Thesis
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UNIVERSITY OF KHARTOUM
FACULTY OF ECONOMIC AND SOCIAL STUDIES
DEPARTMENT OF ECONOMICS

The Sources of Macroeconomic Fluctuations in Sudan

March, 2000

IN THE NAME OF ALLAH
THE MERCIFUL THE COMPASSIONATE

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"Whoso does not thank people will not thank Allah" (S.A.W.)

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Abbreviations

ADF	augmented Dickey-Fuller
AIC	Akiake information criterion
ARMA	autoregressive-moving average
CPI	consumer price index
CV(s)	cointegrating vectors
DF	Dickey-Fuller
GDP	gross domestic product
GIR(s)	generalized impulse response(s)
HPF	Hodrick-Prescott filter
I(d)	integrated of order d
IID	independently and identically distributed
M1	narrow money
M2	broad money
MBN	modified Beveridge and Nelson
PPP	purchasing power parity
SBC	Schwarz Bayesian criterion
S.E.	standard error
VAR	vector autoregression
VECM	vector error-correction model/mechanism

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SUMMARY

Modern theoretical and applied macroeconomics focuses on developed capitalist economies, and its empirical techniques draw heavily from the experiences of these economies. However, progress along these lines drawing from the experiences of the developing countries is currently gaining momentum.

This thesis attempts to study the sources of the Sudanese macroeconomic fluctuations. It starts by motivating the argument. It presents the literature review on the macroeconomic fluctuations, or one would say, the macroeconomics of fluctuations. The main purpose of this literature review is to facilitate the design of the empirical study and to guide its interpretation.

In the light of this , the study proceeds to document the stylized features, as well as the sources of, the Sudanese business cycles fluctuations over the last 44 years. Various cross correlations between domestic output and the key macro aggregates are examined. A theoretical framework pertinent to the analysis of the small open economy model is 'pieced' together in order to examine the main internal and external past macroeconomic developments in the Sudan. The long term equilibria, or equilibrium correction models (ECMs), in the 'internal' output-money-inflation nexus and the 'external' domestic price-foreign exchange nexus is estimated using the cointegration technique. The resulting relationships

from both the cross correlation and the cointegration analysis indicate many similarities between the Sudanese macroeconomic experience and other experiences and, more important, provide a framework for evaluating alternative policy scenarios. The main results of the empirical study could be summarized in the following:

First, the cross correlations examination of macroeconomic fluctuations shows countercyclical behaviour of domestic price and velocity and procyclical variation in the international trade. These results fairly compare with the empirical evidences from the research on business cycle fluctuations in other developing countries.

Second, there exists a stable long run demand for money type of relation between real GDP, money and the general price level as well as a long run relationship between domestic price and the exchange rate. The examination of the short run dynamics of the model in these relationships implies that shocks to the nominal money (money surprise) have small impact on output and are almost inflationary. Likewise, shocks to the foreign exchange, tends to trigger 'a more than proportionate' response in domestic price. The analysis of the persistence of the variable-specific and system-wide shocks indicates that the short run may be 10 years, a quite long period of time as a short run.

Finally, the main policy implications of the analysis is that demand management programme may be inefficient and could produce painful

consequences. Instead, a supply-oriented policy programme aimed at reducing rigidities, promoting efficiency and enhancing the human capital capabilities of the economy would be a better policy programme to manage the Sudanese economy.

بسم الله الرحمن الرحيم

ملخّص

يتركز معظم العمل النظرى والتطبيقى للاقتصاد الكلى فى الدول الراسمالية المتقدمة، وايضاً تعتمد تقنياته الاميبريقية على تجارب هذه الدول. الملاحظ تزايد الرغبة فى الآونة الأخيرة لتطوير تطبيقات في هذا المجال من التحليل لدراسة تجارب الدول النامية. يعتبر هذا البحث محاولة في هذا الإتجاه، وينهد لدراسة مصادر التقلبات للاقتصاد الكلى السودانى.

يبدأ البحث باستعرض الادبيات فى مجال تقلبات الإقتصاد الكلى. بهدف توجيه إجراء الدراسة التطبيقية و تفسيرها. علي ضوء هذا، يوثق البحث الملامح الأساسية وكذلك مصادر التقلبات لدورة الاعمال السودانية على مدى الـ ٤٤ عاماً الأخيرة، وذلك أولاً، عن طريق إختبار الارتباطات التقاطعية بين التغيّر الدورى للناتج المحلى، كدليل لدورة الاعمال، والتغيّر الدورى للمتغيرات التجميعية الاساسية و تشمل؛ الأسعار المحلية، و التضخم، و النقود، و دوران النقود و الميزان التجارى. وثانياً، عن طريق توليف إطار نظرى يلائم تحليل نموذج الإقتصاد الكلى المنفتح للقطر الصغير، بهدف اختبار الروابط الاساسية الداخلية والخارجية، التى يقول بها هذا النموذج، لتطورات المتغيرات التجميعية للإقتصاد وذلك بتقدير وفحص توازنات الامد البعيد، و النماذج التصحيحية المصاحبة– فيما يعرف بنماذج الاخطاء التصحيحية– للرابطة الداخلية بين الناتج المحلي و الأسعار المحلية و النقود، والرابطة الخارجية بين الأسعار المحلية و الأسعار العالمية (أو سعر الصرف الخارجي) و كذلك التقدير الآنى للرابطتين معاً.

تشمل كل طرق هذا التوثيق إجراء تسويات لتوحيد وحدات القياس و المتغيرات المستخدمة. خاصة إذا إتضح أن هذه المتغيرات غير ثابتة وأنها تتحرك معاً عبر الزمن بشكل ثابت.

عموماً تدلل العلاقات المقدرة، الناتجة عن تحليل الروابط التقاطعية وعن تحليل الروابط الداخلية والخارجية، علي تشابه تجربة الإقتصاد الكلى السوداني وتجارب الدول النامية فى هذا المجال. الأهم من ذلك، تقدم هذه العلاقات إطاراً عاماً يمكن الأستفادة منه لتقييم السياسات المغايرة.

يمكن إ يجاز أهم ما توصلت اليه الدراسة من نتائج في الآتي:-

أولاً، أوضحت نتائج الإرتباطات التقاطعية بين دورة الأعمال والأسعار المحلية، وكذلك سرعة دوران النقود إرتباطات معاكسة للدورة. بينما أوضحت التجارة الخارجية إ رتباطاً مؤيداً للدورة. عموماً يعتبر الإرتباط السالب بين دورة الأعمال والأسعار المحلية دليلاً على أهمية جانب العرض كمصدر للصدمات. علاوةً على ذلك فإن إتجاه لإرتباطات بين دورة الأعمال و كل من الأسعار المحلية، والنقود، و دوران النقود تعطى بيّنة لملاءمة المنهج النظرى الذى يتضمّن النظرية الكمّية للنقود لتفسير البيانات التى تضمنتها الدراسه، وفى توجيه النمذجة المُستقبليه لعناصر هذه الرابطة الداخلية.

ثانياً، أوضحت نتائج تقدير نماذج التوازن التصحيحية، بطريقة المتجهة المُسوية للارتباطات الذاتية، أن هناك علاقة ثابتة علي مدي فترة تقدير هذه النماذج بين متغيرات الرابطة الداخلية، أي الناتج المحلي الحقيقي، النقود والمستوي العام للأسعار المحلية. وكذلك بين متغيرات الرابطة الخارجية، أي المستوي العام للأسعار المحلية والأسعار العالمية. كما أوضحت إختبارات السلوك الديناميكي للعلاقات المُنمذجة في الأمد القريب أن إستجابة الانتاج المحلي لبعض الصدمات، مثل صدمات النقود الإسمية (الضخ المُفاجيء للنقود) وكذلك صدمات الاسعارالعالمية ضئيلة. الأهم من هذا، إن مثل هذه الصدمات لها آثار تضخمية في الغالب. وأيضاً، أوضحت نتائج تحليل إستمرارية أثر الصدمة علي مستوي المتغيرات-المُفردة المقدرة وعلي مستوي النموذج ككل، أن المدي الزمني الذي تستغرقه المتغيرات لتعود لحالة التوازن جراء الصدمة قد يكون عشر سنوات، الامر الذي تصعب تسميتة أمداً قريباً.

أخيراً، توضح دلالات التحليل في هذه الدراسة- علي مستوي وصف السياسة وإتخاذ القرار- أن السياسات التصحيحية التي تقوم علي إدارة الطلب التجميعي غيركفؤة، وقد تولد آثاراً ضارة. عليه، فالسياسات التي تتجه لجانب العرض هي البديل المناسب لإدارة الإقتصاد السوداني، خاصة تلك التي تهدف لتطوير رأس المال البشرى و لتفتيت مناطق التحجر، وتفعيل كوامن الكفاءة التشغيلية للإقتصاد.

CHAPTER ONE
INTRODUCTION

Bevan *et al* (1994) started their book with the observation that, most of the research on modern macroeconomics originates in the industrial countries of north America, Europe and Japan. Applied work uses data relating to these economies and the theoretical work assumes silent economic structure pertinent to these developed capitalist countries.

This observation implies that the theoretical and applied macroeconomics are under-researched in the context of the less developed countries. In other words, these issues seem to come in the second order of rating in the 'development economics', as a sub-discipline closely relating itself to the LDCs. It is arguable that at the birth of the sub-discipline, the main concern is with the study of the long run growth in a view to determine the *per capita* income in the LDCs. Whether growth is development, or not, is one of the issues that extensively discussed in this literature. To the extent that development economists concern themselves with growth, which is about the supply side of the economy and the long run, little attention has been paid to the short run macroeconomic analysis, in particular demand management. The structuralist approach, as one strand of the development economics, is an exception. The structuralists, maintain a prolonged polemic with the neoclassical economists. Traditionally the explanation of the sources of inflation persistence and price fluctuations in the LDCs is one of the central issues in the structuralists and neoclassical debate. The structuralists emphasize various domestic price rigidities and thinness of markets in the economies

they investigate while the neoclassicals tended to make little allowance for such issues.

It is only recently when confronted with problems of bad macroeconomic management and growth of excess capacity in addition to pressures from the donors and international lending institutions, that medium to short term macroeconomic management started to dominates the agenda in development discussion. Since then, many LDCs experienced dramatic macroeconomic events and tend to apply wide policy programmes in an alarming vacuum of comprehension (Bevan *et al* 1994). This situation has arisen because both the structuralist and the neoclassical approaches are right. Theory must be tailored to structure in order to be applicable, as alleged by the structualists, but this exercise is *a* theoretic since it is not about optimizing behaviour as maintain by neoclassicals. On this matter, Bevan *et al* (1994) argued that, the misgiving of most structuralists can be accommodated within the neoclassical methodology.

However, whether the structuralism, since its high tide in 1950s has re-entered the mainstream of economic thought or faded from the conscious of the profession is beyond the scope of this work. Even before Bevan *et al* (1994), Lall (1985) had an elaborated argument calling for the immediate demise of the theoretical corpus called 'development economics' as a necessary condition for the health of economic theory and the economies of the LDCs.

We do not intend to launch a defense for structuralism or 'development economics' here. However, we would like to point that Bevan *et al* (1994) and Lall's (1985) type of arguments are acceptable only from a

strict pure theory point of view. In this sense it seems that development economics does not live in isolation, most of the issues treated in this sub-discipline on the macroeconomic performance of the LDCs were in tandem to issues raised in the mainstream theory. The following cursory chronology my suggests so. The beginning of modern macroeconomics could be dated to the famous models of business cycle introduced by Samuelson (1939) and Hicks (1950), which instigated an intensive research on economic growth models in the aftermath of the second World War. This development has resonated in Lewis (1954) growth model for development with unlimited supply of labour. And in a variety of growth models developed for the LDCs *a' la* Harrod (1949) and Domer (1947) types of growth models.

In the 1960s the LS-LM model was the workhorse of macroeconomics, this framework was soon adapted to the situation of the LDCs (see Taylor 1983). As the economist became adapted to the analysis of the dynamics associated with assets accumulation, the limitations of the static IS-LM became evident, especially with the increasing recognition of the importance of expectations - particularly inflationary expectations. As such from mid 1970s to 1980s macroeconomics was dominated with forward looking nature expectations and with the need to provide models with firm microfoundations, that is, models derived from some form of optimization behaviour. Perhaps these developments were behind the resurgence of the new structuralism aided with mathematical idioms. The main argument is that, economists long ago learned that mathematical formulations of their problems help clear away logical and methodological cobwebs. There is no reason not to apply these tools to models for LDCs. In both Taylor (1979 and 1983) there is structuralist

macroeconomic models which incorporate disequilibrium analysis and rational expectations approaches.

Nonetheless, the drift towards the mainstream theory, perhaps, is dictated by the development of economics into a closed technical discipline with the aid of logical positivism. Such an inclination is procedurally acceptable since it helps to demarcate those phenomena which economics capable to explain from those which it not. It is accepted that prediction is an important enterprising in economic theory, and it must be grounded in an empirically sound rule, or to use Hoover 's (1988) words 'determinate laws'. It remains to ask which theory? The answer to this question is again beyond the scope of this work. However, in this regard, it is illuminating to quote Han and Hollis (1975) that; 'when economists think of economics, they usually have a particular kind of pure theory in mind. This is the class of theories predominantly taught in western universities and often called neoclassical (Han and Hollis 1975, p.1)'.

Even if one is to follow this wisdom, and be that as it may, the dispute within the mainstream theory is not less polemical. One of the issues which generates raging debate today as it did with the birth of modern macro theory, is the sources and prorogation of economic fluctuations. As we will see in the next chapter, there are two schools of thought: the classical school emphasizing that, starting from an initial resource endowment, private agents optimize through adjustment of relative price, and the outcome is Pareto efficient allocation of resources. And the Keynesian school which, argues that understanding economic fluctuations requires not understanding the intricacies of general equilibrium, but also appreciating the possibilities that markets do not clear. The argument is

whether, or not, disequilibia are transient, and hence equilibrium models are adequate to explain observed phenomena. At the expense of reductionism, one may say that the classical accept the argument and the Keynesian reject it (see Mankiw 1989).

Generally speaking it is often alleged that, of all the disequlibria in the economy, business cycles, the fluctuations of output, the general price level and related aggregates, about their trends are perhaps the most important[1].

Lucus (1977) opens his classic article "Understanding Business Cycles" with the question, "why is it that, in capitalist economies, aggregate variables undergo repeated fluctuations about trends all of essentially the same character?"[2]. Perhaps Lucas raised the question in speculation of a unified explanation of business cycles grounded in rules or 'determine laws' that governed the market economies, developed or developing. Further to this, Lucas (1977) maintains that understanding business cycles is the first step in designing appropriate stabilization polices. It is widely acknowledged that Lucas's classical work had instigated a sort of a revolution in business cycle research. Particularly, in relation to the understanding of the various factors affecting the short run as well as the long run behaviour of macroeconomic financial time series, which has toped the agenda of quantitative macroeconomics in recent years. Although, virtually all recent research in this area has focused on developed countries, there is a growing interest in documenting empirical

[1] Henceforth we use business cycle and fluctuation interchangeably.

[2] Quoted in Campbell and Mankiw (1987).

regularities in macroeconomic fluctuations in the LDCs. To cite a few examples, Hottmaister and Roldós (1997) start their study by posing a question similar to the earlier one posed by Lucas: "Are Business Cycles Different in Asia and Latin America?". Their empirical study suggests that; a) the main source of output fluctuations is supply shocks , b) the real exchange rate is driven by fiscal shocks, and c) the terms of trade shocks are important in explaining trade balances fluctuations. Hottmaister *et al* (1998) extend the inquiry to study the sources of macroeconomic fluctuations in sub - Sahara Africa. Their results suggest that, differences in the economic structures, *per se*, do not explain differences in macraeconomic fluctuations. And that, the macroeconomic fluctuations in the group of the countries they studied are fairly similar to those in other developing countries, particularly in Latin America. Agner *et al* (1999) document the main stylized features of macroeconomic fluctuations for twelve developing countries. Their empirical findings indicate many similarities between the macroeconomic fluctuations in the developing and the developed countries. For example, the procyclical real wages, the countercyclical variation in government expenditures, and some differences, for example, the countercyclical variations in the velocity of money aggregates.

1.1. The Objectives of the Research

As noted above, the explanation of, and the distinction between, the different sources of the business cycle fluctuations are crucial for designing stabilization and adjustment programmes. The traditional Keynesian interpretation of the macroeconomic fluctuations, as shown by Blanchard and Quah's (1989) influential paper, suggests that, in the short

run, aggregate demand shocks move output and prices in the same direction, while supply shocks move them in the opposite direction. In the long run, the effect of demand shocks are reflected mostly in prices and wages not in output. Aggregate supply shocks - or productivity shocks - are likely to have long run effects on output. Thus movements of output are dominated by demand shocks in the short run, and hence from the policy point of view, demand management would be the right tool to use. In the long run, supply shocks will dominate and demand shifts will be reflected in prices. This traditional view of the business cycle have come under criticism. It has been accused of being, at least, empirically flawed for not capturing important aspects of the data. Blanchard and Quah (1989) found that many of the Untied States time series were consistent with stochastic growth models. Their answer to the question that, whether the United States aggregate time series are consistent with the traditional interpretation of fluctuations, is largely, but not entirely positive. Nelson and Plosser (1982) and Watson (1986) established similar results from the United State data. As such, the standard Keynesian analysis tends to over state the importance of demand shocks as a source of business fluctuations. No doubt that, these issues are highly pertinent to the policy making process. For example, on the one hand, if output fluctuations are deemed undesirable and demand shocks are responsible for them, accordingly, there may be a role for government policy to curb these fluctuations. On the other hand, if output fluctuations can be explained by supply shocks then, the appropriate policy for the government is to build reputation about its policies rather than using demand management.

The broad objective of this research is to document some stylized features of the Sudanese business cycle, more important, to speculate on the study of the long run equilibrium relationships relating to the behaviour of domestic prices. In order to motivate this broad objective we consider the following:

1. The examination of the cyclical properties of the Sudanese financial time series. The contemporaneous correlations between the stationary components of output, price, money and other related aggregates, will be examined as well as the various cross correlations at leads and lags.

2. The examination of the long run equilibrium relationships relating to domestic prices, a demand for money and purchasing power parity. With regard to the former relationship, in general models of the determinants of inflation in the LDCs often postulate a demand for money function and then examined how excess money supply leads to swelling of prices. With regard to the latter relation, the explanation of the equilibrium real exchange rate in these countries starts by postulating a variety of fundamentals, that are based on models derived from the balance of payments, or reduced form equation. In this work we attempt a joint modeling of these long run equilibrium relationships.

3. The unexplained portion of the movement of the system of the variables, relevant for analysis in 2 above, will be given a structural interpretations, through theory - based identification of the patterns of residuals correlations, in order to highlight the economy's propagation mechanism. That is, we assess the short run comovements among the

variables following different types of shocks and their policy implications.

1.2. The Justification of the Research

Despite growing interest in quantitative macroeconomic analysis, the application of such type of studies in the Sudan is less than adequate. Perhaps, the limitation of the data quality and frequency is one of the main reasons that makes the exercise in quantitative macro modeling for the Sudan so demanding. Another general discouraging reason mentioned in the literature is that, in agrarian economies, prone to natural crises as the case of the Sudan, macro variables tend to exhibit 'capricious' behaviour adding to the complications of discerning any type of the 'usual' economic regularities and stable relationships, as would be predicted by a model describing a 'pure' competitive economy[1]. However, this thesis makes an attempt to document the stylized features of the Sudanese business cycles and to speculate on the sources of fluctuations in the level of the economic activities. As pointed earlier, the outcome of such type of studies may be informative, for example, in terms of the design of appropriate stabilization pogrammes.

We will use annual data over the period (1955 - 1998) in order to have a relatively long time series so that asymptotic theory can work and hence reliable statistical inferences could be descend. The difficulties of working with such type of series and their resolutions will be discussed in the empirical part.

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[1] In this case, as indicated by Blanchard and Fischer (1989), the explanation of the macroeconomic fluctations could be based on agricultural cycles.

The rest of this thesis will be organized as follows: Chapter (2) provides an overview of the literature in order to set the context and to motivate the design of the specification search. Chapter (3) presents the methodology to be followed in the analysis. Chapter (4) contains the quantitative analysis. It shows the characteristic features of the economy under study and the data set. It also presents an elaborated discussion of the properties of the Sudanese business cycle, the nature of the long run macroeconomic relationships chosen for analysis as well as the properties of the short run dynamics of the system following different types of shocks. Chapter (5) presents a brief summary of the main findings and the conclusion.

CHAPTER TWO
LITERATURE REVIEW

The explanation of the fluctuation in the level of income, prices and employment is one of the major themes in macroeconomics. This chapter provides an overview of the literature on this theme. Despite the considerable conceptual innovations and the enhanced analytical and empirical techniques that developed macroeconomics as a sub-discipline, two views have persisted on macreconomic behaviour. Traditionally, one view is associated with Keynesian approach and the other with the classical approach. Currently, the protagonists are the new-Keynesians, espoused by coordination failure and imperfect markets theorists , and the neoclassicals, espoused by equilibrium business cycles theorists.

The stand taken here is not to give detailed history of these approaches and the maintained controversies or even to account for the intricacies of the development of the sub - discipline, but to use these two approaches as an organizing framework that systematizes our 'whirlwind' literature review on the macro theme selected for this study. As such, our literature review will be selective and geared more towards the explanations of the fluctuations in the level of the economic activities and the empirical techniques used in that analysis. The main idea is to identify the theoretical and the empirical sources that we draw upon for the design and the interpretation of this research.

2.1. The Keynesian and the Classical Views of Economic Fluctuations

The Keynesian economics was born into the great depression of 1930s. The central issue was stimulation of aggregate demand in the face of falling prices. While there was an awareness that stimulating demand in the face of full employment could result in inflation, full employment was seen as far away. In the aftermath of the second World War, the industrial economies were, by and large, fully employed. The absence of an articulated theory of inflation presented the first challenge to the Keynesian economics. The Phillips curve, which relates the rate of inflation to the level of unemployment was adopted to fill the gap. Thus, fiscal and monetary policies could be used to stimulate the level of aggregate activities, inflation would occur if aggregate demand was stimulated excessively and unemployment results if demand was deficient.

The Philips curve was fully integrated into macroeconomics and seen as providing a trade-off between inflation and unemployment that policy makers can exploit. The research into quantity constraint macro, or fixed price equilibrium macro, was undertaken to fill in the details in a view to give a coherent microfoundations for the aggregate behavioural relationships posited by the Keynesian framework. (see Hoover 1988 and Plosser 1989). As such, the widely held view, in the Keynesian tradition, about the business cycles is that, market imperfections were the main cause of the sharp fluctuations in output and employment. This approach to the explanation of fluctuations in aggregate activities, as argued in the literature, is miss leading, since macroeconomic fluctuations can be explained without involving imperfections. The intellectual origin

of this argument goes to the per-Keynesian economic thinking. However, the early objections to the Keynesian reasoning, that were widely held as giving birth to the neoclassical economics, were made by Friedman (1968) and Lucas (1976 and 1977). At this stage, we mention that the neoclassicals distinguish themselves by commitment to three tenets: First, agents' real economic decisions are based on real not nominal monetary factors. Second, agents are consistent and successful optimizers, that is, they are in a continuos equilibrium. Third, agents make no systematic errors in evaluating the economic environment; that is, they have rational expectations. The last tenet is important to carry the first two features of the neoclassical doctrine to the dynamic problem, that is, if agents are to be optimizers over their future behaviour, their expectations of the future are bound to be important (see Hoover 1988).

Friedman's (1968) view of the Phillips curve, is widely interpreted in the literature as providing a challenge to the Keynesian interpretation of Philips curve as a 'theory' of inflation. Friedman (1968) explanation of Philips curve is based on the idea that rational workers do not suffer from money illusion. Therefore, the fundamental relationship is between the level of real wage and the level of employment. Thus, unemployment is a response to real wages, and as soon as agents grasp that inflation reduces real wage they press for compensatory rise in nominal wage. This line of reasoning demands that Phillips curve is vertical, or to put it differently, real demand and supply curves are homogeneous of degree zero in nominal prices and incomes. As such inflation is compatible with any level of real demand and supply curves. Friedman's argument, as often held, was based on the application of the neoclassicals' tenets, rather than on a particular model of the economy.

The distinction between real and nominal quantities is the most fundamental element in Friedman's (1968) rehabilitation of the quantity theory of money, and more important, it provides the basis for a theory of inflation (see Hoover 1988). In its simplest form, the government and the banking sector determines the nominal stock of money. The public response to real factors determine the real demand for money. Prices adjust to equate the nominal stock to the real balances. With a stable demand for money, continuos growth of money will be reflected in the prices. This formulation of a theory of inflation implies that, money is neutral in the long run. It also provides the basis for synthesizing the invariable empirically observed inverse relationship between inflation and unemployment. Accordingly, the estimated negative inflation - unemployment relations are short- run phenomenon, which gradually converge on the long-run to the vertically sloped Philip curve. Once the natural rate of employment (output) is at its equilibrium, any increase in the money stock must be reflected in the prices.

In the same vein, Lucas (1972 and 1975) provided an explanation of the observed inverse relationship between inflation and unemployment in terms of a model postulating that, money is a means of transferring value between two periods. Agents have rational expectations and their decisions on labour - leisure are based on utility maximization. In the general analysis of the model agents react to any 'surprise' increase in the general price level, caused by an increase in the stock of money, '*as if*' it is an increase in relative price . They will accordingly increase their output - or labour supply - for any increase in the rate of price changes and reduce it for any decrease in the prices. In this formulation expected increase in the money stock are neutral, any unexpected increases are not.

In order to formalize Lucas's intuitive equilibrium explanation of Keynes involuntary unemployment, we briefly review Lucas's (1975) model. Other reasons that motivate this review includes *inter alia* the following:

First, the model provides explanation for unemployment within an equilibrium framework. Phillips (1958) rationalized his curve as an expression of the responses of wage to disequilibruim in labour market. More important, it is the assumption of the competitive markets that distinguishes the model as providing an equilibrium approach to the analysis of economic fluctuations.

Second, the model provides an example of policy ineffectiveness, whereby policies have no effect under perfect information, only unexpected policies would matter, furthermore the model provides evidence on econometric policy evaluation critique. Because the model establishes that the trade-off between inflation and output is only with unanticipated inflation, it implies policy ineffectiveness. And because the slope of Phillips curve, established by the model, is a combination of structural parameters, the elasticities of supplies in different markets and a variance ratio that is affected by policy, the slope of Phillips curve changes in response to policy. Such possibility often is the issue in Lucas's critique.

Third, the model provides a common structure to all the neoclassicals models of the business cycles. It identifies both the source of fluctuations and the propagation mechanisms (see Hoover 1988). It is interesting to note that the model also open up an important line of research into

business cycles returning the earlier Keynesian themes (also see Taylor 1993).

The model postulates a decentralized competitive market economy; participants in each market have only limited information about other markets. Agents in this economy should be thought of as workers - producers. Demand for goods in each period is distributed unevenly over markets, leading to relative as well as general price movements. Because of imperfect information agents are unable to differentiate between relative price movements and absolute price changes. The quantity supplied in each market is assumed to be composed of a normal component, common to all markets, and a cyclical component that is not. The supply curve in each market *i;(i = 1 ,2 , 3 .....n)* is given in logarithm by[1];

$$y_t^i = \bar{y} + y_c^i \quad \text{.....(1)}$$

where $\bar{y}$ is normal component and y^i_c is the cyclical component. If there is no cyclical component, output is supplied at its long - run level which Lucas allows to follow a time trend. However, the cyclical component is assumed to be determined by the perceived relative price as;

$$y_c^i = \gamma\left[p_t^i - E\left(p_t/I_t^i\right)\right] \quad \text{.....(2)}$$

Where, p_t^i is the logarithm of actual price in market *i*, at time *t*, $E\left(p_t / I_t^i\right)$ is the perceived mean general price level, given information available in market *i* at time *t* that is I^i_t. Agents do not observe the price level directly. They have common prior distribution of p_t which is normal with mean $E\left(p_t / I_t\right)$ and variance $\sigma^2.I_t$ and contains the full information about the

[1]The equation numbering will be chapter specific.

economic environment up to (t-1), but not including p^i_t, then, agent's price can be expressed in deviation form as;

$$p_n = p + \varepsilon_n \quad \text{.....(3)}$$

Where ε_n is market specific shock with mean zero and variance τ^2. The relevant information set for estimating the mean general prices p composes of information on previous distribution of observed value of p. Since agent n have rational expectations we write;

$$p^e_n = E(p_n / I) \quad \text{.....(4)}$$

In the light of equation (3) equation (4) can be expressed as;

$$p^e_n = E(p / I) \quad \text{.....(5)}$$

Equation (5) is the classical signal extraction problem. It poses the question of what is the most best guess for the current unobserved mean general price given observed p_n? A sensible answer would be obtained by plotting past values of p_n against associated values of p (see Hoover 1988). If this is acceptable then we need to estimate α and β in the following equation;

$$p = \alpha + \beta p_n + \mu \quad \text{.....(6)}$$

Where μ is normally distributed, the solution to (6) could be expressed as;

$$\hat{\beta} = \frac{\text{cov}(p_n, p)}{\text{var}(p_n)} = \frac{\sigma^2}{\sigma^2 + \tau^2} \quad \text{.....(7)}$$

and;

$$\hat{\alpha} = \overline{p} - \hat{\beta}\overline{p}_n = \left(1 - \hat{\beta}\right)\overline{p} \quad \text{.....(8)}$$

Substituting (7) and (8) into (6) and treating (6) as the best estimate of (5) gives;

$$p_e = E(p/I) = E(p/p_n) = \left(1 - \hat{\beta}\right)\overline{p} + \hat{\beta} p_n \quad \text{.....(9)}$$

It appears from this solution that the cyclical component of output depends on agents own relative price's variance τ^2 and the variance of the general price. If τ^2 is consistent, the higher the variability of the general price, inflation, the less likely a rational agent is to interpret an observed increase in his own price as a favourable shift in relative price. An expression of this signal extraction process in terms of the aggregate supply curve can be written by combining (1), (2) and (9) as;

$$y = \bar{y} + \gamma\left(1-\hat{\beta}\right)\left(p_n - \bar{p}\right) \quad \text{.....(10)}$$

By averaging for all markets we write;

$$y = \bar{y} + \gamma\left(1-\hat{\beta}\right)\left(p - \bar{p}\right) \quad \text{.....(11)}$$

From equation (11) it appears that the higher is $\hat{\beta}$, that is the more variable inflation, the more steeply upward the aggregate supply function will be. This equation is an expression of Lucas's explanation of Phillips curve, and is often referred to in gaps models (see for example Coe and McDermott 1997). The following expression is often used;

$$p_t - p_{t,t-1} = \rho\left(y - \bar{y}\right) + \mu \quad \text{.....(12)}$$

Where $(p_t - p_{t,t-1})$ denotes the prediction of p for time t at t-1 and, $(p_t - p_{t,t-1})$ is the rate of inflation, $\left(y - \bar{y}\right)$ is the output gap, the deviation of actual from potential output, and μ is a well behaved random error [2]. Money enters Lucas analysis in such a way that unanticipated changes in the stock of money are neutral only money surprise can have real effects.

As noted above Lucas's work instigated an important lines of research for the explanation of the business cycle fluctuations along both the

[2] For an application of the gap type of models see Coe and McDermott (1997) and Oppers (1997).

classical and the Keynesian traditions. Below we review briefly the main themes in each line of research.

2.2. The Neoclassical Real Business Cycles Models

Generally speaking Lucas model outlined above is considered as species of the neoclassical growth models. The sources of fluctuations in this model is the noise in money supply process, the assumed serial correlation of the stock of money supply is one of the sources of persistence in the model. The implied assumption that capital stock is long lived is the other. However, Lucas's model has been criticized in the literature for postulating the central relationship summarized in equation (1) rather than deriving it from explicit optimization behaviour. More important no clear dynamics has been specified, and therefore, the question that why demand shocks have lasting effects on output is left open (see Blanchard and Fischer 1989).

An alternative important development of the business cycle is provided by Kyland and Prescotts' (1982) time to build approach which become a paradigm for the explanation of real business cycles. This approach emphasizes real shocks, namely, technological shocks, with monetary shocks assumed to play either little or no role in fluctuations. The approach builds in many ways on previous research. Like Lucas's model Kyland and Prescott (1982) approach is essentially a variation on the one sector neoclassical growth model. Kyland and Prescott assume that agents have rational expectations and face signal extraction problem. The technological structure of production is assumed important, namely the fact that production of any good takes some finite time, money is not

allowed a role. Workers are assumed to have a utility function that allows a high degree of intertemporal substitutability, so that, transient shocks are substantial. Kyland and Prescotts' treatment of the labour market has the effect of permitting an increase in intertemporal substitutability of leisure which in turn makes hours worked more volatile. The fact that technological shocks are serially correlated generates some persistence in output fluctuations.

Hansen (1985) extent Kyland and Prescott approach to explore the effects of indivisibilities in labour supply decisions. In Hansen contribution, agents are assumed either to work full - time or not at all. Hansen's results demonstrate existence of a significant volatility of hours worked in response to productivity shocks.

Other extensions of Kyland and Prescott approach include Long and Plosser (1983) model with heterogeneous goods. Like Kyland and Prescott, Long and Ploser do not allow for monetary mismanagement as a source of the cycle. But unlike both Lucas (1975) and Kyland and Prescott (1982) capital is allowed to long live, but it depreciates each period. Long and Plosser (1983) derive the persistence of output fluctuations from the serial correlation in the technological shocks. However, the model paid particular attention to the separate goods that constitute the aggregate output. Accordingly, the source of the real shock is generated by random fluctuations in the output of a particular good. That is, the model emphasizes changes in the technologies of different sectors rather than the economy - wide changes in technology. Even though the different sectors are independent, sector specific shocks move the aggregate output, through the wealth effects of individuals on demand

for all goods. In order to generate the economy - wide business cycle, the model suggests there be a few sectors and that the sector-specific technological disturbance is substantial. For another type of the sectoral shock approach see Lilien (1982).

2.2.1. The Monetary Models of Business cycles

The relationship between money, output and prices is one of the best documented issues in economics. Lucas's imperfect information model shown above explains this interrelationship because the quantity theory of money is embedded in its structure. That is, 'surprise' money increases result in an increase in output and nominal income. Other models of business cycle in this tradition, attempt to incorporate the monetary sector, with commitment to equilibrium analysis. Money - output relations has been explained as a case of reverse - causality. Building on Tobin's (1970) work, which emphasizes the endogeniety of money, King and Plosser (1984) maintain that standard measure of money are mostly inside money, which is created by the banking system. They suggest that banks use real resources like capital and labour, to produce an output, that is, real monetary services like transaction and accounting. Just as in Long and Plosser model with heterogeneous goods, the output of the banking sector moves with the output of the other sectors. For example, an increase in the productivity in any sector tends to increase the demand for transaction services, and the banking system responses by creating more inside money. This approach implies that, the real volume of inside money is more closely linked to the cycle than the volume of real outside money (see also Mankiw 1989 and Blanchard and Fischer 1989).

The empirical evidence of King and Plosser (1984) is mild, the deposits (inside money) correlate better with output as compared to money base (outside money). And the money base correlates better with prices than do deposits (see Hoover 1988).

2.3. The New Keynesian Business Cycle Models

Both the real and the monetary models of business cycles are equilibrium models developed within the tradition of the neoclassical framework, the basic methodological commitments are not at stake. However, the challenge comes from the resurgence of the earlier Keynesian themes as maintained by the new Keynesians stand. The new Keynesians' approach provides an alternative interpretation of Lucas (1975) imperfect information equilibrium decentralized market model. Imperfect information has been taken as a case of coordination problem, and hence as a case of a grant failure of the unfettered markets. This approach explores more rigorously the idea that imperfection can derive the business cycles, through its effects on aggregate demand (see Blanchard and Fischer 1989). The main argument in this direction of research is that, the response of wages and prices to an increase in aggregate demand is slow. Therefore, there is no, necessarily a pattern to the ratio of wages to prices. Accordingly, there is no reason to expect a particular comovement between wages and employment in response to demand shocks. The new-Keynesians' explanation of nominal rigidities and economic fluctuations takes three thematic research areas. We briefly outline here.

The first addresses the issue that costs of price adjustment and staggered timing of wage and price changes lead to nominal rigidities at the macroeconomic level. Parken (1986), Akerlof and Yellen (1986) developed the idea that small barriers to nominal price flexibility can lead to substantial aggregate nominal rigidities. Ball and Romer (1991) show the conditions under which this small friction can lead to considerable nominal stickiness. Taylor (1979) shows the additional consequences of friction in nominal adjustment. The idea is that not all wages and prices adjust simultaneously. The presence of nominal contracts can cause considerable shifts in demand even if agents have rational expectations and the shifts are anticipated. Models of exogenous and endogenous timing of adjustment of contracts were developed in this strand of research.

The second theme in this research addresses the issue of imperfect competition, including aggregate demand externalities, multipliers and coordination failure. The assumption of imperfect competition, or a monopolisticaly competitive firms is central to the new Keynesians' literature. This assumption is important for many models that strive to give a theoretical explanation for the Keynesian multiplier (see for example Blanchard and Fischer, 1989, and Hall and Cecchetti 1988). Both the presence of Keynesian multiplier that leads to models with multiple equlibria solution, and the presence of considerable positive externalities are examples of coordination failure. Further development along these lines intends to giver insight into the nature of fluctuations. The outcome, as maintained in this literature, provides support for the view that, there can be substantial fluctuations in real output without any changes in the macroeconomic fundamentals, and that, there may be a

role for the government to coordinate movements to superior equilibrium (see Mankiw and Romer 1991).

The third theme explores the macroeconomic consequences of the non-Walrasian features of labour and goods markets. The basic questions are the same. However in the case of the labour market the issue is why shifts in the marginal revenue product of labour lead to movement in employment rather that in wages given prices? And in the case of the goods market the question is why shifts in the demand for goods results mostly in movements in output rather than movements in prices given wages? (See Blanchard and Fischer 1989). If imperfections in the labour market are present, then workers are not necessarily on their labour-supply curve through out the business cycle, and the link between the elasticity of labour supply and real wage breaks down. Research on goods market, beyond imperfect competition, relates to the cyclical behaviour of markup, that is the ratio of price to marginal cost.

In summing up our whirlwind review of the literature we mention that, most of the work in the Keynesian and the classical traditions grew out of practical problems. The Keynesian economics arose in response to the Great Depression which requires a different explanation, a theory capable of providing an understanding of the market failure. The Keynesian economics reached its peak in 1960s with the IS-LM consensus. The neoclassicals grew out of the empirical break down of Phillips curve in early 1970s and the perceived failure of the forecasting ability of the macreconomic models. The new - Keynesians arose in 1980s in response to the theoretical crisis of the 1970s, however, Tyalor (1993) see them as an outgrowth of the rational expectations revolution of the 1970s.

Now, in choosing between the theoretical explanations of the business cycles, like all optimizing agents, one faces a trade-off between the internal and the external consistency. The neoclassicals through their commitment to the neoclassical tenets provide a 'standard' explanation of the business cycles. While the new - Keynesians provide models that mimic the reality through their emphasis on nominal rigidities, and as the argument goes, nominal rigidities are observed but only little understood. The new - keynesians paradigm suggests that to understand these realities require the abandonment of the neoclassical methodology, which means the rejection of the internal consistency (see Mankiw 1989).

2.4. Econometric Issues

Disagreement over the empirical work parallel disagreement over theoretical issues. Our stand here, is to explore the roots of the main issues and their resolutions in the econometric methodology. Again our review will be geared towards justifying the methodological framework of this study.

The celebrated Lucas's (1976) paper on econometric policy evaluation is widely seen as the most formidable challenge to the legitimacy of the application of econometrics to macroeconomics. Blanchard and Fisher (1989) interpreted the critique as applying at two levels: at the first level, the estimated distributed lags may be convolutions of expectational and other lags so that changes in policy rule change the way expectations are formed and so the distributed lags. At the second level, even if the first problem is solved, for example, because expectations are observable, the

coefficients of the model may be function of the policy, as yet, little has been done to address this problem.

Lucas critique has important implications for the specification, estimation and control of the econometric model, however, it has not been taken seriously. For example Fischer (1988) in his survey of the development in macroeconomics maintains that the 'critique has not been shown to be of any empirical significance in accounting for the failures of the econometric models (Fischer 1988, p. 302). One may say that, this does not mean that Lucas critique is not correct in principle, but this ignorance, to a large extent, endorses Sims's (1980) view that, true changes of policy regime, which exposes these models to Lucas critique, are rare and far between. So that even, large scale macro-econometric models, which are not invariant across changes in policy regimes will still be useful for forecasting and policy analysis. Thanks to the incredible identifying restrictions adopted in most of these models. Below we review Sims's argument at some length, because of its important methodological implications, at least in the context of this study.

Sargant and Sims (1977) suggested that a 'structure' is a matter of degree (see also Hendry and Doornik 1984). An econometric relation is structural if it is invariant to specific class of intervention. The structure is identified if we estimate it from given data, in this broad sense, when the policy rule is exogenous variable in a system of variables, the reduced form is itself a structure and is identified. Sims (1980) maintains that, because large scale macro-econometric models are dynamic, they permit the use of 'spurious' a prior restrictions, which weaken the legitimacy of

basing identification restrictions on acceptable theory. Despite the use of false assumptions to identify these large scale macro - econometric models, still they perform well because they are approximations to the reduce form optimal forecasting equation. Sims (1980) proposes the use of vector autoregression often written as (VAR) in a view to systematize the haphazard manner in which the incredible identifying restrictions were applied to macro - econometric models.

The roots of Sims's proposal are found in his earlier work, particularly, his application of Granger - causality tests Sims (1972), as well as in his analysis of business cycles without pretending to have too much a prior economic theory (see Sargant and Sims 1977). In a VAR both behavioural and policy variables are estimated as a joint system. Each variable is treated as a distributed lag of values of all other variables in the system. Lucas critique could apply to the VAR programme, but Sims argued that, true changes of regime are rare. However, if there is no change of regime, it is possible to evaluate policy. In this regard, Hoover (1988) noted that, if policy makers reacted on advice based on policy evaluation, then the regime would have changed unless the advice is not to do policy at all. However, to maintain the argument we follow Sims's characterization of policy from empirical point of view which distinguishes between evaluation of policy and implementation of policy. The argument goes, even if the authorities goals and rules are known, what is not exactly known is the way of implementing such rules. The fact is, in real world policy regime does not follow a deterministic rule. Policy is an outcome of political process in which competing groups pursue incompatible optimal rules. Accordingly the issue is not to evaluate alternative rules, but to implement the 'best' rule. As such agents

act '*as if*' assessing the probability of alternative policy regimes rather than treating particular policy action as new policy strategy. Effective implementation of the existing policy rule therefore, is likely to involve reduce form modeling and policy projection.

In order to implement the VAR programme, the first step is to develop a class of multivariate time series models which will serve as the unrestricted first stage model. The first sets of constraints will be on the lag length or the dampening rate in order to assure that the model is a genuine data generating mechanism (see Hendry and Doornik (1984) and Spnos (1986). Additional constraints, beyond this will be necessary, but the best way to proceed with this is very much an open issue. Even more difficult is the interpretation of the regression coefficients of this system, due to the complicated cross - equation feedback(s) In order to recover a sensible interpretation the system moving average must be traced out (see Sims 1980).

The second step involves Wald - causal chains ordering, whereby, the current values of causally prior variables appear as independent variables in the equations for causally posterior variables. The usual method of displaying the quantitative relationship involves; first, innovation accounting, this method assumes, for example, an 'orthogonalize' one standard shock to one of the equations, and then, traces out the paths of other variables in response to this 'innovation' in the sense of being 'new' effect not predicted from the past values of the variables in the system. The usual practice in this case is to calculate the proportion of the variance of the innovation terms. The second method is the impulse response analysis. This method is closely related to the first one, it shows

the plot of the system of variables in response to, for example one 'standard shock' this method is more convincing, perhaps, because figures are easier to interpret than numbers.

The VAR methodology has been stigmatized as a theoretical macroeconomics, since it puts much less theoretical prior on data. The common method in the neoclassical approach is to use theory to interpret data. Commitment to this methodological requirement is upheld by the strong *a priorists* view which argues that, in order to obtain stable estimate of the deep structural parameters, theory - based restrictions, must be placed on data, and such restrictions are untestable. However, it should be noted that, the rational expectations assumption implies high degree of interdependence between variables in the theoretical models, suggesting that even economic theory may not provide the required restrictions to identify the empirical model. Sargant (1976) provided an example in which both the natural and non-natural rate hypotheses result in observational equivalence. That is, which ever hypothesis is right, the reduce form is the same, and if changes of regime are rare the estimated parameters are stable. More important, Sargan's view that, optimizing rational expectations models do not entirely eliminate the need for side assumptions not grounded in economic theory, is often taken to soften the strong *a priorists* claim (see Hoover 1988).

In closing this section we note that Sims VAR approach coincided with a significant revolution in the statistical basis of econometric modeling that took place during 1980s, which in turn increases its popularity. The main features of this revolution is that, its analytical basis extended the assumption of stationarity to include integrated processes. This shift is

radical, influencing the choice of the model form, modeling practices, statistical inference, distribution theory and interpretation of many traditional concepts such as simultaneity, measurement errors, collinearity, forecasting and exogeniety (Benergee *et al* 1993, p 1).

Taylar (1993) noted that, the VAR and other time series approaches to macro-econometrics are considered as an important part of the post mid 1980s interest in macro-econometric modeling and forecasting.

CHAPTER THREE
CONCEPTS AND METHODOLOGY

We start this methodological chapter with highlighting some conceptual issues concerning the steady-state theoretical relationships to be exploited in the identification scheme in the multivariate analysis.

3.1. Some Conceptual Issues

Different ways of conceptually giving money a role in the policy process, require different empirical relationships between money and the economic activities that are of policy concern. These relationships depends on the economy's aggregate supply process - that is, the technology of the economy so to speak - the degree of price inertia, the behaviour of the money supply and, more important, the behaviour of the agents' money demand.

Sims (1972) bivaraite causality test, using nominal gross domestic product and money stock, and Lucas theoretical model that explains the effect of unanticipated money on output have increased the confidence in the casual role of money. However, the disappearance of Granger - causation for money in a VAR that includes interest rate (see Sims 1980) presents some difficulties. As we saw one route followed is to endogenize money as in King and Plosser (1984). But without outside money, it is difficult to explain why the price level or inflation rate as opposed to real activity is procyclical in King and Plosser model. Once outside money is included the behaviour of the price level follows from the interaction of real demand for outside money and the nominal supply (see Fischer

1988). In the presence of these difficulties, as we saw, the real business cycle approach side step money. The resolutions of there conceptual issues may take us far a field. However, from policy point of view the relevant interpretation of Sims's autocorrelations, is whether fluctuations in money (or any other aggregate of it) can help to predict future fluctuations in money and prices that are not already predictable on the basis of fluctuations in these variables themselves. And whether the information contained in these fluctuations reflects true causation, reversed causation based on anticipation or mutual causation by some independent but unobserved influence is beside the point (see Benjamin and Kuttner 1992).

Usually, the empirical studies on the demand for money starts by postulating a demand for money function. In the standard literature money is demanded because of the role it plays as a medium of exchange and as a store of value. In most of the empirical models demand for money is a positive function of the level of economic activities and the price level (because agents demand real balances). Money is also a negative function of the cost of holding it, that depends on the availability of return yielding assets in the economy, which in turn depends on the level of the development of the money and capital markets as well as the state of the transaction technology. However, the following concepts need to be incorporated in the empirical study. The stock of money, the price level, the level of the economic activities and a measure of the opportunity cost of holding money. There is little controversy in the literature that in the long run money is neutral. This implies stable long run relationships between these variables. However what is controversial is the magnitude and the duration of the effect of

unanticipated money on output. These theoretical relationships will be used for the identification of the long run model, and the short run effects of the money surprises will be determine empirically.

The relationship between exchange rate and fluctuations in output is complex. Intuitively, movements in real exchange over the business cycle depends on the relative importance of the shocks that derive the cycle. One may argue that exchange rate is the monetary aspect of the pure trade model. Perhaps this is one reason behind the ignorance of exchange rate in the macroeconomic theory. Furthermore, Blanchard and Fischer (1989) noted that, it is a tradition to largely ignore the open economy aspects in macroeconomics. One reason they suggested, is that, the rest of the world is not central in the macroeconomic analysis and can be treated as another source of disturbance. The other reason is trading simplicity for complexity. Solow noted that if Almighty Allah wants us to analyze three variables system, a three dimensional page would have been created (noted in Balanchard and Fischer 1989). As they maintained, adding the exchange to a model would extract a price in the need to simplify elsewhere in the model.

It is widely acknowledged that Mundell-Fleming provides a basic framework for the open economy macroeconomic analysis. Nonetheless, the direction of comovements between the income, domestic price and foreign price is so complex. The literature on the experience of the LDCs suggests the vicious circle and the pass-through hypotheses in order to provide a theoretical explanation of a steady-state relation between, domestic and foreign prices. The former, maintains that, changes in the exchange rate constitute an independent source of inflationary pressures

and that the exchange rate and the price level drive each other. While the latter suggests that exchange rate and foreign price affect domestic inflation. As we indicated, it is arguable that, there is no direct steady-state link in theory between domestic price and the exchange rate as such (see also Calvo *et al* 1995).

The long run purchasing power parity is often used to provide steady-state link between exchange rate, domestic price and foreign price. The PPP is important for many reasons; for example, many macro models often use the PPP to link domestic and foreign developments. The validity of many monetary models *a' la* Dornbuch's (1976) extension of Mundell-Fleming framework hinges on the long run PPP. More important, the PPP - although not an explicit theory of exchange rate - can be used to determine the long run exchange rate and to assess exchange rate policies when a long run PPP relationship exists.

Because of its popularity the PPP has been tested extensively using data from both developing and developed countries. For the developing countries current empirical studies, among others, include Mcnown and Wallace (1989), Nagayasu (1998), and Kirchene (1998). Empirical studies for developed countries are reported in many surveys, for example, famous among others are; Rogoff (1996) and Froot and Rosoff (1995).

The building block of the PPP is the law of one price. For good *i* in the absence of trade barriers, the law of one price states that;

$$P_i = EP_i^* \quad \text{.....(1)}$$

where, P_i is the price of good *i* expressed in domestic currency, P_i^* is the price of good *i* expressed in foreign currency and E is the nominal exchange rate expressed in local currency per unit of foreign currency. Aggregating over all goods, the law of one price gives the PPP that states;

$P = EP^{**}$ .....(2)

where P is the price level in the domestic economy and P^{**} is the price level in the foreign economy and E is defined as before. Relations (1) and (2) are known as absolute PPP. However the presence of transport cost and some trade barriers tends to create a wedge among prices across countries. But if these factors are constant over time, they could be stated using a constant, accordingly equation (2) becomes;

$P = AEP^{**}$.....(3)

Using common logarithm form, a testable specification of the long run PPP hypothesis can be expressed in lower litters case as;

$e = a + p + p^{**}$.....(4)

The strict interpretation of the long run PPP requires homogeneity of degree one and asymmetry conditions to hold, that is, (a = 0) , (p= 1) and (p^{**} = -1). Specification (4) is not directly relevant for most of the LDCs, when official exchange rates are used. MacDonald and Marsh (1994) propose a week version of PPP that imposes no parameter restrictions. Following this procedure, we propose to use the following version;

$e = a + c_1 p + c_2 p^*$.....(5)

where c_1 and c_2 are non-zero coefficients. In the standard monetary literature the exchange rate adjusts to restore equilibria, with causality running from money to price to exchange rate. In trade models the exchange rate affects output through its effect on competitiveness, and hence the current account at some time horizon as often held in the J-effect literature.

In the empirical study in this thesis, both the exchange rate and foreign prices will be included to assess whether the PPP seems to be a reasonable long run relationship that could be exploited in the policy dialogues in the Sudanese context.

3.2. The methodology

The discussion in the previous section suggests six variables to be included in the empirical study corresponding to the theoretical concepts. That is, a measure of: money, the price level, the level of the economic activities, the opportunity cost of holding money, the exchange rate and the foreign prices. Two methodological steps will be followed in this thesis: First, in line with the literature on the business cycle, unconditional cross correlation between the GDP and other related aggregates will be determined. Since correlation does not imply 'causality' the results from correlations will be complemented by bivaraite exogeniety tests. The decision to use reduced form or structural form for formal modeling depends largely on the sources of the macroeconomic shocks (see Agner *et al* 1999, and Chadha and Perasad 1997). Second, canonical regression analysis will be used for the analysis of the long run equilibrium.

Generally, an equilibrium state is defined as one in which no inherent tendency to change over finite period of time, the long run equilibrium relationship may fail to hold, however, it will eventually hold to any degree of accuracy if the equilibrium is stable. That is, a long run relationship entails a systematic comovement among economic

variables, which an economic system exemplifies precisely in the long run. Roughly speaking, an equilibrium relationship between two variables x_1 and x_2, written as; $f(x_1, x_2) = 0$ holds, if the error $\varepsilon \equiv f(x_1, x_2)$ is median zero stationary, that is, it does not changes over time. This definition applies only to the time series that are themselves stationary (see Benergee *et al* 1993). It follows that in most empirical work using time series data the issue of non-stationarity, comovement (cointegration), simultaneity and exogeniety have to be addressed.

The rest of this section well be devoted to a more formal characterization of the two aspects of methodology to be followed in the empirical part.

3.2.1. Correlation and Exogeniety Tests

As one of our objectives is to examine the sources of fluctuations at business cycle frequencies, a test of the unit root must be performed. If unit root is present, it is necessary to disentangle the permanent component from the cyclical component, because the validity of correlation, bivriate and multivariate analysis depends on ascertaining the order of integribility of the data.

The simplest case of a process with a unit root is a random walk, written for the variable x_i as;

$$x_t = \alpha + \varphi x_{t-1} + \varepsilon_t, \quad t = 1,2,\ldots\ldots\ldots\ldots,n \qquad (1)$$

where ε_t is iid $(0, \sigma^2)$, and φ equals unity, which implies a shock to ε_t is incorporated permanently in the level of x_t, α is a constant, representing a drift, which allows for secular movement in x_t. A test for difference stationary process, or the trend stationary one, is generally a one-sided

test of the null hypothesis of a unit root against the alternative of stationarity in the following univariate AR (1) process;

$$x_t = \alpha + (1-\varphi)\delta t + \varphi x_{t-1} + \varepsilon_t \quad \text{.....(2)}$$

H_0: $\varphi = 1$ against H_1 : $\varphi<1$.

The test uses Dickey and Fuller (1979) unit-root (DF). In the case where the error ε_t's are serially correlated, augmented Dickey-Fuller (ADF) unit-root statistic should be used, which accommodates error autocorrelation by adding lagged difference x_t;

$$x_t = \alpha + (1-\varphi)\delta t + \varphi x_{t-1} + \sum_{i=1}^{p+1} \varphi x_{t-i} + \varepsilon_t; t = 1,.....,n \quad (3)$$

or,

$$\Delta x_t = \alpha + \rho\delta t - \rho x_{t-1} + \sum_{i=1}^{p} \rho\gamma_i \Delta x_{t-i} + \varepsilon_t; t = 1,.....n, \quad (4)$$

where p is the degree of augmentation. And the null H_0 : $\rho=1-\varphi = 0$.

A series which has a unit root (stationary in first difference) can be represented as a sum of stationary component, denoted by z and a cyclical component, denoted by c (see Beveridge and Nelson 1981), let

$$x_t = z_t + c_t ,$$

where;

$$z = \mu + z_{t-1} + \left(\sum_{j=0}^{\infty} aj\right)\varepsilon_t$$

$$-c = \left(\sum_{j=i}^{\infty} aj\right)\varepsilon_t + \left(\sum_{j=2}^{\infty} aj\right)\varepsilon_{t-2} + ,..... \quad (5)$$

In a finite sample, the stationary component of a series can be obtained using a variety of smothing methods. The most famous one is Hodrick-Prescott's (1980) procedure, which involves fitting a curve to estimate the trend path (x^*, t= 1,2,.....) for a series (x_t, t=1,2 .....n) subject to the constraint that the sum of the squared second difference of the trend series is not too large, that is,

$$\min_{y_1^*, y_2^*, \ldots, y_n^*} \left\{ \sum_{t=1}^{n} (y_t - y_t^*)^2 + \lambda \sum_{t=2}^{n-1} (\Delta^2 y_{t+1}^*)^2 \right\} \quad \ldots\ldots(6)$$

The smoothing parameter λ is usually chosen by trial and error, following Hodrick and Prescott $\lambda = 1600$ for annual series, and $\lambda = 100$ for quarterly series are often used. It is argued that this smoothing procedure, to a large extent, become the industry standard. Business cycles in different economies may not exhibit these standard properties (see Coe and Mcdmermott 1997). However, Harvey and Jaeger (1993) showed that for $\lambda = 1600$ the transfer function for Hodrick-Prescott filter peaks around 30.14 quarter suggesting a value of $\lambda = 7$ for annual data (noted in Pesaran and Pesaran 1997). We employ Hodrick-Prescott filter with a smoothing parameter $\lambda = 7$, to calculate the trend component, if it exists. We also apply Beveridge and Nelson's technique as modified by Miller (1988) as an alternative detrending procdure. The identifying criterion for this technique using equation (5), is that, the trend, z, captures the non-stationary component of the series, while the cycle, c, captures the stationary component.

We assume that, the evolution of the permanent component follows an autoregression moving average representation given by;

$$\Delta z = \mu + \frac{(1-\phi_1-\phi_2-.....-\phi_q)}{(1-\varphi_1-\varphi_2-.....-\varphi_p)}\varepsilon_t \quad .....(7)$$

Where ϕ and φ are the parameters describing the (ARMA) process. If equation (7) meets the necessary stability and inevitability conditions, the estimate of these parameters determines the path of the trend component. Then, the cyclical component would be calculated residually as the difference between the perminant component 'z' and the cyclical component 'c' (see Reinhart and Wickhan 1994).

Akiake (1974) and Schwarz (1978) are often used as standard criteria for determining the optimal parametrization describing the ARMA process. Each criterion chooses the parametrization with the maximum likelihood after imposing a penalty for the number of parameters. Schwarz 'Bayesian' criterion suggests maximizing;

$$-2\ln L - k \ln T,$$

where, L is the likelihood, k = p +q, the numbers of the parameters and T is the number of observations

Akiake criterion suggests maximizing;

$$-2\ln L - 2k,$$

where L and k defined as before. It should be noted that the choice between Schwarz Bayesian and Akiake criteria involves compromises, we refer to this later on.

The correlation coefficients C(j), j: 0,$\pm$ 1, $\pm$ 2 ... between a series x_t with another series say y_t will be determined as a measure of the degree of comovement between the two series. The contemporaneous correlation C(0), from the stationary components of the two series, is considered to be procyclical, acyclical or countercyclical depending on whether the

correlation coefficient is positive, zero or negative (see Agner *et al* 1999). However, correlation does not imply 'causation', it should be noted that, the residual variance of any deterministic relationship is zero by definition, nothing can reduce it and as such, no causal links exist. Similarly since non-stationary time series do not have well defined variances, causality in Garanger sense applies only to stationary series, for example, there is no causal link between trend components.

Granger causality test for the cyclical component of a two series say x_t and y_t could be performed using the following representation;

$$y_t = \alpha + \sum_{j=1}^{p} \beta_j y_{t-j} + \sum_{j=1}^{p} \gamma_j x_{t-j} + \varepsilon_t \quad \text{.....(8)}$$

The null hypothesis of no causation is,

$H_0 : \gamma_1 = \gamma_2 = \text{.....} = \gamma_j = 0$, if the null is rejected, then, x Granger cause y, (or to use a little loaded terminology, x is not exogenous to y, see Granger 1969).

3.2.2. The Cointegrating VAR Test

Here, we highlight the method of analyzing the long run relationships, that is, the equilibrium demand for money and PPP. Cointegration is particularly useful technique in examining such long run relationships. If a stationary 'equilibrium' relation exists between non-stationary variables, this relation is referred to as cointegrating relation and the non-stationary variables are cointegrated. Once a cointegrating 'long run equilibrium' relation has been identified empirically, a dynamic model can be estimated, which indicates the response of the endogenous variables to various disequilibia, or equilibrium correcting mechanisms.

The model to be estimated starts with the familiar VAR expressed as;

$$x_t = a_0 + t + \sum_{i=1}^{p} \varphi x_{t-i} + \Psi z_t + \mu_t, t = 1,2,.....,n \qquad (9)$$

where, x_t is a vector of jointly determined dependent variables, a_0 is a vector of constant terms t is a vectors containing trend (1, 2, ...,n), z_t is a vector of exogenous variables including for example, foreign prices and dummies and μ_t is a vector of disturbances satisfying the normality assumptions, that is, $E(\varepsilon_t) = 0$ and $E(\varepsilon_t \varepsilon_t') = \sum$.

This VAR representation can be estimated by the standard method if the variables are stationary. However, if the variables follow a unit-root process, that is, they are integrated of order one, I(1), and their first difference is stationary, the VAR system can be estimated in first difference rather than in the level of variables. But, in the case that some of the variables show a linear combination in levels that is stationary, a cointegarted VAR system should be used because some information about their long run behaviour is ignored if a VAR in first difference is estimated. This motivates the use of error-correction mechanism representation;

$$\Delta x_t = a_0 + \quad t \quad - \Pi x_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta x_{t-i} \Psi z_t + \mu_t, t = 1,2,.....,n \qquad (10)$$

where, Δx_t is the first difference of x_t, $\Delta x_{t-1},.....,\Delta x_{t-p+1}$ are first differences of x_t at lags, 1,2,.....p-1 equation (10) takes into confederation the short run dynamics through the effects of the first difference Δx_{t-1} and the long run effects via the role of x_{t-1}.

The number of the long run stationary combinations among the variables in vector x_t, or the cointegrating vectors, could be determined by investigating the rank of the matrix Π (see Johansen 1991). If Π is a null matrix, there is no cointegrating relationship. In the case that the multivariate unit root test based on Johansen rejects, then the rank of Π is m and vector x_t is stationary. However, if the rank of Π is greater than zero and less than n , then Π is singular and can be decomposed into two full rank matrices $\alpha(n,r)$ and $\beta(n,r)$ so that, $\Pi = \alpha\beta'$, r is the matrix of adjustments, or the error correction coefficients that is, showing the speed of adjustment of variables to the long run equilibrium following a disturbance and β is the matrix of cointegrating vectors. Equation (10) is generally a reduced form rather than structural, both the parameters and the error terms are linear combination of the structural ones. If r>1, an identification problem has to be solved, an issue we differ to chapter (4). However, having identified the cointegrating relations, and in the case the trend is forced into the cointegrating space, equation (10) will have the common stochastic trends solution;

$$x_t = x_0 + b_0 t + C(1) + C^*(L)(B_t - B_0) + C(1)\mu,\ t=1,2,.....,n \qquad (11)$$

where x_0 is the initial values of x_t;

$B_t = \Psi z + \mu$,

$b_0 = (1)a_0 + C^*(1)a_1$,

$C(l) = C(1) + (1-L)C^*(L)$, and

$$C^*(L) = \sum_{i=0}^{\infty} C_i^* L^i .$$

L is one period lag operator and C_i^* is mxm matrices, which are obtained recursively from;

$$C_i^* = C_{t-1}^* \varphi_1 + ... + C_{i=p}^* \varphi_1, i = 1,2,..... \qquad (12)$$

with $C_0^* = I_m - C(1)$, $C_i^* = 0$, $I < 0$, $\Pi C(1) = C1(1)\Pi = 0$,

and φ_1 , φ_2 , ...,φ_p are the coefficients of the underlying VAR (see Pesaran and Pesaran 1997).

In terms of the covariance stationarity components of the cointegrating relationship, if it exists, the solution of equation (11) can be wrtten as;

$$\beta' x_t = \beta' x_0 + \left(\beta' C^*(1) a_1\right)t + \mu_{t-i} \quad \text{.....(13)}$$

noting that $\beta'(1) = 0$.

The full-information maximum likelihood ratio statistic for testing the null hypothesis that the cointegrating vectors are equal to r versus the alternative r+1 is refered to as the maximum eigenvalue statistic and is given by;

$$\text{maximum eigenvalue} = -n \log(1 - \hat{\lambda}_{r+1}) \quad \text{.....(14)}$$

where $\hat{\lambda}_i$ are the smallest canonical correlations between Δxt and x_{t-1}.

An alternative statistic for testing the null hypothesis that r is less or equal to r_0 agaist alternative hypothesis that r is greater than r_0 is referred to as trace statistic exepressed as;

$$\text{trace} = -n \sum_{t=r+1}^{m} \log(1 - \lambda_{r+1}) \quad \text{.....(15)}$$

The asymptotic critical values for maximum eigenvalues and trace statistc, we use in this application, are given in Pesaran *et al* (1996).

The short run properties of the system - of cointegrating VAR based on vector error corection mechanism VECM - could be assertained from the orthogonolized and/or generalized impluse response analysis as well as from the forcast error varaince decomposition. We briefly review these

two properties for VAR(p), assuming that equation (9) have a finite moving -average representation expressed as;

$$x_t = \sum_{j=0}^{\infty} A_j \mu_{t-j} + \sum_{j=0}^{\infty} \beta_j \Psi_{t-j} \quad \text{.....(16)}$$

From equation (11), an expression for A_j can be obtained as;

$$A_j = C(1) + Cj^*$$

and using equation (12) we write;

$$A_j = A_{j-1}\varphi_i + ...A_{j-p}\varphi_p \text{ , } j = 1,2,..... \quad (17)$$

where, $A_0 = I_m$, $Aj = 0$, for $j < 0$ and $B_j = A_j Z$, $j = 1,2,.....$

it is clear that;

$$\lim_{\to\infty} A_j = C(1)$$

which a non-zero matrix with rank m-r

Sims (1980) decomposition of, Σ, the coveriance matrix of shocks μ_i is expressed as;

$\Sigma = HH'$, where, H is a lower traingler matrix. The orthogonolized, conteporaneouly uncorelated unit standard errors ε are obtained using the transformation matrix H as;

$$x_t = \sum_{j=0}^{\infty} (A_j H)(H^{-1}\mu_{t-j}) + \sum_{j=0}^{\infty} B_j \Psi_{t-j} \quad \text{.....(18)}$$

or,

$$x_t = \sum_{j=0}^{\infty} (A_j^* \varepsilon_{t-j}) + \sum_{j=0}^{\infty} B_j \Psi_{t-j} \quad \text{.....(19)}$$

where, $A_j^* = A_j H$, $\varepsilon = H^{-1}\mu_t$ and,

$$E(\varepsilon_t \varepsilon_t') = T^{-1} E(\mu_t \mu_t') T'^{-1} + T^{-1} \Sigma T'^{-1} = I_m.$$

Form this it appears that, the shocks ε_t ($\varepsilon_{1t}, \varepsilon_{2t}, ..., \varepsilon_{nt}$)' are orthogonal to each other. The orthogonalized response function of one standard error shock at time t to the ith orthogonalized error ε_{it}

on the jth variable at time t+N is given by the jth element of orthogonolized impulse response equation;

$$A_N^* e_i = A_N H e_i \quad \text{.....(20)}$$

where e_i is an mx1 selection vecort, $e(0,0,.....,0,1,0,.....,0)'$. Or expressed more compactly;

$$OI_{ij,N} = e_j' A_N T e_i, \quad i,j = 1,2.....m \qquad (21)$$

Note that, the matrices A_j in the moving - average representation of x_t - process, tend to zero when the undeying VAR model is trend-stationary and tend to non-zero rank deficient matrix C(1) when the underlying VAR model is fist-difference stationary (see Pesaran and Pesaran 1997).

It is known that the orthogonolized impulse responses depend on the ordering of the variables in the VAR. Such ordering will be unique only if, Σ, is diagonal (or almost so). For this reason, the generalized impulse responses are proposed to avoid this problem of non-uniqueness of the responses. From the model of equation (9) assuming that ψ is given, the generalized impulse response (GIR) function for a system wide shock μ_t^0 in the moving - average representation of the equation is expressed as;

$$GIR_x(N,\mu_t^0,\Omega_{t-1}^0) = A_N \mu_t^0 \quad \text{.....(22)}$$

where Ω_{t-1}^0 is a particular historical realization of the process at time *t-1*. The choice of μ_t^0 is arbitrary. But in the case that μ_t^0 is drawn from the same distribution of μ_t, that is, a multivariate distribution with zero mean and covariance matrix Σ, the following analytical result is obtained;

$$GIR_x(N,\mu_t^0,\Omega_{t-1}^0) \sim N(0, A_N \Sigma A_N') \quad \text{.....(23)}$$

The effect of a shock of size $\delta_i = \sqrt{\sigma_{ii}}$ to the ith equation at time t is expressed as;

$$GIR_x(N,\delta_i,\Omega_{t-1}^0) \sim A_N E(\mu_t/\mu_{it} = \delta_i) \quad \text{.....(24)}$$

In the case $\mu_t \sim N(0,\Sigma)$, we can express the conditional expectations of equation (24) as;

$$E(\mu_t/\mu_{it} = \delta_i) = \begin{pmatrix} \sigma_{1i}/\sigma_{ii} \\ \sigma_{2i}/\sigma_{ii} \\ \vdots \quad\quad \vdots \\ \\ \sigma_{mi}/\sigma_{ii} \end{pmatrix} \delta_i \quad \text{.....(25)}$$

where $(\Sigma = \sigma_{ij})$, and for a unit shock defined by $\delta_i = \sqrt{\sigma_{ii}}$ we have;

$$GIR_x = (N\ ,\delta_i = \sqrt{\sigma_{ii}}\ ,\Omega_{t-1}^0) = \frac{A_N \Sigma\ e_i}{\sqrt{\sigma_{ii}}}, \quad i,j = 1,2,...,m \qquad (26)$$

As such, the generalized impulse response function of a unit shock to the ith equation on the jth variable at horizon N is given by the jth element of equation (26) re-expressed compactly as;

$$GIR_{ij,N} = \frac{e_j' A_N \Sigma\ e_i}{\sqrt{\sigma_{ii}}}, \quad i,j = 1,2,...,m \qquad (27)$$

Generally, the effects of shocks on the individual variables in a cointegrating VAR model do not die out. In order to circumvent some of the ambiguities of the response analysis's to the variable-specific shocks, Pesaran and Shin (1996) propose the analysis of the persistence profile, that is, a scale estimate of the speed with which the cointegrating VAR system return to equilibrium following system-wide shocks: first consider the time profile of the effect of a unit shock to vector x_t on the jth cointegrating relation(s) as defined in (11). An expression for both orthogonalized and generalized approaches denoting the effect of a unit shock on the cointegrating vector(s) $\beta_i' x_t$ are respectively;

$$OI_i(\beta_j' x_t, N) = \beta_j' A_N T e_i \quad \text{.....(28)}$$

for i = 1,2,.....,m, j = 1,2,.....,r, N = 1,2,.....

i = 1,2,.....,m, j = 1,2,.....,r, N = 1,2,.....

Second, the scaled persistence profile of the effect of system-wide shocks on the jth cointegrating relationship is obtained as;

$$p\left(\beta_j' x_t, N\right) = \frac{\beta A_{Nj} \Sigma A_N' \beta_j}{\beta_j' \Sigma \beta_j} \quad \text{.....(29)}$$

j = 1,2,.....,r, N = 1,2,.....

The value of this shock is equal to unity on impact and should tend to zero as N increases indefinitely if $\beta_i' x_t$ is a genuine cointegrating vector(s).

Using the VAR model given by (16) the orthogonalized forecast error variance decompositions can be expressed as;

$$\theta_{ij,N} = \frac{\sum_{t=0}^{N} (e_i' A_\ell H e_j)^2}{\sum_{t=0}^{N} e_i' A_\ell \Sigma A_\ell' e_i} \quad \text{.....(30)}$$

ij = 1,2,.....m. H and e are defines as before A_ℓ, ℓ=0,1,2.....the coefficient matrices in the moving-average representation (16). An expression for the generalized forecast error decompositions is obtained as;

$$\psi_{ij,N} = \frac{\sigma_{ii}^{-1} \sum_{t=0}^{N} (e_j' A_\ell \Sigma e_i)^2}{\sum_{t=0}^{N} e_i' A_\ell \Sigma A_\ell' e_i} \quad \text{.....(31)}$$

ij = 1,2,.....m. (see Pesaran and Pesaran 1997).

CHAPTER FOUR

THE EMPIRICAL ANALYSIS

This chapter identifies the sources of the data and reports a summary of the macroeconomic indicators for the Sudan, as well as some descriptive statistics for the main series to be used in the empirical study along with their characteristics. Also provided are the main features of the macroeconomic fluctuations as described by the cross-correlations between output and other macroeconomic aggregates. Then, the chapter presents the multivariate analysis, the results of the tests for the existence of the long run economic relationships and the associated short run dynamics.

4.1. Data Sources and Definition of Variables

The data and the definition of variables are obtained from secondary sources. We use the International Financial Statistics (IMF) as the main source, and when records on a particular item are not available, we use the Bank of Sudan Annual Reports as a supplementary source. As such, nothing will be gained from running a formal test for the differences in the means, for example, of the corresponding time series in each source[1].

First, the GDP line (99e), expressed in millions of the Sudanese pounds, is used as a measure of the level of the economic activities, also denoted as 'Y' in the text. Second, the consumer price index, denoted as CPI, line (64) is used as a deflator for the nominal variables and as abase series

[1]Following the Bank of the Sudan year 1982 is chosen as base year.

for calculating the inflation index, as well as a measure of domestic prices. Third, the exchange rate, defined as, Sudanese pounds per United States dollars, is used as a measure of the nominal exchange rate. We note that, in Sudan nominal exchange rate has been subjected to considerable official restrictions. From this alone it may be argued that the PPP type of concepts is irrelevant in assessing the Sudanese foreign trading system. For an argument along these lines see Nashashibi (1981). Construction of an alternative free (or black market) exchange rate, in order to avoid this problem, would involve a considerable value judgment on our part. However, we have to resort to compromises, in view of this, we use the exchange line (ae) as proxy for the nominal exchange rate, denoted as 'E'. Fourth, the narrow money line (34), which includes demand deposits and currency outside the banks, is used as a measure of the stock of money expressed in millions of Sudanese pounds, denoted as 'M1'. Real money is defines as M1 deflated by the CPI and denoted as MP. Velocity is defined as the ratio of M1 to the nominal GDP and denoted as 'Vel'. Fifth, there are a number of world prices to use, but since the exchange rate is in dollars, the world price should be in dollars. The best way to proceed is to compute an index for effective exchange rate in dollars. However, the cost of proceeding with this exercise must be balanced by its analytical benefits. It is known that the effective exchange rate index involves unilateral exchange rates movements in other currencies viz.-a-viz. the dollar, and can directly affect the level of foreign price, unless the PPP is valid on a global scale, with rapid adjustment. The other candidate suggested by Becker (1999) and we are going to use here, is the United States CPI line (64), denoted as 'WP'. Finally, current exports and imports are respectively line (70) and (71) expressed in millions of the

Sudanese pounds. The Ratio of exports to imports at current prices is used as a proxy for the trade balance, denoted as TB.

4.2. Selected Macroeconomic Indicators of the Sudanese Economy

like the case of many Sub-Saharan countries, the performance of the Sudanese economy has been plagued with problems of internal and external imbalances, especially over the last three decades. On the external front, the Sudanese economy has been saddled with problems of increasing foreign debt, crop failure due to the droughts, unfavourable world prices of primary products, balance of payments imbalances, and most important, the binding balance of payments constraint has caused the modern agricultural and industrial sectors to suffer due to inability to import needed inputs, including petroleum products. On the internal front, the main story is one of intensified problems; the widening fiscal deficit, the reduced export earnings, the growing rate of inflation, low productivity and the declining purchasing power. Sudan has resorted to the IMF support since 1978. The IMF repeatedly singles out bad domestic policies as the main cause of the poor performance. The main factors behind this include; irresponsible management of the economy, unwarranted fiscal and monetary policies, distortions in the products and factors markets, over-valued exchange rate, inefficient import substituting industries and public enterprises. The IMF recommendations were, down sizing of the state sector and adoption of an outward oriented policies through the adjustment and appropriate policy reforms.

Table (1) below presents a snap shots every ten years, from 1955/66 up to 1995/96 of the major macroeconomic indicators for the Sudan. From the

table it appears that the series on the GDP (at current market price), the real GDP and the *per capita* GDP show a rising trend through out the four decades, with year 1985/86 suggesting a collapse in production. A second feature of the GDP series is the change in the composition of production.

Table (1): Selected Indicators on the Performance of the Sudanese Economy Over the Period 1955 -1996/[1]

Item/Year	1955/6	1965/6	1975/6	1985/6	1995/6
GDP (current market price in million Ls.)	284.2	454.3	1848.0	21809	9241499
GDP (deflated by CPI:1975 =100)	8.93	11.22	18.48	23.73	36.5
Real GDP per capita in Ls.	0.85	0.83	1.15	1.04	1.2
Contribution to the GDP % share:					
Agriculture	61.0	54.0	33.9	35.0	44.0
Tradable(000's tons)	489.1	788.4	653.9	266.3	684.3
Non-tradable (000's tons)	1836.1	2616.5	4006.9	4338.9	4749.9
% of tradable to non-tradable	27.0	30.0	16.0	0.06	14.4
Manufacturing	4.5	12.0	8.7	7.0	7.1
Volume of exports (000's tons):					
Cotton	293.2	265.6	164.1	110.9	92.5
Gum Arabic	49.2	61.5	15.6	30.8	17.0
Oil seeds	151.1	302.9	277.6	30.8	130.8
Cereals	24.3	na/[2]	57.4	52.6	214.4
Total recurrent revenues as % of the GDP	15.7	6.6	18.0	9.2	5.1
Total recurrent expenditures as % of GDP	10.7	21.0	23.3	19.0	6.4
M1 (cash) as a % of (M1+M2)	84.0	85.0	83.0	64.0	62.0
Money as a % of GDP	7.7	15.0	15.0	20.0	12.0
Claims on Govt. as a % of domestic credit	1.7	31.0	61.0	49.0	87.0

Notes: 1/.Author calculation based on the Bank of Sudan Annual Reports and the International Financial Statistics (IMF).

2/. Not available.

The share of the agriculture in the GDP is declining through out the period 1955/56 - 1985/86 with a gradual increase thereafter. The share of industry, defined by the manufacturing sub-sector, is small and is declining over the last two decades. This implies a growth in the share of the services sector over the same period. Another structural change over the last two decades is the shift from the production of tradable to non - tradable[1] notably food production. This trend is accompanied by a change in the composition of exports. The share of cotton, the main cash crop, has being declining over the last two decades and that of cereals, a non-conventional export crop, has being increasing. The failure of crop production of the early 1980s and the consequent decline in the volume of exports seems to be concomitant with a fiscal collapse. The fiscal surplus in 1955/56 was reversed into net deficit thereafter, the highest ratio of the fiscal deficit, as could be defined from the table, happened in 1985/86. However, from the information provided in the table, there is no a clear evidence of monetization of the deficit in this year as suggested by the decline of the ratio of money supply to the GDP during the same year.

The general impression from these features of structural change, implies that a considerable regularities could be captured by the Sudanese financial time series, which encourage systematic analysis of the features of the business cycle. We note that in business cycle studies in the LDCs, Agner *et al* (1997) used an index for the industrial component of the GDP in their study in order to control for the sources of business cycle fluctuations. Hoffmaister *et al* (1997) used the GDP as a measure of

[1] We included in the definition of tradables the yearly production of cotton, gum Arabic and oilseeds measured in metric tons. Non-tradables include the yearly production of sorghum, maize, millet and wheat.

the economic activities for examining the sources of macroeconomic fluctuations in sub-Saharan Africa. However, despite the differences in the measure of aggregate activities used and the techniques followed in these two studies, comparable results were obtained. This finding motivates the used of the GDP and other related aggregates in the study of the sources of macreconomic fluctuations in the Sudan.

The next section presents the results of the unit root tests, which will be followed in the subsequent analysis.

4.3. Some Descriptive Statistics and The Results of Unit Root Tests

It is common that most financial time series exhibit substantial comovements. In economic analysis it is important to distinguish between correlations that arise from shared trend and those associated with an underlying causal relationship. Granger and Newbold (1974) showed that, if the independent and the dependent variables contain unit roots, conventional estimation methods using observations on level of these variables will likely to be 'spurious' devoid of genuine economic linkages. That is, two variables behaving like a random walk, will be correlated independent of any common element to their respective shocks. Also in bivariate analysis it is important to distinguish between temporary and permanent shocks to the series. Generally speaking, the 'effectiveness' of policy depends on the persistence of shocks and the duration of the cycles. Table (2) presents some descriptive statistics for the growth rate of the real GDP, the level of inflation, the growth rate of real money and the ratio of exports plus imports to the GDP. From the table it appears that, the mean growth rate of the Sudanese real GDP is

about 2% over the 44 years, considered with years growing at 27.7% and others with negative growth rate of -25.5%. The mean inflation rate, inflation defined as double log difference of the CPI, is 0.3% with some years growing at 34.3%. Real money is growing at 1.1%. Openness of the economy measured by the ratio of exports plus imports to the GDP is 28% over the 44 years reaching 81.9% in some years, but never being below 6.8%.

Table(2): Main Statistics of the Series

Variables	mean	Skewness	Kurtosis	Min	Max
GDP	0.021	0.114	0.203	-.0255	0.277
Inflation	.003	-0.543	1.577	-0.487	0.343
Money	0.011	-1.079	0.709	-0.330	0.175
Openness	0.280	6.217	1.582	0.068	0.819

Source: The Bank of Sudan Annual Reports and the International Financial Statistics (IMF).

The data were subjected to a variety of standard unit root tests in order to determine its properties and, more important, the unit of observation that could be used in the subsequent analysis. These tests includes Dickey-Fuller and augmented Dickey- Fuller, which are based on equations (2) and (4) of the methodological chapter. In effect these statistics test whether the steady-state of the series as well as its variance are well defined or not.

The DF and ADF tests for the level of variables includes a constant and trend, four lags are included in determining the latter. Table (3) reports the results from the application of these standard tests. Generally, the

results indicate that all the series contain unit root in level. The test of first difference indicates that the series are stationary except the CPI, which possibly integrated of order higher than one I(2). Although we have examined only the traditional case where only linear combinations from I(1) to I(0) are considered, there may exist cointegrating vectors at other levels of integration transforming the sets of I(2) to variables to I(1) or even I(0). The price level is possible I(2) and thus inflation, defined as the log difference of the price level is I(1). Becker (1999) argued that, if there

Table (3) : Unit Root Tests/[1]

Variables/[2]	Dickey-fuller		Augmented Dickey-Fuller			
	constant	constant and trend	constant	lags	constant and trend	lags
GDP	-1.62	-1.89	1.73	(0)	1.79	(0)
ΔGDP	-4.26*	4.22*	5.54*	(0)	5.49*	(0)
CPI	1.04	0.33	-1.56	(2)	2.22	(2)
ΔCPI	-1.44	-1.76	1.45	(1)	-3.15	(2)
Δ^2CPI	-3.73*	-3.60*	-9.32*	(0)	-9.28*	(0)
M1	2.45	-0.65	-0.70	(3)	-0.64	(3)
ΔM1	2.29	-3.94*	-1.03	(2)	-3.23	(4)
MP	-1.40	0.38	-2.23	(4)	0.26	(0)
ΔMP	-2.86	-3.97*	-4.02*	(0)	-5.13*	(0)
EW	1.7	-0.50	2.84	(0)	-0.42	(0)
ΔEW	3.20*	-4.37*	-3.97*	(0)	-4.88*	(0)
VEL	-1.10	-0.07	-2.4	(4)	-3.74*	(0)
ΔVEL	-4.57*	-5.18*	-5.97*	(0)	-6.47*	(0)
TB	3.42	-3.08*	-6.76*	(0)	-6.70*	(0)

Notes: 1/. The (*) indicates that the null hypothesis of a unit root can be rejected at the 5 percent level of significance.

2/.All variables are in common logarithms. (EW) is log e plus log wp, and the rest of the variables are defined in the text.

is cointegrating vector from I(1) to I(0), inflation can not be one of the argument of this vector. However, we point that, Lopez *et al* (1997) included stationary inflation in an output-inflation vector in their study, we do not want to go into the resolution of this issue here.

We accept the result reported in table (3), that is all series are non-stationary in levels of variables and stationary in first difference with the exception of the CPI. Thus, there series have a permanent components of unknown size. A measure of persistence of shocks to these variables could be determined by examining the variance of their log difference a possibility which we do not want to pursue here (on this issue see Cochrane 1988).

4.4. The Results of the Cross-Correlation Test

Below we examine the correlations between the cyclical components of output and the other selected aggregates. Both the contemporaneous correlation and correlations at various lags and leads will be considered in order to determine the dynamic patterns given by data.

Since all variables examined contain roots, we apply the procedure described in the methodological chapter to decompose them into their cyclical and permanent components respectively, using HPF and the MBN filtering approach. As we noted earlier, application of HPF in the context of the LDCs is often criticized, hence, the latter approach is used as an alternative filtering technique. The application of the MBN filtering method, involves estimating the ARMA models in order to capture the permanent components of the series and the cyclical component can be

calculated residually. The choice between Akaike information criterion AIC and Schwarz and Bayesian criterion SBC, for determining the optimal parametrization describing the ARMA process, as we noted, involves compromises. In the view of the fact that the sample includes 44

Table (4): Akaike Criterion for Selecting the ARMA Parameters/1/2

Part (a):

Name of variable: GDP				
p/q	0	1	2	3
0	27.48	26.27	24.09	22.63
1	<u>27.49</u>	27.32	26.52	26.36
2	26.68	26.42	26.49	25.36
3	27.00	26.33	26.10	24.76
Name of variable: CPI				
0	20.79	20.79	22.09	20.00
1	7.8	<u>22.49</u>	20.34	15.36
2	18.58	21.58	19.68	22.29
3	19.58	20.79	20.22	21.30
Name of variable: ΔCPI				
0	19.53	21.92	20.03	18.79
1	22.21	20.94	19.85	18.35
2	<u>22.12</u>	20.20	19.10	18.19
3	21.20	19.25	18.95	20.56
Name of variable: money				
0	30.17	30.17	25.87	<u>33.56</u>
1	25.56	31.39	31.46	31.71
2	25.87	33.18	31.04	30.77
3	29.93	32.64	30.11	30.01
Name of variable: velocity				
0	90.69	90.69	87.08	85.83
1	93.40	89.21	87.10	86.82
2	92.43	88.92	86.48	85.82
3	<u>94.12</u>	90.78	87.91	85.12
Name of variable: trade balance				
0	-34.19	-34.20	-34.25	-34.60
1	-34.47	-32.12	-34.24	-33.59
2	-33.30	-32.69	-32.26	-32.63
3	-32.74	-33.28	-32.04	<u>-31.81</u>

Notes: 1/. All models are estimated using log-difference except in the case of ΔCPI and trade balance' where we use log-double difference and log-level respectively.

2/. The selected model is underlined.

observations, and log (44) is near 4, SBC penalizes extra parameter much more heavily (see Campbell and Mankiw 1987). We estimate 16 ARMA (p,q), with p,q, 0,1,2,3 models for each variables. The values of

Table (4): Schwarz Bayesian Criterion for Selecting the ARMA Parameters/[1]

Part (b):

Name of variable: GDP				
p/q	0	1	2	3
0	25.77	24.55	21.52	19.20
1	25.78	24.75	23.95	23.83.
2	24.11	22.99	23.06	21.90
3	23.58	22.04	21.81	20.55
Name of variable: CPI				
0	19.05	19.03	19.38	16.48
1	6.03	19.60	17.77	12.83
2	15.99	19.63	16.26	18.91
3	16.06	17.24	15.94	17.08
Name of variable: ΔCPI				
0	18.66	20.19	17.43	15.31
1	20.46	18.37	17.31	15.86
2	19.52	16.77	15.73	14.86
3	17.73	14.79	14.73	16.40
Name of variable: money				
0	28.43	23.93	23.23	26.40
1	28.41	28.78	28.89	29.17
2	23.22	29.70	27.61	27.39
3	30.03	28.29	25.82	27.39
Name of variable: velocity				
0	88.96	88.93	84.43	82.31
1	91.64	87.11	84.52	84.29
2	91.66	85.44	83.05	82.45
3	90.69	86.42	83.63	80.90
Name of variable: trade balance				
0	-35.96	-35.98	-36.92	-38.17
1	-36.25	-34.76	-36.85	-36.16
2	-35.98	-36.21	-35.73	-36.06
3	-36.31	-37.68	-36.38	-36.10

Note: 1/. All models are estimated using log-difference except in the case of ΔCPI and trade balance' where we use log-double difference and log-level respectively.

AIC and SBC are reported respectively in table (4) part (a) and part (b). However, AIC is followed in selecting the preferred model specifications. In order to facilitate comparison with other existing studies HPF is also used with smoothing parameter of 7 for annual observations as suggested in the methodological chapter.

Table (5) presents the contemporaneous correlation as well as the correlations at various lags and leads for the GDP with the price level, inflation, money supply, velocity and a measure of terms of trade. As it appears the contemporaneous correlation between prices and output are strongly negative using, both methods of filtering, indicating countercyclical behaviour. This result is in line with other studies (see for example Agnore *et al* 1999). Generally speaking, the countercyclical behaviour of the level of price provides support for supply-driven models of business cycle *a'la* real business cycle type of models. However, the sources of the technological shock in the context of the LDCs, as pointed by Hoffmaister *et al* (1997), may be due either to changes in the tradable sector, to changes in the crop production due to weather conditions, or to changes in trade arrangements as well as terms of trade changes. It is arguable that the correlation between inflation and the cyclical output is the relevant correlation for distinguishing between demand-driven and supply- driven models of business cycles.

The table also reports the cyclical behaviour of the level of inflation (see the second row). As it appears, the contemporaneous correlation between inflation and output as well as the correlations at lags and leads do not provide a clear evidence of procyclical inflation, which contradicts the

findings in the literature on evidences of procyclical inflation in the industrial countries.

Table (5): Cross Correlation: Output, Price, Inflation, Money, Velocity and Trade Balance/[1]/[2]

Correlation Between ⇩	type of filter/[3]	Lag -3	-2	-1	0	+1	+2	+3
GDP and CPI	MBN	-0.10	-0.13	-0.05	-0.62	-0.00	0.01	0.07
	HPF	0.22	0.21	-0.05	-0.62	-0.42	-0.34	0.03
GDP and Inflation	MBN	-0.13	-0.04	0.00	-0.40	0.08	-0.06	-0.02
	HPF	-0.47	-0.19	-0.22	-0.01	-0.10	-0.10	-0.05
GDP and Money	MBN	-0.15	0.19	-0.02	-0.21	-0.21	0.33	0.10
	HPF	-0.11	-0.03	0.13	-0.09	-0.19	-0.19	0.10
GDP and velocity	MBN	-0.17	-0.00	0.17	-0.43	0.07	0.25	0.27
	HPF	-0.19	-0.00	0.00	-0.56	0.03	0.32	0.13
GDP and Trade Balance	MBN	0.03	-0.13	-0.13	0.06	0.07	0.22	0.09
	HPF	0.06	-0.27	0.05	0.37	0.37	0.32	-0.11

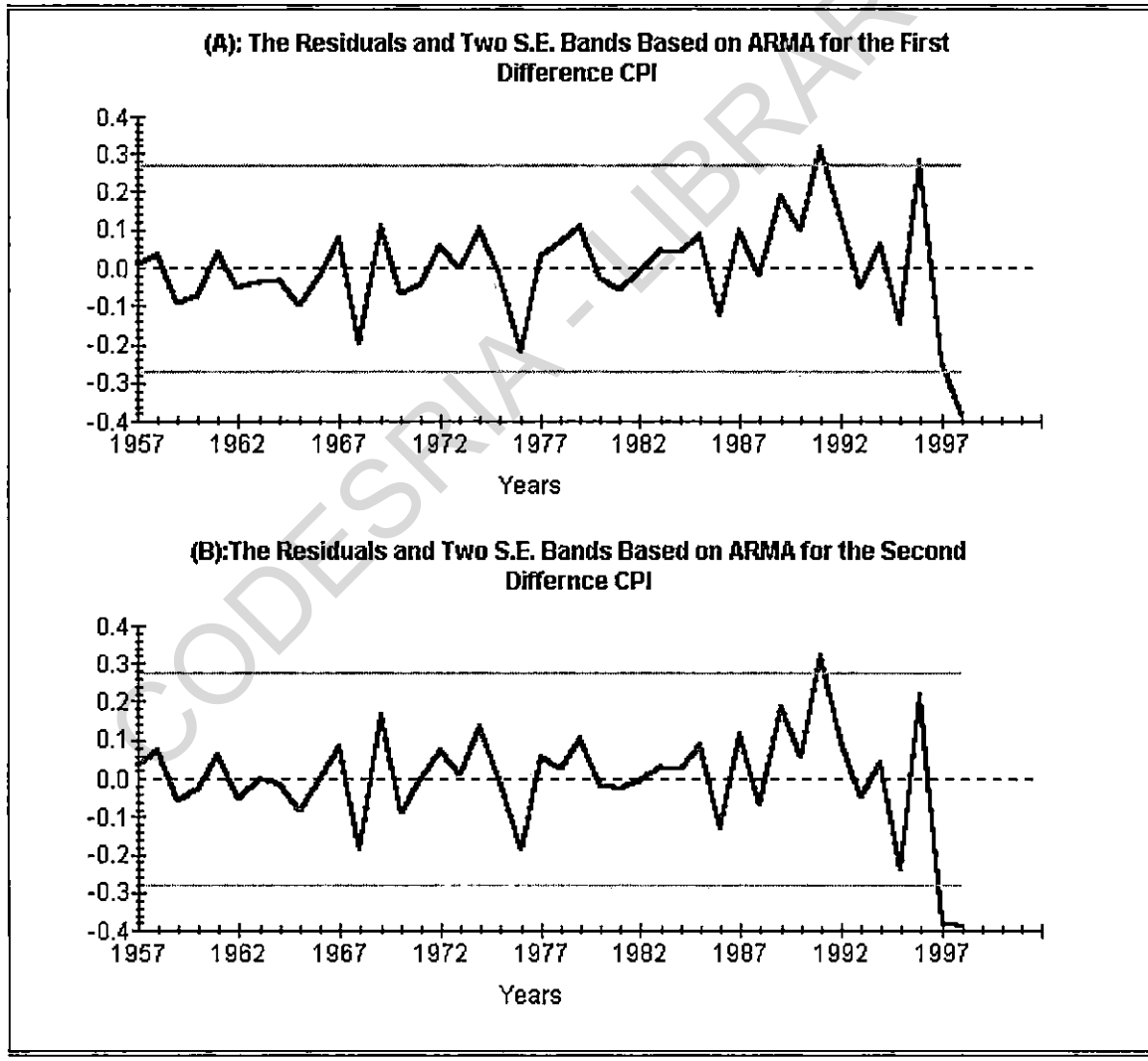
Notes: 1/. The critical value of the correlation coefficients, computed under the null hypothesis that the true correlation coefficient is zero, is about 0.295, that is, $(1/T^{1/2} * 1.96)$, where T is the sample size, (see Cashin and McDermott 1998).

2/. A lag is indicated by a negative sign while a lead is indicated by a positive sign.

3/. MBN is the filter based on the modified Beveridge and Nelson method. HPF is the Hodrick-Perscott filter.

One may be inclined to see the level of price and its rate of growth as an alternative representation of the general price level rather than a different representation of price level and inflation, since in our application, the CPI is I(2). Hence, it is arguable that the first difference of the CPI

should be the base series for determining a white noise ARMA process of the price level. In order to verify this interpretation the residuals with two standard error bands for the ARMA process specified for both the level and the first difference of the CPI are plotted in figures (A) and (B) respectively. The plots of the residuals generally suggest a while noise errors. But, both contain an outlier making it difficult to accept them as alternative representation as suggested above.



However, evidence on countercyclical inflation is documented in the literature in the LDCs (see Agner *et al* 1999). From the data used in this application, the contemporaneous correlation between inflation and the level of the economic activities is strongly negative for the MBN filtering methods implying that the gap type of models, as described by the Phillips curve relationship, may be relevant for describing the inflationary process in the Sudan.

As pointed in chapter (2) money must be accorded a role in whatever model explaining the aggregate behaviour of an economy. Table (5) reports the money-output correlation using narrow money (see the third row). As it appears the contemporaneous correlation is negative, however, a statistically positive correlation at lead is detected. Generally, positive correlation between money and the business cycle *a'la* King and Plosser (1984) indicates the endogenous response of inside money to exogenous shock rather than suggesting causality running from money to output. We further test for the robustness of the bivariate causal relationship, in Granger sense, between the cyclical component on money and income at

Table (6): The Results of Granger-Causality Beween Income and Money

Test if ↓ Granger cuase→		F-statistic	p-value
Money → GDP[/1]	F(4, 27)	0.52	0.72
GDP → Money[/1]	F(4, 27)	0.24	0.91
Money → GDP[/2]	F(4, 28)	0.62	0.65
GDP → Money[/2]	F(4, 28)	0.78	0.55

Notes: 1/. The cyclical componet is obtained residually from the detrending procedure based on the modified Beveridge and Nelson.

2/. The cyclical component is obtained residually from Hodrick-Perscott filter.

four lags length. The results are reported in table above (6).

As it appears from the table above there is no evidence on causality from money to output (or vice the versa), irrespectve of the filter used, again this contradicts the evidence established in the literature on the industrial countries.

To further document the effects of other shocks on the macroeconomic fluctations, we examine an index of velocity defined by the ratio of nominal narrow money to output, the correlations of this index with the cycalical output, at various lags nad leads, are reported in table (5), (see the last row). As it appears, the contemporaneous correlation is significantly negative. As pointed by Agner *et al* (1999), from 'Pure' quantity theory point of view the countercyclical behaviour of velocity would be expected given a procyclical varaition in money and the countercyclical behaviuor of price level. The results reported in table (5) and (6) do not lend a clear support to the interpretation of data included in this application along this line of reasoning.

It is quite typical to attribute a crucial role for international trade in macroeconomic fluctuations specially in a small open economies. A broad array of price and quantity variables relating to international trade should be used in the assessment of such a role. Due to data constraint this study will consider the ratio of export to imports at current prices as a measure of trade balance. The last row of table (5) reports the result of the correlation between exports and imports ratios to the cyclical component of the GDP. As it appears, the contemporaneous correlations are positive irrespective of the filtering procedure used, but the coefficient of

correlation is statistically significant for HPF filter only, and peaks at zero lag, implying a close relationship between the term of trade and output. This result compares fairly with Agner *et al* (1999), however, we note that, Agner *et al* assess this relation between the industrial component of the GDP for selected LDCs and the ratio of exports to imports at current prices. In general the strong procyclical movement of trade balance is documented for the industrial countries (see Bachus and Kehoe 1992). In our case we favour the interpretation that procyclical trade balance may possibly reflect the importance of export shocks in output fluctuations, rather than the lack of sensitivity of imports to domestic demand fluctuation, as alleged to be the case for other LDCs (see Agner *et al*)

The cross-correlation we considered here is based on univariate behaviour of the financial series. Furthermore, it provides information about the average relationship between these variables and output at different phrases of the business cycle. However, this method does not discriminate among the types or the sources of the shocks. Such a distinction would require multivariate time series modeling, which provides an analytical framework that would allow for the distinction of the sources of the macroeconomic fluctuations by type of shock, and more important, it allows for the characterization of the long run relationships and the short run dynamics for the variables included in the analysis. The next section addresses this issue in some details.

4.5. The Structural Econometric Model

The results established in the pervious section motivate the multivariate analysis of the fundamental macreconomic relationships of the Sudanese economy, in order to assess the existence and stability attributes of the long run equilibrium relations, and to identify the sources of the shocks. This section concerns itself with some structural time series modeling. The empirical framework used here is similar to Becker (1999) and Jonsson (1999), who both draw on the influential work of Blanchard and Ouah (1989).

As indicated earlier, the following measure of variables will be included in the analysis; output, domestic price, money, nominal exchange rate and foreign price. We start with testing for cointegrating long run relationships among these variables. Second, we exploit the previous theoretical discussion in the identification scheme in order to isolate the effect of different types of macroeconomic shocks, and to characterize the short-run dynamics. In essence this identification procedure transforms the VAR errors into a set of 'structural', that is, fundamental disturbances that have an economic interpretation.

We start with vector x_t = [y, m, p, wp, e] where, lower letters case indicate that these variables are common logarithms of income (GDP), narrow nominal money (M1), domestic price (CPI), foreign price (WP) and nominal exchange rate (E) respectively. Before proceeding with the analysis we note the following; it is arguable that foreign price should be included as exogenous, or more precisely as exogenous I(1) variable. Accordingly (**wp**) will be included as a long run forcing variable.

Furthermore, since we are using time series over the period 1955 - 1998, structural/institutional breaks are possible[1]. We have not tested directly for the existence of breaks in the series, however, we resort to value judgment and include three (zero/one) dummies. The first accounts for October 1964 revolution, which is followed by a considerable institutional changes, taking the value of zero before the revolution and one thereafter. The second relates to the shift in the exchange rate regime, that is the period of pegging to the dollar 1955-1978, and the period of "free" exchange rate regime, taking zero before 1978 and one thereafter. The third accounts for 1989 political change, taking the value of zero before 1989 and one thereafter. Finally, since Sudan's exports are dominated by cotton, we included the rate of change of world cotton price, based on United States (10 markets) because it is the only complete series we found over the period 1955-1998, at the time of writing this study. This series is included just as an exogenous I(0) variable. These deterministic variables are included primarily to account for possible structural breaks in the data. Hence, they will not be forced to lie into the cointegrating space spanned by the cointegrating vectors. Accordingly, both the long run equilibrium relationships and average rate of growth can change while the cointegrating vectors are not.

Finally, in the light of results of the unit root tests reported in table (3), we use the standard I(1) analysis, that is, a vector x_t of endogenous variables, that are integrated of order one have a VECM representation as described by equation (10) (see chapter 3).

[1]A relatively long time series is needed for asymtotatic theory to work. We note that nothing will be gained from specifying a short time span, in order to aviod possible breaks, and to use high frequecy data, to increase the number of observations for this limited time span.

4.5.1. Testing for the Long Run Relationships

We use Johansen (1991) procedure, for testing for cointegration. Since the test for cointegration using this framework is sensitive to the lag length and the assumptions regarding the deterministic variables, we first estimate an unrestricted VAR for vector x_t defined in the proceeding section. At this stage, we follow the literature on the VAR and include a generous lag profile, with annual observations as the case here, four lags are allowed in the VAR corresponding to equation (9) (see chapter 3). As no priors are imposed on the lag length, both AIC and SBC are used to determine the optimal lag length. All the VAR(p), p = 1,2,3, and 4 are estimated over the period (1955-1998) and the AIC and SBC are reported in table (7).

Table (7):Criteria for Selecting the VAR Order/[1]

Lag Order	AIC	SBC
4	250.37	144.82
3	216.23	131.79
2	212.37	149.64
1	201.57	159.35
0	9.50	-11.61

Note: 1/. The AIC and SBC are obtained from estimating unrestricted VAR(p), p = 1,2,3, and 4 for vector x_t = [y, m, p, wp, e].

As it appears from table (7) AIC select four lags while SBC select one lag. As indicated earlier (see chapter 3) SBC penalizes extra parameter much more heavily suggesting using only a constant term in the estimation. In view of the limited sample included in this application, we do not want run a risk of over parametrization, accordingly we estimate

VAR(p), p = 1 and 2 corresponding to equation (10) of chapter (3) the results of the cointegration tests are summarized in table (8). As it appears from the table, the tests select (1 to 3) vectors in VAR(1) and (1 to 4) vectors in the case of VAR(2). That is, all the tests do not agree with the expected theoretical relationships, and this is not uncommon. It is known that, Johansen likelihood ratio statistics are sensitive to the order of the VAR and about the assumptions with respect to the inclusion of the constant and the trend.

Table (8): Cointegration Analysis of the Demand for Money and the PPP/[1]

	λmax				trace			
	Lags		Critical value		lags		Critical value	
H_0	1	2	95%	90%	1	2	95%	90%
				Restricted constant and no trend				
r = 0	**34.09**	**34.20**	31.48	29.01	**87.55**	**86.21**	62.75	59.07
r <=1	22.29	22.81	25.54	22.98	**53.46**	**52.02**	42.40	39.12
r <=2	**21.34**	**19.45**	18.88	16.74	**31.17**	**29.21**	25.23	22.76
r <=3	9.83	9.75	12.42	10.50	9.83	9.75	12.45	10.50
				Unrestricted constant and no Trend				
r = 0	**33.24**	**34.18**	30.71	28.27	**80.31**	**82.69**	58.63	54.84
r <=1	22.24	21.82	24.59	22.15	**47.07**	**48.51**	38.93	35.88
r <=2	**20.58**	**19.73**	18.06	15.98	**24.83**	**26.69**	23.32	20.75
r <=3	4.25	7.32	11.47	9.53	4.25	7.32	11.47	9.53
				Unrestricted constant and restricted trend				
r = 0	34.32	**40.58**	34.70	32.12	**96.68**	**112.97**	72.10	68.04
r <=1	26.29	**33.81**	28.72	26.10	**62.36**	**72.39**	49.36	46.00
r <=2	21.34	20.40	22.16	19.79	**36.07**	**38.58**	30.77	27.96
r <=3	14.72	**18.18**	15.44	13.31	14.72	18.18	15.44	13.31

Note: 1/ The estimation uses vector x_t = [y, m, p, wp, e]. Asymptotic critical maximum eigenvalues and trace statistic are obtained from Pesaran *et al* (1996). Bold (underlined) statistics indicate that they are significant at 5 percent (10 percent) level. The time period is (1955 - 1998)

Ideally, the number of the cointegrating vectors and the order of the VAR be determined simultaneously using the usual selection criterion, but as

yet little is known about their sample performance (see Persan and Persaran 1997). It should be noted that both theory and a broad 'amount' of judgment have to be used in order to determine unique cointegrating relationships.

In the light of the theoretical discussion we impose two a prior cointegration restrictions and two normalization restrictions per cointegrating relationship in order to jointly identify them exactly. These are a demand for money vector, denoted as cv-dm:[p y m] and ppp vector, denoted as cv-ppp: [p e wp]. The normalization and exclusion restrictions are imposed on the β-matrix the former restrictions are imposed on the P coefficient in both cointegrating vectors. The results are reported in table (9). We note that both nominal and real money balances are used in the analysis. As it appears from the table, the test for the joint vectors are accepted in VECM representation with two lags and both are rejected in a model with one lag at 10% significance level irrespective of the way money is defined. The estimated individual parameters of the long run demand for money relationship, specially when nominal money is used, have the expected signs and are fairly comparable with estimated long run demand for money in other studies using data from the LDCs (see for example Persaran 1999, Jonsson 1999 and Becker 1999). However, the estimated parameters of the PPP relationship are not. More specifically the parameter of the nominal exchange rate is negative, while a positive parameter is expected. We impose this restriction, but it has been rejected using both definitions of money (see bottom table 9).

It should be noted that the coefficient of the nominal exchange rate and foreign price both have negative signs implying that the so called ppp hypothesis, even in its weakest version as used in this study, is not supported by the data. (For a set of different results on the African context see Nagayasu 1998 and Krichene 1998).

Table (9): Restricted Cointegrating Vectors/[1]

VAR Order	The Variables of vector x_t: {p y m e q}	χ^2	(p-value)
	(Nominal money)		
VAR(1)	$\begin{Bmatrix} 1 & 1.58 & -1.25 & 0 & 0 \\ 1 & 0 & 0 & 0.71 & -2.54 \end{Bmatrix}$	-5.30	(0.07)
VAR(2)	$\begin{Bmatrix} 1 & 1.91 & -1.17 & 0 & 0 \\ 1 & 0 & 0 & 0.75 & -1.78 \end{Bmatrix}$	1.66	(0.44)
	(Real money)		
VAR(1)	$\begin{Bmatrix} 1 & -6.32 & 4.99 & 0 & 0 \\ 1 & 0 & 0 & -.71 & -2.53 \end{Bmatrix}$	5.30	(0.7)
VAR(2)	$\begin{Bmatrix} 1 & -10.64 & 4.99 & 0 & 0 \\ 1 & 0 & 0 & -0.75 & -1.79 \end{Bmatrix}$	1.65	(0.44)
	Restricted VAR(1)		
VAR(1)	$\begin{Bmatrix} 1 & 1.29 & -1.10 & 0 & 0 \\ 1 & 0 & 0 & 1 & -5.96 \end{Bmatrix}$	13.96	(0.00)

Note: 1/ The estimation uses vector x_t = [p, y, m, e,wp], where wp is included as exogenous varaible, the rest of the varaibles are endogenous. Three dummies and the rate of growth of foreign cotton price are included as determinstic varaibes. Time period is (1955-1998).

In view of this, we have to resort to short cuts in order to proceed with the modelling process. Balanchard and Fisher (1989) pointed that it is not unusual to take guesses and to rely on battery of models that can not be drived from first principles but have repeatedly proved useful. One short cut, nonetheless, suggested by the estimated models above, is to restrict the coefficient on the nominal exchanage rate and the foreign price to be the same in all cases. That is, in the cointegrating vectors and in the short run dynamics. This way of proceeding economies in the degrees of freedom in estimation, and fully consistent with the theoretical considerations, since both coefficients are respectively zero and one in the money demand and the PPP vectors (see Becker 1999).

As before, we estimate VAR(p), p = 1, 2, 3, and 4; the results of AIC and SBC are reported in table (10).

Table (10): Criteria for Selecting the VAR Order of the Chosen Model/[1]

Lag Order	AIC	SBC
4	115.39	44.45
3	101.26	43.84
2	100.25	56.34
1	100.63	70.23
0	-53.00	-70.45

Note: 1/. The AIC and SBC are obtained from estimating unrestricted VAR(p), p = 1,2,3, and 4 for vector x_t = [y, m, p, ew], all variables are defined as before.

Again the two selection criterion report conflicting results with AIC selecting 4 lags and SBC selecting one lag. However, the results of

cointegration tests using VAR(p), p=1, 2, and different assumptions about the deterministic variables are reported in table (11).

Table (11):Cointegration Analysis of the Demand for Money and the PPP in the Chosen Model Specification/[1]

	λmax				trace			
	Lags		Critical value		lags		Critical value	
H_0	1	2	95%	90%	1	2	95%	90%
				Restricted constant and no trend				
r = 0	**29.52**	**31.75**	28.27	25.80	**80.08**	**81.33**	53.48	49.95
r <=1	22.76	**27.17**	22.04	19.86	**50.56**	**49.58**	34.87	31.93
r <=2	**20.73**	**17.64**	15.87	13.81	**27.79**	**22.40**	20.18	17.88
r <=3	4.76	4.77	9.16	7.53	7.06	4.77	9.16	7.53
				Unrestricted constant and no Trend				
r = 0	**29.16**	**30.72**	27.42	24.99	**73.08**	**77.20**	48.88	45.70
r <=1	**22.50**	**27.04**	21.12	19.02	**43.92**	**46.47**	31.54	28.78
r <=2	**20.32**	**17.58**	14.88	12.98	**21.42**	**19.43**	17.86	15.75
r <=3	1.10	1.85	8.07	6.50	1.10	1.85	8.07	6.50
				Unrestricted constant and restricted trend				
r = 0	29.20	**35.39**	31.79	29.13	**89.79**	**104.00**	63.00	59.16
r <=1	24.24	**27.06**	25.42	23.10	**60.59**	**68.61**	42.34	39.34
r <=2	22.25	**23.97**	19.22	17.18	**36.36**	**41.55**	25.77	23.08
r <=3	14.11	**17.57**	12.39	10.55	**14.11**	17.57	12.39	10.55

Note: 1/. The estimation uses vector x_t = [y, m, p, ew].Asymptotic critical maximum eigenvalues and trace statistic are obtained from Pesaran *et al* (1996). Bold (underlined) statistics indicate that they are significant at 5 percent (10 percent) level. Time period is (1955-1998).

From table above (11) it appears that the tests pick 0 to 3 cointegrating vectors at 5% significance level for VAR(1) using λmax statistic. In the other model specifications at least 3 vectors are detected. As before, theory based normalization and over identifying restrictions are used to test for the joint significance of the cv-md and cv-ppp relations. The results of the tests are reported in table (12) below. As it appears from the table, the joint hypotheses, irrespective of the way money is defined, are accepted in the model with one lag and both are rejected in the model with two lags. The estimated coefficients of the ppp relationship have the expected signs and are of plausible magnitudes in all specifications. The coefficients in the money demand relationship have the correct signs in three out of the four runs, in these three models, the coefficients of income range between -1.3 to -6.90 and the coefficients of the price, the opportunity cost of holding money, range between 0.12 to 1.68.

It should be noted that the theoretical concepts could not arrive at without assumptions regarding the exogeniety status of other variables in these long run relationships. This issue is, in principle, addressed by imposing exclusion restrictions on α-matrix, and it appears from equation (10), the coefficients of α-matrix, the error correction terms, capture the speed of adjustment of a particular variable to a deviation from the long run equilibria. The results of estimating the endogenous variables vector x_t suggest that these variables are not weakly exogenous in the long run theoretical relations examined. As such, we proceed with the "*as if*" assumption that these equations parameters correspond to the theoretical concepts.

Table (12): Restricted Cointegrating Vectors in the Chosen Model Specification/[1]

VAR Order	The Variables of vector x_t: {p y m ew}	χ^2	(p-value)
	(Nominal money)		
VAR(1)	$\begin{Bmatrix} 0.69 & -6.91 & 1 & 0 \\ -0.82 & 0 & 0 & 1 \end{Bmatrix}$	1.60	(0.24)
VAR(2)	$\begin{Bmatrix} -0.88 & -1.30 & 1 & 0 \\ -0.97 & 0 & 0 & 1 \end{Bmatrix}$	10.15	(0.00)
	(Real money)		
VAR(1)	$\begin{Bmatrix} 1.68 & -6.91 & 1 & 0 \\ -0.82 & 0 & 0 & 1 \end{Bmatrix}$	1.41	(0.24)
VAR(2)	$\begin{Bmatrix} 0.122 & -1.30 & 1 & 0 \\ -0.97 & 0 & 0 & 1 \end{Bmatrix}$	10.00	(0.00)

Note: 1/ The estimation uses endogenous vector x_t = [p, y, m, ew]. Three dummies and the rate of growth of foreign cotton price are included as determinstic varaibes. Time period is (1955-1998).

We observe that the models including real money, real output, inflation and PPP suffer from specification problem. Perhaps, this have arisen because the formulation of these models removes the potential I(2) component of the CPI. However in the rest of this analysis we use VAR(1) with nominal money.

4.5.2. The Short Run Dynamics

The empirical results of the preceding analysis, broadly speaking, are compatible with the theoretical considerations, and it is arguable that the comovements of the variables included in the analysis are predictable by theory. In order to establish the short run properties of the chosen model specification we examine the forecast error variance decompositions, as we saw in chapter (3) this quantitatively evaluates the prediction of the forecast error variance at different forecast horizons that can be attributed to each shock in the estimated model. Then we examine the error correction relations of the model and finally we consider the impulse responses. In the subsequent analysis we use generalized shocks, as described in the methodological section, because this procedure does not require a "prior" stand, so to speak, on the causal ordering of the variables. We also note that, it is only heroic to think of the identification scheme used in the preceding analysis as isolating different types of shocks as relating to supply, demand or nominal side of the economy.

First we consider forecast error variance decompositions, which indicate the proportion of the variance on the N-period ahead forecast error that is attributable to each shock. We use the generalized forecast error variance decomposition, this approach allows for the contemporaneous correlation between own forecast error shocks and the shocks to other variables of the model. Table (13) presents the generalized forecast error variance decompositions. As it appears, the result of the variance decompositions for output growth shows that own "supply" shock - of all the different fundamental macroeconomic shocks on output fluctuations - accounts for more than 95% of output fluctuations in all horizons.

Table (13): Generalized Forecast Error Variance Decompositions/[1]

Shock to ⇒	output				Money				domestic Price				foreign price			
Years	y	m	p	ew	y	m	p	ew	y	m	p	ew	y	m	p	ew
1	99.81	2.38	3.87	0.21	1.27	98.80	35.40	21.17	6.93	31.13	97.48	24.27	15.39	24.36	50.34	78.96
2	99.38	3.24	2.85	0.17	1.46	97.45	34.63	18.27	7.31	29.46	95.90	20.08	24.05	21.94	50.22	64.00
3	98.71	4.23	2.78	0.18	1.97	97.32	33.63	16.50	7.01	28.59	95.00	17.80	27.56	20.73	53.29	55.61
4	97.82	5.30	2.93	0.22	2.66	96.78	32.61	15.29	6.50	28.17	94.99	16.39	28.65	20.23	55.77	50.59
5	96.76	6.44	2.93	0.31	3.43	96.27	31.64	14.41	5.98	27.94	94.41	15.43	28.64	20.10	57.90	47.27
6	85.56	7.62	3.29	0.42	4.19	95.78	30.76	13.72	5.50	27.82	93.98	14.75	28.12	20.16	59.74	44.87
7	94.26	8.81	3.76	0.55	4.93	95.32	29.98	13.18	5.07	27.78	93.31	14.22	27.38	20.31	61.35	43.00
8	92.89	10.10	4.38	0.70	5.62	94.89	29.27	12.74	4.70	27.72	93.04	13.80	26.56	20.50	62.75	41.45
9	91.89	11.20	5.08	0.86	6.25	94.50	28.66	12.37	4.37	27.70	92.80	13.45	25.73	20.71	63.98	40.13
10	90.06	12.37	5.83	1.04	6.82	94.14	28.12	12.06	4.09	27.70	92.58	13.16	24.91	20.91	65.07	39.97
11	88.64	13.52	6.63	1.21	7.33	93.83	27.64	11.74	3.84	27.70	92.38	12.93	24.13	21.12	66.04	37.92
12	87.23	14.64	7.46	1.38	7.80	93.54	27.22	11.59	3.62	27.70	92.22	12.72	23.38	21.32	66.91	26.96
13	85.84	15.72	8.29	1.56	8.22	93.28	26.84	11.35	3.42	27.70	92.05	12.54	22.68	21.52	67.70	36.08
14	84.48	16.78	9.11	1.74	8.59	93.04	26.50	11.18	3.25	27.70	91.90	12.38	22.04	21.70	68.43	35.26
15	83.15	17.81	9.94	1.91	8.92	92.83	26.20	11.03	3.10	27.70	91.77	12.43	21.38	21.88	69.10	34.50

Note: 1/. Based on the estimation of the cointegrating VAR(1) for the vector x_t = [y m p ew]. The decompositions indicate the percentage of the variance of the N-period ahead forecast error that is attributable to different types of shocks, that is, shocks to output, money, domestic price and foreign price respectively.

Similarly, in the case of money and inflation growth, a high percentage of the forecast variance is traceable to own shock. In the case of the (ew) equation, it is clear that most of the variability in the within year forecast of (ew) can be attributed to own information. In the long run (ew) shock has important impact on domestic prices and to some extent output growth movements.

Second in the light of our identification assumptions, we examined the error-correction terms of the estimated system. These error-correction relations describe the speed of the 'yearly' adjustment of a variable to any disequilibrium in the (cv-md) and (cv-ppp) vectors. Table (14) presents a summary of the error correction terms along with diagnostic tests of the estimated dynamic equations. The independent variables are the lagged residuals from the two estimated cointegration vectors, the deterministic terms and the lagged observations of all other variables in the system. As it appears from the table, only in the case of output and foreign exchange that the error correction terms associated with the (vc-md) and (vc-ppp) have statistically significant impact. In the case of the former, it is clear that long run money demand has a significant impact on output growth although the within year adjustment is only 3.3%. In the case of the latter, it seems that 85% of the deviation from the (cv-ppp) is adjusted for within one year. However from the reported diagnostic tests, it seems that the (m) and (ew) equations suffer from residual autocorrelation, which may be due to the lag order used in the estimation of the system. Furthermore, without asserting the status of the relative exogeniety of the variables, it may not be appropriate to model a particular variable (ew) for example, in a one error correction parsimonious model (see Jonsson 1999).

Table (14): A Summary of the Error Correction Models/[1]

ECM-term	Coefficient	t-statistic	Diagnostic tests	χ^2	p-value
Dependent variable Δy					
ecm1(-1)	0.033	2.36	Serial autocorrelation	1.27	0.26
ecm2(-1)	-0.00	-0.11	Functional form	3.98	0.06
			Normality	0.53	0.77
			Heteroscedaticity	6.54	0.01
Dependent variable Δm					
ecm1(-1)	0.01	0.37	Serial autocorrelation	4.70	0.03
ecm2(-1)	-0.07	-1.19	Functional form	0.08	0.78
			Normality	2.42	0.28
			Heteroscedaticity	5.60	0.02
Dependent variable Δp					
ecm1(-1)	0.02	0.94	Serial autocorrelation	1.09	0.30
ecm2(-1)	-0.12	-1.60	Functional form	4.76	0.03
			Normality	9.65	0.01
			Heteroscedaticity	5.79	0.01
Dependent variable Δew					
ecm1(-1)	0.16	4.34	Serial autocorrelation	4.11	0.04
ecm2(-1)	-0.85	-5.37	Functional form	17.40	0.00
			Normality	7.46	0.02
			Heteroscedaticity	15.94	0.00

Note:1/. There (ECMs) are obtained from the estimation of the dynamic equations of real income, nominal money, price and foreign exchange based on the cointegarting VAR(1) for the vector x_t=[p y m ew].

Third, an arguably more informative approach to studying the comovements among variables and their short run dynamics, is to examine the impulse response functions from the structural model. The impulse responses allow the examination of the impact of different types of shocks on the model's variables as well as on the estimated long run relations. More important, the impulse response gives an idea about the time profile (that is, the lag structure) of the economy, which contains useful information on the speed of convergence of the model to its long run equilibrium relationships (see persaran and Sigh 1996). For reasons noted earlier, we use the generalized impulse response(s) GIR(s) to account for both the variable-specific and the system-wide response to one standard error (S.E.) shocks. Figures (C) to (I) depict these impulse responses, namely, figures (C) to (E) illustrate the dynamic effects of a shock to the selected variables in the cointegrating VAR, that is, the effects of variable-specific shocks on the long run cointegration relations ($x\beta'$), figures (F) to (H) illustrate the effects of these respective shocks system-wide and figure (I) shows the persistence profile of the effect of a system-wide shock to the cointegrating vectors. From figures (C) and (F) it appears that deviation from the long run equilibrium can occur as a result of shocks to any variable in the system.

From figure (C) it appears that, as a result of one standard error shock to the dynamic equation of output, on impact output rises by the full amount of the shock, nominal money increases by 2/5 percent above the baseline model on impact with the full adjustment taking place within about two years. That is, demand for nominal balances rises and domestic price quickly decreases, after about two years, the nominal money reaches its 'steady-state' and the domestic price starts to rise offsetting the rise in

real income and nominal money. Over time output and money grow by 1/5 and 3/5 percent above the baseline respectively. These results are comparable to other studies (see Jonsson 1999 and Becker 1999). From figure (F) it appears that the effect of output shock on the cointegrating vector (cv-md) dies out in about 15 years and the equilibrium seems to be restored through the adjustment in output (net decrease) and in price (net increase).

Figure (D) shows that a positive shock to nominal money leads to an increase in money by the full amount of the shock on impact. Domestic inflation rises quickly, however, the output gain from the money shock is small and peaks in about 5 years. Thus, the excess nominal balances seem to trigger inflationary pressures on impact that recedes to its steady-state as money decreases and output picks up setting the variables to a new path to restore equilibrium. As it appears from figure (G), again the cointegrating relation is driven back to its steady-state in about 15 years.

These results are in line to our earlier finding that the shocks to output and money are persistent and the within year adjustment is very small. In all, figures (F) and (G) suggest that the equilibrium of the (cv-md) following a shock to output or money is restored in about 15 years quite a long period of time from the short run point of view.

One standard shock to foreign exchange rate in the (cv-ppp) relation is depicted in figure (E), on impact the shock is dominated by foreign exchange response as expected. Both money and price rise on impact, output slightly declines, however, it picks up in about one year. The foreign exchange 'depreciates' to its steady-state in about 4 years, while

money and domestic price in about 2 years. All variables settle in a new path to restore equilibrium. Although this shock is obtained under the identifying restrictions, the adjustments in variables following the shock could be explained along the lines of the J-curve phenomena, which generally holds that, a depreciation of exchange rate leads initially to worsening of the current account, because adjustment in quantities (exports and imports) and hence output takes time (see Becker 1999 and the literature cited therein). From figure (H) it appears that, more than 50% of the adjustment of the (cv-ppp) following a shock to (ew) occurs within about 3 years.

The persistence profile of the effect of a system-wide shock to the cointegrating vectors is depicted in figure (I). As it appears, both of the cointegrating relations tend to their respective equilibria verifying that they are 'genuine' cointegrating relations. In all the shock dies out in about 10 years with the (cv-ppp) in contrast with the (cv-md), converging faster to its long run equilibrium following a shock.

Thus, it appears from this discussion that, the length of the Sudanese business cycle, defined as the speed of attaining full adjustment to equilibrium following a shock, may not be less than 10 years. As such, demand management policies may have a long lasting effects, and more important, unless carefully managed may lead to harmful results.

Figure (C): GIR(s) to One S.E. Shock in (y) Equation

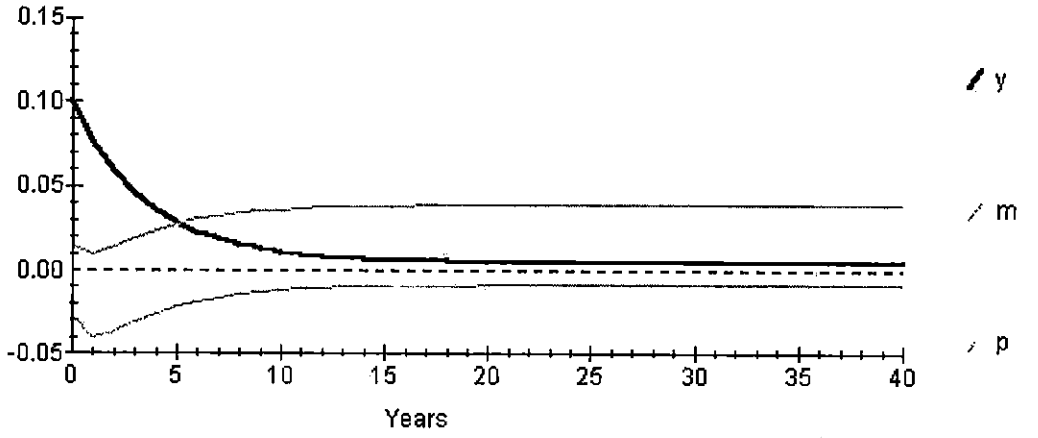


Figure (D): GIR(s) to One S.E. Shock in (m) Equation

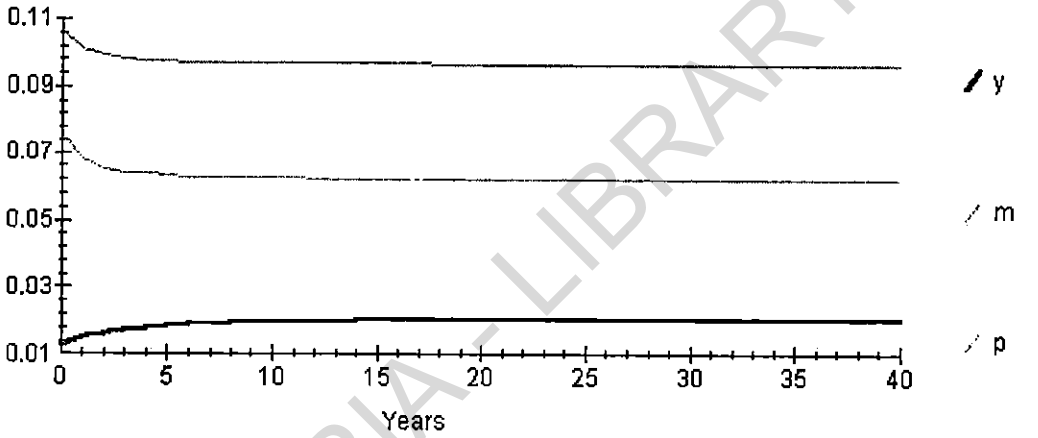


Figure (E): GIR(s) to One S.E. Shock in (ew) Equation

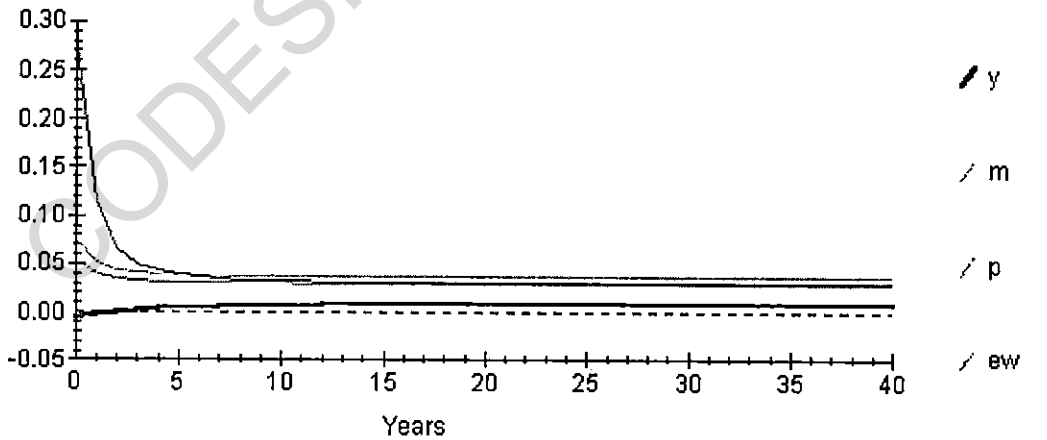


Figure (F): GIR(s) of the cv-md to One S.E. Shock in (y) Equation

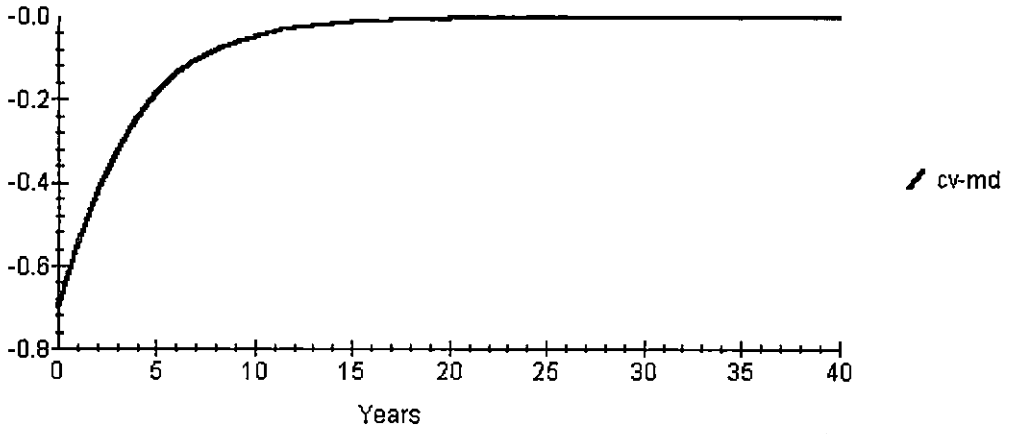


Figure (G): GIR(s) of the cv-md to One S.E. Shock in (m) Equation

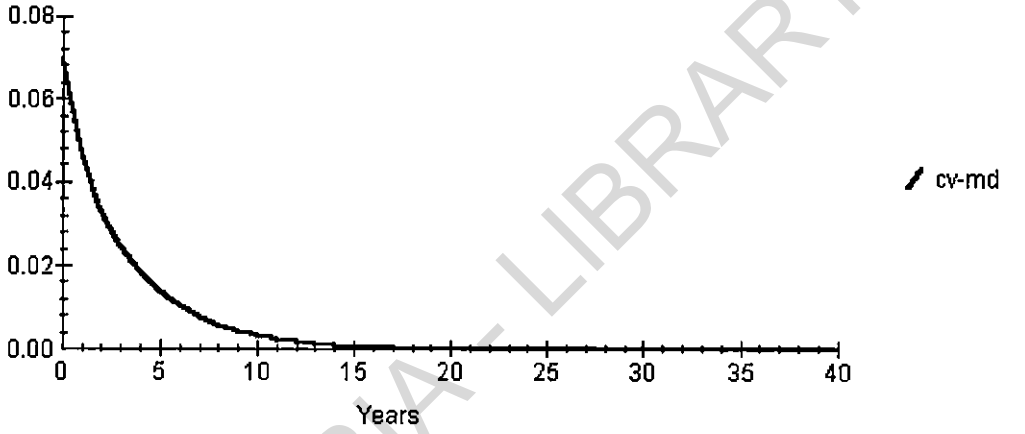


Figure (H): GIR(s) of the cv-ppp to One S.E. Shock in (ew) Equation

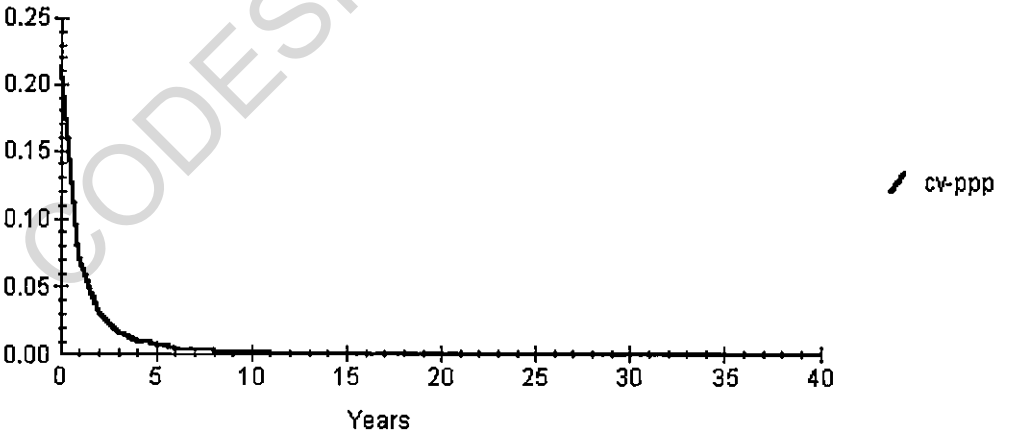
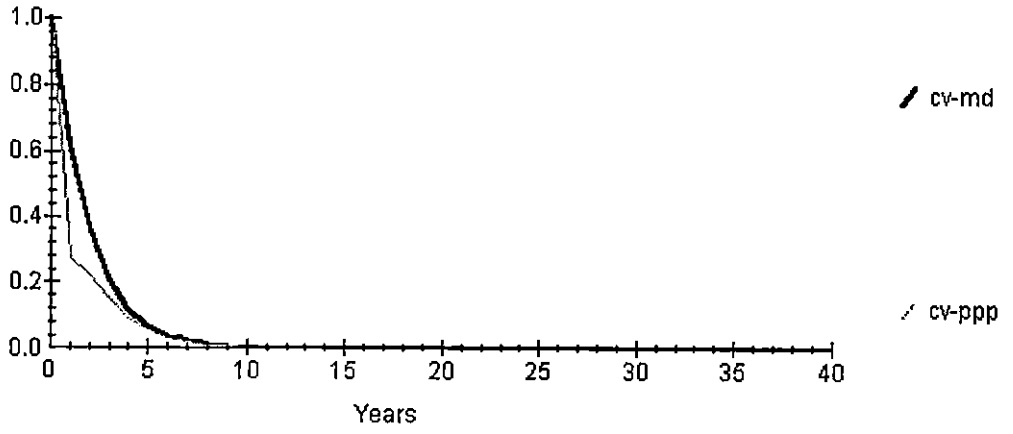


Figure (I): Persistence Profile of the Effect of a System-Wide Shock to CV'(s)



CHAPTER FIVE
SUMMARY AND CONCLUSIONS

In this chapter, the first section provides a summary of the main findings of this research, and the next section briefly concludes by remarks on the methodology and the policy implications of the analysis.

5.1. Summary of the Results

The results of both bivariate and multivariate analysis of the sources of the Sudanese macroeconomic fluctuations, carried out in this research could be summarized under the following:

5.1.1. The Results of the Bivariate Analysis

The unconditional cross correlations between the cyclical components of output, prices, money, velocity and a measure of the international trade, generally indicate that the stylized features of the Sudanese business cycle are comparable to other features documented for the LDCs. More specifically:

a) The variation in the stationary components of output and price are negative. This countercyclical behaviour gives support to supply-driven models of real business cycle. It is arguable that procyclical inflation should be used instead of price, but there is no clear evidence from the data used in this application for procyclical inflation.

b) The cross correlations between money and output are broadly negative with statistically significant one positive correlation at lead. The bivariate Granger-causality test between these two aggregates suggests that money is not of inside variety *a' al* King and Plosser (1984) type of models.

c) The contemporaneous correlation between the velocity and output is significantly negative. The countercyclical behaviour of velocity and price, given the evidence of the countercyclical money, implies that the quantity theory reasoning holds on the margin in the data used in this application.

d) The contemporaneous correlations between the measure of international trade used in this study, and the cyclical component of output are positive. This generally indicates the importance of foreign trade shocks - in view of the index used - in output fluctuations.

It is important to note that, these results are generally consistent across the detrending procedures used. More important, the stylized features of the macroeconomic fluctuations documented here are fairly comparable to those established for other case studies. Therefore, the reservation that the business cycle in an agrarian economy, such as that of Sudan, may exhibit *a* typical features in unwarranted.

We note that, the bivariate analysis provides information about the average relationships between variables, and does not distinguish between the type of the shock nor does it gives a clear idea about the time profile - that is 'the persistence' of the shock - which is the more important from both the 'understanding' and the policy point of view.

5.1.2. The Results of the Multivariate Analysis

Generally, the results of the multivariate analysis indicate that there exists a stable long run type of money demand relationship among income, price and money as well as a (ppp) type of relationship. However, the magnitude of the estimated coefficients are not all in all estimated models consistent with a *strict* theoretical requirements. An interesting aspect of these result, is that, despite the possible structural breaks that could be harboured by the data used in this study, and the considerable policy shifts, the financial time series examined in this study fairly support the existence of sensible macroeconomic relations in consonance with the theoretical requirements.

From the estimate of the chosen model, it appears that, the persistence profile of the effect of both variable-specific shocks on the cointegrating relations as well as the effect of system-wide shock imply that the short run is too long. In particular, the analysis of the short run dynamics reveals two main results:

First, a shock to money (money surprises) trigger inflationary pressures on impact and the output gain in the medium to the long run is small.

Second, a shock to foreign exchange does not seem to have a significant effect on real output, this implies that there is limits to the effectiveness of exchange rate in manipulating competitiveness in the sort run. That is, depreciation of nominal exchange tends to raise inflation more than real output.

5.2. Conclusion

This concluding section raises some remarks on the methodology and the policy implications of the analysis. With respect to the methodology we note that, first; although the correlations results are fairly similar across the filtering procedure used, yet there are some features of the data that are not explainable across the detrending procedures *a la* HPF and MBN filtering method. We already commented on the former, our remark on the latter is that, the MBN method involves the specification of the ARMA. It is known that the empirical specification of the ARMA process is an art. As such, the consideration of alternative detrending methods remains an important exercise.

Second, the low order cointegrating VAR used in the analysis presents its own problems (for example serial autocorrelation). However, in our choice of the VAR order we traded-off efficiency for flexibility to proceed with the estimation. Still there remains some features to be exploited from the data used in the applications in this study. It seems that, specifying a general quantitative models, *a' la* stochastic general equilibrium simulation models designed for small open economy, may be a fruitful exercise for establishing a framework for stabilization policies for the Sudan.

Third, our final remark relates to the data management; it is arguable that increasing the sample size through the inclusion of more annual observations, as we did, may degrade the quality of the data. The stand taken in this study is to include dummies corresponding to possible periods of structural breaks, primarily to facilitate the estimation process.

Despite the caveat about the methodology and the data, robust regularities have been established for the Sudanese business cycle. But, the broad result that the aggregate variables in an economy undergo repeated fluctuations about trend that are comparable to other experiences does not imply ability to correct the macroeconomic imbalances with sufficient speed, nor does it give a clear explanation of the persistence of inefficient policies[1].

With regard to the policy implications of the analysis, we note that, from the persistence profile of the estimated model, the short run may be long, accordingly the demand management policies may have long lasting effects. This gives support to supply - oriented policy programme to enhance the real output growth at a low inflation rate. Such policy programme may include public sector reform, liberalization of markets including the labour market, and strengthening of the human capital capacity of the economy. However, money does matter, while there are limits to the effectiveness of the exchange rate in the operationalization of this policy programme.

[1] In this case, the political economy of macroeconomic cycles is indeed useful in providing an explanation.

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