Macro-econometric Modelling for Policy Analysis in Sudan (1960-2015)

Suliman Abdalla*

Abstract

This study applies a structural vector-autoregression (SVAR) model and its associated impulse response functions to investigate how selected macroeconomic variables in Sudan dynamically respond to a set of internal and external shocks. Shocks considered in the SVAR setup are associated with real GDP, inflation, exchange rate, money supply, oil price, and real-world output. The dataset is split into two parts: pre- and post-secession in South Sudan, where substantial macroeconomic volatility is seen during the post-secession period. The empirical evidence suggests that the selected variables have negligible responses to the included domestic shocks and that the exchange rate is the most responsive variable. Also, there is some evidence that all domestic variables of the system respond significantly to their own fluctuations, but only at short horizons. The results also illustrate that the world real output shocks and those emanating from world oil markets do not seem to have significant impacts on the domestic economy. These results have important implications for policy-makers in their attempts to reduce macroeconomic volatility.

تطوير نموذج قياسي كلي لتحليل السياسات الاقتصادية في السودان (1960-2015)

سليمان عبدالله

ملخص

تهدف هذه الدراسة لتقييم استجابة المتغيرات الاقتصادية الكلية في السودان لمجموعة من الصدمات الاقتصادية الداخلية والخارجية وذلك في سياق نموذج متجه الانحدار الذاتي الهيكلي (SVAR) ودالة الاستجابة للصدمات. يتضمن النموذج الصدمات الداخلية المرتبطة بمتغيرات: الناتج المحلي الإجمالي، التضخم، سعر الصرف، عرض النقود، والصدمات الخارجية الناتجة من تقلبات أسعار النفط، والناتج الإجمالي الحقيقي في العالم. تم تقسيم مجموعة البيانات إلى فترتين، الأولى تمثل فترة ما قبل انفصال دولة جنوب السودان، والثانية تغطي ما بعد الانفصال والتي تميزت بالتقلبات الشديدة في العديد من المتغيرات الاقتصادية الكلية. تشير النتائج التطبيقية المتعلقة بالاستجابة للصدمات المحلية إلى وجود استجابات طفيفة لكافة المتغيرات المتضمنة في النموذج، ماعدا متغير سعر الصرف الذي يتميز باستجابة كبيرة لتلك الصدمات. وتشير النتائج إلى أن المتغيرات المتضمنة في النموذج تستجيب بشكل كبير لتقلباتها في الفترات السابقة، ولكن يتم ذلك خلال مدى زمني قصير جداً. وفيما يتعلق بتأثير تقلبات وصدمات أسعار النفط العالمية والناتج الحقيقي في العالم، فلم تظهر النتائج استجابات ذات أثر معنوي في المتغيرات الاقتصادية الكلية لتلك الصدمات. وتعتبر هذه النتائج ذات أهمية بالنسبة لصانعي السياسات الاقتصادية في السودان في محاولاتهم للحد من التقلبات الكبيرة التي يشهدها الاقتصاد السوداني.

_____

* College of Arts and Social Sciences, Sultan Qaboos University, Muscat, Sultanate of Oman.
  Emails: Sulabdalla@squ.edu.om

1. Introduction

Since South Sudan's secession from the North in 2011, issues like the understanding of macroeconomic fluctuations and the use of macroeconometric modelling in policy analyses and forecasting have become, increasingly, the top priority issues for macro-economic policy-making in Sudan. Building a macro-econometric model (MEM) has come to the forefront of macroeconomic policy debate stirred up by policy makers regarding the national economy's performance. In fact, the shock associated with the South's secession is not the only negative shock that has hit the economy[1]; the country has also experienced a wide variety of shocks associated with different economic and political instability events over the past six decades (see, for example, Abdalla, 2016). These include, for example, oil price shocks during the 1970s, civil war renewal between the northern and southern regions of the country over the early 1980s, severe drought and famine during the 1970s and 1980s, international sanctions overing the late 1990s, and, more importantly, the recurrent changes between military and civilian regimes and the associated recurrent changes in economic development plans. Currently, the country is struggling with the repercussions of the South's secession, together with international sanctions and a heavy debt burden. By the end of 2015, external debt stock continued to grow at a very high level of USD 50 billion, representing approximately 61% of the GDP (84% of which falls into arrears to international financial institutions like the World Bank, IMF, and the African Development Bank). In addition to that, the country is suffering from ongoing political instability and internal conflicts within its many regions, including Darfur, Blue Nile, and South Kordufan states. These turbulent events and constraints have generated profound negative impacts on the country's development prospects and are jeopardising the overall macroeconomic stability (IMF, 2016).

Empirical macroeconomics' literature argues that the persistent economic and political predicaments characterising many least developing countries, like those currently seen for the Sudanese economy, led a large number of these countries to use macro-econometric modelling as the most likely approach to produce really powerful instruments for macroeconomic policy analysis and forecasting (Hall, 1995; Kannapiran, 2003; Valadkhani, 2004). It should be noted that the quality and availability of required data in most least-developing economies, coupled with the weak computational capacity to use more advanced techniques and tools, have

impeded policy makers in taking advantage of the recent developments in MEM building. Notwithstanding these constraints, some interesting studies exist in the empirical literature. For example, Peiris and Saxegaard (2007) developed a dynamic stochastic general equilibrium (DSGE) model[2] for the purpose of monetary policy analysis in Mozambique. Senbeta (2011) provided a very interesting review on the applicability of the New Keynesian DSGE models in the understanding of the dynamic behaviour of low-income economies like those in Sub-Saharan Africa (SSA). Because of the structure and the nature of the shocks these economies are experiencing, Senbeta concluded that DSGE models need to be modified to be practical for such economies.

Today, most policy institutions in developed and emerging economies have developed their own MEMs; these are usually based on a DSGE framework. They use macroeconometric modelling frequently to present their economic outlook and to evaluate the impact of various policy alternatives available to policy makers (see, for example, Shourie, 1972; Wallis, 1989; Bergstrom et al., 1994; Smets and Wouters, 2003; Dreger and Marcellino, 2007; Liu and Gupta, 2007; Jermann and Quadrini, 2012; Luik and Wesselbaum, 2014; Noussair et al., 2015). On the other hand, less attention has been given to the issue in low-income countries like those in SSA. The use of this type of macroeconometric modelling in Sudan, to the best of the authors' knowledge, is fragmented, as there is no comprehensive model currently in use by policy institutions like the Central Bank in the core processes of policy analyses and forecasting. This may be attributed partly to weak institutional capacity and lack of the technical expertise required to take advantage of recent developments in MEM building (IMF, 2016).

Motivated by the importance of macroeconometric modelling, it now seems timely for the monetary and fiscal authorities in Sudan to take serious steps in developing Sudan's MEM for the purposes of policy analyses and projections. Of course, this type of modelling will possibly complement other policy tools currently considered by national policy institutions and with which policy makers have expertise. The empirical findings and policy implications that will be derived from such models will be very useful to policy makers in many respects. For example, it will help them to: (i) address adequately the question of how well Sudan's economy is doing, (ii) quantify the impact of macroeconomic fluctuations (both internal and external

shocks), (iii) analyse the potential impacts of alternative policy measures, (iv) capture both adequately and reasonably the complex and dynamic interrelationships among macroeconomic variables, and (v) help them in their attempts to revitalise the economy at the fastest rates to ensure higher standards of living.

The purpose

The main objective of this study is to construct a MEM for the Sudanese economy with particular emphasis given to monetary policy analysis and forecasting. The remaining part of this study proceeds as follows: The next section gives some background information about the Sudanese economy with some focus on macroeconomic management. Section 3 provides empirical literature and the theoretical model. Empirical results are provided in the fourth section. Lastly, section 5 concludes the study.

2. Macroeconomic policies and performance in Sudan

Since independence in 1956, the Sudanese economy underwent tremendous fluctuations resulting from a wide range of unusual events, as indicated in the introduction. These unusual events have had profound negative impacts on the Sudanese economy. This, in turn, has resulted in considerable challenges to policy makers in Sudan in their attempts to design the appropriate stabilisation policies required for achieving strong and stable macroeconomic performance. In the following subsections, some background information on the Sudanese economy is presented, with a focus on the history of macroeconomic management.

2.1 Macroeconomic management in Sudan

A closer look at the Sudanese economy over the past six decades shows that it has changed significantly, going from relatively good times during the 1950s and 1960s to experiencing significant fluctuations over the successive decades. Overall, Sudan has experienced weak and unstable macroeconomic performance associated with either low or negative growth, severe budgetary imbalances, a volatile and unpredictable exchange rate, a high and unpredictable inflation rate, high unemployment, severe poverty, and underlying external adjustment problems (Ali and Elbadawi, 2004; Abdalla, 2015).

To improve its macroeconomic performance, the country embarked upon a wide range of macroeconomic policies and development plans. The first attempt started in the early 1960s, when the Economic and Social Development Plan was formulated to cover the 1961–1970 period. The main policy feature of this plan was direct government intervention in the economic activity of the country, with increased public investments in state owned enterprises. However, the civil war and the lack of funds prevented the further implementation of this plan.

The second plan was initiated during 1970–1974 to create an independent economy and achieve steady growth. Emphasis was also given to achieving further development of cultural, education, and health services. Unfortunately, as a result of political instability, the plan failed to achieve the target objectives. Accordingly, a new five-year interim program was made in 1972. The main objective was to make some adjustments to the main sectors, including transportation, communication, and agriculture. During this period, the country's economic performance changed radically; it started to experience negative growth rates, the severe balance of payments difficulties, and strong inflationary pressures and instability,[3] as compared to the 1960s (see Table 2).

To address the economic weaknesses of the country during the 1970s, the authorities adopted a set of macroeconomic policies, with some support provided by the International Monetary Fund (IMF) and the World Bank. By the end of the 1970s, the government had begun to review the economic and financial policies of the country with the intention of launching a set of structural adjustment programs (SAPs) and reforms required to correct the country's internal and external imbalances. The potential impacts of these programmes were, however, weakened by increased inflationary pressures, production inefficiencies, and growing foreign debts (Wohlumth and Dirk, 1986; Hag Elamin and El Mak, 1997). Consequently, the country's economy continued to experience higher levels of macroeconomic instability. The barriers to these programmes (especially SAPs) achieving their targets included the method of implementation (Denu, 2011).

By the beginning of the 1990s, the government had begun to initiate a set of development programmes to resolve the country's economic weaknesses. A ten-year plan (1992/93–2002/03) was formulated with the main objective of stopping the hyperinflation. Emphasis was also given to the extension of the role of the private sector in all economic activities (World Bank, 2003). In addition, the government made some important steps – again with some support provided by the IMF. These steps included reform policies within the framework of a Medium-Term Financial Adjustment and Structural Reform Programme. Although the economy started to show some positive responses to these reform policies, macroeconomic instability continued due to higher inflation rates (Alamir et al., 2014; Abdalla, 2015).

Recently, some emergency plans have been approved to deal with the adjustment to the new political and economic realities resulting from the South's secession. The main focus has been the diversification of the economy away from oil to agriculture and other sectors. Key policy measures included exchange rate adjustment, subsidy reductions, fuel price hikes, and tax increases. Considerable efforts were made when the government formulated a Salvation Economic Program to cover the period 2011–2013. The main objectives were to promote import substitution. Thereby, major emphasis was placed on the agricultural sector. More recently, the country has launched the Five Year Economic Program (2015–2019), which continues in the same direction.

To look at the impact of the implemented development policies on the performance of the Sudanese economy over the past six decades, Table 1 provides some statistics. It is very clear that the economy experienced relatively good times during the 1960s in terms of macroeconomic indicators, as shown in Table1. Starting from the early 1970s and up to the late 1990s, the economy experienced tough times before once more enjoying relatively good times during 1999–2011, due to oil production. After the South's secession, the Sudanese economy started to experience a very weak macroeconomic environment. The economy is currently experiencing low growth rates (see Figure 2), high double-digit inflation rates (see Figure 4), and an unstable exchange rate (see Figure 5). In addition, exports have decreased significantly (see Figure 1)

Table1. Major macroeconomic indicators of Sudan 1964–2015

	1964-69	1970-77	1978-89	1990-97	1998-2011	2012-15
Real GDP Annual Growth (%)	5.2	3.2	-1.9	3.8	6.5	3.2
Sectoral Contributions to Real GDP (%)						
Agriculture (% of GDP)	40.8	42.6	34.7	33.9	41.7	58.1
Industry (% of GDP)	15.4	13.6	15.2	15.5	24.9	2.6
Services (% of GDP)	43.8	43.8	50.1	50.6	33.4	39.3
Government Budget (Millions of SDG)						
Government Revenue	0.0985	0.269875	2.58725	341.9964	11814.52	40564.25
Government Expenditure	0.0980	0.346250	4.80175	369.9381	12628.94	41921.33
Overall Fiscal Balance	0.0005	-0.07638	-2.2145	-27.9418	-814.418	-1357.08
Foreign Trade (% of GDP)						
Exports	16.77	13.63	11.44	11.65	20.31	13.20
Imports	20.33	17.15	13.78	16.24	25.31	8.60
Balance of Current Account	-3.56	-3.53	-2.33	-4.58	-5.00	4.60
Monetary Variables						
Inflation Rate	6.1	12.8	34.6	96.6	10.9	30.4
Money Supply Growth	10.2	20.8	39.6	66.7	25.8	22.8
Exchange Rate	0.00035	0.00035	0.00185	0.49565	2.39298	5.02308

Source: Central Bank, Ministry of Finance, and own calculations.

Figure(1): Exports, imports, and current account balance of Sudan 1960–2015
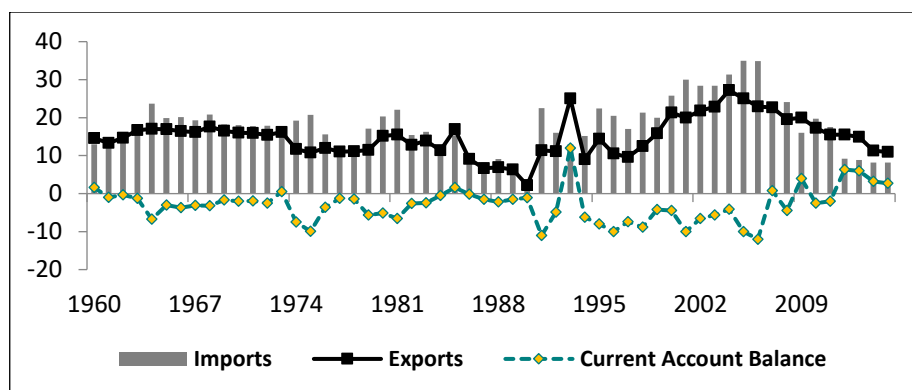
Source: Ministry of Finance and National Economy and own calculations

## 2.2 The patterns of Key macroeconomic variables in Sudan: 1960–2015

The Sudanese economy has repeatedly experienced large fluctuations in macroeconomic fundamentals over the past six decades. The major driving forces behind these fluctuations are political instability, volatile macroeconomic policies, and large external shocks. A closer look at the growth performance trend over several years shows that it has diverged noticeably.

2.2.1 Growth performance

Growth performance was relatively good over the 1960s as indicated by the trend pattern of the growth rates in Figure 2. However, the situation deteriorated considerably since the beginning of the 1970s and up to the early 1990s, when the country started to experience macroeconomic instability, and economic growth started to decline in response to many economic and political events. These included the destructive civil war, shocks originating from the global oil market, policy changes, and political instability. However, this relatively stagnating growth performance was significantly reversed after the last third of the 1990s when the country started, with the advent of crude oil, together with sound economic policies, to enjoy macroeconomic stability. As stated by the World Bank, the growth performance of Sudan over 2005–2008 placed the Sudanese economy within the fastest growing African economies (the World Bank, 2009). However, with the (oil) shock associated with South Sudan's secession in 2011, Sudan started again to experience a huge GDP growth decline. From 5.2 in 2010, the GDP growth rate declined to 1.9 and 1.4 in 2011 and 2012, respectively. Recent statistics show that the growth rate of GDP is fluctuating around 4, driven mainly by the increased production from the mining sector. In fact, Sudan is considered as one of the largest countries in Africa, with a diverse geology and large quantities of mineral resources. Crude oil and gold are the country's main mineral exports. Figure 2 clearly illustrates the pattern of growth performance over 1960–2015.

Figure(2): The pattern of real GDP growth of Sudan (1960–2015)
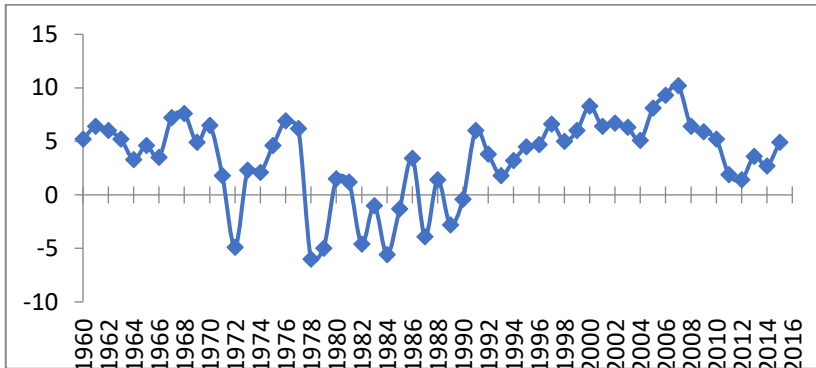
Source: Central Bank of Sudan and the World Bank

Sustaining and achieving high overall growth rates would normally be associated with major structural transformation of the economy. However, there has not been much structural transformation in the relative importance of economic sectors in total output over the last six decades. From Figure 3, it is very clear that the economy's structure is dominated by the agriculture and services' sectors, with each contributing approximately 45% of the country's GDP, leaving only about 10% for industry over 1960–2000. However, while industry has remained the least important economic activity, its contribution to GDP increased markedly from 12% in the early 1990s to more than 20% over 2000–2011. This largely reflected the onset of oil production in 1999, which boosted the share of the mining sector from less than 1% to more than 6% of GDP (Alamir et al., 2014)

Figure(3): Sectoral contributions to real GDP (%) 1960–2015
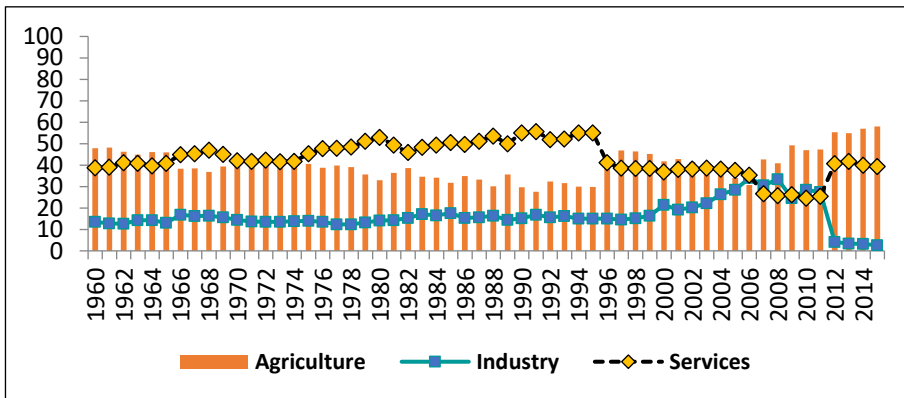
Source: Central Bank and own calculations.

2.2.2 Inflation and money supply

Looking at the pattern of inflation and money supply growth, the striking feature of these two macroeconomic indicators is that the Sudanese economy experienced a series of simultaneous fluctuations, with higher volatility seen in the early 1990s (see Figure 4). As to the pattern of the inflation rate in Sudan over the past six decades, four distinct periods can be identified. Starting from 1960 and up to 1971, the inflation rate was relatively low, at a single-digit level, with an average around 5%. Over the second period (1972–1999), the Sudanese economy started to experience hyperinflation by the beginning of the 1990s, with an average of around 49.9%, owing to money supply expansion. In the third period (2000–2011), the Sudanese economy started to enjoy relatively low inflation again, with a single-digit average of 9.9% for the period, owing to oil revenues and the considerable efforts made by the government to maintain price stability since 2000. However, after the South's secession in 2011, the economy started to struggle again with high double-digit inflation of around 30.4%, on average.

Figure (4): Inflation rate and money supply growth 1960–2015
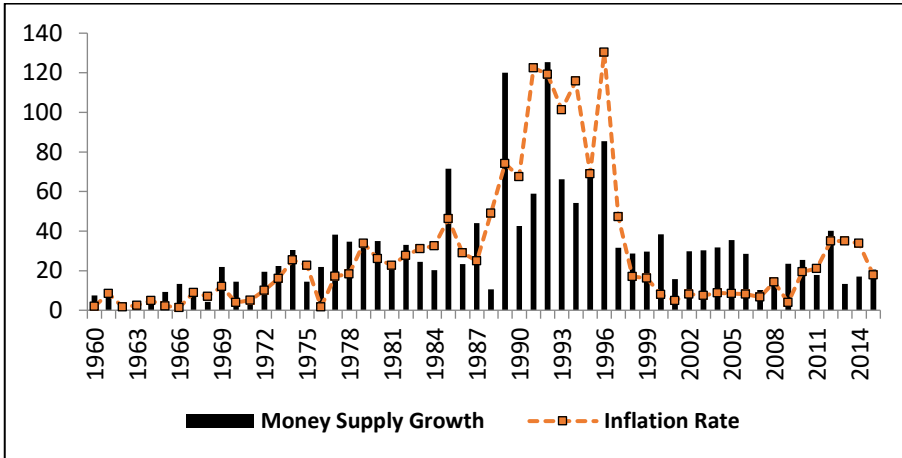
Source: Central Bank and own calculations.

2.2.3 Exchange rate

Over the past six decades, the exchange rate system has experienced a substantial paradigm shift from a fixed to a floating system. Since independence, and up to 1978, the official exchange rate remained fixed at one Sudanese pound (SDG) for USD 2.87. From June 1978, the monetary authority started to consider continuous devaluations of the currency. However, the exchange rate has continued to depreciate sharply since 1992 and remains unpredictable. Over 1999–2010, the exchange rate was relatively stable. However, the loss of a large part of the oil revenues associated with South Sudan's secession, has put increasing depreciation pressure on the local currency. Accordingly, the exchange rate has become more volatile again (Figure 5).

Figure(5): Exchange rate volatility in Sudan 1980–2015
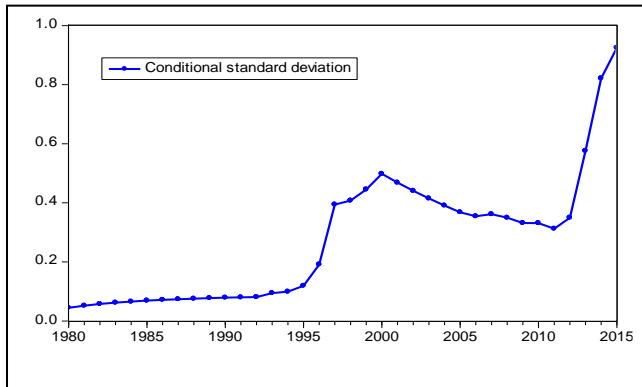
Source: Central Bank and own calculations.

Note: The calculation of exchange rate volatility is based on estimating GARCH (1,1) process.

3. Empirical literature and the theoretical model

3.1 Empirical literature

Macroeconometric modelling has become an indispensable instrument for economic policy analysis and forecasting. In applied macroeconomic literature, it is widely accepted that macro-econometric models have been extensively applied by many central banks and public institutions around the globe to: (i) capture adequately and reasonably the complex and dynamic interrelationships among macroeconomic variables; (ii) evaluate the impact of macroeconomic policy alternatives available to the policy makers (Bergstrom et al., 1994; Bardsen and Nymoen, 2009); (iii) analyse the impacts of domestic and external shocks on the overall performance of the economy(Luik and Wesselbaum, 2014); and (iv) generate both short and long-term forecasts that are consistent between sectors and comparable with the national accounts (Koop, 2013).

The building of MEMs to describe the operation of national economies has a long-standing history. The pioneering work of building and using MEMs as input into policy making and forecasting can be traced back to the 1930s, when Jan Tinbergen constructed a MEM for the Netherland in 1935–1936 with the aim of assisting the Netherlands Central Planning Bureau in the formulation of economic policies. The

next prominent step in applied MEM building was also made by Tinbergen, when he constructed a large model of the US economy. Since then, MEMs have undergone tremendous improvements, owing to decades of research and advances in computational capacity, the development of new estimation techniques, developments in macroeconomic theory, and the accessibility of high quality data. Today, MEMs are available in a wide range of choices, ranging from sectoral MEMs to multi-sectoral economy-wide models, static models to dynamic models, and short-run to long-term models (Welfe, 2013).

It is worth asserting that MEMs were originally designed to implement Keynes' General Theory, which dominated the model-building process until the beginning of the 1970s, when some alternative macroeconomic paradigms, such as Monetarism, New Keynesian, New Classical, and the Real Business Cycle Theory, began to be incorporated into MEMs (Bodkin et al., 1986). Excellent reviews on the development and application of MEMs can be found in the textbooks by Bodkin et al. (1991) and Welfe (2013). Bodkin and his collaborators presented an excellent survey of the first 50 years of the history of MEM building. Welfe provided a great number of MEMs constructed by policy institutions in a wide range of countries throughout the world; including developed, emerging, and developing countries.

Recently, the so called "DSGE models" have become frequently used for policy analysis, with the basic structure being the incorporation of elements of the New Keynesian and the Real Business Cycle approaches. DSGE models are based both on explicit theoretical microeconomic foundations and on the optimisation behaviour of many agents in the economy, including individual firms, households, and monetary and fiscal authorities. For not only developed but also some emerging market economies where business cycles are characterised by persistent output fluctuations, these models have become dominant in the process of economic policy decision-making. They have proven to be useful in analysing the impact of a wide range of shocks, including monetary policy shocks, expansionary fiscal policy, rising housing demand, depreciation of currency risk, and supply shocks (Erceg et al., 2005, 2006). On the other hand, applying DSGE models in low-income developing countries with high macroeconomic instability is not an easy task. For African economies, the empirical literature reports that the practice of considering DSGE models for economic policy analyses and forecasting is rare and has started to appear only very

recently. For instance, Liu and Gupta (2007) generated forecasts for a wide range of macroeconomic variables for the South African economy. For low-income countries, like those in SSA, the work of Peirisand and Saxegaard (2007) may represent the first attempt to estimate a DSGE model for the purposes of monetary policy formulation in Mozambique. Some other types of MEMs have also been considered for some African countries; examples include incorporating IMF's Global Projection Model for Egypt (Arbatli and Moriyama, 2011), the autoregressive distributed lag framework for analysing policy interventions impacts in Rwanda (Gurara, 2013), and the vector autoregression (VAR) methodology for Kenya (Cheng, 2006). This degree of diversity in using MEMs in African economies can be explained, to a large extent, by the features of each country, the specific structure of domestic economies, and their exposure to specific internal and external shocks and crises.

Within the turbulent economic environments in many parts of Africa, Sudan does not seem to be an exception, when considering the fact that the economy has been working for a quite long time under heterogeneous economic sectors, increased income inequality, immature financial institutions, and high political instability. Attempts to construct a MEM for the Sudanese economy have been very limited, and policy analyses with the help of MEMs are rarely undertaken. In fact, official attempts to incorporate economic modelling in macroeconomic management started around 1955 when a macroeconomic input-output model was developed by the Ministry of Finance to both explain the characteristics and analyse the behaviour of the Sudanese economy based on inter-industry analyses. The second attempt was initiated by the development of the Chenery–Strout two-gap model of development.[4] The main objective of this model is the projection of key economic variables needed in the process of the formulation of development plans and programmes. The third attempt was made in the fiscal year 1986, when the Ministry of Finance and Economic Planning constructed a MEM to be used for policy analyses and forecasting of major macroeconomic fundamentals during the Four-Year Salvation Program for Economic Development 1987–1990. In 1990/91 the Chenery–Strout two-gap model of development was again employed by the Ministry of Finance in the formulation of the National Comprehensive Ten-year Strategic Plan (1992–2002). Besides these attempts, the government was also working with the IMF to construct and implement a monetary policy framework. For example, the IMF (2008) suggests the use of

different econometric techniques to focus on the impact of both money supply growth and the developments in the nominal exchange rate on domestic inflation. These include the single equation model, recursive Structural VAR (SVAR), and the vector error correction model. The empirical results of these models are provided in three different models to enable checking the robustness of the estimated parameters for a country with limited data coverage, data quality problems, and possible structural breaks (Moriyama, 2008). The main conclusion is that the growth of the money supply and the changes of the nominal exchange rate affect inflation with 18–24 months. There are also many private endeavours, ranging from single equation to multi-sectoral models, with the main focus of evaluating the overall performance of the Sudanese economy. For example, Hassan (1989) constructed a general equilibrium model to analyse the economy-wide impacts of macroeconomic policies and conduct sector-specific investigations, with the ultimate goal of delineating the appropriate courses of action for economic recovery in Sudan. Alamin (1999) developed an econometric model to analyse stabilisation polices in Sudan over 1970–1994. The model develops linkages between monetary and fiscal policy instruments, the exchange rate, and the target variables, including output, inflation, and trade balance. Simulation results of the model indicate contrasting impacts on the target variables. Arabi (2002) built a MEM to evaluate macroeconomic policies and to forecast key macroeconomic variables in Sudan based on the standard Keynesian income-expenditure approach.

After South Sudan's secession in 2011, many very interesting empirical studies began to reinvestigate the macroeconomic performance of the country. For example, Abdoun (2012) indicated that fiscal monetisation, reserve money, wages, and the exchange rate are the key driving forces of inflation dynamic in Sudan. These findings were based on a small macro model including three equations: an equation explaining price developments for tradable goods, an equation explaining price developments for non-tradable goods, and an equation deriving inflation as a function of both tradable and non-tradable inflation. Gerling (2012) showed that multiple exchange rate systems, coupled with restrictions on access to foreign exchange at official rates, generate a high-risk environment for an economy's competitiveness. Alamir et al. (2014) explained that poor management of oil resources hindered the diversification of the Sudanese economy and led to the current decline in the country's economic activity. They concluded that Sudan's success in restoring

macroeconomic stability will depend, to a large extent, on the government's ability for good governance of revenues from other sectors (especially from the mining sector). Onour (2015) developed a small MEM to look at the domestic inflation dynamics. The model includes growth in money supply, the parallel market rates, and imported inflation. The study concluded that government spending and the impact of the parallel market are the major driving forces explaining inflation dynamics in Sudan, especially in the post-secession period. The analysis of exchange rate behaviour also attracts the attention of many researchers. Based on a SVAR approach, Abdalla (2016) concludes that exchange rate and price shocks have greater impacts on fluctuations of domestic variables as compared to external shocks like the output of the Arab countries and the price of crude oil.

3.2 Theoretical model

For the empirical analysis, this study employs the SVAR framework. SVAR models,[5] their associated impulse response functions (IRFs), and variance decomposition have become standard tools for macroeconomic policy analysis and forecasting (see, e.g., Bernanke 1986; Blanchard and Quah, 1993; Lane and Lutkepohl, 2008; Sims, 1986 and 1992; Taylor, 2004). These types of models were introduced originally to criticise the unrestricted tendency of the standard VAR approach[6] to permit the model to absorb too many parameters without a theoretical framework allowing the accuracy of the findings to be tested.

The main advantages in relying on the SVAR methodology for macroeconomic policy analysis and forecasting is that it uses a parsimonious set of macroeconomic variables to model non-recursive structures of the economy. As noted by McCoy (1997), the advantages also include the fact that economic theory can be used to provide the necessary restrictions to estimate the parameters of the reduced-form model.

SVAR models have been widely used to address two main macroeconomic questions. First, how does the economy respond to different economic shocks? Empirical studies in the SVAR monetary literature cover a wide variety of shocks. For instance, monetary policy shocks were proposed by Sims (1980), Bernanke (1986), Christiano, Eichenbaum, and Evans (1999), and Bovin and Giannoni (2006), among others. Oil

price shocks were proposed by other researchers, such as Hamilton (1983), Blanchard and Gali (2007), Kilian (2009), and Lippi and Nobili (2012). Fiscal policy shocks were also discussed by some researchers, including Mertens and Ravn (2010) and Marcellino (2006). The second question is: What is the contribution of the different shocks to the business cycle? This question has been the subject of many empirical studies (see, e.g., Blanchard and Watson, 1986; King et al., 1991; Cooley and Dwyer, 1998; and Chari, Kehoe, and McGrattan, 2008)

3.2.1 Specification of the Structural VAR Model

To construct the SVAR model for the Sudanese economy, this study uses:

$$AY_t = B(L)Y_{t-1} + C(L)X_t + u_t \qquad (1)$$

Equation 1 is the structural form, where $Y_t = (y_{1t}, y_{2t}, ..., y_{Kt})'$ is a K-dimensional vector including a set of endogenous variables at time $t = 1, 2, ..., T$. $X_t = (x_{1t}, x_{2t} + \cdots, x_{Mt})'$ is a vector of exogenous variables. $B(L)$ and $C(L)$ are the pth degree matrices of polynomials in the lag operator L, where p represents the number of lags used in the SVAR setup. A is a non-singular matrix that includes contemporaneous coefficients. u_t is a white noise structural innovations vector. These innovations are assumed to have mean zero and a covariance matrix $E(u_t u_t') = \sum_u$, where $\sum_u$ is a diagonal matrix.

The main problem with the set of equations in (1) is that it is not possible to uniquely determine the values of the model's parameters. This is simply because the variables have contemporaneous impacts on each other. However, it is possible to transform the previous structural representation in (1) into a reduced-form to derive the standard VAR representation. From the system of equation in (1), the reduced-form model takes the following form:

$$Y_t = D(L)Y_{t-1} + E(L)X_t + \varepsilon_t \qquad (2)$$

Where $D(L)$ and $E(L)$ are the pth degree matrices of polynomials in the lag operator L with the $n \times n$ and $n \times k$ elements, respectively. $D(L)$ and $E(L)$ are obtained from $B(L)$ and $C(L)$ by premultiplying with A^-1. ε_t is a vector of reduced-form innovations with $E(\varepsilon_t) = 0$, $E(\varepsilon_t \varepsilon_{t-\ell}') = 0$ for $\ell \neq 0$ and $E(\varepsilon_t \varepsilon_t') = \Omega$. The estimates

of this reduced-form can be obtained by maximum likelihood, which, in this case, is simply an ordinary least squares (OLS) estimation equation-by-equation.[7]

The structural innovations and the reduced-form residuals are linked by the following relationship:

$$u_t = A\varepsilon_t \tag{3}$$

which indicates that

$$\Sigma = E(A\varepsilon_t\varepsilon_t'A') \tag{4}$$

From Equation (4), the matrices A and Σ can be recovered if sufficient restrictions are imposed on them. Since Ω in the reduced-form is a symmetric matrix, there are only $(n^2 + 1)/2$ free parameters to be estimated, which requires at least $(n^2 - 1)/2$ restrictions to be imposed on the system of equations. Generally, restrictions are imposed depending either on some previous results or on the basis of economic theory. The structural parameters can be recovered through a simple maximum likelihood estimation technique by assuming that the structural error terms are jointly normal. In the first step, Ω is estimated by:

$$\hat{\Omega} = (1/T)\sum_{t=1}^{T}\hat{\varepsilon}_t\hat{\varepsilon}_t'$$

where $\hat{\varepsilon}$ are the OLS residuls associated with each equation in the system.

3.2.2 Identification of the SVAR model

The structural shocks in the SVAR model of this study are identified by placing restrictions on some of the contemporaneous relationships among the system's variables, as shown in the following equation:

$$
\begin{bmatrix} u_{wgdp} \\ u_{oil} \\ u_y \\ u_\pi \\ u_{ms} \\ u_{ex} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & a_{32} & 1 & 0 & 0 & 0 \\ 0 & a_{42} & a_{43} & 1 & 0 & a_{46} \\ 0 & 0 & a_{53} & a_{54} & 1 & a_{56} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{wgdp} \\ \varepsilon_{oil} \\ \varepsilon_y \\ \varepsilon_\pi \\ \varepsilon_{ms} \\ \varepsilon_{ex} \end{bmatrix} \tag{5}
$$

The 6×1 vector of macroeconomic variables in the system of equations (5) is divided into two blocks of shocks, as follows. The domestic shocks are represented by an output shock (u_y), a domestic price shock (u_π), a money supply shock (u_{ms}), and nominal exchange rate shocks (u_{ex}). The external shocks are represented by world output shocks (u_{wgdp}) and oil price shocks (u_{oil}). ε_y, ε_π, ε_{ms}, ε_{ex}, ε_{wgdp}, ε_{oil} on the right-hand side of the system of equations (5) represent the residuals of the reduced- form model. It worth noting here that the reason of including only these variables is that the model is highly parameterized, which would imply that we could encounter degrees of freedom problems when including several variables or many lags (Haug et al., 2013). It is also important to note that the study does not include some variables, such as tax revenues, government spending, real wages due to a problem of data availability.

Each non-zero a_{ij} coefficient in Equation (5) implies that variable j affects variable i contemporaneously. The coefficients on the main diagonal are normalised to 1, while other entries in the matrix are constrained to be zero. The explanations for zero coefficients (restrictions) are as follows: domestic variables are assumed not to have any impact on the foreign variables, as indicated by the zero coefficients in the first two equations. This reflects the assumption that the Sudanese economy is small. On the other hand, foreign shocks are assumed to affect domestic macroeconomic variables contemporaneously. A world real output shock (wgdp) is ordered before commodity price (oil) shocks following the empirical SVAR literature (see, e.g., Christiano et al., 1996; Cushman and Zha, 1997; and Lawson and Rees, 2008).

The third and fourth equations of the model reflect the equilibrium in the goods market. The third equation assumes that the domestic real output (y) responds to oil prices contemporaneously. Meanwhile, the fourth equation allows the domestic price to respond contemporaneously to the oil price, the domestic real output, and the

exchange rate. Similar to many previous empirical studies, the model structure assumes that money supply, exchange rate, inflation, and world real output do not affect the domestic real output contemporaneously; instead these variables are assumed to have an impact only with a lag (see e.g., Berkelmans 2005; Cheng, 2006; Dungey and Pagan, 2000; Kim, 2003; Lawson and Rees, 2008; and Thanabalasingam, 2013, among many others).

The fifth equation in the system relates to the money supply representing the monetary authority reaction function. The assumption here is that money supply responds contemporaneously to other domestic variables. The sixth equation allows the exchange rate to respond contemporaneously to all other variables. This is justified by the fact that the exchange rate variable is a forward-looking asset price (Kim and Roubini, 2000).

3.2.3 Shock analyses

Having estimated the parameters of the SVAR model, the next step will be to analyse the dynamics of the system through IFRs. IFRs are used to investigate the dynamic interactions of given variables in response to various shocks within the system. Generally, IFRs produce the time path of the dependent variables in the system of equations in a SVAR to shocks from the system's explanatory variables. Any kind of these shocks would either decline to zero or die out gradually in a stable system of equations, whereas an unstable system of equations would generate an explosive time path.

4. Data and estimation results

4.1 Data

This study considers annual observations over the period 1960–2015, since GDP is available only at an annual frequency. The variables selected to be included in the SVAR model, their descriptions, and their sources are presented in Table 2.

Table (2): Description and sources of variables

Variable	Description	Source
y	Real GDP	Ministry of Finance
π	Consumer Price Index	Ministry of Finance
ms	Money Supply	Central Bank of Sudan
ex	Nominal Exchange rate per USD (log)	Central Bank of Sudan
oil	Annual Crude Oil Price	US Energy Information Administration (EIA)
wgdp	World Real GDP	World Development Indicators

4.2 Estimation results

4.2.1 Patterns of Key Macroeconomic Aggregates in Sudan

As indicated in the introduction that the secession of South Sudan represents the most challenging shock that has created serious implications for the country's development. One of the strongest effects of this secession is that the Sudanese economy has lost a sizeable portion of its oil revenues. This drastic change led us to survey the patterns of major macroeconomic fundamentals separately over the oil and non-oil periods. Table 3 provides the results, in which it is evident that the post-secession period (non-oil period) has been marred by substantial macroeconomic volatility. For example, in the post-secession period, inflation became much more volatile, with volatility increasing more than threefold compared to the pre-secession period. In the same way, growth and money supply volatilities increased substantially during the non-oil period. Another important feature is that the selected macroeconomic aggregates exhibited higher correlations, to some extent, while the Sudanese economy was relying heavily on oil exports.

Table (3): Key statistics of Sudan's macroeconomic variables

		Statistic		
		Non-oil period	**Oil period**	**Overall period**
Volatility	y	4.007	2.445	3.920
	π	37.56	10.58	33.03
	ms	29.60	9.014	25.35
	ex	0.448	1.249	1.542
Comovement with output	π	-0.057	-0.784	-0.204
	ms	-0.213	0.035	-0.233
	ex	0.241	-0.545	0.321
Comovement with oil price	y	-0.514	-0.528	0.068
	π	0.447	0.711	-0.006
	ms	0.459	-0.371	-0.013
	ex	0.107	0.290	0.736
Comovement with world output	y	0.166	0.033	0.054
	π	-0.534	0.155	-0.341
	ms	-0.463	0.260	-0.310
	ex	-0.182	0.002	-0.291

4.2.2 SVAR results and discussion

A lag length of two is selected for this study, as this provides reasonable dynamics of the system without shortening the estimation sample too much (Berkelmans, 2005). The results are provided in Table 4. For the interrelationship between Sudan's macroeconomic variables, the results show that the exchange rate variable enters significantly in both the inflation and the money supply equations. The significance of the exchange rate in the price equation could be used as an indicator of the

existence of an exchange rate path-through on inflation. This implies that nominal exchange rate fluctuations are likely to affect the domestic price. When the SDG depreciates against foreign currencies, the general level of prices in the economy will increase. It is worth noting here that local currency depreciation poses critical challenges to policy makers in their attempts to design and implement effective monetary policies. This is simply because the Sudanese economy are a highly import dependent economy, in which a large share of goods and services is imported. The situation has become more difficult for the Sudanese authorities, given the fact that the economy is currently experiencing higher levels of exchange rate volatility in the parallel market. This, in turn, has led to the parallel market driving inflation in the Sudanese economy as most agents depend on it to obtain foreign currencies needed for imports of goods and services. Another important result that explains domestic price fluctuations in Sudan is that the general price level responds contemporaneously to the global oil price fluctuations. This finding is consistent with results from many other studies, including Kilian (2009) and Baumeister and Peersman (2013). The results also show that the nominal exchange rate enters significantly in the money supply equation.

One important result from the SVAR model is that the rate of inflation in Sudan responds contemporaneously to money supply growth. In fact, a significant positive relationship exists between the two variables. This result implies that the monetarist theory of inflation applies in the Sudanese economy, indicating that inflation increases significantly if the money supply grows very fast. Recent estimates may explain part of this finding. In Sudan, the money supply grew by 6 percentage points in one year, from 21% in 2015 to 27.3% in 2016. Over the same period, CPI inflation increased to 30.5% in 2016, up from 12.6% at the end of 2015. Figure 4 also clearly shows some evidence of the co-movement between the two variables. The significant impact of the money supply on inflation has important implications for monetary authorities. Policy makers should pay more attention to avoiding excessive growth rates of the money supply. This would help them to keep inflation under control.

As for the relationship between the money supply and the exchange rate, the contemporaneous results indicate that the money supply enters significantly in the exchange rate equation. This suggests that money supply can be considered as one source for nominal exchange rate fluctuations. Real output appears to be insignificant

in all domestic variables. Price, exchange rate, and money supply did not respond contemporaneously to real GDP fluctuations.

Furthermore, if one looks at the impact of foreign variables on the domestic economy, it is very clear that the coefficient representing oil price fluctuations enters significantly in three equations: domestic output, inflation, and exchange rate. This result suggests that oil price fluctuations could have some impact on macroeconomic performance in Sudan. This is especially true given the fact that the reliance on oil of the Sudanese economy has increased considerably over the past few years. In fact, the increased reliance on oil over 1999–2011 has affected the structure of the Sudanese economy and generated considerable challenges. This includes the potential incidence of the Dutch Disease, whereby some productive sectors (like the agricultural sector) were harmed and weakened. There is considerable debate over the issue that oil revenues were not managed successfully enough to diversify the economy. This, in turn, poses critical challenges for policy makers in their attempts to mitigate the negative consequences associated with the loss of oil wealth. Of course, oil price fluctuations in the global economy could be one of the important issues that policy makers must consider in their policy reform agenda. With this in mind, the significance of the oil price in the equations representing macroeconomic variables indicates that a rise in the oil price could result in an increase in production expenditure that then negatively affects real output and slows the overall economy.

The results also indicate that the Sudanese economy responds, to some extent, to fluctuations originating from real world output. This can be seen by the significance of the coefficient representing real word output in the nominal exchange rate equation.

Table (4): Estimation of SVAR Contemporaneous Coefficients

Restriction	Estimate	Z-statistic	Prob.	Restriction	Estimate	Z-value	
a_{32}	9.644957	70.24286	0.0000	a_{56}	-100.9410	-12.55834	0.0000
a_{42}	-54.41954	-18.82994	0.0000	a_{61}	-0.280622	-2.788793	0.0053
a_{43}	-4.754142	-0.252536	0.8006	a_{62}	-2.196969	-16.02037	0.0000
a_{46}	-135.2173	-11.16607	0.0000	a_{63}	-0.002738	-0.014161	0.9887
a_{45}	22.33140	10.92792	0.0000	a_{64}	-0.699484	-9.819637	0.0000
a_{53}	-2.774403	-0.200087	0.8414	a_{65}	0.701854	5.927234	0.0000

Having estimated the contemporaneous coefficients of the SVAR model, the discussion now moves to the understanding of dynamic relationships in the Sudanese economy. To that end, the study applies IFRs. IFRs are used to measure how a sudden and unexpected change (structural shock) in a single variable in the system will impact the domestic macroeconomic variables. The results are reported in Figures 6-9. It is worth noting here that the graphical results of IRFs are presented together with two standard deviation bands. A graph of a given IRF indicates lack of significance when the bands include a zero line. In each graph, the solid line describes the IRF, while dotted lines correspond to 95% confidence intervals for the IRF.

As for the estimated impulse responses on domestic real output to various shocks in the system, the results of Figure 6 show that, at period 1, real GDP does not elicit any responses to shocks emanating from the price level, exchange rate, and money supply. At later periods, insignificant responses appear. It is also evident that the response of real GDP to its own shocks is significant and positive until the third year after the shock, when it becomes insignificant.

The strongest impact of system's shocks can be found on the price level to its own fluctuations (Figure 7). This response remains significant until period 5 and can be explained to some extent by the continuous increase in food prices and the increasing cost of imports resulting from a weakening domestic currency. The results of Figure 8 show that the money supply responded statistically significantly to not only its own fluctuations but also shocks originating from the price level in years 2 and 3, respectively, after the shock.

Finally, the results of Figure 9 indicate that the macroeconomic variable that fluctuates most in Sudan is the exchange rate. For example, price level shocks have statistically significant impacts on exchange rate fluctuations up to the second year. Similarly, exchange rates respond significantly to shocks coming from money supply shocks. In addition, exchange rates respond significantly to their own shocks for up to two years.

The results do not show any responses of the domestic variables to shocks emanating from the world oil market. Analogous results also hold for the responses of domestic variables to real world output shocks. Negligible and statistically insignificant results are seen for all variables, except for the money supply at period 1 where the results

are statistically significant. However, this response is short-lived, as the impact dissipates almost immediately (see Figure 8).

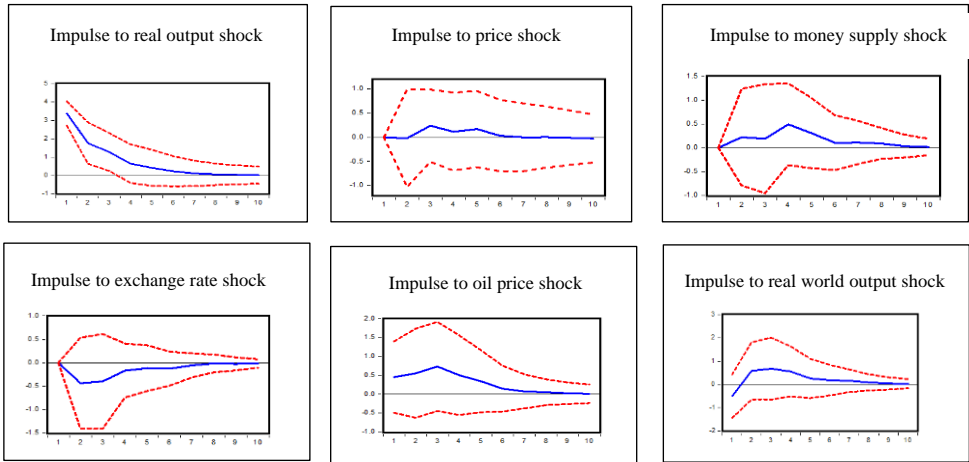Figure (6): Impulse Response Function on Sudan Real Output

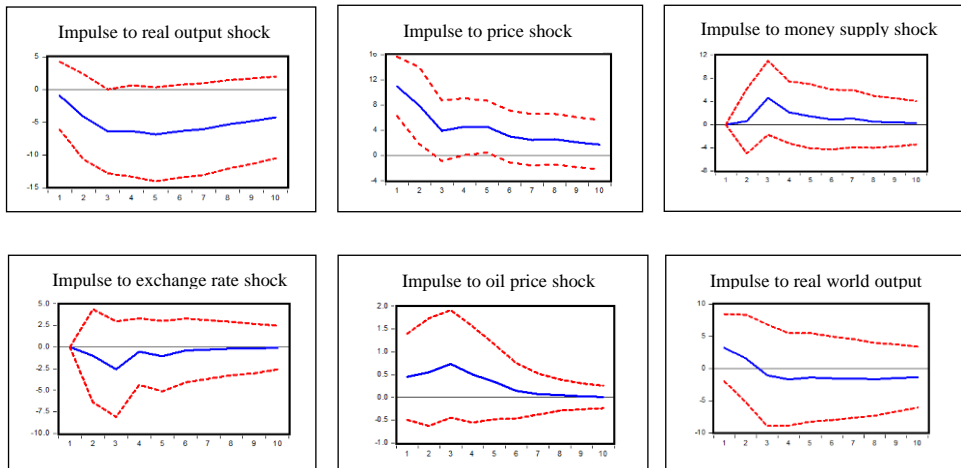Figure (7): Impulse Response Function on Price Level

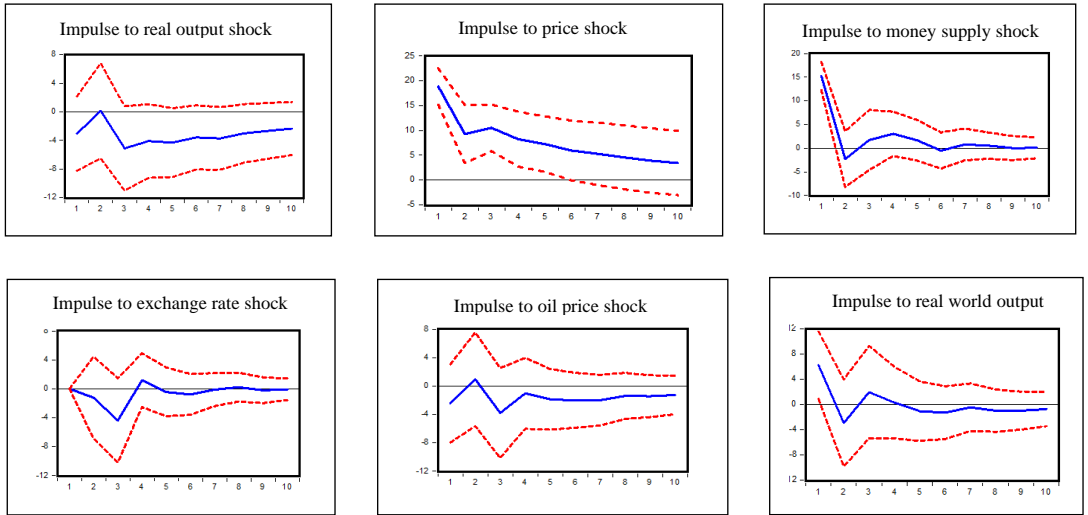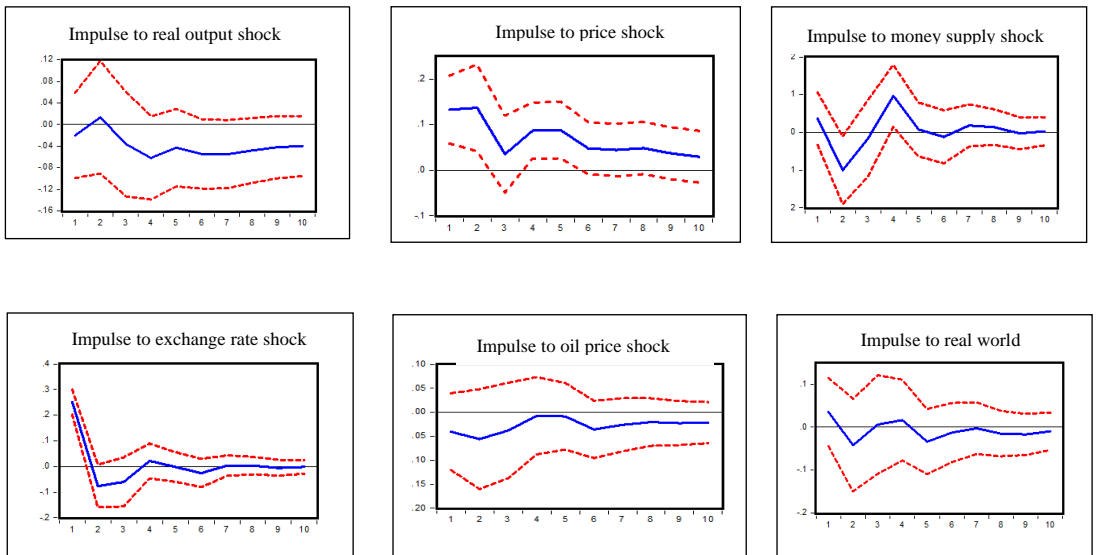Figure (8): Impulse Response Function on Money Supply

Figure (9): Impulse Response Function on Exchange Rate

5. Conclusions and policy implications

After almost seven years of economic adjustment and policy reform, the Sudanese economy continues to suffer strongly from macroeconomic volatility generated by South Sudan's secession in 2011. In fact, many macroeconomic variables are currently experiencing unprecedented levels of volatility. These variables include exchange rate, price level, and money supply, to name just a few. This higher level of volatility poses critical challenges for economists and policy makers in their attempts to find ways to facilitate the country's economic recovery. Given that many efforts have been made over the past few years, policy makers need to look at what has been forgotten in their attempts to maintain macroeconomic stability. Part of their attention should be given to the econometric tools they must consider. In fact, it now seems timely for policy makers in Sudan to take serious steps in building their own macroeconomic model. The use of such a model will provide the foundation for macroeconomic policy analyses and forecasting. Of course, this type of modelling will possibly complement other policy tools being considered by Sudanese policy institutions where policy makers have expertise. To that end, the current study tries to estimate a structural vector-autoregression (SVAR) model for Sudan over 1960–2015. The main purpose here is to investigate how selected macroeconomic indicators in Sudan dynamically react to a set of internal and external shocks. Shocks considered in the SVAR setup are those associated with real output, money supply, exchange rate, price level, real world output, and the global oil price. The structural shocks in the SVAR model are identified by placing restrictions on some of the contemporaneous relationships between the macroeconomic variables in the system.

The examination of the contemporaneous relationships reveals that the exchange rate variable enters significantly in both the inflation and the money supply equations. Therefore, policy makers need to put more effort into ensuring exchange rate stability. More emphasis should be given to the unification of the two exchange rates (official and parallel exchange rates) with further exchange rate flexibility. The contemporaneous relationship between exchange rate and inflation could also be another important reason why monetary authorities should place more emphasis on exchange rate stability.

The results also indicate that the inflation variable enters significantly in both the money supply equation and the exchange rate equation. This implies that the economic reform agenda should also put some effort into dealing with inflation instability. Given the fact that the economy is currently experiencing persistent double-digit inflation, policy makers need to maintain a tighter monetary stance for a considerable period of time to address high inflation rate pressures. Similarly, money supply enters significantly in the exchange rate equation, while real GDP appears to be insignificant in all other equations for domestic variables.

As for the impact of foreign variables on the domestic economy, the results tell us that the coefficient representing oil price fluctuations enters significantly in three equations: domestic output, inflation, and exchange rate. In the same way, world output fluctuations enter significantly in the exchange rate equation.

Based on the impulse response functions' analysis, the empirical results indicate that the domestic variables are responding significantly to their own shocks only at short horizons. No domestic variable is found to play any role over longer horizons. The results also show that foreign shocks do not seem to have significant impacts in explaining the fluctuations in domestic economy.

Generally, the study concludes that the higher levels of macroeconomic volatility in Sudan, especially after the South's secession, can be interpreted as being due to domestic shocks, to a large extent. These are generated, to some extent, by poor macroeconomic management and self-inflicted policy mistakes. In marinating macroeconomic stability, fiscal and monetary authorities should prioritise the understanding of the sources of these higher levels of macroeconomic volatility. They should consider intensifying considerable efforts to diversify the economy away from the oil industry. In fact, they need to use revenues from the oil industry and other industries, like gold production, to develop other real sectors, such as the agricultural sector. This will help to render the economy less vulnerable to fluctuations and crises associated with oil.

As a further possible extension of this work, it would be very interesting for future research in this area to include fiscal policy instruments to measure how shocks associated with fiscal policy will impact the performance of other variables in the system. It is very important to illustrate here that why the current study does not

consider the use of the recently developed methodology, the so called "Dynamic Stochastic General Equilibrium (DSGE) models". This is simply because the applicability of DSGE models in poor developing countries (like Sudan) with less developed and incomplete markets is questionable given the fact that these models placing greater emphasis on full micro-foundations of representative agents of the economy (households, firms, and monetary authority). Accordingly, future research should consider applying this type of modelling when appropriate data are available.

Footnote

[1] Following the South's secession, Sudan's economy lost almost 75% of oil production, approximately 55% of fiscal earnings, and roughly two-thirds of foreign exchange earnings (The World Bank, 2014).

[2] The development of DSGE model has its origin from the seminal research of Kydland and Prescott (1982) and Long and Plosser (1983).

[3] As a result of increased import costs and money supply expansion reflecting accelerated deficit financing.

[4] The two-gap model was pioneered by the contributions of Chenery and Strout (1966) as an extension of theHarrod–Domar model of economic growth. The main feature of this model is that the achievement of a target growth rate in less developed countries like Sudan is restricted by two potential gaps: the gap between domestic savings and the required investment (savings gap), and the gap between export revenues and the imports (trade gap). The first gap requires foreign direct investments, while the second one requires foreign aid to be filled.

[5] Good illustrations of these types of models can be found in Amisano and Giannini (1997).

[6] The VAR model was introduced by Sims in 1980 as an alternative to the traditional large-scale macroeconomic models when the theoretical and empirical support for these models became increasingly doubtful [see Bjørnland (2000) for more details on these models].

[7] According to Enders (2004), an estimator from OLS method is asymptotically unbiased and efficient.

References

Abdalla, S. Z., 2016. Sources and Impacts of Macroeconomic Fluctuations in Sudan: Empirical Evidence from Structural Vector Autoregressive (SVAR) Framework. Visiting Research Fellow Series No. 495, Institute of Developing Economies, Japan.

Abdoun, R., 2012. Sudan's Inflation Problem: Some Lessons from the Past 30 Years. IMF Selected Issues (IMF Country Report 12/299).

Alamin, A., 1999. Stabilization Policies in Sudan: An Econometric Analysis. Forum of International development Studies, Nagoya University, No. 14 (1999,11).

Ali, A. G., and Elbadawi. I., 2004. Explaining Sudan's Economic Growth Performance, AERC Collaborative Research Project on Explaining Africa's Growth Performance. Working paper, No 9.

Amisano, G, and Giannini, C., 1997. Topics in structural VAR econometrics. Springer, Heidelberg and New York.

Arabi, K., (2002), "A macroeconometric model for Sudan". Unpublished Ph.D. Thesis. The University of Khartoum, Khartoum, Sudan.

Baumeister, C., and Peersman, G., 2013. Time-Varying Effects of Oil Supply Shocks on the US Economy. American Economic Journal: Macroeconomics 5.4: 1-28.

Berkelmans, L., 2005. Credit and Monetary Policy: An Australian SVAR. Reserve Bank of Australia Discussion Paper, 2005-6.

Bernanke, B.S., 1986. Alternative Explanations of the Money-Income Correlation. Carnegie-Rochester Conference Series on Public Policy, 25, 49-99.

Bergstrom, A.R., Nowman K.B., and Wandasiewicz S., 1994. Monetary and Fiscal Policy in a Second-Order Continuous Time Macroeconometric Model of the United Kingdom. Journal of Economic Dynamics and Control, 18, 3-4: 731-761.

Bjornland, H. C., 2000. VAR models in macroeconomic Research. Statistics Norway research department, 2000/14.

Blanchard, O.J. and Quah, D., 1993. The Dynamic Effects of Aggregate Demand and Supply Disturbances: Reply. American Economic Review, 83, 653-658.

Blanchard, O. and Perotti, R., 2002. An empirical characterization of the dynamic effects of changes in government spending and taxes on output. Quarterly Journal of Economics 117 (4): 1329–1368.

Blanchard, O.J.,. Watson, M. W.,1986. Are business cycles all alike?", In: Gordon, R. (Ed.), The American Business Cycle: Continuity and Change. University of Chicago Press, Chicago, pp. 123–156.

Blanchard, O. J. and Gali, J., 2007. The Macroeconomic Effects of Oil Price Shocks: Why are the 2000s so Different from the 1970s?. NBER Working Paper, No.13368.

Bodkin, R.G., Klein, L.R., and Marwah, K., 1991. A History of Macroeconometric Model-Building. Edward Elgar, Aldershot.

Bovin, J. and Giannoni, M., 2006. Has monetary policy become more effective?. Review of Economics and Statistics 88 (3): 445–462.

Chari, V.V., P. J. Kehoe, and McGrattan, E. R., 2008. Are structural VARs with long-run restrictions useful in developing business cycle theory?. Journal of Monetary Economics, vol. 55(8), pp 1337-1352.

Chenery, H.B. and Strout, A., 1966. Foreign Assistance and Economic Development. American Economic Review, 56, 679-733.

Cheng, K. C., 2006. A VAR analysis of Kenya's monetary policy transmission mechanism: How does the Central Bank's Repo rate affect the economy?. IMF Working Papers 06/300, International Monetary Fund.

Christiano, L., M. Eichenbaum, and Evans, C., 1996. The effects of monetary policy shocks: evidence from the flow of funds. The Review of Economics and Statistics, Vol.78, No.1, 16-34

Christiano, L., M. Eichenbaum, and Evans, C., 1999. Monetary policy shocks: What have we learned and to what end?. In J. Taylor e M. Woodford (Eds.), Handbook of Macroeconomics, Volume 1A: 91–157. Amsterdam: Elsevier Sccience BV.

Cooley, T. F. and Dwyer, M., 1998. Business Cycle Analysis without Much Theory: A Look at Structural VARs. Journal of Econometrics, Vol 83, iss. 1-2, pp. 57-88.

Cushman, D. O. and Zha, T., 1997. Identifying monetary policy in small open economy under flexible exchange rates. Journal of Monetary Economics, 39, 433-448.

Denu, G. B., 2011. The Role of Institutions in Improving the Performance of Investment in Sudan/ South Sudan after the Comprehensive Peace Agreement /CPA of 2005. Berlin: Lit-Verlag.

Dreger, C.; Marcellino, M., 2007. A macroeconomic model for the Euro economy. Journal of Policy Modeling, 29, pp. 1-13.

Dungey, M. and Pagan, A.R., 2000. A Structural VAR Model of the Australian Economy. Economic Record, 76, 321-342.

Enders, W., 2004. Applied Econometrics Time Series. New York, John Wiley and Sons, Inc.

Gerling, K., 2012. Assessing Sudan's external competitiveness. International Monetary Fund, Selected Issues (IMF Country Report 12/299).

Hag Elamin, N. A., and El Mak, E.M., 1997. Adjustment Programs and Agricultural Incentives in Sudan: A Comparative Study. African Economic Research Consortium, AERC Research Paper 63, Nairobi.

Hall, S., 1995. Macroeconomics and a Bit More Reality. The Economic Journal 105(431), pp. 974-88.

Hamilton, J. D., 1983. Oil and the Macroeconomy Since World War II. Journal of Political Economy, 91, pp. 228-248.

Hassan, R., 1989. A temporary general equilibrium model with endogenous money for economic policy analysis in Sudan". Ph.D. Dissertation. Iowa State University, Ames, Iowa, USA.

Haug, A., Jedrzejowicz, T., & Sznajderska, A. (2013). Combining monetary and fiscal policy in an SVAR for a small open economy. NBP Working Paper no. 168.

Ibrahim, Onour, A., 2015. Modelling inflation dynamics in Sudan 2008-2013. Working Paper, Arab Center for Research and Policy Analysis.

Jermann, U., and Quadrini, V., 2012. Macroeconomic effects of financial shocks. American Economic Review, 102(1), 238-271.

Kannapiran, C.A., 2003. A Macroeconometric Model of a Developing Economy. Journal of the Asia Pacific Economy, 8(1), pp. 41-56.

Kilian L., 2009. Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market. American Economic Review, 99(3), 1053–1069.

Kim, S. and Roubini, N., 2000. Exchange anomalies in the industrial countries: a solution with a structural VAR approach", Journal of Monetary Economics, 45, 561-586.

King, R. G., C., I. Plosser, J., H. Stock, and Watson, M. W., 1991. Stochastic Trends and Economic Fluctuations. American Economic Review, 81, 819-840.

Kydland, F. and Prescott, E., 1982. Time to build and aggregate fluctuations. Econometrica, 50(6), pp. 1345-1370.

Lanne, M. and Lutkepohl, H., 2008. Identifying monetary policy shocks via changes in volatility. Journal of Money, Credit and Banking 40: 1131–1149.

Lawson, J. and Rees, D., 2008. A Sectoral Model of the Australian Economy. RBA Research Discussion Paper No 2008-01.

Lippi, F. and Nobili, A., 2012. Oil and the macroeconomy: A quantitative structural analysis. Journal of the European Economic Association, 10, 1059-1083.

Liu, G. and Gupta, R., 2007. A Small-Scale DSGE Model for Forecasting the South African Economy. South African Journal of Economics, 75(2), pp.: 179-193.

Long, B. and Charles, P., 1983. Real Business Cycles. Journal of Political Economy, 91 (1), pp. 39-69.

Luik, M. A., and Wesselbaum, D., 2014. Bubbles over the US business cycle: A macroeconometric approach. Journal of Macroeconomics, 40, 27–41.

Marcellino, M., 2006. Some Stylized Facts on Non-Systematic Fiscal Policy in the Euro Area. Journal of Macroeconomics 28(3): 461 – 479.

Mertens K. and Ravn, M., 2010. Measuring the Impact of Fiscal Policy in the Face of Anticipation: A Structural VAR Approach. The Economic Journal, 120 (544): 393-413.

McCoy, D., 1997. How Useful is Structural VAR Analysis for Irish Economics?. Central Bank of Ireland Technical Paper 2/RT/97, April.

Moriyama, K., 2008. Investigating inflation dynamics in Sudan". International Monetary Fund Working Paper, No. WP/08/189.

Mosllem A., Ebaidalla, M. and Seif, I.,, 2014. Macroeconomic Policy Formation in Sudan after the Secession of the South. In K. Wohlmuth and T. Knedlik (eds) African Development Perspective Year Book. Vol. 17, Bremen University, LIT Verlag publisher, Berlin.

Mountford, A. and Uhlig, H., 2009. What Are the Effects of Fiscal Policy Shocks?. Journal of Applied Econometrics, 24, 960-992.

Noussair, C.N., D. Pfajfar and Zsiros, J., 2015. Pricing decisions in an experimental dynamic stochastic general equilibrium economy. Journal of Economic Behavior & Organization, 109, 188–202.

Peersman, Gert, and Ine Van R., 2012. Cross-country differences in the effects of oil shocks. Energy Economics 34 (5): 1532-1547.

Peiris, S. and Saxegaard, M., 2007. An Estimated DSGE Model for Monetary Policy Analysis in Low-Income Countries. International Monetary Fund Working Paper, WP/07/282.

Senbeta S.R., 2011. How applicable are the New Keynesian DSGE models to a typical low-income economy?. MPRA Munich Personal RePEc Archive, 31043.

Shourie, A., 1972. The Use of Macro-Economic Models of Developing Countries for Forecasts and Policy Prescription: Some Reflections on Current Practice. Oxford Economic Papers, 24(1), pp. 1-35.

Sims, C.A., 1980. Macroeconomics and Reality. Econometrica, 48, 1-48.

Sims, C.A., 1986. Are Forecasting Models Usable for Policy Analysis?. Minneapolis Federal Reserve Bank Quarterly Review, 10, 2-16.

Sims, C.A., 1992. Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy. European Economic Review, 36, 975-1011.

Smets, F., Wouters, R., 2003. "An estimated dynamic stochastic general equilibrium model of the euro area. Journal of the European Economic Association, 1 (5), 1123–1175.

Taylor, M. P., 2004. Estimating Structural Macroeconomic Shocks Through Long-Run Recursive Restrictions on Vector Autoregressive Models: The Problem of Identification. International Journal of Finance and Economics, (9) 229-244.

Valadkhani, A., 2004. History of Macroeconometric Modelling: Lessons from Past Experience. Journal of Policy Modeling, 26(2), pp.265-81.

Wallis K.F., 1989. Macroeconomic Forecasting: A Survey., The Economic Journal, Vol. 99, No. 394., pp. 28-61.

Welfe, W., 2013. Macroeconometric Models. Advanced Studies in Theoretical and Applied Econometric, 47. Springer-Verlag Berlin Heidelberg 2013 edition.

Wohlumth, K. and Dirk, H., 1986. Sudan: A Case for Structural Adjustment Policies. Sudan Economy Research Group Discussion Paper No. 8, University of Bremen.