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Exogenous Oil Shocks and the Fiscal Policy Response in Oil-exporting Countries: Evidence from Libya

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Abstract: The recent downtrend in oil prices and production represent a challenge for small-open developing and exporting economies. Using Libya as study case this paper employs a general dynamic macroeconomic model developed by Ali and Harvie (2013) to analyze the dynamic adjustment process of key macroeconomic variables, in particular fiscal variables, arising from the recent downtrend in oil price and production. It emphasizes the transmission channels through which the negative oil related shocks affect the domestic economy. The simulation results suggest that the shock would bring about a decrease in government revenue, government spending and this have caused considerable budget deficit. The shock has also negatively affected the other economic variables such as foreign assets, gross domestic income, non-oil GDP, oil exports and the current account. Contraction fiscal policy, in particular reducing government administrative expenditure, and improving non-oil revenue generated from non-oil economic activities are crucial measurement in order to alleviate the budget deficit.

JEL classification: E27, E60, E62, Q33, Q43, Q48.

Keywords: Oil prices and production decrease, budget deficit, dynamic macroeconomic model, simulation scenarios, policy analysis.

1- Introduction

The recent downtrend in oil prices represents a challenge for small-open developing and exporting economies like Libya. This stems from the importance of government revenue generated from natural resource sector in financing government consumption and investment expenditures as well as capital imports. The dependency on the natural resource sector and relatively weak non-natural resource tax base renders fiscal position highly challenging in oil exporting countries. As more than 90 percent of government revenue generated from oil sector, the components of budget are the most influenced factors by oil related shocks. Transitory oil price increases, especially after 2000 brought about fiscal surpluses in the government budget and the trade balance, and this, in turn, induced the government to increase consumption and development spending. In particular, several development projects were implemented which originally aimed to build a viable economy by diversifying it and by increasing the share of the non-oil sector, particularly the non-oil tradable sector such as that of manufacturing and agriculture sectors, in gross domestic product.

However, Libya experienced major political and economic upheaval arising from eight months of internal armed conflict in 2011. As a result of this the non-oil economic activities disrupted, oil production almost halted, government revenues declined, and sanctions that imposed on Libya by the UN Security Council led to the freezing of foreign assets (IMF, 2012). In the wake of the uprising of 2011, Libya has taken serious steps in order to improve security and economic situations in the country, where the oil production rehabilitated, reaching almost the per-war level of 1.6 million barrels per day at the end of 2012[1]. Additionally, the financial situation improved, as most of sanctions imposed on Libya were lifted, and this has enabled the central bank to provide liquidity in foreign currency. Furthermore, significant financial surpluses were achieved and government current expenditures were increased, especially salaries and wages, administrative expenses and fuel subsidies.

Recently, the world oil prices have started to decline since June 2014, falling by more than 50 percent in the end of January 2015. This further compounded when the amount of oil production decreased significantly as a result of the armed conflict in the Oil Crescent in the east of Libya, reaching less than 400 thousand barrels per day, which is adversely affecting the key macroeconomic variables, particularly oil government revenues and expenditures. In the case of continued decline in oil prices and oil production, oil revenue is expected to sharply decline in 2015, and the government's budget is expected to experience a large deficit. This requires designed fiscal policy to curb the growth in government spending, and to increase non-oil revenues generated from non-oil economic activities so as to reduce the expected budget deficit, and finding alternative sources to finance the deficit.

Therefore, there is an urgent need to investigate the impact of lower oil prices and production upon the government's budget and other key macroeconomic variables in Libya, and to develop an appropriate economic policies to address the negative effects on the government's budget.

The remainder of this paper proceeds as follows. Section 2 outlines the theoretical framework of the model. Section 3 describes data sources and estimation procedures. In section 4 simulation outcomes from the model for the case of an oil related shocks. Section 5 provides concluding remarks.

2- Theoretical framework: the model

This study has utilized a general dynamic macroeconomic model for the Libyan economy developed by Ali and Harvie (2013). The model is more applicable for the case of a fixed exchange rate in the context of a developing resource-abundant country. It can also be adapted for the case of a flexible exchange rate in context of a developing resource-abundant country (see, Ali and Harvie, 2015). The model has its foundation in the contributions of Dornbusch (1976), Buiter and Miller (1981), Eastwood and Venables (1982), Buiter and Purvis (1982), Neary and Van Wijnbergen (1984), Harvie and Gower (1993), Harvie and Thaha (1994), and, more recently and importantly, Cox and Harvie (2010) for the case of a flexible exchange rate in the context of advanced resource-abundant economies. The latter is a dynamic general equilibrium model focusing on the long run nature of the adjustment process. An important characteristic of each of these models is the role of financial markets (exchange rate, interest rate and Tobin's q ratio adjustments) in transmitting the effects of oil related shocks to the rest of the economy (goods, labour and external sectors).

[1] For more details about the impact of oil sector rehabilitation upon key macroeconomic variables in Libya after the uprising of 2011, see Ali and Harvie, 2013.

Ali and Harvie (2013, 2015) argue, however, that such a transmission mechanism is not applicable for an oil producing developing economy such as that of Libya, where financial markets are unsophisticated, tightly controlled and largely passive[2]. They argue that since oil production and revenue generated from its production is under government control, the way in which the government spends the oil revenue will have a significant impact upon the transmission of oil related shocks to the rest of the economy, and the future development of the economy.

The Libyan government allocates oil revenue between two types of expenditure. First, consumption or current expenditure on wages and salaries, which stimulates the demand for non-oil output. Second, development (or investment) expenditure, which is divided into three parts; development spending on physical capital, development spending on human capital, and that devoted to imported capital or technology. The second type of government expenditure increases the demand for non-oil output but will also stimulate non-oil output supply.

The model is capable of analyzing the impact of oil related shocks on macroeconomic variables of interest, particularly, government revenues, government spending, budget deficit, foreign assets, real income and non-oil output supply.

The model utilized in this paper is extensively discussed by Ali and Harvie (2013, 2015). The equations of the model and explanation of symbols used in the model are contained in Table 1 and 2, respectively. A brief discussion of the model is presented in appendix 1.

3- Data Sources and Estimation procedures

Due to data limitations the historical data used to estimate the behavioural equations cover the period from 1970 to 2007, which includes the oil boom and post oil boom periods. The relevant data were obtained from two different sources, i.e. international and local publications such as the Central Bank of Libya, International Financial Statistics (IFS) Yearbook published by the International Monetary Fund (IMF), Annual Statistical Bulletin published by OPEC and World Development Indicators (WDI) issued by the World Bank.

The empirical estimation of the behavioural equations of the macroeconomic model developed by Ali & Harvie (2013) was conducted by using robust and contemporary estimation procedures, namely, the Auto-regressive Distributed Lag (ARDL) Model (see, Pesaran & Pesaran, 2009 and Pesaran & Smith, 2001). However, before the model was estimated, it was necessary to verify the following: 1) stationarity of time series and identifying the structural-break points, utilizing the two-break minimum Lagrange Multiplier (LM) unit root test (Lee & Strazicich, 2003, 2004); 2) investigating the existence of a long-run relationship among the variables in the behavioural equations, using the F-test (see Table 3). Once a long-run cointegrating relationship was found to exist, the next step was to estimate the long-run elasticities.

[2]In the Cox-Harvie model there is assumed to be four financial assets available in the economy. These are domestic money, domestic bonds, foreign bonds and equities. In the case of Libya there is assumed to be only one financial asset available in the economy, which is a money asset. This assumption is due to the immaturity of financial assets in the economy, and lack of data available for other financial assets. Control of the money supply and nominal interest rate, therefore, remain blunt instruments of monetary policy.

The parameters obtained from estimation of the behaviour equations and those calculated from available data are summarised in Table 4.

4- Simulation results from decreased oil prices and oil production

The efficiency of the model is not confined to the extent of its quality when estimating the behavioral equations, but also how it works and its performance as a full system. This can be known through the conducting a dynamic simulation process, which provides us with a full solution to the model. The model was simulated by using a program called "Dynare", which is designed for solving and simulating deterministic and stochastic dynamic general equilibrium models (see Adjemian, *et al.* 2011), and It is also suitable for a small open oil-exporting economy such as that of Libya.

The numerical simulations was conducted to analyze possible macroeconomic effects upon the key macroeconomic variables, particularly government revenues and expenditure arising from the exogenous shocks from decreased oil prices and oil production. The focus was placed on identifying the steady state properties of the model as well as the adjustment process towards the long-run steady state arising from oil related shock for a number of key macroeconomic variables. These variables are government revenues, government spending, the government budget, foreign assets, real income, non-oil GDP, prices level, the real exchange rate, and oil exports.

The prediction of government revenue generated from oil sector depends, *enter alia*, on oil prices and the produced and exported quantity of oil. The oil prices have begun to decline from about 100 US dollars per barrel at the beginning of the third quarter of 2014 to about 47 US Dollars per barrel at the end of January 2015. The oil production has fallen from about 1.5 million barrels per day in 2012 to about 450 thousand barrels per day at the end of January 2015. The suggested scenarios for fluctuating oil prices and production, and their impact upon a number of key macroeconomic variables were based on logical and practical facts of political, economic and security circumstances in Libya, and in the international oil markets. The following scenarios represent possible scenarios for changes in the oil prices and production and their impact on the most important macroeconomic variables.

Scenario A: represents the worst case scenario, where oil production amounted to about 450 thousand barrels per day in January 2015. This is due to the armed conflict on oil fields and ports in the Oil Crescent area in east of Libya. Since Oil Crescent area exports about 75 percent of the Libyan oil exports, therefore, the estimated decrease in oil production is about 70 percent. Also, the oil prices fell to around 45 US dollars per barrel with a decreasing rate of about 55 percent.

Scenario B: this scenario is based on the assumption that the conflict in the Oil Crescent area will be ended, and production levels will gradually return to per-conflict level of about 1.5 million barrel per day, with the assumption that oil prices increase to around 55 US dollars per barrel. Also, several companies that extract tight oil is expected to leave the oil market as a result of the high cost of extraction, which is estimated to be about 60 US dollars per barrel. This would reduce the oil supply, and, in turn, causing increase in oil prices. The production levels are expected to be 450,000, 800000, 1,000,000, and 1500000 barrels per day for the first, second, third and fourth quarter of 2015, respectively. Therefore, this scenario assumes a 45 percent decrease in oil prices, and, on average, 37 percent decrease in oil production.

Scenario C: this scenario assumes the same oil production level predicted in scenario B, with expected increase in oil prices to around 65 US dollars per barrel due to expected continual decline in oil supply. Therefore this scenario assumes a 35 percent decrease in oil prices, and 37 percent decline in oil production.

The long run steady state properties of all the above scenarios are summarised in Table 5. The numbers in Table 5 display the deviations of the steady state values of the key macroeconomic variables, in percentage terms, from their presumed initial base values. Also, the impact of each shock upon the adjustment path of key macroeconomic variables of interest is summarised in the Figure 1. The horizontal axis measures the time periods, whilst the vertical axis, for each diagram, measures the percentage deviation of each variable from its initial or base value. Each figure contains the three scenarios; A, B and C.

The findings presented in Table 5 and Figure 1 show that the directions of changes of the macroeconomic variables of interest arising from three possible oil related shocks are analogous. However, the magnitudes of the deviations differ, although they are comparable for all of the variables.

Government Budget (government revenue and spending)

The simulation results in Table 5 and Figure 1 show that a 55 percent decrease in oil prices and a 70 percent decrease in oil production lead to a decrease in the government revenue continuously throughout the adjustment process towards a long-run steady state in all scenarios, where the decline in the government revenue is lower than its base value by 72 percent in worst case scenario (A), whereas it decreased by about 47 percent and 41 percent in scenarios B and C, respectively.

During the oil sector negative shocks period the government decrease its expenditure to retain its balanced budget policy, resulting in decreased demand for both non-oil and imported goods (see Equation 1). The government spending, as pointed by Figure 1, is assumed to be reduced by about 27 percent in scenario A, thereby, the budget deficit will be about 45 percent. Whilst in scenario B and C the government spending is supposed to be reduced by about 18 percent and 15 percent, respectively, which means that the predictable budget deficit will be about 32 percent in scenario B, and 26 percent in scenario C.

Price level and real exchange rate

The reduction in government revenue and spending would reduce the demand for tradable and non-tradable goods. This would result in a lower domestic price level during the early stage of the adjustment path and a depreciation of the real exchange rate (See figure 1). Afterward, the real exchange rate appreciates gradually toward its long run steady state. A depreciation of the real exchange rate during short run will have a significant influence upon the adjustment of a number of key macroeconomic variables, particularly non-oil exports, non-oil imports, and, therefore, the non-oil trade balance (is not shown here), and, consequently, upon the domestic economy as whole. The depreciation of the real exchange rate of the Libyan dinar will improve non-oil trade balance.

Current Account (Foreign Assets)

Figure 1 demonstrates the expected development in foreign assets arising from the oil related shocks, where it shows that the decline in oil prices and production lead to deccumulation of foreign asset stocks continuously throughout the adjustment process towards a long-run steady state in all scenarios, signifying continual decline in oil trade balance and current account surpluses. The decline in current account surplus arises from an immediate decrease in oil exports as it consists more than 95 percent of total exports (see Figure 1). As shown in Table 1 and Figure 1, the foreign assets are expected to decline by 70 percent in scenario A, 46 percent and 39 percent in scenario B and C, respectively.

The decline in foreign assets balances will result in a decline in the money supply and growth in it, and this would put a further downward pressure on domestic prices, and thus further depreciation of real exchange rate. This will eventually help to reduce the non-oil trade deficit.

Real income

Table 5 and Figure 1 indicate that real income decreases continuously throughout the adjustment process toward long run steady state, with most of the decrease in real income occurring very early in the adjustment process. It is adversely influenced directly by a decrease in oil price and production and also by decline in non-oil output (see Equation 17). In long run steady state real income is approximately 50 percent lower than its base value in the worst case scenario (A), 33 percent in B and 28 percent in C, as indicated in Table 5. On the demand side a decrease in real income reduces non-oil imports, which in turn contributes to an improvement of the non-oil trade balance. However, the decline in capital imports may adversely affect the non-oil GDP, which relies on imported capital.

Non-Oil GDP

It is noted that the non-oil output supply will continuously decline throughout the period of the adjustment process toward long-run steady state where it is lower than its base value by about 22 percent in scenario A, 14 percent and 12 percent in scenario B and C, respectively, as shown in Table 5 and Figure 1. The major contributory factors to this adverse development throughout the adjustment process include: the decrease in government investment spending on infrastructure, foreign capital imports and human capital formation (see equation 24).

On demand side declining the non-oil output decreases demand through private investment and private consumption (see Equation 2 and 4). Also, a decrease in non-oil output supply will negatively affect the total real income, which, in turn, reduce imports, thereby possibly leading to ease deficit in non-oil trade balance. Moreover, the decline in non-oil GDP would negatively affect the mount of indirect taxes collected by the government from non-oil economic activities, which may further exacerbate government budget deficit.

5- Concluding remarks

The main objective of this study was to analyze the effects of fluctuations in the oil prices and production on the most important macroeconomic variables, particularly the government budget, using a general dynamic macroeconomic model for the Libyan economy developed by Ali and Harvie (2013). Three main scenarios have been assumed for the anticipated changes in oil prices and production and their impact on a number of key macroeconomic variables. The sharp decline in oil price and production lead to the decrease in government revenue, government spending and this have brought about considerable budget deficit. The decline in oil prices and production have also negatively affected the other economic variables such as foreign assets, gross domestic income, non-oil GDP, oil exports and the current account.

Furthermore, the oil related shocks may lead to lower domestic prices, and then real exchange rate depreciation of the Libyan dinar, and this would improve the performance of the non-oil trade balance. However, the economy is being experiencing another crisis, which resulted from the closure of the sea, air and border ports. This has led to a decline in the flow of imported goods, and thus causing a shortage in domestic supply. Consequently, this would generate an increase in the domestic price level, which may offset the reduction in domestic prices level resulted from decreasing oil prices and production.

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Appendix 1: A brief discussion of the model

The model utilised in this paper is basically the same as that extensively discussed by Ali and Harvie (2013, 2015)[3]. Equilibrium in the model depends upon equilibrium in the product market, assets market and foreign trade sector. The product market is discussed first.

Equations 1 to 18 describe the ***product market***. Equation 1 describes the total demand for non-oil output (No^d). It is a log linear approximation of total spending in the form of private consumption spending (c^p), private investment spending (i^p), government spending (g) and the non-oil trade balance consisting of non-oil exports (x^n) and non-oil imports (m^n). The parameters (β_i) represent the elasticities of spending in each category. The parameters are based on the contribution of a Dinar spent on private consumption and investment, total government spending, non-oil exports and non-oil imports to the demand for non-oil output. The parameters are set to 1 indicating that a Dinar spent in any of these components contributes equally to non-oil product demand.

Private consumption expenditure is given by Equation 2. It depends positively upon non-oil output supply and private sector wealth. The production of non-oil output represents income generated by the public and private sectors, although most non-oil output is produced by the public sector in Libya[4]. Equation 3 describes private sector gross investment, which equals the change in the stock of private capital[5] and is based on the partial adjustment hypothesis. This partial adjustment arises from costs of adjusting the actual physical capital stock (k^p) to the desired capital stock (k^{p*}). The increase in capital from the end of the previous period to the end of the current period is some fraction γ of the divergence between the desired and actual stock of capital. The adjustment coefficient γ was selected to be 0.50, indicating moderate adjustment of the dependent variable. The desired capital stock is assumed to depend upon non-oil output (see Equation 4), where the parameter δ is set to be 0.8.

Total government spending (g) is identified by Equation 5. It depends positively on two components of expenditure; government consumption spending (c^g), which is assumed to be dependent upon oil revenue as shown in Equation 6, and government development expenditure. Government development spending is divided into three parts; government development spending on physical capital (for example, infrastructure) (i^g), government development spending on human capital (for example, education and health care) (i^h) and that devoted to imported capital (for example, imported foreign technology) (i^{cap}). Equation 5 parameters are based on the relative weight of each of these spending components in total government spending. Equations 7, 8, and 9 describe government investment spending on the physical, human and imported capital stocks, respectively, which arises from a gradual adjustment of the actual public capital stock to their policy determined levels. The policy determined levels are determined by oil revenue, as given by Equations 10, 11 and 12. For adjustment equations 7, 8 and 9 the adjustment coefficients were selected to be 0.50, indicating moderate adjustment of the dependent variables. The parameters for Equations 6, 10, 11, and 12 were chosen as weighted averages, indicating how the government distributes oil revenue between desired physical capital stock, desired human capital stock, desired imported capital stock and consumption expenditure according to its policy priorities. The summation of these parameters is one, as all oil revenue goes to the government and this is totally disbursed in the previous four ways.

Equation 13 identifies the budgetary stance, which is government expenditure (g) less tax revenues (t^x). In Libya the government issues bonds to the central bank only, therefore Equation 13 shows that any excess of government expenditure over tax revenue must be financed by borrowing domestically from the Central Bank of Libya (CBL). Tax revenue is generated from two sources, oil production and non-oil production (Equation 14).The parameter (β_{13}) in Equation 14 is set to 0.90 as the bulk of government revenue comes mainly from oil, with oil revenue contributing 70 percent on average of total government revenue during the period 1970-2007.

[3] For more discussion of the model see Ali and Harvie (2013, 2015).
[4] Non-oil output can be considered as a good which can be either consumed domestically or exported, and is an imperfect substitute for the foreign non-oil imported good.
[5] A dot (.) above a variable signifies its rate of change.

The non-oil trade balance is disaggregated into non-oil exports less non-oil imports as shown in Equation 15 and identity Equation 30. Equation 15 specifies that non-oil exports (x^n) depend positively upon the real exchange rate (*e* + *p** — *p*) and world real income (*y**) which is assumed to be exogenous. Non-oil imports is also disaggregated into non-oil consumption imports (m^{con}) and non-oil capital imports (i^{cap}). Equation 16 identifies non-oil consumption imports, which depends negatively upon the real exchange rate and positively on domestic real income (*y*). Equation 9 identifies non-oil capital imports which are assumed to be endogenously determined, arising from a gradual adjustment of actual imported capital spending to its policy determined level. The parameters in behavioural Equations 15 an16 were empirically estimated using the ARDL approach (see Table 4).

Real and permanent income (y^p) definitions, first used by Buiter and Purvis (1982), are given by Equations 17 and 18. Real income, as identified in Equation 17, depends upon non-oil output (No^s), oil production (o^a) that is assumed to be exogenous, the world price of oil (po), that is also exogenous, the real exchange rate as emphasized here and the exogenously determined price of non-oil imported goods ($p*$). Equation 18 represents permanent income, which depends on exogenous permanent non-oil output (No^{sp}), exogenous permanent oil output (o^p), the world price of oil, the real exchange rate and price of non-oil imported goods (see Harvie, 1994). The parameters in identities 17 and 18 are based upon the calculated share of current and permanent oil output in total current and permanent output, respectively. It is assumed that v , the share of current and permanent non-oil production in total current and permanent income, is the same in real and permanent income and constant through time (see Buiter and Purvis, 1982). The share of oil output in domestic real income ($1-v$) is deliberately set to be larger than its share in domestic consumption (μ_2) resulting in the Libyan economy being a net oil exporter in the model.

The asset market is encapsulated by Equations 19–21. The behavioural Equation 19 describes the demand for real money balances (the nominal money stock *m* deflated by the consumer price level *p*). It depends positively upon real non-oil income (No^s), representing a transactions demand, and negatively upon the interest rate representing an asset demand. The interest rate is subject to regulation by policymakers in Libya and it is no longer a good proxy for the cost of holding money. Therefore, the rate of inflation is utilised, besides the interest rate, as a proxy variable for the opportunity cost of holding money in the Ali-Harvie model. The nominal money supply is assumed to be endogenous as the nominal exchange rate is fixed. The estimated parameters of Equation 19 are shown in Table 4.

Domestic private sector real wealth (w^p) is given by Equation 20 and consists of three components. The first component is private capital stock which is owned entirely by the private sector. The second major component is real money balances, which consists of cash, deposits, and savings of the private sector. The final component is permanent non-oil income equivalent to that of permanent non-oil output[6].The parameters in Equation 20 are set to 1 indicating the equal importance of each of the components to total private sector wealth.

Equation 21 shows the money growth equation. It indicates the assumption of a fixed exchange rate combined with imperfect capital mobility. Since a fixed exchange rate is assumed for the case of Libya the money supply and its growth is endogenously determined. It depends upon exogenously determined changes in domestic credit expansion ($d\dot{c}e$) and the accumulation of foreign exchange reserves through balance of payments surpluses/deficits ($f\dot{e}s$) (see Harvie, 1993, and Harvie and Thaha, 1994), as shown in Equation $21*$.

$$\dot{m} = d\dot{c}e + f\dot{e}s \qquad \text{Equation } 21*$$

$d\dot{c}e$ is exogenously determined by government and is assumed for simplicity to be equal to zero. Changes in foreign exchange reserves arise from developments in the current account $(\dot{f})$ and from capital flows due to differences in the domestic and foreign nominal interest rate $(r-r*)$, as shown in Equation $21**$,where τ denotes the sensitivity of capital flows to interest rate differentials, representing the degree of capital mobility. The value of coefficient τ can range from zero to infinity. The greater is τ the greater is international capital mobility, while the smaller is τ the smaller is international capital mobility (Frenkel & Rodriquez, 1982). The parameter τ is chosen to be 0.2 in this

[6] This is a proxy for the present value of the future income stream for the private sector.

base model, which is indicative of the substantial control over capital mobility exercised by the government.

$$f\dot{e}s = \tau(r - r^*) + \dot{f} \qquad \text{Equation } 21^{**}$$

By substituting Equation 21^{**} into Equation 21^*, Equation 21 is obtained.

Equations 22–24 define ***the price level and aggregate non-oil output supply***. Price and inflationary expectations developments are given by Equations 22, 23, and 24. Equation 22 defines the consumer price level, which is a weighted average of nominal wages, the domestic cost of oil and the domestic cost of the world non-oil imported good. The weights used in the consumer price index in Equation 22 are approximated, based on Libyan data. Adjustment of nominal wages is generated by an expectations augmented Phillips curve, as given by Equation 23. Two possible adjustment sources are considered. These being excess demand for non-oil goods relative to its available supply $(No^d - No^s)$, and core inflation (π). Core Inflation depends upon developments in the monetary growth rate (Equation 21). The estimated parameters of Equation 23 are contained in Table 4.

Aggregate non-oil output supply is endogenously determined, as given by Equation 24. It depends positively on the public capital stock[7], human capital stock, private capital stock, imported capital stock and employment. Government investment is divided into three parts; capital that affects non-oil output through physical capital stock accumulation, capital that affects non-oil output through human capital formation and capital imports. The estimated parameters of Equation 24 are shown in Table 4.

The external sector consists of the current account and the oil trade balance. Developments in the current account are given by Equation 25a (see for example Harvie and Gower (1993) and Harvie (1994)).

$$\dot{f} + e - p = \alpha_1 T + \alpha_2 (r^* f + e - p) + \alpha_3 (o^x + po + e - p) \qquad (25a)$$

where (o^x) represents net exports of oil. Re-arranging Equation 25a and expressing this in terms of changes in foreign exchange reserves, Equation 25 is obtained. This shows that changes in foreign exchange reserves, as reflected in the current account balance ($\dot{f}$), depends positively upon the non-oil trade balance (as given by Equation 29), foreign interest income ($r^* f$), net oil exports and on the real exchange rate ($e - p$). In long run steady state the current account balance must be zero, otherwise further wealth effects will arise requiring further macroeconomic adjustment. Equation 25 is as in the Cox-Harvie model. The estimated parameters of this equation are contained in Table 4.

Equation 26 indicates that net oil exports are exogenously determined, being dependent upon government policy towards the domestic usage or export of oil production. The parameter in Equation 26 has been selected as 0.80, indicating a more export oriented policy.

Finally, Equations 27–30 define four variables which are used extensively throughout this study. Equation 27 defines the real exchange rate as used in this study, Equation 28 defines real money balances, Equation 29 defines the non-oil trade balance, and Equation 30 defines non-oil imports.

[7]Inclusion of the public capital stock is attributed to the assumption that it is complementary to that of the private capital stock in nature (see Aschauer, 1989a, 1989b; Morrison and Schwartz, 1996).

Table 1: Ali and Harvie macroeconomic model for Libya

Product market	Equation number
$No^d = \beta_1 c^p + \beta_2 i^p + \beta_3 g + \beta_4 (x^n - m^n)$	1
$c^p = \beta_6 No^s + \beta_7 w^p$	2
$i^p = \dot{k}^p = \gamma(k^{p*} - k^p)$	3
$k^{p*} = \delta No^s$	4
$g = \beta_8 c^g + \beta_9 i^g + \beta_{10} i^h + \beta_{11} i^{cap}$	5
$c^g = (1 - \theta_1 - \theta_2 - \theta_3)(o^a + po + e - p)$	6
$i^g = \dot{k}^g = \varphi(k^{g^*} - k^g)$	7
$i^h = \dot{k}^h = \sigma(k^{h^*} - k^h)$	8
$i^{cap} = \dot{k}^{cap} = \lambda(k^{cap^*} - k^{cap})$	9
$k^{g^*} = \theta_1(o^a + po + e - p)$	10
$k^{h^*} = \theta_2(o^a + po + e - p)$	11
$k^{cap^*} = \theta_3(o^a + po + e - p)$	12
$bd = g - t^x = \beta_{12}(\dot{m} - \dot{p})$	13
$t^x = \beta_{13}(o^a + po + e - p) + (1 - \beta_{13}) No^s$	14
$x^n = \beta_{14}(e + p^* - p) + \beta_{15} y^*$	15
$m^{con} = \beta_{16} y - \beta_{17}(e + p^* - p)$	16
$y = vNo^s + (1 - v)o^a + (1 - v - \mu_2) po + (\mu_1 - v)(e - w) - (1 - \mu_1 - \mu_2) p^*$	17
$y^p = vNo^{sp} + (1 - v)o^p + (1 - v - \mu_2) po + (\mu_1 - v)(e - w) - (1 - \mu_1 - \mu_2) p^*$	18
Asset market	
$m - p = \varepsilon_1 No^s - \varepsilon_2 \pi - \varepsilon_3 r$	19
$w^p = \varepsilon_5 k^p + \varepsilon_6 (m - p) + \varepsilon_7 y^p$	20
$\dot{m} = d\dot{c}e + \tau(r - r^* + \dot{f})$	21
Aggregate supply and prices	
$p = \mu_1 w + \mu_2 (e + po) + (1 - \mu_1 - \mu_2)(e + p^*)$	22
$\dot{w} = \psi_1 (No^d - No^s) + \psi_2 \dot{m}$	23
$No^s = \phi_1 k^p + \phi_2 k^g + \phi_3 k^h + \phi_4 k^{cap} + \phi_5 em$	24
External sector	
$\dot{f} = \alpha_1 (x^n - m^n) + \alpha_2 r^* f + \alpha_3 (o^x + po) - (1 - \alpha_2 - \alpha_3)(e - p)$	25
$o^x = \zeta o^a$	26
Definitions	
$c = e - w$	27
$l = m - w$	28
$T = x^n - m^n$	29
$m^n = m^{con} + i^{cap}$	30

Note: A dot (.) above a variable signifies its rate of change.

Table 2: Explanation of symbols used in the model

Symbol	Description
Endogenous variables	
No^d	Aggregate demand for non-oil output
c^p	Private consumption
i^p	Private investment
k^{p*}	Desired private capital stock
g	Total government spending
c^g	Government consumption expenditure
x^n	Non-oil exports
m^n	Non-oil imports
T	Non-oil trade balance
No^s	Aggregate supply of non-oil output
w^p	Real private sector wealth
k^p	Private capital stock
k^{cap}	Imported capital stock
k^s	Actual public capital stock
k^h	Human capital stock
k^{s^*}	Desired government physical capital stock
k^{h^*}	Desired human capital stock
k^{cap^*}	Desired imported capital stock
i^g	Government investment spending on physical capital
i^h	Government investment spending on human capital
i^{cap}	Government investment spending on imported capital
t^x	Total tax revenue
m	Nominal money supply
π	Inflation rate
p	Consumer price level
w	Domestic nominal wage
m^{con}	Consumption of non-oil imports
y	Total real income
y^p	Permanent real income
f	Foreign asset stocks
o^x	Oil exports
c	Real exchange rate
l	Real money balance
Exogenous variables	
e	Nominal exchange rate
o^a	Oil production
po	World oil price (in foreign currency)
$p*$	Price of non-oil imported goods
$y*$	World real income
No^{sp}	Permanent non-oil income
o^p	Permanent oil-income
$r*$	World nominal interest rate
r	Domestic nominal interest rate
em	Employment

Table 3: Testing for the Existence of a Long-Run Relationship among the Variables*

Equation	95% Lower bound	95% Upper bound	90% Lower bound	90% Upper bound	The computed F-statistic
$F(c^p / No^s, w^p, D_{83}, D_{2000})$	7.1331	8.1223	5.9643	6.8483	8.5036
$F(x^n / (e + p* - p), y*, D_{78}, D_{2000})$	7.2027	8.0224	5.9599	6.8090	9.5687
$F(m^{con} / y, (e - p* - p), D_{87}, D_{2003})$	6.8999	7.9831	5.7676	6.7289	6.9717
$F(m - p / No^s, r, \dot{\pi}, D_{81})$	4.9827	5.9803	4.1361	5.0154	6.1426
$F(\dot{w} / (No^d - No^s), \dot{\pi})$	2.8906	4.1355	2.2636	3.3349	6.7978
$F(No^s / k^p, k^g, k^h, em, k^{cap}, D_{89})$	3.6605	5.0006	3.0991	4.2756	6.2444
$F(\dot{f} / T, r* f, (o^x + po), (e - p))$	4.0285	5.3829	3.3851	4.627	5.9057

*Critical values are obtained directly from the empirical results generated by Microfit 5.

Table 4. Parameters values					
β_1***	1.0	θ_1**	0.3	ε_7***	1.0
β_2***	1.0	θ_2**	0.2	τ***	0.2
β_3***	1.0	θ_3**	0.2	μ_1***	0.6
β_4***	0.75	β_{12}**	1.0	μ_2***	0.1
β_6*	0.6	β_{13}*	0.9	ψ_1*	0.65
β_7*	0.3	β_{14}*	0.45	ψ_2*	0.4
γ***	0.5	β_{15}*	0.5	ϕ_1*	0.1
δ*	0.8	β_{16}*	0.75	ϕ_2*	0.5
β_8**	0.7	β_{17}*	0.25	ϕ_3*	0.4
β_9**	0.3	v**	0.7	ϕ_4*	0.3
β_{10}**	0.15	ε_1*	0.8	ϕ_5*	0.2
β_{11}**	0.15	ε_2*	0.35	α_1*	0.15
φ***	0.5	ε_3*	0.1	α_2*	0.5
σ***	0.5	ε_5***	1.0	α_3*	0.35
λ***	0.5	ε_6***	1.0	ζ***	0.80
				rs***	0.05

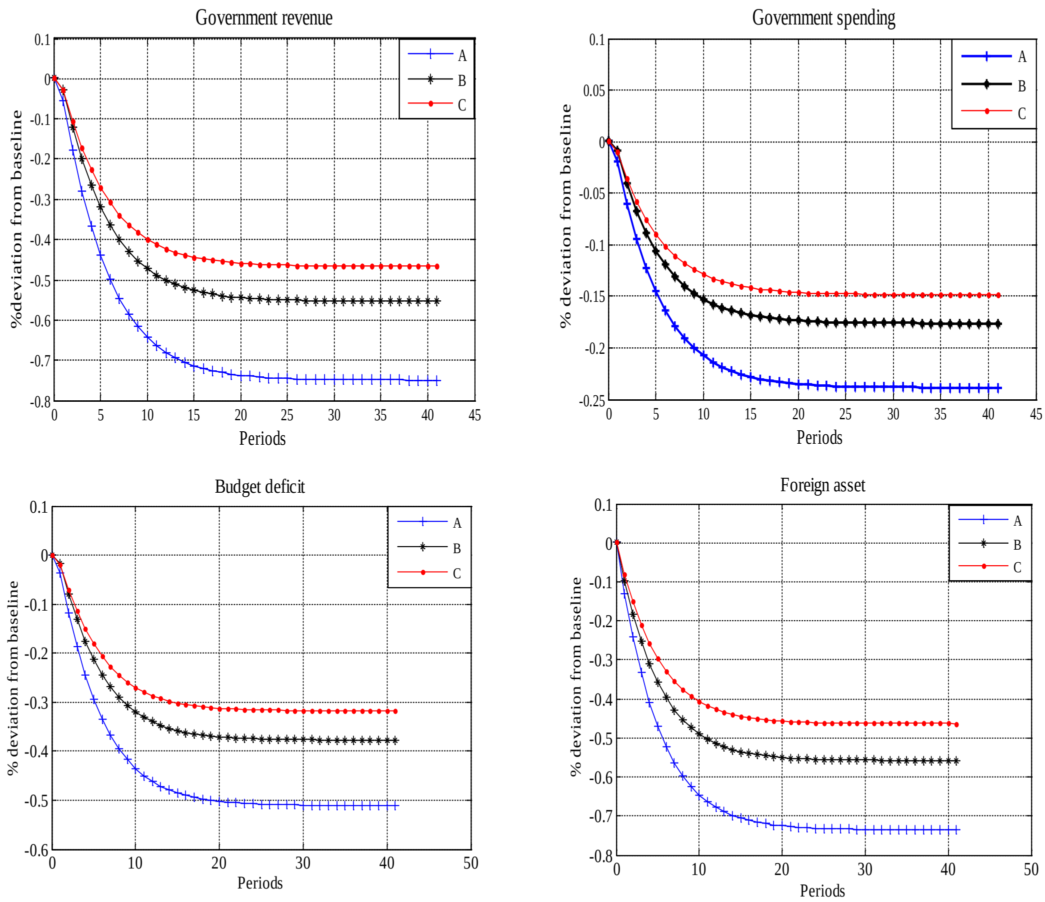
***** Estimated coefficients obtained using ARDL as contained in Table 3.
****** Calculated by the authors based on available data.
*** Cox and Harvie (2010), and Harvie and Thaha (1994).

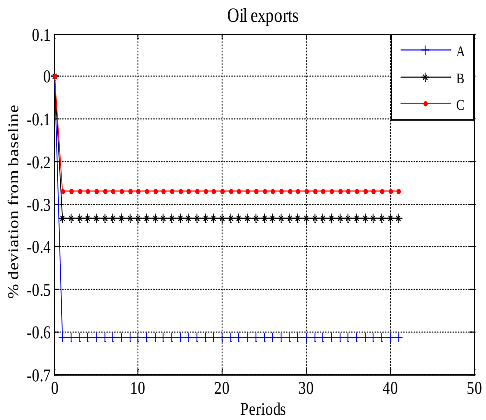
Table 5: Steady State Properties of the simulation results of the Model (Percentage Deviation from Baseline)

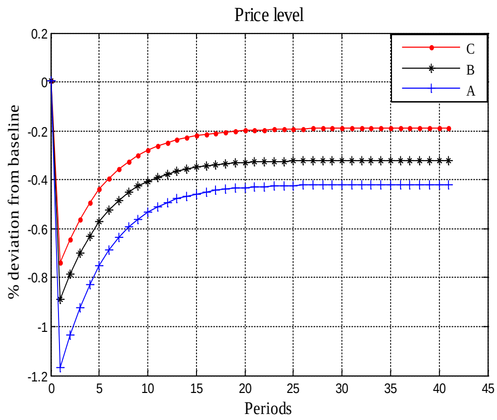
Scenarios	Percentage decline	Gov-revenues	Gov-spending	Gov-budget	Foreign assets	Income	Non-oil GDP	Price level	Real exchange rate	Oil exports
A	*Oa=70% *Op=55%	72%	27%	45%	70%	50%	22%	40%	40%	62%
B	Oa=37% Op=45%	47%	18%	32%	46%	33%	14%	30%	30%	33%
C	Oa=37% Op=35%	41%	15%	26%	39%	28%	12%	20%	22%	28%

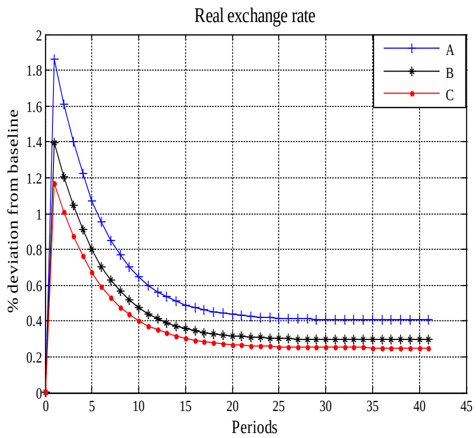
*Oa: represents oil production, and Op: represents oil price

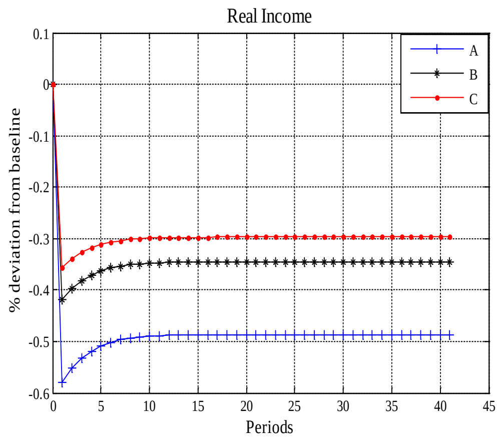
Figure 1: The impact of oil shocks upon the adjustment path of key macroeconomic variables

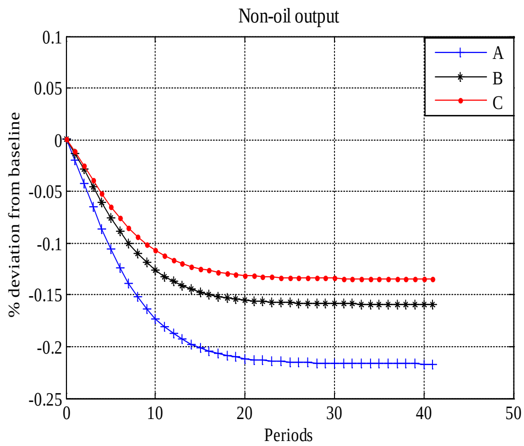



Oil exports
% deviation from baseline
Periods
A
B
C


Price level
% deviation from baseline
Periods
C
B
A


Real exchange rate
% deviation from baseline
Periods
A
B
C


Real Income
% deviation from baseline
Periods
A
B
C


Non-oil output
% deviation from baseline
Periods
A
B
C