Oil-related shocks and macroeconomic adjustment under different nominal exchange rate policies: the case of The Libyan economy

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Abstract
Libya is a country heavily dependent on its oil sector since the 1960s and recently has experienced a considerable increase in oil revenue as a result of increased oil prices particularly after 2000 and oil production rehabilitation since 2011. Like many natural resource-rich developing countries, however, the country has suffered from widespread corruption, including that related to old oil production contracts and a cumbersome bureaucracy, which has resulted in misuse of oil revenues and poor economic performance. By 2011, the country experienced a civil war and political turmoil for a period of eight months. The civil war, in conjunction with international sanctions imposed by the United Nations, adversely affected the domestic economy, in particular the oil sector, and upward pressure on oil prices occurred and oil-related infrastructure was devastated. According to the International Monetary Fund's 2012 Annual Report, the gross domestic product (GDP) considerably contracted and crude oil output was almost halted in July 2011. Moreover, nonoil economic activity was mainly influenced by the destruction of infrastructure and production facilities, the departure of foreign workers, interruptions to the functioning of the banking system, and limited access to foreign exchange. Since the end of the Libyan revolution in late 2011, Libyan oil production has been rehabilitating, registering about 1.2 million barrels per day (b/d) by February 2012. As the restoration of oil output continues, with the aim of reaching the pre-revolutionary level of 1.7 million b/d, significant revenue will be generated to the domestic economy and downward pressure might be placed on global oil prices. If used effectively, such windfall revenue will play a critical role in the future prosperity of Libya and challenge the idea of a "resource curse"; alternatively, it could cause adverse effects arising from so-called "Dutch disease" consequences. Therefore, evaluating the impact of windfall revenue arising from oil production recovery is of considerable contemporary importance not only to the Libyan economy but also European nations that are the predominant source of demand for Libyan oil as well as other key regional trading partners.

Keywords
under, different, nominal, exchange, rate, policies, case, libyan, economy, related, oil, shocks, macroeconomic, adjustment

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Issa Ali and Charles Harvie*

Introduction

Libya is a country heavily dependent on its oil sector since the 1960s and recently has experienced a considerable increase in oil revenue as a result of increased oil prices particularly after 2000 and oil production rehabilitation since 2011. Like many natural resource-rich developing countries, however, the country has suffered from widespread corruption, including that related to old oil production contracts and a cumbersome bureaucracy, which has resulted in misuse of oil revenues and poor economic performance. By 2011, the country experienced a civil war and political turmoil for a period of eight months. The civil war, in conjunction with international sanctions imposed by the United Nations, adversely affected the domestic economy, in particular the oil sector, and upward pressure

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on oil prices occurred and oil-related infrastructure was devastated. According to the International Monetary Fund’s 2012 Annual Report, the gross domestic product (GDP) considerably contracted and crude oil output was almost halted in July 2011. Moreover, nonoil economic activity was mainly influenced by the destruction of infrastructure and production facilities, the departure of foreign workers, interruptions to the functioning of the banking system, and limited access to foreign exchange. Since the end of the Libyan revolution in late 2011, Libyan oil production has been rehabilitating, registering about 1.2 million barrels per day (b/d) by February 2012. As the restoration of oil output continues, with the aim of reaching the pre-revolutionary level of 1.7 million b/d, significant revenue will be generated to the domestic economy and downward pressure might be placed on global oil prices. If used effectively, such windfall revenue will play a critical role in the future prosperity of Libya and challenge the idea of a “resource curse”; alternatively, it could cause adverse effects arising from so-called “Dutch disease” consequences. Therefore, evaluating the impact of windfall revenue arising from oil production recovery is of considerable contemporary importance not only to the Libyan economy but also European nations that are the predominant source of demand for Libyan oil as well as other key regional trading partners.

This paper is concerned with analyzing the dynamic macroeconomic adjustment processes arising from oil output recovery for a small open economy such as that of Libya, where the role of government is pivotal in the recycling of oil revenues, operating under different nominal exchange rate regimes. The paper extends the contribution of I. Ali and C. Harvie by identifying whether the consequences of an oil production recovery (or boom) upon key macroeconomic variables could be alleviated or improved upon depending on which nominal exchange rate policy (fixed or flexible) is in place as well as the degree of capital account liberalization. That is, in order to mitigate the adverse effects of an oil boom upon, say, the nonoil trade balance, moving from a fixed to a flexible nominal exchange rate policy, combined with perfect capital mobility, might produce improved macroeconomic outcomes. Under a flexible nominal exchange rate regime, for example, the exchange rate is capable of adjusting so that capital flows will have no effect upon foreign exchange reserves. As a result, the nominal exchange rate is endogenous and growth of the money stock is exogenous. Therefore, domestic inflation will be influenced only temporarily by the difference between nonoil output supply and demand.

The remainder of this paper proceeds as follows. The next section outlines the theoretical framework adopted and model equations for the case where a fixed exchange rate is adopted and the case where a flexible exchange rate is adopted. The model also allows for varying degrees of capital mobility. In the subsequent simulation, outcomes from the model for the case of an oil production shock under a fixed and flexible exchange rate regime are compared and contrasted. Last, we offer our concluding remarks.
Theoretical Framework: The Model

The dynamic macroeconomic model utilized in this paper has its foundation in the contributions of R. Dornbusch, W. Buiter and M. Miller, R. Eastwood and A. Venables, W. Buiter and D. Purvis, J. Neary and S. Van Wijnbergen, C. Harvie and L. Gower, C. Harvie and A. Thaha, and, more recently and importantly, G. Cox and C. Harvie (hereafter C-H) for the case of a flexible exchange rate in the context of advanced resource-abundant economies, and I. Ali and C. Harvie (hereafter A-H) for the case of a fixed exchange rate in the context of a developing resource-abundant country. In particular, the C-H model and the A-H model are dynamic general equilibrium models focusing on the long-run nature of the adjustment process. An important feature of the C-H model is the role of financial markets in transmitting the effects of oil-related shocks to the rest of the economy. The A-H model assumes, however, that such a transmission mechanism is not applicable for an oil-producing developing economy such as Libya, where financial markets are unsophisticated, tightly controlled, and the economy is operating with a fixed exchange rate regime and controls over international capital flows.

Like the A-H model, the general means by which oil-related shocks transmit their impact to the rest of the economy is via a number of common oil-related effects. First, increased oil-sector production (revenue) will generate increased revenue for the government (revenue effect). Second, increased government consumption and development expenditure from oil revenue will generate a spending effect. Third, increased oil exports will lead to an accumulation of foreign asset stocks through improved trade and current account balances (trade or current account effect). Fourth, increased future oil income also can contribute to an increase in permanent income (wealth effect) for both the government and the private sector that can further influence spending. In the context of Libya the bulk of this wealth effect primarily will accrue to the government. Fifth, the extra spending generated by the spending and wealth effects increase the demand for nonoil output relative to its available supply. This can push up domestic prices and, with a fixed nominal exchange rate, result in an effective appreciation of the real exchange rate (exchange rate effect) and loss of competitiveness for the nonoil sector. Furthermore, like the A-H model, this paper will capture other long-run effects, including human capital stock accumulation (a labor productivity effect) and imported capital stock accumulation via capital imports (a technology effect), emphasizing the supply side in a dynamic modeling context. These effects will expand the long-run productive capacity and efficiency of the nonoil sector.

The Ali and Harvie study evaluates by means of numerical simulation the effects of additional oil revenue, arising from oil-related shocks, upon key macroeconomic variables, including the real exchange rate, nonoil trade balance, foreign asset stocks, human capital stock, physical capital stock, imported capital
The important results observed are that the country’s oil sector recovery potentially will result in an increase in private capital stock and private-sector wealth, real income, domestic physical capital stock, human capital stock, imported capital stock, and nonoil supply (and demand). Dutch disease effects are likely to be confined to the nonoil trade balance during the adjustment process toward a long-run steady state. That is, a recovery of the oil sector also has the potential to deteriorate the nonoil trade balance through a loss of competitiveness from a real exchange rate appreciation. Nevertheless, despite the loss of competitiveness of the nonoil tradable sector, nonoil output supply increases throughout the early periods of adjustment. This is attributable to the fact that the Dutch disease effect upon nonoil output can be mitigated by government development spending on physical, human, and imported capital stocks. In the context of the Libyan economy, this confirms the essential role that the government, which owns the oil sector, must play in enhancing the positive consequences and/or minimizing the adverse effects of the oil-sector recovery upon the nonoil sector. The government could improve productivity and increase the availability and type of capital available for the nonoil sector by increasing or changing the composition of government investment expenditure on infrastructure, human capital formation, and technology acquisition in this sector. This eventually will improve the nonoil sector’s competitiveness.

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The model utilized in this paper is basically the same as that extensively discussed by Ali and Harvie with a minor, but important, change. The equations of the model are amended to incorporate movement from a fixed to flexible nominal exchange rate regime combined with perfect capital mobility. A brief discussion of the model is now presented. Equilibrium in the model depends upon equilibrium in the product market, assets market, and foreign trade sector. The product market is discussed first.

**Product Market:** Equations (1) to (18) describe the product market. Equation (1) describes the total demand for nonoil output ($N_{o}^{d}$). 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 nonoil trade balance consisting of nonoil exports ($x^{n}$) and nonoil imports ($m^{n}$). The parameters ($\beta$) represent the elasticities of spending in each category. The parameters are based on the contribution of a dollar spent on private consumption and investment, total government spending, nonoil exports, and nonoil imports to the demand for nonoil output. In line with the C-H model, the parameters are set to 1 indicating that a dollar spent in any of these components contributes equally to nonoil product demand.

$$N_{o}^{d} = \beta_1 c^{p} + \beta_2 i^{p} + \beta_3 g + \beta_4 (x^{n} - m^{n})$$

Private consumption expenditure is given by equation (2). It depends positively upon nonoil output supply and private sector wealth. The production of nonoil
output represents income generated by the public and private sectors, although most nonoil output is produced by the public sector in Libya.\footnote{12} Equation (3) describes private-sector gross investment, which equals the change in the stock of private capital and is based on the partial adjustment hypothesis.\footnote{13} 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 $\gamma$ of the divergence between the desired and actual stock of capital. The adjustment coefficient $\gamma$ was selected to be 0.50, indicating moderate adjustment of the dependent variable. The desired capital stock is assumed to depend upon nonoil output—see equation (4)—where the parameter $\delta$ is set to be 0.8.

\begin{align*}
  c^p &= \beta_6 N_o^\gamma + \beta_7 w^p & (2) \\
  i^p &= k^p = \gamma (k^p^* - k^p) & (3) \\
  k^p^* &= \delta N_o^\gamma & (4)
\end{align*}

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) ($i^p$); 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 among desired physical capital stock, desired human capital stock, desired imported capital stock, and consumption expenditure according to its policy priorities.\footnote{14} 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.

\begin{align*}
  g &= \beta_8 c^g + \beta_9 i^p + \beta_{10} i^h + \beta_{11} i^{cap} & (5)
\end{align*}
\[ c^g = (1 - \theta_1 - \theta_2 - \theta_3)(o^a + po + e - p) \] (6)
\[ i^s = k^s = \phi(k^{s*} - k^s) \] (7)
\[ i^h = k^h = \sigma(k^{h*} - k^h) \] (8)
\[ i^{cap} = k^{cap} = \lambda(k^{cap*} - k^{cap}) \] (9)
\[ k^{s*} = \theta_1(o^a + po + e - p) \] (10)
\[ k^{h*} = \theta_2(o^a + po + e - p) \] (11)
\[ k^{cap*} = \theta_3(o^a + po + e - p) \] (12)

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 nonoil production—equation (14). The parameter \((\beta_{13})\) in equation (14) is set to 0.70 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.

\[ bd = g - t^x = \beta_{12}(m - \hat{p}) \] (13)
\[ t^x = \beta_{13}(o^a + po + e - p) + (1 - \beta_{13})No^s \] (14)

The nonoil trade balance is disaggregated into nonoil exports less nonoil imports as shown in equation (15) and identity equation (30). Equation (15) specifies that nonoil exports \((x^n)\) depend positively upon the real exchange rate \((e + p^* - p)\) and world real income \((y^*)\), which is assumed to be exogenous. Nonoil imports also are disaggregated into nonoil consumption imports \((m^{con})\) and nonoil capital imports \((i^{cap})\). Equation (16) identifies nonoil consumption imports, which depends negatively upon the real exchange rate and positively on domestic real income \((y)\). Equation (9) identifies nonoil 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 behavioral equations (15) and (16) were empirically estimated using the autoregressive distributed lag (ARDL) approach. Table 1 provides the parameters, table 2 tests for the existence of a long-run relationship among the variables, and table 3 provides the ARDL results.
Real and permanent income ($y^p$) definitions, first used by W. Buiter and D. Purvis, are given by equations (17) and (18). Real income, as identified in equation (17), depends upon nonoil output ($No^s$), oil production ($o^a$) that is assumed to be exogenous, the world price of oil ($p_o$), that is also exogenous, the real exchange rate as emphasized here and the exogenously determined price of nonoil imported goods ($p^*$). Equation (18) represents permanent income, which depends on exogenous permanent nonoil output ($No^{sp}$), exogenous permanent oil output ($o^{sp}$), the world price of oil, the real exchange rate, and price of nonoil imported goods (see C. Harvie). 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 nonoil production in total current and permanent income, is the same in real and permanent income.
income and constant through time (see W. Buiter and D. Purvis). The share of oil output in domestic real income \((1 - v)\) is set deliberately to be larger than its share in domestic consumption \((\mu_2)\), resulting in the Libyan economy being a net oil exporter in the model.

\[
y = v No^{\delta} + (1 - v) \alpha^d + (1 - v - \mu_2) p o + (\mu_1 - v) (e - w) - (1 - \mu_1 - \mu_2) p^*
\]

\[
y_p = v No^{\delta p} + (1 - v) \alpha^p + (1 - v - \mu_2) p o + (\mu_1 - v) (e - w) - (1 - \mu_1 - \mu_2) p^*
\]

**Assets Market**: The asset market is encapsulated by equations (19) through (21). The behavioral 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 nonoil income \((No^\delta)\), representing a transactions demand, and negatively upon the interest rate representing an asset demand. The interest rate is subject to regulation by policy makers in Libya and it is no longer a good proxy for the cost of holding money. Therefore, the rate of inflation is utilized, besides the interest rate, as a proxy variable for the opportunity cost of holding money in the A-H 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 3.

\[
m - p = \varepsilon_1 No^{\delta} - \varepsilon_2 \pi - \varepsilon_3 r
\]
Table 3
ESTIMATED LONG-RUN COEFFICIENTS USING THE AUTOREGRESSIVE DISTRIBUTED LAG (ARDL) TECHNIQUE FOR EQUATIONS (2), (15), (16), (19), (23), (24), AND (25)

Equation (2): The long-run coefficient estimates based on ARDL (3,0,0) and selected lag based on Akaike information criterion (AIC)

\[ \Delta c^p = a_0 + \sum_{j=1}^{n} b_j \Delta c^p_{t-j} + \sum_{j=0}^{n} c_j \Delta n, w^p_{t-j} + \sum_{j=0}^{n} d_j \Delta w^p_{t-j} + \delta_1 c^p_{t-1} + \delta_2 n, w^p_{t-1} + \delta_3 w^p_{t-1} + \delta_4 D_{83} + \delta_5 D_{2000} + \epsilon_t \]

<table>
<thead>
<tr>
<th>Variables</th>
<th>No^p</th>
<th>w^p</th>
<th>Constant</th>
<th>Trend</th>
<th>D1983</th>
<th>D2000</th>
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</thead>
<tbody>
<tr>
<td>Coefficients</td>
<td>0.6636</td>
<td>0.4438</td>
<td>-0.6310</td>
<td>-0.0533</td>
<td>-0.1423</td>
<td>0.0872</td>
</tr>
<tr>
<td>t-statistics</td>
<td>2.9561</td>
<td>2.1632</td>
<td>-0.8602</td>
<td>-4.2839</td>
<td>-1.6100</td>
<td>0.9116</td>
</tr>
<tr>
<td>R^2</td>
<td>0.74</td>
<td>D–W= 2.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equation (15): The long-run coefficient estimates based on ARDL (1,0,0) and selected lag based on AIC

\[ \Delta x^n = a_0 + \sum_{j=1}^{n} b_j \Delta x^n_{t-j} + \sum_{j=0}^{n} c(j) \Delta (e^p + p^* - p)_{t-j} + \sum_{j=0}^{n} d(j) \Delta y^p_{t-j} + \delta_1 c^n_{t-1} + \delta_2 (e^p + p^* - p)_{t-1} + \delta_3 y^n_{t-1} + \delta_4 D_{78} + \delta_5 D_{2000} + \epsilon_t \]

<table>
<thead>
<tr>
<th>Variables</th>
<th>(e^p + p^* - p)</th>
<th>y^*</th>
<th>Constant</th>
<th>Trend</th>
<th>D1978</th>
<th>D2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficients</td>
<td>0.4735</td>
<td>5.0362</td>
<td>-113.30</td>
<td>-0.2154</td>
<td>-0.1012</td>
<td>2.0708</td>
</tr>
<tr>
<td>t-statistics</td>
<td>1.4607</td>
<td>2.3759</td>
<td>-2.3044</td>
<td>-2.0094</td>
<td>-0.1869</td>
<td>2.0416</td>
</tr>
<tr>
<td>R^2</td>
<td>0.60</td>
<td>D–W= 2.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equation (16): The long-run coefficient estimates based on ARDL (1,0,0) and selected lag based on AIC

\[ \Delta m^{com} = a_0 + \sum_{j=1}^{n} b_j \Delta m^{com}_{t-j} + \sum_{j=0}^{n} c(j) \Delta y_{t-j} + \sum_{j=0}^{n} d(j) \Delta (e^p + p^* - p)_{t-j} + \delta_1 m^{com}_{t-1} + \delta_2 y_{t-1} + \delta_3 (e^p + p^* - p)_{t-1} + \delta_4 D_{87} + \delta_5 D_{2003} + \epsilon_t \]

<table>
<thead>
<tr>
<th>Variables</th>
<th>(e^p + p^* - p)</th>
<th>y</th>
<th>Constant</th>
<th>Trend</th>
<th>D1987</th>
<th>D2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficients</td>
<td>-0.2565</td>
<td>0.7438</td>
<td>2.4202</td>
<td>-0.0355</td>
<td>0.6507</td>
<td>-0.6605</td>
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<tr>
<td>t-statistics</td>
<td>-2.2490</td>
<td>3.5753</td>
<td>1.4721</td>
<td>-2.0950</td>
<td>2.1544</td>
<td>-1.9677</td>
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<tr>
<td>R^2</td>
<td>0.67</td>
<td>D–W= 2.31</td>
<td></td>
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(continued)
### Table 3 (continued)

<table>
<thead>
<tr>
<th>Equation</th>
<th>Variables</th>
<th>Coefficients</th>
<th>t-statistics</th>
<th>R²</th>
<th>D-W</th>
</tr>
</thead>
<tbody>
<tr>
<td>(23)</td>
<td>$\Delta m = \alpha_0 + \sum_{j=1}^n \beta_j \Delta(m - p) + \sum_{j=1}^n \gamma_j \Delta \omega_j$</td>
<td>0.4102, 10.1153</td>
<td>10.1153, 1.1204</td>
<td>0.76</td>
<td>2.14</td>
</tr>
<tr>
<td>(24)</td>
<td>$\Delta \omega = \alpha_0 + \sum_{j=1}^n \beta_j \Delta \omega_j + \sum_{j=1}^n \gamma_j \Delta \omega_j$</td>
<td>0.6778, 1.6935</td>
<td>1.6935, 1.1893</td>
<td>0.73</td>
<td>2.13</td>
</tr>
<tr>
<td>(25)</td>
<td>$\Delta \omega = \alpha_0 + \sum_{j=1}^n \beta_j \Delta \omega_j + \sum_{j=1}^n \gamma_j \Delta \omega_j$</td>
<td>0.0866, 0.5061</td>
<td>0.5061, 0.3105</td>
<td>0.87</td>
<td>1.93</td>
</tr>
</tbody>
</table>

**Equation (19):** The long-run coefficient estimates based on ARDL (1,0,1,0) and selected lag based on AIC

$$\Delta(m - p) = \alpha_0 + \sum_{j=1}^n \beta_j \Delta(m - p) + \sum_{j=1}^n \gamma_j \Delta \omega_j + \sum_{j=1}^n \delta_j \Delta \omega_j + \sum_{j=1}^n \epsilon_j$$

**Equation (23):** The long-run coefficient estimates based on ARDL (1,0,1) and selected lag based on AIC

$$\Delta \omega = \alpha_0 + \sum_{j=1}^n \beta_j \Delta \omega_j + \sum_{j=1}^n \gamma_j \Delta \omega_j + \sum_{j=1}^n \delta_j \Delta \omega_j + \sum_{j=1}^n \epsilon_j$$
Table 3 (continued)

ESTIMATED LONG-RUN COEFFICIENTS USING THE AUTOREGRESSIVE DISTRIBUTED LAG (ARDL) TECHNIQUE FOR EQUATIONS (2), (15), (16), (19), (23), (24), AND (25)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficients</th>
<th>T-statistics</th>
<th>R² = 0.86</th>
<th>D-W = 2.16</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta y$</td>
<td>$a_0 + \sum_{j=0}^m \Delta f_{t-j} + \sum_{j=0}^n (e^{(e-p)} + p_0), + \delta (e^{(e-p)})$</td>
<td>0.1506</td>
<td>0.1506</td>
<td>11.327</td>
</tr>
<tr>
<td>Trend</td>
<td>$T$</td>
<td>0.5175</td>
<td>0.5175</td>
<td>4.1594</td>
</tr>
<tr>
<td>Constant</td>
<td>$e^{(e-p)}$</td>
<td>-0.3250</td>
<td>-0.3250</td>
<td>-1.2976</td>
</tr>
<tr>
<td>$r* f$</td>
<td>$p_0$</td>
<td>-0.9352</td>
<td>-0.9352</td>
<td>-1.3189</td>
</tr>
<tr>
<td>$e^{(e-p)}$</td>
<td>$\delta (e^{(e-p)})$</td>
<td>0.0058</td>
<td>0.0058</td>
<td>1.8155</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>$e^{(e-p)}$</td>
<td>-1.3189</td>
<td>-1.3189</td>
<td>1.8155</td>
</tr>
</tbody>
</table>

Equation (25): The long-run coefficient estimates based on ARDL (2,0,2,0,0) and selected lag based on AIC

$$\Delta y = a_0 + \sum_{j=0}^m \Delta f_{t-j} + \sum_{j=0}^n (e^{(e-p)} + p_0), + \delta (e^{(e-p)})$$
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 nonoil income equivalent to that of permanent nonoil output.\(^{18}\) The parameters in equation (20) are set to 1, indicating the equal importance of each of the components to total private-sector wealth.

\[
w^p = \varepsilon_5 k^p + \varepsilon_6 (m - p) + \varepsilon_7 y^p
\]

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 C. Harvie, and C. Harvie and A. Thaha),\(^{19}\) as shown in equation (21*).

\[
\dot{m} = d\dot{c}e + f\dot{e}s
\]

\(d\dot{c}e\) 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 \(\tau\) denotes the sensitivity of capital flows to interest rate differentials, representing the degree of capital mobility. The value of coefficient \(\tau\) can range from zero to infinity. The greater is \(\tau\) the greater is international capital mobility, while the smaller is \(\tau\) the smaller is international capital mobility.\(^{20}\) The parameter \(\tau\) is chosen to be 0.2 in this base model, which is indicative of the substantial control over capital mobility exercised by the government.

\[
f\dot{e}s = \tau(r - r^*) + \dot{f}
\]

By substituting equation (21**) into equation (21*), equation (21) is obtained.

\[
\dot{m} = d\dot{c}e + (\tau(r - r^*) + \dot{f})
\]

**Aggregate Supply and Prices:** Equations (22) through (24) define the price level and aggregate nonoil 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 nonoil 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 nonoil goods relative to its available supply \((No^d - No^s)\) and core inflation \((\pi)\). Core inflation depends upon developments in the monetary growth rate—equation (21). The estimated parameters of equation (23) are contained in table 3.

\[
p = \mu_1 w + \mu_2 (e + po) + (1 - \mu_1 - \mu_2)(e + p^*)
\]

(22)

\[
\dot{w} = \psi_1 (No^d - No^s) + \psi_2 \dot{m}
\]

(23)

Aggregate nonoil output supply is endogenously determined, as given by equation (24). It depends positively on the public capital stock, private capital stock, imported capital stock, and employment. Government investment is divided into three parts: capital that affects nonoil output through physical capital stock accumulation, capital that affects nonoil output through human capital formation, and capital imports. The estimated parameters of equation (24) are shown in table 3.

\[
No^s = \phi_1 k^p + \phi_2 k^g + \phi_3 k^h + \phi_4 k^{cap} + \phi_5 em
\]

(24)

**Overseas Sector:** 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, C. Harvie and C. Harvie and L. Gower).

\[
\dot{f} + e - p = \alpha_1 T + \alpha_2 (r^* f + e - p) + \alpha_3 (o^x + po + e - p)
\]

(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 nonoil trade balance, as given by equation (29), foreign interest income \((r^* f)\), net oil exports and on the real exchange rate \((e - p)\). In the 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 C-H model. The estimated parameters of this equation are contained in table 3.

\[
\dot{f} = \alpha_1 (x^n - m^n) + \alpha_2 r^* f + \alpha_3 (o^x + po) - (1 - \alpha_2 - \alpha_3)(e - p)
\]

(25)

Equation (26) indicates that net oil exports are exogenously determined, being dependent upon government policy toward the domestic usage or export of oil production. The parameter in equation (26) has been selected as 0.70, indicating a more export-oriented policy.
Definitions: Finally, equations (27) through (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 nonoil trade balance, and equation (30) defines nonoil imports.

\[ o^x = \xi o^a \]  

\[ c = e - w \]  

\[ l = m - w \]  

\[ T = x^n - m^n \]  

\[ m^n = m^{con} + i^{cap} \]  

Alternative Exchange Rate Policy: The above discussion has focused on an economy operating with a fixed exchange rate regime. With a flexible nominal exchange rate, some amendments are required. Moving from a fixed to flexible nominal exchange rate combined with perfect capital mobility requires replacement of equation (21) by equation (21a) in the model.

\[ \dot{e} = r - r^* \]  

With a flexible nominal exchange rate regime the exchange rate is capable of adjusting so that capital flows will have no effect upon foreign exchange reserves. As a result, the nominal exchange rate is endogenous and growth of the money stock is exogenous \((m = \bar{m})\). Therefore, domestic inflation will only be temporarily influenced by the difference between nonoil demand and output supply. Equation (21a) is the uncovered interest parity condition. It encapsulates the assumption of perfect capital mobility and perfect foresight in the foreign exchange market. It assumes that in the foreign exchange market agents have forward-looking expectations and anticipate that, when the economy is out of steady state, it will converge ultimately to a new steady state.

Simulation Results Arising from Oil Production Rehabilitation under a Fixed and Flexible Exchange Rate Regime

This section analyses the consequences from the adoption of alternative exchange rate regimes upon the Libyan macro-economy for the case of oil production rehabilitation. Two different nominal exchange rate regime scenarios are conducted. Scenario A assumes a fixed nominal exchange rate
combined with imperfect capital mobility, while scenario B presumes a flexible nominal exchange rate regime combined with perfect capital mobility. A simulation analysis is conducted utilizing a program called “Dynare,” which is designed for solving and simulating deterministic and stochastic dynamic general equilibrium models (see S. Adjemian et al.).

The parameter values utilized to conduct the numerical simulation scenarios are summarized in table 1. It contains 19 estimated parameters for behavioral equations (2), (15), (16), (19), (23), (24), and (25), using the ARDL cointegration approach, where they are significantly different from zero (see table 3). The remaining parameters summarized in table 1 were chosen from prior studies and/or calculated from available data. However, before the behavioral equations are estimated, the major structural break(s) in the intercept and trend using the LM unit root test of J. Lee and M. Strazicich are identified and incorporated in the estimated equations.

Furthermore, testing for the existence of a long-run relationship among the variables is conducted, where the results presented in table 2 indicate conclusive outcomes for the dependent variables $c^p$, $x^p$, $m^{cap}$, $m - p$, $\dot{w}$, $No^s$, and $\dot{f}$ as computed F-statistics are greater than the upper bound critical values. The exception to this result is the computed F-statistic for $m^{con}$, where the result is inconclusive at the 95-percent level as the computed F-statistic is greater than the lower bound but less than the upper bound; however, it is conclusive at the 90-percent level. These results imply that the variables of interest are bound together in a long-run relationship.

Generally, as indicated in table 4 and figure 1, moving from a fixed to flexible nominal exchange rate regime brings about different outcomes during the dynamic adjustment process and, in particular, for the nonoils trade balance. The key variables that contribute to this difference are the inflation rate and nominal exchange rate. The results suggest that the adoption of an alternative exchange rate policy not only leads to a reduction of Dutch disease consequences in the early periods of adjustment, but it also can enhance the supply of and demand for nonoils output.

| Table 4 |
| STEADY STATE PROPERTIES OF THE MODEL FOR ALTERNATIVE NOMINAL EXCHANGE POLICY REGIMES (SCENARIOS A AND B) |
| (in percentage deviation from the base line) |

<p>| Case for Oil Production Increase: Scenario A |</p>
<table>
<thead>
<tr>
<th>low</th>
<th>$f$</th>
<th>$T$</th>
<th>$c$</th>
<th>$w^p$</th>
<th>$y$</th>
<th>$No^s$</th>
<th>$k^g$</th>
<th>$k^h$</th>
<th>$k^{cap}$</th>
<th>$k^p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>-11.5</td>
<td>0.0</td>
<td>25</td>
<td>23</td>
<td>16</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

<p>| Case for Oil Production Increase: Scenario B |</p>
<table>
<thead>
<tr>
<th>low</th>
<th>$f$</th>
<th>$T$</th>
<th>$c$</th>
<th>$w^p$</th>
<th>$y$</th>
<th>$No^s$</th>
<th>$k^g$</th>
<th>$k^h$</th>
<th>$k^{cap}$</th>
<th>$k^p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>-10.5</td>
<td>0.0</td>
<td>27.5</td>
<td>25</td>
<td>19</td>
<td>16</td>
<td>11</td>
<td>11</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>
Simulation outcomes for foreign asset stocks, as seen in figure 1, show that they initially increase in both scenarios, but this is more rapid in scenario B, signifying higher current account surpluses during the early stage of adjustment. Foreign asset stocks decline slightly for scenario B thereafter, before returning to long-run steady state where it has accumulated by 23 percent. This arises from an immediate increase in oil exports and surplus in the oil trade balance and an increase in foreign interest income, which offset the deficit in the nonoil trade balance in both scenarios. The result indicates that a flexible nominal exchange rate combined with perfect capital mobility produces a significant accumulation of foreign asset stocks during the early period of adjustment. This is mainly due to the fact that the deficit in the nonoil trade balance is less in scenario B compared to that of A during the early periods of adjustment (see figure 1).

The price level initially increases by almost 4 percent during the adjustment process for the fixed nominal exchange rate regime scenario (scenario A), and remains above base line for a period of time before it achieves its long-run steady state equilibrium. The adjustment of the price level in the early periods is essentially influenced by oil export revenue that contributes to an accumulation of foreign asset stocks (current account effect), which in turn affects money growth due to balance of payments surpluses and also generates increased spending.

The result would be different with a flexible exchange rate as an increase in oil revenue would not influence the monetary growth rate, but, rather, appreciate the nominal and real exchange rate. This is true as the flexible exchange rate regime allows the economy to retain control over its money supply compared to that of a fixed exchange rate. Thus, the adjustment of the domestic price level reflects the adjustment of the nominal exchange rate. The price level increases by only 2 percent in scenario B in the early periods of the adjustment process and returns quickly to its initial value thereafter.

Developments in the domestic price level affect the evolution of the real exchange rate during the adjustment process. The real exchange rate initially appreciates throughout the adjustment path with the adoption of a fixed nominal exchange rate regime (scenario A) by 6 percent, overshooting its long-run steady state. Also, the appreciation of the real exchange rate for scenario A is larger and is more prolonged before it depreciates toward long-run steady state. The main reason for this is that the higher domestic price level for scenario A, induced by money growth and the difference between nonoil demand and nonoil supply, remains above the base line for a long period of time before reaching its long-run steady state.

With a flexible nominal exchange rate regime the real exchange rate appreciates by less (3 percent), induced by a smaller increase in the domestic price level for scenario B. The price level is unaffected by money growth, but it is, rather, influenced by developments in the nominal exchange rate. Thereafter, the real exchange rate depreciates faster than that of scenario A toward its initial value as the price level returns quickly to its initial value.
Development of the nonoil trade balance is influenced by the adjustment path of the real exchange rate in both scenarios. The nonoil trade balance deteriorates throughout the dynamic adjustment process in both scenarios, with a noticeably larger deterioration in scenario A where it initially deteriorates by almost 14 percent. The deterioration of the nonoil trade balance in the case of a fixed exchange rate, scenario A, is due to a combination of (1) increasing nonoil imports arising from an increase in real income and (2) a decline in nonoil exports throughout the dynamic adjustment process influenced by the initial sizeable appreciation of the real exchange rate. On the other hand, the deterioration of the nonoil trade balance in the case of a flexible exchange rate, scenario B, is due mainly to an increase in nonoil imports stimulated by a larger increase in real income. Nonoil exports experience a minor decline in the early stage of adjustment in scenario B, influenced by a smaller appreciation of the real exchange rate and a prompt return to its base value thereafter. The smaller deterioration of the nonoil trade balance in scenario B means that the competitiveness of nonoil exports is superior with the flexible nominal exchange rate regime combined with perfect capital mobility.

Nooil production increases continuously in both scenarios throughout the adjustment path toward long-run steady state, but it increases more in the case of the flexible exchange rate regime (scenario B). The main contributory factor for this difference is an increase in nonoil production in scenario B, which is stimulated by an accumulation of physical capital stock, human capital stock, imported capital stock, and private capital stock on the supply side, but also by an improved situation for nonoil exports arising from a smaller appreciation of the real exchange rate as compared with that of scenario A. As can be seen from table 4 and figure 1, public physical capital stock, human capital stock, imported capital stock, and private capital stock accumulate in the early periods of adjustment toward their long-run steady state. All capital stocks accumulate more with a flexible exchange rate regime, mainly in the early periods of adjustment. This is due to two reasons: (1) as mentioned earlier, the flexible exchange rate regime offers significant accumulation of foreign asset stocks, particularly during the early periods of adjustment process, which could be used for more accumulation of imported capital stock, and (2) government real oil revenue increases more under a flexible nominal exchange rate system as the economy is insulated from inflation arising from growth of the money supply. Therefore, the larger government real oil revenue, the larger is the accumulation of public physical capital stock and human capital stock. This implies that the major benefits from increased oil production are upon all capital stocks and, in turn, upon nonoil production arising from scenario B (flexible exchange rate regime combined with perfect capital mobility).

The simulation results also indicate that private real wealth increases continuously in both scenarios throughout the adjustment path toward long-run steady state. It increases more in scenario B, where it increases by 27.5 percent, compared with 25 percent in scenario A. Developments in real private wealth are induced
mainly by a significant accumulation of private capital stock, real money balances, and permanent income.

Overall, the alternative policy of a flexible nominal exchange rate regime, combined with perfect capital mobility, offers significant accumulation of foreign asset stocks in the early stage of adjustment, and the competitiveness of nonoil exports improves with a flexible nominal exchange rate regime as the real exchange rate only slightly appreciates during the adjustment path and returns swiftly to base line. Thus, the deterioration of the nonoil trade balance was due to the larger increase in nonoil imports stimulated by a larger increase in real income. Therefore, it can be argued that Dutch disease consequences can be further minimized by moving from a fixed to flexible exchange rate regime in conjunction with greater capital account liberalization. A flexible nominal exchange rate policy provides greater benefits for nonoil production, induced on the supply side by a larger accumulation of public physical capital stock, human capital stock, imported capital stock, and private capital stock. It is also stimulated on the demand side by the improved competitiveness of nonoil exports. Moreover, private-sector benefits from the flexible exchange rate regime are induced mainly by an increase in private capital stock.

**Concluding Remarks**

This paper has utilized a dynamic general equilibrium macroeconomic model for the Libyan economy, aimed at evaluating the effects of additional oil revenue upon key macroeconomic variables under different exchange rate regimes. The simulation scenario of a fixed exchange rate with imperfect capital mobility indicated that a permanent oil production increase by 50 percent would potentially result in an increase in private capital stock, private-sector wealth, real income, public capital stock, human capital stock, imported capital stock, nonoil output supply, and demand. However, the oil sector boom also has the potential to deteriorate the nonoil trade balance through a loss of competitiveness from a real exchange rate appreciation and increasing nonoil imports arising from an increase in real income. On the other hand, for a flexible exchange rate regime with perfect capital mobility, outcomes also suggest that the competitiveness of nonoil exports only slightly deteriorates as the real exchange rate only slightly appreciates during the early part of the adjustment process. Hence, the deterioration of the nonoil trade balance was less and was due primarily to the larger increase in nonoil imports stimulated by an increase in real income. The Dutch disease effects, therefore, are potentially reduced by moving from a fixed to flexible exchange rate regime. In addition, the flexible nominal exchange rate regime, in conjunction with capital account liberalization, offers larger benefits to nonoil production, influenced by a larger accumulation of public physical capital stock, human
Figure 1
THE EFFECTS OF OIL PRODUCTION RECOVERY UPON KEY MACROECONOMIC VARIABLES UNDER A FIXED AND FLEXIBLE EXCHANGE RATE REGIME
(percentage deviation from base line)

PRICE LEVEL

FOREIGN ASSET STOCKS
THE EFFECTS OF OIL PRODUCTION RECOVERY UPON KEY MACROECONOMIC VARIABLES UNDER A FIXED AND FLEXIBLE EXCHANGE RATE REGIME
(percentage deviation from base line)

REAL EXCHANGE RATE

NONOIL TRADE BALANCE
Figure 1 (continued)
THE EFFECTS OF OIL PRODUCTION RECOVERY UPON KEY MACROECONOMIC VARIABLES UNDER A FIXED AND FLEXIBLE EXCHANGE RATE REGIME
(percentage deviation from base line)

NONOIL IMPORTS

NONOIL EXPORTS

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LIBYA: OIL-RELATED SHOCKS & EXCHANGE RATES
THE EFFECTS OF OIL PRODUCTION RECOVERY UPON KEY MACROECONOMIC VARIABLES UNDER A FIXED AND FLEXIBLE EXCHANGE RATE REGIME (percentage deviation from base line)

NONOIL OUTPUT SUPPLY

PHYSICAL CAPITAL STOCK
Figure 1 (continued)
THE EFFECTS OF OIL PRODUCTION RECOVERY UPON KEY MACROECONOMIC VARIABLES UNDER A FIXED AND FLEXIBLE EXCHANGE RATE REGIME (percentage deviation from base line)

HUMAN CAPITAL STOCK

FOREIGN CAPITAL STOCK
THE EFFECTS OF OIL PRODUCTION RECOVERY UPON KEY MACROECONOMIC VARIABLES UNDER A FIXED AND FLEXIBLE EXCHANGE RATE REGIME
(percentage deviation from base line)

PRIVATE CAPITAL STOCK

REAL INCOME
Figure 1 (continued)
THE EFFECTS OF OIL PRODUCTION RECOVERY UPON KEY MACROECONOMIC VARIABLES UNDER A FIXED AND FLEXIBLE EXCHANGE RATE REGIME (percentage deviation from base line)

REAL PRIVATE WEALTH

REAL GOVERNMENT REVENUE
capital stock, imported capital stock, and private capital stock. All of these add to the productivity of the nonoil sector. In addition, the private sector benefits from the flexible exchange rate regime, induced mainly through an increase in private capital stock.

NOTES:


3Ibid.

4This revenue mainly would go to the government as the oil sector is predominantly state owned.


6This term, first coined by *the Economist* in 1977, is an approach to explaining the resource curse emphasizing the declining competitiveness and productivity of the manufacturing and other tradable sectors arising from an appreciation of the real exchange rate in the wake of a resource boom. See M. Brahmbhatt, O. Canuto, and E. Vostoknutova, “Dealing with Dutch Disease,” *Economic Premise*, vol. 16 (2010), pp. 1–7, for an extensive review of Dutch disease theory and empirical evidence.


10 As well as for other developing countries with similar characteristics.

11 For more discussion of the model, see I. Ali and C. Harvie, op. cit.

12 Nonoil output can be considered as a good that can be consumed either domestically or exported and is an imperfect substitute for the foreign non-oil imported good.

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

14 These can be regarded as policy-determined parameters.

15 W. Buiter and D. Purvis, op. cit.


17 W. Buiter and D. Purvis, op. cit.

18 This is a proxy for the present value of the future income stream for the private sector.


Implying that foreign exchange reserves also will be higher, facilitating the purchase of imported capital (technology).