IMPACT OF COMMODITY MARKETS ON ECONOMIC DEVELOPMENT IN SUB-SAHARAN AFRICA

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DECLARATION

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature:………………………………….   Date:……………………………………

ABSTRACT

Commodity issues have assumed renewed importance in debates about the attainment of the United Nation's Millennium Development Goals for Sub-Saharan Africa and objectives of the New Partnership for Africa's Development. For instance thirty-four countries in Africa depend on up to three commodities for more than half of their foreign exchange earnings. Despite the importance of commodity markets to economic development on the continent commodity-related research has not attracted the needed attention. The study considered eighteen primary commodities exported by most countries in Sub-Saharan Africa. The commodities were drawn from metals, agricultural raw materials, food and energy sub-groups. This dissertation presents results of research work underlying six stand-alone essays focusing on the relationship between commodities and various aspects of economic performance in Sub-Saharan Africa. Whilst three of the six essays dwelt on issues affecting commodities of interest to most African countries the others considered particular commodity markets in a selected number of countries.

First the relationship between commodity markets and economic growth is studied. The second essay examined trends and volatility in Sub-Saharan Africa's key commodity prices over the past four decades. Role of commodity prices in macroeconomic policy in South Africa is also investigated using a new research approach. The fourth essay estimated the supply response of a number of tradable and non-tradable agricultural commodities in Ghana. In the fifth essay a range of volatility forecasting models were evaluated using eighteen commodity spot prices. The last essay examined the interaction between changes in commodity prices, money supply, inflation and the real exchange rate in Ghana, Nigeria and South Africa.

The findings of the study indicate that a negative relationship exist between extent of primary commodity dependence and economic growth. The study also revealed that volatility levels have not changed for nine out of the eighteen commodities studied however, changes were observed in the other nine. Another key finding of the study was that there is merit in using gold and metal prices as variables in forming monetary policy in South Africa. It was also observed that random walk and autoregressive models consistently outperform more complex models in forecasting volatility in commodity spot prices. Results of the supply response study suggest that even though producers usually respond to price incentives, structural features of domestic agricultural commodity markets in Ghana may have hindered the conversion of improved incentives to higher agricultural growth. Results of the last paper indicate that in Ghana commodity price increases impact money supply growth and inflation whilst in Nigeria the effects of crude oil price increases produces higher inflation and appreciation of the real exchange. In the case of South Africa effects of gold export booms were transmitted through changes in money supply, inflation and real appreciation of the domestic currency. The results of the study have implications for both decision makers in business and government.

OPSOMMING

Kommoditeits-aangeleenthede het vernuwe belangrikheid in die debat rakende die vervulling van die Verenigde Nasises se Millennium Onwikkelings Doelwitte vir Sub-Sahara Afrika en die doelwitte van die Nuwe Vennootskap vir Afrika se Ontwikkeling aangeneem. By voorbeeld, vier-en-dertig Afrika lande is afhanklik van tussen een en drie kommoditeite vir meer as die helte van hul buitelandse valuta inkomste. Ten spyte van die belangrikheid van kommoditeits-markte vir ekonomiese ontwikkeling op die kontinent het kommoditeits-verwante navorsing nog nie die nodige aandag gekry nie. Die studie het agtien primêre uitvoer-kommoditeite wat deur die meeste Sub-Sahara Afrika lande uitgevoer word oorweeg. Die kommoditeite is afkomstig van metale, onverwerkte landbou produkte, voedsel en energie sub-groepe. Hierdie tesis bied die resultate van navorsing wat gedoen is op ses afsonderlike opstelle wat fokus op die verhouding tussen kommoditeite en verskeie aspekte wat die ekonomiese vertoning in Sub-Sahara Afrika beïnvloed. Drie van die ses opstelle fokus op faktore wat kommoditeite van belang vir meeste Afrika lande affekteer, terwyl die ander geselekteerde lande se unieke kommoditeits-markte oorweeg word.

Die eerste opstel bestudeer die verhouding tussen kommoditeits-markte en ekonomiese groei. Die tweede opstel oorweeg tendense en volitaliteit in Sub-Sahara Afrika se belangrikste kommoditeits-pryse oor die afgelope vier dekades. Die rol van kommoditeits-pryse in Suid-Afrika se makro-ekonomiese beleid word ook ondersoek met behulp van 'n nuwe navorsings benadering. Die vierde opstel maak 'n skatting van Ghana se aanbod van verskeie verhandelbare en nie-verhandelbare landbou kommoditeite. In die vyfde opstel word 'n reeks volitaliteitsvoorspellings-modelle ge-evalueer deur agtien lokopryse te gebruik. Die laaste opstel bestudeer die interaksie tussen veranderinge in kommoditeits-pryse, geld aanbod, inflasie en die reële wisselkoers in Ghana, Nigerië en Suid-Afrika.

Bevindinge van die studie dui daarop dat 'n negatiewe verhouding tussen die graad van primêre kommoditeits-afhanklikheid en ekonomiese groei voorkom. Die studie het ook bevind dat volitaliteits–vlakke vir nege van die agtien kommoditeite wat bestudeer is nie verander het nie, terwyl veranderinge in die ander nege waargeneem is. 'n Kritiese bevinding was dat daar meriete steek in die gebruik van goud en ander metal pryse as veranderlikes in die formulering van die monetêre beleid in Suid-Afrika. Dit is ook waargeneem dat "random walk" en autoregressiewe modelle deurlopend beter vaar in die voorspelling volitaliteit in kommoditeits lokopryse as komplekse modelle. Resultate van die aanbod respons studie dui daarop dat alhoewel produseerders gewoontlik reageer op prys insentiewe, struktule eienskappe van die binnelandse landbou kommoditeits-mark in Ghana moontlik die effek van verbeterde insentiewe op landbou groei kon beperk het. Resultate van die laaste opstel dui daarop dat kommoditeits-prys verhogings in Ghana die geld-aanbod groei en inflasie beinvloed, terwyl in Nigerië die effekte van ru-olie prys verhogings lei tot hoër inflasie en appresiasie van die reële wisselkoers. In die geval van Suid-Afrika word die effekte van die skielike groot toenames in goud-uitvoere die duidelikste waargeneem deur veranderinge in die geld-aanbod, inflasie en die reële appresiasie van die binnelandse geld-eenheid. Die resultate van die studie het implikasies vir beide besluitnemers in besigheide en die regering.

DEDICATION

This work is dedicated to my family for bearing with me for the many months that I was absent from home.

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CHAPTER ONE

1 INTRODUCTION

1.1 Background and Problem Statement

The poor economic growth[1] performance of Sub Saharan Africa[2] (SSA) has attracted a lot of attention in the development economics and finance literature. Easterly and Levine (1997) and Collier and Gunning (1999) presents an extensive survey of Africa's growth challenge. Sachs and Warner (1995) as well as Gallup et al (1998) argue that Africa's growth failure can be largely attributed to her unfavourable geography. The authors' stress Africa's location in a disease-prone tropical environment may have retarded growth particularly in agricultural commodity production.

Rodrik (2002) challenges the treatment of geographical factors in the underlying regressions that form the basis of the assertion that the poor growth record is due to geographical factors. Acemoglu et al (2001a) also contest the use of geography to explain the continent's growth performance. Acemoglu et al (ibid) claim that Africa's growth performance was once impressive and that the issue is one of deterioration. The authors are of the opinion that countries, which are poor now, used to be much wealthier in earlier periods of time. This argument is supported by empirical work by World Bank (2000). The World Bank study shows that unlike other developing regions, Africa's per capita output in constant prices in the 1990's was much lower than the levels in the 1960s.

[1] In most of the post-war literature on economic development (Lewis, 1944; Lewis, 1955; Rostow, 1960) economic growth is used synonymously with economic development. Following the studies by Lewis and Rostow as cited in Arndt (1981), economic growth given by per capita change in output is used to account for economic development in this dissertation.

[2] In this dissertation Sub-Saharan Africa represents all countries south of the Sahara. South Africa is included in the definition of SSA despite its higher level of development, close trade and investment ties with developed countries.

The study further indicates that in some countries (i.e., Democratic Republic of Congo and Niger) output in constant prices had fallen by more than 50 percent. Other countries that recorded a fall in output over the period include Nigeria, South Africa, Senegal, Ghana and many others.

A second interpretation of the poor growth experience is explained by the importance of colonial policy and the continuity of institutions over time (North, Summerhill & Weigast, 2000). Other studies that also support the role of institutions in economic development are the works of Knack and Keefer (1995), Acemoglu et al (2001b), Rodrik (2002) and Djankov et al (2003). For instance Acemoglu et al (2001b) argued that the poor institutional quality of former colonies in the tropics was due to the health risk in those countries. The authors suggest that the prevalence of malaria explains whether Europeans decided to settle in colonies or rather implemented extractive institutions in order to maximise resource exploitation. Acemoglu et al further argued that the persistence of extractive institutions even after the exit of the colonialists explains the poor growth in SSA. It appears that the institutional reasons have become more popular in the literature; it's however important to note that there are still more competing explanations for the slow growth in Africa. Sparseness, ethnic diversity and absence of democracy have also been identified as causes of the slow growth (Collier, 1999).

The economic management approach pursued by most post-colonial governments such as the heavy taxation of the agriculture commodity sector and excessive economic controls has also been identified as reasons for the poor growth (Collier and Gunning, 1999; World Bank, 1989). The high dependence on a limited number of primary export commodities makes African countries vulnerable to terms of trade shocks. These trade shocks have been found to negatively impact economic management and growth outcomes (Rodrik, 1998b). While certain countries like Botswana have responded quite well to the terms of trade shocks others like Zambia have not coped well. There has also been a significant amount of work on aid dependency and economic growth with varying results (Dollar and Burnside, 1997).

The past two decades have witnessed significant changes in commodity markets, shocks associated with price slumps and changing paradigms on the role of the state. This led to a wave of widespread reforms in agricultural commodity markets in Africa (Akiyama et al, 2003). The reforms reduced the role of the state in marketing and pricing of commodities in the domestic markets. Akiyama et al (2003) examined the background, causes, processes and effects of these reforms and draw lessons for successful reform from experiences in the cocoa, coffee, cotton and sugar markets in Africa. Other studies that evaluate the commodity market reforms in Sub-Saharan Africa include Badienne *et al* (2002), Akiyama (2001), Abdulai and Huffman (2000) and Gilbert (1997). Among the conclusions reached by these studies was that the key consequences of the reforms was a shift of political and economic power from the public sector to the private sector in countries that followed the reforms through. The studies also indicate that in most countries that implemented the reforms producers tended to receive a higher proportion of the international commodities prices than before.

Jurajda & Mitchell (2001) studied four markets (financial, labour, natural resource and product) to assess their impact on growth. Drawing on existing empirical and theoretical literature the paper discussed the links between markets and growth in general terms. The paper also considered four scenarios regarding the processes of growth across all six regions of the developing world. Among the conclusions of the paper by Jurajda & Mitchell (2001) was that market policies and institutions were critical for economic growth. With regard to the natural resource market, which is of importance to the present the study, it has been claimed that natural resource abundance in itself depressed economic growth, an assertion that has been corroborated by Sachs & Warner (1995). For instance, Collier & Hoeffler (1998) observe that dependence on natural resources predisposed a country to increased risk of civil war. One of the inferences that may be drawn from the literature of markets and growth is that commodities exports contributed to less positive externalities as against manufacturing to a large extent (Mchanon, 1997).

Commodity markets are of great importance for various interest groups in SSA countries (i.e., governments, exporters and producers). Export earnings variability has implications for external indebtedness[3], foreign exchange reserves, exchange rate and other key macroeconomic variables in these economies. Commodity price shocks have historically distorted national budget outcomes and tended to complicate the debt burden on the continent. Peasant farmers who have no access to efficient savings instruments get by in these economies with income fluctuations through diversification of commodities thus losing the potential benefits associated with specialization. Exporters, on the other hand, are also affected by cash flow variability stemming from variability in commodity prices, as this condition reduces the collateral value of inventories.

Most SSA countries depend on two or three key primary commodities for the greater part of their foreign exchange earnings. For some countries, the dependence is even on a single commodity. For example Ghana obtains over 65 percent of her foreign exchange earnings from cocoa, aluminium and timber. Nigeria and Burkina Faso receives a staggering 99 percent of their foreign exchange earnings from oil and cotton respectively (Larson et al,

[3] Thirty-four out of the forty-two Heavily Indebted Poor Countries are in Africa.

1998). The situation is not any better for the rest of the continent[4]. The economies of Africa have had to put up with booms and busts in commodity prices. This phenomenon of commodities market volatility has impacted negatively on economies on the continent in no small measure through a variety of ways. For example, the volatility problems impact negatively on individual countries' aggregate demand and supply schedules and, subsequently, aggregate output; the unfavourable commodity price movements have hampered economic development efforts on the continent.

The continent's competitiveness in the past decades has also been eroded by a multiplicity of events even in the so-called traditional[5] primary commodities. Prominent among these have been keen competition from South East Asia coupled with agricultural support to producers in the developed economies of the North. As a result SSA's market share dropped from 6 percent to about 4 percent between 1980 and 2000 (UNCTAD, 2003).

The role of a stable macroeconomic environment as a necessary condition for economic growth is a well-established fact in the economic literature. Many empirical works have examined the causal relationship between commodity prices and macroeconomic variables in the developed world, where dependence on commodities is not as much as in SSA (see Bessler, 1984; Hua, 1990; Pindyck and Rotemberg, 1990). However, the findings of these studies have generally been mixed. In the case of Africa not much has been done to examine the relationship between commodity price changes and individual macroeconomic variables such as inflation, exchange rates, money supply, and interest rates.

The research questions that emerge from the discussions above are as follows:

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[4] Thirty-four out of the countries in Africa depended on up to 3 commodities for more than half of their earnings.

[5] This include cocoa, coffee, sugar and cotton among others

- What is the relationship between commodity export earning instability and economic growth?
- Is there a relationship between the degree of commodity dependence and economic growth?
- What role can commodity price play in the design of monetary policy?
- Has commodity price behaviour changed over the past forty years?
- Has agricultural commodity supply responded to the price incentives as a result of the market reforms implemented in some SSA countries in the 1980s?

Other related questions that also come to the fore are as follows:

- Which volatility-forecasting model works for commodity price volatility forecasting?
- What effect does commodity price have on the real exchange rate?

In addressing the above problem statements we formulate the following set of research objectives presented in the next sub-section.

1.2 Research objectives

The broad objective of this dissertation is to find out how commodity price behaviour affects the various macroeconomic variables that underlie economic growth. The dissertation also seeks to ascertain how changes in commodity price can be predicted in order to inform macroeconomic management of imminent price shocks. However, the specific objectives are:

(a) To find out the effect of commodity export volatility on economic growth in SSA

(b) To examine the effect of varying commodity dependence on economic growth

(c) To ascertain whether the long-run price trends and volatility of key commodity prices have changed over the past four decades

(d) To test whether commodity price movements precede movements in interest rate, exchange rate, money supply and the consumer price index.

(e) To examine the supply response of agricultural commodity output to price incentive in Ghana

(f) To examine the forecasting accuracy of seven volatility forecasting models in eighteen commodity markets; and

(g) To investigate the effect of commodity price changes on the real exchange rate in Ghana, Nigeria and South Africa.

1.3 Relevance of the Study

Issues regarding commodities have recently gained prominence in the debate about the attainment of the Millennium Development Goals[6] (MDGs) and particularly the objectives of the New Partnership for Africa's Development[7] (NEPAD). Indeed the importance of commodities in the economic well being of SSA is well documented (Collier, 2002). Most SSA countries (i.e. 34 countries out of 48) depend on up to 3 commodities for 50 percent or more of their foreign exchange earnings (Larson et al, 1998). This is coupled with the fact that these countries import almost all their technologies and capital goods for both infrastructure development and their production processes. Consequently, to spur on economic development foreign exchange earnings are very important. Given that commodity earnings remain a major source of foreign exchange for SSA it stands to reason that additional insight into commodity markets can be helpful in the pursuance of successful economic management.

[6] See http//www.developmentgoals.org
[7] http://www.uneca.org/eca_resources/Conference_Reports_and_Other_Documents/nepad

Despite the crucial role that commodity markets play in the economic well being of the continent there is a severe dearth of comprehensive studies on the impact of commodities markets on economic development in Africa. The results of the study help fill gaps in policy makers', investment analysts' as well as supra and sub-regional bodies' understanding of the impact on economic development on the continent. Finally, it is hoped that the results of the study will help in the choice of policy instruments by African governments aimed at smoothening and lessening the effects of commodity market down-turns and its impacts on economic growth.

1.4 **Organisation of the study**

The dissertation is made up of six stand-alone essays, which are presented in individual chapters. The commodities that the study focused on were drawn from the metals[8], agricultural raw materials[9], food[10], beverage and tobacco as well as energy[11] sub-groups. The second chapter of the dissertation constitutes the first essay, which looks at the relationship between primary commodity exports and economic growth in Sub Saharan Africa. The essay also ascertains the effect of varying degrees of commodity dependence on economic growth. Chapter three examines the trends and volatility of SSA commodity prices for the past forty years. The possible role of commodity prices in macroeconomic management is assessed in chapter four; South Africa is used as a case study. Chapter five presents the fourth essay; this essay examines how agricultural commodity output has responded to price incentives over the years. In the 1990s most SSA countries were encouraged to liberalise their input and output markets for their agricultural commodities.

[8] Aluminium, copper and gold
[9] Rubber, sisal, timber and cotton,
[10] Cocoa, coffee, tea, groundnut, ground nut oil, palm oil, beef, shrimp, sugar and tobacco
[11] Crude oil

The argument then was that a liberalised commodity market would provide the incentives for increased output. The essay, which dwells on Ghana as a case study considers the major tradable and non-tradable agricultural commodities produced in the country.

Chapter six, the fifth essay, evaluates a number of volatility forecasting models using spot prices from eighteen commodity markets. The last essay is presented in chapter seven. The essay examines the channel through which cocoa, crude oil and gold price changes are transmitted to the real exchange rates of Ghana, Nigeria and South Africa respectively. The three countries were selected because of their unique economic performance and the structure of their economies. Though all three are commodity dependent economies, the degree of dependence is varied, at one end there is Nigeria with its very high oil dependent economy; then there is South Africa at the other end with a fairly diversified economic base. Ghana was also selected because it can be placed in-between the two examples of Nigeria and South Africa, since the country depends on three main commodities for the greatest part of her foreign exchange earnings.

Each essay is organised into seven components; first there is an introduction of the theme that sets the background to the research question. The introductory sub-section also presents the purpose of the essay. A brief review of the related literature constitutes the second sub-section. Selected stylised facts that provide additional motivation for the research question addressed in a particular essay are provided in certain instances. Where stylised facts are provided they constitute a sub-section on their own; this is followed by the methodology. Each essay also has a section on data issues containing a discussion of the sources of data and statistical properties of the data series used in the estimation process. Following the data issues, results of the empirical estimates are presented and discussed. The last section of each essay presents the concluding remarks.

List of References

Acemoglu, D., Johnson S. & Robinson, J. A., 2001a. Reversal of fortune: geography and institutions in the making of modern world income distribution. *Social Science Resources Networks Electronic Library*, No. 252.

Acemoglu, D., Johnson S. & Robinson, J. A., 2001b. The colonial origins of comparative development: an empirical investigation, *NBER Working Paper* No 7771, Cambridge, Mass.: National Bureau of Economic Research.

Abdulai, A. & Huffman, W., 2000. Structural adjustment and economic efficiency of rice farmers in northern Ghana. *Economic Development and Cultural Change*, 48 (3), p. 505-520.

Akiyama, T., 2001. Coffee market liberalization since 1990, in: Akiyama, Baffes, Larson and Varangis, eds., *Commodity Market Reforms: Lessons of Two Decades*, Washington, D.C.: World Bank.

Akiyama, T., Baffes, J., D., Larson, F. & Varangis, P., 2003. Commodity market reform in Africa: some recent experience. *World Bank Policy Research Working Paper,* No. 2995, Washington D.C.: World Bank.

Arndt, H.W., 1981. Economic development: a semantic history. *Economic Development and Cultural Change,* 29 (3), p.457-466.

Badienne, O., Ghura, D., Goreux, L. & Mason, P., 2002. Cotton sector strategies in West and Central Africa. *World Bank Policy Research Working Paper*, No. 2867. Washington, D.C.: World Bank.

Collier, P. & Hoeffler, A., 1998. Economic causes of civil war. *Oxford Economic Papers,* 50 (4), p. 563-573.

Collier, P & Gunning, J. W., 1999. Why has Africa grown so slowly? *Journal of Economic Perspectives* 12 (3), p.3-22.

Collier, P., 1999. On the economic consequences of civil war. *Oxford Economic Papers* 51, p. 168-83.

Collier, P. 2002. *Primary Commodity Dependence and Africa's Future*. Washington, D.C., World Bank.

Dollar, D. & Burnside, C., 1997. Aid, policies and growth. *Policy Research Working Paper* 1777, Washington, D.C: World Bank.

Djankov, S., La Porta, R., Lopez-de-Silanes, F. & Shleifer, A., 2003. The new comparative economics. *Journal of Comparative Economics* 31, p.595-619.

Easterly, W. & Levine, R., 1997. Africa's growth tragedy: politics and ethnic divisions. *Quarterly Journal of Economics* 112, p.1203-1250.

Gallup, J. L., Sachs, J.D., & Melinger, A.D., 1998. Geography and economic development. *NBER Working Paper No.* W6849, Cambridge, Mass: National Bureau of Economic Research.

Gilbert, C. L., 1997. International Commodity Agreements: Design and Performance. *World Development*, 15, p.591-616.

Jurajda, S. & Mitchell, J., 2001. Markets and growth. Cerge-Ei/ECARES/CEPR/WDI. Prague: Charles University.

Knack, S., & Keefer, P., 1995. Institutions and economic performance: cross-country tests using alternative institutional measures", *Economics and Politics,* 7, 207-227.

Larson, D., Varangis, P., & Yabuki, N., 1998. Commodity risk management and development. *World Bank Policy Research Working Paper* 1963. Washington, D.C.:World Bank.

Lewis, W. A., 1955. *The theory of economic growth,* London: Allen & Unwin.

Lewis, W.A., 1944. An economic plan for Jamaica. *Agenda* 4, p.156.

Mchanon, G., 1997. *The natural resource curse: myth or reality*. Washington, D.C: World Bank.

North, D. C., Summerhill, W. R. & Weingast, B. R., 2000. Order, disorder, and economic change: Latin America versus North America, in Bruce Bueno de Mesquita and Hilton L. Root (eds), *Governance for Prosperity*. New Haven: Yale University Press.

Rodrik, D., 1998b. Trade Policy and Economic Performance in Sub-Saharan Africa, *NBER Working Paper* 6562, Cambridge, Mass: National Bureau of Economic Research.

Rodrik, D., 2002. Institutions rule: the Primacy of institutions over geography and integration in economic development. *NBER Working Paper,* No. W9305, Cambridge, Mass: National Bureau of Economic Research.

Rostow, W.W., 1960. *The Stages of Economic Growth*, Cambridge: Cambridge University Press.

Sachs, J.D. & Warner, A. M., 1995. Natural resource abundance and economic growth", *NBER Working* Paper No. W5398, Cambridge, Mass: National Bureau of Economic Research.

UNCTAD. 2003. *Economic Development in Africa: Trade Performance and Commodity Dependence.* Geneva: United Nations Conference on Trade and Development, United Nations.

World Bank, 1984. *Africa's Adjustment and Growth in 1980s*, Washington, D.C.: World Bank.

World Bank, 2000. Can Africa reclaim the 21st century? Washington, D.C.: The International Bank for Reconstruction/ World Bank.

CHAPTER TWO

2 PRIMARY COMMODITY EXPORTS AND ECONOMIC GROWTH IN SUB SAHARAN AFRICA: EVIDENCE FROM PANEL DATA ANALYSIS

2.1 Introduction

Issues relating to commodities have recently gained prominence in the debate about the attainment[12] of the Millennium Development Goals (MDGs) and as well as the set objectives of the New Partnership for Africa's Development[13] (NEPAD). Indeed the importance of commodities in the economic well-being of Sub-Saharan Africa (SSA) is well documented (Collier, 2002). Most SSA countries depend on up to 3 commodities for 50 percent or more of their foreign exchange earnings (Larson *et al.,* 1998). This is coupled with the fact that these countries also import almost all their technologies as well as capital goods for both infrastructure development and their production processes. Consequently, to spur on economic development, foreign exchange earnings from commodity exports may be very important. The main objective of the paper is to find out the effect of commodity export volatility on economic growth in SSA. The other related objective is to examine the effect of varying commodity dependence on economic growth.

Despite the possibly crucial role of commodities markets in the economic development of the continent, there is a dearth of comprehensive studies on the impact of commodities markets on economic development in Africa. The handful of studies that consider commodities markets in Africa rather dwell mostly on assessing the impact of domestic

[12] See http//www.developmentgoals.org

[13] See http://www.uneca.org/eca_resources/Conference_Reports_and_Other_Documents /nepad/NEPAD

market reforms for individual commodity markets (see Baffes, 2001; Varangis & Schreiber, 2000). Others have also mostly reviewed the various stabilization schemes and their effectiveness (Akiyama *et al.,* 2003; Kruger, Schiff & Valdes, 1991; Mundlak, Cavallo & Domenech, 1993). Even though a few studies have looked at the relationship between export instability and economic growth, they have been conducted for regions of the developing world other than Sub-Saharan Africa, except Gyima-Brempong (1991). The present study uses a new approach, i.e. a panel data model, to study the relationship between primary commodity export and long-term economic growth in SSA.

The rest of the paper is organized as follows. The next section describes the extent of commodity dependence and performance of the region in commodity exports. A review of previous work in the study area is the subject of section 3. Section 4 discusses the theoretical framework and the empirical model to be estimated, and data issues are discussed in section 5. Section 6 distils the empirical results and draws out the development policy implications for SSA.

2.2 **Commodity Export Dependence**

Primary commodity export dependence of SSA can be illustrated by considering the proportions of foreign exchange earnings that accrue to the individual countries' 3 key exports. Average earnings *per annum* over the period 1990-1999 from the 3 major primary commodities varied from a low of 4% (Djiboti) to a high of 95% (Botswana). Thus, only 5 countries had less than 10% of their earnings from 3 key exports (UNCTAD, 2004). Fifty-two percent of the 48 countries of SSA obtain more than 60% of their export earnings from only 3 commodities. Another 31% also derived between 30-59% from their 3 leading primary commodities (see Table 2 in the Appendix of the paper. The four major non-oil commodities have been identified as cocoa, cotton, tea and coffee. For instance, the impact of a decline in the price of cotton is usually most severe in Burkina Faso, Mali, Benin and Togo, where cotton exports average 5-8 percent of GDP (IMF, 2005).

Despite the high dependence on primary commodity exports in SSA, the region's share of the world market for these commodities has declined over the past two decades. Whilst developing countries in Asia and America recorded an average non-fuel primary commodity export growth of 5.0% and 2.9% per annum respectively for the period 1980-2000, the figure for Africa was 0.4% (see Table 2-1).

Table 2-1. Average growth of exports (percentage), 1980-2000

	All Merchandise	Primary* commodities	Non-fuel primary commodities	Manufacturers
Developed countries	5.9	3.3	2.9	6.4
Developing countries	6	1.4	3.3	12.4
Africa	1.1	0.6	0.6	6.3
America	5.9	2.2	2.9	11.5
Asia	7	1.3	5	13.6
Memo item:				
Sub-Saharan Africa**	1.3	1.3	0.4	5.6

Source: UNCTAD. 2003. *Economic Development In Africa, Trade Performance and Commodity Dependence*. UN, New York and Geneva.

Notes: *Primary commodities (0-4) sections of SITC Revision 3.
**Excluding South Africa

Clearly, changes in export instability and the extent of dependence for individual countries in SSA is expected to have some significant impact on their economic growth. It is this impact that the present study seeks to ascertain among other things.

2.3 **Literature Review**

Empirical efforts aimed at estimating the long-run economic relationship between export instability and economic growth has generated conflicting results. Whilst some studies find a negative relationship between export instability and economic growth, others indicate a positive relationship. Yet another group of authors concludes that the relationship between export instability and economic development in the long run is statistically insignificant.

Studies that find a negative relationship between economic growth and export instability include: Adams, Behrman and Roldan, 1979; Glazekos, 1984; Kennen & Voivodas, 1972; Priovolus, 1981; Gyimah-Brempong, 1991; and Ozler & Harrigan, 1988. On the other hand, MacBean, 1966; Knudsen & Parnes, 1975; Lam, 1980; and Savvides, 1984 conclude that the relationship between economic growth and export instability was positive.

The school of thought that finds a positive relationship asserts that in periods of export instability Less Developed Countries (LDCs) respond to the volatility by adjusting and reducing consumption accordingly. It is further argued that as economies reduces consumption, so savings and investment are increased with a resultant increase in economic growth. Thus risk-aversion behaviour was implicitly assumed in the analytical framework.

MacBean (1966) was one of the early economists who studied export instability and economic growth; he sought to ascertain empirically the widely held view that export fluctuation in developing countries was detrimental to economic performance. MacBean's book looked at the statistical and analytical dimension of the issues concerning stabilization policies at the time. The book also looked at both the short- and long-run effects of export instability on economic growth. Maizels (1968), when reviewing MacBean's book, concluded that the policy implications of the study were doubtful, because the data series on the sample of countries used in the study was very short and hence defective. Articles which establish a negative relationship between export instability and economic growth point out that the negative effect that instability in exports has on output was as consequence of the creation of uncertainty in long-term planning coupled with imported input shortages.

Researchers who take the position that export instability has no significant impact on economic growth in LDCs are of the opinion that LDCs are able to anticipate export instability. They argue further that individual countries are then in a position to put in place measures to assuage the impact of instability; hence economic growth was largely unaffected (see Obidegwu & Nziramasanga, 1981; Yotopoulus & Nugent, 1977).

Mullor-Sebastian (1988) studied export instability and economic growth with disaggregated data based on the level of development of the individual countries in the sample as well as the characteristics of products exported. Mullor-Sebastian's assertion was that studies that lump all exports together were flawed because of the differences in the level of development and the products exported. However, since most SSA exports are primary commodities, Mullors-Sebastian's concern may not be quite pertinent to studies about SSA.

The value addition in the present paper therefore is the focus on SSA countries and the use of the panel data estimation approach as against the cross-sectional regressions used in most of the previous studies. The paper also examines effect of varying degrees of commodity dependence and economic growth.

2.4 Methodology

In this paper the theoretical framework developed by Kreuger (1980) and Feder (1983) is extended. Exports are assumed to be one of the inputs in the production function for SSA. The production function is augmented with an exports revenue instability measure. The intuition here is that fluctuations in export earnings are likely to have an impact on economic growth. Consequently continued technical progress in these countries will depend on their sustained ability to import needed technologies (Gyimah-Brempong, 1991). However, the ability to sustain continued access to improved technologies depends on stable export earnings. Output generation in SSA economies can therefore be linked to their ability to import technologies at the right time during the production process. Again, since domestic markets are quite small, in order to specialize and harness the inherent advantages of economies of scale, the exporting of primary commodities cannot be compromised.

The low level of financial sector development in SSA, which accounts for the poor state of capital mobility in the region, also means that export revenue fluctuations cannot be smoothed with inward capital flows. The economic growth function for the study may therefore be formally written as follows:

$$y = f(\underset{+}{l}, \underset{+}{k}, \underset{+}{x}, \underset{+/-}{\tau}) \qquad (1)$$

where *y* is growth rate of output and *l, k, x* and τ are changes in labour force, gross capital stock, exports and export instability. The corresponding *a priori* expectations about the signs of the arguments of the function are positive for all except that of instability, which cannot be determined *a priori*. In estimating equation (1) it is required that the selected functional form is motivated. However, economic growth theory does not provide any leads in this direction. Hence, following earlier papers (Feder, 1980; Balassa, 1978; Ram, 1987) that estimated growth equations for LDCs and other developing countries, a linear specification growth model is used.

Unlike previous studies that used cross-sectional data, a panel data set is used in the present study. The selected data structure affords one the opportunity to exploit both the time series nature and cross-sectional properties of export instability and economic growth. And more importantly, the data structure allows greater flexibility in modelling differences in behaviour across countries in the region. The panel data set used is of the form:

$$y_{i,t} = x'_{i,t}\gamma + \lambda_t + \eta_i + \nu_{i,t} \qquad t=1,\ldots\ldots T;\ i=1,\ldots\ldots\ldots N \qquad (2)$$

where y is the changes in real per capita GDP, *x* represents the set of explanatory variables that explains variation in per capita GDP. It includes an export instability measure, value of commodities exports, labour and stock of capital. The λ_t and η_i are time and individual specific effects, whilst $x'_{i,t}$ is a *k* vector of explanatory variables. The total number of observations is *NT*. Some of the time invariant country effects considered in the modelling exercise is the degree of commodity dependence. The "*t*" time period subscript denotes a 10-year average.

2.5 Data Issues

Period averages of 10 years were used in the construction of the panel. Non-overlapping 10-year periods starting from 1960 to 1999 were utilized, hence a maximum of 4 observations per country (i.e., 1960-1969; 1970-79…1999). A sample of 36 SSA countries was selected for the study. Two dummies, high and medium primary commodity dependence, were introduced. The dummies took on the value of 1 for countries that exhibited high and medium commodity dependence respectively, and 0 for otherwise. Countries that obtained more than 70% of their export earnings from three main primary commodity exports were designated as high commodity-dependent countries (*Hdep*) and those that had less than 70% as medium-dependent (*Mdep*) (See Appendix Tables 1 and 2). Population figures in the various countries were used as proxies for labour participation in the economies. Gross capital formation was the other independent variable. The value of exports was assumed to be equal to earnings from primary commodity exports for lack of data on primary commodity exports. In any case, as indicated in the earlier section on stylized facts about SSAs exports, the share of manufactures in merchandise trade was quite insignificant (UNCTAD, 2003).

The literature indicates an absence of a well-defined measure of export revenue instability (Gyimah-Brempong, 1991). In the present study, however, the Holdrick-Prescott Filter was used in the construction of the export instability index (Holdrick & Prescott, 1997). First, the export series was decomposed into its trend and cyclical components respectively. Normalized deviations from the trend were then used as a measure of instability. All the data used in the construction of the dependent and independent variables were obtained from the World Development Indicators, WDI (World Bank, 2004).

Summary statistics

The descriptive statistics for our panel data set presented in the Table below indicate that SSA experienced very low real per capita GDP growth over the past 40 years. Per capita GDP in SSA on the whole grew at an average rate of 0.8% *per annum* and varied from –6.4% to 17.3% *per annum*. A cursory look at the other explanatory variables also indicates some weaknesses that appear not to have encouraged strong growth. Export performance across the region reveals a grim picture. On average SSA exports grew by barely 11% *per annum* over the period 1960-1999. Growth in exports varied from -20% *per annum* to 15%. Export instability, on the other hand, varied from 17% below trend to less than 1% above trend (see normalised instability indices in Table 2-2). It can therefore be inferred that primary commodity export instability has mostly been on the negative side (below trend). The paradox, however, is the fact that in the midst of such unfavourable instability certain countries in SSA such as Botswana and Ghana have recorded steady growth (modest for Ghana but strong for Botswana) over the past two decades. Yet countries such as Zambia and Nigeria, among others, have not seen much stability and resilience in per capita growth. Those countries in the less resilient group have seen their fortunes fluctuate alongside export earnings.

Table 2-2. Summary Statistics of common Panel (N=89), 1960-1999

Statistic	Per capita output growth, Y_{it}	Exports growth, X_{it}	Instability in exports, $\gamma_{i,t}$	Growth in Capital formation, K_{it}	Growth in population, L_{it}
Mean	0.834	0.107	1.000	5.817	0.026
Standard Deviation	3.075	0.190	1.566	11.188	0.007
Coefficient of variation	3.688	1.781	0.328	1.923	0.272
Maximum	17.247	0.150	0.007	56.695	0.045

Minimum	-6.436	-0.198	-0.167	-23.605	0.001
Median	0.547	0.067	-0.168	4.558	0.026

2.6 **Results**

The econometric estimation was begun by experimenting with pooled-OLS, OLS-differences and Least Square Dummy Variable (LSDV) estimators. Within, Between and Maximum Likelihood estimators were also used in the estimation of the empirical model. An inspection of the estimations of the various coefficients, the signs and other robustness criteria indicated the superiority of the OLS-differences estimator. Results of the model estimated with the OLS-difference estimators are presented in Table 2-3. The first column of the Table presents estimates of the base model. Per capita GDP growth rate, $Y_{i,t}$, was the dependent variable, whilst changes in population $L_{i,t}$, exports $X_{i,t}$ and changes in gross capital formation $K_{i,t}$ constituted the regressors.

In order to draw a meaningful conclusion from the empirical work a base model is used as a benchmark along which the substantive model for the investigation is assessed. In addition to the base model two other models were estimated. These were essentially the base model augmented with two different regressors of importance. The variables that were used in the subsequent and systematic augmentations were export proceeds instability index ($INST_{i,t}$) and dummies that captured the extent of dependence on primary commodities. The dummies were $Hdep_{i,t}$ and $Mdep_{i,t}$ for high and medium commodity dependence respectively. These take on unity for high and medium dependence and 0 for otherwise.

The coefficient estimates, standard errors of the estimates and a select range of statistics are presented in the Table 2-3. The models progressively explain reasonably large proportions of the variations in economic growth performance across countries in SSA. The highly significant Wald Chi^2 statistic (an analogue of the F-test), which tests the joint significance of the explanatory variables, appears to be significant at the 99% level of significance for all 3 models. The value of the statistic also increases across the models steadily from 21.53 for the base model, and to 21.69 and 28.16 for models 2 and 3 respectively. The apparently high R^2 for the models – given that panel data estimations usually have characteristically low R^2 values – further underscores the usefulness of the selected models. Thus the selected model fits the data quite well.

The base or control model explains a reasonably high proportion of the variation in economic growth across SSA. The coefficients of all the explanatory variables have signs that conform to *a priori* expectations. Changes in gross capital formation in particular have a positive sign and a coefficient (with t-probability of 0.002) indicating economic growth is strongly related to gross capital formation in SSA. Export, the other significant regressor with t-probability of 0.028 indicating significance at 95%, was found to have the right sign. This result is consistent with earlier studies that find a positive relationship between exports and economic growth (Feder, 1983; Kreuger *et al.,* 1980 and Gyimah-Brempong, 1991). Intuitively this appears right, since most SSA countries depend on a narrow range of commodity exports to finance the imported inputs for production.

Even though the labour coefficient had the right expected sign, this was not statistically significant. The fact that the coefficients of growth in exports and gross capital formation were significantly different from zero [at least at α =0.05] indicates that economic growth in SSA is positively related to growth rates of gross capital formation and exports. These results are consistent with neoclassical growth theory and previous results of studies on growth in LDCs. The key objective of the present paper, as stated earlier, was to ascertain empirically the relationship between export earning instability and economic growth. Consequently we now turn to discussions of models 2 and 3. These are basically the base model which has been augmented by an instability and dependency index and a dummy respectively. When the instability measure is added to the base model, the explanatory power of the model as measured by R^2 and the Wald Chi^2 statistics, improves significantly (see Table 2-3).

More importantly, the coefficient of export instability is negative, but not significantly different from zero at $\alpha = 0.10$. Again, when the instability indices were added to the base model, the signs and coefficients did not vary significantly; however, the adjusted R^2 and the Wald Chi^2 statistics improve modestly from 0.43 and 21.53 to 0.45 and 21.69 respectively.

Table 2-3. Modelling per capita GDP growth, $Y_{i,t}$ using OLS-differences estimator

Variable	Base Model	Model 1	Model 2
	Coefficients		
Exports, $X_{i,t}$	19.737 (8.494)	22.100 (9.172)	21.414 (8.808)
Capital, $K_{i,t}$	0.139 (0.040)	0.146 (0.041)	0.146 (0.039)
Labour, $L_{i,t}$	33.919 (86.20)	39.89 (87.22)	23.455 (90.220)
Instability, $INST_{i,t}$	-	-5.496 (7.616)	-7.872 (7.412)
High dependence, $Hdep_{i,t}$	-	-	-3.286 (1.584)
Medium dependence, $Mdep_{i,t}$	-	-	-2.410 (1.603)
Constant, b_0	-0.143 (0.039)	-0.154 (0.393)	-0.187 (0.377)
Adjusted R^2	0.434	0.445	0.529
Wald Chi^2	21.53**	21.69**	28.16**

Observations	**89**	**89**	**89**

Notes: Econometric analysis was carried with PCGive 10.

This underscores the fact that introduction of the instability measure do not necessarily introduce any meaningful biases to the coefficient estimates nor does it introduce multi-collinearity.

The results of the coefficient estimates of the new model (i.e. model 3) lend empirical support to the significance of primary commodity dependence to growth outcomes in SSA countries. The signs of the two dummies were negative, as expected. However, the coefficient of medium commodity dependence, unlike high commodity dependence, was not significantly different from zero. The significant improvements in the test statistics R^2 and the Wald Chi^2 from 0.45 and 21.69 to 0.53 and 28.16 respectively further enhance the capability of the model to explain variations in real per capita growth rates in SSA countries. Better still, when model 3 is put beside the base model, marked improvements in the evaluation test statistics are seen.

2.7 **Conclusions**

This paper ascertained whether export-earnings instability has any significant effect on economic growth performance in SSA countries. Also examined was the impact of varying degrees of commodity dependence on economic growth. The study used a panel data framework and data on a sample of 38 SSA countries with estimation period 1960 to 1999. The key finding is that there exist a negative relationship between commodity export instability and economic growth but this was statistically insignificant. However, the relationship between extent of commodity dependence and economic growth was negative and statistically significant.

The results indicate the need for a diversification of the export base of these countries in the short to medium term. In the long term, however, deliberate efforts need to be directed at diversifying exports to include manufactures. Hitherto conventional wisdom has pushed for increased commodity exports but since commodity price changes results in export revenue instability efforts need to made to move away from high commodity dependence. Development policies need to be aimed at manufacturing and service sector export-led growth. Nonetheless, it's not suggested that all countries on the continent follow such a prescription. This is especially true for those parts of Africa that are landlocked and may not necessarily be successful in export-led growth in manufactures in low-wage industries, because of the high transport costs involved.

List of References

Adams, F.G., Behrman, J. R. & Roldan, R. A., 1979. Measuring the impact of primary commodity fluctuations on economic development: coffee in Brazil. *American Economic Review,* 69 (2), p.164-168.

Akiyama, T., J. Baffes, Larson, D. F. & Varangis, P., 2003. Commodity market reform in Africa: some recent experience. *World Bank Policy Research Working Paper,* 2995. Washington D.C.: World Bank.

Baffes, J., 2001. Policy reform experiences in cotton markets, in: Akiyama, Baffes, Larson and Varangis, eds., *Commodity market reforms: lessons of two decades*. Washington, D.C.: World Bank.

Collier, P., 2002. *Primary commodity dependence and Africa's future*. Washington, D.C.: World Bank.

Cuddington, J.T. & Urzua, C.M., 1989. Trends and cycles in the batter trade net terms of trade: a new approach. *Economic Journal*, 99, p.426-442.

Cuddington, J.T & Liang, H., 1998. *Commodity price volatility across exchange rate regimes*. Washington, D.C.: Department of Economics, George Town University.

Coulson, N. & Robins, R., 1985. Aggregate economic activity and the variance of inflation: another look. *Economic Letters*, 17, p. 71-75.

Feder, G., 1983. On exports and growth. *Journal of Development Economics,* 12, p. 59-73.

Glezakos, C., 1984. Export instability and economic growth: reply. *Economic Development and Cultural Change*, 32, p. 229-36.

Gyimah-Brempong, K., 1991. Export instability and economic growth in Sub-Saharan Africa. *Economic Development and Cultural Change,* 39, p. 815-28.

Hendry, D.F. & Doornik, J. A., 2001. *PCGive 10, an interactive econometric modelling system.* London: Timber Lake Consultants Press.

Hodrick, R. & Prescott, E. C., 1997. Postwar U.S. business cycles: an empirical investigation. *Journal of Money, Credit, and Banking*, 29(1), p.1-16.

IMF, 2005. International Financial Statistics Year Book. [CD-Rom]. Washington, D.C: International Monetary Fund.

Kenen, P.B. & Voivodas, C., 1972. Export instability and economic growth. *Kyklos* 25, p. 791-801.

Knudsen, O & Parnes, A., 1975. *Trade instability and economic development*. London: D.C. Heath & Co.

Kreuger, A. O., Schiff, M. & Valdes, A., eds., 1991. *The political economy of agricultural pricing policy*. Baltimore: Johns Hopkins University Press.

Lam, V.M., 1980. Export instability and primary commodity concentration. *Economia Internazionale*, 33 (1), p. 40-57.

Larson, D., Varangis, P. & Yabuki, N., 1998. Commodity risk management and development. *World Bank Policy Research Working Paper* 1963. Washington, D.C.: World Bank,

Love, J., 1992. Export instability and the domestic economy: questions of causality. *Journal of Development Studies,* 28(4), p.735-42.

MacBean, A. I., 1966. *Export instability and economic development.* London: Allen & Unwin.

Maizels, A., 1968. Review of export instability and economic development by MacBean. *American Economic Review,* 58, pp 575-580.

Mullor-Sebastian, A., 1988. Export fluctuations and economic growth. *Economic Development and Cultural Change*, 36 (3), p. 3:217-36.

Mundlak, Y.,Cavallo, D. & Domench, R., 1993. Agriculture and economic growth in Argentina, 1913-84, *Research Report No. 76*, Washington, D.C.: International Food Policy Research Institute.

Ozler, S & Harrigan, J., 1988. Export instability and growth. *Department of Economics Working Paper,* No. 486, Los Angeles: University of California.

Obidegewu, C.F & Nzimasanga, M., 1981. *Copper and Zambia: An econometric Analysis*. Lexington, Mass: Lexington Books, D.C. Heath & Co.

Priovolos, T., 1981. *Coffee and the Ivory Coast: an econometric study*. Lexington, Mass: Lexington Books, D.C. Heath & Co.

Savvides, A., 1984. Export instability and economic growth: some evidence. *Economic Development and Cultural Change*, 32, p.607-14

Sinha, D., 1999. Export instability, investment and economic growth in Asian countries: a time series analysis. *Economic Growth Centre Discussion,* Paper, No. 799. Yale University and Macquarie University, Australia.

Yotopoulus, P. A & Nugent, J. B., 1977. *Economic development: empirical investigations*. New York: Harper & Row.

UNCTAD. 2003. *Economic development in Africa: trade performance and commodity dependence*. Geneva: United Nations Conference on Trade and Development, United Nations.

Varangis, P. & Schreiber, G., 2000. Cocoa market reforms in West Africa: policy challenges. *World Bank Technical Paper* No. 444. Washington, D.C.: World Bank

Wilson, P., 1994. Export earnings and instability in Singapore, 1957-1988: a time series analysis. *Journal of Asian Economic, 5*, p.399-412.

World Bank, 2004. World development indicators. [CD-Rom]. Washington, D.C.: World Bank.

APPENDIX

The sample of 36 SSA countries for the study was grouped into 3 sub-samples. The grouping was based on the level of primary commodity concentration. Level of primary commodity concentration was defined using the proportion of national revenue that was obtained from a given country's 3 key primary commodity exports. Period average earnings from primary commodity exports for 1990-1999 were used (UNCTAD, 2003). Countries that obtained 70% or more of foreign exchange earnings from their 3 major primary commodity exports were classified as high primary commodity concentration countries. Those that obtained between 30-69% were designated medium commodity concentration countries and for less than 30% low concentration (see Table A1). Table A2 describes the degree of commodity dependence generally in SSA

Table A1. Measure of primary commodity diversification

High primary commodity concentration	Medium primary commodity concentration	Low primary commodity concentration
Botswana	Mali	Mauritius
Burundi	Cote d'Ivoire	Swaziland
Cameroon	Seychelles	Lesotho
Central Africa Republic	Kenya	
Chad	Madagascar	
Congo, Rep.	Senegal	
Equatorial Guinea	Burkina Faso	
Ethiopia	Zimbabwe	
Gabon	Gambia	
Ghana	Benin	
Guinea	Sudan	
Guinea Bissau	Cape Verde	
Malawi		
Niger		
Nigeria		
Rwanda		
Togo		
Uganda		
Zambia		

Table A2. Primary Commodity Dependence

No.	Country	Average 90-99 (%)	Leading commodity exports
1	Botswana	95	Diamonds sorted, bovine meat, hides and skin
2	Niger	94	Uranium, live animals, tobacco
3	Gabon	92	Oil, timber, manganese ore

No.	Country	Average 90-99 (%)	Leading commodity exports
4	Congo, Rep.	91	Oil, timber, sugar
5	Congo, Democratic Rep.	89	Diamonds, coffee, timber
6	Nigeria	87	Oil, cocoa, rubber
7	Comoros	87	Vanilla, essential oils, cloves
8	Burundi	87	Coffee, tea and sugar
9	Equatorial Guinea	83	Oil, timber, cocoa
10	Guinea Bissau	82	Nuts, fish, cotton lint
11	Sao Tome and Principe	81	Cocoa, fish, coffee
12	Ethiopia	80	Coffee, hides and skins, sesame seeds
13	Angola	80	Fuels, diamonds sorted, coffee
14	Malawi	76	Tobacco, tea, sugar
15	Mauritania	76	Iron ore, fish, oil
16	Central Africa Republic	70	Diamonds sorted, timber, cotton lint
17	Uganda	68	Coffee, fish, crude metals
18	Zambia	68	Copper, sugar, cotton lint
19	Togo	66	Phosphate, cotton lint, coffee
20	Rwanda	65	Coffee, tea, hides and skin
21	Cameroon	62	Oil, timber, cocoa
22	Chad	62	Cotton lint, cattle, crude metals
23	Guinea	62	Bauxite, alumina, fish
24	Ghana	61	Cocoa, diamonds, gold
25	Mali	58	Cotton lint, live animals, oil of groundnuts
26	Cote d'Ivoire	56	Cocoa, oil, coffee
27	Seychelles	55	Fish, oil, cinnamon oil
28	Somalia	51	Live animals, bananas, fish
29	Namibia	50	Diamonds, fish, live animals
30	Mozambique	49	Fish, nuts, timber
31	Kenya	46	Tea, coffee, oil
32	Madagascar	45	Fish, coffee, cloves
33	Senegal	45	Fish, oil, groundnut oil
34	Burkina Faso	39	Cotton lint, sesame seed, hides and skin
35	Zimbabwe	36	Tobacco, cotton, gold
36	Gambia	35	Groundnuts, fish, groundnut oil
36	Benin	33	Cotton lint, cotton seed, oil of pal,
37	Sudan	32	Sesame seed, crude metals, coarse grains
38	Cape Verde	30	Fish, apples, timber
39	Mauritius	27	Sugar, crude metals, fish
40	Sierra Leone	23	Fish, coffee, cocoa
41	Swaziland	22	Sugar, citrus fruits, other fruits
42	Liberia	18	Rubber, timber, oils

Source: UNCTAD, 2003

CHAPTER THREE

3 TRENDS AND VOLATILITY IN SUB SAHARAN AFRICA'S PRIMARY COMMODITY EXPORTS[14]

3.1 Introduction

Much empirical work has generated stylized facts that indicate that volatility, trends and cyclical behaviour are inherent salient features of primary commodity prices. Recent trends in primary commodity prices in general have been unfavourable for most exporters. For instance over the last forty years real commodity prices have been continuously declining. Many reasons have been given for the long-term decline of prices; one of the important reasons explaining the long-term decline in trends has been structural change particularly in agricultural commodity markets. The argument is that basic supply and demand dynamics due to increased productivity has increased supply hence the fall in prices (FAO, 2004). However, the extent to which these features vary across individual commodities traded by various Sub Saharan African (SSA) countries has received scant attention if any at all. The fact that more than 50 percent of SSA countries depend on up to three primary commodity exports for the greater share of their incomes (UNCTAD, 2003) makes commodity issues a subject of great concern. Therefore the role of commodities markets in the attainment of the United Nations' Millennium Development Goals (MDGs) and sustainable debt burdens for countries that have reached the completion points of the Heavily Indebted Poor Country initiative (HIPC) cannot be over-emphasized. For example lack of an understanding of commodity price behaviour can erode most of the gains from debt relief obtained by commodity dependent countries. The high commodity dependence also makes exports a major source of

[14] A paper based on this essay has been accepted for publication in the March 2007 issue of the South African Journal of Economic and Management Science.

economic destabilisation; consequently the behaviour of commodity prices assumes increased importance in implementing meaningful economic policies and developing hedging strategies.

In the light of the above, additional information on the pattern of trends and volatility features of the individual primary commodities that are exported by SSA countries can be helpful. Despite the importance of an understanding of price behaviour of commodities of importance to SSA the issue has not attracted adequate attention in the literature. The research questions that come to the fore are as follows: has there been change in the long-run price trend over the past forty years? Has the level of volatility in price changed over the study period? The purpose of the present paper therefore is to broadly study the price behaviour of SSA's eighteen key primary commodity exports over the period 1960 to 2005. However, the specific objectives are to ascertain whether the long-run price trends and volatility have changed over the past four decades. In order to address the issues raised above, selected primary commodity prices are compared over two sub-periods to see if there have been changes. The sub-periods are the period encompassing the two major oil price shocks, i.e. 1960-1980 and the post-shock period, 1981-2005. The selection of the two sub-periods was also informed by the distinct "breakpoint" observed in the long-term trends of commodity prices as observed by FAO (2004). The FAO study asserts that the distinct "breakpoint" observed in most commodity price trends may be due to trade liberalization, technological change and increased manufactured exports by developing countries in Asia.

The paper draws its relevance from the fact that increased insights into SSA's commodity price behaviour can be useful in the implementation of macroeconomic policy, particularly in the design of relevant policy instruments to neutralize the effects of unfavourable price movements. The paper is organized as follows: sub-section two reviews previous studies on trends, cycles and volatility. Stylized facts on SSA major commodity exports are discussed in the third sub-section of the essay. Sub-section four presents the methodology whilst the relevant data issues are discussed in the fifth sub-section. The results of estimations are given in sub-section six whilst sub-section seven concludes and distils the policy implications.

3.2 **Literature Review**

This section of the paper reviews briefly the associated literature in relation to the study; papers that have looked at commodity price cycles, volatility and trends are therefore discussed. The discussion identifies a gap with respect to key primary commodity exports of major importance to SSA economies. An attempt is made to fill this gap by focusing on the 18 key primary commodity exports that most SSA countries depends on for the bulk of their foreign exchange earnings.

Agenor *et al.* (2000), Reinhart & Wicham (1994) and Cashin, Liang & McDermot (2000) have shown that commodity price shocks that trigger commodity price cycles can display varying degrees of persistence across commodities. However, two approaches emerge in the literature on the duration of commodity price cycles. The Beveridge-Nelson decomposition defines cycles in terms of deviation of a price series from a trend-growth cycle (see Cuddington, 1994; Reinhart & Wicham, 1994). The second approach (see Watson, 1994; Cashin & McDermott, 2002) deals with the price data in levels. The approach thus avoids the element of subjectivity inherent in the selection of de-trending methods. Consequently, price slumps and booms are then expressed as periods of absolute decreases and increases respectively in the price series and not as periods below trend or above trend in the series. The classical definition therefore renders the decomposition of a series into its "trend" and "cycle" components redundant. Following the seminal work of Burns and Micthel (1946) in the study of business cycles, the definition of booms and slumps depends on movement of prices between peaks and troughs. Commodity prices are therefore said to have moved from a boom to slump phase if prices fall from their earlier (local) peak.

Most previous studies on commodity price volatility (uncertainty) have studied the phenomenon with either unconditional standard deviation or the coefficient of variation[i] (see UNCATD, 2003; Baclair, *n.d*; Moledina, Roe & Shane, *n.d*; Marinkov & Burger, 2005). Volatility measures based on time series in which cyclical components are filtered out such as that provided by the Holdrick-Prescott and the Bandwith filters have been criticized as ineffective (see Agenor *et al*., 2000; Canova, 1998; Harding & Pagan, 2002). It has indeed been argued quite strongly that the exercise leads to loss of certain features in the time series that rob researchers of full information regarding a given series.

Clem (1985) found that the volatility indices for food commodities were consistently higher than those of non-food. The paper used two alternate measures of volatility: a *static* volatility measure and a *dynamic* volatility measure. These measures were based on two different definitions of volatility. Whilst the former depended on changes in price level, the latter considered changes in the rate of change.

Generally the literature points out that volatility measures such as standard deviation and coefficient of variation are reckoned to overstate variability in non-trending series. They are also deemed to have no constant range; their squaring further tends to aggravate the problem of outliers (see Offut & Blandaford, 1986). The possibility of variation over time in the confidence interval of volatility forecasts calls for an approach that models the variance of the errors. The body of knowledge on volatility identifies the ARCH-type of models as the most suitable in the assessment of volatility (Bollerslev, 1986, Nelson, 1994; Zukonian, 1994; Swarmy, 2002).

Previous studies that considered trends in commodity prices present two main approaches. One group of researchers asserts that difference stationary ought to be used in describing the underlying data-generating processes of commodity prices. Grilli & Yang (1988) used the time trend approach; however, in a study by Cuddington & Uzua (1998) it was found that the use of either difference stationary or trend stationary did not make any difference in the results.

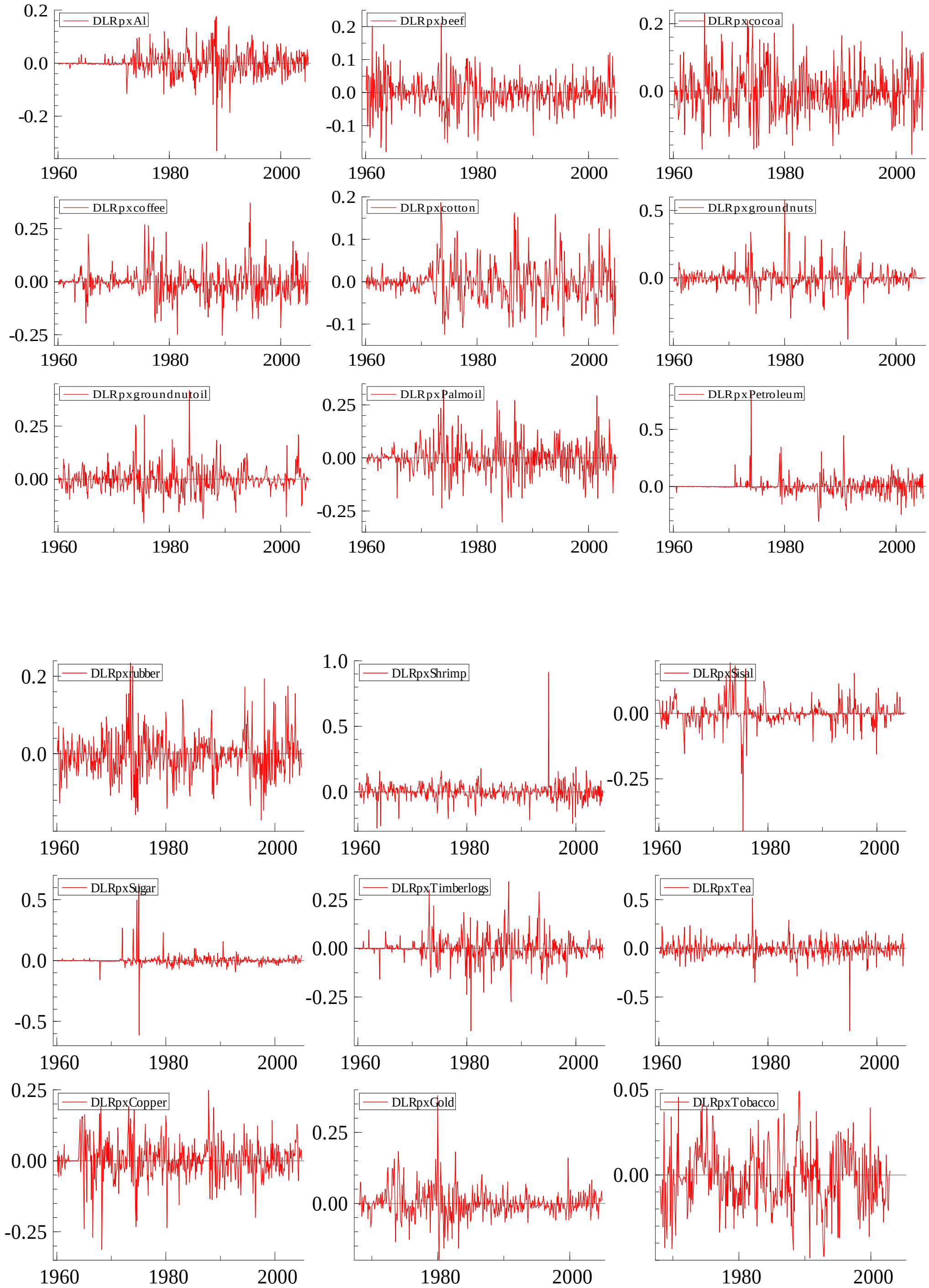
3.3 SSA's Major Commodity Exports: Selected Stylized Facts

SSA countries export over 60 assorted primary commodities, but 18 of these happen to be among the 3 leading exports of countries in the region. These primary commodities can be broadly classified into (i) agricultural raw materials, (ii) minerals including crude oil, and (iii) food and beverages. As indicated earlier in the paper, the typical SSA country depends on 3 or less of these primary commodities for more than 50% of their foreign exchange earnings. The region's commodity problem is defined in terms of the continued heavy dependence on primary commodity exports (see Ocran & Biekpe, 2005).

In order to get some understanding of the volatility of the real prices of the commodities being studied, we calculated the percentage month-on-month changes in the real prices and plotted them against time (see Table Figure 3-1). A cursory look at the charts indicates that all the major commodities have seen tremendous volatility in prices, with the worse being crude oil; this commodity recorded the highest peaks during the oil price shocks in 1973 and 1978. The first shock was a result of the Yom Kippur war that caused major Arab oil-producing countries to cut back on production. These oil producers also placed an embargo on oil exports to perceived pro-Israel countries such as the US and the Netherlands. The second oil shock could be described as the Iranian oil price shock. Following the deposition of the Shah of Iran and the assumption of power by the Ayatollah Khomeini, border clashes between Iran and Iraq developed into full-scale war, which led to the shutting down of Iranian oil production facilities. At the time Iran accounted for about 20% of the world's supply of crude oil, and hence the gap left by the absence of Iranian output led to a severe price shock. The invasion of Afghanistan by the Soviet Union around the same time did not help matters as this led to panic buying in anticipation of a major world crisis.

Gold and groundnuts among others were some of the commodities that saw huge price changes, with tobacco recording modest price variations, which did not exceed 5% in any month-on-month period over the years 1965-2005. The increased demand for sea foods as the developed world becomes more affluent probably accounts for the big positive spikes in the prices of shrimps (see panel of figures below).

Figure 3-1. Month-on-Month Changes in Real Prices 1960(1) - 2004(12)



3.4 Methodology

The analytical framework for validating the set of hypotheses for the present essay has two dimensions. First, we present the Augmented Dickey Fuller (ADF) and Phillips-Peron (PP) frameworks testing for unit roots respectively Cuddington & Liang, 1998. The second part of the section presents the theoretical underpinnings for the volatility assessment; the adopted GARCH model is briefly discussed. The GARCH approach was chosen out of the range of volatility models because of its best statistical fit, particularly in modelling commodity prices (see Swaray, 2002).

Trends in Sub-Saharan Africa's Key Commodity Exports

Studies have indicated that before one proceeds to measure the temporal variation in the second moments of a time series, it is important that other specifications of its trend are considered (see Cuddington & Liang, 1998). However, there appears to be some debate among researchers about whether difference stationary (DS) or trend stationary (TS) models are more appropriate in describing the data-generating processes. Following Cuddington & Liang (ibid), we first examine the statistical properties of the price series by testing for unit roots using both the ADF and the PP Test.

Understanding the underlying cause of non-stationarity helps in addressing the question of whether price shocks have permanent consequences for future levels of commodity prices or whether they rather represent temporary setbacks that have no permanent consequences (Hamilton, 1994).

$$\log p_t = \alpha + \beta T + e_t \qquad (1)$$

$$(1-\rho)A(L)e_t = B(L)\varepsilon_t \qquad (2)$$

where p_t is the natural log of real commodity price index and *T* is the trend variable Time. The error process in (2) is written with the largest root factorized out. It is also assumed that the lag polynomial *A (L)* is invertible and likewise *B (L)*; therefore *A (L)*$^{-1}$ *(B) L* is a stable polynomial lag operator. It is serially uncorrelated with zero mean and finite variance. If $\rho = 1$ in equation (2), the data process underlying the commodity process is said to have a unit root. In that case we first difference equation (1). The presence or otherwise of a unit root is tested with a PP test; this examines the significance of the regression below:

$$d \log p_t = \mu + \theta \log p_{t-1} + \beta T + \mu_t \qquad (3)$$

where $\theta = \rho - 1$ and $d \log p_t$, the first difference of log of *p*. The ordinary least squares regression estimate of the above model and the t-test for the null hypothesis $\theta = 0$ or $(\rho - 1)$ are then obtained. First equation (3) estimated at the least restrictive level with the inclusion of a constant and time, T. If the null hypothesis is not rejected, the significance of the constant and trend terms are explored to ascertain whether the model will gain more power dropping one or both terms (see Enders, 1995).

It can be asserted that 7 out of the 18 major primary commodity prices in SSA had undergone changes that appear to have had a permanent effect on the real prices of the commodities concerned (see Table 3-1).

Table 3-1. Unit Root Test Results

Real Commodity Price	Model Selected	Lag order γ	Coefficient β	t-ADF t(β)
Aluminium	I,T	5	0.965	-3.632**
Beef	I,T	0	0.975	-2.922*
Cocoa	I,T	9	0.984	-2.546

Coffee	I,T	10	0.986	-2.591
Copper	I,T	1	0.975	-3.937*
Cotton	I,T	1	0.978	-3.619**
Gold	I	12	0.986	-2.588
Groundnuts	I,T	1	0.963	-3.780**
Groundnut oil	I,T	6	0.972	-3.510*
Iron	I,T	12	0.986	-2.264
Palm oil	I,T	?	0.962	-3.556**
Petroleum	I,T	4	0.987	-2.068
Rubber	I,T	12	0.962	-4.187**
Shrimp	I,T	3	0.968	-3.062*
Sisal	I,T	11	0.973	-4.140**
Sugar	I	0	0.963	-3.114*
Tea	I,T	1	0.979	-2.785
Timber logs	I	2	0.962	-3.764**
Tobacco	I,T	11	0.980	-3.173

Note: Critical values used in the ADF test were 5% =-2.87 and 1%=-3.45.
** denotes significance at 1% and * denotes significance at 5%.

Source: Data used in the analysis were obtained from the International Monetary Fund's International Financial Statistics CD ROM, August 2005. The data were monthly data from 1960(1) to 2004(12), except for Gold and Tobacco. The Tobacco series began in 1969 and ends in 2002, whereas Gold begins in 1976 and ends in 2004.

Table 3-2 presents the results of the Phillips-Peron tests on SSA major primary commodities examined in the present study. Data for the tests were drawn from the International Monetary Fund (IMF) International Financial Statistics (IFS) CD ROM and they spanned the period 1960(1) to 2004(12). The third column of the Table presents the kind of model selected for the analysis; I denote model with intercept and T model with trend. For all the series except groundnuts the null hypothesis of $\theta = 0$ was rejected at the 5% level.

Table 3-2. Phillips-Peron Unit Root Test Results For Real Prices

Commodities	Test-Statistic	Model Selection
Aluminum	-2.120	I
Beef	-2.736	I
Cocoa	-1.540	I
Coffee	-1.889	I
Copper	-3.302	I
Cotton	-1.159	I
Gold	-1.988	I
Groundnut	-3.079**	I
Groundnut oil	-2.253	I

Hardwood Timber Logs	-3.252	I
Iron ore	-0.936	I
Palm oil	-3.247	I, T
Petroleum	-1.666	I
Rubber	-3.209	I, T
Shrimp	-2.600	I
Sisal	-2.364	I
Sugar	-2.758	I
Tea	-3.418	I, T
Tobacco	-1.003	I

Notes: *** Denotes significance at 1%.
Data used in the analysis were obtained from the International Monetary Fund's International Financial Statistics CD ROM, August 2005. The data were monthly data from 1960(1) to 2004(12), except for Gold and Tobacco. The Tobacco series began in 1969 and ends in 2002, whereas Gold begins in 1976 and ends in 2004.

Commodity Price Volatility

Following the seminal work by Engle (1982) that led to the Autoregressive Conditional Heteroskedasticity (ARCH) model, which makes use of a time-varying and measurable function of the time t-1 information set, various extensions of the model have emerged over the years. One of these extensions is the generalised ARCH model (GARCH). See Gourieoux, (1997) and Bollerslev (1992) for an extensive discussion of the various extensions. The linear ARCH (q) models usually call for a long lag length "q". An alternative and more flexible lag structure is offered by the GARCH extension GARCH (p, q), as presented in Bollerslev (1986). It is, however, worth noting that the simple GARCH (1, 1) was independently suggested by Taylor (1986).

In fashioning out the theoretical framework for the GARCH model used in the present work, the approach is first explained by way of a discussion of the basic ARCH model, from where extensions are made to derive the GARCH model. Given that the dependent variable of primary commodity prices is denoted p_t and that this is a result of an autoregressive process,

$$p_t = \eta_0 + \sum_{i=1}^{k} \eta_i p_{t-1} + \varepsilon_t \qquad (1)$$

An ARCH (p) process is obtained by expressing the conditional variance of (1) as a function of its past values squared:

$$\varepsilon_t | \Omega_{t-1} \sim \quad N(0, \sigma) \qquad (2)$$

$$\sigma_t = \delta + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-1}^2 \qquad (3)$$

where σ^2 stands for the conditional variance of the information set Ω_{t-1} available at time t-1 and $\delta_1 \succ 0$, $\alpha_i \geq 0$ for all $i = 2, \ldots.. p$ and $\alpha_1 + \alpha_2 + \ldots\ldots\ldots.\alpha_n \prec 1$ are required to render ε_t^2 positive and covariance stationary. Bollerslev (1986) extended the framework represented in (3) into (4), which incidentally is an Autoregressive Moving Average (ARMA) representation of ε_t^2.

$$\sigma_t^2 = \delta + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-1}^2 + \sum_{i-1}^{q} \beta_i \sigma_{t-1}^2 \qquad (4)$$

The resultant ARCH extension represented by (4) denotes conditional variance of a commodity price series that depends on a constant, past information about volatility (i.e., ε_{t-1}^2 terms) and past forecast variance (the σ_{t-1}^2 terms). Consequently the lagged conditional variances can be said to capture the *adaptive learning* phenomenon that characterises the process. A simpler form of equation (4), first suggested by Taylor (1986), is the GARCH (1, 1) model;

$$\sigma_t^2 = \delta + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \qquad (5)$$

One of the strengths of the formulation in (5) is its ability to make do with fewer coefficient restrictions. Another appealing feature of the GARCH (p,q) is the model's time series dependence on ε_t^2. However, for a well-defined variance and covariance function of the model, its coefficients ought to lie inside a unit circle:

$\delta, \alpha \succ 0; \beta \geq 0$ and $\alpha + \beta \prec 1$.

It is also important to note that the sum of $\alpha + \beta$ is a measure of volatility persistence.

3.5 **Data Issues**

The US dollar prices of the commodities selected for the study were obtained from IMF's International Financial Statistics database CD-ROM, August 2005 issue. The monthly price data spanned the period January 1960 to December 2004. Real commodity prices were generated by deflating the nominal commodity prices using the US consumer price indices. The CPI indices were obtained from the IMF's IFS CD ROM. The 18 leading commodities selected for the study were obtained from an UNCTAD study that identified the key leading exports from SSA (see UNCTAD, 2003). Commodities considered in the study were: aluminium, bananas, beef, cocoa, coffee, copper, cotton, crude oil, fish, gold, hardwood, groundnut oil, groundnut, hides, palm oil, rubber, sawn wood, shrimps, sugar, tea, tobacco. The price description of the various commodities is presented in Table below.

The price variable in commodity studies is defined differently in the literature. Heifer and Kinishita (1999) used nominal and real prices from USDA for price. However, in an earlier study Blandford (1983) simply used nominal prices, while Leon and Soto (1997) in their paper used real dollars. Cashin, McDermott & Scott (1999a, 1999b and 1999c) used the IMF reference international commodity prices deflated by manufacturing unit value index. In a study by Dehn (2004), the author constructed an index of CIF prices in US dollars. Again, Cashin & McDermott (2001), unlike their earlier study, used commodity price weighted by imports and deflated by the US CPI. In the present study, however, we deflate the IMF's commodity prices in US dollars with the US CPI. We felt that since the IMF prices were recorded in US dollars, the most appropriate deflator was the GDP deflator. But these were not available in monthly series for the US economy, hence the use of the CPI.

Table 3-3 presents the descriptive statistics of the 19 key SSA commodities studied. First, the chi^2 asymptotic and normality tests indicate significant deviation from normal distribution of the prices of each of the commodities. Again, results describing significant excess kurtosis and Skewness in the series further reinforce the normality statistic. Generally, all the real prices were leptokurtic (i.e., exhibited fat tails) just like the prices of most financial assets. Apart from groundnuts, sisal, hardwood timber logs, cocoa and sugar, all the other commodities were significantly skewed to the right, i.e. the right tails of the various distributions were heavier to the left of the means of the commodities. Aluminium and beef recorded the least skewness among the commodity groups under discussion. Whilst aluminium and beef were fairly platykurtic, the rest had very prominent spikes, with groundnuts and sisal exhibiting the highest peak. The least excess kurtosis was seen in shrimps. The stylized facts presented by the summary statistics are consistent with most of the literature (Deaton, Laorwue, 1992; Cashin, McDermott & Scott, 1999; Swarmy, 2002).

Table 3-3. Descriptive statistics of selected real commodity prices, 1960M1-2004M12

Commodities	Mean	Min.	Max.	Standard Deviation	Skewness	Excess Kurtosis
Aluminum	23.55	12.83	52.21	7.27	0.33	-0.31
Beef	1.82	0.73	4.26	0.69	0.37	-0.33
Cocoa	31.56	8.65	123.25	20.92	1.92	4.00
Coffee	7.66	1.81	22.66	3.82	0.80	0.80
Copper	37.60	13.50	108.57	18.11	1.20	1.33
Cotton	1.29	0.36	3.29	0.54	0.56	0.59
Gold*	5.16	2.53	14.92	2.25	1.71	3.75
Groundnut oil	14.80	5.77	38.39	6.41	1.16	1.76
Groundnuts	12.14	5.61	54.50	5.58	3.02	14.20
Iron	0.47	0.28	0.79	0.13	0.11	-1.20
Palm oil	7.66	1.81	22.66	3.82	0.80	0.80
Petroleum	0.26	0.08	0.90	0.40	1.30	1.44
Rubber	0.84	0.22	2.45	0.40	0.88	0.79
Shrimp	0.09	0.04	0.20	0.04	0.98	0.17
Sisal	11.30	5.58	37.85	5.78	2.49	7.55
Sugar	0.32	0.22	0.91	0.07	1.80	10.15
Tea	3.91	0.71	11.92	2.32	0.43	-0.51
Timber logs (Hardwood)	2.22	1.22	6.22	0.72	2.07	5.96
Tobacco	43.82	25.36	68.86	10.31	0.35	-0.49

Notes: Data span the period 1963(1) to 2004(12).

3.6 Results

Commodity Price Volatility

Following Cuddington & Liang (1998) and Swaray (2002), this paper has sought to ascertain the suitability of GARCH as a good descriptor of the price instability in the 18 commodities under discussion. GARCH (1,1) was therefore fitted for each of the commodities. Interestingly, the estimated coefficients of the variance equation for every one of the commodities were found to be significant at the 1% level, except for tobacco (see Table 3-4). The univariate GARCH (1, 1) estimates for the mean and variance equations of the 18 commodities under discussion are presented in Table 4 below. Thirteen of the 18 commodities exhibited relatively high coefficients estimates for the variance equations, whilst the parameter estimate for tobacco was low – it was statistically insignificant. On the other hand, low and significant variance equation estimates were observed for cotton, sisal, tea and cocoa. In order to validate the hypothesis that price volatility for SSA key commodity exports have varied between the two periods, 1960-1980 and 1981-2004, we introduced a time dummy that took on the value of unity in the later period and zero in the former. Half of the commodities under discussion did not experience statistically significant volatility changes over the two periods. These commodities were aluminium, beef, cocoa, groundnut oil and palm oil.

Table 3-4. Estimation of the GARCH (1, 1) Model, 1960(1) – 2004(12)

Commodity	Constant	ARCH(1) (α)	GARCH(1 (β)	Time Dummy	Log-Likelihood
Aluminium	5.05E-06*	0.1881*	0.8517*	-1.13E-05	1109.111
Beef	9.75E-05*	0.1457*	0.8112*	-1.43E-06	933.2172
Cocoa	0.0011*	0.3062*	0.5078*	-0.000198	0.001053
Coffee	4.78E-05*	0.2717*	0.7618*	0.0002*	776.873
Cotton	7.99E-05*	0.5741*	0.3766*	0.0005*	1034.719
Groundnut	0.0005*	0.2460*	0.7301*	-0.0001*	685.2739
Groundnut oil	0.0003*	0.3878*	0.6149*	2.85E-05	820.1029
Palm oil	4.54E-05*	0.0920*	0.8994*	8.71E-05	706.8984
Petroleum	0.0002*	0.5712*	0.6052*	2.02E-05	845.8932
Rubber	4.54E-05*	0.0920*	0.8994*	8.71E-05	706.8984
Shrimp	2.71E-06*	-0.0114*	1.018012*	-3.65E-05*	712.3838
Sisal	0.0004*	0.5664*	0.4032*	-0.0001*	1036.266
Sugar	0.000219	0.3853*	0.7312*	-0.0002*	1044.996
Timber	0.0002*	0.2391*	0.7518*	1.05E-05	832.0788
Tea	0.0016*	0.2410*	0.4825*	0.0015*	586.3338
Copper	5.43E-05*	0.3347*	0.6899*	0.0002*	781.4507
Gold	0.0002*	0.1630*	0.8026*	-0.0001**	781.7768
Tobacco	0.0002*	0.3084*	0.2113	-3.75E-06	1119.462

Notes: * denotes significance at 1% level of significance.
** denotes significance at 5% level of significance.

The other commodities that did not show any meaningful change in volatility over the past four decades were crude oil, rubber, timber and tobacco. On the other hand, the other half of the range of commodities did indeed experience changes in the level of volatility over the two periods (see Table 3-4). Certain commodities recorded increased volatility in the second period (coffee, cotton, tea, copper and rubber), while others saw a relative decline in their price volatility (sugar, groundnut, gold and shrimp).

The literature indicates that the magnitude of the summation of the ARCH and GARCH terms in the variance equation is an indication of the measure of persistence in volatility shocks. When the sum of the coefficients of the ARCH and GARCH terms amounts to unity, the implication is that shocks dampen out quite slowly; thus the lower the value of the terms, the faster volatility shocks die out. Persistence measures that approach unity are an indication of the presence of an integrated GARCH (IGARCH) phenomenon. Consequently, it can be asserted that the autoregressive moving average (ARMA) process of the variance in a given commodity price could be either non-stationary or posses an infinite variance. The presence of an IGARCH process in most of the regions major (15) primary commodities underscores an incessant variation in the volatility levels of their prices. Whilst tobacco, cocoa and tea had the least measure of persistence, crude oil prices exhibited the highest level of volatility persistence; this was followed by sugar, aluminium and coffee (See Table 3-5). The level of volatility persistence obtained for the beverages cocoa, coffee, tea and for tobacco compared favourably with that obtained by Swaray (2002).

Table 3-5. Volatility Persistence in Commodity Prices

Commodities	Volatility Persistence, ($\tau = \alpha + \beta$)

Petroleum	1.18
Sugar	1.12
Aluminium	1.04
Coffee	1.03
Shrimp	1.01
Groundnut oil	1.00
Palm oil	0.99
Timber logs (Hardwood)	0.99
Cotton	0.98
Groundnuts	0.97
Sisal	0.97
Gold	0.97
Beef	0.96
Copper	0.95
Rubber	0.90
Cocoa	0.81
Tea	0.72
Tobacco	0.52

Source: Authors computations using EViews.

3.7 **Conclusion**

Using the GARCH model the paper empirically investigated the persistence of shocks in SSA's major primary commodity exports and again ascertained the asymmetry pattern or otherwise in the nature of the price volatilities. The differences in SSA's real commodity prices across commodities were examined. The hypothesis that variability in price volatility had not changed for the prices over the past 40 years was examined. The paper sought to ascertain whether volatility in the region's key primary commodities had increased or decreased after the 1980s as compared to the period 1960-1980, when the world suffered two major oil price shocks.

The highlights of the study can be summarised as follows. For nine (9) of the major exports volatility variation did not show any significant change over the past 40 years. These commodities were aluminium, beef, cocoa, groundnut oil, crude oil, palm oil, rubber, timber and tobacco. On the other hand, the other 9 commodities saw changes in volatility variations. However, whilst some (gold, sisal, shrimps, groundnuts and sugar) saw a decrease in the levels of volatility, the rest rather witnessed deterioration in levels of volatility (copper, coffee, cotton, tea and sisal).

Clearly, evidence of long-run volatility persistence in the major primary commodity prices of interest to SSA can be adduced. For these commodities international stabilization efforts such as that supported by commodity organizations such as the International Coffee and Cocoa Organization (ICCO) cannot be sustained perpetually. Usually when commodity prices soar as result of the volatility phenomenon, SSA governments' revenues receive a boost from the windfalls either directly or indirectly, or better still both directly and indirectly. In countries where governments control commodity marketing organisations, the impact on revenues has been direct. Indirect impacts are realised in instances where commodity trade is in private hands; in this case revenues from trade taxes and income taxes surge. Governments in SSA have typically assumed that positive commodity price shocks are enduring, whilst negative shocks are rather transitory (Cooper, 1991). Indications are that the windfall gains are rather used to provide funding for pro-cyclical expenditures. Consequently, when the trend for prices is downward, these countries have had to run huge fiscal deficits (see Collier & Gunning, 1996).

It is important that governments realise that price swings are a more or less permanent feature and that when positive shocks are experienced efforts need to be made to save for a rainy day. The collapse of the various stabilization schemes under the strain of continued swings in prices further underscores the unsustainability of external attempts aimed at ameliorating the effects of negative shocks. It is important that governments in SSA pursue expenditure smoothening policies so that savings can be made during good times and dissaving in difficult periods. Additionally, efforts need to be made to diversify extensively their portfolio of primary agricultural commodity exports by including new products that appear to have reduced price volatilities in the past decades. This is crucial for countries that depend on 3 or less agricultural primary commodities for the bulk of foreign exchange earnings.

List of References

Agenor, Pierre-Richard, McDermott, C. J. & Prasad, E., 'Macroeconomic fluctuations in developing countries: Some Stylized Facts', *World Bank Economic Review,* 14, p.251-86.

Baclair, M., *n.d.* Trends, cycles and volatility in export prices: the case of Turkey. Kyrgz-Turkish Manas University, Department of Economics.

Bollerslev, T., 1986. 'Generalized autoregressive conditional heteroskedascity', *Journal of Econometrics* 31, p.307-27.

Burns, A. F. & Micthel, W. C., 1946. 'Measuring business cycles' *NBER Studies in Business Cycles,* 2. New York: National Bureau of Economic Research.

Cashin, P., Liang, H. & McDermott, C.J., 1999. How persistent are shocks to world commodity prices?. IMF Working paper 80, Washington, D.C.: International Monetary Fund.

Cashin, P., C.J. McDermott & Scott, A., 1999a. Booms and slumps in world commodity prices. IMF Working Paper WP/99/155. Washington, D.C.: International Monetary Fund.

Canova, F., 1998. Detrending and business cycle facts. *Journal of Monetary Economics* 41, p.475-512.

Cashin, P., C.J. McDermott & Scott, A., 1999b. The myth of co-moving commodity prices. *Reserve Bank of New Zealand Discussion Paper* G99/9, Wellington: Federal Reserve Bank of New Zealand.

Clem, A., 1995. Commodity price volatility: trends during 1975-84. *Monthly Labour Review.* Washington, D.C.: Bureau of Labour Statistics.

Collier, P. & Gunning, J. W., Policy Towards Commodity Shocks in Developing Countries' Working Paper No. 96/84. Washington, D.C.: International Monetary Fund.

Cooper, R. N., 1991. Economic stabilization in developing countries: San Francisco, California ICS Press.

Cuddington, J. & Uzua, C.M., 1989. 'Trends and cycles in the net batter terms of trade: a new approach. *Economic Journal,* 99, p.426-442.

Cuddington, J.T. & Liang, H., 1998. Commodity price volatility across exchange rate regimes. George Town: Department of Economics, George Town University.

Cuddington, J., 1992. Long-run trends in 26 Primary commodity prices: a disaggregated look at the Prebisch-Singer hypothesis. *Journal of Development Economics* 39, p.207-227.

Dehn, J., 2000. Commodity price uncertainty in developing countries' centre for the study of African economies. Working Paper WPS/2000-10. Washington, D.C.: World Bank.

Deaton, A. S. & Laroque, G., 1992. On the behaviour of commodity prices. *The Review of Economic Studies 59*, p.1-42.

Enders, W., 1995. *Applied Econometric Time Series*. London: John Wiley and Son, Inc.

Engle, R. F. & Bollerslev, T., 1986. Modelling the persistence of conditional variances'. *Econometric Reviews* 5, p.1-50.

Engle, R., 1982. Autoregressive conditional hetroskedascity with estimates of variance of United Kingdom inflation. *Econometrica* 50, p.987-1007.

Ocran, M. K. & Biekpe, N., 2005. Commodity exports in SSA and economic growth: evidence from panel data analysis. Bellville, Cape Town: Working Paper, African Centre for Investment Analysis, ACIA, Graduate School of Business, University of Stellenbosch.

Offcut, S. E. & Blandford, D., 1986. Commodity market instability: empirical techniques for analysis', *Resource Policy,* 12 (1), p.62-67.

Gourieroux, C., 1997. *ARCH models and financial applications*. New York: Springer Verlag.

Grilli, R. E. & Yang, M.C., 1988. 'Commodity prices, manufactured goods prices and the terms of trade of developing countries'. *World Bank Economic Review* 2, p.1-48.

Hamilton, J.D., 1994. *Time series analysis*. New Jersey: Princeton University Press.

Heifner, R. & Kinithita, R., 1994. Differences among commodities in real price variability and drift. *The Journal of Agricultural Economics Research* 45 (3), p.10-20

Harding, D. & Pagan, A., 2002. Dissecting the cycle: a methodological investigation. *Journal of Monetary Economics* 49, p.365-81.

Leon, J & Soto, R., 1995. Structural breaks and long-run trends in commodity prices. *Policy Research Working Paper*, WPS 1406. Washington, D.C: World Bank.

Marinkov, M. & Burger, P., 2005. The various dimensions of commodity dependence in Africa. *South African Journal of Economics* 73(2), p.

Moledina, A. A., T. L. Roe & Shane, M., *n.d.* Measuring commodity price volatility and the welfare consequences of eliminating volatility. Working Paper, USDA/ERS and the Economic Development Centre, Minnesota: University of Minnesota.

Reinhart, C. M. & Wickham, P., 1994. Commodity prices: cyclical weakness or Secular Decline?, International Monetary Fund Papers 41(2), p.175 -213. Washington: International Monetary Fund.

Swaray, R. B., 2002. Volatility of primary commodity prices: some evidence from agricultural exports in Sub-Saharan Africa. *Discussion Paper in Economics*. No. 2002/06. The University of York.

Taylor, S. J., 1987. *Modelling financial time series*. New York: John Wiley.

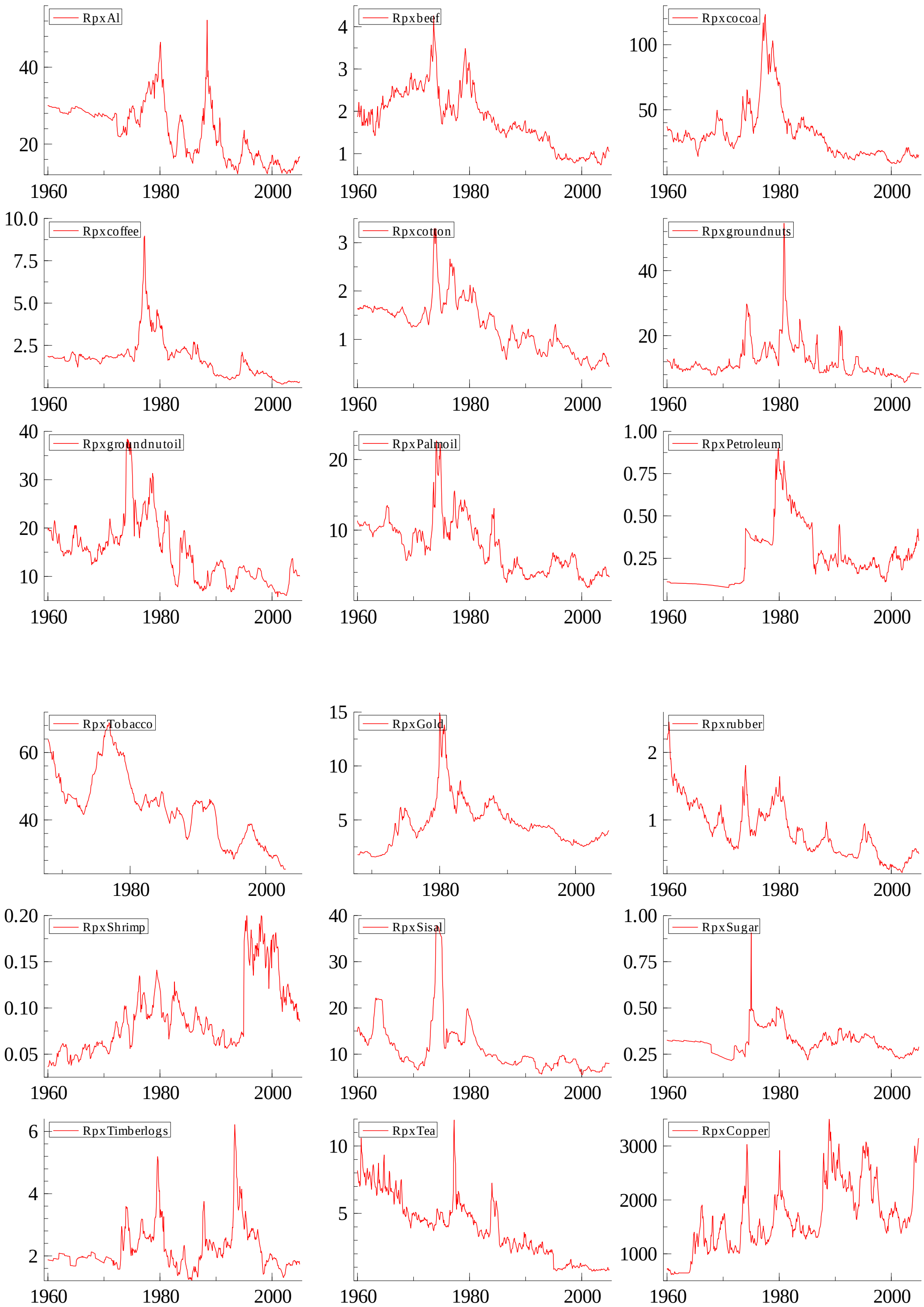
UNCATD, 2003. Economic development in Africa – trade performance and commodity dependence. New York and Geneva: United Nations

Watson, M., 1994. Business cycle durations and post war stabilization of the US economy,' *American Economic Review* 84, p.24-46.

Zakonian, J.M., 1994. Threshold heteroskedastic model. *Journal of Economic Dynamics and Control*, 18, p.931-955.

APPENDIX

Figure A1. Performance of SSA Key Primary Commodity Real Prices, 1960(1) – 2004(12)



CHAPTER FOUR

4 THE ROLE OF COMMODITY PRICE IN MACROECONOMIC POLICY IN SOUTH AFRICA

4.1 Introduction

Though the South African economy is much more diversified than that of a typical Sub-Saharan African (SSA) country, it continues to have a very important primary commodity component, similar to the Australian and Canadian economies. The country exports nearly 60 primary commodities, mostly metals. The country is the world's largest producer of the platinum group[15] of metals and gold. South Africa is also major supplier of aluminium, coal, iron ore and nickel among others, on the world market. The metals sub-group of primary commodity exports is estimated to have contributed R87 billion to the total value of merchandise exports in 2003, representing 30 percent of all merchandise exports. If other semi-processed primary commodities such as steel, ferro-alloys and chemicals from coal are added, the figured is reckoned to be more than 50 percent of total merchandise trade (CMSA, 2005). The importance of the price of gold, for instance, to the SA economy can be amply demonstrated by the over-valuation of the rand witnessed during much of the 1970s and early 1980s as a result of the strength of gold prices (Van de Merwe and Meijer, 1990).

Over the years the role of commodities prices informing the macroeconomic/monetary policy stance has been vigorously debated amongst researchers. The debate has focused on the usefulness of commodity prices as an early indicator of the current state of the economy, mostly because of the setting within which these prices are fixed. For instance

[15] This includes platinum, palladium, rhodium, ruthenium, iridium, osmium and osmiridium.

most commodities are traded in a continuous auction market based on efficient information (Marquis & Cunningham, 1990; Cody & Mills, 1991). The importance of commodity prices in the macroeconomy underlines the argument that commodity prices should be included in monetary vector auto-regression models (Christainao *et al.*, 1996). Others such as Garner (1989) have also called for the use of commodity prices as an indicator of changes in the general price level of any economy. These researchers support monetary policy proposals that use commodity prices as targets to adjust short-run money growth target bands. Despite the huge role played by primary commodities in the South African economy, the country has not attracted attention in the debate about the possible informational role of commodity prices in monetary policy formulation. Yet one of the two cornerstones of the objectives of the South African Reserve Bank is price stability, hence the informational role of commodity prices in, say, inflation can prove useful to the monetary authorities.

The purpose of this paper therefore is to examine the informational role that commodity prices can play in monetary policy formulation in South Africa. The specific objective, however, is to test whether commodity price movements precede movements in interest rates, exchange rate, money supply and the consumer price index. Consequently we test the a priori assumption that commodity prices Granger-cause changes in the defined monetary variables.

The structure of the paper is as follows: A brief review of the relevant literature is the subject of sub-section two. The theoretical framework that serves as basis for empirical estimations is presented in sub-section three. Data issues and empirical patterns of the data are discussed in sub-section four. The results of the study are presented in sub-section five whilst conclusions and policy implications are given in sub-section six.

4.2 Literature Review

Increases in commodity prices may be considered as signals that the economy may be heating up (growing too rapidly) and hence inflation may tend to rise. Hence, a continuous rise in commodity prices should prompt central bankers to apply the appropriate response of tightening monetary policy by raising interest rates to cool off the economy. On the other hand, some economists claim that commodity prices are ineffectual as monetary policy indicators, because they may not necessarily have macroeconomic implications, especially since commodity prices are prone to large market-specific shocks (Marquis & Cunningham, 1990; Cody & Mills, 1991).

Furlong & Ingenito (1996) examined the empirical relationship between variations in non-oil commodity prices and inflation, among other things, in the United States. The study used bivariate and multivariate vector auto-regression estimation (VAR). A rolling regression approach was used to assess the stability of the relationship between consumer price index (CPI) inflation and changes in commodity prices. This approach helped in identifying two distinct sub-periods based on the varying stability of the regression results of the sub-periods. The Granger causality test was then used to test for causality between commodity prices and CPI. The results indicated that after the 1970s the usefulness of commodity prices as indicators of monetary performance declined. The results of the multivariate VARs also demonstrated the inadequacy of the commodity price as a stand-alone indicator for inflation.

Some of the studies that assessed the relationship between commodity prices by focusing on non-oil commodity prices include Garner (1995) and Bloomberg & Harris (1995).

Their papers conclude that some commodity prices have not been credible as good indicators of inflation, especially from about the mid-1980s onwards, even though the authors established causality in the Granger sense for commodity prices to monetary variables. The debate is broadened further by a group of researchers who appear to question the direction of causality; they rather assert that causality runs from monetary variables to prices of commodities (see Bessler, 1994; Pindyck & Rotemberg, 1990; Hua, 1998).

The research approach adopted by studies in the estimation of the role of commodity prices in informing monetary policy direction has been criticised by Toda & Yamamoto (1995). The authors assert that the standard Granger causality test is weakened when there are stochastic trends and cointegration in a given system. It is further argued that the perceived weakness can only be addressed if sufficient cointegration rank conditions are met (see Toda & Philip, 1973). Toda & Yamamoto (1995) and Dolado & Lutkpohl (1996) suggest an alternative approach for testing for Granger causality in a possibly integrated and cointegrated system, even of arbitrary ordering with the aid of augmented VAR modelling. Unlike other systems that make no room for long-run information because of the first differences and pre-whitening procedures applied, the Toda-Yamamoto approach maintains the long-run information in the system, since the abovementioned transformation in the data does not arise. A gap in the literature is that all previous studies that considered the informational role of commodity prices in monetary policy dwelt on developed economies. Thus the role of commodity prices in informing monetary policy direction in emerging market economies such as that of South Africa have received little or no attention. It is in this respect that the present study intends contributing to the literature by using South African data.

4.3 Methodology

The theoretical framework of the paper follows the approach for examining causal relationships as described by Toda & Yamamoto (1995). The Toda & Yamamoto (ibid) procedure tests restrictions on the coefficient estimates of levels of vector auto-regression (VAR), after which the Wald test is applied. The approach requires the determination of optimal lag length for the series in the VAR system as well as the order of integration of the series. In order to establish the optimal lag structure of the VAR, information criteria statistics such as the Akaike information criterion (AIC) and Scwhartz's information criterion (SIC) are used. Following the determination of the optimal lag length (*k*), the order of integration $d_{\max}$ is also ascertained. Consequently, a level VAR with lag length *p* (i.e., $p = [k + d_{\max}]$) is tested for causality. The standard Wald test statistic is used to test for restrictions on the VAR coefficient matrix from which causal inferences in the Granger sense are made.

With the aid of the four-variable VAR (*k*) model[16] – including commodity price, P_C; consumer price index, P_{CPI}; money supply, M; exchange rate, E; and Interest rate, I – dynamic causality from P_C to $P_{CPI,} M, E$ and I in the Granger sense (Granger, 1969) is tested. The formal relationship that is examined is as follows:

$$Z_t = \beta + \sum_{i=1}^{p-1} \Omega_i Z_{t-k} + \varepsilon_t \qquad \varepsilon_t \sim i.i.d.\ N(0, \Sigma_\varepsilon) \qquad (1)$$

where $Z_t = (P_C, P_{CPI}, M, E, I)'$. In equation (1) the null of non-causality from commodity price can be given as the (1, 4) element of all coefficient matrices $(\Omega, i =, \ldots\ldots\ldots k)$ being

[16] Where *k* is the optimal lag length.

equal to zero. Assume $S_i' = (1,0,0,0)'$, $S = I_k \otimes (0,0,0,1)'$ with I_k being a matrix of order *k*. Again, let D be a column vector obtained by stacking rows of matrix D. Then, according to Toda and Yamamoto (1995), it can be demonstrated that the Wald statistic (*W*) has χ^2 distribution with *k* degrees of freedom in the limit when the maximum order of integration of y_t is *d*.

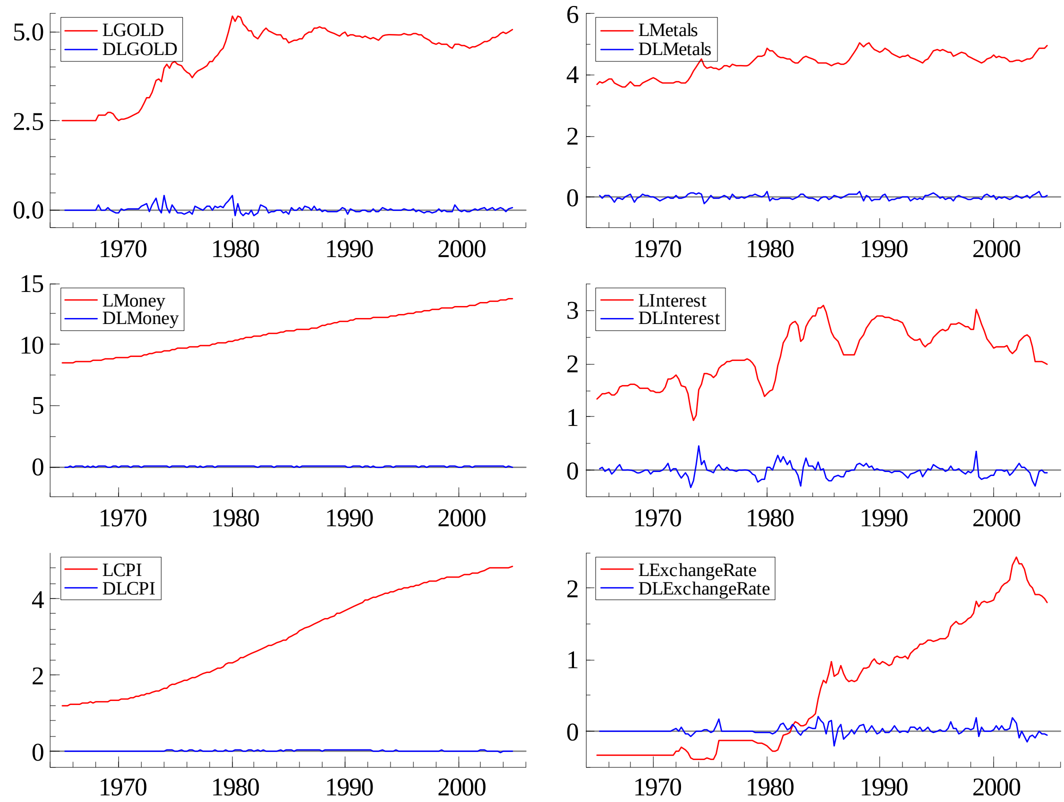
$$W = T\{(S_1' \otimes S')vec\Omega'\}[(S_1' \otimes S')\hat{\Sigma}(S_1' \otimes S')']^{-1}(S_1' \otimes S')vec\hat{\Omega}$$

Where, $\hat{\Omega}$ is the ordinary least square estimator (OLS) of $\hat{\Omega} = (\Omega_1, ...\Omega_k)$ and $\hat{\Sigma}$ is a consistent estimator of the asymptotic covariant matrix of $T^{\frac{1}{2}} vec(\hat{\Omega} - \Omega)$, when $(k+d)^{th}$ order VAR is evaluated with a constant term. In order to apply the procedure, the required information is the lag length (*k*) and the maximum order of integration of the variables.

4.4 **Data Issues**

A metals price index and the real gold price were used alternatively as proxies for primary commodity exports of relevance to South Africa. Real gold prices were obtained by deflating the average world market price of the commodity with the US CPI, following Hau (1998). The monetary variables used were interest rates, money stock and the nominal exchange rate. Specifically we used the interest rate on the 91-day Treasury bill, principal exchange rate for the Rand/US dollar exchange and the broad definition of money, M3, in the South African economy. The CPI represented the CPI for all the urban and metropolitan areas in the country. All data series were quarterly in frequency and they span the period 1965(1) to 2000(4). The data were drawn from IMF (2005). Before applying econometric methods in the estimation of the specified model, graphical analysis was used to examine behaviour of the individual data series. See Figures below.

Figure 4-1 Statistical nature of variables in levels and difference, 1965(1) – 2004(4)



Unit root test

A unit root test was conducted for the variables P_{CPI}, P_M, P_G, M, E and I in both levels and first differences. The null hypothesis that the series in levels contain a unit-root (i.e. non-stationarity) was not rejected for all variables. However, when one differenced the series, the null hypothesis of a unit root was rejected. The unit root test was undertaken with the Augmented Dickey-Fuller (ADF) unit root test; results of the test are presented in Table 4-1. The results of the test indicate that all the series are integrated of the same order, i.e. I (1). Therefore the cointegration test can be undertaken to establish the existence or otherwise of a long-run relationship between data series under examination in the present study.

Table 4-1. **Unit test results**

Variable	T-Value[1]	Lag included[2]	Additional regressors
Levels			
P_{CPI}	-0.191	0	Constant
P_M	-0.253	0	Constant
P_G	-2.096	0	Constant
M	0.253	0	Constant
E	-0.010	0	Constant
I	-0.168	0	Constant
First Differences			
P_{CPI}	-5.696**	0	Constant
P_M	-8.558**	0	Constant
P_G	-9.666**	0	Constant
M	-10.78**	0	Constant
E	-9.436**	0	Constant
I	-8.558**	0	Constant

Note: [1]The "T" value is the test statistic from the (augmented) Dickey-Fuller Test.
[2] Lag length was chosen as using the Akiake Information Criteria and F-Test assuming a maximum lag of four. ** denotes rejection of the null hypothesis of non-stationarity at the 1 percent level of significance.

4.5 **Results**

As mentioned earlier, the Toda & Yamamota (1995) approach requires the identification of the optimal lag length (*k*) and the order of integration (*d*) of the series of interest. Using the Akaike, Schwartz and Hinn-Quinnan information criteria the optimal lag length of two was obtained (see Tables 4-2 and 4-3).

Table 4-2. Lag Order Selection Criteria

Lag length	AIC	SC	HQ
0	2.969320	3.068789	3.009728
1	-18.71207	-18.11525*	-18.46962
2	-19.10945*	-18.01529	-18.66497*
3	-18.95611	-17.36460	-18.30959
4	-19.05764	-16.96877	-18.20907
5	-18.96400	-16.37779	-17.91339
6	-18.92731	-15.84375	-17.67466
7	-18.78600	-15.20509	-17.33131

8	-18.76788	-14.68962	-17.11115

Notes: * indicates lag order selected by the criterion. AIC: Akaike information criterion. SC: Schwarz information criterion. HQ: Hannan-Quinn information criterion; Sample: 1965Q1 2004Q4.

Table 4-3 Lag Order Selection Criteria

Lag length	AIC	SC	HQ
0	1.467608	1.567078	1.508016
1	-18.80324	-18.20642	-18.56079
2	-19.47229*	-18.37812*	-19.02780*
3	-19.32048	-17.72896	-18.67395
4	-19.39776	-17.30889	-18.54919
5	-19.32597	-16.73975	-18.27536
6	-19.18742	-16.10386	-17.93477
7	-19.08684	-15.50593	-17.63215
8	-18.95761	-14.87935	-17.30088

Notes: * indicates lag order selected by the criterion.
AIC: Akaike information criterion;
SC: Schwarz information criterion.
HQ: Hannan-Quinn information criterion; Sample: 1965Q1 2004Q4.
Included observations: 152.

The augmented Dickey-Fuller (ADF) test was used to find the order of integration of the series (see Table 4-1). Results of the unit-root test suggested first-order integration in all the series; with the two pieces of information a level VAR with lag length *p* (i.e., $p = [k + d_{\max}]$) is tested for causality. The Wald test of coefficient restriction was then applied in testing the null hypothesis of non-causality. The F-test and chi square test statistics of the modified Wald test are reported in Tables 4-2 and 4-3 below.

Table 4-2 **Results for gold-monetary/macroeconomic variables causality test**

Variable	Order of integration (d)	Lag length (k)	F-Test statistic	χ^2 Test Statistic
Interest rate	1	2	3.3429* (0.0120)	13.3716* (0.0096)
Money	1	2	3.1218* (0.0171)	12.4873* (0.0141)
Exchange rate	1	2	1.9024 (0.1135)	7.6095 (0.1070)
CPI	1	2	2.6430* (0.0363)	10.5723* (0.0318)

Note: Values in brackets are probability values.

Table 4-3. Results for metals - monetary/macroeconomic variables causality test

Variable	Order of integration (d)	Lag length (k)	F-Test statistic	χ^2 Test Statistic
Interest rate	1	2	2.9330* (0.023)	11.7328* (0.0195)
Money	1	2	2.3924* (0.0536)	9.5698* (0.0483)
Exchange rate	1	2	4.7181** (0.0013)	18.8726** (0.0008)
CPI	1	2	1.9998 (0.0980)	7.9994 (0.0916)

Note: Values in brackets are probability values.

The results indicate that the null of non-causality from average gold price to interest, money, exchange rate and the consumer price index can be rejected. However, for the metal's price index, whilst non-causality was rejected for interest rate, money supply and the exchange rate, it could not be rejected for consumer price index.

Two key observations can be made from the empirical results. First, average gold prices are significant in explaining the future direction of the Government of South Africa's 91-day Treasury bill rate, money supply, the principal Rand/US dollar exchange rate, broad definition of money supply and the consumer price index. In the case of the IMF's metal price index, the index was insignificant in explaining the future path of the consumer price index even though it was found significant in predicting the direction of the three other macroeconomic variables. The results regarding the relevance of commodity price (i.e. gold) in the prediction of inflation (measured as log of CPI) is consistent with findings in developed economies (Garner, 1998; Marquis & Cumming, 1991; Septon, 1991 and Awukose & Yang, 2003).

4.6 **Conclusions**

This paper examined the possible role of commodity prices in the formation of macroeconomic policies in South Africa by testing Granger causality from commodity prices to selected macroeconomic variables. The macroeconomic variables considered were the interest rate, money supply, the exchange rate and the consumer price index. The study used an alternative procedure for conducting Granger causality test developed in Toda & Yamamoto (1995) by testing the null hypothesis of non-causality from commodity price to selected macroeconomic variables with the aid of an augmented level VAR modelling. The approach allows the conduct of a Granger causality test without the loss of long-run information often overlooked in the traditional Granger causality test procedure that strictly requires first differencing.

Average gold prices and the IMF's IFS metal price index were used alternatively as proxies for commodity prices of relevance to the South African economy. In the gold macroeconomic variable, Granger causality test evidence of causality from gold prices to interest rate, money supply and consumer price index was observed. However, in the case of the metal price index to macroeconomic variable causality tests, evidence of causality is noticed for metals to interest rate, money and exchange rate. The results of the study suggest that there is some merit in using South Africa's commodity prices particularly the average gold price and the IMF's metals price index, as informational variables in setting monetary policy. The outcome of the present study particularly regarding commodity price (i.e. gold price) and inflation is consistent with the conclusions of work carried out in developed economies such as the US (Garner, 1989; Awukose & Yang, 2003). Garner (1989), Furlong & Ingenito (1996) and Awukose & Yang (2003) assert that commodity prices can be considered as an early indicator of the state of the economy of the United States. The study also provides evidence of the usefulness of commodity prices in predicting the performance of macroeconomic variables such as money supply which was previously un-documented. It is however important to caution that commodity prices may be included in monetary VAR models and not be considered as stand-alone indicators (Christiano et al, 1996).

List of References

Awukose, T.O. & Yang, J., 2003. The informational role of commodity prices in formulating monetary policy: A re-examination, *Economic Letters* 79, p.219-224

Bloomburg, S. & Harris, E. S., 1995. The commodity consumer price connection: fact or fable? *Economic Review Policy* 1 (3) p. 21-38.

Furlong, F. & Ingenito, R., 1996. Commodity prices and inflation. San Francisco: Federal Reserve Bank of San Francisco Economic Review, Vol. 2.

CMSA, 2005. Annual Report 2003-2004. Johannesburg: Chamber of Mines of South Africa.

Marquis, M. H. & Cunningham, S.R., 1990. Is there a role of commodity prices in the design of monetary policy? Some empirical evidence. *South Economic Journal,* 57, p.394-412

Cody, B. J. & Mills, L.O., 1991. The role of commodity prices in formulating monetary policy, *Review of Economics and Statistics* 73, p.358-365.

Christaino, L.J., M. Eichenbaum & Evans, C., 1996. The effects of monetary policy shocks: evidence from the flow of funds. *Review of Economics and Statistics* 78, p.16-34.

Dolado, J.J. & Lutkepohl, H., 1996. Making Wald test work for cointegrated VAR systems, *Econometrics Review* 15, p.369-386.

Garner, C.A., 1989. Commodity prices, policy target or informational variable? *Journal of Money, Credit and Banking* 21, p. 508-14.

Sephton, P. S., 1991. Commodity prices: policy target or informational variable? A comment, *Journal of Money, Credit and Banking* 23, p.260-266.

Toda, H. Y. & Yamamoto, T., 1995. Statistical inference in vector autoregression with possibly integrated processes. *Journal f Econometrics* 66, p.225-250.

Toda, H.Y. & Philips, C.B., 1993. Vector autoregression and causality. *Econometrica* 61, p.1367-1393.

Pyndyck, R.S. & Rotemberg, J. J., 1990. The excess comovement of commodity prices. *Economic Journal* 100, p.1173-1189.

Van der Merwe, E.J. & Meijer, J. H., 2000. Notes on oil, gold and inflation. *Occasional Paper* No. 2*,* Pretoria: South African Reserve Bank.

CHAPTER FIVE

5 AGRICULTURAL COMMODITY SUPPLY RESPONSE IN GHANA[17]

5.1 Introduction

The economy of Ghana, which had been strong at independence, deteriorated steadily over the period 1973 to 1982. Between 1955 and 1960 Gross Domestic Product (GDP) grew on average by 5.1 percent per annum. During the same period agricultural output also recorded average annual growth of 5.7 percent and for cocoa 9 percent. This good performance soon gave way to a gradual decline in all sectors of the economy, including that of agriculture. Between 1973 and 1982 GDP shrank by 1.3 percent annually, whilst food commodity production also declined by 2.7 percent per annum and cocoa production declined by 7 percent annually. The poor state of the economy[18] by the end of 1982 led to the implementation of the World Bank and International Monetary Fund-supported Economic Recovery Programme in April 1983.

Under the agricultural policies of the 1970s and 1980s a lot of support was given to farmers. This included subsidized inputs and services; fertilizer, agro chemicals, improved seeds and farm equipment services. However, from 1987, as part of the economic reforms, subsidies were gradually withdrawn and completely removed by 1989. Apart from the cocoa sector and to a limited extent the oil palm sector, price controls and input subsidies were successfully removed.

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[17] This paper was presented at the 3rd African Finance Journal conference, held in Ghana on 12th-13th July, 2006.

[18] See Tabatabai, H. 1986 for a more detailed discussion of the economic decline and access to food, among others.

The reason underlying liberalization of the agricultural input and output markets was to remove distortions in the market and to allow price incentives to stimulate output growth. The importance of agriculture price policy in the whole reform programme is derived from three major characteristics of the sector: (a) it is the biggest production and employment sector in the economy; (b) it has important supply and demand linkages with the rest of the economy; and (c) resource use decisions in agriculture are determined by producers in response to price and non-price incentives. Despite the policy relevance of agricultural supply response, the extent of the response in Ghana is largely unknown and it is this gap that the present paper helps to bridge. The purpose of this paper, therefore, is to examine the supply response of agricultural output to price incentives between 1970 and 2003.

Agricultural commodity supply response may be examined at different levels, given the type of resource use question that is of interest (Rao, 1989). Since the present paper is concerned with the pace of agricultural output growth, the relevant concept of interest is the response of an index of aggregate agricultural output to an index of relative price of agriculture output. The rest of the paper is structured as follows: section two presents a brief review of the commodity supply response literature. Section three focuses on the methodology adapted for the study, whilst section four discusses data issues related to the estimation. The results are given in section five and the conclusions to the study drawn in section six.

5.2 Literature Review

Most of the empirical work on agricultural supply response has been undertaken with the Nerlove partial adjustment model (Nerlove, 1979). The approach assumes that in each period a proportion of the difference between current output and long-run desired output is corrected. However, the framework fails to accommodate the full dynamics of supply, thereby underestimating elasticity of supply or biasing it downwards (Nickel, 1995).

In an alternative procedure Griliches (1959) uses input demand elasticities in estimating agriculture supply response with the aid of a constant returns Cobb-Douglas production function. So far the Griliches approach has been used only for developed countries, mostly because of its exacting demands in terms of data requirement for input and output prices. The absence of extensive data on agricultural input and outputs for low-income countries makes the Griliches approach unsuitable for work on Sub-Saharan Africa.

Estimating supply response of a cross-section of countries instead of a single country at a time has also been used to address shortcomings of the Nerlove partial adjustment procedure. Peterson (1979) argues that cross-section regressions tend to result in higher long-run response estimates, but when other omitted non-price variables are introduced, the elasticities drop significantly. Chhibber (1989) finds that supply response estimates from cross-country regressions are very sensitive to inclusion of different control variables.

The strength of the Dynamic General Equilibrium (DGE) procedure lies in its ability to explain the impact of shifts in factors of production and their sectoral allocations in an economy over time (Coeymans & Mundlak, 1993). The strong points notwithstanding, others have also argued that DGE estimates for Argentina and Chile, which are middle-income countries, cannot be extended to work on low-income countries considering the existence of institutional constraints that affects these economies (Thiel, 2002). Some of the other reasons advanced for the unsuitability of the model to low-income countries are the absence of extensive data and the demanding modelling efforts required.

Hallam & Zanoli (1993) suggest error-correction models as providing a more useful theoretical framework for studying agricultural supply response after detailed theoretical analyses of the prevailing frameworks. Studies by Thiel (2000; 2002), Mackay *et al.* (1999) and Abdulai & Reider (1995) all lend support to the superiority of cointegration and error correction modelling. The superiority of the cointegration technique lies in its flexibility; the approach does not impose any restrictions on the short-run behaviour of prices and quantities, and it rather requires a co-movement of the variables in the long run. The strength of the approach is that, unlike the partial adjustment framework, it allows for forward-looking behaviour (Nickel, 1995).

5.3 Methodology

The theoretical framework of the paper is based on an extension of the standard supply function derived from the Cobb-Douglas production function (see Sadoulet & de Janvry, 1995). The supply response model used is thus written formally as:

$$Q_t^e = f(P_t^e, Z_t^e) \qquad \textbf{(1)}$$

where, Q_t^e is the expected agricultural commodity output at time t; P_t^e, expected price of aggregate output at time *t*; and Z_t^e a vector of exogenous factors that affect output (i.e. shift factors). Following Hallam and Zanoli (1993), rational expectations are assumed; this means that future values of aggregate commodity price and quantity supplied are reflected in their generation process. It is further assumed that producers have naïve expectations, as is common in supply response models (Mackay *et al.*, 1999). Consequently, we assume $Q_t^e = Q_{t-1}$; $P_t^e = P_{t-1}$ and $Z_t^e = Z_{t-1}$. However, given that Q_t^e, P_t^e and Z_t^e follow an autoregressive process of lag one [AR (1)], a static model is not appropriate as it would suffer from serial correlation, since the short-run dynamics are captured in the residual. Hence, to test for the presence of a long-run relationship between aggregate output, price and the other output supply determinants the following dynamic specification are estimated:

$$A(L)q_t = \alpha_0 + \alpha_1 B(L)P_t + C(L)Z_t \varepsilon \qquad (2)$$

where *A(L), B(L)* and *C(L)* are the polynomial lag operators for Q_t, P_t and Z_t respectively. The Johansen cointegration test is used in assessing the presence of a long-run relationship in the model. Even though there are other approaches for examining the presence of long-run relationships between economic variables, the literature emphasises the superiority of the Johansen cointegration approach (see Hallam & Zanoli, 1991; Mackay *et al.*, 1999).

If a long-run relationship is established in equation (3), then a single equation error correction model (ECM) for commodity supply response that incorporates feedback from the long run can be formulated. The ECM is then represented as:

$$\Delta Q_t = \alpha_0 + \sum_{i-1}^{n-1} \varphi_{1i} \Delta P_{t-i} + \sum_{i-1}^{n-1} \varphi_{2i} \Delta Z_{t-i}^{s} + \sum_{i-1}^{n-1} \varphi_{3i} \Delta Q_{t-1} + \alpha_1 (Q - P - Z) + D\varphi_{3i} + \upsilon_t$$

(3)

The sign Δ denotes the difference operator; D_t is a vector of impulse response dummies that include policy changes such as the phased withdrawal of agricultural subsidies. The error correction term is obtained as residual from the long-run relationship in equation (1). Thus, the difference between the actual levels of output and its predicted value captures the long-run effect of agricultural output supply. Consequently, by construction equation (3) has both long-run and short-run components.

The specification in equation (3) relates change in output supply in period t to current and lagged values of output price and other supply determinants such as rainfall shock and relative price. The error correction term represents the short-run responses required to move output to its long-run equilibrium.

If the absolute value of the error term is less than unity, the adjustment process is said to be stable and Q_t adjusts to its long-run value. The closer the term is to unity, the faster the adjustment process (see Agenor, 2004). The *a priori* expectations of the sign of own price is positive, and negative for relative price and rainfall shock. It is also expected that the coefficients of the subsidy removal dummy could be either positive or negative.

5.4 **Data Issues**

Data on quantities and prices of agricultural commodity output were obtained from the Food and Agricultural Organization (FAO) Statistics database and the Ministry of Food and Agriculture, Ghana, respectively. The aggregate price and quantity indices were constructed using the Tornqvist formula, which is an approximation of the Divisia[19] index (see Theil, 1976). The Tornqvist index is written as:

$$\ln Q_t - \ln Q_{t-1} = \sum_i [(s_{it} + s_{it-1})(\ln x_{it} - \ln x_{it-1})]/2 \qquad (4)$$

where, $s_{it} = (p_{it} x_{it})/(\sum_i (p_{it} x_{it})$ (5)

Q_t is the quantity index at time *t*; x_t is the quantity of the i^{th} commodity at time *t*; P_{it} is the price of the i^{th} commodity at time *t*; and s_{it} is the value share of the i^{th} crop at time *t*. A similar approach is used in estimating the aggregate price indices. The period covered is 1970-2003, with 1970 as base year $((Q_{1970} = P_{1970} = 1)$. The quantity indices are expressed per capita (by dividing an index by the total population) and the price index is given in real terms using the agricultural Gross Domestic Product (AgGDP) deflator. The AgGDP deflator was calculated using Agricultural GDP data from the World Bank's World Development Indicators CD Rom. Commodities used in the construction of the aggregate agricultural commodity output index were: cocoa, coffee, maize, millet, sorghum and paddy rice. The rest of the commodities were cassava, yam and plantain. Whilst cocoa and coffee were considered as tradables, the rest of the commodities were grouped under non-tradables (food commodities). The price and quantity indices of the food commodities are denoted as P^f and Q^f. Export commodities price and quantity indices are represented as Q^x and P^x respectively, whilst aggregate quantity and price index are given by Q^a and P^a. The relative price between non-tradable and tradable commodities is denoted by P^f/P^x. An impulse response dummy that took on a value of 1 in the post-reform era and zero in all

[19] The Tornqvist-Theil discrete-time approximation of price and quantity indices has been found to be superior to the traditional Laspeyres approach (see Mackay *et al.*; Theil, 1936, 1976).

the periods was included in the model to account for the shift in agricultural commodity price policy over the study period.

In addition to output and price, rainfall shocks were also used as a regressor, since the country's agricultural commodity output is mostly dependent on rainfall. Rainfall shock (R_{Shock}) was defined as standard deviation of average annual precipitation; these were then converted into indices with 1970 as base year. The underlying rainfall data were obtained from Jefferson and O'Connell (2004).

Before pursuing the econometric analysis of the data described above, graphical analyses of the various underlying data series of the indices were undertaken. When per capita outputs of the nine commodities are considered, tradable commodities were found to have declined steadily in output since the 1970s. The only food commodity that follows a similar pattern is millet (see Appendix Figure 1). On the other hand, the other six commodities, after experiencing declines from the 1970s to the early 1980s, picked up again and seem to have recovered by the 1990s. Thus the modest increases in aggregate commodity output can be said to have been largely due to non-export commodity output increases (see Appendix Figure 3).

A look at the graph of real producer prices of food and export commodities suggests that for most of the study period real producer prices of food commodities have led export prices. Thus it can be argued that producers substitute food commodities for export commodities as the relative prices of the two commodity sets change. This phenomenon compares well with the situation in Tanzania, a country that also went through economic reforms as Ghana did (see Mackay *et al.*, 1999).

A plot of the relative producer price of food and export commodity prices further underscores the substitution of food for export commodities (see Appendix Figure 2). In sum, the graphical analysis provides evidence that producers in Ghana do respond to relative commodity prices. It can therefore be argued that the agricultural trade liberalization pursued as part of the economic reforms in the 1980s and 1990s was not able to stimulate export commodity output as envisaged. Trends in the rainfall shock indices suggest some co-movement with aggregate commodity output, food and export commodities (see Appendix Figure 4), thus indicating correlation between rainfall shocks and output.

5.5 **Results**

The empirical econometric approach begins with unit root tests to ascertain the level of integration (i.e. stationarity) of the various variables selected following the theoretical framework. A vector autoregresssion analysis (VAR) is then used to identify the long-run relationship between the various commodity groups and their respective prices. Error correction representations of the VARs are then estimated to obtain the short-run dynamics of commodity supply responses at the three levels of aggregation.

Unit Root Tests

A unit root test was conducted for the variables; P^f , P^x, P^a. P^f/P^x , Q^f, Q^x, Q^a as well as R_{Shock}. The null hypothesis that the series in levels contain a unit root (i.e. non-stationarity) was not rejected for all variables. However, when one differenced the series, the null hypothesis of a unit root was rejected. The unit root test was undertaken with the Augmented Dickey-Fuller (ADF) unit root test; the results of the test are presented in the Table 5-1. The results of the test indicate that all the series are integrated of the same order, i.e. I (1). Therefore cointegration tests can be undertaken to establish the existence or otherwise of long-run relationships between commodity output variables and their respective prices.

Table 5-1. Unit-root test results

Variable	T-Value[1]	Lag included[2]	Additional regressors
Levels			
Q^a	-2.686	3	Constant
Q^f	-1.543	2	None
Qx	-2.407	2	Constant
P^a	-1.710	2	None
P^f	-2.988	3	Constant, Trend
P^x	-2.833	3	Constant, Trend
P^f/P^x	-2.900	4	Constant
R_{Shock}	-0.985	0	None
First Differences			
Q^a	-7.971**		Constant
Q^f	-6.574**		Constant
Qx	-7.525**		Constant
P^a	-6.933**		Constant
P^f	-6.179**		Constant
P^x	-7.264**		Constant
P^f/P^x	-6.716**		Constant
R_{Shock}	-6.525**		None

Note: [1]The "T" value is the test statistic from the (augmented) Dickey-Fuller Test,
[2] Lag length was chosen as using the Akiake Information Criteria and F-Test assuming a maximum lag of four.
** denotes rejection of the null hypothesis of non-stationarity at the 1 percent level of significance.

Cointegration tests and long-run supply response

A vector of endogenous variables x_t integrated of order 1; I (1) can be tested for cointegration by estimating the VAR encompassing the endogenous variables. The Johansen cointegration analysis is performed on the unrestricted VAR using a maximum likelihood estimator (Johansen, 1988). The objective is to estimate the long-run matrix Γ, and subsequently determine its rank (the rank also indicates the number of cointegrating vectors in the VAR). The matrix Γ can then be factorized as $\Gamma = \alpha\beta'$. Whilst β is a matrix of cointegrating vectors, k, α is a matrix of factor loadings. A vector identification problem arises if $k \succ 1$, the problem is addressed by imposing restrictions on the parameters in the α and β matrices. It is only after the identification of the long-run vector that meaningful economic interpretation can be assigned to the relationship. The Johansen (1988a and 1988b) 1991) cointegration test evaluates the test results against the Trace statistic. The null hypothesis of the trace statistic tests whether the number of cointegrating vector(s) is less than k $(k \prec 0, k \prec 1, k \prec 2, ...)$ against the alternate of $k = 1$ (or $k = 2, k = 3, ...$).

Long-run relationships examined were: (1) aggregate commodity output, aggregate commodity prices and rainfall shocks; (2) aggregate export commodity, prices and rainfall shocks; and lastly (3) aggregate food commodity, aggregate food commodity prices and rainfall. The Johansen test conducted for the three systems (i.e. food, export and all commodities aggregates) indicated the existence of two long-run relationships in each system of VAR. In order to identify the unique cointegrating vector that represents the various long-run relationships, identifying restrictions were tested using the Likelihood ratio test of restrictions.

Table 5-2. **Johansen Cointegration Test**

Variables in the VARs	**Ho: rank≤=**	Trace Test (λ_{Trace})
Q^a, P^a, R_{Shock}	0	72.157**
	1	34.045**
Q^f, P^f, P^x	0	32.77**
	1	11.95**
Q^x, P^f/P^x	0	72.157**
	1	34.045**

Notes: * denote the rejection of null hypothesis at 5% level of significance and ** rejection at 1% level of significance.
Implementation of the cointegration test was undertaken with PCGive 10.

(i) All commodities

The results of the tests show that in the long-run aggregate commodity output is responsive to price and rainfall shock, and that output was inversely proportionally related to rainfall shocks. On the other hand, aggregate output's relationship with price related directly to price. The price elasticity of output supply was less than unity (i.e. 0.8); this estimate is considerably higher than the 0.30 obtained by Bond (1983).

(ii) Export commodities

Export commodity output was found to be unresponsive to own price, but responsive to relative price with an elasticity of 0.40. This observation corroborates the conclusion from the graphical analysis that export commodity supply response has not been as strong as that of food price over the years.

(iii) Food commodities

With regard to food commodities, own price and export price elasticities were found to offset each other. The implication is that a decrease in the producer price of export commodities has a similar effect as a proportional increase in food commodity price. The hypothesis that the coefficient of food price was not significantly different from the coefficient export price was not rejected. See Table 5-3 for the restrictions tested and the resultant long-run supply response model relationship obtained.

Table 5-3. Identified long-run relationships

Restricted cointegrated VAR	Likelihood ratio test of restrictions
$Q^a = 0.807P^a - R_{Shocks}$	$\hat{Ch}^2(1) = 0.16108$ [0.6882]
$Q^f = 0.758P^f - 0.75P^x$	$\hat{Ch}^2(2) = 1.193$ [0.2747]
$Q^x = -0.40P^f/P^x$	$\hat{Ch}^2(2) = 3.8312$[0.0503]

Short-run supply response models

The short-run supply response model for each of the commodity groups was formulated using the ECM representation of the long-run relationship (see equation 3). The general-to-specific approach (Hendry, 1995) was used in the modelling process to obtain the most suitable reduced form for each of the commodity supply response relationships. For instance, the appropriate lag length[20] for the estimation of the individual vector auto regressions (VAR) was undertaken with the aid of the Schwartz and Akaike Information Criteria as well as F-tests. Again, variables that were found insignificant in the contributions to the overall significance of the individual models were dropped based on their F-statistics. A general observation about the short-run estimation was that simpler models were found more appropriate considering the diagnostic test results obtained.

(i) All commodities

Even though in the long run producers are responsive to price incentives, they were not responsive in the short run. Rainfall shocks and past output levels were found to be more significant in driving output levels in the short run than any other factor. The negative effect of past output levels may be due to the poor nature of the marketing infrastructure as it is unable to support high output levels. Rather it tends to depress prices. On the adjustment to long-run equilibrium, this was found to be very slow; less than 10 percent of the disequilibrium was corrected in a given year (see Table 5-4).

Table 5-4. Error correction model for *Aggregate Commodity Output*, 1970-2003

Variables	Coefficient	Std. Error	T-Value	T-Prob.
ΔQ^a_{t-1}	-0.416	0.181	-2.30	0.03
ΔP^a	-0.071	0.047	-1.52	0.14

[20] For the sake of brevity the results are not presented in the paper.

$ECMQ^a$	-0.017	0.008	-2.06	0.09
$\Delta Rshocks$	-0.280	0.124	-2.24	0.03

R^2 = 0.61 | ARCH 1-1 test: F(1, 23) = 0.1096 [0.7436]
F(4, 25) = 9.939[0.000]** | Normality test: Chi ^2 (2) = 4.4636 [0.1073]
DW = 2.42 | RESET test: F(1, 24) = 0.002 [0.964]

(ii) Export commodities

Export commodity responsiveness to own price in the short-run was 0.30. The cross-price elasticity (due to food price) was less than proportionate (-0.11), indicating that in the short run an increase in the producer price of food commodities is not strong enough to cause export commodity producers to switch to food commodities. However, the proportion of long-run disequilibrium that was corrected in a year was low (see Table 5-5). The negative coefficient on the lagged quantity is consistent with the downward trend in export commodity output pointed out in the graphical analysis.

Table 5-5. Error correction model for food commodity output,

Variables	Coefficient	Std. Error	T-Value	T-Prob.
ΔP^f	0.249	0.145	1.72	0.099
ΔP^f_{t-1}	0.159	0.135	1.18	0.249
$\Delta Rshocks_{t-1}$	-1.049	0.264	-3.97	0.001
$ECMQ^f$	-0.526	0.005	-6.62	0.005

R^2 = 0.53 | ARCH 1-1 test: F(1, 23) = 0.014[0.9034]
F(4, 25) = 7.192 [0.001]** | Normality test: Chi ^2 (2) = 0.5682[0.7527]
DW = 2.28 | RESET test: F(1, 24) = 0.32734[0.5725]

(iii) Food commodities

Short-run price elasticity for food commodities was estimated at 0.24. Unlike the other commodity aggregates, disequilibrium in long-run food supply was corrected faster. The coefficient of the error correction mechanism was estimated at 0.53. This means that 53 percent of disequilibrium in food commodity output supply is corrected in a given year. The relatively fast rate of equilibrium restoration may be due to the relatively short gestation period of most food commodities. Rainfall shocks were also found to be a major determinant of short-run output supply. The relationship between output and rainfall shocks was inversely proportional, thus further underscoring the vulnerability of food output to rainfall outcomes (see Table 5-6).

Table 5-6. Error correction model for *Export Commodity Output*, 1970-2003

Variables	Coefficient	Std. Error	T-Value	T-Prob.
ΔQ^{x}_{t-1}	-0.416	0.181	-2.30	0.030
ΔP^{x}_{t-1}	-0.071	0.047	-1.52	0.140
ΔP^{f}	-0.118	0.058	-2.02	0.055
$ECMQ^{x}_{t-1}$	-0.033	0.005	-6.62	0.005
R^2 = 0.66		ARCH 1-1 test: F(1, 23) = 0.7156 [0.4063]		
F(5, 25) = 9.83 [0.000]**		Normality test: Chi ^2 (2) = 0.0156 [0.9922]		
DW = 2.11		RESET test: F(1, 24) = 0.04509 [0.8336]		

5.6 Conclusions

Though Ghana has made considerable progress in economic reform following the Bank and Fund-supported Economic Reform Programme initiated in April 1983, weaknesses in certain sectors of the economy still persist. One of these sectors is agriculture, where growth has been less than satisfactory. The slow growth of agriculture as demonstrated by the steady fall in real per capita export output and the marginal increases in aggregate output indicate the existence of structural constraints in the sector that need to be addressed. This paper sought to estimate price elasticity of supply for three commodity aggregates, namely food, export and all commodities. In examining whether producers do respond to price incentives, vector autoregresssion and error correction modelling were used to estimate the long- and short-run responses of commodity aggregates to price.

The key finding was that producers were rational and hence responded to price. Like Mackay *et al.* (1999), we obtained relatively higher supply response estimates compared to previous studies on Sub-Saharan Africa and Ghana. For instance, Bond (1983) estimated short- and long-run aggregate supply response for Ghana as 0.20 and 0.3 respectively. In the present paper, however, aggregate commodity supply was found unresponsive to price in the short run but responsive in the long run, with price elasticity of supply at 0.8. Absence of significant short-run response does not necessarily suggest that producers are unresponsive to price in the short run. Rather it can be inferred that other non-price incentives may be hindering translation of price incentives to increased output supply. For instance, both the graphical analysis and econometric estimates show falling trends in per capita export commodity output over the years despite the reforms. To reverse the falling trend in export commodity output and to stimulate increased aggregate commodity supply, non-price incentives need to be provided. For example, the weak commodity marketing infrastructure and high transaction costs in commodity production, when addressed, can together help stimulate increased output significantly.

List of References

Abdulai, A. & Reider, P., 1995. The impacts of agricultural price policy on cocoa supply in Ghana: an error correction estimation. *Journal of African Economies* 4 (3) p.315 – 35.

Agenor, P-R.,, 2004. The economics of adjustment and growth. 2nd Ed. Cambridge, Massachusettes, and London: Harvard University Press.

Bond, M., 1983. Agricultural responses to prices in Sub- Saharan Africa: *International Monetary Fund Staff Papers,* 30 (4), p.703 – 26.

Chhibber, A., 1989. The aggregate agricultural response: a survey. In S. Commander (ed) *Structural Adjustment and Agriculture*. London: ODI

Colman, D., 1983. A Review of the arts of supply response analysis. *Review of Marketing and agricultural economics,* 51(3), p.201 – 30.

Coeyman, J. E & Mundlak, Y., (1993). Sectoral growth in Chile, 1962-82. IFPRI Research Report. Washington, D.C.: International Food Research Institute.

FAO. (2006). FAOSTAT [Online]. Available at http://faostat.fao.org/faostat. last [accessed February 2006]

Griliches, Z., 1959. The demand for inputs in agriculture and derived supply elasticity. *Journal of Farm Economics*, 40, p.309-322.

Hallam, D. & Zanoli, R., 1993. Error correction models of agricultural supply response. .*European Review of Agricultural Economics* 2, p.111-20.

Hendry, D. F.,1995. Dynamic econometrics: advanced text in economic reform. Oxford: Oxford University Press.

Jefferson, P. & O'Connell, S., 2004. *Drought and rainfall data*. Available at: http://www.acad.swarthmore.edu/rain-econ/framesets/homepage.htm [Accessed on 25, May 2006]

Johansen S., 1988b. .Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control* 12, p.231-254.

Johansen, S., 1988a. .The mathematical structure of error correction models. *Contemporary Mathematics* 12, p. 359-386.

Mackay, A., O. Morrissey & Valliant, C., 1999. Aggregate agricultural supply response in Tanzania agriculture. *Journal of International Trade and Economic Development* 8, p.107-123.

Nerlove, M., 1979. The Dynamics of supply: retrospect and prospect. *American journal of Agricultural Economics*, 61 (5), p.874-88.

Nickel, S., 1995. Error correction, partial adjustment and all that: an expository note. *Oxford Bulletin of Economics and Statistics*. 47(2), p.119-29.

Petersen, W., 1979. International farm prices and the social cost of cheap food policies. *American Journal of Agricultural Economics*, 61 (12), p.12-21.

Rao, J.M., 1989. Agricultural supply response: a survey. *Agricultural Economics*, 3, p.1-22.

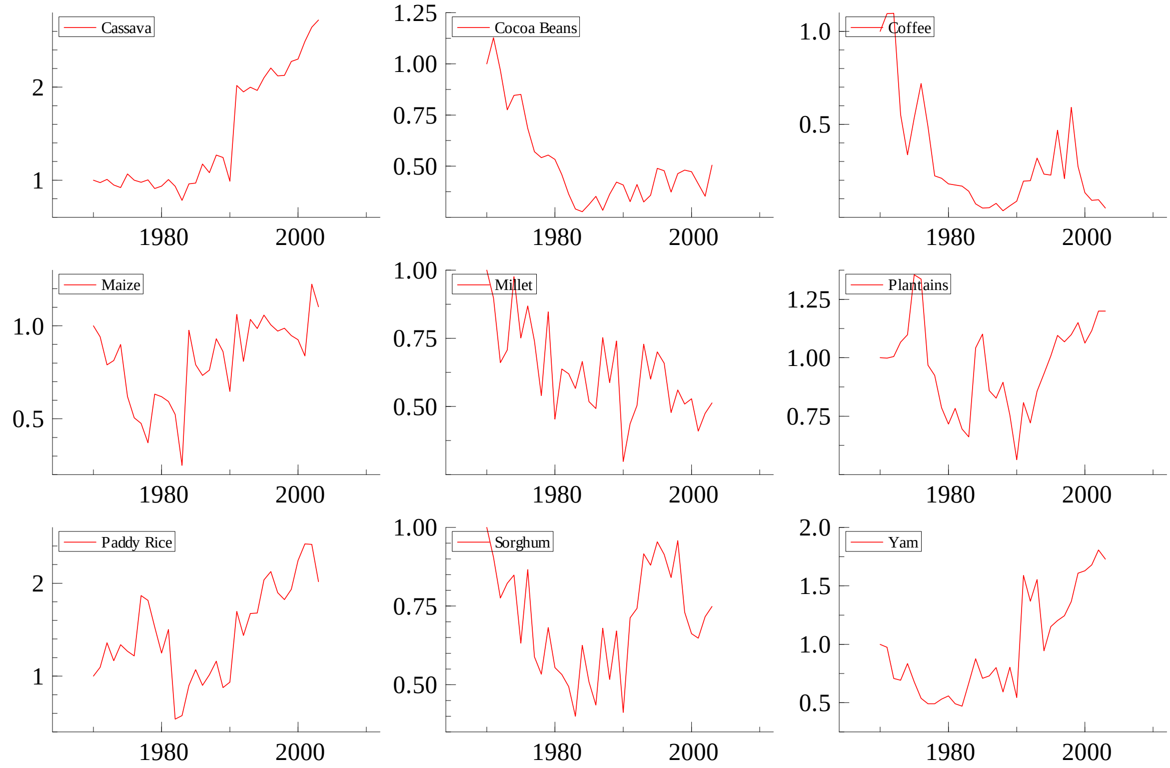
Sadoulet, E. & de Janvry, A., 1995. *Quantitative development policy analysis*, The Baltimore: Johns Hopkins University Press.

Tabatabai, H., 1986. Economic decline, access to food and structural adjustment in Ghana. *World Employment Programme Research Working Paper*, WEP 10-6/WP 80. Geneva: International Labour Organisation.

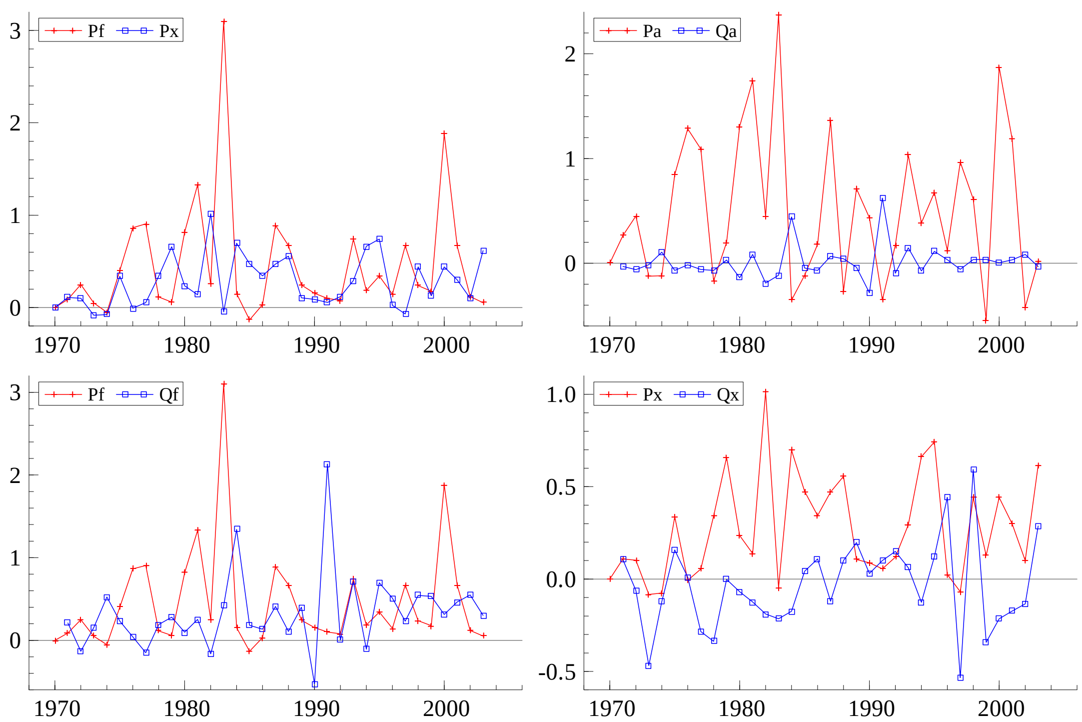
Theil, R., 2002. Price incentives, non-price factors and agricultural production in Sub-Saharan Africa: a cointegration analysis. Kiel Institute for World Economics. Working Paper No. 1112.

Theil, R., 2000. Estimating the aggregate agricultural supply response: a survey of techniques and results for developing countries. Kiel Institute for World Economics. Working Paper No. 1016.

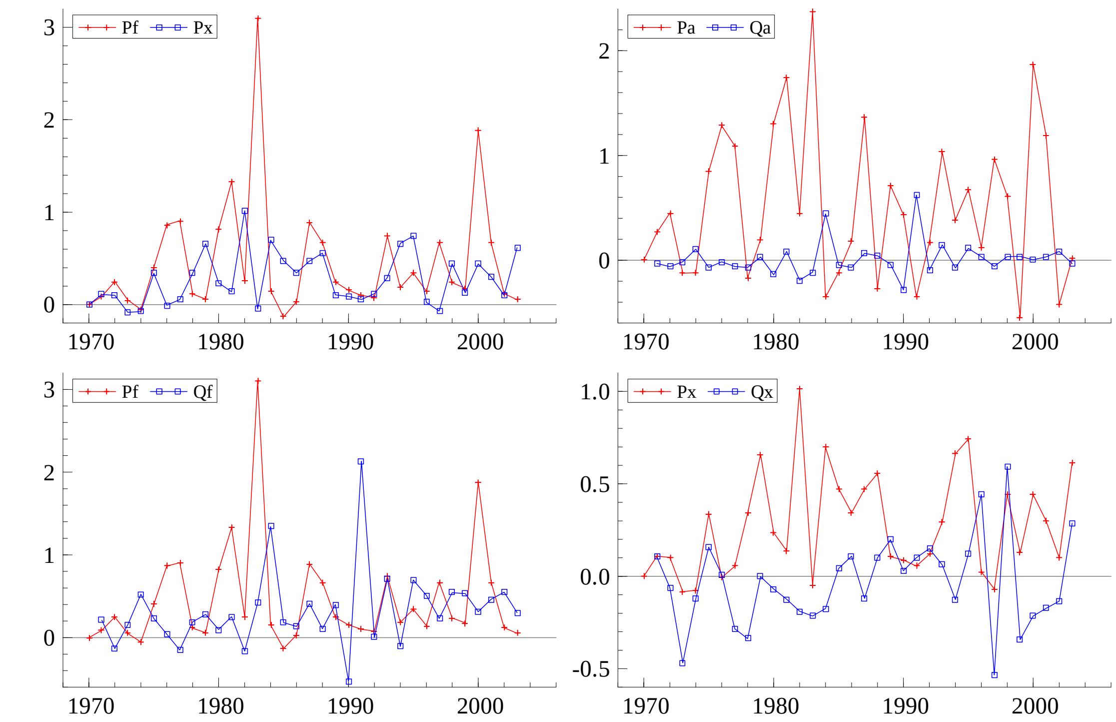
Appendix Figure 1: Per capita output of selected agricultural commodities in Ghana, 1970-2003



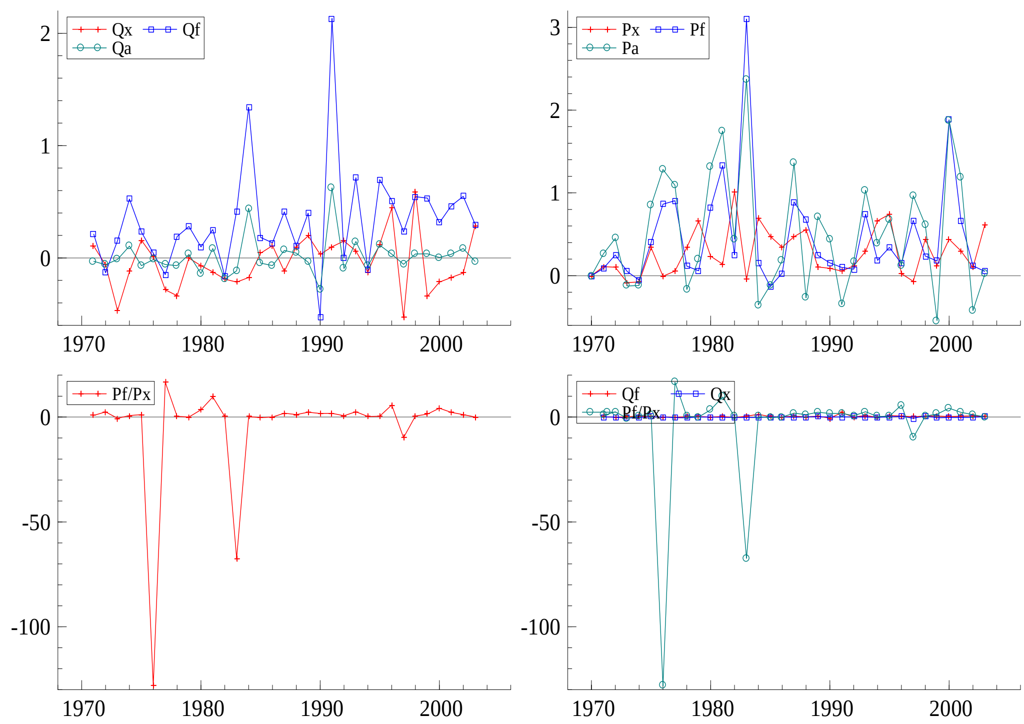
Appendix Figure 2: Trends in real commodity price and per capita output indices, 1970-2003



Appendix Table 3. Trends in real commodity price and per capita output indices, 1970-2003



Appendix Table 4 Aggregate per capita output and aggregate real price indices, 1970-2003



CHAPTER SIX

6 VOLATILITY FORECASTING IN COMMODITY MARKETS

6.1 Introduction

Commodity prices have been one of the most volatile international asset prices. Kroner *et al.* (1993) argue that failed attempts at forecasting commodity prices can be attributed in part to their relatively high volatility. However, most commodity price forecasts have not dealt with the issue of volatility adequately. In order to address price forecast failures, forecasts have sometimes been generated within given confidence intervals. Confidence intervals are then described with their associated probabilities to reduce ex-post forecast errors. As discussed in Kroner *et al* (1993), these confidence intervals are estimated on the assumption that volatility does not change over time. However, there are papers that show the existence of volatility changes in commodity prices. For instance, Ocran & Biekpe (2005) indicate that nine out of eighteen commodities of importance to Sub-Saharan African economies experienced significant changes in volatility over the past four decades. Given the crucial role that commodities play in the economies of Sub-Saharan Africa, understanding volatility forecasting can be very helpful in economic decision-making. Poon & Granger (2003) discuss in detail why forecasting volatility is critical in various spheres of influence of international asset prices as well as in monetary policy.

The purpose of this paper therefore is to examine the forecasting accuracy of seven volatility forecasting models using weekly prices in eighteen commodity markets. Earlier studies examined volatility forecasting using market expectations (Taylor, 1986; Kroner *et al.*, 1995; Fleming *et al.*, 2000; Martiens and Zein, 2002; Szakmary *et al.*, 2002). Thus far no empirical work has examined the efficiency of volatility forecasting models for commodity markets considering a wide range of time-series models, though such work has been done for stock.

Forecasting models evaluated include both linear and non-linear models and competing models are evaluated with the aid of standard (symmetric) loss functions. The range[21] of commodities selected makes it possible to answer the question as to whether different commodities show a similar or different forecasting ability. The study also addresses the concerns raised in Leamer (1983) and Mackinlay (1990) that investigating alternate data samples (i.e. across markets or time) provides reliable out-of-sample robustness check.

To the extent that most SSA countries depend on commodities for the greater part of their export earnings, an improved understanding of future volatility outcomes can be useful in managing risk associated with export earnings. Again, results of the study would prove valuable to risk managers who rely on measures of volatility for assessing commodity price risk in order to develop risk-management strategies. The rest of the paper is structured as follows: section 2 briefly reviews selected studies on volatility forecasting and section 3 discusses data issues. The methodology is outlined in section 4, whilst empirical results and forecast evaluations are given in section 5. The conclusions of the study are presented in section 6.

6.2 **Literature Review**

In a comprehensive review by Poon & Granger (2003) they examine ninety-three published and unpublished papers that evaluate volatility forecasting models of financial

[21] Commodities studied include agricultural raw materials, industrial and precious metals as well as food commodities.

market assets. The questions that Poon & Granger (ibid) address are whether volatility forecasting as a procedure was implementable. The other research question addressed is determination of the relative efficiency of the range of volatility forecasting models in the literature. The paper identified four main types of models for volatility forecasting. These were historical,[22] the ARCH family of models, implied volatility[23] and stochastic volatility forecasts (see Poon & Granger (2003) for detailed descriptions of the various model types). The range of assets covered in the volatility forecasting literature was mostly stocks, bonds and foreign exchange. Futures options underlying market indices and returns of various asset markets have also attracted a lot of research attention. However, commodity spot and futures option volatility forecasting do not appear to have attracted much attention. Of the ninety-three studies reviewed by Poon & Granger (ibid), only five consider commodities.

Empirical work on volatility forecasting can also be grouped based on the nature of the information used. One of these uses market expectations derived from option pricing models, whereas the other uses time-series modelling. In addition to the two main methods, there is also a strand of literature that uses a parametric approach. However, researchers have argued that parametric methods perform poorly (Pagan & Schwert, 1990), hence they are left out of the present review. Following the mainstream literature on financial markets, neural network-based models, genetic programming and time change and duration approaches are also ignored (cf. e.g. Engle & Russel, 1998; Kroner *et al.*, 1993).

[22] This class of models included random walk and historical averages of squared returns. Also included in the historical volatility models are time-series models that use moving averages, exponential weights and autoregresssion models.
[23] These are related to models that estimate volatility using the Black-Scholes (1973) model and other assumptions. The approach uses implied standard deviations of option prices.

Literature on volatility forecasting of financial market assets usually examines whether implied[24] volatility predicts realised volatility underlying futures better and, if so, whether this is done efficiently (see Latane & Rendlemen, 1976). Studies on implied volatility and realised volatility are not decisive about the relative importance of implied volatility as against realised volatility. The strand of literature that disagrees with the use of implied volatility claims that implied volatility has no correlation with realised volatility (see Canina & Figlewski, 1993; Day & Lewis, 1992; and Lamoureux & Lastrapes, 1993). For instance, Canina & Figlewski (1993) assert that options markets do not necessarily process market information efficiently; consequently volatility forecasts using option price were flawed. Christensen & Prabhala (1998) conclude with a set of results that is opposed to the conclusions of Canina & Figlewski (1993). Other papers, such as that by Jorion (1995), suggests that implied volatility is efficient in predicting return volatility of foreign exchange futures; however, the author concedes that estimated implied volatility forecasts are biased.

Day & Lewis (1993) evaluated volatility forecasting models of crude oil futures and options. The models in order of merit ranking based on efficiency were: implied historical, GARCH-M and EGARCH. The study used daily data covering November to March 1991. Using an exponential weighted variance-covariance matrix, Fleming *et al.* (2000) forecast volatility of the Standard and Poor's 500 Index Futures (S&P 500), T-bond and gold futures. Among the conclusions of the authors was that an equally weighted bill portfolio was effective in forecasting volatility and risk premia of assets of varying maturities. In another study on commodities (Kroner *et al.*, 1995), the authors examined the futures options on cotton, corn, cocoa, wheat, sugar, silver and gold. The paper compares the volatility forecasting abilities of seven models. Three of these were tested

[24] Thus the volatility component of the Black-Scholes (1973) option pricing formula.

using derived volatilities, two using historical volatility, whilst the last model combined both derived volatility and realised volatility in the forecasting exercise. Kroner *et al.* (1993) suggest that when different forecasting models were combined they tend to predict commodity price volatility better than the various individual forecasting models. Martiens &Zien (2002) evaluated the efficiency of implied volatility, log ARFIMA and GARCH models in forecasting volatility in Standard and Poor's 500 Index Futures (S&P 500), the yen/dollar exchange rate futures and crude oil futures. Like most studies that attempt to forecast volatility using futures options, the authors identified implied volatility models as the most efficient. Using data from futures options from various exchanges, Szarkmary *et al.* (2003) compared implied volatility models based on option prices. The authors studied financial asset prices across various financial asset markets. These included commodities, interest rates, foreign exchange and futures options on S&P 500. Szarkmary *et al.* (2003) concluded that generally implied volatility outperform models based on realised volatility.

Thus far the paper by Kroner *et al.* (1993) is the only one to have examined volatility forecasting models within the framework of time-series analysis; however, the authors did not explore a broader range of time-series models as they considered only GARCH and historical forecast models. However, the authors came to a conclusion that suggests that combined volatility forecasting models are superior to either the time-series or GARCH model evaluated. Poon & Granger (2003) contradict this result by arguing that combinations of forecasts rather suggest mixed results. One contribution of this paper is that a broader spectrum of time-series models from the existing literature on volatility forecasting is examined.

6.3 Data Issues

Monthly spot prices for eighteen commodities traded by most Sub-Saharan African countries covering the period 1980(1) and 2006(5) were used. The commodities examined are: gold, aluminium, copper, iron, crude oil, rubber, cotton and timber. The rest were cocoa, coffee, tea, sugar, groundnut, groundnut oil, palm oil, sisal and tobacco. All data series were obtained from IMF (2005). See Appendix Table for description of the individual series.

According to the literature on volatility forecasting, volatility may be defined as the standard deviation of returns over a given forecast horizon (Kroner *et al.*, 1993). Following the literature, the series used in the present work were obtained by estimating the square root of average monthly returns over the forecast horizon. The estimated volatility series are termed as 'actual' as they are used to represent actual volatility over the period under consideration. Thus the actual monthly volatility is defined as the within-month standard deviation of commodity spot market prices.

6.4 Methodology

This section of the paper summarises seven models identified for volatility forecasting. Since all the forecasting models are standard in the literature, they are discussed only briefly. Models used for the forecasts are: random walk, simple regression (i.e. autoregresssion model), ARCH, GARCH, GJR-GARCH, E-GARCH and PGARCH.

The approach adopted for forecasting involves first obtaining parameters of selected models using first half of the data and then applying the estimates to the second half of the data for out-of-sample forecasts.

6.4.1 Random Walk (RW) Model

The thrust of this model is that the best forecast of this month's volatility is volatility observed in previous month. The model is formally written as:

$$\hat{\sigma}_{F,m}(RW) = \hat{\sigma}_{m-1} \qquad (1)$$

where $\hat{\sigma}^2_{F,m}$ is monthly volatility forecast for month *m* and $\hat{\sigma}_{m-1}$ actual volatility for previous month.

6.4.2 Simple Regression (SREG)

A simple autoregresssion procedure is used as a forecasting tool following Brailsford and Faff, 1996, and Balaban *et al.* (2003). Monthly volatility is regressed on its lagged values over the sample period: *m = 1………124*. The model is represented as:

$$\sigma_{\alpha,m} = \kappa + \beta\sigma_{\alpha,m-1} + \delta_{m-1} \qquad (2)$$

With the aid of the estimated regression parameters, the forecast for the first month of forecast period is constructed (*m*=124):

$$\sigma_{f,m} = \gamma + \beta\sigma_{a,m-1} \qquad (3)$$

The regression is updated monthly with a rolling sample of 125 observations. Thus for each commodity the estimation involves 125 regressions in order to obtain out-of-sample forecasts of monthly volatility.

6.4.3 ARCH Model

Changes in variance in price behaviour of financial assets are very important in predicting prices on financial markets, including commodity markets. However, unlike the ARCH family of models, other volatility models tend to assume constant variance, hence a range of ARCH type of models are examined to assess their usefulness in forecasting volatility in commodity prices. The simplest form, standard ARCH (1), in which conditional mean function is considered as first-order autoregresssion (Engle, 1982) and is given as:

$$R_t = c + \rho R_{t-1} + \varepsilon_t \qquad (4)$$

whilst the conditional variance is defined as:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 \qquad (5)$$

The monthly forecast errors (ε_t) are assumed to be conditionally normally distributed with mean zero and variance h_t, with information set γ at t-1. Like the simple regression model, SREG, the ARCH model is routinely updated using monthly returns in the mean and variance functions.

6.4.4 GARCH Model

The GARCH model's attractiveness for forecasting financial time series is well documented in the literature (Harris & Solis, 2003). The model estimates conditional mean and conditional variance jointly. Studies have suggested that adequacy of GARCH (1, 1) as against higher-order GARCH (p,q) models, hence the focus on GARCH (1,1) (see Akjiray, 1989; Lamourex and Lastrapes, 1990). The essence of the model is that volatility in time t depends on volatility in time t-1 and the squared forecast error of time t-1:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta h_{t-1} \qquad (6)$$

6.4.5 GJR-GARCH

Glosten, Jagannathan and Runkle (1993) modify the GARCH model to address asymmetric problem[25] in conditional volatility due to the leverage effect. Another reason for the perceived asymmetry in volatility is due to the relationship between information

[25] One stylised fact about financial market returns suggests a negative correlation between past returns and future volatility (see Bouchard and Porters, 2001); this is termed the leverage effect.

arrival and volatility (see Campell & Hentschel, 1992). The Glosten modification of GARCH (GJR-GARCH) introduces a dummy variable, *D,* which takes on the value of one if $\varepsilon_{t-1} \prec 0$ and zero if $\varepsilon_{t-1} \succ 0$. The model is given as:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \varepsilon_{t-1}^2 D_{t-1} + \beta h_{t-1} \quad (7)$$

6.4.6 EGARCH

Another variation of the standard GARCH aimed at addressing problem of asymmetry in financial asset price behaviour is the exponential GARCH by Nelson (1991). Unlike GJR-GARCH, EGARCH does not require restrictions on the coefficients of the residual terms. Since the model is about the natural log of h_t; variance of h_t can only be positive no matter the sign of the other coefficients in the model. Following Balaban *et al.* (2003), the simplest form of the model, EGARCH (1, 1) is used:

$$\ell n h_t = \alpha_0 + \gamma\left(\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right) + \lambda\left((\frac{|\varepsilon_{t-1}|}{\sqrt{h_{t-1}}}) - \sqrt{\tfrac{2}{\pi}} \right) + \beta \ell n h_{t-1} \quad (8)$$

6.4.7 P-GARCH

The standard deviation of the GARCH model – known as Power GARCH (PGARCH) – was introduced by Taylor (1986) and Schwert (1989). In PGARCH the standard deviation is rather modelled as against modelling of variance in most of the ARCH-family of models. Din *et al.* (1993) generalised the Power GARCH specification. In Power GARCH an optional parameter γ can be added to account for asymmetry in modelling up to order r. The model also affords one the opportunity to estimate the power parameter δ instead of imposing it on the model. PGARCH can be represented as follows:

$$\sigma_t^{\delta} = w + \sum_{i=1}^{p} \alpha_i \left(|\varepsilon_{t-i}| - \gamma \varepsilon_{t-i} \right)^{\delta} \quad (9)$$

where, $\delta \succ 0$, $|\gamma_i| \leq 1$ for all $i, \ldots\ldots\ldots r$

$\gamma_i = 0$ for all $i \succ r$, and $r \succ p$

In symmetric PGARCH $\gamma_i = 0$ for all *i***.** It is also interesting to note that PGARCH model becomes standard GARCH when $\delta = 2$ and $\gamma_i = 0$ for all *i.*

6.5 Empirical Results and Forecast Evaluation

6.5.1 Out-of-sample forecast results

Following the literature on volatility forecasting, the popular loss functions or error statistics are used in measuring the performance of the various models examined (see Pindyck & Rubbenfield, 1991; Brailsford & Faff, 1991 and Balaban *et al.*, 2004). The error statistics used are: Root Mean Squared Error, RMSE; Mean Absolute Error, MAE; Mean Absolute Percentage Error, MAPE and the Theil Inequality Coefficient, TIC. The statistics are defined as:

$$RMSE = \tfrac{1}{12} \sum_{m=125}^{249} \sigma_{f,m} - \sigma_{a,m} \qquad (10)$$

$$MAE = \tfrac{1}{124} \sum_{m=125}^{249} \left| \sigma_{f,m} - \sigma_{a,m} \right| \qquad (11)$$

$$MAPE = 100 \times \tfrac{1}{124} \sum_{m=125}^{249} \left| \sigma^2_{f,m} - \sigma^2_{a,m} \right| / \sigma_{a,m} \qquad (12)$$

$$TIC = \sqrt{\sum_{m=125}^{249} (\sigma_{f,m} - \sigma_{a,m})} \Big/ \sqrt{\sum_{m=125}^{249} \sigma^2_{f,m}} + \sqrt{\sum_{m=125}^{249} \sigma^2_{a,m}} \qquad (13)$$

In the equations above, $\sigma_{f,m}$ denotes volatility forecast for month m, whilst $\sigma_{a,m}$ signifies actual volatility in month m. Forecast errors represented by equations 10 and 11 are determined largely by the scale of the dependent variable; they are therefore useful as relative measures for comparing forecasts for the same series across different models. Smaller forecasting error statistics indicate superior forecasting ability of a given model. MAPE and TIC, on the other hand, are scale invariant. Theil inequality coefficient lies between zero and one, with zero denoting perfect fit.

For each of the error statistics a standardized (relative) error statistic is also computed following Balaban *et al.*, 2004. The worst performing model for each commodity volatility forecast is used as benchmark. The advantage of benchmarking is that it makes error statistics readily interpretable. Tables 6-1, 6-2, 6-3 and 6-4 shows actual and relative volatility forecast error statistics across the four volatility forecast error measures. Discussion of the findings of the study would therefore be conducted along individual error statistics after which conclusions shall be drawn regarding the efficacy of individual models based on their ranking.

6.5.2 Root Mean Squared Error, RMSE

Considering the RMSE statistics, it is found that the autoregressive model of order two, AR (2) and the random walk models were virtually at par. They both outperform the whole range of models evaluated on nine out of the eighteen commodities examined. Among the ARCH-type of models ARCH (1) and EGARCH (1, 1) perform better than the others. The worse performer was, however, GARCH (1, 1). See Tables 6-1

Table 6-1. Root Mean Squared Error statistic

	Tea		**Cocoa**		**Coffee**		**Sugar**		**Groundnut**		**Groundnut oil**	
Model	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
Random walk	0.11072	0.30277	0.12008	0.25282	0.07922	0.09757	0.03035	0.22846	0.71143	**1.00000**	0.07999	0.18296
AR(2)	0.11286	0.30861	0.12015	0.25298	0.07122	0.08773	0.02956	0.22250	0.06429	0.09037	0.07998	0.18295
ARCH(1)	0.28336	0.77483	0.46381	0.97653	0.78805	0.97070	0.12595	0.94802	0.20901	0.29379	0.42517	0.97251
GARCH(1,1)	0.26579	0.72680	0.46837	0.98613	0.78499	0.96692	0.13285	**1.00000**	0.21090	0.29644	0.42506	0.97227
EGARCH(1,1)	0.26005	0.71109	0.47326	0.99643	0.63747	0.78521	0.12290	0.92507	0.27828	0.39116	0.42560	0.97350
GJR-GARCH(1,1)	0.26538	0.72567	0.47496	**1.00000**	0.78131	0.96239	0.13021	0.98012	0.23461	0.32978	0.41102	0.94014
PGARCH(1,1)	0.36570	**1.00000**	0.47182	0.99339	0.81184	**1.00000**	0.12636	0.95110	0.21546	0.30285	0.43719	**1.00000**

Continuation of Table 6-1

	Cotton		**Sisal**		**Palmoil**		**Rubber**		**Shrimp**		**Tobacco**	
Model	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
Random walk	0.04933	0.20402	0.06111	0.09165	0.01149	0.01845	0.04954	0.14708	0.04385	0.37740	0.03468	0.08638
AR(2)	0.04431	0.18326	0.06279	0.09416	0.11231	0.18031	0.05777	0.17151	0.04353	0.37471	0.03781	0.09417

ARCH(1)	0.22692	0.93847	0.65575	0.98347	0.57085	0.91647	0.33530	0.99544	0.11576	0.99643	0.37379	0.93100
GARCH(1,1)	0.23444	0.96959	0.66578	0.99852	0.57739	0.92697	0.33663	0.99940	0.11533	0.99275	0.40149	**1.00000**
EGARCH(1,1)	0.24179	**1.00000**	0.60540	0.90796	0.58199	0.93435	0.33350	0.99011	0.11663	1.00386	0.31204	0.77721
GJR-GARCH(1,1)	0.23696	0.98001	0.66677	**1.00000**	0.57609	0.92488	0.33683	**1.00000**	0.11570	0.99591	0.30996	0.77201
PGARCH(1,1)	0.23738	0.98176	0.62842	0.94248	0.62288	**1.00000**	0.33566	0.99653	0.11618	**1.00000**	0.36765	0.91570

Continuation of Table 6-1

	Crude oil		Timber		Aluminum		Iron ore		Copper		Gold	
Model	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
Random walk	0.07259	0.19848	0.05782	0.18793	0.07370	0.14112	0.04986	0.19201	0.10830	0.16382	0.05034	0.15205
AR(2)	0.07998	0.21871	0.05045	0.16397	0.07326	0.14028	0.04985	0.19199	0.10349	0.15654	0.05046	0.15241
ARCH(1)	0.36136	0.98812	0.28318	0.92035	0.52221	0.99995	0.25950	0.99944	0.65928	0.99726	0.33109	**1.00000**
GARCH(1,1)	0.36471	0.99728	0.29037	0.94370	0.52087	0.99738	0.25965	**1.00000**	0.65467	0.99028	0.32958	0.99545
EGARCH(1,1)	0.36533	0.99899	0.28743	0.93416	0.39331	0.75313	0.25880	0.99674	0.65715	0.99404	0.33322	1.00646
GJR-GARCH(1,1)	0.27901	0.76293	0.29124	0.94652	0.52223	**1.00000**	0.25618	0.98663	0.66110	**1.00000**	0.32393	0.97837
PGARCH(1,1)	0.36570	**1.00000**	0.30769	**1.00000**	0.38987	0.74654	0.22970	0.88464	0.62695	0.94836	0.32504	0.98173

6.5.3 Mean Absolute Error, MAE

The autoregressive model, AR (2), clearly dominates as the best when the models' performances are evaluated using the mean absolute error statistic. The model occupies top rank for twelve commodities, whilst random walk takes first position for the remaining six commodities. The AR (2) outperforms all the other models predicting price volatilities in metal (aluminium, iron, copper and gold) as well as price volatility for food commodities. However, for the random walk model no clear pattern regarding particular commodity groups could be established. See Table 6-2.

Table 6-2 Mean Absolute Error statistic

	Tea		Cocoa		Coffee		Sugar		Groundnut		Groundnut oil	
Model	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
Random walk	0.08465	0.38173	0.09135	0.22280	0.05526	0.07893	0.02445	0.21248	0.05110	0.21773	0.04803	0.13211
AR(2)	0.08761	0.39508	0.09003	0.21957	0.05625	0.08034	0.02410	0.20939	0.04726	0.20135	0.04320	0.11884
ARCH(1)	0.22176	**1.00000**	0.39255	0.95739	0.67576	0.96520	0.10768	0.93561	0.16555	0.70536	0.35746	0.98328
GARCH(1,1)	0.20567	0.92746	0.39745	0.96933	0.67114	0.95859	0.11509	**1.00000**	0.16805	0.71601	0.35739	0.98308
EGARCH(1,1)	0.20068	0.90494	0.40694	0.99248	0.52031	0.74317	0.10683	0.92828	0.23470	**1.00000**	0.35499	0.97648
GJR-GARCH(1,1)	0.20530	0.92581	0.41002	**1.00000**	0.66718	0.95294	0.11258	0.97819	0.19083	0.81306	0.34727	0.95525
PGARCH(1,1)	0.20894	0.94222	0.40418	0.98575	0.70013	**1.00000**	0.10968	0.95304	0.17205	0.73306	0.36354	**1.00000**

Continuation of Table 6-2

	Cotton		Sisal		Palm oil		Rubber		Shrimp		Tobacco	
Model	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
Random walk	0.03828	0.18525	0.03534	0.05640	0.09125	0.17121	0.03548	0.12251	0.03561	0.34826	0.02831	0.07926
AR(2)	0.03398	0.16444	0.03622	0.05781	0.08924	0.16744	0.04419	0.15258	0.03527	0.34492	0.02977	0.08336
ARCH(1)	0.19034	0.92105	0.61485	0.98126	0.48647	0.91274	0.28907	0.99818	0.10165	0.99405	0.32023	0.89657
GARCH(1,1)	0.20006	0.96810	0.62554	0.99832	0.49201	0.92314	0.28951	0.99970	0.10134	0.99101	0.35717	**1.00000**
EGARCH(1,1)	0.20665	**1.00000**	0.56084	0.89507	0.49770	0.93383	0.28869	0.99684	0.10225	**1.00000**	0.25714	0.71993

GJR-GARCH(1,1)	0.20244	0.97961	0.62659	**1.00000**	0.49091	0.92107	0.28960	**1.00000**	0.10161	0.99365	0.25517	0.71441
PGARCH(1,1)	0.20282	0.98147	0.58561	0.93460	0.53297	**1.00000**	0.28919	0.99860	0.10192	0.99677	0.31333	0.87724

Continuation of Table 6-2

	Crude oil		Timber		Aluminum		Iron ore		Copper		Gold	
Model	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
Random walk	0.05830	0.21018	0.04258	0.11710	0.06027	0.12855	0.01039	0.06247	0.08515	0.14171	0.03941	0.05653
AR(2)	0.06147	0.22159	0.03971	0.10920	0.05986	0.12767	0.01034	0.06217	0.07937	0.13208	0.03902	0.05597
ARCH(1)	0.27354	0.98614	0.22822	0.62765	0.46882	0.99994	0.16611	0.99864	0.59941	0.99754	0.2737	0.39258
GARCH(1,1)	0.27651	0.99683	0.23550	0.64767	0.46737	0.99685	0.16634	**1.00000**	0.59556	0.99113	0.28951	0.41522
EGARCH(1,1)	0.27706	0.99881	0.23255	0.63956	0.32691	0.69725	0.16501	0.99203	0.59764	0.99461	0.27495	0.39433
GJR-GARCH(1,1)	0.19028	0.68596	0.36361	**1.00000**	0.46885	**1.00000**	0.16347	0.98276	0.60088	**1.00000**	0.69725	**1.00000**
PGARCH(1,1)	0.27739	**1.00000**	0.24595	0.67641	0.32308	0.68910	0.11821	0.71064	0.56926	0.94737	0.27034	0.38772

Again, like the RMSE measure, the non-ARCH type of models performed better than the ARCH-types as a group. Among the ARCH-type the best performing model was EGARCH (1,1) followed by ARCH (1), with GARCH (1,1) as the poorest performer.

6.5.4 Mean Absolute Percentage Error, MAPE

Again using mean absolute percentage error as model evaluation criterion, AR (2) performed better than all the other models. Following AR (2) was the Random Walk (RW) model. Among the ARCH-family of models volatility forecasts error associated with E-GARCH was the lowest for six commodities, the lowest in five commodities for the ARCH model, three for P-GARCH and GJR-ARCH respectively. The simple GARCH model recorded the highest forecast errors.

Table 6-3. Mean Absolute Percentage Error statistic

	Tea		Cocoa		Coffee		Sugar		Groundnut		Groundnut oil	
Model	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
Random walk	2.17767	0.39098	1.29727	0.22097	2.52914	0.06940	2.71777	0.20815	0.86018	0.22136	0.77271	0.13031
AR(2)	2.25517	0.40490	1.28150	0.21829	2.58760	0.07100	2.68587	0.20571	0.79536	0.20468	0.69733	0.11760
ARCH(1)	5.56974	**1.00000**	5.63914	0.96056	35.01615	0.96085	12.63211	0.96748	2.75886	0.70998	5.92981	**1.00000**
GARCH(1,1)	5.12995	0.92104	5.71218	0.97300	35.04374	0.96160	13.05678	**1.00000**	2.80065	0.72074	5.92837	0.99976
EGARCH(1,1)	5.09813	0.91533	5.83161	0.99334	27.51979	0.75514	12.01000	0.91983	3.88581	**1.00000**	5.65212	0.95317
GJR-GARCH(1,1)	5.21010	0.93543	5.87069	**1.00000**	34.85199	0.95634	12.88419	0.98678	3.16707	0.81503	5.71651	0.96403
PGARCH(1,1)	5.30015	0.95160	5.79668	0.98739	36.44306	**1.00000**	12.45665	0.95404	2.86398	0.73704	5.76324	0.97191

Continuation of Table 6-3

	Cotton		Sisal		Palm oil		Rubber		Shrimp		Tobacco	
Model	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
Random walk	1.64567	0.18113	0.61002	0.05760	1.95691	0.18068	1.76043	0.12625	3.06468	3.49305	0.32634	0.08025
AR(2)	1.46066	0.16077	0.62337	0.05886	1.91136	0.17648	2.24104	0.16072	3.03281	3.45673	0.34676	0.08527
ARCH(1)	8.13715	0.89561	10.38982	0.98099	9.96648	0.92021	13.90204	0.99701	8.75846	9.98270	3.64729	0.89692

GARCH(1,1)	8.72599	0.96042	10.57311	0.99830	10.06662	0.92946	13.91262	0.99777	8.75455	9.97824	4.06644	**1.00000**
EGARCH(1,1)	9.08559	**1.00000**	9.46364	0.89354	10.16168	0.93823	13.94378	**1.00000**	0.87736	**1.00000**	2.92408	0.71908
GJR-GARCH(1,1)	8.85742	0.97489	10.59114	**1.00000**	10.04667	0.92761	13.91146	0.99768	8.75789	9.98205	2.90158	0.71354
PGARCH(1,1)	8.87843	0.97720	9.88357	0.93319	10.83065	**1.00000**	13.91826	0.99817	8.76339	9.98832	3.56771	0.87735

Continuation of Table 6-3

	Crude oil		Timber		Aluminum		Iron ore		Copper		Gold	
Model	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
Random walk	3.64830	0.22416	1.14428	0.17955	0.83845	0.13020	0.50363	0.05962	1.08972	0.13870	0.88733	0.06378
AR(2)	3.81446	0.23437	1.07230	0.16825	0.69733	0.10829	0.50130	0.05935	1.01648	0.12938	0.87876	0.06316
ARCH(1)	16.07778	0.98786	5.96522	0.93601	6.43917	0.99994	0.16611	0.01967	7.83392	0.99714	6.30875	0.45345
GARCH(1,1)	16.23006	0.99722	6.14937	0.96490	6.41902	0.99681	8.44708	**1.00000**	7.77528	0.98967	13.91262	**1.00000**
EGARCH(1,1)	16.25823	0.99895	6.07476	0.95319	4.66450	0.72435	8.37185	0.99109	7.80707	0.99372	6.33918	0.45564
GJR-GARCH(1,1)	11.89028	0.73057	6.17112	0.96831	6.43956	**1.00000**	8.32057	0.98502	7.85642	**1.00000**	6.20862	0.44626
PGARCH(1,1)	16.27538	**1.00000**	6.37306	**1.00000**	4.41346	0.68537	5.73240	0.67863	7.37277	0.93844	6.22408	0.44737

6.5.5 Theil Inequality Coefficient, TIC

Theil inequality coefficient statistics also indicate superiority of the AR (2) model in forecasting commodity price volatility among the commodities examined. In thirteen of the commodities AR (2) produced the least forecast errors for eleven commodities, whilst random walk was the preferred model for five commodities. However, in cases where the random walk proved superior, the difference in forecast error as compared with AR (2) was quite marginal. Considering the relative performances of the ARCH family of models, GJR-GARCH and ARCH were at par. E-GARCH and P-GARCH were also of equal strength, with GARCH as the worst model. See Table 6-4 below.

Table 6-4. Theil Inequality Coefficient statistic

	Tea		Cocoa		Coffee		Sugar		Groundnut		Groundnut oil	
Model	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
Random walk	0.01459	0.38556	0.00852	0.25140	0.01538	0.02956	0.01619	0.02389	0.05110	**1.00000**	0.00647	0.01864
AR(2)	0.01488	0.39328	0.00852	0.25152	0.01561	0.03000	0.01572	0.02319	0.00540	0.10567	0.00614	0.01767
ARCH(1)	0.03783	**1.00000**	0.03315	0.97854	0.15171	0.29157	0.06651	0.09813	0.01770	0.34629	0.03405	0.09806
GARCH(1,1)	0.03557	0.94005	0.03348	0.98816	0.15235	0.29280	0.06885	0.10158	0.01783	0.34882	0.03405	0.09804
EGARCH(1,1)	0.03475	0.91848	0.03388	**1.00000**	0.52031	**1.00000**	0.06470	0.09546	0.02378	0.46543	0.03485	0.10034
GJR-GARCH(1,1)	0.03551	0.93849	0.03402	1.00404	0.15176	0.29168	0.67776	**1.00000**	0.01994	0.39019	0.34727	**1.00000**
PGARCH(1,1)	0.03610	0.95419	0.03376	0.99652	0.15658	0.30093	0.06612	0.09756	0.01825	0.35721	0.03589	0.10335

Continuation of Table 6-4

	Cotton		Sisal		Palmoil		Rubber		Shrimp		Tobacco	
Model	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
Random walk	0.01035	0.09189	0.00052	0.00868	0.01203	0.17641	0.01219	0.14266	0.01878	0.37235	0.00200	0.00927
AR(2)	0.00930	0.08261	0.00538	0.08918	0.01176	0.17251	0.01410	0.16504	0.01865	0.36971	0.00121	0.00561
ARCH(1)	0.04775	0.42416	0.05924	0.98242	0.06193	0.90823	0.08494	0.99422	0.04997	0.99051	0.02197	0.10171
GARCH(1,1)	0.04879	0.43342	0.06020	0.99842	0.06272	0.91974	0.06885	0.80587	0.04972	0.98553	0.02358	0.10917
EGARCH(1,1)	0.05007	0.44476	0.05442	0.90260	0.06313	0.92572	0.08436	0.98739	0.05045	**1.00000**	0.01826	0.08453

GJR-GARCH(1,1)	0.11258	**1.00000**	0.06030	**1.00000**	0.06256	0.91745	0.08544	**1.00000**	0.04993	0.98979	0.01813	0.08396
PGARCH(1,1)	0.04930	0.43789	0.05662	0.93898	0.06819	**1.00000**	0.08506	0.99560	0.05020	0.99510	0.21597	**1.00000**

Continuation of Table 6-4

	Crude oil		**Timber**		**Aluminum**		**Iron ore**		**Copper**		**Gold**	
Model	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
Random walk	0.05830	0.46565	0.00676	0.02860	0.00513	0.13646	0.01396	0.18300	0.00693	0.16647	0.005578	0.06534
AR(2)	0.02558	0.20434	0.00676	0.02860	0.00510	0.13566	0.01396	0.18299	0.00662	0.15910	0.00559	0.06549
ARCH(1)	0.12340	0.98563	0.03887	0.16444	0.03761	0.99995	0.07623	0.99937	0.04153	0.99753	0.03592	0.42075
GARCH(1,1)	0.12479	0.99670	0.03992	0.16889	0.03751	0.99729	0.07628	**1.00000**	0.04127	0.99126	0.08537	**1.00000**
EGARCH(1,1)	0.12505	0.99877	0.03949	0.16707	0.02803	0.74508	0.07600	0.99634	0.04141	0.99462	0.03614	0.42332
GJR-GARCH(1,1)	0.09912	0.79171	0.23636	**1.00000**	0.03762	**1.00000**	0.07536	0.98790	0.04164	**1.00000**	0.03519	0.41217
PGARCH(1,1)	0.12520	**1.00000**	0.04220	0.17854	0.02777	0.73833	0.06646	0.87126	0.03972	0.95403	0.03530	0.41350

In summary, the two non-ARCH-based models, namely autoregressive (2) and random walk, consistently outperforms the ARCH-family of models. This outcome is largely in conformity with the findings of studies that dwelt on returns on other financial assets other than commodities (see Tse, 1991; Tse and Tung, 1992, McMilan, Speight and Gwilym 2000; Balan *et al.* 2004). The second notable outcome of the work is that within the ARCH family of models no clear pattern of superiority could be established with the respect to model complexity and forecast ability. Nonetheless, the E-GARCH model had a slight advantage over the standard ARCH model. The GARCH model consistently generated the highest forecast errors and was thus clearly the worst performing model. Results concerning the ACH-family of models are also consistent with mixed results in the literature concerning identification of the most superior model in the sub-group of the ARCH family of models.

6.6 Conclusions

Though volatility forecasting appears to be a widely researched area in the finance literature, commodity markets have not attracted much attention thus far. The performance of a wide range of volatility forecasting models has been investigated with mixed results. This paper sought to add to the literature by using a single unifying framework evaluating a large number of volatility forecasting models across 18 commodity markets. The analysis covered the 26-year period 1985 – 2005. The commodities considered were: gold, iron, aluminium, copper, crude oil, rubber, timber, cotton, cocoa, tea, coffee, sugar, tobacco, sisal, groundnut, groundnut oil, shrimp and palm oil.

Seven forecasting models used in the analysis were random walk, the autoregressive model of order two, ARCH, GARCH, E-GARCH, GJR-GARCH and P-GARCH. The forecast models were then compared using the traditional symmetric evaluation statistics root mean squared error, mean absolute error, mean absolute percentage error and the Thiel inequality coefficient statistic.

The main finding of the study is that the autoregressive regression model of order two, AR (2), forecasts commodity price volatility better than the other six models evaluated. The results of the study suggest that government agencies in Sub-Saharan Africa which manage inflows from commodity markets can use autoregressive models in predicting volatility of inflows. Again, risk-management strategies involving the use of commodity market volatility will be best served with autoregressive models in forecasting commodity volatility.

List of References

Akigray, V., 1989. Conditional heteroscekedasticity in time series models of stock returns: evidence and forecasts, Journal *of Business* 62, p.55-99.

Balaban, E., A. Bayar & Faff, R., 2004. Forecasting stock market volatility: further international evidence, Quebec: ASAC.

Black, F. & Scholes, M., 1973. The valuation of options and corporate liabilities. *Journal of Political Economy* 81, p.637-654.

Jeane-Philippe, B. & Potter, M., 2001. More stylized facts of financial markets: leverage effect and downside correlations". *Physica A*. 299, p.60-70.

Brailsford, T. J. & Faff, R.W., 1996. An evaluation of volatility forecasting techniques, *Journal of Banking and Finance* 20, p.419 – 438.

Canina, L. & Figlewski, S., 1993. The informational content of implied volatility, *Review of Financial Studies* 6, p. 659-681.

Christensen, B.J & Prabhala, N.R., 1998. The relation between implied and realised volatility. *Journal of Financial Economics* 50, p.125-150.

Campbell, J.Y. & Hentschel, L., 1992. No news is good news: an asymmetric model of changing volatility in stock returns, *Journal of Financial Economics* 31, p.281-318.

Day, T.E. & Lewis, C.M., 1992. Stock market volatility and information content of stock index options. *Journal of Econometrics* 52, p.267 – 287.

Ding, Z., C. W.J. Granger & Engel, R.F., 1993. Distribution of autoregressive time series with a unit root, *Journal of American Statistical Association,* 74, p.427 – 431.

Engel, R. F. & Russell, J. R., 1998. Autoregressive conditional duration: a new model for irregularly spaced transaction data, *Econometrica* 66(5), p. 1127-62.

Fleming, J., C. Kirby & Osteidiek, B., 2000. The economic value of volatility timing, *Journal of Finance* 56 (1).

Glosten, L.R., Jagannathan, R. & Runkle, D.E., 1993. On the relation between the expected value and volatility of the nominal excess return on stocks, *Journal of Finance* 48, p.1779-1801.

Harris, R. & Sollis, R., 2003. Applied time series forecasting. Chichester, West Sussex: John Wiley and Sons.

Jorion, P., 1995. Predicting volatility in the foreign exchange market. *Journal of Finance* 50, p.507-528.

Kroner, K.F., D.P. Kneafsey & Classens, S., 1993. Forecasting volatility in commodity markets. *Policy Research Working Paper* 1226. Washington, D.C.: World Bank.

Lamoureux, C. G. & Lastrapes, W.D., 1991. Forecasting stock return variance: toward an understanding of stochastic implied volatilities, unpublished manuscript, Washington University.

Latane, H. A. & Sundaresan, S.M., 1976. Standard deviations of stock price ratios implied in option prices. *Journal of Finance* 31, p.369-381.

Leamer, E. E., 1983. Let's take the con out of economics. *American Economic Review* 73, p.31-43.

Lo, A. & Mackinlay, C., 1990. Data snooping biases in tests of financial asset pricing models, *Review of Financial Studies* 3, p.431-467.

Martens, M. & Zein, J., 2002. Predicting financial volatility: high frequency forecast vis-à-vis implied volatility. Working Paper, Erasmus University.

Nelson, D. B., 1991. Conditional heteroskedasticity in asset returns: a new approach, "*Econometrica* 59 (2), p.347-70.

Ocran, M.K. & Biekpe, N., 2005. Trends and volatility Sub Saharan African primary commodity exports. Working Paper, Graduate School of Business, University of Stellenbosch.

Pagan, Adrian R. & Schwert, G.W., 1990. Alternative models for conditional Stock volatility. *Journal of Econometrics* 45(1), p.267-90.

Pindyck, R. S. & Rubbenfeld, D. L., 1991. *Econometric Models and Econometric Forecasts,* 3rd Edition. New York: McGraw-Hill.

Poon, S. & Granger, C., 2003. Forecasting volatility in financial markets: a review. *Journal of Economic Literature* 41, p.468-539.

Schwert, C.W., 1989. Why does stock market volatility change over time? *Journal of Finance* 44, p.1115-1153.

Szakmary, A., E. Ors, J.K. Kim & Davidson III, W. D., 2002. The predictive power of implied volatility: evidence from 35 futures markets. Working Paper, Southern Illinois University.

Taylor, S.J., 1986. *Modelling Financial Time Series.* New York: John Wiley.

West, K. D. & Cho, D., 1995. The predictive ability of several models of exchange rate volatility. *Journal of Econometrics* 69, (2), p.367-91.

Yu, J., 2002. Forecasting volatility in the New Zealand stock market. *Applied Financial Economics* 12, p.193-202.

Appendix Table 5. **Commodity Data Description**

Commodity	Description
Crude Oil	Simple average of three spot prices; Dated Brent, West Texas Intermediate, and the Dubai Fateh, US$ per barrel
Tea,	Mombasa, Kenya, Auction Price, US cents per kilogram
Sugar,	Sugar, Free Market, Coffee Sugar and Cocoa Exchange (CSCE) contract no.11 nearest future position, US cents per pound
Tobacco	US Dollars per Metric Ton, US
Cocoa beans	Cocoa, International Cocoa Organization cash price, CIF US and European ports, US$ per metric tonne
Coffee	Coffee, Other Mild Arabicas, International Coffee Organization New York cash price, ex-dock New York, US cents per pound
Cotton,	Cotton Outlook 'A Index', Middling 1-3/32 inch staple, CIF Liverpool, US cents per pound
Groundnuts (peanuts),	Groundnuts (peanuts), 40/50 (40 to 50 count per ounce), cif Argentina, US$ per metric tonne
Groundnut oil	US Dollars per Metric Ton, Nigeria
Sisal	US Dollars per Metric Ton, East Africa.
Timber	Hard Logs, Best quality Malaysian meranti, import price Japan, US$ per cubic meter
Palm oil	Malaysia Palm Oil Futures (first contract forward) 4-5 percent FFA, US$ per metric tonne
Rubber	No.1 Rubber Smoked Sheet, FOB Malaysian/Singapore, US cents per pound
Shrimp	Frozen shell-on headless, block 16/20 count, Indian origin, C&F Japan, US$ per kilogram
Gold	United Kingdom, average price US$/oz
Copper	Copper, grade A cathode, LME spot price, CIF European ports, US$ per metric tonne
Iron Ore	Iron Ore, 67.55% iron content, fine, contract price to Europe, FOB Ponta da Madeira, US cents per dry metric tonne unit
Aluminium	Aluminium, 99.5% minimum purity, LME spot price, CIF UK ports, US$ per metric tonne

CHAPTER SEVEN

7 COMMODITY EXPORT PRICES AND THE REAL EXCHANGE RATE: EVIDENCE FROM SELECTED AFRICAN COUNTRIES

7.1 Introduction

The effect of commodity export price changes on real exchange rate behaviour in commodity-dependent countries has been the subject of a number of studies (Cuddington & Liang, 1998; Chen & Rogoff, 2003). High commodity prices are known to result in real appreciation of domestic currencies of commodity-dependent countries. To varying degrees Ghana, Nigeria and South Africa can be described as commodity-dependent economies, since commodities constitute a large share of their production and exports (Chen and Rogoff, 2003). Export earnings from crude oil alone accounts for over 95 percent of exports from Nigeria, whereas cocoa and gold constitute over 70 percent of Ghanaian exports (UNCTAD, 2003). While the importance of gold in South Africa's exports has declined considerably from 56 percent of revenue in 1980 to 36 percent in 1992, its current share of about 35 percent is still substantial. Though each of the three countries is a significant player on the commodity markets that they trade in, they are still price takers and have no influence on determining the prices at which their commodities are sold.

Edwards (1985) shows changes in commodity export prices can also have effects on money supply in the short-run with possible spill-over to the real exchange rate. The author argues that a primary commodity export boom usually leads to balance of payment surpluses, which result in increased foreign exchange reserves. The argument is that, if accumulated foreign reserves resulting from a commodity price boom are not fully neutralised, it may lead to an increase in the monetary base and as a result increased inflation. The price level increase is one of the channels through which real appreciation will occur (See Edward, *ibid.*). Despite the importance of an understanding of the channel through which changes in commodity export prices are transmitted into changes in real exchanges, few researchers have addressed this question apart from the earlier work of Edward (*ibid.*). Most of the studies in this area of the literature mostly establish the relationship between primary commodity price changes and real exchange movements (Chen and Rogoff, 2003; Cuddington & Liang, 1998, Cashin, Cespedes & Sahay, 2003).

The purpose of this paper therefore is to build a model that examines the interaction between commodity export prices, money supply, inflation and the real exchange rate. The empirical analyses investigate the effect of commodity price changes on the real exchange rate in Nigeria, Ghana and South Africa with the aid of a Two-Stage Least Square (2SLS) estimator. Since the real exchange rate is an important macroeconomic variable that determines to a large extent the competitiveness of a country's exports in general and non-commodity exports in particular, the results of the study will be useful for policy makers. The outline of the rest of the paper is as follows. Section 2 presents briefly previous work in the research area. Section 3 presents an overview of the performance of selected economic variables in the three countries. However, the emphasis is on descriptive evidence of how closely or otherwise domestic currencies in the countries track world market prices of their export commodities. Section 4 develops the empirical model for examining the transmission of commodity price changes in the three countries. The results of the study are given in Section 5 and conclusions in Section 6.

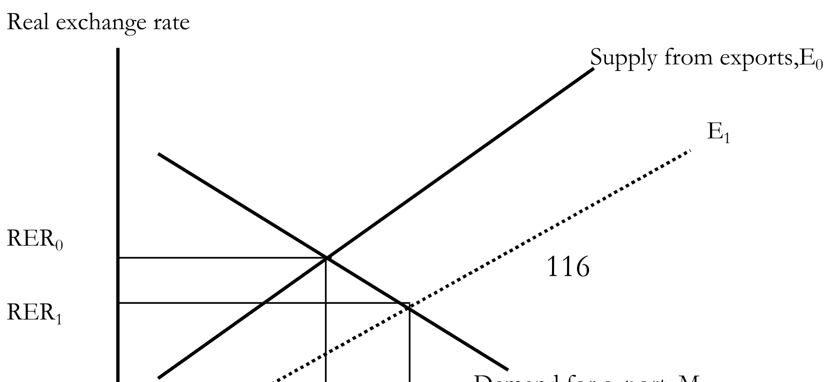
7.2 **Literature Review**

This section of the paper briefly reviews relevant studies by considering the theoretical literature and selected empirical papers. Whilst there is a limited amount of work considering the transmission of the effects of real commodity price on real exchange rate, there are a substantial number of studies that focus on resource-export booms (Spatafora & Waner, 1999; Gauzier, 1986; Olomola & Adejumo, 2006). These studies examine the long-run impact of primary commodity price changes on the real exchange rate, employment, output and wages. Corden (1984) undertakes a survey of studies focusing on booming primary commodity sectors and their effects on other sectors as well as the real exchange rate. The phenomenon where a primary commodity export boom tends to have an undesirable effect on other sectors of the economy has been described as "Dutch disease" (see Corden, 1984 for a discussion of Dutch disease economics).

7.2.1 Theoretical literature

The review of the theoretical literature discusses the effect of changes in export earnings as a result of increased commodity prices on the real exchange rate, money supply and inflation. Also presented are other effects that commodity price booms have on other sectors of the economy. A shift in the export schedule (see Figure 7-1) leads to a decrease in the real exchange rate. A sudden increase in commodity price may result in increased foreign exchange supply as seen in oil-exporting countries in 1973–1974 and 1979–1980 (Harbenger 1986, 1989 and Sadoulet & de Janvry, 1995).

Figure 7-1. Commodity boom and the Real Exchange Rate



A positive commodity price shock can have undesirable effects on the rest of the economy. A fall in the real exchange rate (appreciation) results in a decline in price relative to other tradables, non-tradables as well as wages (Sadoulet & de Janvry, 1995). As a result of the exchange rate appreciation, other sectors in the economy – especially those that use imported intermediate goods in production – lose their competitiveness. Resources in the economy are thus directed towards the booming sector at the expense of the other tradable and non-tradable sectors; this phenomenon has been described as the Dutch disease. Another effect of increased commodity prices is an accumulation of foreign reserves due to the build-up of a balance of payment surplus; if the increased foreign exchange reserve is not completely neutralised, it may give rise to increases in money supply. The increase in money supply has the potential of increasing inflation.

7.2.2 Empirical literature

Cashin *et al.* (2003) investigated the existence of a long-run relationship between the real commodity price changes and the real exchange rate changes for 58 commodity-exporting countries. The objective in the study was to find commodity dependent countries that had *commodity currencies*. Cointegration analysis was used for the estimation process; the study also used data on 44 commodity prices covering the period 1980 to 2002. The authors concluded that commodity prices and the real exchange rate for about one third of the countries studied tended to move together. Cashin *et al.* (*ibid.*) further argued that *commodity currencies* were key in explaining deviations of long-run real exchange rates from their respective purchasing power parity. Contrary to the purchasing power parity theory, the study concluded that the long-run real exchange rates of commodity-dependent countries were not constant but rather time varying based on commodity price movements.

Chen & Rogoff (2002) investigated the question of whether commodity price shocks explained a reasonable proportion of the changes in the exchange rates of Australia, New Zealand and Canada. These developed economies were selected because they depended on commodities for a significant share of their export earnings. The study also sought to find out if the introduction of commodity prices into monetary models was enough to help explain the PPP puzzle. Univariate models were used in assessing the relationship between commodity prices and exchange rates. After establishing strong correlations between commodity prices and the exchange rate in the three economies, the authors concluded that real commodity prices had a strong and stable influence on the real exchange rates. Nonetheless, the relationship between real exchange rate and commodity prices for Canada was not robust.

In another related study Sanidas (2005) concluded that the Australian exchange rate was determined largely by a number of related cycles, which in turn were based on commodity price, production and general economic cycles. The author further argued that the world commodity markets in turn drove all three cycles. Sanidas (*ibid.*) used the Fourier analysis and ordinary least square estimator. The results of the study reveal the behaviour of the cycles studied. Like earlier studies on commodity prices and the real exchange rate, the paper concludes that commodity price and production cycles as well as the Australian real exchange rate moved together.

Since primary commodity exports constitute the lion's share of exports from Africa, commodity price changes are most likely to account for a greater share of changes in terms of trade in the region. Therefore, studies on terms of trade and real exchange rate are relevant points of reference for the present study. Some of the studies that have established the relevance of the terms of trade fluctuations in explaining changes in the real exchange rate include De Gregario & Wolf (1994); Chinn & Johnston (1996); and Montiel (1997). Even though there appears to be a general consensus in the literature regarding co-movement in terms of trade and the real exchange rate in developing countries, there are differences regarding estimation of the terms of trade measure. Because of perceived endogeneity problems as pointed out by Obstfeld and Rogoff (2000), and earlier argued in Deaton & Miller (1996) defined terms of trade using world commodity prices as opposed to the use of producer price, has since become popular (Cashin *et al.*, 2004).

With a sample ranging from 1973 to 1996 and covering seventy-five countries, Broda (2002) examined the nature of real exchange rate response to changes in the terms of trade. The paper sought to determine the extent of response, given the particular exchange rate regime in place. Countries with different exchange rate regimes were therefore included in the sample of countries studied. The paper suggests that floating exchange rate regimes were better at dealing with the effects of terms of trade changes than fixed exchange rate regimes. In another related study Mendoza (1995) investigated the interaction between terms of trade and business cycles using a three-sector inter-temporal equilibrium model using multi-country data. Simulations undertaken by the author revealed that terms of trade variations accounted for about half of the observed changes in the real exchange rates of the countries studied.

Edwards (1985) examined the effect of coffee price changes on real exchange rate changes in Columbia, a primary commodity-dependent country. The study traced the effects of real coffee price changes on real exchange rate changes with a system of equations. The estimation was undertaken with two-stage least square and three-stage least square equations and using data over the period 1952-1982. The results of the 2SLS and 3SLS estimations were comparable. The results indicate that commodity export booms tend to produce increases in the supply of money, inflation and real appreciation of the domestic currency. The author maintains that the currency appreciation through the money supply and inflation channels may be higher than the appreciation due to the "equilibrium" real appreciation as a result of the boom. Edwards (1985) concedes that the model was kept simple in order to effectively isolate the role of the coffee price boom in the devaluation process in Columbia. However, one possible issue that may cast some doubts on the results of the study was the implicit assumption that the variables used in the estimation process were stationary in levels. Later work on the behaviour of economic variables have proven that most economic time series were indeed non-stationary in levels and this position has become fairly standard in econometric modelling since the 1990s (see Hendry, 1995). Even though the present paper draws on the theoretical approach of Edwards (1985), stationarity of the data series is empirically established before estimations are carried out.

7.3 Commodity Exports and the Real Exchange: Selected Stylized Facts

In this section of the paper the behaviour of the real exchange rate and key commodity exports of Ghana, Nigeria and South Africa are briefly reviewed using descriptive statistics and graphical analysis. This part of the work provides background information about the parameters being studied before formally examining the transmission of the effects of commodity price changes on the real exchange rates. The discussion also provides an opportunity to ascertain the extent to which the data describing the relationships being studied conforms to the theoretical and empirical literature.

7.3.1 Cocoa and the Real Exchange Rate in Ghana

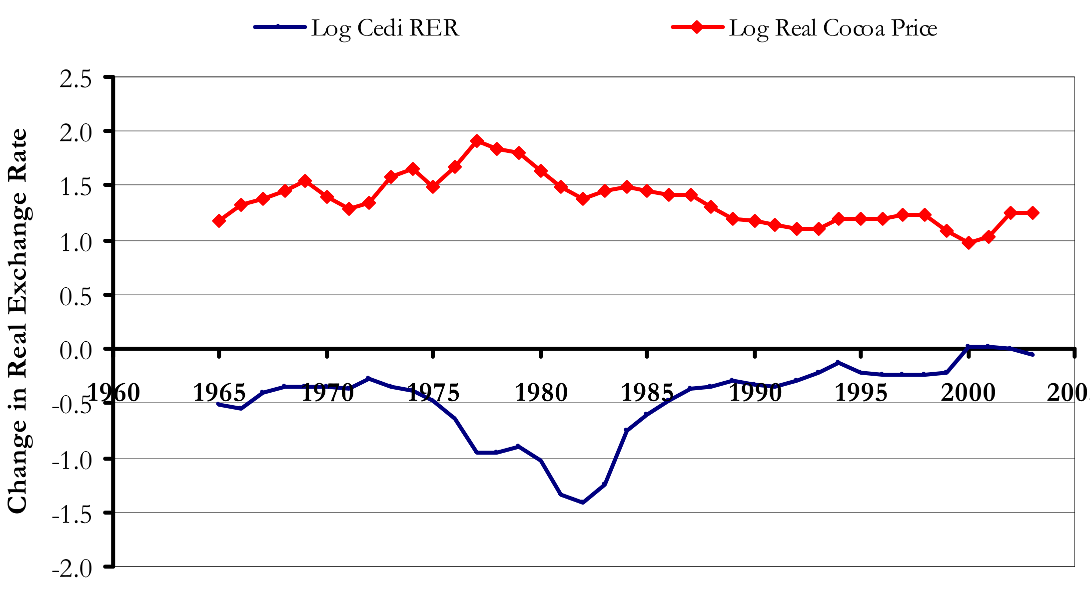
A consideration of real cocoa prices, foreign reserves, nominal exchange rate, inflation and money supply raises a number of issues. However, it is important that the huge nominal exchange rate changes observed for 1983-1984 are put into perspective. This phenomenal devaluation occurred in the early days of the structural reform programme pursued by Ghana when the cedi was devalued to remove price distortions in the economy (Kapur *et al.*, 1991). Though the relationships that are described in the Table and Figure below are not empirical, they bring certain indicative facts to the fore. Generally episodes of real cocoa price changes seem to have been associated with increases in the growth of the money supply and inflation (see Table 7-1). In these instances of cocoa price changes the nominal exchange rate recorded modest changes, particularly in the period before 1983. This could be due to the kind of exchange rate regime that was in place. The exchange rate markets prior to the reforms in 1983 were mostly fixed or variances of a crawling peg (Kapur *et al.*, 1991). It can also be observed that real cocoa price falls were also related to negative changes in foreign reserves accumulation (Table 7-1). The high depreciation rate seen in 1999-2000 is significant, though, because of the kind of exchange rate policy at the time and the general direction of the economy as a whole. Unlike much of the period before 1983, there was a floating exchange rate in place and an appreciable level of independence of the central bank as far as monetary policy management was concerned. Hence the fact that the relationships between the variables are consistent with the theoretical literature is notable (Table 7-1).

Table 7-1. Ghana: Changes in selected macroeconomic variables, 1966-2004

Period averages	(1) International Reserves	(2) Changes in nominal exchange rate	(3) Inflation	(4) Changes in money supply	(5) Changes in real cocoa price
1966-1969	**-0.10**	**0.10**	**0.05**	**0.05**	**0.23**
1970-1971	-0.23	0.00	0.06	0.05	-0.26
1972-1974	**0.63**	**0.05**	**0.15**	**0.30**	**0.35**
1975-1975	0.74	0.00	0.30	0.44	-0.33
1976-1977	**0.18**	**0.00**	**0.86**	**0.54**	**0.64**
1978-1982	0.06	0.22	0.63	0.38	-0.22
1983-1984	**0.56**	**2.64**	**0.81**	**0.55**	**0.15**
1985-1992	0.18	0.38	0.25	0.39	-0.10
1993-1995	**0.30**	**0.40**	**0.36**	**0.37**	**0.09**
1996-1996	0.19	0.36	0.47	0.32	-0.02
1997-1998	**-0.33**	**0.19**	**0.21**	**0.33**	**0.06**
1999-2000	-0.14	0.60	0.19	0.27	-0.26
2001-2003	**0.87**	**0.17**	**0.25**	**0.46**	**0.25**

Source: Raw data were obtained from IMF (2005), period average changes are computations of author.

Figure 7-2. Real Cocoa Price and the Real Exchange Rate of the Cedi



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may be due to a lot more besides a commodity price boom. The Heavily Indebted Poor Country (HIPC) Initiative that Ghana adopted led to a considerable reduction in external debt repayment. This saving may have partly contributed to the accumulation of foreign reserves. Figure 7-2 presents a graph of the real exchange rate and real cocoa prices; the graph describes the long-run relationship between the two variables. It can observed be that, apart from the late to middle 1980s, the real exchange rate of the Ghanaian cedi moved together with the cocoa price fairly well over the period of study. This relationship therefore is in conformity with the literature on the real exchange rate and real commodity prices, particularly for commodity-dependent economies such as Ghana.

7.3.2 Crude Oil and the Real Exchange Rate in Nigeria

Between 1966 and 2004 Nigeria recorded eight episodes of average crude price increases. For instance, the period average price increase for 1971-1974 was estimated at 66 percent per year. This crude price boom was associated with an average increase of 262 percent in foreign reserves per year over the period. Again, the 1979-1980 period average of 61 percent crude price increase led to an average growth rate of 139 percent in foreign reserves per year (see Table 7-2).

Table 7-2. Nigeria: Changes in selected macroeconomic variables, 1966-2004

Period averages	(1) Changes Foreign* Reserves	(2) Changes in nominal Exchange Rate	(3) Inflation	(4) Changes in Money Supply	(5) Changes in Real Crude Price
1966-1970	0.07	0.00	0.06	0.16	-0.02
1971-1974	2.62	-0.03	0.10	0.32	0.66
1975-1976	-0.04	0.00	0.28	0.52	-0.12
1977-1977	-0.18	0.02	0.15	0.45	0.04
1978-1978	-0.55	0.00	0.22	-0.06	-0.04
1979-1980	1.39	-0.07	0.11	0.35	0.61
1981-1986	-0.22	0.25	0.14	0.06	-0.16
1987-1987	0.08	1.30	0.11	0.18	0.32
1988-1988	-0.44	0.13	0.55	0.44	-0.21
1989-1990	1.45	0.36	0.29	0.27	0.19
1991-1994	-0.05	0.31	0.43	0.51	-0.10
1995-1996	0.93	0.00	0.51	0.15	0.10
1997-1998	0.40	0.00	0.09	0.18	-0.20
1999-2000	0.29	1.66	0.07	0.42	0.48
2001-2001	0.06	0.09	0.19	0.26	-0.19
2002-2004	0.35	0.06	0.14	0.18	0.15

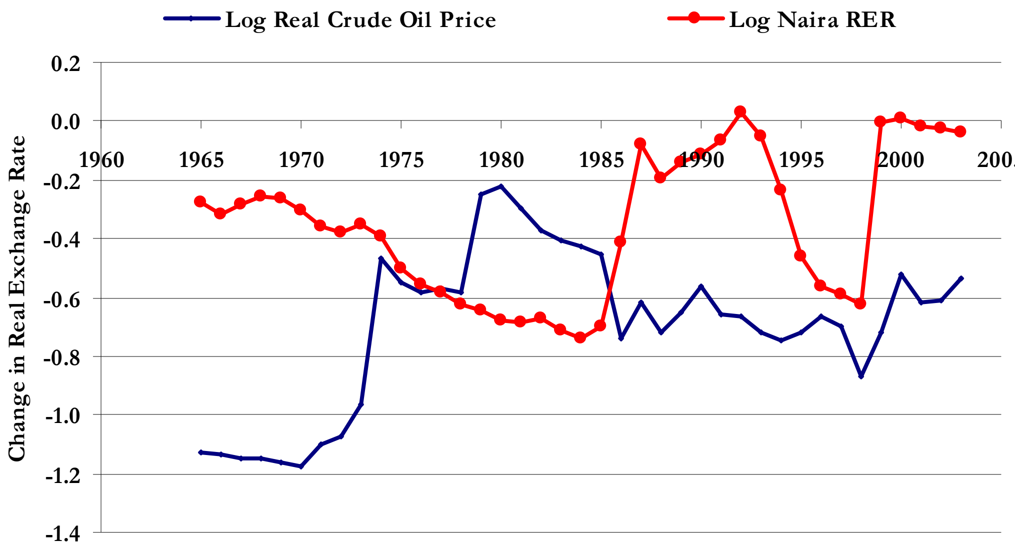
Source: Raw data were obtained from IMF (2005), period average changes are computations of author.
Note: * Foreign reserves are defined in the International Financial Statistics as foreign reserves less gold reserves.

In all the instances of real crude price increases, money creation recorded appreciable increases as well. Out of the eight episodes of increased period average crude prices, there were six corresponding episodes of foreign accumulation increases as against two periods of decreases in growth of reserves.

The story of money creation and sudden crude price increases in Nigeria is mixed, whilst certain periods of price declines were associated with low money growth, others were linked to increased growth in money supply. Concerning the nominal exchange rate, no clear pattern could be identified. This could be due to the nature of exchange rate regimes in Nigeria over the study period.

A visual observation of the relationship between the real crude oil price and the real exchange rate of the naira before 1986 does not suggest any meaningful pattern; however, there appears to be an indication of co-movement to some extent after the late 1980s (see Figure 7-3).

Figure 7-3. Real Crude Oil Price and the Real Exchange Rate of the Naira



7.3.3 Gold and the Real Exchange Rate in South Africa

Table 7-3 shows that positive gold price changes in South Africa have been associated with strong growth in foreign reserve accumulation. Out of the seven episodes of gold prices increases identified over the period 1965–2004, four were associated with more than proportionate growth in foreign reserve accumulation.

Table 7-3. South Africa: Changes in selected macroeconomic variables, 1966-2004

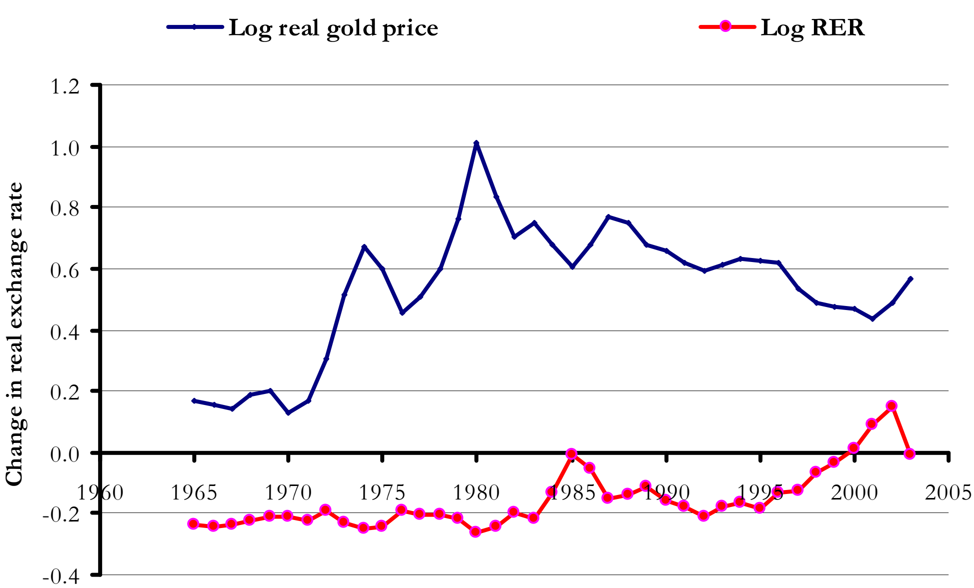
Period Average	(1) International Reserves	(2) Changes In Nominal Exchange Rate	(3) Inflation	(4) Changes In Money Supply	(5) Changes In Real Gold Price
1966-1968	0.10	0.00	0.03	0.12	-0.03
1969-1970	**0.23**	**0.00**	**0.04**	**0.05**	**0.07**
1971-1971	-0.23	0.00	0.06	0.08	-0.16
1972-1975	**0.29**	**0.01**	**0.10**	**0.15**	**0.38**

1976-1977	-0.08	0.09	0.11	0.04	-0.22
1978-1981	**0.16**	**0.01**	**0.13**	**0.25**	**0.40**
1982-1983	0.21	0.13	0.13	0.21	-0.29
1984-1984	**-0.71**	**0.32**	**0.12**	**0.41**	**0.10**
1985-1986	0.24	0.27	0.17	0.00	-0.15
1987-1988	**0.47**	**0.00**	**0.14**	**0.31**	**0.21**
1989-1993	0.06	0.08	0.14	0.11	-0.08
1994-1995	**0.66**	**0.05**	**0.09**	**0.22**	**0.05**
1996-2002	0.53	0.17	0.07	0.18	-0.06
2003-2004	**0.56**	**-0.21**	**0.04**	**0.09**	**0.17**

Source: Raw data were obtained from IMF (2005), period average changes are computations of author.

These price booms were also related to relatively high rates of money supply growth in the economy. However, changes in real gold prices and inflation did not appear to have followed any particularly defined path. Concerning the real gold price and the real exchange rate of the rand, there appears to be co-movement between real gold price and the real exchange rate (see Figure 7-4). This phenomenon is in agreement with earlier studies which conclude that the rand is a commodity currency because its movement is related closely with movements in South Africa's primary commodity exports including gold (Chen & Rogoff, 2003).

Figure 7-4. Real Gold Price and the Real Exchange Rate of the Rand



7.4 **Methodology**

The focus of this part of the paper is on building an empirical model for examining the interaction between commodity prices, money supply, inflation and the real exchange rate. The thrust of this section, though, is to test the hypothesis that commodity price changes impact on money supply, inflation and the real exchange rate in African countries. The modelling effort draws on the earlier work of Edwards (1985); the general model is then tested with data from three countries from Africa with varying degrees of commodity dependence and economic development, i.e. Nigeria, Ghana and South Africa.

7.4.1 Model

The emphasis in the model building effort was to trace commodity price changes through money supply, inflation and the real exchange rate. First, it is assumed that the economies studied produced three goods. The goods produced are: a key tradable primary commodity (C); other tradables (T); and non-tradables (N). The capital account is also assumed to be exogenously determined, since the countries being studied have in place some levels of capital control. The main features of the model are represented by equations 1 to 11. The theoretical model has three main building blocks: monetary (equations 1 to 4), inflation (equations 5 and 8) and the real exchange rate (equations 9 to 11) components.

$$\dot{M}_t = \omega \dot{R}_t + (1-\omega)\dot{C}_t \qquad (1)$$

$$\dot{C}_t = c_0 + \phi FD_t + z_t \qquad (2)$$

$$\dot{R}_t = \theta[\dot{M}_t^d - \dot{M}_{t-1}] + \psi\dot{P}_t^c \quad (3)$$

$$\dot{M}_t^d = \dot{P}_t + \eta\dot{y}_t \quad (4)$$

$$\dot{P}_t = (1-\delta)\dot{P}_{NT} + \delta\dot{P}_{Tt} \quad (5)$$

$$\dot{P}_{Tt} = \dot{E}_t + \dot{P}_{Tt}^* \quad (6)$$

$$\dot{P}_t^C = \dot{E}_t + \dot{P}_t^{C*} \quad (7)$$

$$\dot{P}_{NT} = \dot{P}_{Tt} + \lambda[\dot{M}_t - M_t^d] + \rho\dot{y}_t \quad (8)$$

$$\dot{E}_t = \gamma_0\dot{P}_t - \gamma_1 P_t^{C*} - \gamma_2\dot{y}_t - \gamma_3\dot{P}_{Tt}^* + \gamma_4 x_t \quad (9)$$

$$\dot{y}_t = \ell_t + \tau(P_t^{C*} - \dot{P}_{Tt}^*) \quad (10)$$

$$e_t = {(E_t * P_t^{C*})}/{P_t} \quad (11)$$

The "dot" operator indicates percentage change, whilst the other notations are defined as follows:

$\dot{M}_t$	=	rate of change of nominal money in period *t*
$\dot{C}_t$	=	rate of change of domestic credit in period *t*
$\dot{R}_t$	=	rate of change of foreign reserves at period *t*
$F\dot{D}_t$	=	fiscal deficit in period *t* as a ratio of the stock of high powered money in period *t-1*
P_t^C	=	domestic price of commodity key tradable commodity in period *t*
E_t	=	nominal exchange rate, defined as local currency units, LCU per unit of foreign currency at period *t*
y_t	=	real income at period *t*
P_t	=	domestic price level at period *t*
P_{Tt}	=	domestic price of tradables at period *t*
P_{Nt}	=	price of non-tradables at period *t*
P_{Tt}^*	=	world price of tradables at period *t*
P_t^{C*}	=	world price of key commodity export at period *t*
$\dot{P}_{Tt}^*$	=	world inflation rate period *t*
ℓ_t	=	other output sources in the economy besides key commodity export at period *t*
z_t	=	other factors driving domestic credit policy at period *t*
x_t	=	other factors determining changes in the exchange rate at period *t*
e_t	=	real exchange rate at period *t*

and the symbols; ω, ϕ, θ, ψ, η, δ, λ, ρ, τ and γ are the parameters.

Equations (1) to (4) constitute the monetary block of the theoretical model; the equation shows that a percentage change in monetary supply in nominal terms is a weighted average of the rate of change in domestic credit and foreign currency reserves. Domestic credit is given in equation (2); the assumption underlying the equation is that domestic credit is connected with fiscal deficit. Even though in reality other forces in the economy may drive fiscal deficit, it is assumed here that it is exogenous. Equation (2) also assumes that the monetary base may be affected by other factors besides fiscal deficit; these other factors are accounted for by the variable z_t. Equation (3) represents the foreign reserves relationship. The reserve equation has two parts; one part describes the effect of excess demand or supply for money on the level of reserves accumulated and the other part depends on commodity price changes. As discussed in Edwards (1985) this part of the equation creates a channel for transmitting the effect of changes in foreign reserve to money supply in the short run. Nonetheless, changes in foreign reserves remain constant in the long run, because in the long run $\dot{P}_t^C = 0$ and $\dot{M}_t^d = \dot{M}_t = \dot{M}_{t-1}$, consequently $\dot{R}_t = 0$. Equation (4) describes demand for money in nominal terms; it is assumed that demand for nominal money simply depends on real income and price level. Equations (1) to (4) can be solved for money supply. This can be formally written as:

$$\dot{M}_t = -\omega\theta\dot{M}_{t-1} + \omega\theta\dot{P}_T + \omega\theta\eta\dot{y}_t + \omega\psi\dot{P}_t^C + (1-\omega)\dot{C}_t \qquad (12)$$

Given that ω and θ are smaller than unity but positive, equation (12) will be fluctuating even at equilibrium. From the equation it can be observed that, if there is a sudden increase in commodity price, there will be increase in the rate of growth of the monetary base in the economy.

Equations (5), (6) and (8) constitute the inflation system of equations. Equation (5) indicates that domestic rate of inflation is determined by the weighted average of prices of tradable and non-tradable goods in the economy. The assumption here is that the tradable part of the inflation equation as given in equation (5) does not include the key commodity exported. In equation (6) changes in domestic price of other commodities besides the key commodity is equal to rate of change in nominal exchange rate plus world inflation. Equation (7) indicates that the domestic price of a given tradable commodity is determined by the going nominal exchange rate and the world market price of the commodity. Equation (8) shows that a change in price of non-tradables is determined by changes in price of tradables, real income and excess supply of nominal money. Equations (4), (5) and (8) can be solved for rate of domestic inflation and the resultant equation may be written as:

$$\dot{P}_t = \frac{(1-\delta)\lambda}{1+\lambda(1-\delta)}\dot{M}_t + \frac{1}{1+\lambda(1-\delta)}(\dot{E}_t + \dot{P}_{Tt}) - \frac{(1-\delta)(\lambda\eta-\rho)}{1+\lambda(1-\delta)}\dot{y}_t \qquad (13)$$

It is worthy to note that the coefficients of money supply and world inflation amount to one. However, the coefficient of the real income could be either positive or negative, depending whether $\lambda\eta$ is greater or less than δ.

Equation (9) shows that change in nominal exchange rate in time *t* depends on domestic and world inflation. The other determinants are changes in the nominal exchange rate, key commodity price and real income. Other factors that are not explicitly stated but are thought to influence nominal exchange rate movements are all subsumed under x_t. Equation (10) indicates that change in real income is dependent on a term that has a role for commodity prices $(\dot{P}_t^{C*} - \dot{P}_{Tt}^{*})$ and another that has no role for commodity prices (ℓ_t). It can be observed that world price of a country's key commodity export is positively related to real income. Lastly equation (11) constitutes the real exchange rate equation.

Even though there are three main ways of representing the real exchange rate (Agenor, 2005), the consumer price-related definition suits the purposes of the present modelling effort (Edwards, 1985).

The operation of the model is as follows: an upward movement of the key commodity price leads to higher real income in the exporting country through equation (10) and as a result an increase in demand for non-tradables in the domestic economy via equation (8). Again, through equation (8) the increased demand drives up the price for non-tradables in relative terms; this phenomenon has been described as the spending effect. Higher prices of non-tradables lead to a real appreciation when the real exchange rate is defined alternatively (i.e. $\dot{E}_t \dot{P}_{Tt} / \dot{P}_{Nt}$); thus even without any effects from the monetary or nominal exchange rate, there is an impact on the real exchange rate.

Considering the monetary block of the set of equations higher commodity price leads to increase in real income and also an increase in price of non-tradables. These changes affect both sides of the money relationship (i.e., demand and supply). From equation (4) an increase in real income will push up demand for money. Increased rate of money demand is also produced through an export boom, as can be seen in equations (3) and (1). It can therefore be observed that higher commodity prices may create excess supply or demand for money, subject to the sizes of the parameters of the either the money demand or supply variables respectively. It also seems probable that an increase in commodity price (see equation 8) may affect the nominal price of non-tradables, thus leading to an increase (appreciation) of the real exchange rate. For definitions of $\dot{M}_t$, $\dot{P}_t$ and $\dot{E}_t$ in exogenous terms only, equations (9), (12) and (13) are used. The new representations of $\dot{M}_t$, $\dot{P}_t$ and $\dot{E}_t$ are then combined with $\dot{P}^*_{Tt}$ to produce the reduced forms (see Appendix

2 for derivation of the reduced forms) for estimation of changes in the real exchange rate. Given that $\dot{P}^*_{Tt} = 0$, $z_t = 0$ and $\lambda_4 = 0$, a change in the real exchange rate in period t may be formally written as:

$$\dot{e}_t = -\beta_0 \pi_1 (\gamma_0 - 1)\Delta^{-1}\dot{M}_{t-1} + \beta_0 \pi_6 (\lambda_0 - 1)\Delta^{-1} FD_t - A_1 \ell_t - [A_1 + A_2]\dot{P}^{*C}_t \qquad (14)$$

where,

$$A_1 = [\gamma_2 (1 - \beta_0 (\pi_2 + \pi_4) - \beta_1) + \beta_2 (\lambda_0 - 1) + \beta_0 \pi_3 (1 - \gamma_0)]\Delta^{-1}$$

$$A_2 = [\gamma_1 (1 - \beta_0 \pi_2) + \beta_0 \pi_4 (1 - \gamma_0) - \gamma_1 (\beta_1 + \pi_5)]\Delta^{-1}$$

$$\beta_0 = \frac{(1-\delta)\lambda}{1 + \lambda(1-\delta)} \quad ; \quad \beta_1 = \frac{1}{1 + \lambda(1-\delta)}$$

$$\beta_2 = \frac{(1-\delta)(\lambda\eta - \rho)}{1 + \lambda(1-\delta)} \quad ; \quad \pi_1 = \omega\theta$$

$$\pi_2 = \omega\theta \quad ; \quad \pi_3 = \omega\theta\eta$$

$$\pi_4 = \omega\psi \quad ; \quad \pi_5 = \omega\psi$$

$$\pi_6 = (1-\omega)\phi \quad ; \quad \Delta = 1 - [\beta_0 \pi_2 + \lambda_0 (\beta_0 \pi_5 + \beta_1)]$$

Equation (14) provides a mechanism for tracing the effect of commodity price increase on the real exchange rate. The term A_1 accounts for the spending effect of commodity price change on the real exchange rate. Given that stability demands that $\Delta \succ 0$, the spending effect will lead to real appreciation. Regarding impact of commodity price increase on inflation and the exchange rate and their subsequent effect on the real exchange rate, consider the term A_2. As can be seen in equation (14), there appear to be three distinct transmission channels for impacting the real exchange rate in equation (14). Two of these paths indicate that higher commodity price will lead to a decrease in the real exchange rate (appreciation). However, the third channel suggests otherwise; because $\dot{e}_t$ and $\dot{P}_t^{C*}$ are positively related, an increase in commodity price causes an increase in the real exchange rate (depreciation).

The empirical question therefore is this: of the two opposing forces – i.e., those that give rise to appreciation and that which causes depreciation – which one dominates? Some of the additional assumptions underlying the model building effort include exogeniety of the fiscal deficit and the existence of a single exchange rate regime. These are Herculean assumptions, since the countries being studied have had varying exchange rate experiences. Indeed Ghana operated a dual exchange rate regime for most of the early years of her reforms that started in the 1980s (Kapur *et al.*, 1991) as did South Africa until the early 1990s.

7.5 **Data Issues**

Annual data covering the period 1960 to 2004 were used in the estimation process. Three countries in Africa with varying levels of commodity dependence were selected. These were Ghana for cocoa, Nigeria – crude oil and South Africa – gold. The figures for the real exchange rate, E; money supply, M; consumer price index, P and real GDP, y were obtained from IMF (2005). The price of tradables was estimated as a product of US wholesale price index and the domestic country's exchange rate, this is based on the assumption that the law of one price prevails. Commodity prices, P^{C*} in US dollars, were also obtained from IMF (2006). Fiscal deficit data were also obtained from IMF (2005).

Graphical analyses of the variables used for the empirical estimation provides an insight into the behaviour of the variable series and reveals certain stylised facts related to the variables. All the variables are in logarithms (see figures below). Clearly all the variables exhibit trend terms. Prices of tradables, money supply, consumer prices and fiscal deficit in all three countries surveyed have over the period shown consistent upward trends. From a fairly stable level in the pre-1980s, the post-1980s recorded upward movement in nominal exchange rate, again for all three countries. The point of departure for the countries, though, appears to be trends in real income. Ghana's real income peaked in the early years of her economic reforms in the mid-1980s and then stabilized in the 1990s. Since the late 1980s real income in Nigeria has been cyclical, whilst South Africa saw a steady decline in real income with a certain degree of recovery after 2002.

Figure 7-5. Ghana: Selected macroeconomic variables in logs, 1965-2004

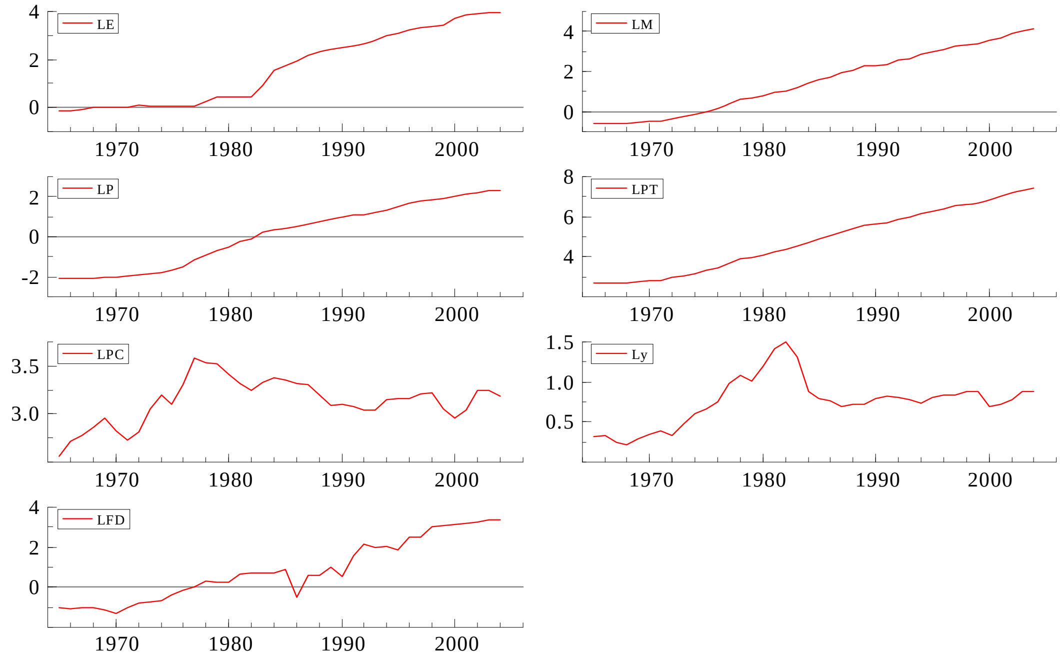


Figure 7-6 Nigeria: Selected macroeconomic variables in logs, 1965-2004

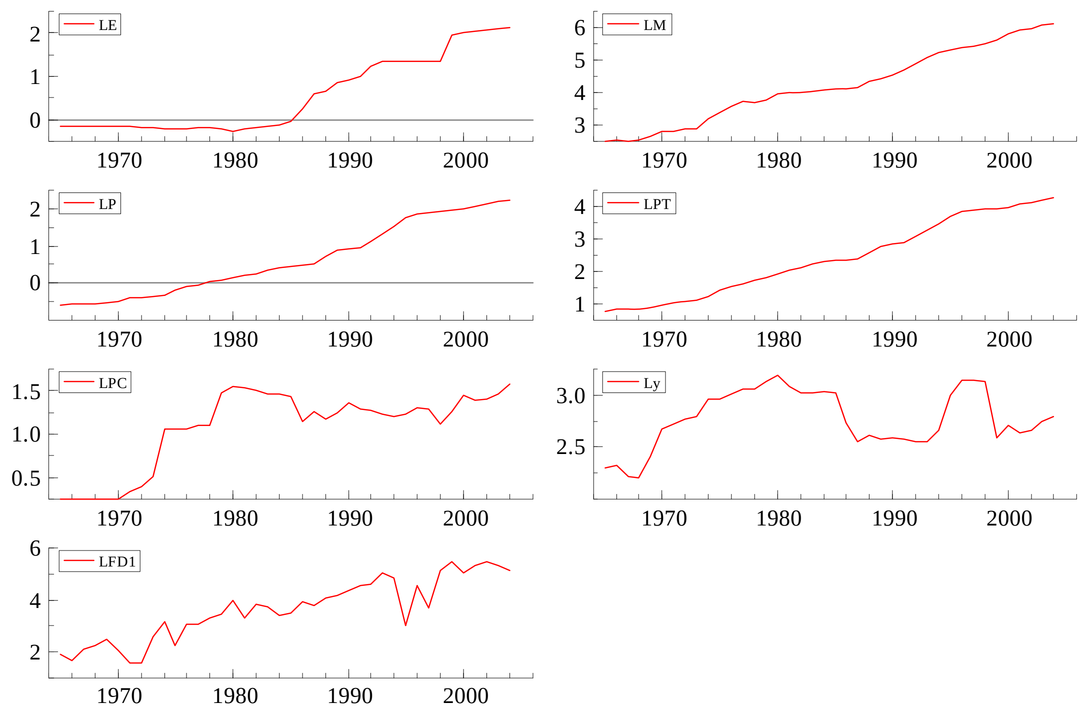
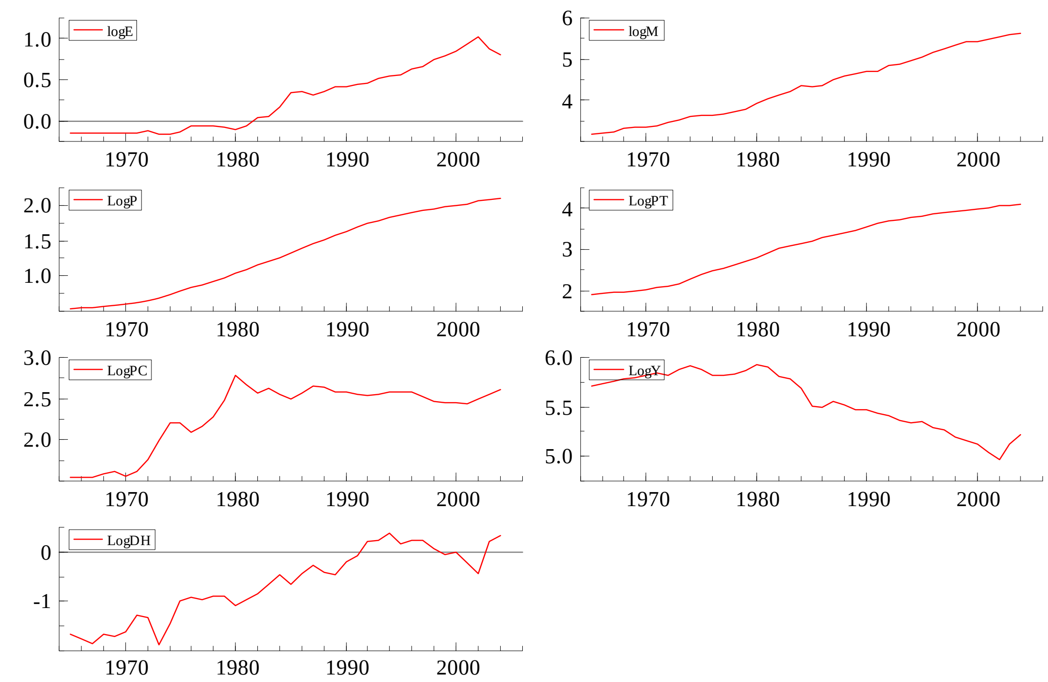


Figure 7-7. South Africa: Selected macroeconomic variables in logs, 1965-2004



7.5.1 Time series properties of variables

Having examined the long-run behaviour of the data series this section of the paper investigates the time series properties of the variables. The augmented Dickey-Fuller unit root test is used. The purpose of this exercise is to examine the roots that characterise the data. This will help in deciding whether to detrend or difference the data series prior to the estimation process (Maddala, 2002). The results of the unit root tests are summarized in the Tables below. The reported test statistics are all less than the critical value at the 1 percent and 5 percent level of significance respectively. This implies that the null hypothesis of no unit root in data series cannot be rejected. Thus there is unit root in the raw data series an indication that the data are non-stationary. However, test results for the first differenced series showed that they all fell beyond the critical values, suggesting a rejection of the null hypothesis of no unit root in favour of the alternative hypothesis. The conclusion is that stationarity in the variables selected for the analysis can be induced by first differencing. The implication for the estimation process is that all the variables enter the estimation equations as rate of change.

Table 7-4. Unit Root Test Results: Ghana, Nigeria and South African

Variable	ADF-Test Variable in levels	ADF-Test Variable in First-differences
Ghana		
Exchange Rate	-2.264	-3.564**
Fiscal Deficit	-2.138	-9.376***
Money	-0.149	-4.168***
Consumer Price Index	-1.435	-3.561***
Cocoa Price	-2.077	-4.552***
Price of Tradable	-1.580	-4.168***
Real Income	-2.195	-3.973***
Nigeria		
Exchange Rate	-1.752	-4.984***
Fiscal Deficit	-1.299	-9.797***
Money	-2.761	-4.291***
Consumer Price Index	-1.566	-3.082**
Crude oil Price	-2.420	-5.691***
Price of Tradable	-2.420	-4.217***
Real Income	-1.957	-5.098***
South Africa		
Exchange Rate	-2.718	-4.539***
Fiscal Deficit	-2.816	-6.318***
Money	-2.585	-5.723***
Consumer Price Index	-1.611	-4.082***
Gold Price	-1.260	-4.929***
Price of Tradable	-0.629	--6.124***
Real Income	-2.695	-4.228***

Note: All the variables were first converted to natural logarithms.
*** Denote null hypothesis of non-stationarity is rejected at the 99 percent level of significance.
** Denote null hypothesis of non-stationarity is rejected at the 95 percent level of significance.

7.5.2 Estimation of empirical model

This part of the paper presents the empirical model and the results from the estimation effort. The Two-Stage Least Square (2SLS) estimators were chosen because of the inadequacy of the ordinary least square estimator for the model used in the present paper. The 2SLS is by definition able to estimate meaningfully models that violate ordinary least square regression (OLS) assumptions of recursivity, among others. The models are also robust enough to provide useful estimates, even when there is possibility of correlation between the disturbance term of the dependent and independent variables. Hasio (1997) observes the robustness of the 2SLS in the presence of cointegration and argues that 2SLS was a consistent estimator with good statistical properties. The empirical equations were estimated with slight medications following Edward (1985) so as to make it easy for tracing the channels of interest. The estimated equations are as given below:

$$\dot{M}_t = \alpha_0 + \alpha_1 M_{t-1} + \alpha_2 \dot{M}_{t-2} + \alpha_3 \dot{M}_3 + \alpha_4 FD + \alpha_5 (\dot{E}_t + \dot{P}_{Tt}^{C*}) + \upsilon_{it} \quad (15)$$

$$\dot{P}_t = \delta_0 + \delta_1 \dot{M}_t + \delta_2 \dot{y}_t + \delta_3 (\dot{E}_t + \dot{P}_{Tt}) + \delta_4 Dum_t + \upsilon_{2t} \quad (16)$$

$$\dot{E}_t = \mu_0 + \mu_1 \dot{P}_t + \mu_2 (\dot{P}_t Dum_t) + \mu_3 P_{Tt}^{*} + \mu_4 P_t^{C*} \mu_5 Dum_t + \upsilon_{3t} \quad (17)$$

7.6 **Results**

The empirical equations represented by equations 15, 16, and 17 with slight modifications following Edwards (1985) were tested with South African data using Two-Stage Least Square (2-SLS) estimation technique. This sub-section of the report discusses the coefficient estimates for Ghana, Nigeria and South.

Statistical properties of the models were evaluated with a range of test statistics in order to validate the results. The models appear to be statistically well specified. In addition to the relatively low residual sum of error square values, there seems to be no evidence of serial correlation (AR Test) and autoregressive heteroscedasticity (ARCH test). The regression also appears to have been well specified, since the assumption that the model was well specified was not rejected (RESET test). However, the assumption about normally distributed errors could not be accepted for the Nigerian model. Generally, it can be argued that the residuals appear to be well behaved. For brevity the results of the battery of diagnostic tests are not reported for each estimated equation. These are fairly standard as the PCGive software generates the results automatically.

7.6.1 Ghana

The results of the estimations for Ghana presented mixed results. Effect of commodity price on money creation in Ghana has been quite marginal, as indicated by the coefficient of cocoa price in the money supply model. A ten percent increase in cocoa price, assuming all other factors given, causes less than 1 percent increase in money supply. Lagged value of money was more potent at influencing money creation (see first column of Table 7-5).Regarding the inflation model all the signs of the coefficient were consistent with the literature. World inflation, money supply and output growth were found to drive inflation in Ghana. For instance, a ten percent appreciation in the exchange rate and/or increase in world inflation will generate a twelve percent increase in inflation in Ghana. However, there was no evidence of a role for cocoa price movement on inflation. In sum, the role of cocoa price changes in the conduct of macroeconomic policy in Ghana appears to be quite marginal. In the case of money creation, where there appear to be a role of cocoa price the pass through of the commodity's price changes seem to be quite low.

Table 7-5. Two-Stage Least Square estimation of model: Ghana

	Money supply (M_t)	Inflation $(\dot{P}_t)$	Exchange rate $(\dot{E}_t)$
Constant	0.062***	-0.033	-0.042
	[2.54]	[-1.40]	[-0.57]
$\dot{M}_t$		2.745***	
		[4.59]	
$\dot{M}_{t-1}$	0.121	-0.024	
	[0.78]	[-0.18]	
$\dot{M}_{t-2}$	0.393**		
	[2.73]		
$F\dot{D}_t$	0.024		
	[1.09]		

$P^{C*}_t + \dot{E}_t$	0.085**		
	[2.67]		
y_t		1.319***	
		[6.20]	
$\dot{E}_t + \dot{P}_T$		1.192***	
		[5.65]	
$\dot{P}_t$			0.15
			[0.47]
$P_t Dum$			0.89***
			[2.70]
$\dot{P}_{Tt}$			0.45**
			[1.91]
P^{C*}_t			-0.10
			[-1.03]
Dum_t		0.02	
		[1.50]	
RSS	0.069	0.052	0.548
SEE	0.049	0.043	0.137

Note: RSS denote Residual Sum of Squares and SEE stands for standard error of the estimated equation

7.6.2 Nigeria

Contrary to the a priori expectation, oil price changes do not seem to have impacted on money supply growth in Nigeria. However, past levels of money creation growth rather determined money growth in the short run. A ten percent increase in output led to a two percent increase in money supply growth. On the other hand, a ten percent rise in lagged money supply growth produced nearly a four percent increase growth in money supply. Results from the inflation equation show that inflation in Nigeria is explained by changes in past levels of money supply growth, output growth and world inflation denominated in naira. A ten percent increase in either the rate of depreciation and or higher world inflation gave rise to a two percent change in domestic inflation when all other factors are held constant. Again, output growth of ten percent generated a four percent increase in the rate of inflation, whereas lagged money supply growth of ten percent also led to a four percent increase in inflation.

The exchange rate model indicates that pass through of oil price changes to the real exchange rate was almost unity, as a ten percent increase in oil price led to a ten percent increase (appreciation) in the exchange rate of the Nigerian currency (see Table 7-6).

Table 7-6. Two-Stage Least Square estimation of model: Nigeria

	Money supply (M_t)	Inflation $(\dot{P}_t)$	Exchange rate $(\dot{E}_t)$
Constant	0.046* [1.36]	-0.012 [-0.76]	0.06 [0.44]
$\dot{M}_t$		-0.150 [-1.35]	
$\dot{M}_{t-1}$	0.354** [2.05]	0.416*** [5.07]	
$\dot{M}_{t-2}$	-0.233 [-1.43]	0.05 [0.46]	
$F\dot{D}_t$	0.024 [1.22]		
$P_t^{C*} + \dot{E}_t$	0.012 [1.32]		
y_t	0.209** [2.42]	0.391** [5.55]	
$\dot{E}_t + \dot{P}_T$		0.151*** [4.48]	
$\dot{P}_t$			2.89 [0.73]
$\dot{P}_{Tt}$			
P_t^{C*}			-0.96* [-1.88]
Dum_t		0.031*** [2.29]	0.15 [1.10]
RSS	0.141	0.036	2.02
SEE	0.069	0.0347	0.27

Note: RSS denote Residual Sum of Squares and SEE stands for standard error of the estimated equation.

7.6.3 South Africa

The results of the model estimation effort using South African data generally seem satisfactory as signs that the coefficients are consistent with theory. However, the level of significance for the money supply equation at 10 percent does not appear to be strong; nonetheless certain indicative inferences can be drawn. First, the money-creation model corroborates the a priori assumption that higher gold prices tend to increase the rate of money growth in the South African economy in the short run. Output growth's effect on money supply growth appears to be very important; however, previous levels of money growth did not affect the rate of money growth. The money-creation model also does not provide any evidence of a role for fiscal policy in money creation (see the first column of Table 7-7).

Unlike the money-creation model, the inflation model presents more interesting results. Apart from the wrong sign of the coefficient of money supply, all the other coefficients of the other variables were statistically significant at the conventional levels of one and five percent levels of significance respectively. The results indicate the strong influence of output growth and rand-denominated world inflation on domestic inflation (see column two of Table below). A ten percent increase in output growth, given that all other factors are held constant, will translate to a four percent increase in inflation. On the other hand, looking at the coefficient of the variable $(\dot{E}_t + \dot{P}_{Tt})$, a ten percent increase in either rate of depreciation and/or world inflation will lead to a four present increase in the domestic price level.

The exchange rate equation was quite difficult to model. However, the reported results which appear to be best among a number of formulations and regressions, considering values of the model estimation best fit measures for instrumental variables namely the sum of residual squares and standard errors of the estimated models. These statistics are reported below the regression estimates in Table 7-7.

Table 7-7. Two-Stage Least Square estimation of model: South Africa

	Money supply (M_t)	Inflation $(\dot{P}_t)$	Exchange rate $(\dot{E}_t)$

Constant	0.018	0.01	0.003
	[0.55]	[1.33]	[1.33]
$\dot{M}_t$		0.03	
		[0.47]	
$\dot{M}_{t-1}$	0.03		
	[0.14]		
$\dot{M}_{t-2}$	0.004		
	[0.02]		
$F\dot{D}_t$	-0.013		
	[-0.35]		
$P_t^{C*} + \dot{E}_t$	0.88*		
	[1.67]		
y_t	1.01*	0.36***	
	[1.86]	[3.96]	
$\dot{E}_t + \dot{P}_T$		0.36***	
		[4.87]	
$\dot{P}_t$			0.20
			[1.21]
$P_t Dum$			-0.59
			[-0.44]
$\dot{P}_{Tt}$			-0.47
			[-0.86]
P_t^{C*}			-0.32***
			[-3.40]
Dum_t		0.14***	0.03
		[2.65]	[0.71]
SEE	0.045	0.011	0.048
RSS	0.059	0.004	0.068

Note: RSS denote Residual Sum of Squares and SEE stands for standard error of the estimated equation

Despite the difficulties, the hypothesis that the gold price drives the nominal exchange change rate in South Africa is confirmed. The results indicate that, assuming all other factors are fixed, a ten percent increase in the price of gold leads to a three percent appreciation in the rand.

7.6.4 Commodity Price and the real exchange rate

The coefficients of the model estimates given in Tables 7-5 to 7-7 represent point estimates. Following Edwards (1985), the point estimates can be combined to produce estimates that are good approximations of how changes in cocoa, crude oil and gold prices on the world market are transmitted to the domestic real exchange rates for Ghana, Nigeria and South Africa respectively. The underlying formulation that combines the coefficients of the money supply, inflation and nominal exchange rate models to obtain the commodity price and real exchange rate relation is given below in equations 18 to 20.

$$\dot{P}_t = \frac{(\alpha_5\delta_1 + \delta_3 + \alpha_4\delta_1)}{(\mu_1 + \mu_2 dum)(\delta_3 + \alpha_5\delta_1)} * \dot{P}_t^C \qquad (18)$$

$$\dot{E}_t = \frac{(\mu_1 + \mu_2 dum)\delta_1\alpha_4 + \mu_4}{(\mu_1 + \mu_2 dum)(\delta_3 + \alpha_5\delta_1)} * \dot{P}_t^C \qquad (19)$$

$$\dot{e}_t = \frac{[(\mu_1 + \mu_2 dum)\delta_1\alpha_4 + \mu_4] - (\alpha_5\delta_1 + \delta_3 + \alpha_4\delta_1)}{(\mu_1 + \mu_2 dum)(\delta_3 + \alpha_5\delta_1)} * \dot{P}_t^C \qquad (20)$$

Drawing on the relationships above, the estimated effect of cocoa, crude oil and gold price changes on the world market on the real exchange rate for the countries considered in the study is as follows:

Ghana

$$\dot{P}_t = 0.41\dot{P}_t^C;\ \dot{E}_t = -0.21\dot{P}_t^C;\ \dot{e}_t = -0.62\dot{P}_t^C$$

Nigeria

$$\dot{P}_t = 0.04\dot{P}_t^C;\ \dot{E}_t = -0.25\dot{P}_t^C;\ \dot{e}_t = -0.29\dot{P}_t^C$$

South Africa

$$\dot{P}_t = 0.64\dot{P}_t^C\,;\ \dot{E}_t = -0.56\dot{P}_t^C\,;\ \dot{e}_t = -1.24\dot{P}_t^C$$

It is important that the results of the above exercise are interpreted cautiously as the results are obtained within the context of a range of assumptions that simplify the analysis. For instances changes in real income and fiscal deficit as a result of changes in commodity prices are assumed away.

One general observation, though, is that cocoa, crude oil and gold price movements tend to have serious implications for the rate of inflation, depreciation and the real exchange rate in the countries considered in the study. Though the estimates obtained can at best be considered as indicative, it appears that gold price movements have much more serious implications for the real exchange rate in South African than the key commodities do for Ghana and Nigeria.

7.7 **Conclusions**

Despite the importance of the need to understand the channels through which commodity price changes affect real exchange rate changes, the research question has not attracted much attention. This paper sought to examine the effect of key commodity export price movement on changes in the real exchange rate in Ghana, Nigeria and South Africa. The Two-Stage Least Square (2SLS) estimator was used in estimating the coefficients of the system of equations constituting the model for each of the study countries.

The results indicate that cocoa price changes have been closely associated with changes in money supply and inflation in Ghana. Concerning the relationship between commodity price increases and the changes in the nominal exchange of the Ghanaian cedi, there was no evidence that cocoa export booms have been related to an appreciation of the nominal exchange rate. In the case of Nigeria, the estimated coefficients of the model suggest crude oil price increases on the world market have been closely related to the rate of money supply growth, inflation and appreciation of the nominal exchange rate. Most strikingly, unlike the other countries, the pass through of crude oil price boom to appreciation of the naira was almost unity. The South African model estimates also produced some notable results. Gold price increases were linked to money supply growth, but the relationship was not significant at the conventional 1 percent and 5 percent levels of significance respectively. The level of significance was rather at the 10 percent level. Hence this part of the result needs to be interpreted cautiously. Nonetheless, in the nominal exchange rate model it was found that one third of the increases in gold price in the short run were passed onto the appreciation of the exchange rate of the rand when all other factors are fixed.

Using the point estimates from the 2SLS modelling, it was also found that in all the countries studied the increases in the key commodity export price were transmitted through an appreciation of the exchange rate. The analysis revealed that the real exchange rate of the South African rand was more sensitive to commodity price than was the situation in the other countries. The policy recommendations that can be drawn from the study are as follows: first, open market operations could be used to neutralise the monetary effects of commodity booms in the countries studied. The second suggestion would be to open up the capital account through limited liberalization so that excess liquidity as a result of commodity booms can be neutralised through outflows of capital.

List of References

Agenor, P-R., 2004. *The economics of adjustment and growth,* 2ed. Cambridge, Massachusetts and London: Harvard University Press.

Broda, C., 2002. Terms of trade and exchange regimes in developing countries. New York: Federal Reserve Bank of New York.

Cashin, P., L. F. Cespedes & Sahay, R., 2004. Commodity currencies and the real exchange rate. *Journal of Development Economics* 75, p. 239-269.

Chen, Y. & Rogoff, K., 2003. Commodity currencies and the empirical exchange rate puzzles. International Monetary Fund, IMF, Washington, D.C.

Corden, M., 1984. Booming sector and the Dutch-Disease economics: a survey. Australian National University Working Paper No. 079. Australia National University

Cuddington, J.T. & Liang, H., 1998. Commodity price volatility across exchange rate regimes. Department of Economics, George Town University. http://www.georgetown.edu/departments/economics.

Chinn, M. & Johnston, L., 1996. Real exchange rate levels, productivity and demand shocks: evidence from a panel of 14 Countries. NBER Working Paper 5907. Cambridge MA: National Bureau of Economic Research.

Deaton, A. & Miller, R., 1996. International commodity prices, macroeconomic performance and politics in Sub-Saharan Africa, *Journal of African Economies* 5 (AERC Supplement), p. 99-191.

De Gregario, J. & Wolf, H., 1994. Terms of trade, productivity and the real exchange rate, NBER *Working Paper 4807.* Cambridge MA: National Bureau of Economic Research.

Edwards, S., 1985. Commodity export prices and the real exchange rate in developing countries: coffee in Columbia. NBER Working Paper No. 1570. Cambridge MA: National Bureau of Economic Research

Gauzier, A., 1996. Prices and output in two oil-based economies: the Dutch disease in Nigeria and Iran. *IDS Bulletin* October, 14-21.

Harberger, A., 1986. Economic adjustment and the real exchange rate in *Economic Adjustment and Exchange Rates in Developing Countries*, edited by S. Edwards, C. Ahmend. Chicago: University of Chicago.

Harberger, A., 1989. Application of real exchange rate analysis, *Contemporary policy Issues* 7, p.1-26.

Hendry, D., 1995. *Dynamic Econometrics*. London: Oxford University Press.

Hsiao, C., 1997. Statistical properties of the two-stage least squares estimator under cointegration. *Review of Economic Studies* 64, p.385-398.

IMF, 2005. International financial statistics. [CD-Rom]. Washington, D.C.: International Monetary Fund.

IMF, 2006. International financial statistics. [CD-Rom]. Washington, D.C.: International Monetary Fund.

Kapur, I., Hadjimichael, M.T., Hilbers,P., Schiff, J. & Szymczak, P., 2001. Ghana: adjustment and growth, 1983-91. International Monetary Fund, Washington, D.C

Madala, G.S., 2001. *Introduction to Econometrics,* 3rd Edition. Singapore: John Wiley and Sons Ltd.

Montiel, P., 1997. Exchange rate policy and macroeconomic management in ASEAN countries, in *Macroeconomic Issues Facing ASEAN Countries,* J. Hinklin, D. D. Robinson and Singh (eds.). Washington, D.C International Monetary Fund:, 253-98

Mendoza, E., 1995. The terms of trade, the real exchange rate and economic fluctuations. *Journal of International Economics* 14, p.3-24.

IMF, 2005. International Financial Statistics. [CD-Rom]. Washington, D.C.: International Monetary Fund.

Obstfeld, M. & Rogoff, K., 2000. New directions for stochastic open economies, *Journal of International Economics* 50, p.117 –53.

Olomola, P. A. & Adejumo, A. V., 2006. Oil price shocks and macroeconomic activities in Nigeria. *International Research Journal of Finance and Economics,* 3

Sadoulet, E. & de Janvry, A., 1995. *Quantitative Development Policy Analysis.* Baltimore and London: Johns Hopkins University Press.

Sanidas, E., 2005. The Australian dollar's long-term fluctuations and trend: commodity prices-cum-economic cycle hypothesis. Department of Economics Working Paper, No. WP05. University of Wollongong.

Spatofora, N. & Warner, A., 2001. Macroeconomics and sectoral effects of terms-of- trade shocks, the experience of oil-exporting developing countries. *IMF Staff Paper* 134/99.

UNCTAD, 2003. Economic development in Africa: trade performance and commodity dependence. Geneva: United Nations Conference on Trade and Development, United Nations.

Appendix 1

Even though there several definitions of the real exchange rate we The real exchange rate, *RER* used in the study is as given in Sadoulet and Janvry (1995). Unlike other definitions this index measures the real price of the dollar with adjustments in changes in the value of the dollar.

$$RER = \left(\frac{e}{e_0}\right)\left(\frac{p_i^{\$}}{p^d}\right) \qquad \text{(A.1)}$$

where, e_i = nominal exchange rate (Local Currency Unit per unit foreign currency); e_o = base year nominal exchange rate; p^d = country's own consumer price index and $p_i^{\$}$ = general price index of dollar prices on the world market;

Appendix 2.

The addition of equations (10), (11) and (12) in producing the reduced form solutions for $\dot{M}_t, \dot{P}_t$ and $\dot{E}_t$. The underlying assumption in the derivation of the reduced form solutions is that $\dot{P}_{Tt}^{*} = 0$. It also assumed that real output growth includes both the commodity price induced component and an exogenous component, ℓ.

$$\begin{aligned}\dot{M}_t &= -\pi_1(1-\gamma_0\beta_1)\Delta^{-1}\dot{M}_{t-1} + \pi_6(1-\gamma_0\beta_1)\Delta^{-1}FD_t \\ &\quad + [\pi_4(1-\gamma_0\beta_1) - \gamma_1(\pi_2\beta_1 + \pi_5)]\Delta^{-1}\dot{P}_t^{C*} \\ &\quad - [\beta_2(\pi_2 + \gamma_0\pi_5) + \lambda_2(\pi_2\beta_1 + \pi_5) - \pi_3(1-\gamma_0\beta_1)]\Delta^{-1}\dot{y}_t \qquad \text{(A.2)}\end{aligned}$$

$$\begin{aligned}\dot{P}_t &= -\beta_0\pi_1\Delta^{-1}\dot{M}_{t-1} + \beta_0\pi_6\Delta^{-1}FD_t - [\beta_2 + (\pi_5\beta_0 + \beta_1)\Delta^{-1}\dot{y}_t \\ &\quad + [\beta_0\pi_4 - \gamma_1(\pi_5\beta_0 + \beta_1)]\Delta^{-1}\dot{P}_t^{C*} \qquad \text{(A.3)}\end{aligned}$$

$$\dot{E}_t = -\beta_0\gamma_0\pi_1\Delta^{-1}\dot{M}_{t-1} - [\gamma_1(1-\beta_0\pi_2) - \beta_0\gamma_0\pi_4]\Delta^{-1}P_t^{*C}$$

$$\beta_0 = \frac{(1-\delta)\lambda}{1+\lambda(1-\rho)} \quad ; \quad \beta_1 = \frac{1}{1+\lambda(1-\rho)}$$

$$\omega_2 = \frac{(1-\delta)(\lambda\eta-\theta)}{1+\lambda(1-\delta)} \quad ; \quad \pi_1 = \omega\theta$$

$$\pi_2 = \omega\theta \quad ; \quad \pi_3 = \omega\theta\eta$$

$$\pi_4 = \omega\psi \quad ; \quad \pi_5 = \omega\psi$$

$$\pi_6 = (1-w)\phi \quad ; \quad \Delta = 1-[\beta_0\pi_2 + \gamma_0(\beta_0\pi_5 + \beta_1)]$$

CHAPTER EIGHT

8 CONCLUSIONS AND RECOMMENDATIONS

A review of the literature on the pace of economic development in Sub Saharan Africa suggests that the region has fallen behind the rest of the world. While the literature is unanimous on the fact that growth outcomes have been poor, a number of competing reasons have been assigned to account for Africa's slow growth over the years. A close look at the set of reasons indicate that in more ways than one, commodity markets have been identified as having a possible role in explaining the poor economic performance over the years. The present study therefore set out to examine how commodity markets influence economic development.

The broad objective of the study therefore was to investigate how commodity price behaviour affects various macroeconomic variables that underlie economic growth in SSA. The study considered eighteen primary commodities exported by most countries in Sub-Saharan Africa. The commodities were drawn from metals, agricultural raw materials, food and energy sub-groups. The study results are presented in six stand-alone essays. Three essays focused on individual countries, another essay looked at a cross-section of 34 countries while the remaining two dwelt on certain aspects of the price behaviour of the key commodities of interest to most SSA countries.

First the relationship between commodity markets and economic growth was studied. The second essay examined trends and volatility in Sub-Saharan Africa's key commodity prices over the past four decades. Role of commodity prices in macroeconomic policy formulation in South Africa was assessed using a new research approach. The fourth essay estimated the supply response of a number of tradable and non-tradable agricultural commodities in Ghana. In the fifth essay a range of volatility forecasting models were evaluated using spot prices of eighteen commodities. The last essay examined the interaction between changes in commodity prices, money supply, inflation and the real exchange rate in Ghana, Nigeria and South Africa.

In determining the relationship between the degree of commodity dependence and economic growth panel data analysis was used as the estimation technique. The commodity price trends and volatility essay was undertaken using time series analysis based on the ARCH-family of models. Cointegration and error correction modelling was used in the estimation of the supply response of agricultural commodities in Ghana. In examining the possible role of commodity price in monetary policy formulation in South Africa, the Wald test was used. The essay on volatility forecasting model evaluation was undertaken with seven models that included both linear and non-linear models. Lastly, the channel through which commodity prices changes were transmitted to the real exchange rate was investigated using an instrumental variable estimation model, the two-stage least square estimator.

The findings of the study indicate that a negative relationship exists between the extent of primary commodity dependence and economic growth. The results of the study suggest that the extent of commodity concentration matter as far development outcomes are concerned. It is therefore suggested that individual countries broaden the range of commodities that they are currently engaged in, at least in the short to medium term. This policy recommendation is particularly relevant for countries in the region that depend on a very narrow range of commodities such as Malawi which is mostly dependent on tobacco, tea and sugar. It is important that countries such as Malawi consider the possibility of adding on non-traditional exports so as to increase their export base.

The study also revealed that volatility levels have not changed for nine out of the eighteen commodities examined however, changes were observed in the other nine. The need for primary commodity diversification has been mentioned in a number of studies over the years. In the present study however, it's argued that diversification should be informed by the historical relative price volatility of commodities. This study has identified commodities that have recorded reduced price volatilities over the past forty years and it is hoped these commodities may be considered when deciding on which commodities to diversify into.

Another key finding of the essay was that there is merit in using gold and metal prices as variables in forming monetary policy in South Africa. The main objective of the central bank is to ensure price stability; however, the bank considers a range of targets to help form the basis of monetary policy stance. The work affirms that gold and metal prices need to be factored in the monetary policy forecasting models used by the bank. If the bank already has these commodity prices in her models the study outcome is an affirmation if it's not presently done then it may be worth considering.

Results of the supply response essay imply that even though producers usually respond to price incentives, structural features of domestic agricultural commodity markets in Ghana may have hindered the conversion of improved incentives to higher agricultural growth. The outcome of the this work demonstrate that in Sub Saharan African countries that have not benefited from improved price incentives as a result of the reforms in the agricultural sector there may be a need to look at the issue of transaction cost. High transaction costs as a result of the poor state of rural infrastructure may be reduced by additional investment to improve the state of rural roads as well as the provision of marketing infrastructure such as storage facilities among others. Reduced transaction cost can increase the overall incentive to produce; this approach could be more suitable than the provision of subsidies to producers as a means of stimulating increased output.

It was also observed that random walk and autoregressive models consistently outperform more complex models in forecasting volatility in commodity spot prices. This outcome further underscores the sheer difficulty in predicting commodity price volatility. Nonetheless, the point is made that sophisticated models may not necessarily be more appropriate in forecasting volatility in spot market prices.

Results of the last paper indicate that in Ghana commodity price increases impact money supply growth and inflation whilst in Nigeria the effects of crude oil price increases produces higher inflation and appreciation of the real exchange. In the case of South Africa the effects of gold export booms were transmitted through changes in money supply, inflation and real appreciation of the domestic currency. The results of the study have implications for both decision makers in business and government. The study therefore underscores the important role that commodity price changes can play in monetary policy formulation.

In sum, the following general policy recommendations may also be considered for countries in Sub Saharan Africa;

1. Domestic and international policy initiatives must assign a far greater importance to the need for diversifying Africa's exports. Second, since it is unlikely that major shifts in the composition of exports can occur in the short to medium-term the removal of general anti-export biases in African countries' domestic policies, as well as initiatives to promote more competitive prices for traditional exports must be pursued.

2. The withdrawal of the state from direct commercial activities related to commodity markets should not be interpreted as the withdrawal from the important role of providing public goods that facilitate activity in domestic commodity markets. Governments and international development partners need to halt and possibly reverse the declining investments in agricultural commodity research among others. Additional investments in transport infrastructure and the promotion of sustainable use of natural resources, development of public services such as market information, plant protection and disease control may all go a long way in creating the non-price incentive required to stimulate increased primary commodity production.

3. The Africa's development partners can also play a role in assisting countries to access risk management instruments. Research should be funded on programs and policies that complement small-holder attempts to self-insure against commodity price fluctuations. For example research into limits of self-insurance may be required. The international development partners can also be more active in providing technical assistance and strategy advice regarding the design and implementation of risk management instruments. For instance advice on regulatory, institutional and policy reforms that would facilitate the use of risk management instruments is required. Finally, international financing institutions should think about ways to extend limited markets. Such help should include combining risk management instruments with their lending products.