extra amount of output (Y_t) made possible by unit of capital declines very quickly as the capital stock (K_t) arises. A value of α near one means that each additional unit of capital makes possible as almost as large as an increase in output as the last additional unit. Dividing both sides of equation (2.13) yields:

$$\frac{Y_t}{P_t} = A.K_t^{\alpha}.\frac{P_t^{1-\alpha}}{P_t} = A.K_t^{\alpha}.P_t^{-\alpha}$$

$$\Rightarrow \quad \frac{Y_t}{P_t} = A.K_t^{\alpha}.P_t^{-\alpha}.\frac{P_t^{\alpha}}{P_t^{\alpha}} = A.\frac{K_t^{\alpha}}{P_t^{\alpha}},$$

$$\Rightarrow \quad y_t = A.k_t^{\alpha}, \tag{2.14}$$

where we have used the per capita magnitudes $y_t = Y_t/P_t$ and $k_t = K_t/P_t$.

Implications of the Solow Growth Model in the Long Run

Equation (2.14) suggests that per capita output (y_t) is proportionally related to per capita stock (k_t). The absence of savings (S_t) means that savings have no growth effects in the long run, but only level effects. Intuitively, per capita output grows at decreasing rates until a country's economy reaches the steady state, a situation that only occurs through capital accumulation, which is a function of per capita output (y_t). Now, based on the fact that an increase in capital in relation to labour (L_t) moves up the capital-output ratio (ξ), that per capita output (y_t) grow less will be expected to grow less, according to the following deductions:

$$\xi = \frac{K_t}{Y_t} = \frac{K_t/P_t}{Y_t/P_t} = \frac{k_t}{y_t}$$

$$\Rightarrow \qquad y_t = \frac{k_t}{\xi}. \tag{2.15}$$

In the steady state, capital stock (K_t) is constant and so is per capita stock (k_t), and hence per capita output (y_t). In that case, equation (2.15) becomes:

$$y_t = \delta, \tag{2.16}$$

where $\delta = k_t/\xi$ is a constant. Substituting the expression $y_t = Y_t/P_t$ into equation (2.16) and re-arranging the results yields the following relation:

$$Y_t = \delta.P_t. \tag{2.17}$$

Equation (2.17) means that output grows at the same rate as population growth rate. At this point the capital-labour ratio becomes constant, and so K, L and Y grow at the same rate in the steady state. Thus, the most important features of the Solow Growth Model that must be observed are that:

- diminishing returns to capital.
- in the long run, output, capital and labour grow at the same rate.
- the capital-output ratio increases overtime, until it gets constant in the steady state.

Implications of the Solow Growth Model at the Steady State

In the steady state, capital stock and output are constant. Therefore $K_t = K_{t+1} = K$ and $Y_t = Y_{t+1} = Y$. Therefore, at the steady state, equation (2.12) becomes:

$$(1+r)k_{t+1} = (1-\lambda)k_t + s.y_t$$

$$(1+r)k = (1-\lambda)k + s.y$$

$$\Rightarrow \qquad (1+r)k - (1-\lambda)k = s.y$$

$$\Rightarrow \qquad (r+\lambda)k = s.y$$

$$\Rightarrow \quad \frac{k}{y} = \frac{s}{r+\lambda}$$

$$\Psi = \eta . s, \tag{2.18}$$

where $\eta = 1/(r+\lambda)$ is a constant and $\Psi = k/y$. Equation (2.18) suggests that an increase in s will increase Ψ. Now, from the relation $\Psi = k/y$, the following deductions can be made:

$$\Psi = \frac{k}{y} = \frac{K/P_t}{Y/P_t} = \frac{K}{Y} = \frac{\xi/Y}{Y} = \frac{\xi}{Y^2}$$

$$\Rightarrow \quad \xi = \Psi . Y^2 . \tag{2.19}$$

Equation (2.19) means that an increase in s, which will increase Ψ, will cause a higher capital-output ratio, ξ. A higher capital-output ratio under the assumption of diminishing returns implies in the new steady state a higher capital per capita level and therefore higher output per capita level. This means that even though savings have no growth effects in the long run, it does in the short run, so that it is possible to move from one steady state to another.

Cobb-Douglas Production Function: The Capital-Labour Ratio Form

The Capital-Labour form of the Cobb-Douglas Production Function can compactly be written as:

$$Y_t = K_t^{\alpha} . (L_t . E_t)^{1-\alpha}, \tag{2.20}$$

where L_t is labour force and E_t is labour efficiency, and $0 < \alpha < 1$. Dividing both sides of equation (2.20) by L_t yields the capital-labour (i.e., the capital-per-worker) form of the Cobb-Douglas Production Function:

$$\frac{Y_t}{L_t} = \left(\frac{K_t}{L_t}\right)^{\alpha} . E_t^{1-\alpha} \tag{2.21}$$

where Y_t/L_t is output per worker (i.e. output-labour ratio or productivity per worker) and K_t/L_t is capital stock per worker (or capital-labour ratio). Assuming capital stock is constant, then this year's capital stock (K_t) will be the same as that of next year (K_{t+1}) and so $K_{t+1} = K_t = K$. Thus, equation (2.10) becomes:

$$K_{t+1} = (1-\lambda)K_t + s.Y_t,$$

$$K_t = (1-\lambda)K_t + s.Y_t$$

$$\text{or} \qquad \frac{K_t}{Y_t} = \frac{s}{\lambda}. \qquad (2.22)$$

Equation (2.22), called the *capital-output ratio*, suggests that if the capital-output ratio (K_t/Y_t) is lower than s/λ, then

$$\frac{K_t}{Y_t} < \frac{s}{\lambda}$$

$$\Rightarrow \qquad \lambda.K_t < s.Y_t \qquad (2.23)$$

and so depreciation ($\lambda.K_t$) will be less than investment ($s.Y_t$) so that capital stock and capital-output ratio will grow until K_t/Y_t reaches s/λ. Conversely, if the capital-output ratio (K_t/Y_t) is greater than s/λ, then

$$\frac{K_t}{Y_t} > \frac{s}{\lambda}$$

$$\Rightarrow \qquad \lambda.K_t > s.Y_t \qquad (2.24)$$

and so depreciation ($\lambda.K_t$) will be more than investment ($s.Y_t$) so that capital stock and capital-output ratio will shrink until K_t/Y_t reaches s/λ. Thus, in the long run, the capital-output ratio will be s/λ.

Cobb-Douglas Production Function: The Capital-Output Ratio Form

The capital-output form of the Cobb-Douglas Production Function can be derived from the *capital-labour form* of the Cobb-Douglas Production Function:

$$\frac{Y_t}{L_t} = \left(\frac{K_t}{L_t}\right)^{\alpha}.E_t^{1-\alpha}, \qquad (2.25)$$

Substituting the relation $K_t/L_t = (K_t/Y_t).(Y_t/L_t)$ in equation (3.25), yields the capital-output form of the Cobb-Douglas Production Function:

$$\frac{Y_t}{L_t} = \left(\frac{K_t}{L_t}\right)^{\alpha}.E_t^{1-\alpha} = \left(\frac{K_t}{Y_t}.\frac{Y_t}{L_t}\right)^{\alpha}.E_t^{1-\alpha}$$

$$\Rightarrow \quad \frac{Y_t}{L_t} = \left(\frac{K_t}{Y_t}\right)^{\alpha}\left(\frac{Y_t}{L_t}\right)^{\alpha}.E_t^{1-\alpha}$$

$$\Rightarrow \quad \left(\frac{Y_t}{L_t}\right)^{1-\alpha} = \left(\frac{K_t}{Y_t}\right)^{\alpha}.E_t^{1-\alpha}$$

$$\Rightarrow \quad \frac{Y_t}{L_t} = \left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}}.E_t^{\frac{1-\alpha}{1-\alpha}} = \left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}}.E_t. \qquad (2.26)$$

The equilibrium value of output per worker can therefore be calculated by substituting $\frac{K_t}{Y_t} = \frac{s}{\lambda}$ into equation (2.26):

$$\frac{Y_t}{L_t} = \left(\frac{s}{\lambda}\right)^{\frac{\alpha}{1-\alpha}}.E_t. \qquad (2.27)$$

By adding realism, one would expect that labour efficiency and labour force grow over time. We will assume that, over time, both labour efficiency E_t and labour force L_t will grow at constant rates g and r, respectively. Now, recalling that

$$\frac{Y_t}{L_t} = \left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}}.E_t,$$

if K_t/Y_t and E_t is growing at a constant rate g, then mathematically, Y_t/L_t will also grow at a constant rate g (i.e., output per worker will also grow at the rate g). Thus, with output per worker growing at the rate g and labour force growing at the rate r, the total output will be growing at the constant rate $(r+g)$, and so is capital stock, K_t. This means that period-over-period change in the capital stock, $(K_{t+1} - K_t)$, will be:

$$K_{t+1} - K_t = (r+g)K_t . \qquad (2.28).$$

But, we also have it that:

$$K_{t+1} = (1-\lambda)K_t + s.Y_t$$

or $$K_{t+1} - K_t = s.Y_t - \lambda K_t . \qquad (2.29)$$

From equations (2.28) and (2.29), we have:

$$(r+g)K_t = s.Y_t - \lambda K_t$$

or $$\frac{K_t}{Y_t} = \frac{s}{r+g+\lambda} . \qquad (2.30)$$

which is the equilibrium condition for the Solow Growth Model, also called the balanced-growth capital-output ratio or the equilibrium capital-output ratio. If

$$\frac{K_t}{Y_t} < \frac{s}{r+g+\lambda} \qquad \text{or} \qquad (r+g+\lambda).K_t < s.Y_t , \qquad (2.31)$$

then, the economy's total investment $(s.Y_t)$ will be more than enough to provide new workers with the capital they need to be productive. Conversely, if

$$\frac{K_t}{Y_t} > \frac{s}{r+g+\lambda} \qquad \text{or} \qquad (r+g+\lambda).K_t > s.Y_t , \qquad (2.32)$$

then, the economy's total investment $(s.Y_t)$ will be insufficient to keep capital stock growing in order to provide new workers with the capital they need to be productive. Lastly, substituting equation (2.30) into equation (2.26), we obtain:

$$\frac{Y_t}{L_t} = \left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}} .E_t$$

$$\frac{Y_t}{L_t} = \left(\frac{s}{r+g+\lambda}\right)^{\frac{\alpha}{1-\alpha}} . E_t = c.E_t \qquad (2.33)$$

where $c = \left(\frac{s}{r+g+\lambda}\right)^{\frac{\alpha}{1-\alpha}}$ is a constant. Equations (2.27) and (2.33) suggest that along the balanced-growth path, output per worker (Y_t/L_t) is directly proportional to the labour efficiency (E_t). Thus, as labour efficiency (E_t) grows at a rate of g, period-over-period, so will the output per worker (Y_t/L_t).

Cobb-Douglas Production Function: Incorporating Common Technology

The Cobb-Douglas Production Function incorporating common technology is given by

$$Y_t = K_t^{\alpha}.(A_t.L_t)^{1-\alpha}, \qquad (2.34)$$

where Y_t, K_t, L_t have their usual meanings while A_t represents the level of technology and $0 < \alpha < 1$. Denote the rate of growth of labour-augmenting technology by p and the growth of labour by r. Next, dividing both sides of equation (2.34) by L_t, using the relations $A_t = A_0.e^{gt}$ and $L_t = L_0.e^{rt}$, and re-arranging the results yields:

$$\frac{Y_t}{L_t} = \left(\frac{K_t}{L_t}\right)^{\alpha} .A_t^{1-\alpha},$$

$$\text{or} \qquad y_t = k_t^{\alpha}.(A_0 e^{gt})^{1-\alpha} \qquad (2.35)$$

where the lowercase letters represent the per capita terms of such variables. Then, in logarithmic terms, equation (2.35) becomes:

$$\ln(y_t) = \ln(k_t^{\alpha}) + \ln(A_0 e^{gt})^{1-\alpha} = \alpha.\ln(k_t) + (1-\alpha)\ln(A_0 e^{gt})$$

$$\Rightarrow \qquad \ln(y_t) = \alpha.\ln(k_t) + (1-\alpha)(\ln A_0 + \ln e^{gt})$$

$$\Rightarrow \qquad \ln(y_t) = \alpha.\ln(k_t) + (1-\alpha).\ln A_0 + (1-\alpha).gt. \qquad (2.36)$$

Differentiating equation (2.36) with respect to time t, we obtain:

$$\frac{\frac{\partial}{\partial t}(y_t)}{y_t} = \alpha.\frac{\frac{\partial}{\partial t}(k_t)}{k_t} + 0 + (1-\alpha)g$$

$$\Rightarrow \qquad \frac{\dot{y}_t}{y_t} = \alpha.\frac{\dot{k}_t}{k_t} + (1-\alpha).g \tag{2.37}$$

where $\dot{y}_t$ and $\dot{k}_t$ are, respectively the derivatives of y_t and k_t, with respect to time, and the fact that $(1-\alpha).\ln A_0$ is a constant. Equation (2.37) is similar to that used in growth accounting exercises, allows econometric estimation of both the degree of diminishing returns to capital $(1-\alpha)$ and the rate of technological progress, g. Next, if we express the relation:

$$k_t = \frac{K_t}{A_t L_t} \tag{2.38}$$

in the logarithmic form, we have

$$\ln(k_t) = \ln(K_t) - \ln(A_t) - \ln(L_t). \tag{2.39}$$

Differentiating equation (2.39) with respect to time t, we obtain:

$$\frac{\frac{\partial}{\partial t}(k_t)}{k_t} = \frac{\frac{\partial}{\partial t}(K_t)}{K_t} - \frac{\frac{\partial}{\partial t}(A_t)}{A_t} - \frac{\frac{\partial}{\partial t}(L_t)}{L_t}$$

$$\Rightarrow \qquad \frac{\dot{k}_t}{k_t} = \frac{\dot{K}_t}{K_t} - \frac{\dot{A}_t}{A_t} - \frac{\dot{L}_t}{L_t}. \tag{2.40}$$

Substituting the relations $\dot{L}_k = r.L_t$, $\dot{A}_t = g.A_t$ and the capital accumulation relation $\dot{K}_t = s.Y_t - \lambda.K_t$ in equation (2.40) yields:

$$\frac{\dot{k}_t}{k_t} = \frac{s.Y_t - \lambda.K_t}{K_t} - \frac{g.A_t}{A_t} - \frac{r.L_t}{L_t}$$

$$\Rightarrow \qquad \frac{\dot{k}_t}{k_t} = \frac{s.Y_t}{K_t} - (r + g + \lambda). \tag{2.41}$$

Also, from $y_t = Y_t/(A_tL_t)$ and $k_t = K_t/(A_tL_t)$, we have

$$Y_t = \frac{y_t.K_t}{k_t}. \tag{2.42}$$

Substituting equation (2.42) into equation (2.41) yields:

$$\frac{\dot{k}_t}{k_t} = \frac{s.\left(\frac{y_t.K_t}{k_t}\right)}{K_t} - (r+g+\lambda) = \frac{s.y_t}{k_t} - (r+g+\lambda)$$

$$\Rightarrow \quad \dot{k}_t = s.y_t - (r+g+\lambda)k_t. \tag{2.43}$$

Also, dividing both sides of equation (2.34) by $A_t.L_t$ and the using the relations $y_t = Y_t/(A_tL_t)$ and $k_t = K_t/(A_tL_t)$, we have:

$$Y_t = K_t^{\alpha}.(A_t.L_t)^{1-\alpha}$$

$$\Rightarrow \quad \frac{Y_t}{A_tL_t} = \frac{K_t^{\alpha}.(A_t.L_t)^{1-\alpha}}{A_t.L_t} = K_t^{\alpha}.(A_t.L_t)^{-\alpha} = \left(\frac{K_t}{A_t.L_t}\right)^{\alpha}$$

$$\Rightarrow \quad y_t = k_t^{\alpha} = f(k_t). \tag{2.44}$$

Thus, y_t is a function of k_t. Substituting equation (2.44) into equation (2.43) yields:

$$\dot{k}_t = s.f(k_t) - (r+g+\lambda)k_t, \tag{2.45}$$

Equation (2.45) means that the rate of change per unit of effective labour, $\dot{k}_t$, is just the difference between the actual investment $(s.f(k_t)$ and the break-even investment $(r+g+\lambda)k_t$.

Also, the economy will converge to a steady state when:

$$\frac{\dot{k}_t}{k_t} = 0$$

$$\Rightarrow \quad \dot{k}_t = 0, \tag{2.46}$$

and so, at the steady state, equation (2.46) becomes:

$$0 = s.f(k_t) - (r+g+\lambda)k_t$$

$$\Rightarrow \qquad s.f(k_t) = (r+g+\lambda)k_t. \qquad (2.47)$$

But, recalling that $f(k_t) = k_t^{\alpha}$, equation (2.47) becomes:

$$s.k_t^{\alpha} = (r+g+\lambda)k_t \qquad \text{or} \qquad k_t^{\alpha-1} = \frac{r+g+\lambda}{s}$$

$$\Rightarrow \qquad k_t = \left(\frac{r+g+\lambda}{s}\right)^{\frac{1}{\alpha-1}} = \left(\frac{s}{r+g+\lambda}\right)^{\frac{1}{1-\alpha}}. \qquad (a)$$

Then from the relation, $k_t = K_t/(A_t L_t)$, the value for capital per worker is given by:

$$\frac{K_t}{L_t} = k_t.A_t = A_t.\left(\frac{s}{r+g+\lambda}\right)^{\frac{1}{1-\alpha}}. \qquad (b)$$

Also, at the steady state, y_t and k_t are constant, while A_t grows at the rate g and L_t grows at the rate r. Then, since:

$$y_t = \frac{Y_t}{A_t.L_t}$$

$$\Rightarrow \qquad Y_t = y_t.(A_t L_t) \qquad (2.48)$$

and

$$k_t = \frac{K_t}{A_t.L_t}$$

$$\Rightarrow \qquad K_t = k_t.(A_t L_t), \qquad (2.49)$$

implies that, at the steady state, both Y_t and K_t will grow at the rate $(g+r)$.

2.3.5 The New Growth Theory

The new growth theory is based on the intuition that education is beneficial for growth. By broadening the concept of capital to include its human form (excluding unskilled labour), the production can be determined by the following relation:

$$Y_t = K_t^{\alpha}.H_t^{1-\alpha}, \qquad (2.50)$$

where H is human capital. Dividing equation (2.50) by population P_t and using the per capita magnitudes, $y_t = Y_t/P_t$, $k_t = K_t/P_t$ and $h_t = H_t/P_t$, we have:

$$\frac{Y_t}{P_t} = K_t^{\alpha}.\frac{H_t^{1-\alpha}}{P_t},$$

$$\Rightarrow \qquad \frac{Y_t}{P_t} = K_t^{\alpha}.\frac{H_t^{1-\alpha}}{P_t}.\frac{H_t^{\alpha}}{H_t^{\alpha}}.\frac{P_t^{\alpha}}{P_t^{\alpha}} \qquad (2.51)$$

Re-arranging equation (2.51) yields:

$$\frac{Y_t}{P_t} = \frac{K_t^{\alpha}}{P_t^{\alpha}}.\frac{H_t}{P_t}.\frac{P_t^{\alpha}}{H_t^{\alpha}} = \left(\frac{K_t}{P_t}\right)^{\alpha}.\frac{H_t}{P_t}.\left(\frac{P_t}{H_t}\right)^{\alpha} = \left(\frac{K_t}{P_t}\right)^{\alpha}.\frac{H_t}{P_t}.\left(\frac{H_t}{P_t}\right)^{-\alpha},$$

$$\Rightarrow \qquad \frac{Y_t}{P_t} = \left(\frac{K_t}{P_t}\right)^{\alpha}.\frac{H_t}{P_t}.\left(\frac{H_t}{P_t}\right)^{-\alpha}$$

$$\Rightarrow \qquad y_t = k_t^{\alpha}.h_t.h^{-\alpha} = k_t^{\alpha}.h_t^{1-\alpha}. \qquad (2.52)$$

Then for an output, the part that is not consumed can be saved and invested in both physical capital and human capital. Denote the part that is saved for physical capital accumulation by s and the part saved for human capital accumulation, by w.

Assuming population is constant, then in the absence of capital depreciation ($\lambda = 0$), equation (2.10) becomes:

$$K_{t+1} = K_t + s.Y_t$$

$$\Rightarrow \qquad k_{t+1} = k_t + s.y_t, \qquad (2.53)$$

and

$$H_{t+1} = H_t + w.Y_t$$

$$\Rightarrow \qquad h_{t+1} = h_t + w.y_t, \qquad (2.54)$$

where lowercase letters represent variables in per capita terms.

Let $R = h_t / k_t$ be the ratio of human capital to physical capital. Then, by dividing both sides of equation (2.53) by k_t and re-arranging the results yields:

$$k_{t+1} - k_t = s.y_t$$

$$\Rightarrow \quad y_t = \frac{k_{t+1} - k_t}{s}. \tag{2.55}$$

Similarly, dividing both sides of equation (2.54) by h_t and re-arranging the results yields:

$$h_{t+1} - h_t = w.y_t$$

$$\Rightarrow \quad y_t = \frac{h_{t+1} - h_t}{w}. \tag{2.56}$$

Then, substituting equation (2.55) into equation (2.52) yields the following relation:

$$y_t = k_t^{\alpha}.h_t^{1-\alpha} \qquad \text{or} \qquad \frac{k_{t+1} - k_t}{s} = k_t^{\alpha}.h_t^{1-\alpha}$$

$$\Rightarrow \quad k_{t+1} - k_t = s.k_t^{\alpha}.h_t^{1-\alpha}. \tag{2.57}$$

Dividing both sides of equation (2.57) by k_t and rearranging with the results yields:

$$\frac{k_{t+1} - k_t}{k_t} = \frac{s.k_t^{\alpha}.h_t^{1-\alpha}}{k_t} = s.\frac{h_t^{1-\alpha}}{k_t^{1-\alpha}} = s.\left(\frac{h_t}{k_t}\right)^{1-\alpha},$$

$$\Rightarrow \quad \frac{k_{t+1} - k_t}{k_t} = s.\left(\frac{h_t}{k_t}\right)^{1-\alpha}$$

$$\Rightarrow \quad \frac{k_{t+1} - k_t}{k_t} = s.R^{1-\alpha}. \tag{2.58}$$

Similarly, equation (2.56) substituted into equation (2.52) yields the following relation:

$$y_t = k_t^{\alpha}.h_t^{1-\alpha}$$

$$\Rightarrow \quad \frac{h_{t+1} - h_t}{w} = k_t^{\alpha}.h_t^{1-\alpha}$$

$$\Rightarrow \quad h_{t+1} - h_t = w.k_t^{\alpha}.h_t^{1-\alpha}. \tag{2.59}$$

Dividing both sides of equation (2.59) by h_t, and rearranging with the results yields:

$$\frac{h_{t+1} - h_t}{h_t} = w.k_t^{\alpha}.\frac{h_t^{1-\alpha}}{h_t} = w.k_t^{\alpha}.h^{-\alpha}$$

$$\Rightarrow \quad \frac{h_{t+1} - h_t}{h_t} = w.\frac{k_t^{\alpha}}{h_t^{\alpha}}.h_t^{\alpha}.h_t^{-\alpha}$$

$$\Rightarrow \quad \frac{h_{t+1} - h_t}{h_t} = w.\left(\frac{h_t}{k_t}\right)^{-\alpha}$$

$$\Rightarrow \quad \frac{h_{t+1} - h_t}{h_t} = w.R^{-\alpha}. \tag{2.60}$$

Equations (2.58) and (2.60) are, respectively, the growth rates of physical and human capital. If, in the long-term, both growth rates converge, then:

$$\frac{k_{t+1} - k_t}{k_t} = \frac{h_{t+1} - h_t}{h_t}$$

$$\Rightarrow \quad s.R^{1-\alpha} = w.R^{-\alpha}$$

$$\Rightarrow \quad R = w/s. \tag{2.61}$$

Substituting equation (2.61) either into equation (2.58) or into equation (2.60) yields:

$$\frac{k_{t+1} - k_t}{k_t} = s.R^{1-\alpha} = s.\left(\frac{w}{s}\right)^{1-\alpha} = s^{\alpha}.w^{1-\alpha}, \tag{2.62}$$

and

$$\frac{h_{t+1} - h_t}{h_t} = w.R^{-\alpha} = w.\left(\frac{w}{s}\right)^{-\alpha} = s^{\alpha}.w^{1-\alpha}. \tag{2.63}$$

Equations (2.62) and (2.63) imply that, in the long run the growth rate of any variable will be $s^{\alpha}w^{1-\alpha}$. This expression means that, in the absence of depreciation, although the assumption of diminishing returns to physical capital is maintained, returns to physical and human capital put together are constant. The inclusion of savings rate, s, in equation (2.62) or (2.63) means that variables such as savings and investment in human capital have growth effects, not just level effects as in the Solow model. However, if unskilled labour is introduced in the model as a third input, then returns to physical and human capital will no longer be constant, but decreasing over time. The inclusion of the unskilled labour variable in the original Solow Growth Model creates what is called the Extended Solow Growth Model (ESGM).

2.4 Chapter Remarks

This chapter has focused on the review of the related literature as well as three major theories of economic growth, viz, the Harrod-Domar Model (HDM), the Solow Growth Model (SGM), and the New Growth Theory. The applications of these theories will be considered in the light of the South African economy with the assessing the performance of the economy.

Chapter 3

Data, Methods, and Exploratory Analysis

3.1 Introduction

This study is quantitative oriented with several econometric methods used with the aim of addressing the study questions. This chapter discusses the data, methods, with special attention to the data and the variables included in the study. The applicable analytical methods used are discussed as well as the conduct of an exploratory analysis to assess the data used in the study before further analyses.

3.2 Data

The study uses quarterly data from the first quarter of 1990 to the second quarter of 2010 (1990Q1-2010Q2). All data came from the South African Reserve Bank. Table 1.1 describes the data used in the study. To remove the potential of noise in the data, analysis only use data in natural logarithmic format.

Table 1.1: Data and Description

	Variable	Definition of Variable
Original Variables	EXP	Exports of Goods and Services
	IMP	Imports of Goods and Services
	GDP	Gross Domestic Product
	GFCF	Gross Fixed Capital Formation
	M2	Monetary Base M2
	GEXP	Government Expenditure
Transformed Variable	Log(EXP)	Natural logarithmic Value of Exports of Goods and Services
	Log(IMP)	Natural logarithmic Value of Imports of Goods and Services
	Log(GDP)	Natural logarithmic Value of Gross Domestic Product
	Log(GFCF)	Natural logarithmic Value of Gross Fixed Capital Formation
	Log(M2)	Natural logarithmic Value of Monetary Base M2
	Log(GOE)	Natural logarithmic Value of Government Expenditure

3.3 Methods

Analytical methods used to address the objectives of the study include, non-stationarity tests, cointegration tests, causality tests, vector autoregression (VAR), impulse response functions (IRFs), and variance decomposition technique. Other methods include regression analysis, correlation analysis and principal component analysis. Early research papers that studied the relationship between economic growth and other economic variables relied on such methods as rank correlation coefficients and simple ordinary least squares regressions. Multiple ordinary least squares regressions were used by some researchers as a confirmation of the export-led growth hypothesis (Feder, 1983; Kormendi and Meguire, 1985; Dollar, 1992).

This section presents some of the analytical techniques that will be used in studying the economic growth in South Africa. The analytical techniques to be used to address the research objectives include stationarity tests, cointegration tests, causality tests, vector autoregression (VAR), as well as the concepts of Impulse Response Functions (IRFs) and Variance Decomposition.

3.3.1 Non-Stationarity Tests

Non-stationarity of time series data could be problematic in empirical analysis. Their direct use may lead to spurious results from which further inference is meaningless. It has therefore become a standard norm in econometric analysis, first, to test for stationarity of all the variables. Knowing the existence of a time series' stationarity is important for the following three main reasons:

- The fundamental question in the ARIMA modelling of a single time series is the number of times the series needs to be for the first differenced before fitting the ARIMA modal because each unit root requires a differencing operation.

- Stationarity in regression and causality test models is assumed in the derivation of standard inference procedure. Non-stationarity of variables in typical regression and causality test models invalidates the standard results.

- An important questions in cointegration is weather the disturbance term of the cointegrating vector has a unit root.

Dealing with time series, special consideration needs to be given to the data generating process (DGP) with trend, cycle, and seasonality and by removing these patterns, the remaining DGP should be stationary. Tests often performed to ascertain the existence or otherwise of non-stationarity are called the unit root tests. Using unit root test for time series is a process because if we find that the data is not stationary, the original data is differenced a number of times until stationarity is attained.

In this way, we will be able to identify the order of the integrated process for each time series. The two most popular non-stationarity tests are the Augmented Dickey-Fuller (ADF) and Phillips-Perron unit root tests.

Given the time series $\{Y_1, Y_2, ..., Y_n\}$. The Augmented Dickey-Fuller (ADF) regression equations are:

$$\Delta Y_t = (\rho - 1).Y_{t-1} + \sum_{j=1}^{p-1} \delta_j.\Delta Y_{t-j-1} + \varepsilon_t, \quad (3.1)$$

$$\Delta Y_t = \alpha_0 + (\rho - 1).Y_{t-1} + \sum_{j=1}^{p-1} \delta_j.\Delta Y_{t-j-1} + \varepsilon_t, \quad (3.2)$$

and $$\Delta Y_t = \alpha_0 + \alpha_1.t + (\rho - 1).Y_{t-1} + + \sum_{j=1}^{p-1} \delta_j.\Delta Y_{t-j-1} + \varepsilon_t, \quad (3.3)$$

where α_0 is a drift, $t = 1,2,...,n$ is the time trend, $\Delta Y_t = Y_t - Y_{t-1}$, p is a large enough lag length to ensure that ε_t follows a white noise process, and $\{\alpha_0, \alpha_1, \rho, \delta_1, \delta_2, ..., \delta_{p-1}\}$ is a set of parameters to be estimated. The null hypothesis and alternative hypothesis in stationarity tests are:

$$H_0 : \rho = 1 \quad (Y_t \text{ is non-stationary}), \quad (3.4a)$$

$$H_1 : |\rho| < 1 \quad (Y_t \text{ is stationary}). \quad (3.4b)$$

The null hypothesis is rejected if the non-standard t-test statistic

$$\tau = \frac{\hat{\rho} - 1}{\text{std.err}(\hat{\rho} - 1)} \quad (3.5)$$

from these tests is greater than the critical value tabulated (Gujarati, 1995). The ADF non-stationarity test uses the parametric autoregressive structure to capture serial correlation in the residual term, whereas the Phillips-Perron non-stationarity test uses non-parametric corrections based on estimates of long-run variance of ΔY_t. The Phillips-Perron non-stationarity test is based on the structure:

$$\Delta Y_t = f(.) + (\rho - 1)Y_{t-1} + \varepsilon_t, \quad (3.6)$$

where f(.) could be zero, a constant, or a trend line, and ε_t is the residual term which is often suspected to be serially correlated.

3.3.2 Cointegration Analysis

The primary objective of cointegration analysis is to estimate long-run relationships among non-stationary, integrated variables. For a two-variable cointegration analysis, three methods will be used - *Cointegrating Regression ADF Test*, *Cointegration* and *Cointegrating Regression Durbin Watson* (CRDW), and *Engle-Granger Cointegration Test*. For three variables or more, the *Johansen-Juselius cointegration* (Johansen and Juselius, 1990) method will be used. Two-variable cointegration tests are based on the linear relationship:

$$Y_t = \alpha + \beta.X_t + \varepsilon_t. \qquad (3.7)$$

If Y and X are cointegrated, then their residual term, $\varepsilon_t = Y_t - (\alpha + \beta.X_t)$, can be used to test the null hypothesis of non-stationarity:

$H_0 : \varepsilon_t$ is non-stationary (variables are not cointegrated) (3.8a)

$H_1 : \varepsilon_t$ is stationary (variables are cointegrated). (3.8b)

Cointegrating Regression ADF Test

The application of *Cointegrating Regression ADF Test* (CRADF) is based on the assumption that the residuals from the cointegrating mechanism follow a first order autoregressive process:

$$\hat{\varepsilon}_t = \rho\hat{\varepsilon}_{t-1} + u_t, \qquad (3.9)$$

where u_t is a white noise process. Special critical values are used to test the null hypotheses.

Cointegrating Regression Durbin Watson Test

The Cointegrating Regression Durbin Watson (CRDW) test, developed by Sargan and Bhargava (1983), uses the Durbin-Watson (DW) statistic from the cointegrating regression. If the residuals are non-stationary, the DW statistic will approach 0 asymptotically – i.e., large values of DW are evidence for rejection of the null hypothesis of no cointegration. The test formally uses specially tabulated sets of critical values. If the null hypothesis of no cointegration is rejected, a general dynamic model for Y is estimated, parameterized in an error-correction form, which incorporates the estimated disequilibrium errors:

$$\Delta Y_t = c_0 + c_1.\Delta Y_{t-1} + c_2.\Delta X_t + c_3.\Delta X_{t-1} + c_4.\hat{\varepsilon}_{t-1} + e_t \tag{3.10}$$

where $\{c_0, c_1, c_2, c_3, c_4\}$ is a set of coefficients to be estimated from the OLS estimation of equation (3.10), Δ is the first-difference operator, and e_t is a white noise process. To confirm the cointegration result, another test for cointegration can be done based on equation (3.10). The hypotheses of interest are:

$$H_0 : c_4 = 0 \tag{3.11a}$$

$$H_1 : c_4 < 0. \tag{3.11b}$$

Failure to reject the null hypothesis means there is no error correction mechanism operating, and so the variables are not cointegrated.

Engle-Granger Cointegration Test

The Engle-Granger Cointegration (EGC) test is based on the co-integrating regression:

$$Y_t = \alpha + \mathbf{X}_t \beta + \varepsilon_t, \tag{3.12}$$

where $Y_t = X_{1,t}$, $\mathbf{X}_t = (X_{2,t}, X_{3,t}, ..., X_{m,t})$ and ε_t is a white noise process. In general, if $Y_t \sim I(1)$ and $\mathbf{X}_t \sim I(1)$, then $\boldsymbol{\varepsilon}_t \sim I(1)$. If $\boldsymbol{\varepsilon}_t \sim I(0)$, then the variables $[Y_t, \mathbf{X}_t]$ cointegrate with (m-1) linearly independent cointegrating vectors of the form $k(\mathbf{I} - \boldsymbol{\beta})'$ (k is an integer constant). A test of cointegration in the Engle-Granger sense applies stationarity test on the residuals of the above regression equation using either of the stationarity tests. If the null hypothesis of non-stationarity on the residuals, ε_t, is rejected, then the variables $[Y_t, \mathbf{X}_t]$ are cointegrated. Special critical values of cointegration tests for both cointegrating regression with and without trend are used to test the null hypothesis. For two variables, Y_t and X_t, the stationarity test for cointegration is based on the autoregression:

$$Y_t = \alpha + \beta X_t + \varepsilon_t, \tag{3.13}$$

where ε_t, which takes any of the forms:

$$\text{with} \quad \Delta\varepsilon_t = (\rho - 1)\varepsilon_{t-1} + u_t, \tag{3.14a}$$

$$\text{or} \quad \Delta\varepsilon_t = (\rho - 1)\varepsilon_{t-1} + \sum_{j=1}^{p} \rho_{t-j}.\Delta\varepsilon_{t-j} + u_t, \tag{3.14b}$$

is tested for non-stationarity. When $|\rho| < 1$ and $u_t \sim I(0)$, short-term dynamics of the model (called error correction models) can be estimated.

The Johansen-Juselius Cointegration Test

The most general of the cointegration tests is the multivariate test based on the autoregressive representation discussed in Johansen and Juselius (1990) which uses the maximum likelihood method to provide two different test statistics - the trace test and the maximum eigenvalue test statistics - to determine the number of cointegrating vectors (Juselius and Johansen, 1990). The test statistics assume that the orders of integration of the variables have been identified and that the lag length, p, is known. The Johansen-Juselius cointegration test is based on the vector autoregressive (VAR) and vector error correction model (VECM) models:

$$\text{VAR:} \quad \Delta\mathbf{Y}_t = \mathbf{c} + \sum_{j=1}^{p-1} \mathbf{\Gamma}_j \Delta\mathbf{Y}_{t-j} + \boldsymbol{\varepsilon}_t, \tag{3.15}$$

$$\text{VECM:} \quad \Delta\mathbf{Y}_t = \mathbf{c} + \sum_{j=1}^{p-1} \mathbf{\Gamma}_j \Delta\mathbf{Y}_{t-j} + \mathbf{\Pi}\mathbf{Y}_{t-1} + \mathbf{e}_t, \tag{3.16}$$

where $\mathbf{Y}_t$ is an $(n \times 1)$ vector of variables with the same order of integration, Δ is the differencing operator, $\mathbf{c}$ is a vector of $(n \times 1)$ constants, $\mathbf{\Gamma} = \boldsymbol{\alpha}\boldsymbol{\beta}'$ is an $(n \times n)$ matrix of coefficients between the levels of the series where $\boldsymbol{\alpha}$ is an $(n \times r)$ matrix of adjustment coefficients and $\boldsymbol{\beta}$ is the matrix that includes the cointegrating vectors. r represents the number of stationary variables. The term, $\boldsymbol{\beta}'\mathbf{Y}_{t-1}$, is a vector of the error correction terms representing deviations from the long-rum equilibrium relationship. If the term, $\boldsymbol{\beta}'\mathbf{Y}_{t-1} = 0$, then the system of variables converge to a long-run equilibrium. Otherwise, the system is out of equilibrium. The critical values for the test statistics have been tabulated by Osterwald-Lenum (1992).

The finding of the presence of cointegration allows the use of the error correction model. The null hypothesis that tests whether there are $r = r_0$ or fewer cointegrating vectors uses two likelihood ratio test statistics – the trace test or the maximum eigenvalue test.

- *The Trace Test*:
  The trace test evaluates the hypotheses

$$H_0 : r \leq r_0 \tag{3.17a}$$

$$H_1 : r > r_0 + 1, \tag{3.17b}$$

where $0 \leq r_0 \leq m$ (m is the number of variables being tested). The trace test statistic is given as

$$\lambda_{trace} = -n.\sum_{i=r+1}^{M} \ln(1-\lambda_i), \tag{3.18}$$

where n is the sample size, λ_i are the estimated eigenvalues $\lambda_1 > \lambda_2 > \ldots > \lambda_m$. Large values of λ_{trace} suggest against the hypothesis of r or fewer cointegrating vectors. Also, λ_{trace} has a chi-square distribution with m –r degrees of freedom, denoted by $\lambda_{trace} \sim \chi^2(m-r)$.

- *The Maximum Eigenvalue Test*:
  The maximum eigenvalue test evaluates the hypotheses

$$H_0 : r \leq r_0 \tag{3.19a}$$

$$H_1 : r = r_0 + 1, \tag{3.19b}$$

where $0 \leq r_0 \leq m$ (m is the number of variables being tested). The maximum eigenvalue test statistic is given as

$$\lambda_{max} = -n.\ln(1-\lambda_{r_0+1}). \tag{3.20}$$

Johansen and Juselius (1990), however, argue that the maximum eigenvalue test is more powerful than the trace test.

3.3.3 Granger Causality Tests

Given the variables, $\{Y_{1,1}, Y_{1,2}, \ldots, Y_{1,n}\}$, $\{Y_{2,1}, Y_{2,2}, \ldots, Y_{2,n}\}$, …, $\{Y_{K,1}, Y_{K,2}, \ldots, Y_{K,n}\}$, the hypothesis of non-causality conducted separately for $r = 2,3,\ldots,K$, is formulated as:

$$H_0 : \beta_{r,j} = 0 \quad \text{for } j = 1,2,.3,\ldots,p_r$$

$$H_1 : \beta_{r,j} \neq 0, \quad \text{for at least one j,} \qquad (3.21)$$

based on the following regression:

$$\Delta^d Y_{1,t} = \alpha + \sum_{j=1}^{p_1} \beta_{1,j} \Delta^d Y_{1,t-j} + \sum_{j=1}^{p_2} \beta_{2,j} \Delta^d Y_{2,t-j} + \ldots + \sum_{j=1}^{p_K} \beta_{K,j} \Delta^d Y_{K,t-j} + \varepsilon_t, \qquad (3.22)$$

where $Y_{1,t}$ is the time series of interest which is assumed to relate to the other remaining time series, and $p_1, p_2, \ldots, p_K$ are the lag lengths appropriately selected using any of the information criteria – Akaike Information Criterion (AIC), the Schwarz Information Criterion (SIC), the Final Prediction Error (FPE). A rejection of the null hypothesis means that $Y_{r,t}$ ($r = 2,3,\ldots,K$) causes $Y_{1,t}$ Y in the K-variable universe.

Two-Variable Causality Test

Let $X \sim I(d)$ and $Y \sim I(d)$ (i.e., differencing each variable d times will induce stationarity), the two-variable causality test specification takes the form:

$$\Delta^d X_t = \alpha + \sum_{j=1}^{p_1} a_j \Delta^d X_{t-j} + \sum_{j=1}^{p_2} b_j \Delta^d Y_{t-j} + u_t, \qquad (3.23a)$$

$$\Delta^d Y_t = \beta + \sum_{j=1}^{p_3} c_j \Delta^d X_{t-j} + \sum_{j=1}^{p_4} d_j \Delta^d Y_{t-j} + v_t, \qquad (3.23b)$$

where $\{\alpha, a_1, a_2, ..., a_{p1}, b_1, b_2, ..., b_{p2}\}$ and $\{\beta, c_1, c_2, ..., c_{p3}, d_1, d_2, ..., d_{p4}\}$ are two sets of variables to be estimated while u_t and v_t are white noise processes. The hypotheses to be tested in the four-variable Granger causality, equations (3.23a) and (3.23b) are:

Equation(3.23a):	$H_0 : b_j = 0$	for $j = 1,2,.3,..., p_3$	(3.24a)
	$H_1 : b_j \neq 0$,	for at least one j.	(3.24b)
Equation (3.23b):	$H_0 : d_j = 0$	for $j = 1,2,.3,..., p_4$	(3.25a)
	$H_1 : d_j \neq 0$,	for at least one j.	(3.25b)

Equations (3.23a) and (3.23b) are estimated by Ordinary Least Square (OLS) method. The rejection/acceptance of the null hypothesis uses the reported F-statistic.

- A rejection of the null hypothesis in equation a1a means that Y causes X.
- A rejection of the null hypothesis in equation a1b means that X causes Y.

Three-Variable Causality Test

Let $X \sim I(d)$, $Y \sim I(d)$, and $W \sim I(d)$ (i.e., differencing each variable d times will induce stationarity), the three-variable causality test specification takes the form:

$$\Delta^d X_t = \alpha + \sum_{j=1}^{p1} a_j \Delta^d X_{t-j} + \sum_{j=1}^{p2} b_j \Delta^d Y_{t-j} + \sum_{j=1}^{p3} f_j \Delta^d W_{t-j} + \varepsilon_{1,t}, \quad (3.26a)$$

$$\Delta^d Y_t = \beta + \sum_{j=1}^{p4} c_j \Delta^d Y_{t-j} + \sum_{j=1}^{p5} d_j \Delta^d X_{t-j} + \sum_{j=1}^{p6} g_j \Delta^d W_{t-j} + \varepsilon_{2,t}, \quad (3.26b)$$

$$\Delta^d W_t = \gamma + \sum_{j=1}^{p7} m_j \Delta^d W_{t-j} + \sum_{j=1}^{p8} q_j \Delta^d X_{t-j} + \sum_{j=1}^{p9} h_j \Delta^d Y_j + \varepsilon_{3,t}, \quad (3.26c)$$

where $\{\alpha, a_1, a_2, ..., a_{p_1}, b_1, b_2, ..., b_{p_2}, f_1, f_2, ..., f_{p_3}\}$, $\{\beta, c_1, c_2, ..., c_{p_4}, d_1, d_2, ..., d_{p_5}, g_1, g_2, ..., g_{p_6}\}$ and $\{\gamma, m_1, m_2, ..., m_{p_7}, q_1, q_2, ..., q_{p_8}, h_1, h_2, ..., h_{p_9}\}$ are three sets of variables to be estimated while $\varepsilon_{1,t}$, $\varepsilon_{2,t}$ and $\varepsilon_{3,t}$ are white noise processes.

The hypotheses to be tested in the three-variable Granger causality, equations 3.26a, 3.26b and 3.26c are:

Equation (3.26a): $H_0 : b_j = 0$ for $j = 1,2,.3,...,p_2$ (3.27a)

$H_1 : b_j \neq 0$, for at least one j. (3.27b)

$H_0 : f_j = 0$ for $j = 1,2,.3,...,p_3$ (3.28a)

$H_1 : f_j \neq 0$, for at least one j. (3.28b)

- A rejection of the null hypothesis $(H_0 : b_j = 0)$ in equation (3.26a) means that Y causes X in the three-variable universe.
- A rejection of the null hypothesis $(H_0 : f_j = 0)$ in equation (3.26a) means that W causes X in the three-variable universe.

Equation (3.26b): $H_0 : d_j = 0$ for $j = 1,2,.3,...,p_5$ (3.29a)

$H_1 : d_j \neq 0$, for at least one j. (3.29b)

$H_0 : g_j = 0$ for $j = 1,2,.3,...,p_6$ (3.30a)

$H_1 : g_j \neq 0$, for at least one j. (3.30b)

- A rejection of the null hypothesis $(H_0 : d_j = 0)$ in equation (3.26b) means that X causes Y in the three-variable universe.
- A rejection of the null hypothesis $(H_0 : g_j = 0)$ in equation (3.26b) means that W causes Y in the three-variable universe.

Equation (3.26c): $H_0 : q_j = 0$ for $j = 1,2,.3,...,p_8$ (3.31a)

$H_1 : q_j \neq 0$, for at least one j. (3.31b)

$H_0 : h_j = 0$ for $j = 1,2,.3,...,p_9$ (3.32a)

$H_1 : h_j \neq 0$, for at least one j. (3.32b)

- A rejection of the null hypothesis ($H_0 : q_j = 0$) in equation (3.26c) means that X causes W in the three-variable universe.
- A rejection of the null hypothesis ($H_0 : h_j = 0$) in equation (3.26c) means that Y causes W in the three-variable universe.

Remark

The concept can easily be generalized to $n \geq 4$ variables, each in an n-variable universe.

3.3.4 Impulse Response Functions and Variance Decomposition

Once VECM has been estimated, variance decomposition function (VDF) and impulse response function (IRF) can be estimated. Both VDF and IRF provide indicators of dynamic properties of the macro econometric system. VDFs provide out of sample causality tests, by partitioning the variance of the forecast error of a one macro variable into proportions attributable to shocks in each variable including its own. The information contained in the VDFs is equivalently represented by IRFs. IRFs show the dynamic response path of a variable due to a one-period standard deviation shock to another variable. In VAR analysis, a series of autocorrelated ordinary least squares regressions are run and the results of these regressions are used to determine the direction of causality. The optimal lag length, p, can be selected using AIC or SBC criteria. In this study, the technique will be used to confirm the direction of causality where there may be doubts and to examine the dynamic effect of the impact of shocks on a variety of macroeconomic variables in relation to economic growth.

IRFs are used widely in the empirical literature to uncover the dynamic relationship between macroeconomic variables within vector-autoregressive (VAR) models. IRFs basically measure the time profile of the effect of a shock, or impulse, on the (expected) future values of a variable.

3.3.5 Forecasting Economic Growth

The path of economic growth for any country depends on a number of factors, the combined effect of which is most commonly represented in the country's Gross Domestic Product (GDP). Decomposition of the time data series of GDP statistically can throw light on the long-run trend, business cycles, and short-run shocks of GDP to the economy. In the literature, a number of techniques have been suggested for separating the trend from the cyclical component of an economic time series. These include the Hodrick-Prescott (1997), the Rotemberg (1999), and the Baxter-King filter (1995) techniques. This section presents a brief summary of the Hodrick-Prescott decomposition mention method (HP) and the ARIMA forecasting technique.

The Hodrick-Prescott Decomposition Technique

Given that the time series Y_t can be decomposed into a long-run trend T_t and cyclical component, C_t, symbolically, we have

$$Y_t = T_t + C_t + I_t, \tag{3.33}$$

where I_t is the erratic or irregular component, which cannot be measured directly. The HP filter can be to extract the long-run trend (T_t) from the original series (Y_t), and then to filter out cycles (C_t) from the rest. Assuming Y_t has two components - a smooth part (S_t) and deviations (E_t), then

$$Y_t = S_t + E_t, \tag{3.34}$$

such that $\lim_{n\to\infty} \sum_{t=1}^{n} E_t \to 0$. Filtering out S_t from Y_t involves minimizing the expression:

$$\aleph = \sum_{t=1}^{n} E_t + \delta.\sum_{t=1}^{n} [\Delta^2 S_t]^2 , \tag{3.35}$$

where $\delta = 1600$ for quarterly data and Δ is the difference operator. The application of the HP filter will be executed as follows:

- The HP filter is applied to the original series, Y_t, to extract the trend component (T_t) from it.

- Next, the trend T_t is subtracted from the original series:

$$Y_t - T_t = C_t + I_t . \tag{3.36}$$

- The HP filter is once again applied to $Z_t = Y_t - T_t$ to wheedle out oscillations around the smooth component that is nothing but the cyclical component, C_t.

- The erratic component, I_t, is just difference between Z_t and C_t. That is:

$$Z_t = C_t + I_t \quad \Rightarrow \quad I_t = Z_t - C_t . \tag{3.37}$$

Forecasting Trend and Cyclical Component of Economic Growth

Once the two components, T_t and C_t, have been extracted, the next step will be to project the trend and cyclical components into the future over a certain period. For this study projection will be made over 5 years. For this purpose, the ARIMA modelling technique will be used. The ARIMA modelling of the two components will follow the usual process of modelling a time series. The procedure includes:

- establishing order of integration by non-stationarity test;
- identifying the model with the help of autocorrelation and partial autocorrelation functions; and
- performing diagnostic checks on the model.

The ARIMA representations of the two components take the forms:

$$(1 - \phi_1 L - \phi_2 L^2 - \ldots - \phi_p L^p)(1 - L)^b T_t = \alpha_0 + (1 - \theta_1 L - \theta_2 L^2 - \ldots - \theta_q L^q)\varepsilon_t , \tag{3.38}$$

$$(1 - \delta_1 L - \delta_2 L^2 - \ldots - \delta_r L^r)(1 - L)^d C_t = \beta_0 + (1 - \pi_1 L - \pi_2 L^2 - \ldots - \pi_s L^s) e_t , \tag{3.39}$$

where L is the lag operator such that $L^{\aleph} Z_t = Z_{t-\aleph}$; $(\phi_1, \phi_2, \ldots, \phi_p)$ and $(\delta_1, \delta_2, \ldots, \delta_r)$ are autoregressive coefficients; $(\theta_1, \theta_2, \ldots, \theta_q)$ and $(\pi_1, \pi_2, \ldots, \pi_s)$ are moving average coefficients; (p, q) and (r, s) are, respectively, the lag lengths of the trend model and the cyclical component, to ensure that the residual terms, ε_t and e_t, are white noise processes. The estimated models will then be used to project into the future over 5 years.

3.3.6 Optimal Lag Length Selection

Determining the lag length in VAR, Vector correction (VEC) and ARIMA specifications is crucial. The most frequently used criteria in the literature the AIC, the SIC, FPE and the Hannan-Quin Criterion (HQC). These criteria take into account certain tradeoffs between better fit, smaller residuals, and loss of degrees of freedom due to number of estimated parameters. The best fitting model is the one that minimizes the information criterion function. Lütkepohl (1991) argues that over-fitting (selecting a higher order lag length than the true lag length) causes an increase in the mean-square forecast errors of the VAR or VEC model and that under-fitting (selecting a lower lag length) often generates autocorrelated errors.

3.3.7 Diagnostic Tests

To ensure the appropriateness of the estimated VAR and VEC models, a number of diagnostic tests can be employed. For this study, diagnosis of the specified VAR and VEC models will employ the Ljung-Box test for autocorrelation and the Jarque-Bera test for normality (Pindyck et al., 1998). For the Ljung-Box (LB) test, the null hypothesis specifies that there is no autocorrelation up to the lag specified and the alternative hypothesis is that there is autocorrelation up to the lag specified and is based on the test statistic:

$$LB = n(n+2)\sum_{j=1}^{p}\frac{\rho_j^2}{n-j} \sim \chi^2(j), \qquad (3.40)$$

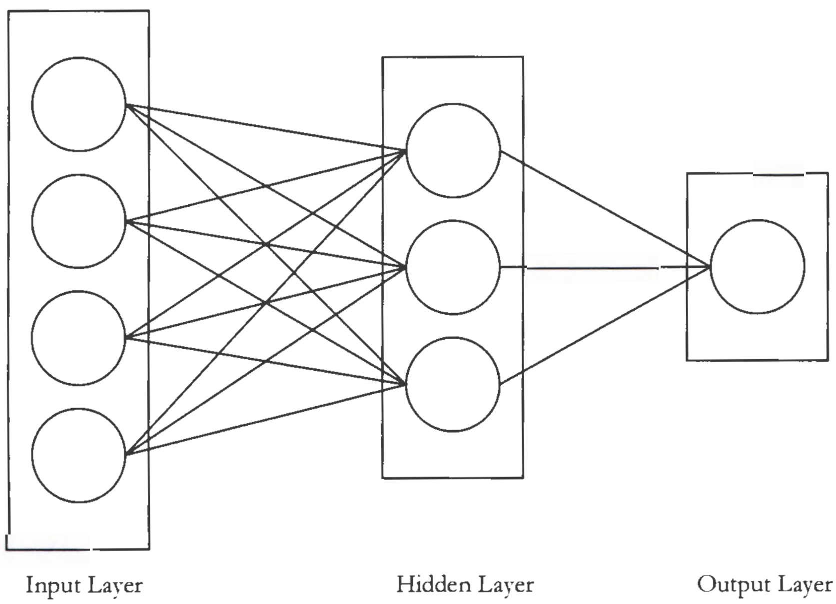
where n is the sample size, ρ_j is the autocorrelation at lag j, and p is the lag length being tested. A probability value (p-value) of the statistic that is less than the 5% or 0.05 level of significance suggests no autocorrelation. The Jarque-Bera (JB) test for normality compares the skewness and kurtosis of the residuals to those of the normal distribution. For the Jarque-Bera test, the null hypothesis specifies normality up to the lag specified and the alternative hypothesis specifies non-normality up to the lag specified and is based on the test statistic:

$$JB = \frac{n}{6}\left[S^2 + \frac{(K-3)^2}{4}\right] \sim \chi^2(2), \quad (3.41)$$

where n is sample size, K is kurtosis and S is skewness (Pindyck et al., 1998). A probability value (p-value) of the statistic that is less than the 5% or 0.05 level of significance suggests normality.

3.3.8 Neural Network Analysis

Neural network analysis is a computation technique with the capability of handling various problems in a number of scientific disciplines. Neural networks consist of neurons which are connected to each other and operate in parallel. The information processing mechanism in every neuron is adopted from the biological neuron. The figure below is a schematic representation of a typical neural network architecture.



Neurons in a neural network are grouped into several layers. Every layer can have one or more neurons. There are three layers in neural network architecture: the input layer, the output layer, and the hidden layer. The function of the input layer is for data entry, data processing takes place in the hidden middle layer and the output layer functions as the data output result. The following illustration shows the architecture of neural networks. Information processing in every neuron is done by adding the multiplication result of connection weights with input data. The result is transferred to the next neuron through the activation function. There are several kinds of activation functions, i.e. linear, semi linear, sigmoid, bipolar sigmoid and hyperbolic tangent.

In time series data forecasting, the input value for the input layer can be variable data of previous period or the other variable used to help forecasting. To perform a univariate forecasting, the input data for the input layer and output data in the output layer is similar to the autoregressive model AR(p). At certain time point t, forecasted data, $\hat{Y}_{t+1}$, is calculated by using $p = n$ observations $Y_t, Y_{t-1},.., Y_{t-n+1}$ from n previous point, $t, t-1, t-2,..., t-n+1$, where n shows the number of neuron inputs in a neural network.

3.4 Computer Aids

Five statistical and econometric software packages were used to analyze the data. They are SAS, EViews, Minitab, Gretl, and Zaitun Time Series. Each of the software packages has its own strong points when it comes to data analysis, hence their inclusion in this study.

3.5 Scope and Limitations

One of the problems encountered in this study is the lack of existing research in this area in the context of the South African economy. This has also led to the use of reference of older studies. The unavailability of some variables has resulted in such variables being replaced by the nearest proxies. One important variable, CPI, which is collected on monthly basis, had to be transformed to quarterly data by striking the average of three consecutive monthly figures and use the average as quarterly figures.

3.6 Concluding Remarks

This chapter has presented the analytical techniques used to address the objectives in this thesis. These analytical techniques and other commonly used techniques, such as the simple and multivariate regression modelling techniques, as well as their related tests including heteroskedasticity, multicollinearity, etc, will be applied to real time series data from South Africa with the aim of addressing the stated objectives in this study.

Chapter 4

Data Analyses, Results and Discussions

4.1 Introduction

In this chapter, the objective is to conduct exploratory analyses of the variables used in this thesis. The chapter is structured into two sections. Section I is based on the exploratory data analysis which are conducted to examine the nature and stationarity of the variables involved in the study. Section II is then divided into two parts. Part Ideals with bivariate and multivariate part of the study and part II focuses on the univariate analyses part of the study.

SECTION I: Data Exploration

The first step in analyzing any time series data set is to plot the observed series $\{Y_1, Y_2, \ldots, Y_n\}$ by time $t = 1,2,\ldots,n$. Visual inspection of the plotted time series can provide the first clues to the nature of the series – it helps in the identification of trends, seasonality, and non-stationary effects. Figure 4.1 through Figure 4.6 present the graphical representations of the raw variables being used in the study. As observed from these plots, each of the variables appears to exhibit a curvilinear pattern.

To remove the curvilinear pattern in the raw variables, the variables were expressed in the natural logarithmic form and the plots of the transformed variables are reported in Figure 4.7 to Figure 4.12. As revealed in Figure 4.7 through Figure 4.12, the quadratic trend in each of the six variables has been removed by applying logarithms to the raw data. Hereafter, all analyses will be based on transformed data - the logarithmic data. It is also worth passing that the transformed variables are non-stationary at levels. Next, it is imperative to establish whether each of the macroeconomic time series being used in this study is stationary even before attempting to address the research aims and objectives.

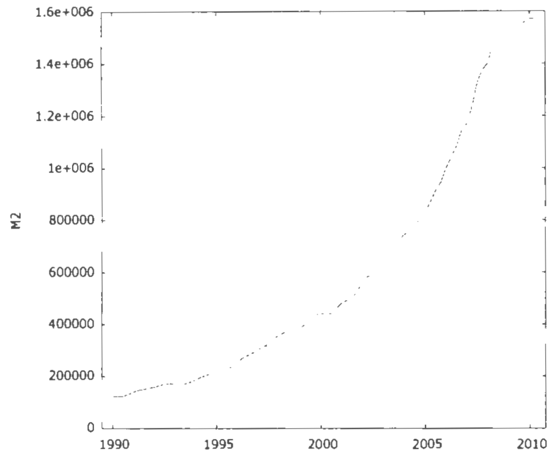


Figure 4.1: Plot of Money Stock M2

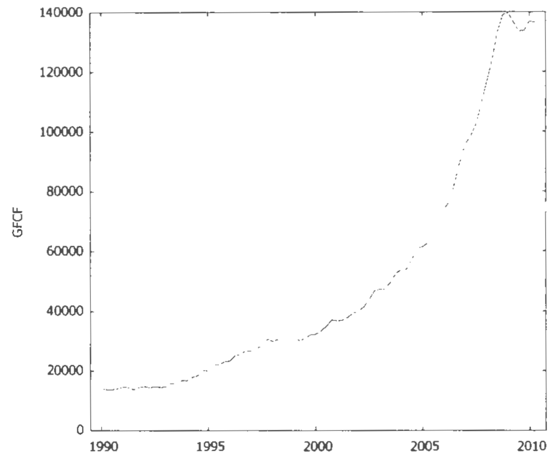


Figure 4.2: Plot of GFCF

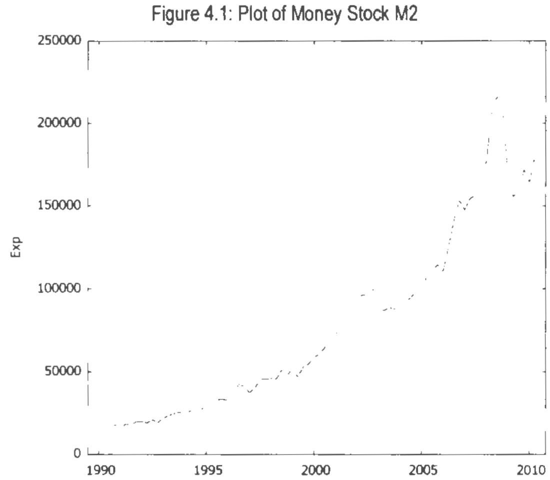


Figure 4.3: Plot of Exports

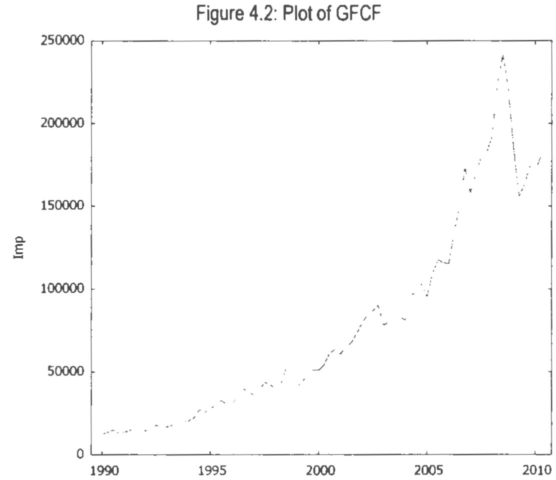


Figure 4.4: Plot of Imports

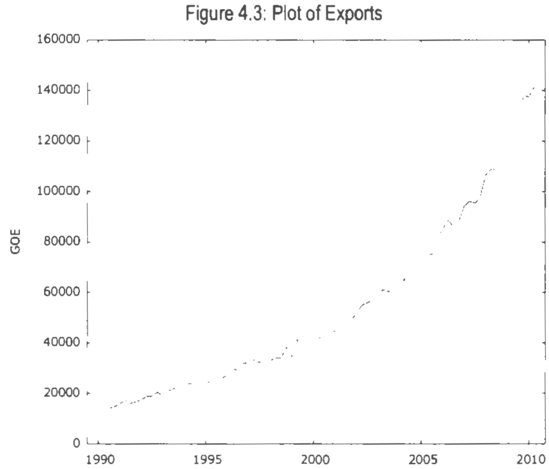


Figure 4.5: Plot of GOE

Figure 4.6: Plot of GDP

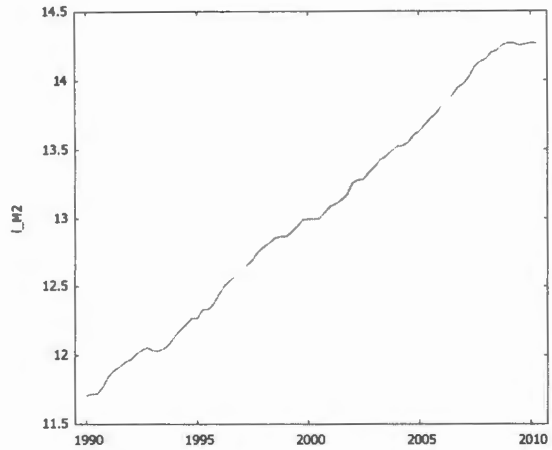


Figure 4.7: Plot of log(M2)

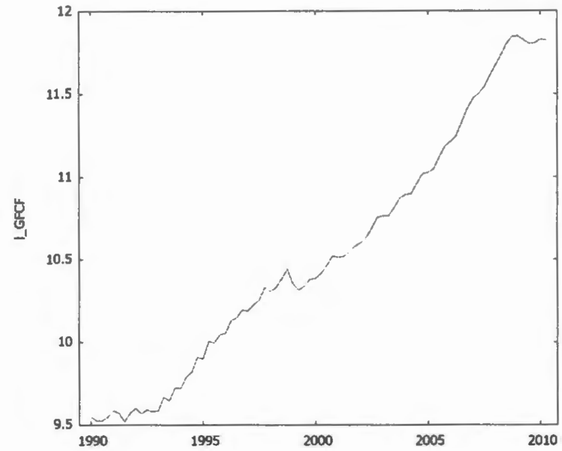


Figure 4.8: Plot of log(GFCF)

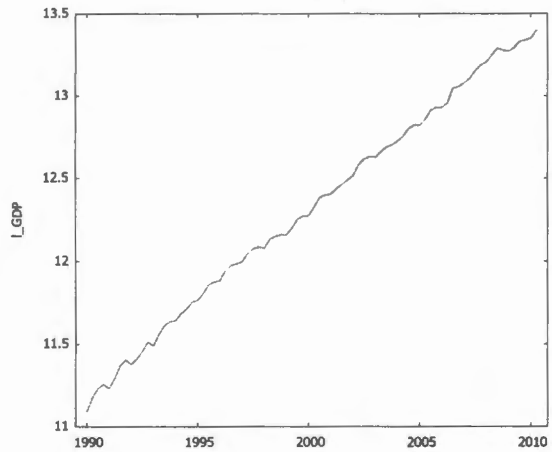


Figure 4.9: Plot of log(Exports)

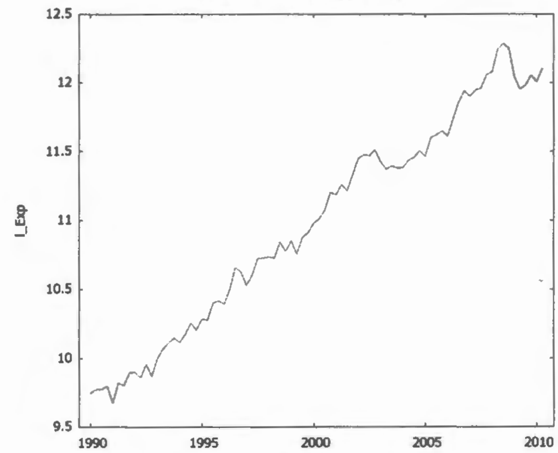


Figure 4.10: Plot of log(Imports)

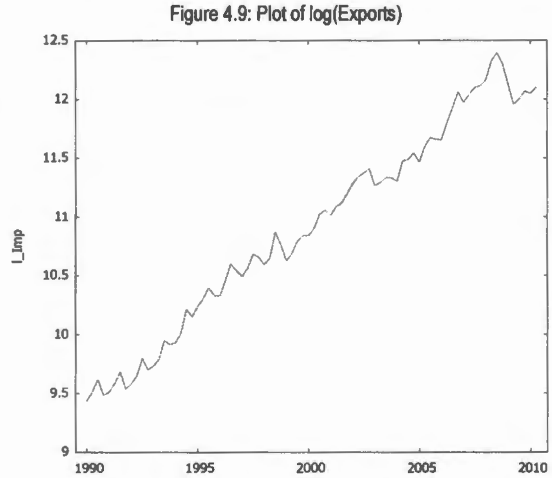


Figure 4.11: Plot of log(GOE)

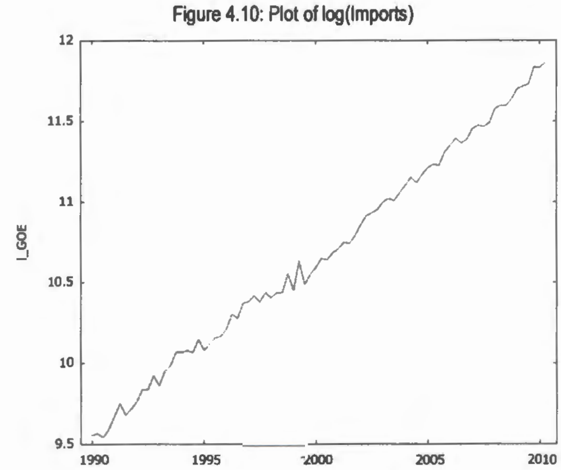


Figure 4.12: Plot of log(GDP)

Table 4.1: ADF Unit Root Test for Log Variables at Levels

Variable	Lag	ADF	5% Critical Value	Information Criterion		
				AIC	SBC	HQC
Log(M2)	0	-0.925587	-3.466248	-3.732961	-3.644278	-3.697380
	1	-1.364562	-3.466966	-3.775894	-3.656793	-3.728143
	2	-1.029756	-3.467703	-3.837914	-3.687949	-3.777834
	3	-1.072926	-3.468459	-3.811638	-3.630353	-3.739066
	4	-0.773375	-3.469235	-3.788151	-3.575078	-3.702924
	5	-0.757518	-3.470032	-3.748765	-3.503425	-3.650715
Log(Exp)	0	-3.136968	-3.466248	-2.446544	-2.357861	-2.410963
	1	-2.775303	-3.466966	-2.408957	-2.289855	-2.361205
	2	-3.058158	-3.467703	-2.396270	-2.246305	-2.336190
	3	-2.341326	-3.468459	-2.366751	-2.185465	-2.294179
	4	-2.640131	-3.469235	-2.427646	-2.342419	-2.342419
	5	-3.283846	-3.470032	-2.458496	-2.213156	-2.360446
Log(Imp)	0	-3.084345	-3.466248	-2.085200	-1.996517	-2.049619
	1	-3.411600	-3.466968	-2.076287	-1.957186	-2.028536
	2	-2.245905	-3.467703	-2.090671	-1.940671	-2.030556
	3	-1.471996	-4.466459	-2.117985	-1.936699	-2.045413
	4	-3.832970	-2.417183	-2.417183	-2.204110	-2.331956
	5	-2.841083	-3.470032	-2.389332	-2.291282	-2.291282
Log(GFCF)	0	-2.261144	-3.466248	-3.812512	-3.723829	-3.776931
	1	-2.009595	-3.466966	-3.779771	-3.660670	-3.732020
	2	-1.978641	-3.467703	-3.753131	-3.603166	-3.693050
	3	-1.954285	-3.468459	-3.722852	-3.541566	-3.650279
	4	-2.883764	-3.469235	-3.964418	-3.751345	-3.879191
	5	-2.582552	-3.470053	-3.923927	-3.825877	-3.825877
Log(GOE)	0	-4.704378	-3.466248	-4.817013	-4.728330	-4.781432
	1	-4.162334	-3.466966	-4.795510	-4.767408	-4.747759
	2	-2.502915	-3.467703	-5.013902	-4.863937	-4.953821
	3	-1.794985	-3.468459	-5.087338	-4.906053	-5.014767
	4	-3.088343	-3.469235	-5.371854	-5.158781	-5.286627
	5	-3.057339	-3.470032	-5.342240	-5.096899	-5.244190
Log(GDP)	0	-4.704378	-3.466248	-4.817013	-4.728330	-4.781432
	1	-4.162334	-3.466966	-4.795510	-4.676408	-4.747759
	2	-2.502915	-3.467703	-5.013902	-40863937	-4.953821
	3	-1.794985	-3.468459	-5.087338	-4.906053	-5.014767
	4	-3.088343	-3.469235	-5.371854	-5.158781	-5.286627
	5	-3.057339	-3.470032	-5.342240	-5.096899	-5.244190

Using the Augmented-Dickey Fuller (ADF) unit root test, tests of stationarity are conducted by including a linear time trend to ADF autoregression model due to the presence of a linear time trend in each of the transformed variables. The underlying ADF autoregression model is therefore given as:

$$\Delta Y_t = \alpha + \beta t + (\rho - 1)Y_{t-1} + \sum_{j=0}^{p} \lambda_j . \Delta Y_{t-j} + \varepsilon_t .$$

The ADF test results for lags p=0,1,2,..,5 are summarized in Table 4.1. From the ADF results for variables at levels reported in Table 4.1, the ADF test statistic for each variable is greater than the corresponding 5% critical value. Thus, the null hypothesis of non-stationarity cannot be rejected for each variable at levels. This means that each of the transformed variables is non-stationary at levels. To induce stationarity, each of the transformed variables was differenced once.

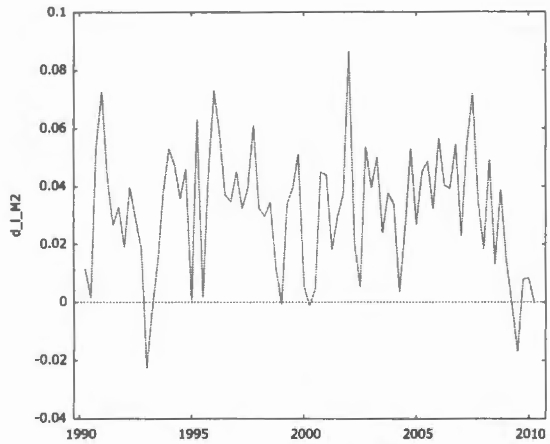


Figure 4.13: First-Differenced log(M1)

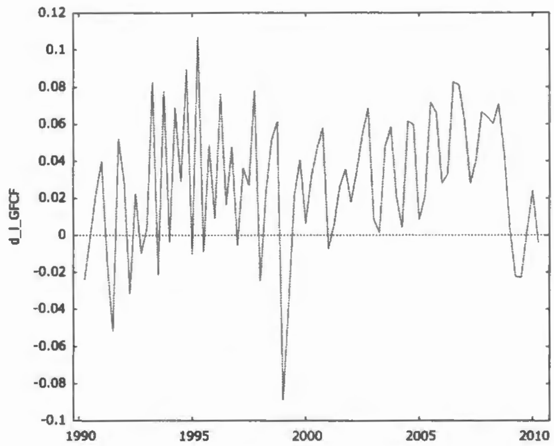


Figure 4.14: First-Differenced Log(GFCF)

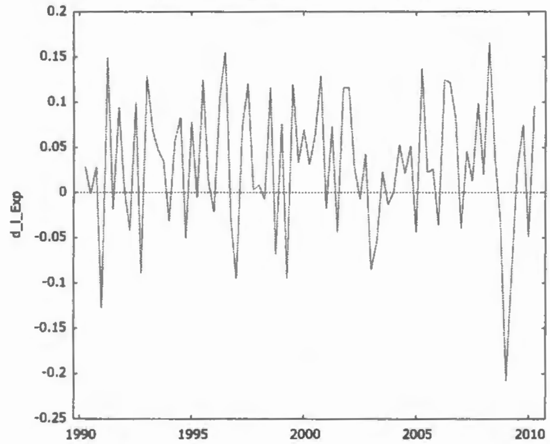


Figure 4.15: First-Differenced Log(Exports)

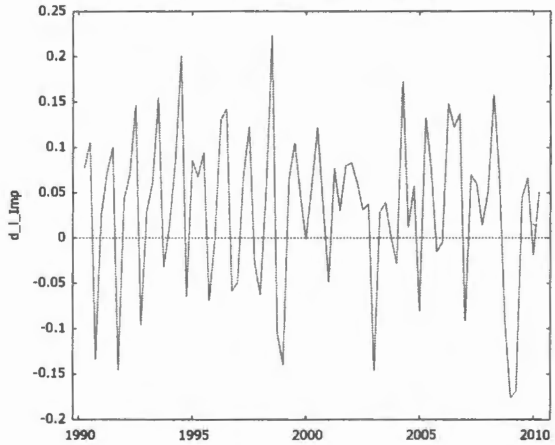


Figure 4.16: First-Differenced Log()Imports

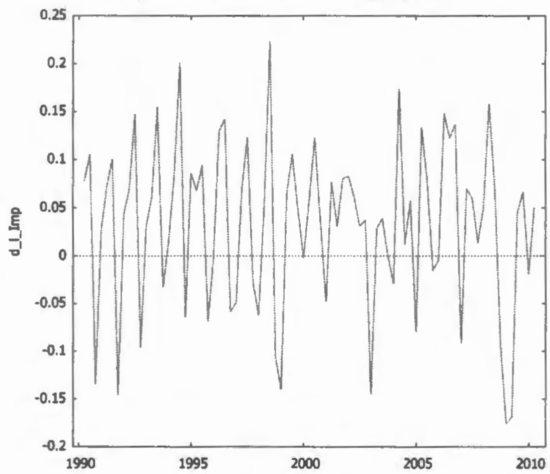


Figure 4.17: First-Differenced Log(GOE)

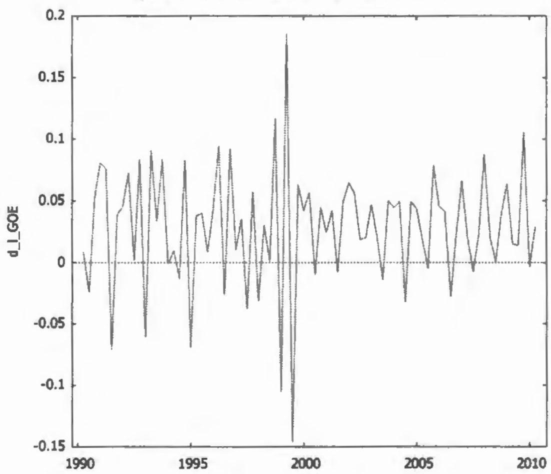


Figure 4.18: First-Differenced Log(GDP)

Table 4.2: ADF Unit Root Test for Once-Differenced Log Variables

Variable	Lag	ADF	5% Critical Value	AIC	SBC	HQC
	0	-7.287937	-2.898145	-3.786084	-3.786084	-3.762208
Log(M2)	1	-6.838366	-2.898623	-3.833424	-3.743445	-3.797376
	2	-4.897411	-2.899115	-3.818845	-3.697988	-3.770463
	3	-4.693234	-2.899619	-3.804689	-3.652494	-3.743813
	4	-4.026171	-2.900137	-3.763735	-3.579729	-3.690197
	5	-2.937906	-2.900670	-3.752891	-3.536592	-3.666526
	0	-10.21134	-2.898145	-2.360544	-2.300993	-2.336668
Log(Exp)	1	-6.414419	-2.898623	-2.325129	-2.235150	-2.289081
	2	-6.439492	-2.899115	-2.339890	-2.219033	-2.291508
	3	-4.997085	-2.899619	-2.369792	-2.217597	-2.308915
	4	-3.853860	-2.900137	-2.356091	-2.172086	-2.282554
	5	-4.557523	-2.900670	-2.388626	-2.172327	-2.302260
	0	-8.813769	-2.898145	-1.980288	-1.920737	-1.956412
Log(Imp)	1	-8.798296	-2.898623	-2.070735	-2.034687	-2.058138
	2	-7.563433	-2.899115	-2.121407	-2.000550	-2.073025
	3	-3.600892	-2.899619	-2.270577	-2.118382	-2.209701
	4	-4.435643	-2.900137	-2.320074	-2.246536	-2.246536
	5	-4.341195	-2.900670	-2.295188	-2.078889	-2.20882
	0	-8.740674	-2.898145	-3.755205	-3.695654	-3.731330
Log(GFCF)	1	-5.560648	-2.898623	-3.738455	-3.648476	-3.702406
	2	-4.923181	-2.899115	-3.703806	-3.582949	-3.655424
	3	-2.414775	-2.899619	-3.903765	-3.751569	-3,842888
	4	-2.638792	-3.881277	-3.881277	-3.697272	-3.807739
	5	-2.888260	-2.900670	-3.909955	-3.693656	-3.823589
	0	-16.82765	-2.898145	-3.507648	-3.448097	-3.483772
Log(GOE)	1	-9.005693	-2.898623	-3.519872	-3.429892	-3.483823
	2	-8.958100	-2.899115	-3.616053	-3.495196	-3.567671
	3	-5.432885	-2.899619	-3.602864	-3.450669	-3.541988
	4	-4.996364	-2.900137	-3.629089	-3.445084	-3.555552
	5	-3.863598	-2.900670	-3.609218	-3.392919	-3.522852
	0	-9.435614	-2.898145	-4.631397	-4.571846	-4.607521
Log(GDP)	1	-11.79939	-2.898623	-4.952068	-4.862089	-4.916019
	2	-9.796416	-2.899115	-5.039382	-4.918525	-4.991001
	3	-3.723374	-2.899619	-5.274382	-5.122187	-5.213505
	4	-3.661764	-2.900137	-5.167696	-5.057228	-5.167696
	5	-4.097656	-2.900670	-5.268398	-5.052099	-5.182032

Figure 4.13 through 4.18 are the graphical displays of the once-differenced transformed variables. A visual evaluation of the once-differenced series plots in Figure 4.13 through Figure 4.18 show that each variable is stationary after one differencing. However, formal ADF tests were again conducted to confirm this finding. Table 4.2 is a summary of the ADF unit root tests for the once-differenced log variables. As can be seen, each ADF test statistic is less than its corresponding 5% critical value. This means that stationarity in each of the six economic variables being used in this study can only be induced through differencing once. Hence, each log variable is integrated of order 1.

SECTION II

Part I: Multivariate Analysis

This part of the chapter focuses on modelling economic growth as proxied by GDP multivariately. Five multivariate methods in econometrics are used with the aim of addressing some of the stated research aims and objectives - the Granger causality test, Johansen-Juselius cointegration test, error correction mechanism, impulse response functions, and variance decomposition analysis.

4.3 Economic Growth and Export

Following the common practice, the starting specification is a bivariate structure. This section investigates the export-led growth hypothesis bivariately – Log (GDP) and Log (Exp). To avoid spurious results, stationary series of the two variables are used.

4.3.1 Causality Analysis

In Granger causality analysis, the choice of the optimal lag length for the analysis is crucial. In this study, the choice of lag structure is based on the informational criteria - AIC, SBC, FPE, and HQC. The use of stationary variables in a causality test dictates that a constant term (and not a trend) be included in optimal lag selection process. Table 4.3 presents the results of the optimal lag selection analysis of the first-differenced series of log(GDP) and log(Exp) with a constant. From the results, four criteria - log likelihood (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), and Hannan-Quinn Criterion (HQC) - select the lag length of 5 while the Schwartz Bayesian Criterion (SBC) selects lag structure of 4. However, due to the robustness of the SBC, the lag length 4 is selected as optimal.

Table 4.3: Optimal Lag Section for First-Differenced Log(GDP) and Log(Exp)

VAR Lag Order Selection Criteria
Endogenous variables: L_GDP L_EXP
Exogenous variables: C
Sample: 1990Q1-2010Q2 (Included observations: 75)

Lag	LogL	LR	FPE	AIC	SBC	HQC
0	7.035614	NA	0.002997	-0.134283	-0.072483	-0.109607
1	280.1328	524.3466	2.29e-06	-7.310208	-7.124809	-7.236180
2	288.2703	15.19000	2.05e-06	-7.420541	-7.111543	-7.297162
3	305.6551	31.52444	1.44e-06	-7.777469	-7.344871	-7.604738
4	315.7539	17.77385	1.22e-06	-7.940103	-7.383906*	-7.718020
5	321.9973	10.65546*	1.15e-06*	-7.999928*	-7.320132	-7.728493*
6	325.4218	5.661780	1.18e-06	-7.984581	-7.181185	-7.663793
7	328.9783	5.690437	1.19e-06	-7.972754	-7.045759	-7.602615

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 4.4: Causality Analysis Results from First-Differenced Log(GDP) and Log(Exp)

VAR system, lag order 4
OLS estimates, observations 1991:1-2010:2 (T = 78)
Log-likelihood = 322.50356
Determinant of covariance matrix = 8.7847685e-007
AIC = -7.8078
BIC = -7.2639
HQC = -7.5901
Portmanteau test: LB(19) = 77.4459, df = 60 [0.0643]

Equation 1: l_GDP

F-tests of zero restrictions:

All lags of l_GDP	F(4, 69) =	224.62 [0.0000]
All lags of l_Exp	F(4, 69) =	3.3593 [0.0143]
All vars, lag 4	F(2, 69) =	6.7234 [0.0021]

Equation 2: l_Exp

F-tests of zero restrictions:

All lags of l_GDP	F(4, 69) =	4.3154 [0.0036]
All lags of l_Exp	F(4, 69) =	15.895 [0.0000]
All vars, lag 4	F(2, 69) =	0.14578 [0.8646]

Using lag length 4, Granger causality test was performed and the results reported in Table 4.4. At the 0.05 level of significance, Equation 1 results shows that exports Granger-cause economic growth

(GDP; F=3.3593, prob=0.0143). In Equation 2, the results also shows that economic growth (GDP) causes export flow (F=4.3154, prob=0.0036). The conclusion is that the causality relationship between economic growth (GDP) and export flow is bidirectional.

4.3.2 Long-Run Relationship between Economic Growth and Exports

This section investigates whether there is a long-run equilibrium relationship between economic growth, as proxied by GDP, and exports. In checking the cointegration rank of the GDP-export system, the Johansen-Juselius (1991) based on maximum likelihood techniques to a VAR (vector autoregression) model assuming the Gaussian structure of the residuals is used. At this point, an essential choice that has to be made is the optimal number of lags to be included in the models on which cointegration rank tests is based. Using up to 7 lags in the VAR system of log(GDP) and log(Exp), the optimal lag selection result is presented in Table 4.4, which shows four criteria – LR, FPE, AIC, and HQC – selecting lag length 5, while the SBC criterion selects lag length 4. The SBC results are used for subsequent analyses due to its power.

Table 4.5: Optimal Lag Selection for Log(GDP) and Log(Exp)

VAR Lag Order Selection Criteria
Endogenous variables: L_GDP L_EXP
Exogenous variables: C
Sample: 1990Q1 - 2010Q2 (Included observations: 75)

Lag	LogL	LR	FPE	AIC	SBC	HQ
0	7.035614	NA	0.002997	-0.134283	-0.072483	-0.109607
1	280.1328	524.3466	2.29e-06	-7.310208	-7.124809	-7.236180
2	288.2703	15.19000	2.05e-06	-7.420541	-7.111543	-7.297162
3	305.6551	31.52444	1.44e-06	-7.777469	-7.344871	-7.604738
4	315.7539	17.77385	1.22e-06	-7.940103	-7.383906*	-7.718020
5	321.9973	10.65546*	1.15e-06*	-7.999928*	-7.320132	-7.728493*
6	325.4218	5.661780	1.18e-06	-7.984581	-7.181185	-7.663793
7	328.9783	5.690437	1.19e-06	-7.972754	-7.045759	-7.602615

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Thus, using lag length 4, a Johansen-Juselius cointegration analysis was performed and the results presented in Table 4.5. From the results, both trace and maximum-eigenvalue test statistics identify one cointegrating relations between log(GDP) and log(Exp). In other words, there is a long-run equilibrium relationship between economic growth and exports. The cointegrating relation describing the long-run relationship between economic growth and exports is given as:

$$\log(GDP)_t = -6.4153 - 0.7049 * \log(Exp)_t .$$

Table 4.5: Johansen-Juselius Cointegration Test Results - Log(GDP) and Log(Exp)

Sample (adjusted): 1991Q2 - 2010Q2
Included observations: 77 after adjustments
Trend assumption: No deterministic trend (restricted constant)
Series: L_GDP L_EXP
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.258465	30.10064	20.26184	0.0016
At most 1	0.087789	7.075057	9.164546	0.1225

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.258465	23.02558	15.89210	0.0032
At most 1	0.087789	7.075057	9.164546	0.1225

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

1 Cointegrating Equation(s): Log likelihood 323.7799

Normalized cointegrating coefficients (standard error in parentheses)

L_GDP	L_EXP	C
1.000000	-0.704880	-6.415320
	(0.09968)	(1.27332)

The cointegrating equation indicates that exports are negatively related to economic growth, with estimated elasticities of -0.7049. The negativity of exports, in relation to economic growth, is however strange as a positive relation between the two is expected. These results are the same as those in the study by Njikam,(2003) where he found that exports have a negative influence on economic growth in the long run in Zambia .

4.3.3 Short-Run Equilibrium Relationship

The fact that both log(GDP) and log(Exp) are cointegrated in the system, the short-run adjustment mechanism could be modelled as an Error Correction Mechanism (ECM). The Error Correction Term (CointEq1) derived from long-run equilibrium relationship using the Johansen-Juselius procedure is used in the short run.

Using the selected lag length 4, the ECM derived from the cointegration relationship is reported in Table 4.7. The ECM results indicate that the estimated coefficients of lagged log(GDP) are negative. This implies that South Africa's short-run economic growth during the period 1990-2010Q2 is negatively influenced by the past economic growth. The error correction term, CointEq1, of -0.019932, representing the proportion by which a long-run disequilibrium in economic growth can be corrected in each quarter suggests that approximately 2.0% of total disequilibrium in economic growth was being corrected in each quarter.

Table 4.7: ECM - Log(GDP) and Log(Exp)

Vector Error Correction Estimates
Sample (adjusted): 1991Q2-2010Q2 (Included observations: 77)
t-statistics in [ ]

Cointegrating Eq:	CointEq1	
L_GDP(-1)	1.000000	
L_EXP(-1)	-0.704880 [-7.07109]	
C	-6.415320 [-5.03827]	

Error Correction:	D(L_GDP)	D(L_EXP)
CointEq1	-0.019932	0.034496
	[-3.59389]	[1.51695]
D(L_GDP(-1))	-0.227952	1.725240
	[-1.88943]	[3.48773]
D(L_GDP(-2))	-0.410400	0.365128
	[-3.15753]	[0.68516]
D(L_GDP(-3))	-0.145132	1.221891
	[-1.13522]	[2.33106]
D(L_GDP(-4))	0.407283	0.881707
	[3.45577]	[1.82464]
D(L_EXP(-1))	0.072109	-0.244369
	[2.39342]	[-1.97825]
D(L_EXP(-2))	0.012950	-0.137071
	[0.39639]	[-1.02331]
D(L_EXP(-3))	-0.028688	-0.307433
	[-0.91403]	[-2.38899]
D(L_EXP(-4))	-0.005581	-0.066426
	[-0.19581]	[-0.56843]
R-squared	0.548416	0.250451
Adj. R-squared	0.495288	0.162269
F-statistic	10.32262	2.840149
Log likelihood	212.6525	104.0044

Next, the adequacy of the EC model is tested as an account of the data. The underlying statistical assumption is that the errors are identically, independently distributed (i.i.d.) and ideally normally distributed. The residual plots are shown in Figure 4.19. Table 4.7 reports the autocorrelation portmanteau tests for the EC residuals up to lag 12.

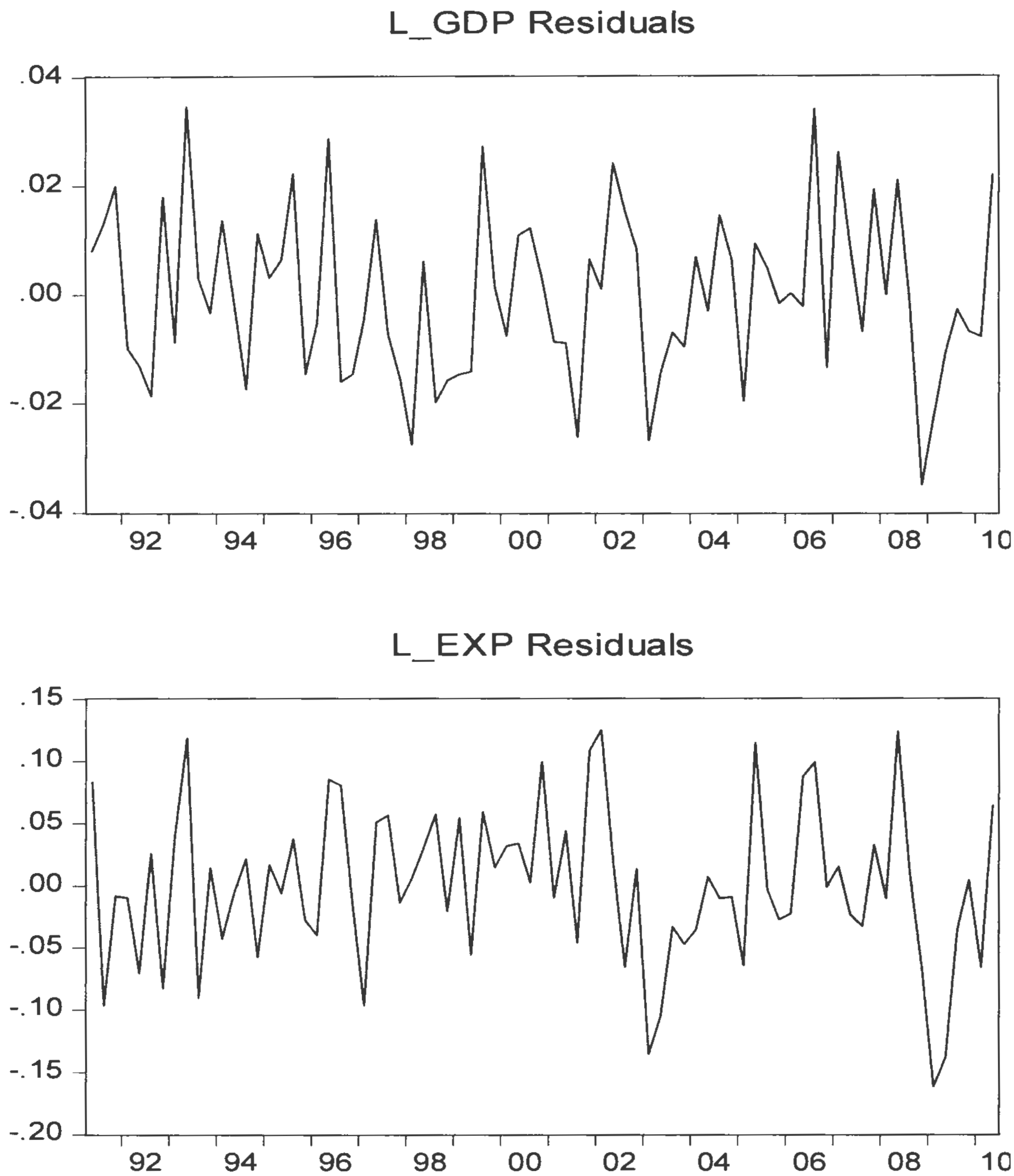


Figure 4.19: Plots of log(GDP) and log(Exp) Residuals

Table 4.8: Autocorrelation Portmanteau Tests of Residuals from ECM of Log(GDP) and Log(Exp)

VEC Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Sample: 1990Q1 - 2010Q2
Included observations: 77

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	1.121753	NA*	1.136513	NA*	NA*
2	1.290157	NA*	1.309407	NA*	NA*
3	5.950478	NA*	6.158660	NA*	NA*
4	7.736146	NA*	8.042174	NA*	NA*
5	13.95121	0.0521	14.68884	0.0502	7
6	16.62276	0.1195	17.58616	0.0917	11
7	17.95489	0.2650	19.05149	0.2114	15
8	24.79592	0.1674	26.68569	0.1122	19
9	26.37437	0.2835	28.47305	0.1984	23
10	28.78550	0.3714	31.24405	0.2612	27
11	33.53458	0.3454	36.78465	0.2186	31
12	35.12727	0.4622	38.67137	0.3073	35

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Table 4.9: Heteroskedasticity Tests of Residuals from ECM of Log(GDP) and Log(Exp)

VEC Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Sample: 1990Q1 2010Q2
Included observations: 77

Joint test:

Chi-sq	df	Prob.
73.17284	54	0.0422

Individual components:

Dependent	R-squared	F(18,58)	Prob.	Chi-sq(18)	Prob.
res1*res1	0.141085	0.529280	0.9322	10.86353	0.9001
res2*res2	0.329451	1.583126	0.0955	25.36771	0.1151
res2*res1	0.355615	1.778238	0.0510	27.38235	0.0721

At the 0.05 level, the tests for normality fail to reject the null hypothesis with the probability values of all the Q-statistics being greater than 0.05. Hence, there is no evidence of EC residual autocorrelations. With regards to heteroskedasticity, the White test results in Table 4.9 fail to reject the overall hypothesis with the probability value of the joint chi-square test statistics being greater than 0.05. The Doornik-Hansen tests for normality results in Table 4.10 also fail to reject the null hypothesis with the probability values of al the chi-square statistics being greater than 0.05.

Table 4.10: Normality Tests of Residuals from ECM of Log(GDP) and Log(Exp)

VEC Residual Normality Tests
Orthogonalization: Residual Correlation (Doornik-Hansen)
Null Hypothesis: residuals are multivariate normal
Sample: 1990Q1-2010Q2 (Included observations: 77)

Component	Skewness	Chi-sq	df	Prob.
1	0.138331	0.284669	1	0.5937
2	-0.119065	0.211293	1	0.6458
Joint		0.495962	2	0.7804

Component	Kurtosis	Chi-sq	df	Prob.
1	2.282131	1.595006	1	0.2066
2	2.739849	0.001702	1	0.9671
Joint		1.596708	2	0.4501

Component	Jarque-Bera	df	Prob.
1	1.879675	2	0.3907
2	0.212994	2	0.8990
Joint	2.092670	4	0.7187

4.4 Economic Growth, Exports, Imports and Gross Fixed Capital Formation

In this section, the relationships of economic growth, as proxied by GDP, with exports of goods (hereafter referred to as exports) and imports of goods and services (hereafter referred to as imports) are examined. The inclusion of imports is based on the argument by Riezman et al (1996) that imports and Gross Fixed Capital Formation (GFCF) are crucial in testing the export-growth hypothesis to avoid spurious causality results. The authors argued that possible finding of no cointegration between exports and economic growth may be due to the omitted variables such as imports and GFCF. Moreover, considering the fact that export externality effects are possibly due to the role of exports in relieving a foreign borrowing constraints (Serletis, 1992), the influence of imports and GFCF are expected to be significant in the analysis. Besides, increase in imports may reduce a country's international reserves, thereby slowing down economic growth. Hence, the relationship between imports and economic growth (GDP) is expected to be negative.

4.4.1 Causality Analysis of GDP, Exports, Imports, and GFCF

To avoid spurious causality, the stationary series of log(GDP), log(Exp), log(Imp) and log(GFCF) are used in the causality test. Furthermore, since the participating variables in the causality test are stationary, only a constant is included in the search for the optimal lag length to the causality test. Table 4.9 presents the VAR optimal lag length search results. The results show three criteria - LR, FPE, and AIC - selecting lag length 5, while two criteria - SBC and HQC - select lag length 2. Again, since SBC is the most robust among the information criteria, the SBC result is adopted.

Table 4.11: Optimal Lag Section for First-Differenced Log(GDP), log(Exp), Log(Imp) and Log(GFCF)

VAR Lag Order Selection Criteria
Endogenous variables: D_L_GDP D_L_EXP D_L_IMP D_L_GFCF
Exogenous variables: C
Sample: 1990Q1-2010Q2 (Included observations: 74)

Lag	LogL	LR	FPE	AIC	SBC	HQC
0	525.3245	NA	8.93e-12	-14.08985	-13.96531	-14.04017
1	565.6308	75.16576	4.63e-12	-14.74678	-14.12406	-14.49837
2	607.0895	72.83288	2.34e-12	-15.43485	-14.31395*	-14.98771*
3	621.8286	24.29968	2.44e-12	-15.40077	-13.78170	-14.75491
4	651.8573	46.26047	1.70e-12	-15.77993	-13.66268	-14.93533
5	672.3087	29.29515*	1.56e-12*	-15.90023*	-13.28481	-14.85691
6	679.8229	9.951241	2.05e-12	-15.67089	-12.55729	-14.42883
7	692.5076	15.42736	2.40e-12	-15.58129	-11.96951	-14.14050

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SBC: Schwarz information criterion
HQC: Hannan-Quinn information criterion

Using lag length 2, a causality analysis was conducted and the results are reported in Table 4.11. From the first equation results, the null hypotheses that exports and gross fixed capital formation do not cause economic growth (GDP) cannot be rejected since the probability values of the F-statistics for log(Exp) and log(GFCF), 0.7522 and 0.1018, respectively, are greater than the 0.05 level of significance. Import flow was, however, found to cause economic growth since the probability value of log(Imp), 0.0001, is less than 0.05. On the other hand, the second equation results in Table 4.11

show that the null hypothesis of economic growth (GDP) not causing exports can be rejected since the probability value of the F-statistic, 0.0279, is less than 0.05. The conclusion, therefore, is that the causality relationship between economic growth and exports is unidirectional with economic growth 'Granger-causing' exports and not vice versa.

Table 4.12: Causality Analysis Results from First-Differenced Log(GDP), Log(Exp), Log(Imp) and Log(GFCF)

```
AR system, lag order 2
OLS estimates, observations 1990:4-2010:2 (T = 79)
Log-likelihood = 628.2251
Determinant of covariance matrix = 1.4551076e-012
AIC = -14.9930          SBC = -13.9133        HQC = -14.5605
Portmanteau test: LB(19) = 313.542, df = 272 [0.0422]

Equation 1: d_l_GDP

F-tests of zero restrictions:

All lags of d_l_GDP          F(2, 70) =   16.492 [0.0000]
All lags of d_l_Exp          F(2, 70) =  0.28592 [0.7522]
All lags of d_l_Imp          F(2, 70) =   10.277 [0.0001]
All lags of d_l_GFCF         F(2, 70) =   2.3611 [0.1018]
All vars, lag 2              F(4, 70) =   11.334 [0.0000]

Equation 2: d_l_Exp

F-tests of zero restrictions:

All lags of d_l_GDP          F(2, 70) =   3.7680 [0.0279]
All lags of d_l_Exp          F(2, 70) =   3.6849 [0.0301]
All lags of d_l_Imp          F(2, 70) =   2.8669 [0.0636]
All lags of d_l_GFCF         F(2, 70) =  0.48916 [0.6152]
All vars, lag 2              F(4, 70) =   1.2747 [0.2882]
```

```
AR system, lag order 2
OLS estimates, observations 1990:4-2010:2 (T = 79)
Log-likelihood = 628.2251
Determinant of covariance matrix = 1.4551076e-012
AIC = -14.9930          SBC = -13.9133          HQC = -14.5605
Portmanteau test: LB(19) = 313.542, df = 272 [0.0422]

Equation 3: d_l_Imp

F-tests of zero restrictions:

All lags of d_l_GDP          F(2, 70) =   12.375 [0.0000]
All lags of d_l_Exp          F(2, 70) =   2.8498 [0.0646]
All lags of d_l_Imp          F(2, 70) =   4.0695 [0.0213]
All lags of d_l_GFCF         F(2, 70) =   1.6088 [0.2074]
All vars, lag 2              F(4, 70) =   10.473 [0.0000]

Equation 4: d_l_GFCF

F-tests of zero restrictions:

All lags of d_l_GDP          F(2, 70) =   5.2695 [0.0074]
All lags of d_l_Exp          F(2, 70) = 0.0063422 [0.9937]
All lags of d_l_Imp          F(2, 70) =   8.6793 [0.0004]
All lags of d_l_GFCF         F(2, 70) =   2.2835 [0.1095]
All vars, lag 2              F(4, 70) =   3.2052 [0.0178]
```

4.4.2 Long-Run Relationship of GDP, Exports, Imports, and GFCF

Having established the existence or otherwise of any causal relationship among the four variables, the next step is to investigate the long-run equilibrium relationships among them. To execute this task, the Johansen-Juselius multivariate cointegration procedure is used again. Next, an essential choice that has to be made is the optimal number of lags to be included in the models on which cointegration rank tests is based. Using up to 5 lags in the VAR system, the lag selection results are presented in Table 4.12, with the AIC selecting lag length 6 and SBC, lag length 3. The lag length choice from SBC result is adopted due to its power. Thus, using lag length 3, a Johansen-Juselius cointegration analysis was performed and the results presented in Table 4.12. From the results, the trace test statistic identifies two cointegrating relations among the four variables.

In other words, there is at least one long-run equilibrium relationship between the four variables. The cointegrating relation describing the long-run relationship between economic growth and the three other economic variables is given as:

$$\log(GDP)_t = -3.4031 - 3.2930 * \log(Exp)_t + 3.7409 * \log(\text{Im p})_t - 1.4076 * \log(GFCF)_t .$$

Table 4.13: Optimal Lag Section for log(GDP), log(Exp), log(Imp) and log(GFCF)

VAR Lag Order Selection Criteria
Endogenous variables: L_GDP L_EXP L_IMP L_GFCF
Exogenous variables: C
Sample: 1990Q1 2010Q2 (Included observations: 75)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	173.2220	NA	1.29e-07	-4.512588	-4.388988	-4.463236
1	555.6512	713.8677	7.36e-12	-14.28403	-13.66603	-14.03727
2	586.3874	54.09574	4.99e-12	-14.67700	-13.56460	-14.23283
3	631.4398	74.48666	2.32e-12	-15.45173	-13.84494*	-14.81015
4	651.7589	31.42690	2.11e-12	-15.56690	-13.46571	-14.72792
5	680.7831	41.79486	1.53e-12	-15.91422	-13.31863	-14.87783*
6	700.8231	26.71991*	1.44e-12*	-16.02195*	-12.93196	-14.78815
7	711.2649	12.80863	1.78e-12	-15.87373	-12.28935	-14.44253

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

The cointegrating equation indicates that the variables, exports and gross fixed capital formation, are negatively related to economic growth, with estimated elasticities of -3.2930 and -1.4076, respectively. Imports were, however, found to be positively related to economic growth with an elasticity of 3.7409. The negativity of exports, in relation to economic growth, is however strange as a positive relation between the two is expected. On the other hand, the positive relation of imports to economic growth is shocking as imports of goods and services could be unproductive in promoting economic growth, albeit the fact that it does not contribute to the capital generation.

Table 4.14: Johansen-Juselius Cointegration Results from Log(GDP), Log(Exp), Log(Imp) and Log(GFCF)

Sample (adjusted): 1991Q1-2010Q2 (Included observations: 78 after adjustments)
Trend assumption: No deterministic trend (restricted constant)
Series: L_GDP L_EXP L_IMP L_GFCF
Lags interval (in first differences): 1 to 3
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.536975	101.8323	54.07904	0.0000
At most 1 *	0.251397	41.77431	35.19275	0.0085
At most 2	0.187647	19.18973	20.26184	0.0697
At most 3	0.037481	2.979740	9.164546	0.5845

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.536975	60.05802	28.58808	0.0000
At most 1 *	0.251397	22.58457	22.29962	0.0456
At most 2 *	0.187647	16.20999	15.89210	0.0446
At most 3	0.037481	2.979740	9.164546	0.5845

Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

1 Cointegrating Equation(s): Log likelihood 640.6084

Normalized cointegrating coefficients (standard error in parentheses)

L_GDP	L_EXP	L_IMP	L_GFCF	C
1.000000	-3.292986	3.740871	-1.460755	-3.403132
	(1.24558)	(1.42651)	(0.61257)	(2.11438)

4.4.3 Short-Run Equilibrium Relationship

Once economic growth has been established to co-integrate with exports, imports, and gross fixed capital formation, a natural extension is to estimate the Error Correction Model (ECM). The ECM has cointegration relations built into specification so that it restricts the long-run behaviour of the four variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. Using lag length 3 as chosen by the SBC in the VAR system of the four variables, an ECM analysis was performed and the results reported in Table 4.14. The ECM results show that the estimated coefficients of lagged log(GDP) are negative, implying South Africa's short-run economic growth during the period 1990Q1-2010Q2 is negatively affected by the past economic growth. In addition, the error correction term, CointEq1, of -0.023029, means that approximately 2.3% of total long-run disequilibrium in economic growth was being corrected in each quarter.

To assess the adequacy of the ECM as an account of the data used, three tests about the residual series from the four variables were conducted and analyzed - tests of autocorrelation, normality, and heteroskedasticity.

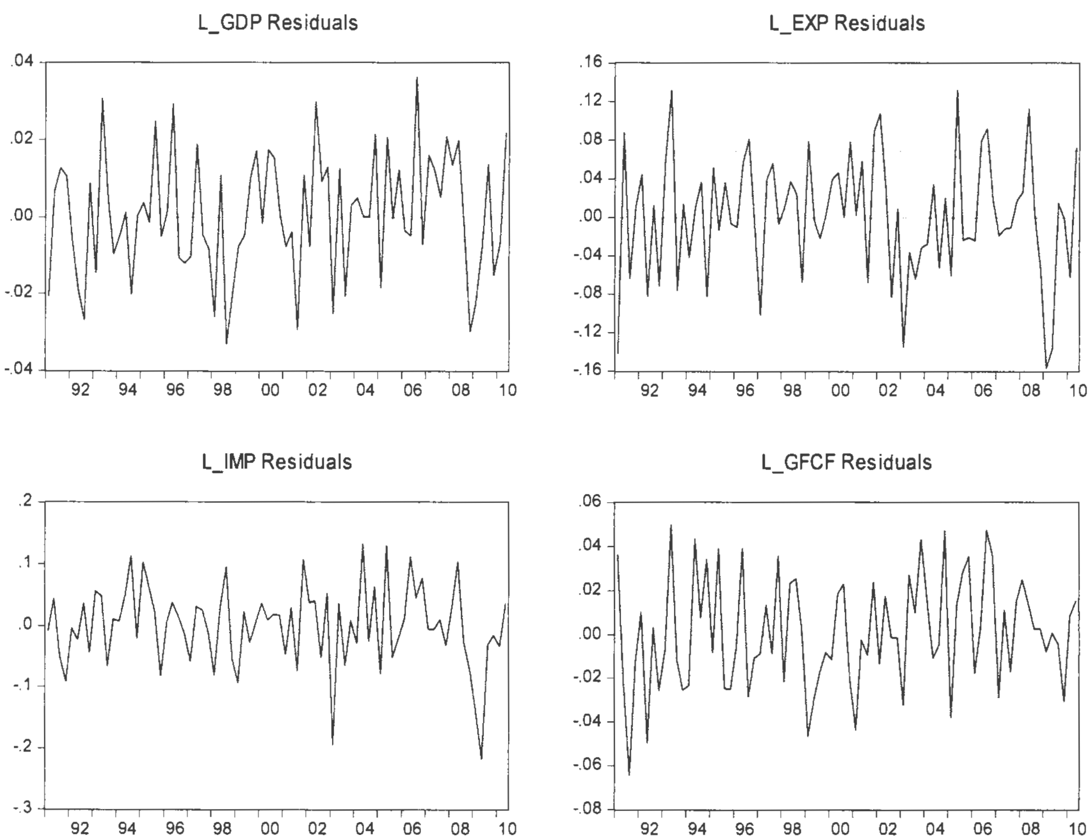


Figure 4.20: Plots of Residuals from ECM of Log(GDP), Log(Exp), Log(Imp) and Log(GFCF)

Table 4.15: ECM Results - Log(GDP), Log(Exp), Log(Imp) and Log(GFCF)

Vector Error Correction Estimates
Sample (adjusted): 1991Q1- 2010Q2 (Included observations: 78)

Cointegrating Eq:	CointEq1	t-statistics in [ ]
L_GDP(-1)	1.000000	
L_EXP(-1)	-3.292986	[-2.64373]
L_IMP(-1)	3.740871	[2.62239]
L_GFCF(-1)	-1.460755	[-2.38464]
C	-3.403132	[-1.60952]

Error Correction:	D(L_GDP)	D(L_EXP)	D(L_IMP)	D(L_GFCF)
CointEq1	-0.023029	0.017125	0.001328	0.017630
	[-5.67546]	[1.06079]	[0.07879]	[2.69515]
D(L_GDP(-1))	-0.215372	1.469694	1.347310	0.664025
	[-1.69499]	[2.90724]	[2.55292]	[3.24166]
D(L_GDP(-2))	-0.539974	-0.019392	-1.037371	0.940597
	[-4.39758]	[-0.03970]	[-2.03407]	[4.75170]
D(L_GDP(-3))	-0.114474	1.263642	1.219730	0.446835
	[-0.73926]	[2.05110]	[1.89646]	[1.78995]
D(L_EXP(-1))	-0.014148	-0.381352	0.268571	-0.036637
	[-0.33300]	[-2.25596]	[1.52188]	[-0.53488]
D(L_EXP(-2))	0.008028	0.002445	0.221307	7.70E-05
	[0.16775]	[0.01284]	[1.11341]	[0.00100]
D(L_EXP(-3))	0.005430	-0.070784	0.198661	0.120969
	[0.13633]	[-0.44668]	[1.20086]	[1.88394]
D(L_IMP(-1))	0.170459	0.289918	-0.129332	0.184050
	[4.06752]	[1.73884]	[-0.74303]	[2.72427]
D(L_IMP(-2))	-0.014471	-0.185722	-0.539905	-0.159270
	[-0.32710]	[-1.05516]	[-2.93826]	[-2.23317]
D(L_IMP(-3))	0.042637	-0.080013	-0.217786	-0.079250
	[1.00983]	[-0.47632]	[-1.24189]	[-1.16430]
D(L_GFCF(-1))	-0.046639	-0.089871	0.158460	-0.187164
	[-0.58747]	[-0.28453]	[0.48055]	[-1.46237]
D(L_GFCF(-2))	0.044798	-0.019351	-0.065696	0.165071
	[0.69379]	[-0.07533]	[-0.24496]	[1.58578]
D(L_GFCF(-3))	0.114250	-0.022317	-0.023214	0.122773
	[1.94381]	[-0.09544]	[-0.09509]	[1.29571]
R-squared	0.544420	0.283374	0.423970	0.511579
Adj. R-squared	0.460313	0.151074	0.317626	0.421409
F-statistic	6.472946	2.141905	3.986785	5.673489

Table 4.16: Autocorrelation Tests of Residuals from ECM of Log(GDP), Log(Exp), Log(Imp) and Log(GFCF)

VEC Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Sample: 1990Q1 - 2010Q2 (Included observations: 78)

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	4.046913	NA*	4.099471	NA*	NA*
2	18.02317	NA*	18.44352	NA*	NA*
3	28.75230	NA*	29.60182	NA*	NA*
4	48.03883	0.0146	49.93086	0.0092	29
5	64.61345	0.0291	67.64073	0.0161	45
6	80.20897	0.0502	84.53588	0.0247	61
7	90.91642	0.1328	96.29899	0.0676	77
8	108.5495	0.1292	115.9473	0.0538	93
9	114.8812	0.3313	123.1048	0.1681	109
10	118.6831	0.6421	127.4659	0.4219	125

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Table 4.17: Normality Tests of Residuals from ECM of Log(GDP), Log(Exp), Log(Imp) and Log(GFCF)

VEC Residual Normality Tests
Orthogonalization: Residual Correlation (Doornik-Hansen)
Null Hypothesis: residuals are multivariate normal
Sample: 1990Q1 - 2010Q2 (Included observations: 78)

Component	Skewness	Chi-sq	df	Prob.
1	-0.226501	0.762655	1	0.3825
2	0.069918	0.073948	1	0.7857
3	-0.447846	2.830764	1	0.0925
4	-0.124430	0.233261	1	0.6291
Joint		3.900628	4	0.4196

Component	Kurtosis	Chi-sq	df	Prob.
1	2.531048	0.598246	1	0.4392
2	2.895561	0.128315	1	0.7202
3	4.356356	4.838560	1	0.0278
4	2.571854	0.218071	1	0.6405
Joint		5.783192	4	0.2159

Component	Jarque-Bera	df	Prob.
1	1.360901	2	0.5064
2	0.202263	2	0.9038
3	7.669324	2	0.0216
4	0.451332	2	0.7980
Joint	9.683819	8	0.2879

Table 4.17: Heteroskedasticity Tests of Residuals from ECM of Log(GDP), Log(Exp), Log(Imp) and Log(GFCF)

VEC Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Sample: 1990Q1-2010Q2 (Included observations: 78)

Joint test:

Chi-sq	df	Prob.
295.5818	260	0.0638

Individual components:

Dependent	R-squared	F(26,51)	Prob.	Chi-sq(26)	Prob.
res1*res1	0.256930	0.678237	0.8573	20.04053	0.7896
res2*res2	0.429393	1.476094	0.1165	33.49262	0.1483
res3*res3	0.408901	1.356922	0.1737	31.89429	0.1966
res4*res4	0.506129	2.010226	0.0165	39.47808	0.0439
res2*res1	0.376209	1.183007	0.2977	29.34431	0.2957
res3*res1	0.369727	1.150668	0.3267	28.83874	0.3185
res3*res2	0.373502	1.169419	0.3097	29.13316	0.3051
res4*res1	0.379935	1.201904	0.2816	29.63496	0.2830
res4*res2	0.393825	1.274391	0.2260	30.71838	0.2389
res4*res3	0.309080	0.877487	0.6335	24.10827	0.5698

Figure 4.21 displays the plots of the residuals from each of the four variables serving as a dependent variable. From the autocorrelation portmanteau test results in Table 4.16 for the EC residuals up to lag 12, the null hypothesis of normality cannot be rejected since the probability values of all the Q-statistics are greater than the 0.05 level of significance. Hence, there is no evidence of EC residual autocorrelations. The Doornik-Hansen tests for normality results in Table 4.17 also fail to reject the null hypothesis since the probability values of all the chi-square statistics are greater than the 0.05 level of significance. With regards to heteroskedasticity, the White test results in Table 4.18 fail to reject since the probability value of the joint chi-square test statistics is greater than 0.05.

4.4.4 Impulse Response Function and Variance Decomposition Analyses

To further elaborate on the ECM results, impulse response Function (IRF) analysis and Variance Decomposition Analysis (VDA) were conducted. Within a ten-quarter forecasting horizon, the generalized impulse response functions for the four-variable system are reported both numerically and pictorially in Table 4.19 and Figure 4.21, respectively. As can be seen from the results, the shock effect of export flow leads to positive impact on economic growth with the largest positive impact occurring in the sixth quarter and the least positive exports impact occurring in first quarter.

Table 4.19: Impulse Responses to Generalized One Standard Deviation Innovations

Response of L_GDP:

Period	L_GDP	L_EXP	L_IMP	L_GFCF
1	0.017286	0.007484	0.005864	0.005655
2	0.016936	0.014150	0.013377	0.006894
3	0.011621	0.011071	0.007591	0.005440
4	0.010777	0.008763	0.005156	0.006413
5	0.019801	0.012089	0.007563	0.008441
6	0.020814	0.015317	0.010679	0.009286
7	0.016627	0.014313	0.007913	0.008231
8	0.015957	0.012365	0.005558	0.008719
9	0.021255	0.014422	0.006849	0.010068
10	0.022876	0.016506	0.008343	0.010516

Response of L_EXP:

Period	L_GDP	L_EXP	L_IMP	L_GFCF
1	0.029775	0.068771	0.048499	0.011597
2	0.050016	0.067177	0.060221	0.021107
3	0.044587	0.074549	0.057442	0.017453
4	0.041718	0.058007	0.039286	0.012150
5	0.042446	0.066461	0.048270	0.017366
6	0.051554	0.068160	0.052822	0.020766
7	0.047441	0.071532	0.054368	0.021157
8	0.046849	0.067451	0.046838	0.018552
9	0.048645	0.068754	0.048403	0.020451
10	0.053813	0.071599	0.050907	0.021838

Response of L_IMP:

Period	L_GDP	L_EXP	L_IMP	L_GFCF
1	0.024358	0.050632	0.071795	0.026498
2	0.053934	0.073333	0.085198	0.038255
3	0.032089	0.060444	0.064478	0.022113
4	0.038274	0.052503	0.046388	0.019569
5	0.046773	0.060797	0.065893	0.029276
6	0.052573	0.069227	0.073774	0.032843
7	0.039548	0.063237	0.065546	0.029403
8	0.042098	0.060064	0.057076	0.027624
9	0.051960	0.064063	0.063427	0.031623
10	0.054494	0.069987	0.068595	0.032869

Response of L_GFCF:

Period	L_GDP	L_EXP	L_IMP	L_GFCF
1	0.009117	0.004699	0.010285	0.027866
2	0.022228	0.014946	0.025449	0.031314
3	0.038510	0.022248	0.027123	0.039619
4	0.034494	0.028048	0.031104	0.038897
5	0.038058	0.026709	0.029854	0.042870
6	0.043167	0.031546	0.036029	0.047444
7	0.049362	0.034236	0.036875	0.048508
8	0.046809	0.035408	0.036824	0.048805
9	0.047346	0.034840	0.035106	0.049282
10	0.050238	0.036221	0.036817	0.051332

Generalized Impulse

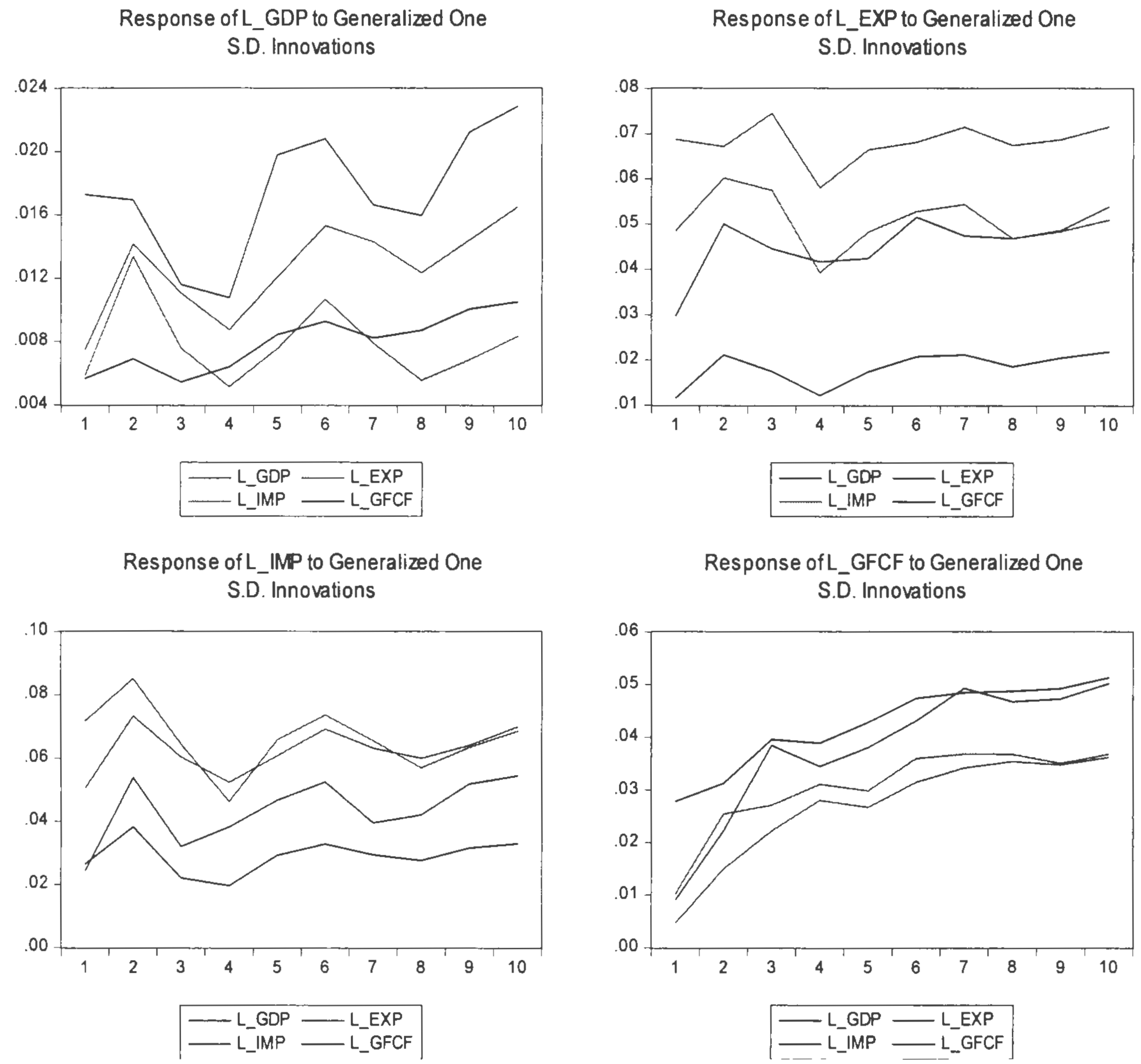


Figure 4.21: Generalized Impulse Response Functions, Log(GDP), Log(Exp), Log(Imp), and Log(GFCF)

Similarly, the shock effect of imports on economic growth (GDP) within a ten-quarter forecasting period is positive with the largest positive imports impact occurring in the second quarter while the least positive imports impact occurs in the fourth quarter. The impact of shocks from gross fixed capital formation on economic growth within a ten-quarter forecasting period is also positive with the largest positive shock effect occurring in the tenth quarter, and the least shock effect occurring in the third quarter. Regarding the responses of export flow, the shock effects of GDP on exports within a ten-quarter forecasting period is positive with the largest shock effects occurring in the tenth quarter and the least, in the first quarter. The shock effect of import flow on export flow is also positive with the largest effect occurring in the second quarter and the least, in the fourth quarter. The shock effect of gross fixed capital formation on export flow is also positive within a ten-quarter forecasting period with the largest positive GFCF shock effect occurring in the tenth quarter and the least effect occurring in first quarter.

As revealed by the VDA results in Table 4.20, GDP is fully exogenous as it is fully explained by its own innovation (100%) in the first quarter. However, by the tenth quarter (2012Q4), nearly 83% of the variation in South Africa's economic growth (GDP) can be explained by its own innovation. By the tenth quarter, exports, imports, and gross fixed capital formation explain about 8%, 3%, and 4%, respectively, of the variation in economic growth (GDP). On the other hand, the VDA results show that nearly 81% of the variations in export flow in the first quarter can be explained by its own innovations. By the tenth quarter, variations in export flow can be attributed to nearly 57% of its own innovations with GDP explaining 42% and the remaining variations shared between import flows and gross fixed capital formation.

Table 4.20: Variance Decomposition Results from ECM of Log(GDP), Log(Exp), Log(Imp) and Log(GFCF)

Variance Decomposition of L_GDP:					
Period	S.E.	L_GDP	L_EXP	L_IMP	L_GFCF
1	0.017286	100.0000	0.000000	0.000000	0.000000
2	0.025695	88.69805	8.661831	2.624662	0.015455
3	0.029057	85.35688	12.09038	2.112043	0.440693
4	0.031611	83.74565	12.28228	2.129929	1.842138
5	0.037685	86.53413	9.713628	1.845290	1.906953
6	0.043727	86.92803	9.773797	1.423941	1.874230
7	0.047782	84.90976	10.91382	1.790844	2.385578
8	0.051313	83.29829	10.85498	2.537560	3.309170
9	0.056386	83.19250	10.04393	3.080117	3.683453
10	0.061774	83.02777	9.774242	3.383892	3.814100
Variance Decomposition of L_EXP:					
Period	S.E.	L_GDP	L_EXP	L_IMP	L_GFCF
1	0.068771	18.74519	81.25481	0.000000	0.000000
2	0.100376	33.62856	63.45443	2.837904	0.079101
3	0.125931	33.90053	63.99880	2.041496	0.059183
4	0.139919	36.35118	61.87312	1.708362	0.067341
5	0.155655	36.80887	61.73894	1.386059	0.066139
6	0.171761	39.23824	59.46850	1.237652	0.055612
7	0.187032	39.52647	59.30204	1.103457	0.068034
8	0.199813	40.12881	58.81609	0.977559	0.077544
9	0.212384	40.76493	58.26544	0.868625	0.101006
10	0.225577	41.82681	57.29147	0.771129	0.110596
Cholesky Ordering: L_GDP L_EXP L_IMP L_GFCF					

Table 4.20 continued: Variance Decomposition Results from ECM of Log(GDP), Log(Exp), Log(Imp) and Log(GFCF)

Variance Decomposition of L_IMP:					
Period	S.E.	L_GDP	L_EXP	L_IMP	L_GFCF
1	0.071795	11.51057	38.36564	50.12379	0.000000
2	0.115183	26.39755	38.07920	35.41175	0.111499
3	0.133772	25.32503	43.13468	31.45716	0.083133
4	0.145272	28.41553	44.10516	27.39140	0.087919
5	0.162174	31.11947	43.08396	25.70576	0.090816
6	0.181329	33.29787	42.54331	24.05919	0.099628
7	0.194754	32.98898	43.77995	23.05428	0.176786
8	0.205650	33.77662	44.35758	21.60672	0.259085
9	0.218501	35.57505	43.74678	20.38114	0.297027
10	0.232495	36.91538	43.53984	19.22785	0.316930

Variance Decomposition of L_GFCF:					
Period	S.E.	L_GDP	L_EXP	L_IMP	L_GFCF
1	0.027866	10.70357	0.089597	11.44719	77.75964
2	0.045659	27.68847	1.705349	23.69811	46.90807
3	0.066589	46.46387	1.664276	15.84744	36.02441
4	0.081765	48.61494	4.269649	13.73257	33.38285
5	0.096357	50.60568	4.461939	11.99922	32.93316
6	0.112232	52.09526	4.903875	11.33900	31.66187
7	0.128047	54.88206	5.009574	10.26141	29.84696
8	0.141759	55.68149	5.491440	9.474772	29.35230
9	0.154385	56.35119	5.691896	8.695111	29.26181
10	0.167167	57.09465	5.776893	8.106135	29.02232

Cholesky Ordering: L_GDP L_EXP L_IMP L_GFCF

4.5 Economic Growth, Government Expenditure and Money Stock

The relationship between government expenditure and economic growth is not without controversy. On the one hand, Singh and Sahni (1984), Ram (1986), and Holmes and Hutton (1990) argue that government expansion has a positive effect on economic growth. On the other hand, Landau (1986) Barth et al (1990) argue the opposite is true that government expansion tends to exert a negative impact on economic growth for many developed and less-developed countries. Following the study by Cheng and Lai (1997), this section examines the relationships between South Africa's economic growth (GDP) and government expenditure (GOE) along with money stock M2.

4.5.1 Causal Relationship between GDP and GOE along with Money Stock

To examine the causal relationship between economic growth (GDP) and government expenditure along with money stock, stationary series of log(GDP), log(GOE), and log(M2) are used in the causality test. To obtain an optimal lag length selection for the causality test, a VAR optimal lag selection procedure was performed for lags up to 7 and the results reported in Table 4.19. The results show five information criteria selecting lag length 2 as optimal. Using lag length 2, a causality analysis was performed and the results reported in Table 4.22. According to the Equation 1 results in Table 4.22, the null hypothesis that government expenditure does not cause economic growth (GDP) can be rejected since the probability value of the F-statistics for first-differenced log(GOE), 0.0099, is greater than the 0.05 level of significance. The null hypothesis that money stock, M2, causes economic growth (GDP) cannot be rejected since the probability value of its F-statistic, 0.7275, is greater than 0.05.

On the other hand, the Equation 2 results in Table 4.22 show that the null hypothesis of economic growth (GDP) not causing government expenditure can be rejected since the probability value of its F-statistic, 0.0002, is less than 0.05. The conclusion, therefore, is that the causality relationship between economic growth and exports is bidirectional with economic growth 'Granger-causing' exports and vice versa.

Table 4.21: Optimal Lag Section for Log(GDP), Log(GOE), and Log(M2)

VAR Lag Order Selection Criteria
Endogenous variables: D_L_GDP D_L_GOE D_L_M2
Exogenous variables: C
Sample: 1990Q1 - 2010Q2 (Included observations: 74)

Lag	LogL	LR	FPE	AIC	SBC	HQC
0	474.8026	NA	5.82e-10	-12.75142	-12.65801	-12.71416
1	500.6380	48.87791	3.69e-10	-13.20643	-12.83280	-13.05739
2	522.5087	39.60367*	2.61e-10*	-13.55429*	-12.90043*	-13.29346*
3	526.1830	6.355441	3.02e-10	-13.41035	-12.47627	-13.03773
4	534.8722	14.32550	3.07e-10	-13.40195	-12.18765	-12.91755
5	541.0361	9.662410	3.35e-10	-13.32530	-11.83077	-12.72912
6	545.1903	6.175130	3.87e-10	-13.19433	-11.41958	-12.48636
7	548.1756	4.195511	4.65e-10	-13.03177	-10.97680	-12.21202

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SBC: Schwarz information criterion
HQC: Hannan-Quinn information criterion

Table 4.22: Granger Causality Test Results for Log(GDP), Log(GOE), and Log(M2)

```
VAR system, lag order 2
OLS estimates, observations 1990:4-2010:2 (T = 79)
Log-likelihood = 554.74284
Determinant of covariance matrix = 1.5969526e-010
AIC = -13.5125
BIC = -12.8826
HQC = -13.2601
Portmanteau test: LB(19) = 130.21, df = 153 [0.9091]

Equation 1: d_l_GDP

F-tests of zero restrictions:

All lags of d_l_GDP         F(2, 72) =   12.437 [0.0000]
All lags of d_l_GOE         F(2, 72) =   4.9232 [0.0099]
All lags of d_l_M2          F(2, 72) =  0.31962 [0.7275]
All vars, lag 2             F(3, 72) =   14.827 [0.0000]

Equation 2: d_l_GOE

F-tests of zero restrictions:

All lags of d_l_GDP         F(2, 72) =   9.4936 [0.0002]
All lags of d_l_GOE         F(2, 72) =   18.788 [0.0000]
All lags of d_l_M2          F(2, 72) =  0.48724 [0.6163]
All vars, lag 2             F(3, 72) =   3.2649 [0.0262]

Equation 3: d_l_M2

F-tests of zero restrictions:

All lags of d_l_GDP         F(2, 72) =   1.2587 [0.2902]
All lags of d_l_GOE         F(2, 72) =   1.4830 [0.2338]
All lags of d_l_M2          F(2, 72) =   3.8369 [0.0261]
All vars, lag 2             F(3, 72) =  0.87613 [0.4576]
```

4.5.2 Long-Run Equilibrium Relationships

According to Cheng and Lai (1997), the long-run relationship between economic growth (GDP) and government expenditure along with money stock was examined. The VAR optimal lag length search results in Table 4.21 show four information criteria selecting lag length 3 while the SBC selects lag length 2. Again, on the basis robustness of the SBC, lag length 2 is selected as optimal. Using lag length 2, the Johansen-Juselius cointegration test results are summarized in Table 4.24.

An inspection of the cointegration test results for two lags in Table 4.24 shows clear evidence of cointegration; this outcome does not depend on the deterministic specification or on the type of test used. The conclusion reached is therefore that the economic growth and government expenditure are cointegrated and proceed to a consideration of the implications of this relationship. The cointegrating relationship economic growth and government expenditure along with money stock is specified as:

$$\log(GDP)_t = 2.0575 - 1.4536 * \log(GOE)_t + 0.2233 * \log(M2).$$

Table 4.23: Optimal Lag Selection for Log(GDP), Log(GOE) and Log(M2)

VAR Lag Order Selection Criteria
Endogenous variables: L_GDP L_GOE L_M2
Exogenous variables: C
Sample: 1990Q1-2010Q2 (Included observations: 75)

Lag	LogL	LR	FPE	AIC	SBC	HQC
0	164.6498	NA	2.69e-06	-4.310662	-4.217963	-4.273648
1	500.7244	636.3011	4.39e-10	-13.03265	-12.66185	-12.88459
2	522.0508	38.67191	3.17e-10	-13.36135	-12.71246*	-13.10226
3	539.0037	29.38501*	2.57e-10*	-13.57343*	-12.64644	-13.20329*
4	542.9964	6.601253	2.95e-10	-13.43990	-12.23481	-12.95872
5	551.3293	13.11043	3.03e-10	-13.42211	-11.93892	-12.82989
6	559.1142	11.62542	3.18e-10	-13.38971	-11.62842	-12.68645
7	563.0576	5.573392	3.71e-10	-13.25487	-11.21548	-12.44056

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SBC: Schwarz information criterion
HQC: Hannan-Quinn information criterion

Table 4.24: Johansen-Juselius Cointegration of Log(GDP), Log(GOE) and Log(M2)

Sample (adjusted): 1990Q4-2010Q2 (Included observations: 79 after adjustments)
Trend assumption: No deterministic trend (restricted constant)
Series: L_GDP L_GOE L_M2
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.378547	50.79614	35.19275	0.0005
At most 1	0.091336	13.21624	20.26184	0.3468
At most 2	0.069017	5.649614	9.164546	0.2196

1 Cointegrating Equation(s): Log likelihood 556.0522

Normalized cointegrating coefficients (standard error in parentheses)

L_GDP	L_GOE	L_M2	C
1.000000	-1.453572	0.223254	2.057474
	(1.63176)	(1.33236)	(1.38434)

The cointegrating equation indicates that government expenditure is negatively related to economic growth, with estimated elasticity of -1.4436 while money stock is positively related to economic growth with an elasticity of 0.2233. The negativity of government expenditure in relation to economic growth is not surprising as it is expected.

4.5.3 Short-Run Equilibrium Relationships

Having established that there is a long-run equilibrium relationship between economic growth (GDP) and government expenditure, a natural extension is to estimate the Error Correction Model (ECM) to assess their short-run equilibrium relationship. Using lag length 2 as chosen by the SBC in the three-variable VAR system of log(GDP), log(GOE), and log(M2), an ECM analysis was performed and the results reported in Table 4.25.

Table 4.25: ECM of Log(GDP), Log(GOE) and Log(M2)

Vector Error Correction Estimates
Sample (adjusted): 1990Q4 - 2010Q2 (Included observations: 79)
t-statistics in [ ]

Cointegrating Eq:	CointEq1	
L_GDP(-1)	1.000000	
L_GOE(-1)	-1.453572	[-0.89080]
L_M2(-1)	0.223254	[0.16756]
C	2.057474	[1.48625]

Error Correction:	D(L_GDP)	D(L_GOE)	D(L_M2)
CointEq1	0.021261	0.031612	0.010741
	[5.10979]	[3.87772]	[2.36318]
D(L_GDP(-1))	-0.098688	-0.639882	0.026576
	[-1.05814]	[-3.50168]	[0.26086]
D(L_GDP(-2))	-0.513375	0.427124	0.148467
	[-5.18531]	[2.20186]	[1.37278]
D(L_GOE(-1))	0.012322	-0.544569	-0.046849
	[0.22661]	[-5.11165]	[-0.78876]
D(L_GOE(-2))	0.148938	-0.042311	0.043314
	[2.73238]	[-0.39617]	[0.72744]
D(L_M2(-1))	0.025940	0.078331	0.307133
	[0.24357]	[0.37540]	[2.64011]
D(L_M2(-2))	0.051372	-0.211924	-0.045555
	[0.48519]	[-1.02155]	[-0.39386]

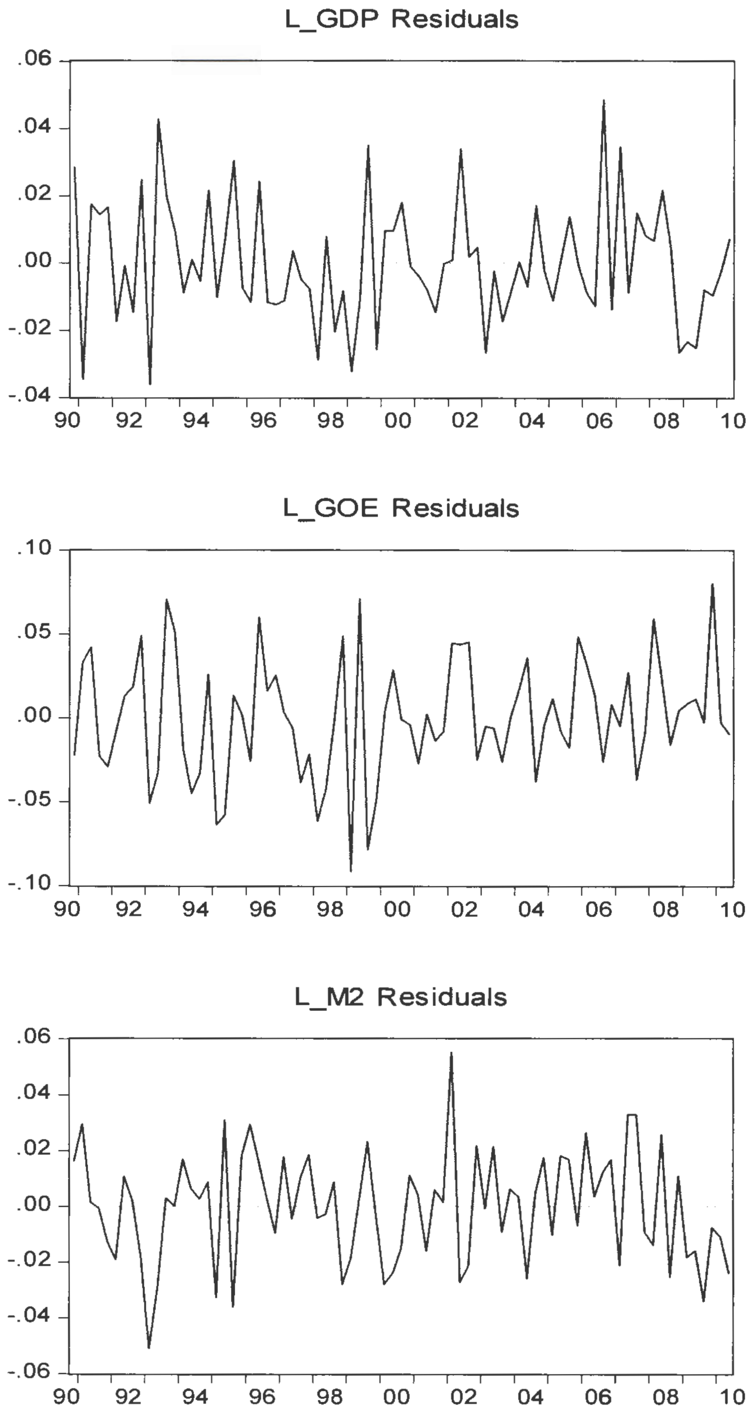


Figure 4.22: Plots of Residual Series from ECM of Log(GDP), Log(GOE) and Log(M2)

The ECM results show that the estimated coefficients of lagged log(GDP) are negative, implying South Africa's short-run economic growth during the period 1990Q1-2010Q2 is negatively affected by the past economic growth. Furthermore, the error correction term, CointEq1, of 0.021261, means that approximately 2.1% of total long-run disequilibrium in economic growth was being corrected in each quarter. To examine the adequacy of the ECM as an account of the data used, three tests about the residual series from the four variables were conducted and analyzed - tests of autocorrelation, normality, and heteroskedasticity. Figure 4.4 displays the plots of the residuals from each of the three variables serving as a dependent variable.

From the autocorrelation portmanteau test results in Table 4.4 for the EC residuals up to lag 12, the null hypothesis of normality cannot be rejected since the probability values of all the Q-statistics are greater than the 0.05 level of significance. Hence, there is no evidence of EC residual autocorrelations. The Doornik-Hansen tests for normality results in Table 4.27 also fail to reject since the probability values of all the chi-square statistics are greater than the 0.05 level of significance. With regards to heteroskedasticity, the White test results in Table 4.28 fail to reject since the probability value of the joint chi-square test statistics is greater than 0.05.

Table 4.26: Autocorrelation Tests of Residual from ECM of Log(GDP), Log(GOE) and Log(M2)

VEC Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Sample: 1990Q1- 2010Q2
Included observations: 79

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	4.273763	NA*	4.328554	NA*	NA*
2	9.323089	NA*	9.509032	NA*	NA*
3	15.02685	0.5227	15.43794	0.4928	16
4	21.11781	0.6860	21.85375	0.6442	25
5	25.68226	0.8467	26.72661	0.8083	34
6	30.20888	0.9295	31.62529	0.9000	43
7	32.70566	0.9833	34.36481	0.9718	52
8	44.20180	0.9481	47.15628	0.9035	61
9	49.67473	0.9687	53.33287	0.9308	70
10	53.12905	0.9888	57.28782	0.9687	79
11	55.66574	0.9972	60.23486	0.9897	88
12	64.89338	0.9950	71.11521	0.9776	97

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Table 4.27: Normality Tests of Residual from ECM of Log(GDP), Log(GOE) and Log(M2)

VEC Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Sample: 1990Q1 - 2010Q2 (Included observations: 79)

Component	Skewness	Chi-sq	df	Prob.
1	0.396177	2.066590	1	0.1506
2	-0.022688	0.006778	1	0.9344
3	-0.017003	0.003806	1	0.9508
Joint		2.077174	3	0.5565

Component	Kurtosis	Chi-sq	df	Prob.
1	2.919012	0.021590	1	0.8832
2	2.777924	0.162338	1	0.6870
3	2.817368	0.109792	1	0.7404
Joint		0.293721	3	0.9612

Component	Jarque-Bera	df	Prob.
1	2.088180	2	0.3520
2	0.169116	2	0.9189
3	0.113598	2	0.9448
Joint	2.370894	6	0.8826

Table 4.28: Heteroskedasticity Tests of Residual from ECM of Log(GDP), Log(GOE) and Log(M2)

VEC Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Sample: 1990Q1 - 2010Q2
Included observations: 79

Joint test:

Chi-sq	df	Prob.
106.6031	84	0.0486

Individual components:

Dependent	R-squared	F(14,64)	Prob.	Chi-sq(14)	Prob.
res1*res1	0.279633	1.774547	NA	22.09104	0.0768
res2*res2	0.397430	3.015126	0.0013	31.39699	0.0049
res3*res3	0.147100	0.788434	0.6776	11.62087	0.6367
res2*res1	0.158291	0.859698	0.6041	12.50498	0.5658
res3*res1	0.274598	1.730497	0.0711	21.69325	0.0851
res3*res2	0.122139	0.636033	0.8249	9.648968	0.7874

PART II: Univariate Modelling and Forecasting Economic Growth

Part II of the chapter focuses on modelling and forecasting economic growth as proxied by GDP univariately. Five univariate time series analysis, modelling methods, and forecasting methods are used - the Hodrick-Prescott filter, trend analysis, Autoregressive (Integrated) Moving Average modelling method, Brown's double-exponential smoothing modelling, and Back Propagation Neural Network.

4.6 Exponential Smoothing Model for Economic Growth

This section uses Brown's exponential smoothing method to model and forecast economic growth as proxied by GDP. The use of this methods is underscored by the existence of a linear trend in the log(GDP) series and the lack of a seasonal pattern. By employing a heuristic grid search procedure to minimize errors, the grid search identified a smoothing constant of 0.25 which produces better forecast accuracy. The estimated level and trend equations are:

$$L_t = 0.25 * \log(GDP)_t + 0.75 * L_{t-1}, \qquad \text{(level equation)}$$

$$T_t = 0.25(L_t - L_{t-1}) + 0.75 * T_{t-1}. \qquad \text{(trend equation)}$$

The k-step-ahead prediction equation is given as:

$$\hat{y}_{t+k} = L_t + [(k-1) + 4] * T_t, \qquad k = 1,2,3...$$

where $\hat{y}_t$ is the estimated $\log(GDP)_t$ at time point t. Using these results, the estimated log(GDP) series was obtained and the overlay plot of the actual and estimated log(GDP) series presented in Figure 4.5 along with the residual series. On the performance of this model, the residual plot in Figure 4.5 show that there is a minimum error between the actual log(GDP) and estimated log(GDP) and that the residuals are very small, most of which are close to zero. More specifically, the residuals fall within the [-0.055, 0.064].

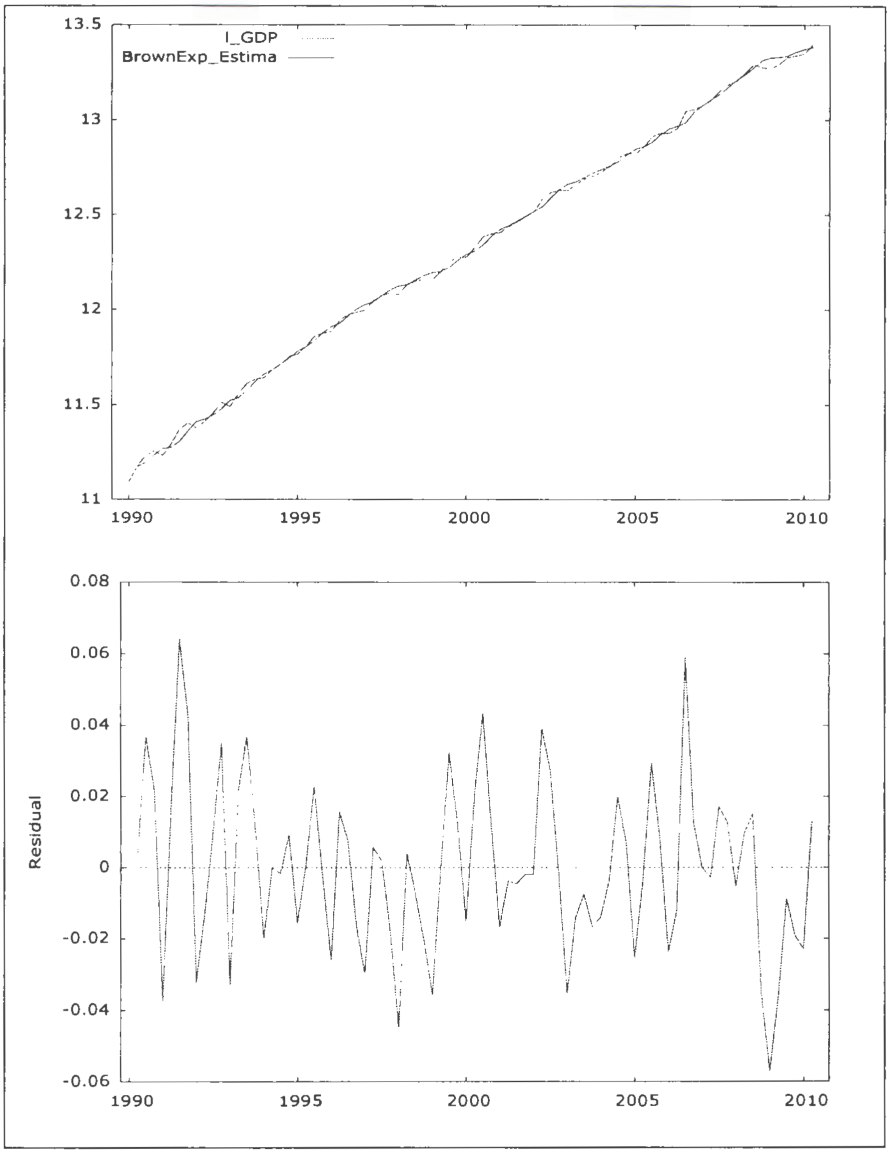


Figure 4.23: Plots of Actual and Estimated Log(GDP) and Residuals – Brown's Exponential Smoothing

4.7 ARIMA Model for Economic Growth

As previously established, log(GDP) is integrated of order 1, that is, stationarity in log(GDP) is only induced after differencing once. Consequently, the Box- Jenkins procedure on the stationary data series can be used to model South Africa's economic growth during the period 1990Q1-2010Q2. The first task involved in the use of the Box-Jenkins method to a stationary time series is to identify the corresponding ARIMA (p, q) process. The stationary series correlogram allows the researcher to choose potential p and q for the stationary time series. Table 4.29 presents the correlogram of the first-differenced (stationary) log(GDP) series. An examination of the stationary series correlogram reveals high spikes in the autocorrelation functions (ACFs) at lags 2, 4, 6, 8, 10, and 12, suggesting the possibility of MA(2), MA(4), MA(6), MA(8), MA(10), and MA(12). However, due to parsimony, high orders of 6 and above are excluded. Similarly, the high spikes in the partial autocorrelation functions (PACFs) at lags 2 and 4 suggests the possibility of AR(2) and AR(4). Thus, the combination of MA(2), MA(4), AR(2) and AR(4) produces eight potential models for log(GDP) - ARIMA(2,1,2), ARIMA(2,1,4), ARIMA(4,1,2), ARIMA(4,1,4), ARIMA(2,1,0), ARIMA(4,1,0), ARIMA(0,1,2), and ARIMA(0,1,4).

To determine the most appropriate ARIMA(p,1,q) representation for log(GDP), the eight potential models were estimated and their informational criteria Akaike and Schwartz Bayesian values reported in Table 4.28. From both the Akaike and Schwartz Bayesian criteria's point of view, the proper model to best adjust the data is ARIMA (4,1,4). Table 4.31 presents the initial ARIMA estimated results. From the initial estimated results six components were not significant - AR(1), AR(2), AR(3), MA(1), MA(2), and MA(3) - even though the other statistics, DW=2.1 and coefficient of determination (R-squared = 60.3%) let portend a good fitting. As a result, the six non-significant components were excluded, the model re-estimated, and the results presented in Table 4.30.

Table 4.29: Correlogram of First-Differenced Log(GDP)

Data: First-Differenced Log(GDP)
Sample: 1990Q1 - 2010Q2 (Included observations: 81)

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>. | . |</td><td>. | . |</td><td>1</td><td>-0.035</td><td>-0.035</td><td>0.1034</td><td>0.748</td></tr>
<tr><td>****| . |</td><td>****| . |</td><td>2</td><td>-0.504</td><td>-0.505</td><td>21.678</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>**| . |</td><td>3</td><td>-0.127</td><td>-0.231</td><td>23.073</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. |*** |</td><td>4</td><td>0.599</td><td>0.438</td><td>54.368</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>.*| . |</td><td>5</td><td>-0.005</td><td>-0.113</td><td>54.370</td><td>0.000</td></tr>
<tr><td>***| . |</td><td>.*| . |</td><td>6</td><td>-0.410</td><td>-0.066</td><td>69.463</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>7</td><td>-0.108</td><td>-0.012</td><td>70.519</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. |*. |</td><td>8</td><td>0.523</td><td>0.198</td><td>95.682</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>**| . |</td><td>9</td><td>-0.075</td><td>-0.207</td><td>96.209</td><td>0.000</td></tr>
<tr><td>***| . |</td><td>. | . |</td><td>10</td><td>-0.361</td><td>-0.002</td><td>108.58</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>11</td><td>-0.042</td><td>0.043</td><td>108.75</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>12</td><td>0.442</td><td>0.014</td><td>127.82</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>13</td><td>-0.076</td><td>-0.056</td><td>128.39</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. | . |</td><td>14</td><td>-0.339</td><td>-0.023</td><td>139.93</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>15</td><td>-0.013</td><td>0.019</td><td>139.95</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>16</td><td>0.380</td><td>-0.042</td><td>154.84</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>17</td><td>-0.068</td><td>0.007</td><td>155.33</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. | . |</td><td>18</td><td>-0.289</td><td>-0.001</td><td>164.22</td><td>0.000</td></tr>
</table>

Table 4.30: Informational Criteria and Model Selection for Log(GDP)

Model Number	ARIMA Model	AIC	SBC
1	ARIMA(2,1,2)	-330.710	-321.132
2	ARIMA(2,1,4)	-350.862	-336.495
3	ARIMA(4,1,2)	-406.200	-391.833
4	ARIMA(4,1,4)	**-419.988**	**-400.832**
5	ARIMA(2,1,0)	-330.869	-326.080
6	ARIMA(4,1,0)	-404.159	-394.581
7	ARIMA(0,1,2)	-331.059	-326.270
8	ARIMA(0,1,4)	-351.465	-341.888

From the re-estimated results, the coefficients of the model are significantly different from 0 (probability values of the t-statistics are less than 0.05) while the coefficient of determination is 56.4%. To assess the residual series, two criteria are used - normality and autocorrelation tests. The normality test in Figure 4.24 points out that the mean of residuals is approximately 0 (0.0006). From the autocorrelation results in Table 4.31, the residual follows a white noise process, since probability values of the Q-statistics are all greater than the 0.05 level of significance. Figure 4.23 is the overlay plot of the series from the fitted ARIMA model and the actual log(GDP) series. As observed, the adequacy of the estimated ARIMA model is clearly unquestionable. The estimate ARIMA model is:

$$(1-0.976L^4)(1-L)\log(GDP)_t = (1+0.818L^4)\varepsilon_t$$

where L is the lag operator.

Table 4.31: ARIMA Model Estimation Results for Log(GDP) – Initial Results

Dependent Variable: D_L_GDP
Method: Least Squares
Sample (adjusted): 1991Q2-2010Q2 (Included observations: 77 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	0.069347	0.051390	1.349432	0.1816
AR(2)	-0.041540	0.051178	-0.811687	0.4198
AR(3)	0.085337	0.050473	1.690760	0.0954
AR(4)	0.877374	0.050771	17.28096	0.0000
MA(1)	-0.055249	0.115578	-0.478020	0.6341
MA(2)	-0.052056	0.114510	-0.454593	0.6508
MA(3)	-0.172822	0.110306	-1.566754	0.1217
MA(4)	-0.718936	0.115519	-6.223515	0.0000

R-squared	0.603463	Sum squared resid	0.015804
Adjusted R-squared	0.563235	Akaike info criterion	-5.445641
Log likelihood	217.6572	Schwarz criterion	-5.202129
Durbin-Watson stat	2.068288	Hannan-Quinn criter.	-5.348238

On the performance of this model, the residual plot show that there is a minimum error between the actual log(GDP) and estimated log(GDP) and that the residuals are very small, most of which are close to zero. More specifically, the residuals fall within the [-0.030, 0.054].

Table 4.32: ARIMA Model Estimation Results for Log(GDP) – Final Results

Dependent Variable: D(L_GDP)
Method: Least Squares
Sample (adjusted): 1991Q2-2010Q2 (Included observations: 77 after adjustments)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(4)	0.976201	0.013643	71.55256	0.0000
MA(4)	-0.818475	0.048675	-16.81498	0.0000

R-squared	0.564226	Sum squared resid	0.017368
Adjusted R-squared	0.558416	Akaike info criterion	-5.507131
Log likelihood	214.0245	Schwarz criterion	-5.446253
Durbin-Watson stat	2.006922	Hannan-Quinn criter.	-5.482780

Table 4.33: Correlogram of Squared Residuals from ARIMA(4,1,4) Modelling of Log(GDP)

Data: Residual Series from ARIMA(4,1,4) Modelling of Log(GDP)
Sample: 1991Q2-2010Q2 (Included observations: 77)
Q-statistic probabilities adjusted for 2 ARMA term(s)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. | . |	. | . |	1	-0.012	-0.012	0.0115	
.*| . |	.*| . |	2	-0.099	-0.099	0.8037	
.*| . |	.*| . |	3	-0.121	-0.125	2.0030	0.157
. | . |	. | . |	4	0.008	-0.007	2.0082	0.366
. | . |	. | . |	5	0.019	-0.006	2.0383	0.564
. | . |	. | . |	6	-0.045	-0.062	2.2147	0.696
.*| . |	.*| . |	7	-0.102	-0.106	3.1115	0.683
. |*. |	. |*. |	8	0.111	0.100	4.1991	0.650
. | . |	. | . |	9	0.047	0.020	4.3987	0.733
. | . |	. | . |	10	0.003	-0.002	4.3995	0.819
.*| . |	.*| . |	11	-0.128	-0.100	5.8991	0.750
.*| . |	.*| . |	12	-0.078	-0.078	6.4685	0.774
. | . |	. | . |	13	-0.015	-0.054	6.4910	0.839
. | . |	. | . |	14	0.056	0.012	6.7934	0.871
.*| . |	.*| . |	15	-0.096	-0.105	7.6915	0.863
. | . |	.*| . |	16	-0.059	-0.080	8.0398	0.887

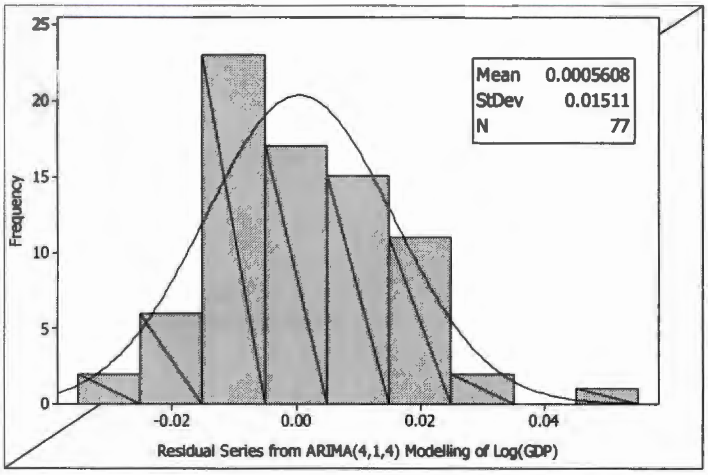


Figure 4.24: Histogram and Normality Curve of Residuals from ARIMA(4,1,4)

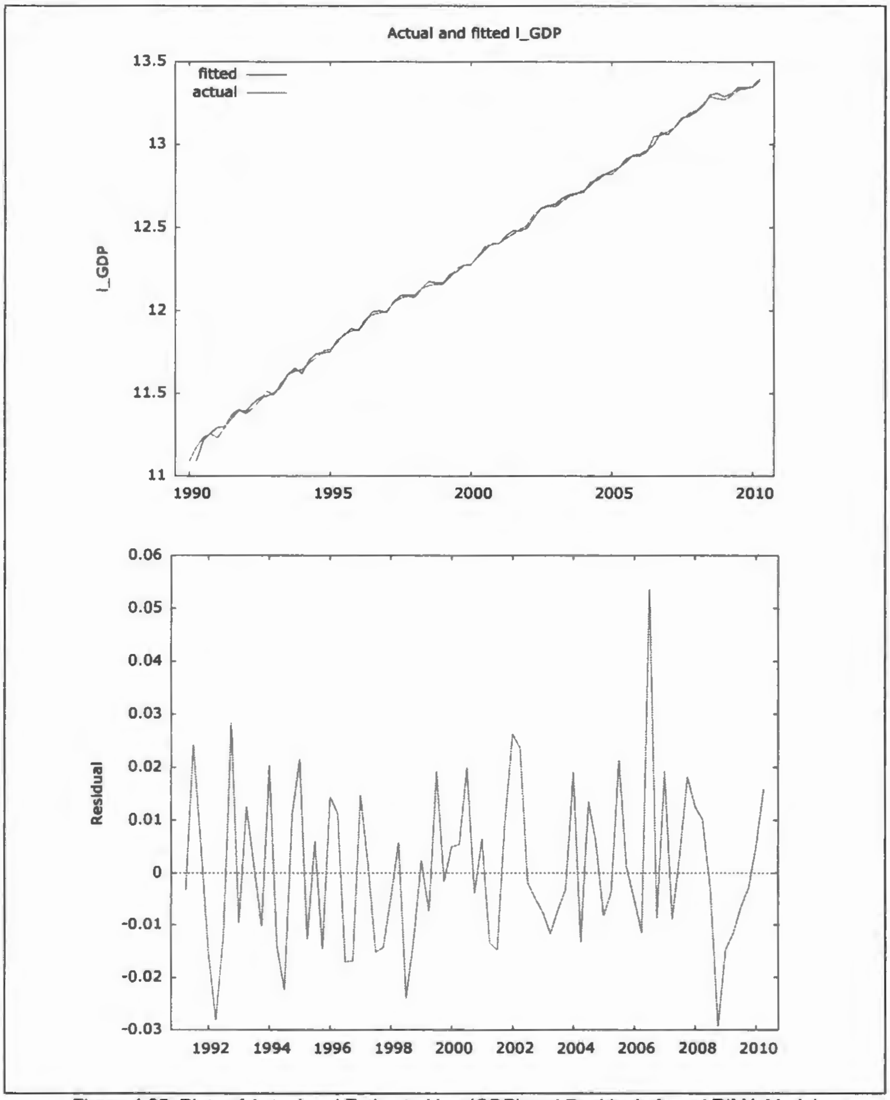


Figure 4.25: Plots of Actual and Estimated Log(GDP) and Residuals from ARIMA Model

4.8 Neural Network Model for Economic Growth

In this section, artificial neural network was used to model economic growth. The network used had three layers - an input layer, a hidden layer, and an output layer. The topology used included 12 input layer neurons, 12 hidden layer neurons, and 1 output layer neuron. The input and hidden layers are connected with the tangent hyperbolic activation function and the back-propagation technique to estimate network weights. The same function serves to connect the hidden and output layers. Table 4.32 summarizes the details of the back-propagation neural network architecture used to model log(GDP).

Table 4.34: Neural Network Summary for Log(GDP)

Variable Included	Variable Included Observation	Log(GDP) 70 (After adjusting endpoints)
Network Architecture	Input Layer Neurons Hidden Layer Neurons Output Layer Neurons Activation Function	12 12 1 Hyperbolic Tangent Function
Back Propagation Learning	Learning Rate Momentum	0.05 0.05
Error Measure	Error MSE MAE	0.001844 0.000071 0.006148

Based on the network architecture presented in Table 4.34, estimates of log(GDP) and actual log(GDP) are presented graphically in Figure 4.8. Visual assessment of the actual and estimated series plots show that the neural network architecture has a very good performance in predicting economic growth over the period 1990Q1-2010Q4. The residual plot in Figure 4.26 suggests that there is a minimum error between the actual log(GDP) and estimated log(GDP) and that the residuals are very small as they are very close to zero, lying in the interval [-0.25,0.25].

Although artificial neural network does not require a time series to be stationary before analysis, the first-differenced log(GDP) is also modelled and assessed with sole aim of comparing its performance with the ARIMA(4,1,4) modelled in the previous section. Table 4.35 summarizes the details of the back-propagation neural network architecture used to model first-differenced log(GDP). Figure 4.27 is the overlay representation of the first-differences of actual log(GDP) and estimated log(GDP).

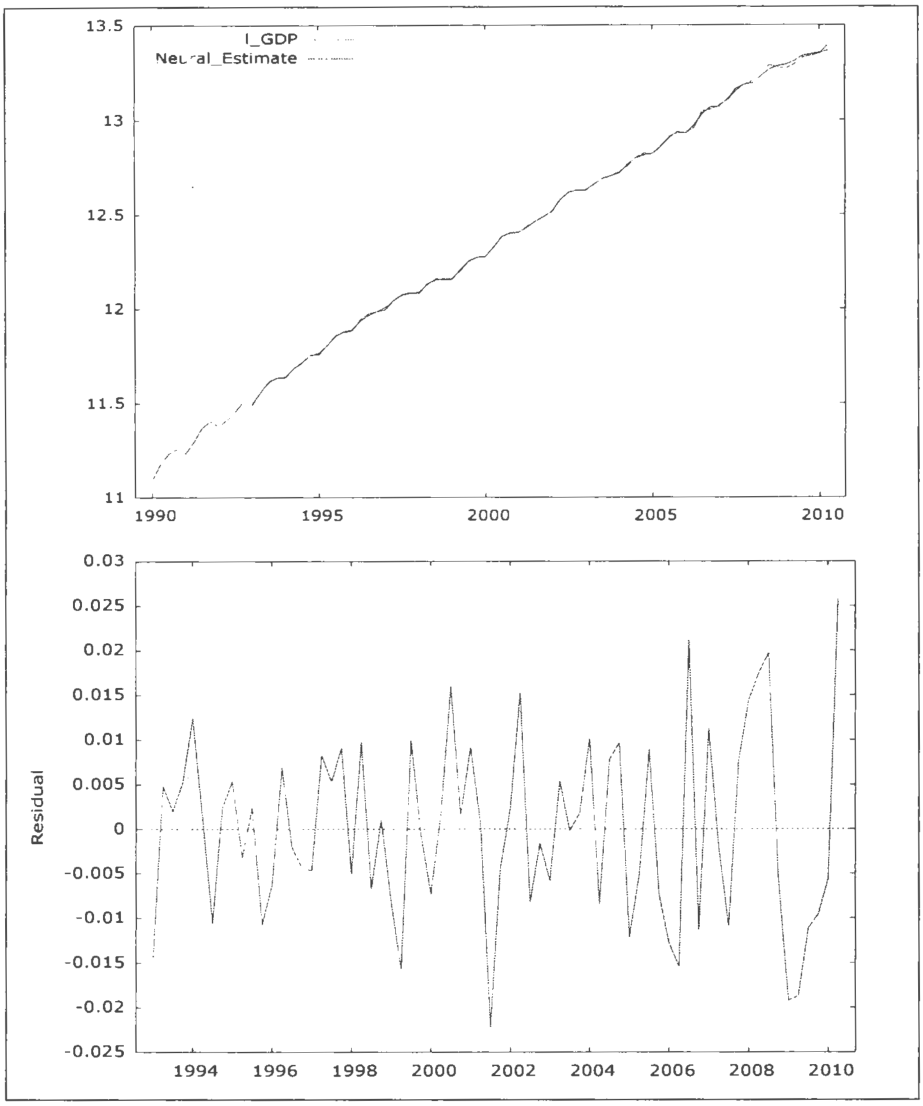


Figure 4.26: Plots of Actual and Estimated Log(GDP) and Residuals from Neural Network

Table 4.35: Neural Network Summary for First-Differenced Log(GDP)

Network Architecture	Input Layer Neurons Hidden Layer Neurons Output Layer Neurons Activation Function	12 12 1 Hyperbolic Tangent Function
Back Propagation Learning	Learning Rate Momentum	0.05 0.05
Error Measure	Error MSE MAE	0.007211 0.000001 0.000594

A visual examination of the actual and estimated first-differences series plots show that the neural network architecture has a very good performance in predicting first-differenced log(GDP) over the period 1990Q1-2010Q4. The residual plot in Figure 4.27 suggests that there is a minimum error between the first differences of the actual log(GDP) and estimated log(GDP) and that the residuals are very small as they are very close to zero, lying in the interval [-0.003, 0.005].

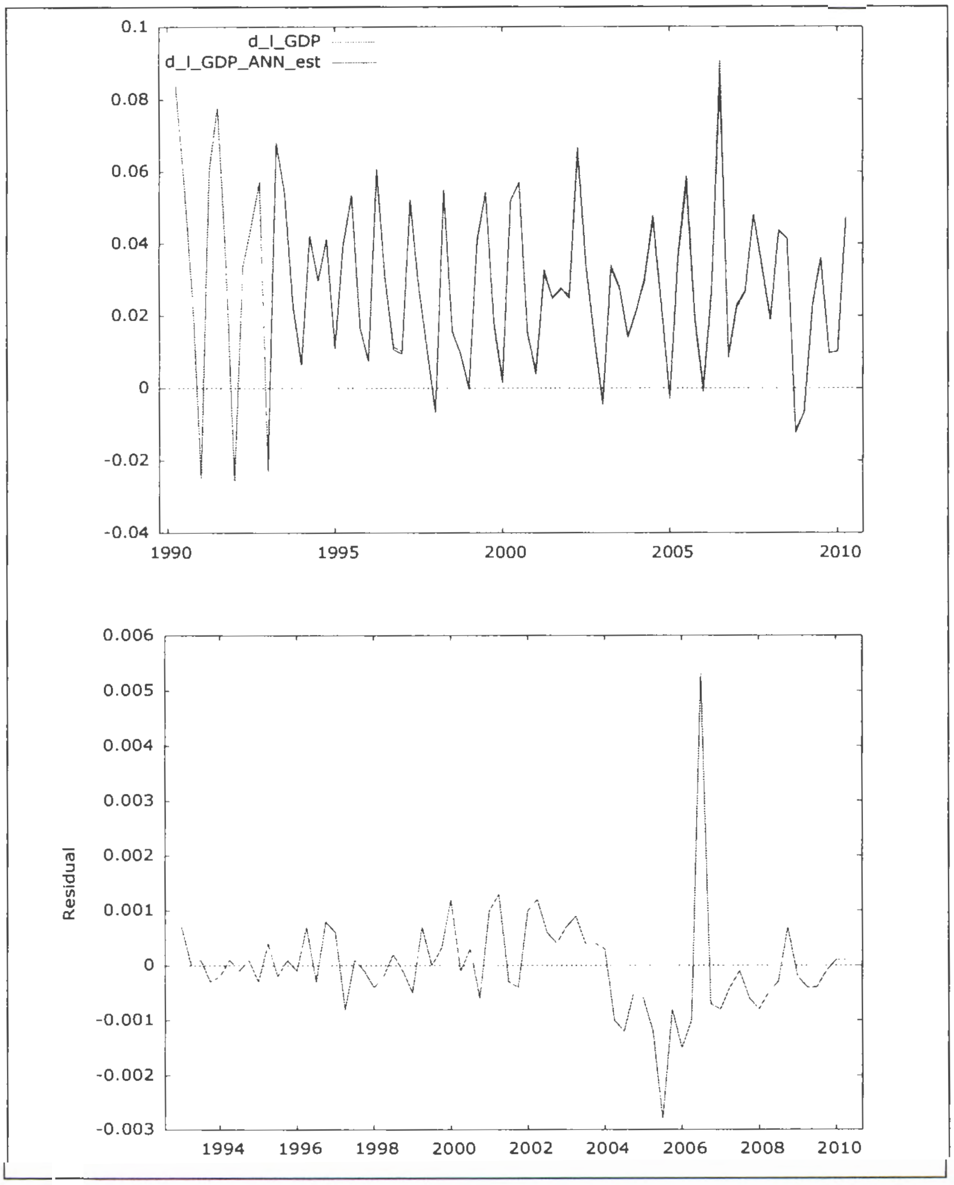


Figure 4.27: Plots of Actual and Estimated First-Differenced Log(GDP) and Residuals from Neural Network

4.9 Comparison of Model Performance and Future Forecasts

Table 4.36 presents the levels of accuracy of the three models postulated for log(GDP as well as the out-of-sample forecasts covering the period 2010Q3-2012Q4. As can be seen, all three statistics, MAE, MFE, and MAPE select the artificial neural network model as the one that best models South Africa's economic growth over the period 1990Q1-2010Q2. However, even though the neural network model has the best performance, the out-of-forecast values from the three models do not differ much.

Table 4.36: Out-of-Sample Forecasts for Economic Growth, 2010Q3-2012Q4

Error Measures			
	Neural Network	ARIMA	Brown's Double Expo. Smoothing
MAE	0.0084000	0.0436000	0.0185000
MPE	-0.0000041	-0.0030452	0.0000327
MAPE	0.0006688	0.0035084	0.0015127
Forecasts in Natural Logs			
2010Q3	13.3853	13.4407	13.4103
2010Q4	13.3842	13.4513	13.4322
2011Q1	13.3883	13.4587	13.4541
2011Q2	13.4015	13.4943	13.4761
2011Q3	13.4054	13.5390	13.4980
2011Q4	13.4039	13.5495	13.5199
2012Q1	13.4090	13.5568	13.5419
2012Q2	13.4146	13.5921	13.5638
2012Q3	13.4155	13.6365	13.5858
2012Q4	13.4169	13.6469	13.6077
Actual Forecasts (R Million)			
2010Q3	650372	687419	666836
2010Q4	649657	694745	681601
2011Q1	652326	699905	696693
2011Q2	660994	725271	712190
2011Q3	663577	758426	727959
2011Q4	662582	766431	744077
2012Q1	665970	772046	760628
2012Q2	669710	799786	777470
2012Q3	670313	836097	794764
2012Q4	671252	844838	812361

4.10 Patterns of Economic Growth in South Africa

The path of economic growth for any country depends on a number of factors including structural changes in the economy, global recessionary trends, and self-feeding business cycles. The combined effect of all these factors is most commonly represented in the country's Gross Domestic Product

(GDP). This last section of the chapter performs univariate data analysis of economic growth as proxied by GDP.

In statistical terms, GDP time series data can be considered a combination of three processes - a long-run trend, business cycles, and short-run shocks to the economy, which can be separated from each other by using statistical techniques. The aim of this section is to decompose the GDP time series into the three components mentioned, and also to project them for determining future path of economic growth in South Africa. Analysis of this nature gives more insights to the understanding of the changing pattern of economic growth. As indicated in Chapter 4, a number of methods have been proposed for separating the trend from the cyclical component of an economic time series. The most popular of these is the Hodrick-Prescott filter (Hodrick and Prescott, 1997), which is adapted in this study. To extract the components, the HP-filter is applied to log(GDP) in two stages - first, to extract the long-run trend, T_t, from log(GDP) and then filter out cycles, C_t, from the rest, $Z_t = \log(GDP)_t - T_t$.

Figure 4.28 is a graphical illustration of the irregular component (short-run shocks) in log(GDP). Figure 5.29 presents the time series plots of the long-run trend. As observed from Figure 4.11, South Africa's GDP has a positive long-run trend throughout the period under discussion. However, it may be noted that though GDP trend increases over time, its rate of increase as depicted in Figure 4.12 had different behaviour in different periods.

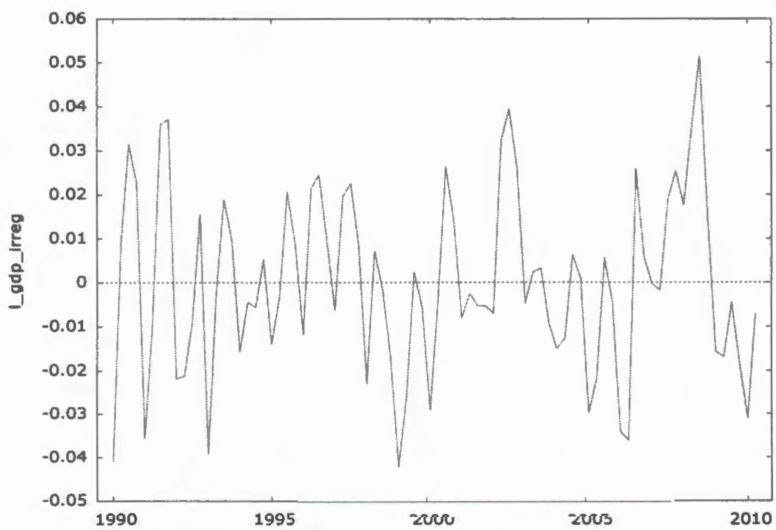


Figure 4.28: Short-Run Shocks in Log GDP (Irregular Component of Log GDP)

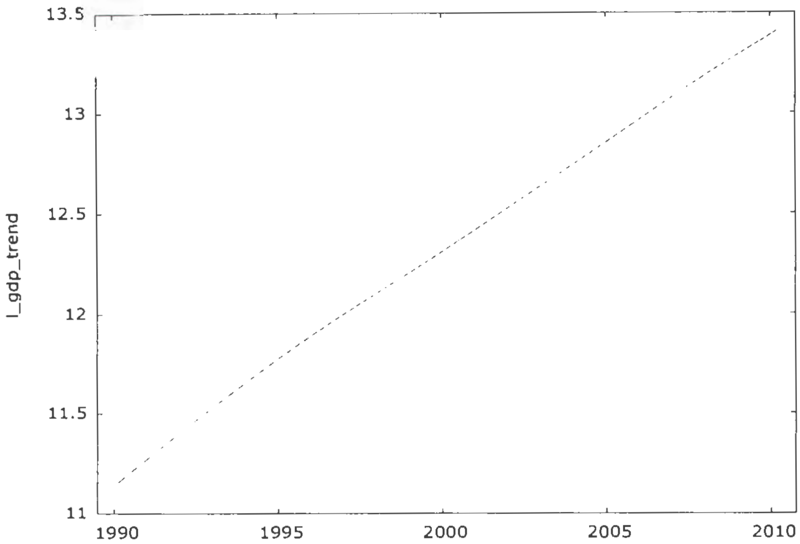


Figure 4.29: Trend Component of Log GDP

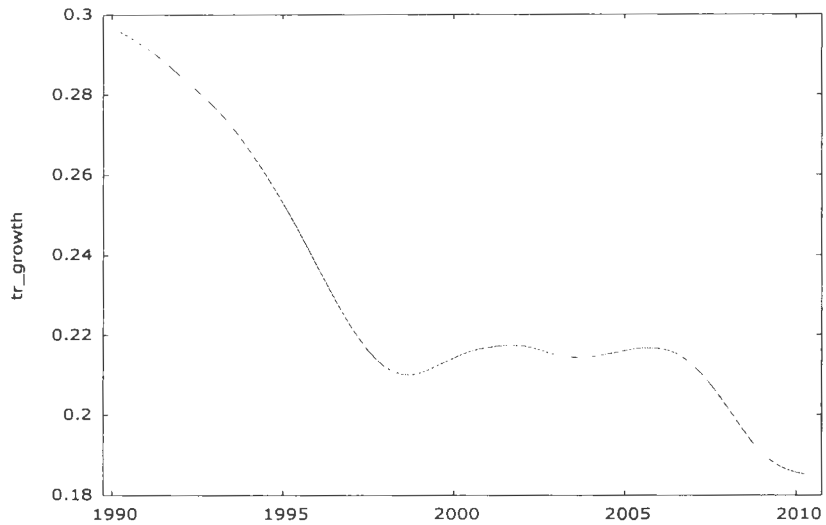


Figure 4.30: GDP Trend Growth Rate (Percent)

More specifically, during 1990Q1-1998Q4, the growth of trend component was declining while the period 1999Q1-2001Q4 witnessed a rising trend growth. The period 2002Q1-2003Q4 witnessed a rising growth in trend while the period of 2004Q1-2005Q4 witnessed a rising growth in trend component. The remaining period of 2006Q1-2010Q2 revealed a declining growth in the trend component. The next task is to project trend into the future over the next 10 quarters (2010Q3-2012Q4) in order examine the growth trend in the near future. To project the long-run trend, a linear time trend analysis is used. Table 4.37 reports the linear time trend analysis results for the trend component. The estimated trend line is:

$$T_t = 11.1706 + 0.0276t\ ,$$

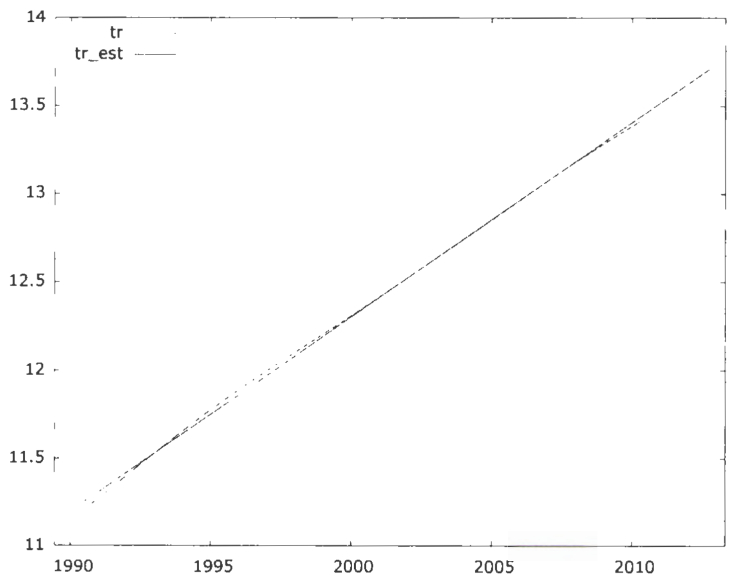
where t represents the time points 1,2,....,n.

Table 4.37: Linear Time Regression Results for Trend Component

Dependent Variable: TR (Trend)
Method: Least Squares
Sample: 1990Q1-2010Q2 (Included observations: 82)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	11.17059	0.004301	2597.084	0.0000
T	0.027611	9.00E-05	306.6888	0.0000

R-squared	0.999150	Sum squared resid	0.029789
Adjusted R-squared	0.999140	Akaike info criterion	-5.033680
S.E. of regression	0.019297	Schwarz criterion	-4.974980
F-statistic	94057.99	Hannan-Quinn criter.	-5.010113
Prob(F-statistic)	0.000000	Durbin-Watson stat	0.016072



Date	%Growth
2010/03	0.3844
2010/04	0.2050
2011/01	0.2046
2011/02	0.2042
2011/03	0.2038
2011/04	0.2034
2012/01	0.2030
2012/02	0.2025
2012/03	0.2021
2012/04	0.2017

tr = Actual trend
tr_est = Estimated trend

Figure 4.31: Overlay Plot of Actual and Projected Long-Run Trend

Figure 4.31 is an overlay display of the actual, estimated, and projected long-run trend in log(GDP) and the projected growth rates in trend for the period 2010Q3-2012Q4, which reveals a declining growth trend over that period. Figure 4.32 graphically describes the time series plots of the cycles in the log(GDP) series. As regards the cyclical movements, it is revealed in Figure 4.14 that South Africa's GDP completed three cycles over the period under investigation - one ending with a peak in 1995Q3-1995Q4, a second ending in 2004Q1-2004Q3, and third ending in 2007Q4. Table 4.36 gives a time frame of phases of business cycles in South Africa over the 1990Q1-2010Q2 period.

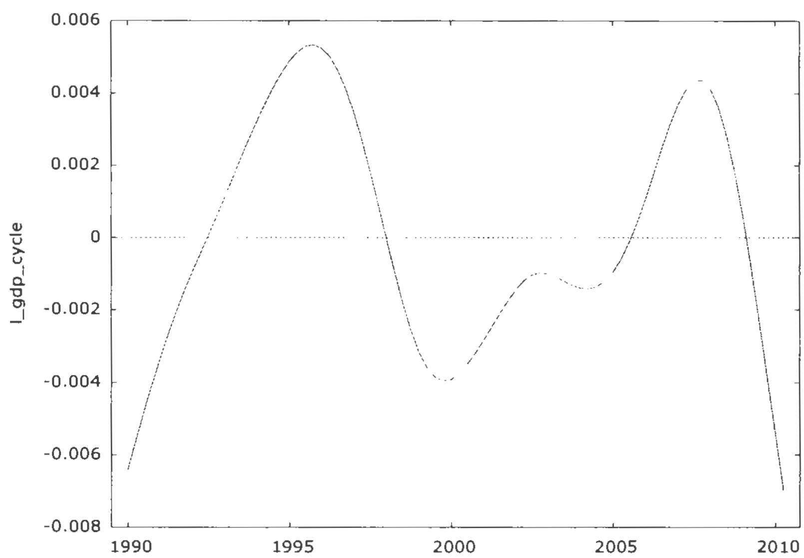
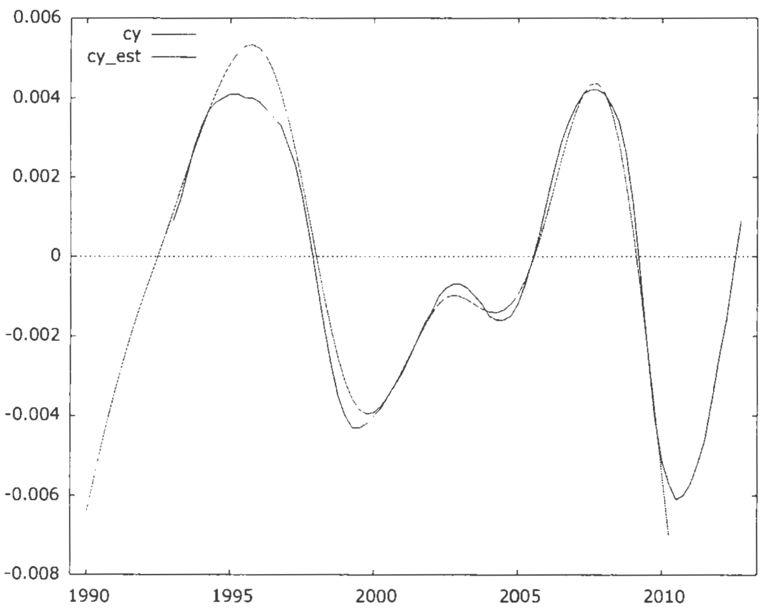


Figure 4.32: Cyclical Component of Log(GDP)

Table 4.38: Time Frame of Business Cycles in South Africa (1990Q1-2010Q2)

Business Cycle	Expanded	Peak	Sluggish	Trough
First Business Cycle: 1990Q1-1995Q4	1990Q1-1995Q3 (4.75 years)	1995Q3-1995Q4	1996Q1-1999Q3 (3.75 years)	1999Q4
Second Business Cycle: 2000Q1-2003Q4	2000Q1-2002Q2 (1.50 years)	2002Q3-2002Q4	2003Q1-2003Q4 (1.00 year)	2004Q2-2004Q3
Third Business Cycle: 2004Q4-2010Q2	2004Q4-2007Q3 (4.00 years)	2007Q4	2008Q1-2010Q2 (2.50 years)	????

The next task is to project cycles into the future over the next 10 quarters (2010Q3-2012Q4) with the purpose of having an idea of what one should anticipate in the near future. For this purpose, a back propagation neural network is again used to model the cyclical component uses and to predict values for the near future. Figure 4.33 is the overlay graphical representation of the actual, estimated, and projected cyclical components of log(GDP). From Figure 4.32, the cyclical component of the log(GDP) is projected to reach another trough in 2010Q3 and recover over the period 2010Q4-2012Q4. The projection is based on the assumption that economy will not suffer from positive and negative shocks during that period.



Projected Cycle

Date	Cycle
2010/03	-0.0061
2010/04	-0.0060
2011/01	-0.0057
2011/02	-0.0052
2011/03	-0.0046
2011/04	-0.0036
2012/01	-0.0025
2012/02	-0.0016
2012/03	-0.0003
2012/04	0.0009

cy = Actual cycle
cy_est = Estimated cycle

Figure 4.33: Overlay Plots of Actual and Projected Cyclical Components of Log(GDP)

Table 4.39: Neural Network Summary for Cyclical Component of Log(GDP)

Network Architecture	Input Layer Neurons Hidden Layer Neurons Output Layer Neurons Activation Function	12 12 1 Bipolar Sigmoid Function
Back Propagation Learning	Learning Rate Momentum	0.05 0.05
Criteria	Error MSE MAE	0.179092 0.000000 0.000590

4.11 Chapter Remarks

This chapter has presented detailed analyses of South Africa's economic growth over the period 1990Q1-2010Q2 using various univariate and multivariate econometric and statistical methods. Summary of the findings are presented in Chapter 5.

Chapter 5

Conclusions and Implications

5.1 Introduction

Economic growth has long been under meticulous study due to its importance. This study investigated South Africa's economic growth path over the period 1990Q1-2010Q2 by applying some intermediate and advanced econometric methods. This final chapter presents a summary of the findings as well as the implications of the findings.

5.2 Summary of Findings

5.2.1 Economic Growth and Exports

At the 0.05, the causality analysis of economic growth as proxied by GDP and exports established a bidirectional causal relationship between economic growth (GDP) and export flow. A follow-up cointegration analysis revealed a long-run equilibrium relationship between economic growth and exports. The equation describing the long-run relationship between economic growth and exports showed that export is negatively related to economic growth, with estimated elasticity of -0.7049. A follow-up error correction model evaluation derived from the cointegration relationship indicated that South Africa's short-run economic growth during the period 1990-2010Q2 is negatively influenced by the past economic growth and that the error correction term, representing the proportion by which a long-run disequilibrium in economic growth can be corrected in each quarter suggests that approximately 2.0% of total disequilibrium in economic growth was being corrected in each quarter.

5.2.2 Economic Growth, Exports, Imports, and Gross Fixed Capital Formation

Two important economic variables were included in the analysis – gross fixed capital formation (GFCF) and imports of goods and services (Imp). A causality analysis conducted with the four variables revealed that exports and gross fixed capital formation did not cause economic growth during the period under study, and that only import flow was found to cause economic growth. On the reverse side, the causality test results revealed economic growth (GDP) causing exports. The conclusion, therefore, is that the causality relationship between economic growth and exports is unidirectional with economic growth 'Granger-causing' exports and not vice versa. A follow-up cointegration analysis revealed, at least, one long-run equilibrium relationship between the four variables. The cointegrating equation indicates that the variables, exports and gross fixed capital formation, are negatively related to economic growth, with estimated elasticities of -3.2930 and -1.4076, respectively. Imports were, however, found to be positively related to economic growth with an elasticity of 3.7409. The negativity of exports, in relation to economic growth, is however strange as a positive relation between the two is expected. On the other hand, the positive relation of imports to economic growth is shocking as imports of goods and services could be unproductive in promoting economic growth, albeit the fact that it does not contribute to the capital generation. An Error Correction Modelling test among the four variables revealed that the estimated coefficients of lagged log(GDP) are negative, implying South Africa's short-run economic growth during the period 1990Q1-2010Q2 is negatively affected by the past economic growth. In addition, the error correction term revealed that approximately 2.3% of total long-run disequilibrium in economic growth was being corrected in each quarter when the four variables are simultaneously used to assess the existence of any short-run equilibrium relationship among the four variables.

A follow-up impulse response Function (IRF) analysis and Variance Decomposition Analysis (VDA) within a ten-quarter forecasting horizon revealed that shock effects of export flow leads to positive impact on economic growth with the largest positive impact occurring in the sixth quarter and the least positive exports impact occurring in first quarter. Shock effects of imports on economic growth (GDP) was also found to be positive with the largest positive imports impact occurring in the second quarter while the least positive imports impact occurs in the fourth quarter. The impact of shocks from gross fixed capital formation on economic growth was also positive with the largest positive shock effect occurring in the tenth quarter, and the least shock effect occurring in the third quarter. The shock effects of GDP on exports were also positive with the largest shock effects occurring in the tenth quarter and the least, in the first quarter. The shock effects of import flow on export flow was also positive with the largest effect occurring in the second quarter and the least, in the fourth quarter while the shock effects of gross fixed capital formation on export flow was also positive with the largest positive GFCF shock effect occurring in the tenth quarter and the least effect occurring in first quarter.

A follow-up variance decomposition analysis showed that economic growth is fully exogenous. However, by the tenth quarter (2012Q4), nearly 83% of the variation in South Africa's economic growth (GDP) can be explained by its own innovation. By the tenth quarter, exports, imports, and gross fixed capital formation explain about 8%, 3%, and 4%, respectively, of the variation in economic growth (GDP). On the other hand, the VDA results show that nearly 81% of the variations in export flow in the first quarter can be explained by its own innovations. By the tenth quarter, variations in export flow can be attributed to nearly 57% of its own innovations with GDP explaining 42% and the remaining variations shared between import flows and gross fixed capital formation.

5.2.3 Economic Growth, Exports, Government Expenditure and Money Stock

A causality analysis of economic growth, government expenditure along with money stock revealed that government expenditure, along with money stock, does not cause economic growth. However, economic growth was found to cause government expenditure. The conclusion, therefore, is that the causality relationship between economic growth and exports is unidirectional with economic growth 'Granger-causing' exports. A follow-up cointegration test revealed a long-run relationship between economic growth (GDP) and government expenditure along with money stock The cointegrating equation revealed that government expenditure was negatively related to economic growth, with estimated elasticity of -1.4436 while money stock was positively related to economic growth with an elasticity of 0.2233. The negativity of government expenditure in relation to economic growth is not surprising as it is expected. An error correction modelling of the three economic variables revealed a short-run relationship among the three variables. The ECM results produced negative lagged log(GDP) coefficients, implying South Africa's short-run economic growth during the period 1990Q1-2010Q2 is negatively affected by the past economic growth. Furthermore, the error correction term, revealed that approximately 2.1% of total long-run disequilibrium in economic growth was being corrected in each quarter.

5.2.4 Examination of Economic Growth Path

The path of economic growth for any country depends on a number of factors including structural changes in the economy, global recessionary trends, and self-feeding business cycles. The combined effect of all these factors is most commonly represented in the country's Gross Domestic Product (GDP). Using the Hodrick-Prescott filter to decompose the GDP series into the three components, further analysis of the components revealed enormous information about economic growth in South Africa. More specifically, during 1990Q1-1998Q4, the growth of trend component was declining while the period 1999Q1-2001Q4 witnessed a rising trend growth. The period 2002Q1-2003Q4 witnessed a rising growth in trend while the period of 2004Q1-2005Q4 witnessed a rising growth in trend component. The remaining period of 2006Q1-2010Q2 revealed a declining growth in the trend component.

As regards the cyclical movements, the analysis showed that South Africa's GDP completed three cycles over the period under investigation - one ending with a peak in 1995Q3-1995Q4, a second ending in 2004Q1-2004Q3, and third ending in 2007Q4. To anticipate the near future cycles in South Africa's economic growth, projections for the next 10 quarters (2010Q3-2012Q4) were done based on the assumption that economy will not suffer from positive and negative shocks during that period. The cyclical component of economic growth is projected to reach a trough in 2010Q3 and recover over the period 2010Q4-2012Q4.

5.2.5 Future Forecast

The use of three econometric modelling methods revealed positive economic growth in the near future. More specifically, the out-of-sample forecasts covering the period 2010Q3-2012Q4 were found to be in neighbourhoods of R650 372 million in 2010Q3 and R844 838 million in 2012Q4.

5.3 Findings and Policy Implications

What policy implications can then be drawn from the findings of this study? As a policy suggestion, despite the initial small size of the economy, it would still be advisable for a developing country to intensify participation in international trade, i.e. to increase the share of trade in GDP. Such measures would enhance, probably slowly but steadily, the size of economy. Thereafter, the larger the size of the economy becomes, the more substantially trade openness will contribute to growth.

Also from all indications, it seems that the South African government's efforts at stimulating the country's economic growth are not enough. Its current fiscal and monetary policies seem not to have yielded the expected results. In recent years, the country's nominal interest rates have been lowered with the aim of helping to stimulate capital inflow for domestic investment so as to boost economic growth but it appears the expected yields are minimal. It is recommended that monetary authorities should continue to consider further reduction in the nominal interest rates as well as ensuring that the real exchange rate does not rise above the ideal real exchange rate.

Bibliography and Appendix

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Data Used in the Study

Date	M1	GFCF	Exp	GDP	GOE	Imp
1990/01	50328	14050	17071	65620	14140	12555
1990/02	49608	13718	17580	71345	14258	13567
1990/03	47035	13707	17546	75476	13924	15077
1990/04	50462	14010	18046	77375	14669	13177
1991/01	54627	14582	15868	75471	15904	13520
1991/02	56742	14369	18419	80163	17160	14538
1991/03	58460	13638	18067	86666	15985	16071
1991/04	60617	14365	19853	89679	16618	13891
1992/01	61307	14779	19919	87377	17397	14496
1992/02	61921	14319	19108	90347	18710	15545
1992/03	67877	14650	21108	94468	18748	18005
1992/04	71359	14507	19310	100032	20402	16357
1993/01	69221	14562	21976	97813	19191	16853
1993/02	70852	15817	23559	104717	21010	17911
1993/03	69769	15482	24692	110546	21729	20907
1993/04	73504	16740	25560	113057	23621	20248
1994/01	81872	16677	24758	113766	23590	20544
1994/02	89249	17865	26218	118683	23824	22323
1994/03	89339	18391	28494	122255	23521	27291
1994/04	92072	20112	27092	127416	25568	25589
1995/01	91763	19904	29287	128816	23854	27883
1995/02	96776	22146	29127	134079	24775	29836
1995/03	98255	21948	32984	141411	25787	32778
1995/04	105232	23044	33418	143794	26008	30596
1996/01	120369	23257	32708	144880	27170	30556
1996/02	128814	25098	36376	153960	29853	34808
1996/03	136772	25517	42504	158648	29079	40129
1996/04	150179	26760	41228	160466	31911	37847
1997/01	155968	26613	37447	162109	32240	36039
1997/02	156080	27600	40249	170682	33411	38576
1997/03	168876	28350	45416	175532	32182	43643
1997/04	182475	30658	45547	177407	34070	42460
1998/01	189150	29893	45918	176201	33009	39911
1998/02	198340	30585	45568	186158	34019	42097
1998/03	220549	32198	51159	189138	34059	52622
1998/04	220715	34236	47808	190927	38284	47342
1999/01	221567	31328	51592	190861	34454	41164
1999/02	227407	30164	46928	198944	41478	43900
1999/03	235583	30820	52918	210034	35841	48776
1999/04	261415	32104	54706	213844	38179	51197
2000/01	262242	32315	58640	214418	39825	51087
2000/02	263326	33358	60504	225851	42145	54079
2000/03	258828	34952	64492	239131	41739	61116
2000/04	268311	37031	73375	242748	43639	63475
2001/01	274014	36763	72102	243952	44726	60472
2001/02	283914	36971	77581	252100	46639	65295
2001/03	294850	37950	74251	258388	46289	67308
2001/04	306687	39324	83369	265567	48626	72926

Date	M1	GFCF	Exp	GDP	GOE	Imp
2002/01	333705	40034	93646	272507	51879	79234
2002/02	345672	41446	96390	291317	54866	84253
2002/03	349208	43782	95677	301519	55901	86930
2002/04	352476	46889	99847	305743	57059	90219
2003/01	348375	47285	91608	304566	59817	77990
2003/02	339860	47355	86783	315122	61071	80232
2003/03	346057	49686	88801	324061	60245	83421
2003/04	373715	52673	87593	328788	63352	83392
2004/01	403317	53782	87674	335936	66232	81030
2004/02	395897	54005	92442	346030	69594	96369
2004/03	406551	57433	94435	362553	67392	97517
2004/04	418905	60960	99399	370754	70816	103263
2005/01	428358	61478	95129	369683	73977	95252
2005/02	453339	62770	109071	383251	75446	108865
2005/03	484525	67447	111511	405293	75086	117597
2005/04	497419	72059	114458	412855	81224	115845
2006/01	523895	74095	110440	412413	85012	115332
2006/02	548205	76584	125081	423588	88608	133736
2006/03	577455	83189	141298	463765	86152	151163
2006/04	598242	90215	153514	467656	88156	173358
2007/01	622306	95891	147549	478182	94197	158085
2007/02	657543	98609	154432	491044	96148	169519
2007/03	695087	102670	156343	515171	95415	179975
2007/04	722929	109748	172578	532705	97653	182483
2008/01	761763	116972	176107	542706	106574	192043
2008/02	737994	124235	207768	566758	108770	224940
2008/03	743839	133330	216341	590592	108840	241392
2008/04	759713	139212	209429	583767	113129	220161
2009/01	726167	139649	170037	579767	120562	184591
2009/02	761542	136551	155381	592905	122397	155934
2009/03	768175	133458	159656	614533	124123	163012
2009/04	787576	133734	172039	620484	137958	174203
2010/01	802872	136959	163815	626870	137435	171014
2010/02	818329	136429	180237	657170	141447	179843