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Oil revenue and economic development case of Libyan economy (1970-2007)

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OIL REVENUE AND ECONOMIC DEVELOPMENT
CASE OF LIBYAN ECONOMY (1970-2007)

A thesis submitted in total fulfilment of the requirements
for the award of the degree

DOCTOR OF PHILOSOPHY

from

University of Wollongong

UNIVERSITY OF WOLLONGONG
SCHOOL OF ECONOMICS, FACULTY OF COMMERCE
2011

by

Issa Saleh Ali

BA in Economics from University of Garyounis, Benghazi, Libya
MA in Economics from University of Garyounis, Benghazi, Libya
Declaration

I, ISSA SALEH ALI, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Economics of the Faculty of Commerce, University of Wollongong, is wholly my own original work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Issa Saleh Ali

14 February 2012
Dedication

This dissertation is dedicated to
my parents

and

to my brothers and sisters, my wife and my sweet little children Abdu Almalik, Zainab
and Jana
Acknowledgements

In the name of Allah, Most Gracious, Most Merciful
All praise is due to Allah, Lord of the worlds, who helped me to achieve
this modest effort

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love you very much.
List of papers and presentations

Refereed Conference Papers


Presentations


2. Ali, Issa 2010, ‘Application of New Perron-Type Innovational Unit Root Test with Break(s) at an Unknown Time’ paper presented at Workshop, School of Economics, Faculty of Commerce, University of Wollongong.
Abstract

This study aims to investigate different aspects of the relationship between oil revenues and economic development for the Libyan economy. To do so this thesis revises the historically fundamental role of oil revenues in the economic development of the Libyan economy, and the potential adverse consequences of the oil boom sector upon the non-oil sector. It then develops a long run dynamic macroeconomic model for the Libyan economy that is capable of analysing the impact of oil related shocks on its macroeconomic adjustment and development. The model explicitly incorporates the fundamental features of the Libyan economy, and it is capable of incorporating alternative government policy responses toward the allocation of oil production for either domestic usage or export, the spending of the oil revenue either upon consumption or investment, and budget financing. The spending of oil revenue, in particular development expenditure in the form of government investment spending upon infrastructure, human capital formation and technology acquisition, is a key policy issue which has important implications for the development of the Libyan economy. The model is also capable of incorporating different degrees of international capital mobility, along with the adoption of either a fixed or flexible exchange rate regime.

A numerical simulation procedure is adopted to analyse the positive and negative macroeconomic effects on the Libyan economy arising from exogenous shocks from increased oil production and oil prices, and how such positive and negative effects can be maximised and minimised, respectively, through conducting a number of alternative government policies.

It is obvious from the simulation analysis of the base model that either a positive oil production shock or oil price shock exert a significant influence upon the domestic economy throughout the adjustment process to long run steady state. The positive oil related shocks will potentially result in an increase in private capital stock, private sector wealth, real income, domestic physical capital stock, human capital stock, imported capital stock and non-oil supply (demand). However, the oil sector boom also has the potential to deteriorate the non-oil trade balance through a combination of increasing non-oil imports and declining non-oil exports. Increasing non-oil imports is stimulated by an appreciation of the real exchange, an increase in real domestic income and government spending on capital imports. The adjustment of non-oil exports is strongly influenced by the appreciation of the real exchange rate.

Regarding the appropriate alternative government policies, aiming to enhance the benefits and/or minimise the adverse impact arising from oil related shocks, the major outcomes of this study suggest that a development oriented policy in the form of increased government investment on public physical capital, human capital formation, and technological acquisition results in an improvement of economic growth and development. However, it leads to Dutch Disease consequences, as indicated by developments in the non-oil trade balance, in the early stage of the adjustment process.
On the contrary, motivating government consumption spending at the expense of government investment (development) spending upon physical capital, human capital formation or imported capital produces less favourable results during the early periods of the adjustment process for key macroeconomic variables and throughout the remainder of the adjustment process to long run steady state equilibrium.

A more oil export oriented policy can result in advantageous developments throughout the adjustment process to long run steady state for some key macroeconomic variables, particularly that of foreign asset stock. However, it deteriorates the non-oil trade balance during the early stage of adjustment, exacerbating the Dutch Disease effect.

It is also found that a flexible nominal exchange rate policy combined with perfect capital mobility not only contributes to improved outcomes for key macroeconomic variables such as that of non-oil output supply, but also minimises the Dutch Disease consequence upon the non-oil trade balance and, therefore, leads to better macroeconomic performance.

Hence, it is apparent that the short and long-run feasible strategy of sustainable development for Libya is to utilise the oil revenue not only to develop its infrastructure, but also to accumulate foreign technology acquisition and to achieve a highly skilled and well-educated labour force. This strategy, in conjunction with an alternative nominal exchange rate policy, will offer Libya the capacity to use and absorb the foreign capital and ultimately develop its own economy. An accumulation of physical, human and foreign capital stock, along with adoption of a more flexible nominal exchange rate, would transfer the economy into a well-equipped one able to diversify and build a viable non-oil economy, and, therefore, to maintain and improve its competitive advantages. That is, it will enhance the ability of the Libyan economy to withstand shocks in the future by promoting diversification of the economy towards other tradable and more labour-intensive sectors such as that of agriculture and manufacturing.

The study concludes that such policies require well-established government institutions and well-skilled and informed policy-makers to implement these strategies expeditiously and efficiently. Well-established institutions will enable the well-skilled policy-makers to carry out sound policies in response to positive oil related shocks, and hence stimulate economic development and avoid adverse effects such as that of the Dutch Disease. On the other hand, the lack of such institutions would lead to poor policy choices, and hence a deepening and extension of the negative effects of the external shock.
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Chapter 1

Introduction

1.1 Background to the study

Natural resources have played an essential role in the development of several developed economies, such as the United States, Sweden, Canada and Australia. These countries based their early development strategies on natural resource exploitation and continue to be net resource exporters (Carneiro, 2007). The experience of these countries suggests that valuable lessons can be learned for contemporary oil-exporting developing countries about how best to utilise their oil revenues in order to achieve sustainable economic development, so that such oil wealth can be seen as a blessing and not a curse.

The oil-rich countries, many of which can be classified as developing, experienced substantially increased revenue as a result of increased oil prices during the period of the late 1970s and early 1980s, and then after 2000. However, many oil-rich countries exhibit some of the lowest economic and social indicators in the world (Carneiro, 2007). In addition, several studies have found that oil-exporting countries among others, achieve a lower long-run economic growth rate when compared with non-oil producing and exporting economies (Auty, 2001; Nili & Rastad, 2007; Sachs & Warner 1999, 2001), and their income and government revenues experience much higher volatility as a result of turbulence in the price of oil (Barnett & Ossowski, 2002; Hausmann & Rigobon, 2003). The Libyan economy is no exception to these countries. Although Libya has been a considerable producer of crude oil since the 1960s, it displays lower economic and social indicators when compared with other developing oil and non-oil producing economies. This puzzling issue is attributed to a number of factors that
have been identified by many researchers, and these factors are identified in more detail in Chapter 3.

The features of economic development in Libya, at the time of independence in 1951 and before oil discovery, were discouraging. The economy was based mainly upon the agriculture sector, animal husbandry and other industries such as textiles and handicrafts. Per capita income was below $US50 per year, the agriculture sector faced limitations due to climatic conditions, capital formation was negligible, and there was no skilled labour supply (Higgins, 1968). Also there was a deficit in both the trade balance and fiscal budget.

The beginning of oil exports in the last quarter of 1961 was the turning point in the contemporary history of Libya. Since then the economy has been heavily dependent on the oil sector, and the prospects for economic development in Libya have extraordinarily changed. Per capita income has increased remarkably and the economy shifted from being a deficit to surplus economy, particularly for the balance of trade, as the oil trade balance has dominated the non-oil trade balance. Consequently, oil revenue has had both direct and indirect effects on the development of the Libyan economy. The significance of oil in the Libyan economy stems from its role as a major source of government revenue, exports and foreign exchange. Also, a major share of national income is derived from the oil sector.

Regarding government revenues the major source comes from oil, constituting on average 70 percent of total government revenue during the period 1970-2007 (see Table 2.2). Oil revenue is dominated by government since the oil sector is publicly owned; therefore it affects the domestic economy through the different ways in which government spends the revenue. Such expenditure is in the form of administrative
expenditure and capital or development expenditure. The administrative expenditure covers the government’s current expenditure, such as salaries, other purchases of goods and services, and food subsidies, and hence stimulating the demand for domestic non-oil output. Development expenditure covers the finance of economic and social projects such as that of infrastructure, education and health spending, and capital imports (western technology) which has positive effects on the private sector, hence on economic development, specifically due to a more productive capital and labour force. In other words, development expenditure enhances the supply of non-oil output as well as the demand for non-oil output. Traditional discussion in the literature has focused upon the demand side effects, with insufficient attention given to supply side effects.

Oil exports have also been a major source of foreign exchange, constituting on average approximately 95 percent of total exports throughout the period 1970-2007 (see Table 2.7 of Chapter 2). The main objectives of economic development plans in Libya have been to diversify the domestic economic base, and to find other sources of income other than oil and gas to achieve growth and employment in the non-oil sector; such foreign exchange can play a crucial role in the economic development process through financing various imports such as capital imports (technology). Furthermore, the availability of such foreign exchange, as a part of international reserves, can act as a buffer stock against any future financial or economic crises (Clark, 1970). However, holding too large a level of reserves, exceeding the secure and sufficient level, involves an opportunity cost that may be high for the Libyan economy that is looking for sources of alternative income. The economy can also use such financial assets to generate income in the form of short or long term investments.
The contribution of oil production to real gross domestic product has also been considerable during both the oil boom (the late 1970s and early 1980s, and then since 2000) and non-oil boom periods. However, development in Libya’s Gross Domestic Product (GDP) by sector shows some of the major structural changes that have taken place over the period of study (see Table 2.5). That is, the contribution of the non-tradable sector, such as that of services and construction, in real gross domestic product has experienced an extensive increase, implying that the oil boom was followed by an expansion in the non-oil tradable sector. However it might have attracted some of the labour force and undermined the growth of the non-oil tradable sector such as that of the manufacturing and agriculture sectors.

Despite the significant contribution of the oil sector to the Libyan economy it may also have had an adverse consequence upon non-oil tradable sectors, suggesting the existence of the so called Dutch Disease effect. That is, a boom in one tradable sector, such as oil, contributes towards a contraction of other non-booming tradable sectors such as the manufacturing sector. The huge revenue windfall generated during the oil boom period (revenue effect) leads to an increase in government consumption and investment spending to maintain its balanced budget policy. On the one hand, government development spending results in an accumulation of physical capital and human capital stock, which benefits the private sector and stimulates non-oil output supply. On the other hand, government consumption and development spending increases the demand for both non-oil as well as imported goods (spending effect). Consequently, this will lead to a higher domestic price level during the short-run as well as an appreciation of the real exchange rate (exchange rate effect). Consequently, domestic production, particularly that of tradable goods, becomes less attractive compared to that of imports, undermining the growth rate of the agricultural, manufacturing, and other non-oil tradable sectors of
the economy. Also, the huge inflow of foreign exchange during the oil boom (*current account effect*) can play a critical role in the economic development process via financing capital imports (*technology effect*), and acting as a buffer stock against any future financial or economic crises. However, it will cause rising demand for the domestic currency, which in turn will cause a further appreciation of the real exchange rate. Moreover, the huge income arising from the oil sector (*income effect*) reallocates production factors (labour and capital) towards the oil sector and non-tradable sector and, therefore, leads to job losses in the non-oil tradable sectors (*resource movement effect*) and makes the economy heavily dependent on the oil sector. As the oil sector is relatively capital intensive it will draw relatively more capital from other non-oil sectors.

The booming sector economies and the Dutch Disease theory have attracted a remarkable amount of work in the economics literature during the 1980s, focusing on both a static and dynamic analysis\(^1\). A number of these emphasise that resource production affects the economy, specifically during the short-run, through a number of channels including: *resource movement; spending; income; and exchange rate effects* (see, for example, Buiter & Miller, 1981; Buiter & Purvis, 1982; Corden, 1984; Corden & Neary, 1982; Eastwood & Venables, 1982; Harvie, 1989; Neary & van Wijnbergen, 1984). The first effect is the *resource movement effect*, which takes place when the higher income of the natural resource sector attracts production factors from other sectors, tradable and non-tradable, which in turn contributes to a slowdown in their output growth. The second effect is the *spending or wealth effect* that can be observed when lucrative natural resources cause increased demand, and hence inflation, in other sectors in the economy both tradable and non-tradable. Since the price of goods in the tradable sector is determined by the global market, the economy becomes less

\(^1\) Chapter 3 discusses the static and dynamic analysis in more detail.
competitive in those sectors. The third effect is the exchange rate effect, arising from a higher domestic price level during the short-run. This is mainly attributed to increased demand for non-oil output and the huge inflow of foreign exchange, which comes from oil exports during the boom period. The latter also causes rising demand for the domestic currency, which in turn causes an appreciation of the nominal and real exchange rate. Consequently, local tradeable production becomes less attractive than imports, and this can lead to undermining the growth rate of the traditional export sectors, and in turn overall non-oil output and employment.

This literature was extended during the 1990s to capture long-run effects including capital stock accumulation (an additional wealth effect), and foreign asset stock accumulation via the current account (a current account effect). Furthermore, the literature has also taken into account implications for adjustment arising from different exchange rate regimes (fixed or flexible) and the identification of optimal policy responses in a dynamic context with the objective of minimising the adverse effects of a resource boom on the non-resource sector (see, Harvie, 1991; Harvie, 1992a, 1992b, 1992c; Harvie & Gower, 1993; Harvie & Maleka, 1992; Harvie, 1993; Harvie & Thaha, 1994; Harvie & Tran Van Hoa, 1994a, 1994b; Harvie & Verrucci, 1991).

Moreover, given the recent turbulence in resource prices, particularly that of oil, Cox and Harvie (2010) revisited this issue again by including the implications of this for government revenue (a revenue effect arising from revenue generated by the government from the production of the resource) and its implications for the fiscal budget.

Given that oil production constitutes the major source of Libyan exports, the major share of national income and the main source of government revenue, the sector exerts a significant influence on the economy. The impact has been more tangible since
the oil boom and the development projects established in the early 1970s. From this point of view the Libyan economy presents an interesting case for analysing the macroeconomic effects of oil revenue on economic development over the last four decades. Its experiences are also likely to be of interest to other developing economies with a similar abundance of natural resources. This issue has become of even more concern to the Libyan authorities due to the recent surge in oil prices and oil production, which has further boosted government revenue and exports and intensified the need to identify how best to use this oil windfall for the sustained growth and development of the economy. Therefore, there is a need to analyse the aforementioned impacts arising from oil related shocks upon a number of key macroeconomic variables, and to identify the impact from alternative policies in order to maximise the benefits and/or to minimise the adverse effects arising from additional oil revenue in Libya.

This study will clearly emphasise the aforementioned effects and extend the existing literature to capture long-run effects, including human capital stock accumulation (another additional wealth effect), imported capital stock accumulation via capital imports (a technology effect), and spending options, emphasising the supply side in a dynamic modelling context. The contributions of this study along with other amendments to the existing models will be discussed in more detail in Chapter 4.

1.2 Research Objectives and Research Questions

This study aims to investigate different aspects of the relationship between oil revenues and economic development for the Libyan economy. The following objectives will be addressed, in order to achieve this aim:
1. The historically significant role of oil revenues in the economic development of the Libyan economy will be emphasised, and the potential adverse effects of the oil sector upon the non-oil sectors identified.

2. A long-run, dynamic, general equilibrium macroeconomic model will be developed and empirically estimated to analyse the effects of the oil sector, and in turn oil revenues and its usage, upon the Libyan economy.

3. The dynamic macroeconomic model will be simulated using a program called “Dynare”, which is designed for solving and simulating deterministic and stochastic dynamic general equilibrium models, to analyse and determine the positive and negative macroeconomic effects on the Libyan economy arising from exogenous shocks from increased oil production and oil prices.

4. Optimal policies that can be implemented by policymakers and government agencies to enhance and/or to mitigate the impact of exogenous oil related shocks, oil production and price, upon the non-oil sectors will be identified with the objective of maximising economic growth and development, as well as for the conduct of policy experiments.

The key questions of the research corresponding to the objectives of this study are as follows:

1. What is the historical role of oil revenue in the economic development of the Libyan economy?

2. What are the positive and negative impacts of additional oil revenue, arising from increased oil production and oil prices upon key macroeconomic variables in the Libyan economy?
3. How can policy makers (government agencies) minimise the adverse effects and/or maximise the positive effects, arising from oil related shocks?

Three sub-research questions are derived from the third research question. They are as follows:

3a. What is the impact of the development oriented policy, in the form of increased government expenditure on infrastructure, human capital formation, and imported technological acquisition, on economic development in Libya?

3b. What is the impact of the alternative policy of distribution of oil production between domestic usage and exports on key macroeconomic variables in the Libyan economy?

3c. What is the impact of an alternative nominal exchange rate policy (a flexible nominal exchange rate regime) on key macroeconomic variables in the Libyan economy.

1.3 Methodology

In order to achieve the above objectives and answer the research questions, four analytical approaches will be used in this study. First, a descriptive analytical approach will be used to identify and review oil developments and its impact upon a number of key macroeconomic variables for the Libyan economy. These include government revenue and spending, real GDP, exports, current account, monetary variables (money supply, inflation, interest rate and exchange rate) and investment.

Second, this study will review the literature to further understand the macroeconomic adjustment process of key macroeconomic variables arising from
resource (oil) related shocks, emphasising both a static and dynamic analysis. It will also review basic models that can be used to develop a macroeconomic model for a net oil-exporting economy such as Libya, with suitable amendments for a developing economy.

Third, a quantitative analytical approach will be used to develop and quantitatively estimate, using robust and contemporary estimation procedures, a long-run dynamic model which will incorporate the key characteristics of the Libyan economy, and its oil production.

Fourth, a numerical simulation approach using “Dynare” will be utilised to evaluate the macroeconomic consequences, arising from oil related shocks, upon key macroeconomic variables in the Libyan economy, as well as to simulate and analyse the results from a number of alternative government policies.

The organised use of these methodologies in this research guarantees that the objectives of this study will be sufficiently addressed. By utilising the best available dataset, and robust and contemporary estimation and simulation procedures, this study will provide unique and reliable findings with notable policy implications for economic units such as government, producers and consumers in Libya.

1.3.1 Macroeconomic model and contributions

A macroeconomic model will be developed for the Libyan economy in this study. The theoretical framework of the model has its foundation in the contributions of Dornbusch (1976), Buiter & Miller (1981), Buiter & Purvis (1982), Eastwood & Venables (1982), Harvie & Gower (1993), Harvie & Thaha (1993); and, more recently and importantly, Cox & Harvie (2010) (C-H henceforth).
The model explicitly incorporates the fundamental features of the Libyan economy and recognises the important contribution of oil production, and in turn oil revenues, to the economic development of the economy. The model will emphasise the way in which government allocates the oil production between domestic usage and exports, and the way in which government spends the oil revenue either on consumption or investment. The model will also focus upon nominal exchange rate policy and the degree of capital mobility. However, to do so many amendments are required of existing models, especially the C-H model, so as to make it more applicable to the case of the Libyan economy, particularly to analyse the impact of oil related shocks on macroeconomic variables, and identifying optimal policies that can be implemented by policymakers to mitigate the impact of exogenous oil related shocks. These are as follows:

First, the model incorporates the fact that oil production and its revenues are under the control of government owned entities. Therefore, the allocation of oil production to either domestic usage or exports, and the spending of oil revenues either on consumption or investment in the form of government spending upon infrastructural (physical capital), human capital formation, and technological acquisition are determined by the government. *This assumption is considered as the first extension to the C-H model.*

Second, the model emphasises the long-run nature of the dynamic adjustment process, since oil production has a long-run impact on non-oil output and the overall economy. This impact arises from physical capital stock accumulation in the non-oil sector induced by government capital spending, human capital accumulation, technology acquisition through capital imports, foreign asset stock accumulation via developments in the current account and budgetary financing requirements. *The inclusion of human capital (another additional wealth effect) and imported capital (technology effect) are*
considered as major contributions and represent a second extension and amendment to the C-H model.

Third, the model developed assumes that the Libyan economy operates with a fixed nominal exchange rate, and international capital mobility is highly controlled by the government. Under a fixed exchange rate regime the nominal exchange rate will not adjust to correct disequilibrium in the balance of payments, and there will be effects upon foreign exchange reserves due to balance of payments surpluses/deficits. Therefore, the money supply is endogenous and the nominal exchange rate is exogenous. This is the third amendment of the C-H model.

Fourth, Libyan financial markets are immature and still in the process of being liberalised, as the Libyan economy only started its transition to a market economy in 2002. Hence, it will be assumed that there is only one financial asset available in the economy, which is a money asset. This is unlike the previously identified models where four financial assets, i.e. domestic money, domestic bonds, foreign bonds, and equities, are assumed. This is the fourth major amendment to the C-H model.

Fifth, the non-oil export and non-oil imports equations will be modelled separately, rather than only modelled as a non-oil trade balance equation. The reason for conducting this is to examine the major factors influencing non-oil exports and imports separately, rather than only the overall non-oil trade balance. Furthermore, the non-oil import equation will be disaggregated into non-oil capital imports and non-oil consumption imports in order to examine the influence of non-oil capital imports on non-oil output supply. This can be considered as another amendment to the C-H model.
Sixth, the model emphasises both the demand and supply of non-oil output. The long-run nature of the model indicates that non-oil output supply is not fixed (at some natural level), but can vary with private capital stock, public physical capital stock, human capital stock, and imported capital stock accumulation/decumulation in the non-oil sector. Developments in the supply of non-oil output can be interpreted to represent a change in the potential output supply in this sector. Furthermore, economic agents possess rational expectations, as in the C-H model.

These contributions and amendments amongst others will be highlighted and discussed in more detail in Chapter 4.

1.3.2 Data collection

Due to data limitations, the period of analysis will be from 1970 to 2007, during which time a number of important economic development plans were started in Libya. Also, it includes the oil boom and post oil boom periods, and other important events which took place during the 1980s and 1990s such as the embargo and sanctions imposed by the United States and the United Nations. Different local and international sources for data are used:

2. Secretariat of the General People’s Committee for Planning.
4. OPEC, Annual Statistical Bulletin. Also available online: http://www.opec.org/.
6. World Development Indicators (WDI), World Bank.
1.3.3 Estimation of the model

The Microfit 5 package is used in this study to estimate the behavioural equations of the model. Annual real data from 1970 to 2007 will be utilised for the estimations. However, before the behavioural equations of the macroeconomic model for the Libyan economy are estimated, it is essential to check each time series for stationarity and identify whether the variables are integrated of order I(0) or I(1), and not integrated of order I(2). Furthermore, it is crucial to accurately identify structural breaks in the data for any economy. In order to test if time series are integrated of order I(0) or I(1) the traditional unit root tests (Dickey & Fuller, 1979, 1981; Phillips & Perron (PP) test, 1988) will be used. The two-break minimum Lagrange Multiplier (LM) unit root test (Lee & Strazicich, 2003) will be used to examine the hypothesis that the variable in each equation has a unit root, and to identify the major structural breaks in the data. Furthermore, the Auto-regressive Distributed Lag (ARDL) Model developed by Pesaran and Shin (1998), Pesaran, Shin and Smith (1996, 2001), and Pesaran and Smith (1998) will be used in this study to examine the long-run relationship between variables which are included in the behavioural equations, and the relevant structural breaks as well as to estimate short-run and long-run elasticities.

1.3.4 Simulation analysis

The numerical simulation will utilise the parameters derived from estimation of the behavioural equations of the macroeconomic model, along with those calculated from available data, those set as adjustment coefficients, those obtained from other studies, and those imposed due to data limitation or in order to ensure model stability. Focus will be placed upon analysing exogenous shocks from increased oil production and oil prices and their impact upon key macroeconomic variables, as well as analysing optimal policies that can be implemented by policymakers to mitigate the impact of exogenous oil related
shocks upon the non-oil sector with the objective of maximising economic growth and development, as well as to conduct policy experiments. This simulation analysis will be conducted using a program called “Dynare”, which is designed for solving and simulating deterministic and stochastic dynamic general equilibrium models.

1.4 Structure of the Study

The remainder of this thesis is structured as follows. Chapter 2 sheds some light on oil development and production and its impact upon key macroeconomic variables. The focus is to investigate the historically significant role of oil revenues in the economic development of the Libyan economy, and the potential adverse effects of the oil sector upon non-oil sectors. The oil sector constitutes the major source of government revenue, exports and foreign exchange, and the main share of national income. Therefore, the emphasis will be placed upon the effect of such oil revenue on the main aggregate variables such as government revenue and spending, exports, current account, monetary variables (money supply, inflation, interest rate, and exchange rate) and investment over the period 1970-2007.

Chapter 3 reviews the existing theoretical literature analysing the macroeconomic adjustment process of key macroeconomic variables arising from resource (oil) related shocks. Specifically, a static and dynamic analysis of the ‘Dutch Disease’ effects arising from resource related shocks will be considered. Regarding the static analysis the well-known economic model developed by Salter (1959), Corden and Neary (1982) as well as Corden (1984) will be utilised in Chapter 3 to analyse the booming sector and Dutch Disease hypothesis, in particular for the case of oil abundant economies like Libya.

The dynamic models will be divided into two categories; short-run and long-run models. The dynamic theoretical short-run models discussed in Chapter 3 for analysing
adjustment arising from oil or resource related shocks, are Buiter and Miller (B-M) (1981), Buiter and Purvis (B-P) (1982), Eastwood and Venables (E-V) (1982) and Neary and Van Wijnbergen (N-W) (1984). The long-run models of relevance are those developed by Harvie and Gower (H-G) (1993), Harvie and Thaha (H-T) (1993), and, more recently, Cox and Harvie (C-H) (2010). In this regard the Cox and Harvie (2010) general equilibrium macroeconomic model will be specifically highlighted in Chapter 3. The emphasis of the above model is placed upon the problem of dynamic adjustment arising from oil or resource related shocks in a small open economy. Therefore, the model will be investigated and adopted with the aim of developing a dynamic macroeconomic model for an oil producing and exporting economy such as Libya. A key characteristic of these models is that they emphasise spending, income, wealth, current account and exchange rate effects in the adjustment process.

Chapter 4 discusses the theoretical framework of the macroeconomic model for the Libyan economy. The model will explicitly incorporate the fundamental characteristics of the Libyan economy and recognises the important contribution of oil production, and in turn oil revenues, to the development of the economy. The economic developments emphasised here relate to that of real income, real government oil revenue, non-oil output, physical capital stock, human capital stock, imported capital stock, foreign asset stock, non-oil trade balance, real exchange rate, the domestic price level and private sector real wealth. The oil related macroeconomic model adopted in this chapter for the Libyan economy has its foundation in the C-H model for the case of a flexible exchange rate, but suitably amended, as discussed previously, for the case of Libya. The model emphasises the above mentioned effects in the adjustment process but also a technology effect and another additional wealth effect (human capital accumulation) not previously emphasised.
The empirical estimation of the behavioural equations of the macroeconomic model developed in Chapter 4 will be conducted in Chapter 5. Time series data will be investigated to ensure they are integrated of order I(0) or I(1) by using the traditional unit root tests, which are the Augmented Dickey-Fuller (ADF) test, and Phillips and Perron (PP) test. Moreover, relevant structural breaks will be identified by using the Minimum Lagrange Multiplier (LM) unit root test and a new Perron-type innovational unit root test. The bounds testing approach for cointegration will also be utilised to test for the long-run relationship among the variables of interest and to estimate long-run and short-run coefficients.

Chapter 6 presents the simulation results of the base macroeconomic model developed in Chapter 4, obtained by Dynare program, where a fixed exchange rate and highly controlled capital mobility will be assumed. A simulation analysis will be conducted in this chapter so as to analyse the dynamic adjustment path and the long-run steady state equilibrium arising from two oil related shocks, namely an increase in oil production and oil price. The analysis of the steady state and dynamic adjustment processes of the model will be implemented by utilising a numerical simulation procedure. This is due to the complexity of the theoretical model, where the attainment of analytically unambiguous results is not possible. The numerical simulations will utilise the parameter values obtained from the estimation procedure conducted in Chapter 5, using the ARDL cointegration technique, those calculated from data available, those set as adjustment coefficients, those obtained from other studies, and those imposed due to data limitation or in order to ensure model stability. The simulation analysis will emphasise the impact of additional oil revenue upon foreign asset stock accumulation, physical capital stock accumulation, human capital stock accumulation, and imported capital stock accumulation, which in turn influences non-oil supply. The simulations will
also take into account the possible effect of oil revenue upon the real exchange rate, and hence upon the non-oil trade balance.

The main focus of Chapter 7 will be upon conducting several simulation scenarios in order to provide alternative policies for policymakers and government agencies to manage the additional oil revenue arising from oil related shocks. In this chapter, three alternative policies will be analysed. First, emphasis will be placed upon the allocation of additional oil revenue between government investments in the form of increasing government investment spending on infrastructure (physical capital), human capital formation (education and training), and technology acquisition, and government consumption. Second, focus is placed upon the distribution of oil production between domestic usage and for export. Finally, focus will be upon different nominal exchange rate policies combined with different degrees of capital mobility. The analysis will emphasise the adjustment path as well as the long-run steady state of eleven key macroeconomic variables. These are foreign asset stocks, non-oil trade balance consisting of non-oil exports and non-oil imports, real exchange rate, inflation rate, non-oil production, physical capital stock, human capital stock, imported capital stock, private capital stock, private sector real wealth and real income.

Chapter 8 provides a summary of the major conclusions derivable from the study, its limitations and suggestions for future study.

1.5 Summary

This chapter has presented the background to the study about oil revenue and economic development in Libya, and mentioned the remarkable amount of work conducted in the economics literature on the impact of resource production and its major economic effects. It also outlined the research objectives and research questions of this
study and explained the methodologies that will be utilised to achieve these objectives. The possible amendments of existing models, especially the C-H model, and the contributions of this study to Dutch Disease studies in general and the booming sector in Libya in particular, were emphasised. Also, data collection, unit root tests and structural breaks procedures, estimation procedure, and simulation procedures were identified. The chapter also provided the organisation of the study which consists of eight chapters. A detailed discussion of the aforementioned issues will be covered in subsequent chapters.
Chapter 2

Oil Development and the Libyan Economy

2.1 Introduction

The purpose of this chapter is to shed some light on oil development and production and its impact upon a number of key macroeconomic variables for the Libyan economy. It mainly aims to investigate the historically significant role of oil revenues in the economic development of the Libyan economy, and the potential adverse effects of the oil sector upon the non-oil sectors. The chapter is divided into six sections; section 2.2 describes the demography of Libya, section 2.3 conducts a comparative analysis of the Libyan economy before and after the discovery of oil, section 2.4 presents a brief historical overview of oil development in Libya, section 2.5 discusses the impact of oil revenues upon a number of key macroeconomic variables that have been influenced by oil production and price developments. Section 2.6 provides a conclusion.

2.2 Location, Population and Language

Libya is an economically small developing Arab country located in North Africa, covering an area of 1,775,000 square kilometres with an estimated population of around six million in 2007 (UNCTAD, 2008), mainly concentrated along the Mediterranean coast. Libya is geographically one of the largest countries in Africa, however more than 90 percent of Libya’s land is desert and only 10 percent can be put to economic use. It has a northern coastline of 1,900 kilometres with the Mediterranean Sea and is bordered on the east by the Arab Republic of Egypt and Sudan, in the south by the Republics of Chad and Niger, and on the west by the Republics of Tunisia and Algeria. The Arabic language is the official language; however Italian and English are understood in some areas.
2.3 Libyan Economy Before and After Oil Exports

At the time of independence in 1951, and before the discovery of oil, Libya was one of the poorest countries in the world. The features of economic development at that time were extremely discouraging. In the words of Benjamin Higgins, an economic adviser to the Libyan government in the early 1950s, the conditions of the Libyan economy in 1952 were desperate:

“... an economy where the bulk of the people live on a subsistence level, where the per capita income is well below $US50 per year, where there are no resources of power and no mineral resources, where agricultural expansion is severely limited by climatic conditions, where capital formation is zero or less, where there is no skilled labour supply and no indigenous entrepreneurship” (Higgins, 1968, p. 819).

Furthermore, up to the end of the 1950s, the Libyan economy was described by many observers as a “deficitary” economy (Higgins, 1968). There were deficits in both the balance of trade and fiscal budget. For example, the total value of exports and re-exports amounted to $US10.9 million in 1954, whilst imports amounted to $US31.6 million in the same year. Also public expenditures for the fiscal year 1950-1951 amounted to $US15.4 million, whilst domestic revenue was $US10.4 million (Bhairi, 1981). The chronic deficit was not covered by net receipts from foreign investment, but by foreign aid received from both the UK and USA in return for the use of military air bases. Additional foreign aid was provided by the United Nations. These deficits reflected the hard fact that the economy could not produce enough to preserve even its low standard of living.

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2It is worth mentioning that Higgins worked as an economic advisor to the Libyan government after the Second World War. Before that time Libya was occupied by Italy during the period 1911-1945, and the Italian government, particularly during the 1920s and 1930s, invested into the infrastructure of Libya’s towns, roads, railways, and agriculture to develop the economy. However, most of these economic developments were destroyed during the Second World War.
By 1955, oil exploration had started and by the beginning of 1960 sixteen multinational oil companies were operating in Libya (World Bank, 1960). However, the turning point in the contemporary history of Libya was the beginning of oil exports in the last quarter of 1961. Since then the prospects for economic development in Libya have been totally changed. For instance, per capita income, estimated in the early 1950s by the World Bank to be $US50, had risen to $US1,070 by 1967 (Bahairi, 1981). Furthermore, the structure of the Libyan economy changed from economic dependence upon agriculture, animal husbandry and other industries such as textiles and handicrafts to an economy heavily dependent upon the oil sector. According to the World Bank the agriculture sector contributed about 30 percent of GDP and employed more than 70 percent of the labour force in the early 1950s (World Bank, 2006). This figure declined significantly by 1970 when the contribution of the agriculture sector accounted for only 3.1 percent of total GDP, while the oil sector contributed about 63 percent of total GDP (see Table 2.4). In addition, the economy shifted from being a deficit to surplus economy, particularly for the balance of trade. There is a consensus among scholars now (for example Abohobiel, 1983, 2003) that the oil sector has become the most important sector in the economy. It enables the government, which is the sole owner of all natural resources and the recipient of their revenues, to actively dominate all other economic activities.

2.4 Oil development: a brief historical review

The exploration for oil in Libya began in 1955 following its independence, and by the beginning of 1960 several companies were engaged in oil exploration and production. However, commercial quantities of oil production and exports only began in the early 1960s. Figure 2.1 shows the production of crude oil during the period 1961-2007. It shows that Libya produced only 0.018 million barrels per day (mb/d) in 1961,
but this figure increased gradually to more than 1.2 mb/d by 1965. The production of oil increased further and reached its peak of 3.3 mb/d in 1970. This trend of increasing production in the 1960s can be mainly attributed to the production policies that were formulated by international oil companies and several concessionary agreements\(^3\) that were applied in the country during 1955-1970.

![Figure 2.1](image)

Figure 2.1  
The development of oil production during 1961-2007, mb/d

Note: The plot demonstrates the second column in Table (2.1).

On September 1\(^{st}\) 1969 the political situation changed as a revolution brought the military to power in Libya. Subsequently, the conditions of the oil production policies were changed as well\(^4\). For instance, in the following year the National Oil Corporation (NOC) was officially established and essentially controlled the oil and gas industry. Furthermore, the process of nationalisation and government participation in the oil industry started in 1971, and several of the new operating companies that were founded on the nationalised assets of foreign companies operating in Libya at the time came...

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\(^3\) According to this kind of agreement the state delegates a company with the right to research, develop, extract and export oil and gas from large areas without any restrictions over a long time in return for the payment of royalties and taxes.

\(^4\) The new government conducted the process of nationalisation and participation in the oil industry from 1971 to 1974, and after that converted all existing concessionary agreements into exploration and production-sharing agreements which have undergone steady evolution in 1974, 1981 and 1988. For more information see Mahmud and Russell (1999).
under the control of the NOC (UK Trade & Investment, 2005). Subsequently, oil production decreased to approximately 2.7 mb/d in 1971 and 2.2 mb/d in 1972. The trend of reduced oil production persisted to reach its lowest level of 1.4 mb/d by the middle of the 1970s. This reduction can be attributed to the Arab oil embargo after the Arab/Israeli war in 1973, and decreased global oil demand (Mahmud & Russell, 1999). The sharp upward trend in real oil prices in the late 1970s and early 1980s, as Figure 2.2 indicates, encouraged an increase in oil production, which increased to 2.09 mb/d in 1979.

![Figure 2.2](image_url)  
**Figure 2.2**  
Real oil price during 1970-2007, in US Dollars a barrel

Note: the base year used here is 1997.

During the period 1980-2002, with the exception of the years 1980 and 1991, the production of oil ranged between 0.972 mb/d and 1.4 mb/d. It can be argued that the reduction of production capacity of oil resulted from the United States embargo that began and increased gradually from the early 1980s\(^5\), followed by sanctions imposed on Libya by the United Nations from the early 1990s. In addition, during the 1980s Libya accepted an OPEC imposed quota, as a consequence of its membership of this

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\(^5\) In 1981 the USA imposed a trade embargo on Libya, including the prohibition of several companies to import Libyan oil to the USA, and restriction of all exports to Libya including technology and equipment used in the oil industry.
organisation since 1962. In addition, since most spare parts are made in the USA and western countries, the oil sector in Libya during the period of sanctions and the trade embargo suffered seriously from a lack of appropriate and emergency maintenance. Therefore, the oil sector’s production capacity was severely curtailed on the one hand by a lack of foreign investment and technology, mainly due to economic sanctions, and on the other hand by the commitment to OPEC quotas. Consequently, it can be said that the oil sector, which is the crucial engine of the Libyan economy, was profoundly affected and suffered vast losses in terms of production capacity and revenue.

Since 2003 oil production has increased gradually, amounting to over 1.7mb/d in 2006. This is about 52 percent of the peak production level of 3.3 mb/d achieved in 1970. This increase can be mainly attributed to the lifting of the UN sanctions and the USA embargo in 2003 and 2004, respectively. Furthermore, the nominal oil price has experienced a sharp increase since 2000. These developments have allowed major oil companies to return to Libya and raise their exploration efforts for oil and natural gas in the country. By 2013, Libya aims to raise its production of oil gradually to reach 3 mb/d (Energy Information Administration, 2007).

In general, the oil sector is an extremely capital-intensive activity with a high level of labour productivity (Porter & Yergin, 2006). The oil and gas sector accounted for more than 60 percent of national GDP, in nominal terms, in 2003 but employed only 3 percent of the formal workforce, despite the fact that employment in the oil sector grew at an annual average estimated 10 percent between 1999 and 2003.

Even though Libya’s production of oil is surpassed by a number of other oil producing countries such as Saudi Arabia and Iran, it can still influence the world price of oil. As Table 2.1 indicates, Libyan oil production averaged approximately 4-14
percent of total OPEC oil production over the period 1961-2007. This contribution is expected to increase as Libya has the potential to raise oil production significantly in coming years, given its proven oil reserves of 43.67 billion barrels in 2007 (OPEC, 2008).
## Table 2.1 Average Oil Production, Selected Countries, 1961-2007 (million barrels per day) and Libyan Share of Daily Production (%)

<table>
<thead>
<tr>
<th>Year</th>
<th>Libya</th>
<th>OPEC</th>
<th>Indonesia</th>
<th>Algeria</th>
<th>Saudi Arabia</th>
<th>Kuwait</th>
<th>Iran</th>
<th>Libya/OPEC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>0.0182</td>
<td>8.6826</td>
<td>0.4243</td>
<td>0.3309</td>
<td>1.4801</td>
<td>1.7350</td>
<td>1.2022</td>
<td>0.21</td>
</tr>
<tr>
<td>1965</td>
<td>1.2188</td>
<td>14.3254</td>
<td>0.4806</td>
<td>0.5587</td>
<td>2.2053</td>
<td>2.3603</td>
<td>1.9083</td>
<td>8.51</td>
</tr>
<tr>
<td>1971</td>
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2.5 Oil and the macroeconomy

The Libyan economy is a small developing economy that has been heavily dependent on the oil sector since the early 1960s, and it has been dominated by the public sector since the late 1970s; however the economy started its transition to a market economy in 2002. Oil revenue has had both direct and indirect effects on the factors that lead to development in the Libyan economy. The significance of oil in the Libyan economy stems from its role as a major source of government revenue, exports and foreign exchange. Also, a major share of national income is derived from the oil sector. Consequently, a number of key macroeconomic variables are influenced by oil production and oil price developments. These are government revenue and spending, real GDP, exports, current account, monetary variables (money supply, inflation, interest rate and exchange rate) and investment.

2.5.1 Government budget

In Libya, the majority of oil production is produced by companies that are either 100 percent state owned, under the control of NOC, or are joint ventures between NOC and international companies in which NOC usually has a controlling share of 51 percent. Such a situation has had a major impact on government revenue, as pointed out in Table 2.2 and Figure 2.3. In real terms oil revenue contributed between 70.8 percent and 88.7 percent of government revenue during the period 1970-1983. After that it declined due to deteriorating oil prices in world markets as well as a considerable reduction in oil production, as it reached its lowest level of 0.9725 mb/d in 1987. However, despite this, the contribution of oil revenue to total government revenue did not fall below 44.3 percent after the post oil boom. Even though the price of oil remained modest the contribution of oil revenue to total oil revenue increased slightly again to reach its peak

\[\text{For more details see UK Trade & Investment, 2005.}\]
in 1995 of about 74 percent. This can be mainly attributed to a slight increase in oil production.

During the period 2000-2007, with the exception of 2000 and 2003, oil revenue contributed between 60 percent and 92.7 percent of total government revenue, and this was due to a substantial increase of oil production on the one hand, which amounted to 1.7512 mb/d in 2006, and a significant increase in oil prices on the other hand. It can be clearly seen that 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. Other sources of government revenue arise from profits from other government enterprises, import duties, income taxes, fees and customs duties.

Oil revenue is controlled by government; therefore it affects the domestic economy through the way in which government spends the revenue. Such expenditure is in the form of administrative expenditure, extra budgetary expenditure and capital or  

7 The Libyan economy benefited from the windfall earnings arising from the Gulf war in 1991, when government oil revenue increased by approximately 17.3% and 43.8% in real terms in 1990 and 1991, respectively (see Table 2.2).
development expenditure. Administrative expenditure covers the government’s current expenditure\textsuperscript{8}, such as on salaries and wages, other purchases of goods and services, and food subsidies, which stimulate the demand for domestic non-oil output. As can be seen from Table 2.3, such expenditure constituted, on average, 42.4 percent of total government expenditure during the period 1970-2007. Extra budgetary expenditure covers the oil reserve fund and defence.

On the other hand, development expenditure covers the finance of economic and social projects such as that of infrastructure, education and health sector spending, development projects of the NOC and development projects of the Great Man Made River (GMMR)\textsuperscript{9}, which have positive effects on the private sector, and hence on economic development, specifically due to a more productive labour force and productivity enhancing infrastructure. In this context Aschauer (1989a, 1989b) argues that public capital spending on infrastructure, such as highways, streets, water and sewerage system and airports, operates as a complement to private sector inputs and “crowds in” private capital accumulation. Also, Morrison and Schwartz (1996) examine the relationship between public capital and the cost of private production. They find that the public infrastructure investment on highways, water, and sewers results in a reduction in the cost of private production, and hence leads to an increased productivity performance. Hence it has potentially positive and significant effects on output supply and demand.

During the period of rapid increase in oil production and prices, 1970-1983, the share of development to total expenditure ranged between 35.7 percent and 47.8 percent

\textsuperscript{8} The government’s current expenditure will refer henceforth to government consumption spending.

\textsuperscript{9} In 1984 Libya started the Great Man-Made River project as one of the world’s largest engineering ventures. This project draws water from aquifer wells in the Sahara desert in the south, and transports it along a network of huge underground pipes to the northern coastal belt.
(see Table 2.3). Nevertheless, with the collapse in oil prices this share fell to reach its lowest level at 11.3 percent of total government expenditure in 1995\(^{10}\). Since then it has increased and peaked in 2007 at about 61.5 percent\(^{11}\), reflecting the considerable increase of oil production and significant increase in oil prices. An increase in government investment spending would stimulate the demand side and also the supply side. It can stimulate the non-oil output supply through physical capital accumulation (through government investment spending upon infrastructure), human capital formation (through government investment spending upon education and health care) and imported capital accumulation (through government investment spending upon technological acquisition from overseas)\(^{12}\).

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\(^{10}\) Given Libya’s dependence on oil revenues the oil price collapse of the 1990s caused serious problems and had adverse consequences for the development budget, in particular spending upon infrastructure and construction.

\(^{11}\) The increase in development expenditure was concentrated mainly on infrastructure and construction (42%).

\(^{12}\) For more details see Chapters 4 and 6.
Table 2.2: Real Government Revenue  
(Constant 1997 Price, millions of Libyan Dinars)  

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Table 2.3: Real Government Expenditure  
(Constant 1997 Price, millions of Libyan Dinars)

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2.5.2 Gross domestic product (GDP)

The Libyan government has implemented several development plans since the early 1970s, which have stressed the goal of building 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, in gross domestic product. However, the contribution of oil production to real gross domestic product has been considerable during both the oil boom (the late 1970s and early 1980s, and then since 2000) and non-oil boom periods. Moreover, the contribution of the non-tradable sector, such as that of services and construction, in real gross domestic product has experienced a considerable increase, meaning that the oil boom was followed by an expansion in the non-oil non-tradable sector.

Developments in Libya’s GDP by sector show some of the major structural changes that have taken place since the time of Libya’s independence. As mentioned earlier, in 1951 and before oil discovery the Libyan economy was based primarily upon the agricultural sector, which employed more than 70 percent of the labour force, and contributed about 30 percent of GDP (World Bank, 2006). The share of agricultural output in real GDP declined to 23.9 percent during 1962-1968, and the share of manufacturing output was about 9.5 percent during the same period (Abohobiel, 1983).

Table 2.5 shows that the contribution of agriculture and manufacturing in real GDP experienced a further decline over the period of study, particularly during the first oil boom period. During the major oil boom period of 1973 the oil sector contributed 55.9 percent of real GDP, manufacturing only 2.8 percent, agriculture 4.8 percent and the services and construction sectors 22.7 percent and 13.9 percent, respectively. Therefore, non-oil GDP contributed 44.1 percent of real GDP. By 1981 the contribution of the oil
sector decreased to 34.4 percent, manufacturing increased slightly to 4.4 percent, agriculture increased to 6.5 percent, while the services and construction sectors increased considerably to 37.9 percent and 16.7 percent respectively.

During the 1980s, with decreasing oil prices, oil’s contribution ranged between 28.2 percent and 39.3 percent of real GDP, whilst non-oil output’s contribution ranged between 60.7 percent and 71.8 percent. In 1987 manufacturing’s contribution increased to 7.3 percent and, agriculture’s increased to 11.3 percent, whereas the services sector increased to 46.5 percent. Oil-output’s contribution remained between 28.2 percent and 39.2 percent of real GDP during 1991-2007, manufacturing’s contribution was, on average, 7.1 percent, and agriculture’s contribution was, on average, 7.6 percent. On the other hand the contribution of services’ output to real gross domestic product was, on average, 44.4 percent during the same period.

It can be said that an increase in income arising from the boom in the oil sector resulted in increased spending and demand for non-tradable sector output, and in particular that of the services sector; however it has undermined the growth of the non-oil tradable sector such as that of the manufacturing and agriculture sectors. In other words the oil sector may have had an adverse effect on the development of the non-oil tradable sectors, arising from the existence of the so called Dutch Disease effect\textsuperscript{13}.

\textsuperscript{13} A more detailed discussion of this will be conducted in Chapter 3.
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Source: Secretariat of the General People's Committee for Planning.
Table 2.5 The Contribution of Sectors as a Per Cent of Total GDP

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Note: This table is calculated from Table 2.4.
Source: Secretariat of the General People's Committee for Planning.
2.5.3 Exports and the current account

A third macroeconomic variable to be affected by oil production and price developments is the current account and overall exports. Libyan oil exports have been a major source of foreign exchange. Such revenue can play a crucial role in the economic development process by financing various imports, particularly capital imports, technology and services essential to economic development (Harvie & Thaha, 1993). Furthermore, the availability of such foreign exchange, as a major part of international reserves, is regarded as one of the most significant issues for economic activities, such as acting as a buffer stock against any future financial or economic crises (Clark, 1970). It helps to maintain trust in the financial management of the economy and enables the economy to protect domestic consumption, production, and economic growth from temporary or seasonal decreases in the prices and revenues of exports and/or sudden increases in imports prices, and it can support a policy of exchange rate stability (Landell-Mills, 1989). However, holding too large a level of reserves, exceeding the secure and sufficient level, involves an opportunity cost that may be high for the Libyan economy, which is looking for alternative income sources. The economy can use such financial assets to generate income in the form of short or long term investments.

Table 2.6 identifies the development of the current account over the period of study. It summarises the trade balance, the services balance and the current account itself. The trade balance achieved sizeable surpluses over the period of study, with the exception of 1981. These surpluses have mainly reflected oil production and price fluctuations, where they increase with the increase of oil production and oil price and vice versa. The services trade balance has been in persistent deficit throughout the whole period of study, and has had a negative effect upon the current account for several years. Indeed, the current account was in an unstable situation over the period 1970-1999,
reflecting the decline in trade balance surpluses, due to turbulence in oil production and oil prices, and it was also profoundly affected by the services trade balance deficits. Despite the continual deficits in the services trade balance the current account has been in continual surplus since 2000, reflecting a sizeable increase in oil production and prices.

Figure 2.4 and Table 2.7 identify the oil and non-oil export performance over the period 1970-2007. They reveal that oil exports have been a major source of foreign exchange, constituting more than 95 percent of total exports during both the oil boom and non-oil boom periods. It can be said that despite the main objective of economic development plans in Libya since the early 1970s being to diversify the domestic economic and export base, the economic authorities in Libya have not yet achieved these objectives. Oil exports still dominate total exports, and the contribution of non-oil exports to total exports is not yet tangible.

Figure 2.4
Oil and non-oil exports as per cent of total exports

Note: The plot demonstrates the fifth and sixth columns in Table 2.7.
Sources: 1) The Central Bank of Libya, the economic bulletin, various issues.
2) National Authority for Information and Documentation.
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Sources: 1) The Central Bank of Libya, the economic bulletin, various issues; 2) National Authority for Information and Documentation; 3) International Monetary Fund, IMF, August 2008.

14 Using current price instead of constant price is due to the lack of a price index for the services sector.
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Source: 1) The Central Bank of Libya, the economic bulletin, various issues
2) National Authority for Information and Documentation

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2.5.4 Monetary policy

Libya has abundant foreign exchange due to oil revenue. The effects of this windfall revenue are mainly visible in the budgetary and external financial position as mentioned above, as well as in monetary policy\textsuperscript{15}. Thus monetary policy in the Libyan economy is affected by the boom in the oil sector, impacting upon the exchange rate, money supply, and interest rate.

2.5.4.1 Exchange rate

The huge inflow of revenue during the oil boom caused rising demand for both non-oil as well as imported goods. Consequently, in the case of a fixed nominal exchange rate, this will lead to a higher domestic price level during the short-run as well as an appreciation of the real exchange rate. Also, the accumulation of foreign assets resulting from balance of payments surpluses during the oil boom will lead to a temporarily higher money stock so as to maintain the fixed nominal exchange rate policy, leading to an increase in the domestic price and a further appreciation of the real exchange rate. Consequently, local production, particularly that of tradable goods, became less attractive to that of imports undermining the growth rate of the agricultural, manufacturing, and other non-oil tradable sectors of the economy. Moreover, it led to job losses in the non-oil tradable sectors and made the economy heavily dependent on the oil sector.

Figure 2.5 shows the development of the Libyan nominal exchange rate. It can be observed that the Libyan Dinar (LD) regime has witnessed three phases since 1970; first it was pegged to the US dollar and then to special drawing rights (SDRs), second it was managed in the parallel market and then divided into two rates, and, finally, it was unified and managed by the Central Bank of Libya (CBL).

\textsuperscript{15} Since the 1970s Libya’s banking system has been under state control. The central bank of Libya (CBL) is the monetary authority; hence it is responsible for monetary policy.
For many years the official nominal exchange rate was fixed. Since the early 1970s the official exchange rate of the LD was pegged to the US dollar where one LD was equal to 3.37 US$, and remained steady at this rate even during the period of the oil boom in the late 1970s and early 1980s until 1985. By 1986 the monetary authority pegged the exchange rate to the SDR instead of the US$. Despite this, no considerable change was noted until the early 1990s. As a result of control of foreign exchange policy by the CBL, and direct quantitative restrictions upon imports, the LD experienced illegal informal market trading, particularly during the 1990s\textsuperscript{16}. From 1999 to 2001 this parallel foreign exchange market and market exchange rate was legalised and a dual exchange rate system was introduced by the CBL, with an official exchange rate of LD1 = $2.15 and a special exchange rate close to the prevailing parallel market rate introduced at LD1 = $0.36\textsuperscript{17} (IMF, 2003). Since then the CBL aimed to close the gap between the two rates via a depreciation of the official rate whilst, at the same time, appreciating the special

\textsuperscript{16}As a result of decreasing oil revenue from lower oil prices in the mid 1980s, and the low participation of non-oil sectors in exporting, the economic authorities conducted fiscal, monetary and trade policies to rationalise the use of resources, particularly with regard to foreign exchange.

\textsuperscript{17}The special rate was used for transactions related to personal imports, travel, medical treatment abroad and pilgrimage.
rate. In January 2002 the exchange rate system was unified and the LD has been pegged to the SDR at a rate of LD 1 = SDR 0.608. The exchange rate was devalued by 15 percent to LD 1 = 0.517 in 2003 (IMF, 2006).

The above discussion has indicated that the monetary authority in Libya has attempted to keep the nominal exchange rate fixed and/or under control during the period of this study. Under a fixed nominal exchange rate regime the money supply is endogenously determined, and depends upon exogenously determined changes in domestic credit expansion and the accumulation of foreign exchange reserves through balance of payments surpluses/deficits. That is, the oil trade balance during the oil boom period has generated balance of payments surpluses and an accumulation of foreign exchange reserves. This eventually led to an increase in the money stock so as to maintain the fixed nominal exchange rate policy, leading to an increase in the domestic price level in the short term, and therefore, an appreciation of the real exchange rate (see Figure 2.6). In addition, during the oil boom period the government increased its spending to maintain its balanced budget policy, resulting in an increased demand for both non-oil as well as imported goods. Accordingly, increased demand for non-oil output led to a higher domestic price due to a spending effect in the short-run, and in turn a further appreciation of the real exchange rate. An appreciation of the real exchange rate (an exchange rate effect) significantly influenced the adjustment of a number of key macroeconomic variables, particularly non-oil exports, non-oil imports, and overall non-oil trade balance, and consequently upon the domestic economy as whole (for more discussion see Chapter 6).
2.5.4.2 Money supply, inflation rate and the interest rate

During the oil boom period 1970-1985, both development and consumption spending increased. Development spending increased on average by 43 percent per year, and consumption spending increased on average by 28 percent per year (see Table 2.3). To maintain the exchange rate peg to the US$ during this period, without any noticeable change as mentioned above, the real money supply increased from approximately 50.7 LD million in 1971 to about 1557.5 LD million in 1985 as indicated in Figure 2.7. This led to a high domestic inflation rate as indicated in Figure 2.8. The increased inflation rate, with the nominal exchange rate fixed, reflected the increasing price of non-traded goods. Since the exchange rate was fixed, arbitrage had occurred through a change in the money supply and current account rather than through the nominal exchange rate. This is a typical finding since in order to control the money supply there has to be a flexible exchange rate. With a fixed exchange rate control over the money supply is lost.

From the mid 1980s budget deficits emerged due to: declining oil revenue arising from falling oil prices, lower tax revenues resulting from the absence of effective

\* Real exchange rate is measured as nominal exchange rate times the imported goods price index divided by consumer price index

![Real Exchange Rate Graph](image-url)
taxation of the private sector, inefficient public enterprises which required subsidies, and a general expansion of public expenditure without a sufficient revenue base to finance this. In order to finance the budget deficit the government resorted to printing money, i.e. monetary accommodation of the deficit, which aggravated both public debt and monetary expansion. Growth in the money supply was above that for the real growth of gross national product (Abdualsalam, 2003). As a result new inflationary pressures during the 1990s emerged in the economy and the consumer price index (CPI, 1997=100) reached its peak in 1998 (see Figure 2.8), and this in turn caused a further appreciation of the real exchange rate. It should also be noted that monetary policy throughout this period was not clearly defined, as it had not been used before to reduce inflation.

Despite the increased money supply the consumer price index (CPI, 1997=100) indicated that inflation was under control during the period 1999-2004, mainly due to price controls and a wage freeze imposed in 1981. In addition, the unification of the exchange rate, where the special exchange rate was appreciated and the official one was depreciated, and reduced customs duties as part of trade liberalisation, contributed to reducing the price of consumer imports (OECD, 2008). Moreover, during this period public enterprises were exempted from all taxes and customs duties (IMF, 2003).

In recent years current account surpluses, as a result of a high oil price, have increased the money supply, with the money supply increasing by about 36.5 percent and 50.4 percent in 2004 and 2007, respectively. Besides this, wage increases and high public

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18 By 1977 the regime in Libya introduced the concept of “people’s power” and the economic policies that were implemented after that restricted private sector activities. By 1984 most private commercial transactions such as retail and wholesale had become illegal. For more details see Altunisik (1996).
19 In 1981 the General People’s Congress issued law No 15 on the wages and salaries system for employees in the public sector. Since then wage levels in the public sector were not increased until the early 2000s. However, living standards were supported through an extensive social safety net, with the provision of housing, education and healthcare, subsidized food and utility prices and sizeable energy subsidies.
20 Imports were valued at a special exchange rate.
Investment have led to inflation increasing from 2.5 percent in 2005 to 7.8 percent in 2007. Fiscal and monetary expansions caused further upward pressure on the domestic price level.

As a monetary policy instrument the interest rate is not significant in Libya, making monetary policy increasingly ineffective in influencing macroeconomic goals. This can be seen from a constant interest rate throughout most of the period of study. Even though interest rates were reduced in February 2004, the first change since 1994, they are still controlled by the CBL. IMF Staff advice to the CBL in 2005 was to ease interest rate controls, with the aim of full liberalisation of interest rates (IMF, 2005). Without these reforms, financial markets will not be able to deliver an efficient allocation of credit, which is needed to jump-start private sector activities and increase the overall efficiency of the economy.

**Figure 2.7**

Real money supply in millions of LD (1970-2007)

Source: The Central Bank of Libya, the economic bulletin, various issues.
The final major impact of oil production and price developments to be discussed is that upon gross investment, as measured by gross fixed capital formation. The features of economic development in Libya before the discovery of oil were extremely discouraging. As mentioned above, Higgins (1968) stated that capital formation by the early 1950s was negligible. However, these features changed entirely with oil exports in the last quarter of 1961, and experienced a further remarkable change during the oil boom period of 1970 – 1985. Since then the government has been in a position to muster the available resources for construction and development when it conducted three economic development plans\textsuperscript{21}.

Gross fixed capital formation is considered to be an essential engine of economic development. Consequently, during the oil boom of 1970-1985 government development expenditure increased. As Table 2.8 and Figure 2.9 indicate, gross fixed capital formation increased during the oil boom from 1165.06 million LD in real terms in 1970 to 2858.05 million in 1975, increasing further to reach a peak of 5194.56 million in 1980 which

\textsuperscript{21} During this period there were three Libyan economic development plans: these being the three-year plan of 1972-75, the five-year plan of 1976-1980, and finally the five-year plan of 1981-1985.
constituted about 31.8 percent of total real GDP. Declining oil revenue from the mid 1980s resulted in a decline in gross fixed capital formation to its lowest level of 1364.1 million by 1995, constituting just 10.4 percent of total real GDP. This decline in gross fixed capital formation can be mainly attributed to falling oil prices and the suspension of economic development plans during the period 1986-2000\textsuperscript{22}. It was also due to the trade embargo and sanctions imposed upon Libya by the USA and UN, respectively.

After 2000 fixed capital formation considerably increased in real terms, reflecting favourable developments in the oil market and the five-year economic development plan which was conducted by the government during 2000–2005. Gross fixed capital formation increased during this oil boom period to 6565.3 million LD in real terms in 2005, then increasing further to reach a peak at 6902.7 million in 2007 which constituted about 26.2 percent of total real GDP.

![Figure 2.9
Fixed capital formation (1970-2007)](image)

Note: The plot demonstrates the second column in Table 2.8.
Sources: 1) Secretariat of the General People's Committee for Planning

\textsuperscript{22} The postponement of economic development plans, and reliance only on annual development budgets, resulted in a decline of the of real GDP growth rate, particularly during 1986-87 and 1991-94 (see Abohobiel, 2003).
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Source: 1) Secretariat of the General People's Committee for Planning
2.6 Conclusions

This chapter has reviewed oil developments and its impacts upon a number of key macroeconomic variables for the Libyan economy. These being as follows; firstly, oil production and revenue have been adversely affected by several events, particularly the trade embargo and sanctions imposed by the United States and United Nations, and it has also been affected by oil price fluctuations in the global market. Despite this oil production still plays a crucial role in the economic development of the Libyan economy, constituting the major source of government revenue, exports and foreign exchange. Moreover, the major share of national income is derived from the oil sector.

Secondly, government revenue has been affected by both changes in oil production and oil prices. Despite this, oil revenue, which has primarily accrued to the government, has enabled government to expand both its administrative (consumption) and development expenditure. Oil revenue has, therefore, created rising demand for tradable and non-tradable goods. This resulted in a higher domestic price level (spending effect), and caused an appreciation of the real exchange rate of the Libyan Dinar. The spending effect is dominated by government policy decisions, and is most likely to have been the main channel in transmitting the effects of oil production to the overall macroeconomy. This is because the oil sector is extremely capital-intensive with a high level of labour productivity, which means the resource movement effect is negligible.

Thirdly, developments in Libya’s GDP by sector indicate some of the major structural changes that have taken place before and after oil discovery. The economy was mainly based upon agricultural and other industries such as textiles and handicrafts before the discovery of oil; however, after the discovery of oil it has become based upon the oil sector. An increase in income arising from the boom in the oil sector (income
effect) brought about increased spending and demand for goods in the non-tradable sector, in particular that of the services sector; however it has undermined the non-oil tradable sector such as that of the manufacturing and agriculture sectors. In other words the oil sector may have had an adverse effect on the development of the non-oil tradable sectors, arising from the existence of the so called Dutch Disease effect. This effect will be further examined in Chapter 6.

Fourthly, oil production has generated an increase in exports and enhanced the current account. This implies that oil production and price developments exert a major influence upon the economy through foreign asset accumulation via the current account (current account effect), and thereby the money stock as the nominal exchange rate was fixed. The accumulation of foreign asset stocks can exercise a major influence upon non-oil output supply through financing capital imports (technology effect), particularly technology and services necessary for economic development.

Fifthly, including the oil boom period of 1970-1985 and until the mid 1990s the official nominal exchange rate was fixed; hence the nominal and real money supply increased. This resulted in a high domestic inflation rate which was reflected in a higher price for non-tradable goods, thus causing a further appreciation of the real exchange rate.

The final impact of the oil developments has been upon gross fixed capital formation (gross investment). Oil sector development exerts a crucial influence not only upon the accumulation of foreign asset stocks through the current account, but also through accumulation of physical capital stock and human capital stock via the investment in infrastructure, education and health care. This could be referred to as a long-run sustainable impact of oil production upon non-oil output supply.
These fundamental features will be incorporated in a dynamic theoretical general equilibrium macroeconomic model for the Libyan economy to be presented in the fourth chapter, and will be further examined by empirical estimation and simulation analysis of this model in the fifth and sixth chapters, respectively.
Chapter 3
A Review of the Literature

3.1 Introduction

The disappointing growth performance of resource-abundant economies over the short and long terms has become a major concern, in both developed and developing resource producing countries (Auty, 2001; Carneiro, 2007; Nili & Rastad, 2007; Sachs & Warner 1999, 2001; among others). The resource-rich countries, many of which can be classified as developing, have recently experienced substantially increased revenue as a result of increased resource production and prices. However, the resource-rich economies, including oil producing economies, have experienced on average lower growth rates than resource-poor economies (Carneiro, 2007). For example, several natural resource-rich economies, such as Nigeria, Venezuela, Angola, and Ecuador, have achieved lower economic growth rates during the past few decades, whilst resource-poor economies in Asia have experienced rapid economic growth (Oomes & Kalcheva, 2007). This puzzling issue is attributed to a number of factors that have been identified by many researchers, and these factors will be identified in the remaining sections of this chapter.

The chapter is structured as follows; section 3.2 explains the booming sector and Dutch Disease hypothesis, section 3.3 presents dynamic adjustment processes arising from oil related shocks in which short-run models, long-run models and fundamental differences and similarities between these models are outlined, and section 3.4 suggests potential amendments of these basic models so as to be more applicable for the Libyan economy. Section 3.5 provides a summary and conclusions.
3.2 Background

In a well-known paper, Sachs and Warner (1995) show a robust negative relationship between real GDP growth per capita and the ratio of natural resource exports to GDP in a sample of 97 developing countries during the period 1970-1989. This negative relationship holds true even after controlling for other determinants of economic growth, such as that of initial per capita income, trade policy, government efficiency, and investment rates.

Sachs and Warner (2001) extend their research by using other geographical variables in an attempt to explain the curse of natural resources. They used cross-country data which includes the oil states in the Arabic Gulf, Iran, Nigeria, and Venezuela, among others. The variables that they use are real growth per person 1970-1990 as the dependent variable, the log of GDP in 1970, an interaction variable between an openness variable and initial income, and natural resource exports as a share of GDP. In addition, the geographical variables include percent of land area within 100 kilometres of the sea, kilometres to the closest major port, the fraction of land area in the geographic tropics, and the falciparam malaria index from 1966 are also used as independent variables. They find that the geographical or climatic variables explain little of the natural resources curse. They also show evidence that resource-abundant economies tend to be high-price economies and, perhaps as a result, these economies tend to miss out on export led growth or other kinds of growth.23 Auty (2001) has also indicated that oil-abundant economies present lower long-term growth rates when compared to non-oil economies. This paradox of plenty has been widely discussed in the literature.

23 However Sala-i-Martin (1997) and Doppelhofer et al. (2000) classify natural resources as one of the ten most important variables in empirical studies on economic growth. Sachs and Warner (2001) criticise this result and show that none of the economies with extremely abundant natural resources in 1970 grew rapidly for the next 20 years. Moreover, they show that most of the countries that did grow rapidly started as resource poor, not resource rich.
An extensive theoretical and empirical literature has been developed to examine the relationship between the discovery and production of a natural resource and a number of key macroeconomic variables, in particular that with real GDP. They provide different explanations of how the “resource curse” may work. Accordingly, two major explanations are emphasised in the literature.

One possible explanation for the natural resource curse is that natural resource wealth tends to cause a conflict with the usage of the resources, which in turn leads to poor institutional quality and lower growth. The argument here is that the large revenue generated from the natural resource sector creates motivations for interested groups, such as government officials and local or foreign investors, to engage in rent-seeking behaviour, which can be in the form of voracity, corruption, or even civil conflict as in the case of Nigeria (for example Carneiro, 2007; Hausmann & Rigobon, 2003; Leite & Weidmann, 1999; Rodrik, 2003; Tornell & Lane, 1999). This behaviour can lead to economic failure and political crisis, including a collapse in non-natural resource production, capital flight, higher inflation, poor institutional quality and hence lower growth. Institutions play an important role in determining the government's ability to adopt and implement policies that would mitigate risks that may have adverse effects upon economic growth (Rodrik, 2003). Countries with well established institutions will be able to implement sound policies in response to external shocks, and hence will be able to maintain their economic growth. On the other hand the lack of such institutions would result in poor policy choices, therefore deepening and extending the negative effects of the external shock.

The second possible explanation from the literature is that economic factors arising from the boom in the resource (oil) sector and its revenue volatility are the
primary causes of the natural resource curse. It suggests that natural resource wealth may result in lower growth in the non-resource sector. This can be briefly summarised as the notion that a boom in one tradable sector, such as oil, contributes toward a contraction of other non-booming tradable sectors such as the manufacturing sector. That is, the windfall revenues arising from the oil sector brings about a real exchange rate appreciation, which in turn reduces the competitiveness of the non-resource tradable sector, thus undermining the growth of the non-resource tradable sector. It also leads to undermining of economic growth in the non-booming tradable sector by reallocating production factors towards the natural resource sector and non-tradable sector (for example Corden, 1984; Corden & Neary 1982; Buiter & Purvis, 1982; Eastwood & Venables, 1982; Neary & van Wijnbergen, 1984). *This study focuses on the latter literature and on what is perhaps best known as the Dutch Disease hypothesis.*

During the 1980s there was extensive literature on the so called Dutch Disease effect, named after the problems experienced by the Dutch economy following the discovery of vast domestic reserves of natural gas and its adverse effects upon the non-resource sector. The Dutch Disease literature emphasises that resource production affects the economy, specifically during the short-run, through a number of channels including: resource movement; spending; income; and exchange rate effects (see, for example, Buiter & Purvis, 1982; Corden, 1984; Corden & Neary, 1982; Eastwood & Venables, 1982; Harvie, 1989; Neary & van Wijnbergen, 1984).

This literature was extended during the 1990s to capture long-run effects including capital stock accumulation (*an additional wealth effect*), and foreign asset stock accumulation via the current account (*a current account effect*). Furthermore, the literature has taken into account implications for adjustment arising from different
exchange rate regimes (fixed or flexible) and the identification of optimal policy responses in a dynamic context with the objective of minimising the adverse effects of a resource boom on the non-resource sector (see, Harvie, 1991; Harvie, 1992a, 1992b, 1992c; Harvie & Gower, 1993; Harvie & Maleka, 1992; Harvie, 1993; Harvie & Thaha, 1994; Harvie & Tran Van Hoa, 1994a, 1994b; Harvie & Verrucci, 1991). Moreover, given the recent turbulence in resource prices, particularly that of oil, Cox and Harvie (2010) revisited this issue again by including implications of this for government revenue, the fiscal budget and spending options.

3.3 Booming Sector and Dutch Disease Hypothesis – an Overview

The Dutch Disease refers to the situation in which a booming sector, natural resource in this case, results in an increase in the relative price of non-tradable goods to that of tradable goods, resulting in a reallocation of production factors towards the natural resource sector and harming growth in the non-resource tradable goods sector. This economic term first originated in The Economist in November 26th, 1977 (Corden, 1984). It arose from the adverse effects of natural gas discoveries in the North Sea on Dutch manufacturing in the 1960s, basically through the subsequent appreciation of the Dutch real exchange rate. Evidence of a Dutch Disease has been identified in many economies, notably that of oil-exporting economies. The initial discussion of the booming sector and Dutch Disease hypothesis will draw on that of the seminal contributions of Corden (1984), Corden and Neary (1982), Salter (1959) and Stijns (2002).

Corden and Neary (1982) developed one of the best-known economic models to analyse the Dutch Disease effects. They assumed a small open economy which produces three goods: two of which are traded with prices determined on world markets, hence
they are subject to international competition, and consists of a booming traded sector (B) and non-booming traded sector (L), and a third which is the non-traded sector (N) whose price is determined by domestic supply and demand; hence, it is not subject to international competition. The booming sector can be the oil, gas or mineral sector and the non-booming traded sector, or lagging sector as Corden (1984) named it, is typically thought to be either the manufacturing or agricultural sector\textsuperscript{24}. The non-tradable sector is usually defined as the services sector and it can be extended, as Stijns (2002) states, to include the construction sector. The real exchange rate is defined as the price of non-booming traded goods relative to the price of non-traded goods. Other assumptions underlying the analysis are that the three sectors use a common factor of production. That is one specific non-mobile factor (capital) for each sector and labour which is mobile between all three sectors and moves between them so as to equalise its wage in all three types of employment. Also, all goods are assumed to be normal. That is their income elasticity of demand is positive. The boom arises in one of three ways\textsuperscript{25}; (1) a once-for all technical improvement in the booming sector, represented by a favourable shift in the production function, (2) a windfall discovery of new resources, equivalent to a windfall of oil revenue, and (3) the booming sector produces only for export, with no sales at home, and there has been an exogenous rise in the price of this product. According to Corden and Neary (1982) the rest of the economy might be affected in two main ways: through a \textit{spending effect and resource movement effect}.

To illustrate the effects of the boom on the economy the familiar Salter diagram is used, as shown in Figure 3.1. The horizontal axis represents the output of non-tradable goods (NTG), services in this case, and the vertical axis represents the output of tradable goods (TG), including oil and non-oil tradable goods. The schedule SP represents the

\textsuperscript{24} This depends upon the stage of development of the resource abundant economy.

\textsuperscript{25} See Corden (1984).
production possibility curve (PPC) which embodies all possible combinations of tradable and non-tradable goods that can be produced with existing production factors and available technology, whilst the schedule I₀ represents society’s indifference curve which is utilised to represent aggregate demand. The initial pre-boom equilibrium in the economy is represented by point A, where the production possibility curve SP is tangential to the highest attainable indifference curve I₀. The initial relative price of non-tradable goods, i.e. the initial real exchange rate, is given by the slope of the line AP₀, which is tangent to the two curves. At the point A non-tradable goods output is OT₂ and tradable goods output is OT₁, where at the same point output or income is equal to demand or expenditure. The expansion path OY₀ reflects the demand expansion path when relative prices are held constant at AP₀, and national income increases.

Consider now the effects of an oil production (income) boom, which is equivalent to a windfall gain to the economy, assuming no domestic consumption of oil. The oil boom does not change the economy’s maximum output of non-tradable goods OS, but it raises the maximum output of tradable goods and in particular oil. Therefore, the production possibilities curve (PPC) shifts asymmetrically upward from OP to OP* on the vertical axis.

### 3.3.1 Spending effect

In order to isolate the spending effect the resource movement effect can be eliminated by assuming that the demand for labour is held constant. The boom in the oil sector shifts PPC upward to SP* and the new total production point is at A*, where AA* is oil output whereas the output of non-tradable goods and non-oil tradable goods remain at A. The point A* lies vertically above point A, and the relative price of non-tradable goods does not change as the AP₁ line is parallel to the AP₀ line.
The demand for non-oil output, in particular non-tradable goods, rises with income, moving along the income expansion path $OY_o$. Point N is a disequilibrium point since producers are willing to produce at $A^*$, but the consumer wants to consume at point N. Hence, there is excess demand for non-tradable goods by NM as output of non-tradable goods remains at point A with a relative price $AP_0$, and the excess demand for non-oil tradable goods is AM, whereas the rest of the distance $MA^*$ represents the balance of payments situation.

In order to clear the market the relative price of tradable goods to non-tradable goods must decline, i.e. the real exchange rate must appreciate, as represented by the line $AP^*$, so as to reduce the excess demand for non-tradable goods and to restore balance of payments equilibrium. The new equilibrium point will be somewhere between $A^*$ and the intersection of $SP^*$ with the line $OY_o$, for example at point D. Therefore, an increase in income arising from the oil boom increases the demand for non-tradable goods from M to N, but the appreciation of the real exchange rate lowers demand to $N^*$ resulting in a net increase by $MN^*$. This is equivalent to increasing non-tradable output by $T_2T_3$. The boom increases demand for non-oil tradable goods from A to M and the appreciation of the real exchange rate increases this further to $M^*$, which is equivalent to the decline in the non-oil tradable output $T_1T_4$. At the new relative price $AP^{**}$ which is parallel to $AP^*$ the domestic output of non-tradable goods and non-oil tradable goods moves along the production possibilities curve $SP$ to $D^*$, which is a new equilibrium of non-tradable and non-oil tradable production. Non-tradable output increases from $T_2$ to $T_3$ and non oil tradable output declines from $T_1$ to $T_4$. To cover the increased demand for non-oil tradable goods, imported non-oil tradable goods increase from D to $D^*$. 

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3.3.2 Resource movement effect

In order to isolate the resource movement effect the spending effect can be eliminated by assuming that the income elasticity of demand for non-tradable goods is zero, which implies that the income-consumption curve $OY_0$ in Figure 3.2 is a vertical line through point $A$, intersecting $SP^*$ at point $j$. As the marginal product of labour, and hence wages, has increased in the oil sector, labour is attracted from the non-tradable sector and lagging sector into the oil sector. Thus, point $B$ represents the new production point after the boom with an unchanged relative price for non-tradable goods, as $AP_1$ is parallel to $AP_0$. The overall effect is an increase in oil output and a decline in non-oil...
tradable and non-tradable outputs. Thus, at the initial real exchange rate the resource movement affect results in excess demand for non-tradable goods, as it is represented by the intersection of the $OY_0$ line with the $AP_1$ line at point C. In order to clear the market the real exchange rate must appreciate, i.e. the price of non-tradables must rise to eliminate the excess demand, switching demand away from non-tradable goods and dampening the decline in non-tradable output induced by the resource movement effect. The equilibrium following this adjustment must be somewhere between points B and J, say at point D, implying that the output of non-tradable goods is lower than that in initial equilibrium as a consequence of the resource movement effect. On the other hand the output of the non-oil tradable sector must have declined as a result of a further exchange rate appreciation.

By using one mobile factor and one specific non-mobile factor in all sectors, Corden and Neary (1982) show that both the spending effect and the resource movement effect cause a shift of the mobile factor away from the tradable sector and an appreciation of the real exchange rate. This in turn makes this sector less competitive and results in an unambiguous decline in tradable output. However, there is ambiguity regarding the change in output of the non-tradable sector. The resource movement effect implies a contraction of this sector, whilst the spending effect implies an expansion. The strength of the spending effect depends on the propensity to consume non-tradable goods, such as that from the services sector, which is usually high in resource-abundant countries (Stijns, 2002). The strength of the resource movement effect depends upon the factor intensity of each sector. If the booming resource sector is the capital intensive sector, which is the case for the Libyan economy, the resource movement effect will be dominated by the spending effect.
Corden and Neary (1982) call the decline in non-booming sector output caused by the resource movement effect alone direct de-industrialisation\textsuperscript{26}, whilst the additional decline caused by the appreciation of the real exchange rate, which in turn results from both the reduced output of the non-tradable sector and from the increased demand for non-tradable due to the spending effect, indirect de-industrialisation.

The above analysis clearly shows that there are Dutch Disease effects as indicated by the contraction of non-booming tradable output arising from a movement of production factors out of the non-booming tradable sector, and the real exchange rate

\textsuperscript{26}The term de-industrialization refers to a decline in the non-booming part of the tradeable goods sector.
appreciation induced by the booming sector revenue. This makes this sector less competitive, leading to a deterioration of the non-booming sector trade balance.

3.4 Dynamic Adjustment Processes Arising from Oil Related Shocks

Much of the theoretical literature on a booming sector and the ‘Dutch Disease’ focuses on the problem of dynamic adjustment arising from oil or resource related shocks in a small-open economy. These shocks could be in the form of increased oil production or oil price. Therefore, existing models will be investigated in this section so as to develop a dynamic general equilibrium macroeconomic model for an oil producing and exporting economy such as Libya. These contributions include that of Buiter and Miller (B-M henceforth) (1981), Buiter and Purvis (B-P henceforth) (1982), Eastwood and Venables (E-V henceforth) (1982), Neary and Van Wijnbergen (N-W henceforth) (1984), Harvie and Gower (H-G henceforth) (1993), Harvie and Thaha (H-T henceforth) (1993), and, more recently and importantly, Cox and Harvie (C-H henceforth) (2010). These represent extensions to the basic Dornbusch model (1976), incorporating features particularly arising from oil production and its related economic effects. In these models a deterministic framework is adopted in which economic agents are assumed to possess rational or forward looking expectations. This is equivalent to the case of perfect foresight. Non-financial markets are subject to sticky prices and in some models, like (H-G) and (C-H), sticky quantity adjustment, and can be in disequilibrium throughout the adjustment process. On the other hand, financial markets are assumed to be in continual equilibrium. Thus, the effects arising from oil related shocks are transmitted primarily through the financial market, and then to the product and labour markets.

The models mentioned in this section can be divided into two categories, i.e. short and long-run. Models such as B-M (1981), E-V (1982), B-P (1982), N-W (1984) can be
classified as short-run models, whilst H-G (1993), H-T (1993), and C-H (2008) are classified as medium to long-run models. Major differences between short and long-run models are that the long-run models emphasise developments in the current account, capital stock accumulation in the non-oil sector and budgetary financing requirements, and hence emphasise the longer term development of the economy. Each of these groups of dynamic models is now discussed in turn.

3.4.1 Short-run models

The key assumptions underlying the short-run models are as follows. First, the economy is assumed to be a net oil exporter and oil revenues are considered as a windfall gain, affecting the economy through the spending created from these revenues. Second, there is a non-oil domestic good which is produced domestically but consumed at home and abroad, and is an imperfect substitute for the foreign good equivalent. Third, the economy operates with a flexible exchange rate and economic agents in the foreign exchange market are endowed with rational expectations and perfect information, so that uncovered interest parity holds. Fourth, international capital mobility is perfect, and, finally, there is sluggish adjustment of prices and/or nominal wages.

3.4.1.1 The theoretical contributions of the short-run models

The approach adopted here is to analyse the key theoretical contribution of each model, and, at the same time, identify the fundamental differences and similarities between them. The major differences are summarised in Table 3.1. The E-V model is analysed first.
**E-V Model:**

Before discussing the theoretical contribution of the E-V model it may be appropriate to identify its equations. The E-V model is based on the following Dornbusch model’s equations, where all of the variables are in log form except that of the domestic interest rate \( r \) and the world interest rate \( r^* \):

\[
\begin{align*}
No^d &= a_1y + a_2(e - pn) - a_3(r - p\hat{n}) \\
m &= p\epsilon + \epsilon_2y - \epsilon_1r
\end{align*}
\]

(3.1) IS equation

Equation (3.1) identifies a standard Keynesian demand function for domestic non-oil output \( No^d \). Demand depends positively on domestic real income \( y \), the real exchange rate (nominal exchange rate \( e \) deflated by the domestic price level \( p\hat{n} \)), which is equivalent to the relative price of imported \( e \) and domestic goods \( pn \), and negatively upon the real interest rate \( r - p\hat{n} \), which is the nominal interest rate \( r \) less the domestic inflation rate \( p\hat{n} \).

Equation (3.2) represents money market equilibrium characterised by a conventional LM equation. The nominal money supply \( m \) is assumed to be fixed. The demand for real money balances (the nominal money stock \( m \) deflated by the consumer

\[
\begin{align*}
&\text{pc = } \mu_1pn + (1 - \mu_1)e \\
&\dot{\epsilon} = r - r^* \\
p\hat{n} = \psi_1(No^d - No^*) \\
No^d &= y
\end{align*}
\]

(3.2) LM equation

(3.3) Consumer price

(3.4) Uncovered interest rate parity

(3.5) Phillips curve

(3.6) Identity

27 In the Dornbusch and E-V models no distinction is made between oil and non-oil output. Hence \( No^d \) and \( y \) relate only to non oil output.
price level \( pc \) is a positive function of real income \(( y )\), representing a transactions demand, and negatively on the domestic nominal interest rate \(( r )\). It is assumed that the money market always clears, so that this equation always holds.

Equation (3.3) shows that the consumer price level is a weighted average of the domestic output price \(( pn \)\) and the import price \(( e + p^* )\), where \( p^* \) is the world price of the imported good and is assumed to be zero for simplicity.

Equation (3.4) embodies the assumption of perfect capital mobility and perfect foresight in the foreign exchange market. It assumes that in the foreign exchange market agents have rational expectations and anticipate that when the economy is out of steady state it will ultimately converge to a new steady state. Therefore, this equation holds at all dates, except those at which unanticipated shocks occur in the system. At such dates both \( e \) and \( r \) may move discontinuously.

Equation (3.5) indicates that the rate of change of the domestic non-oil goods price is represented by a non-forward looking Phillips curve. Such adjustment arises from excess demand for goods \(( No^d )\) relative to their available supply as given by the natural level of output or full employment level \(( No' )\).

Finally, equation (3.6) indicates that output demand equates with the actual production of non-oil output\(^{28}\).

The E-V model extends the basic Dornbusch model (1976) to analyse the economic effects arising from an oil discovery, incorporating rational expectations and sticky price adjustment. The major extension of the E-V model comes through an

\(^{28}\) In this model there is no supply side. Non output is entirely demand driven.
additional demand variable for non-oil goods, which is generated from oil revenue\(^{29}\) \((f)\) denominated in foreign currency\(^{30}\). This means that an oil discovery will only affect the goods market equation (3.1), and will have no influence on the money market equation (3.2). Therefore, following the oil discovery, the economy is described by equations (3.2), (3.3), (3.4), (3.5) and (3.6) as before, while equation (3.1) is replaced by:

\[
No^d = a_1y + a_2(e - pn) - a_3(r - pn) + \eta(f + e - pn)
\]  

(3.1a)

where \((f + e - pn)\) is the logarithm of the present value of future oil revenue in real domestic currency terms, and \(\eta\) the elasticity of aggregate demand with respect to oil revenue.

The essence of the results from the E-V model is that an oil discovery leads to an increase in demand for non-oil output and this in turn causes a higher price of domestic non-oil output and a lower price of the foreign good resulting in a real exchange rate appreciation. As a consequence of this the excess demand associated with oil revenue switches towards foreign goods, which means that non-oil output competitiveness is lost gradually as the economy moves towards a new steady state\(^{31}\). However, in this model, the real appreciation of the exchange rate is not accompanied by an immediate increase in the price of the domestic output, therefore the contractionary impact of the real exchange rate appreciation is not sufficient to offset the additional increase to demand generated by oil.

---

\(^{29}\) In the E-V model oil revenue is defined as the infinite term annuity value of the foreign exchange increment to national wealth.

\(^{30}\) \(f\) effectively captures the discounted present value of future income flows generated from oil production, and is, therefore, equivalent to an oil related wealth effect.

\(^{31}\) According to the E-V model the exchange rate appreciation following the oil discovery takes place only when the extra demand generated by unanticipated oil revenue occurs.
**B-M Model:**

The major difference between the B-M model and that of the E-V model is that the B-M model does not distinguish between the general and domestic price levels, i.e. $\mu_i = 1$ in equation (3.3) above. This implies that the general and domestic price levels are equivalent; hence the cost of imports has no effect on the general price level. Furthermore, the B-M model modifies the E-V model to include an oil production variable in the demand for money equation, therefore equation (3.2) above is replaced by:

$$m = pc + \varepsilon_i (y + o^a) - \varepsilon_2 r$$

(3.2a)

where $o^a$ represents actual oil production expressed as a fraction of total real income. It is also assumed to be constant, lasting only a few years and affects the demand for money by $\varepsilon_1 o^a$.

The B-M model assumes that $o^a$ takes place during time period 0-T. After T no oil production takes place, however the economy still has its permanent income from oil as a consequence of actual oil production through 0-T.

**N-W Model:**

The N-W model is identical to that of the E-V model except that oil has a direct effect on the demand for money, again through a wealth effect, besides its effect on the demand for non-oil output. Thus, the N-W model amends the E-V model by incorporating a direct wealth effect on asset markets. The N-W model amends equation (3.2) as follows:

---

32 The B-M model distinguishes between the value of current oil production $o^a$ which affects the demand for money (by $\varepsilon_1 o^a$ per cent) and lasting for only a limited period, and the permanent income value of the oil which is assumed to only affect the demand for non-oil output.
The direct wealth effect arising from an oil discovery increases the demand for money, and this, in turn, results in a greater appreciation of the exchange rate and results in a lower post-shock equilibrium price level than in the case considered by the E-V model. This indicates that the economy is in recession (i.e. $N_o^d < \overline{N_o}^e$ when $p\hat{m} < 0$) even without a spending lag. Furthermore, if there is a spending lag during the time period 0-T the N-W model shows that the recession induced by the nominal exchange rate appreciation will not be followed by a boom once spending responds at time T, but instead the recession will continue past time $T^{33}$.

**B-P Model:**

The B-P model is also based on the Dornbusch model, but it amends the Dornbusch model to capture the economic effects arising from oil related shocks such as that of an oil discovery and oil price disturbance. Unlike the E-V, B-M and N-W models the B-P model identifies that both the oil price and oil production contribute to current and permanent income as follows:

\[
y = vN_o^s + (1 - v)o^o + (1 - v - \mu_z)p_o + (\mu_1 - v)(e - p\hat{m})
\]  

\[
y^p = vN_o^{sp} + (1 - v)o^o + (1 - v - \mu_z)p_o + (\mu_1 - v)(e - p\hat{m})
\]  

where equations (3.7) and (3.8) represent real and permanent income definitions respectively, as used in the B-P model. Real income, as identified in equation 7, depends upon non-oil output ($N_o^s$), oil production ($o^o$) (assumed exogenous), the world price of oil ($p_o$), also assumed to be exogenous, and the real exchange rate as defined here.

---

33 In the E-V model the period after T is characterised by a boom ($N_o^d > \overline{N_o}^e$).
Equation (3.8) represents permanent income, which is a function of exogenous permanent non-oil output \( (No^p) \), exogenous permanent oil output \( (o^p) \), the world price of oil, and the real exchange rate.

Equations (3.7) and (3.8) are log-linear approximations to the definitions of real and permanent income given by (3.7’) and (3.8’), where uppercase symbols are the antilogarithms of the corresponding lower ones:

\[ Y = (Pn^*No^s + EPo^*O^s) / Pc \]  
\[ Y^p = (Pn^*No^p + EPo^*O^p) / Pc \]  

It is assumed that \( v = Pn^*No^s / PcY \) is the share of non-oil production in total value added. It is further assumed that \( v \) does not change as a result of oil production, is treated as being the same in real and permanent income, and is constant through time. For convenience, the B-P model defines permanent income in terms of current rather than permanent prices.

If the share of oil output in domestic real income \( (1-v) \) is larger than its share in domestic consumption \( (\mu_2) \)\(^{34}\), then the economy will be an oil exporter during its period of production. This case should be emphasised in the theoretical model for the Libyan economy.

From the above discussion the main differences and similarities between the short-run models can be identified as follows. First, the B-P model indicates that oil production contributes to both current and permanent income (see equations (3.7) and

---

\(^{34}\) The consumer price level Equation (3.3) in the E-V model is replaced by \( pc = \mu_1pn + \mu_2(e + po) + (1-\mu_1-\mu_2)e \) in the B-P model, where \( (e + po) \) is the domestic currency cost of oil (i.e. the nominal exchange rate \( e \) multiplied by the world oil price \( po \)).
(3.8), while the E-V, B-M and N-W models focus only upon the contribution of oil production to permanent income. Hence equation (3.8) is replaced by \( y^p = o^p + e + po - pn \) in the E-V, B-M, and N-W models. Second, the B-P model also distinguishes between non-oil output and real income, although no such distinction is found in the E-V, B-M, and N-W models; therefore, equation (3.7) entirely drops out from these models. Third, the B-P model is similar to that of the N-W model in that permanent income (wealth) influences demand for real money balances; however, in the B-M and E-V models wealth has no direct role to play in the determination of the demand for money (i.e. \( \epsilon_3 = 0 \)). The implications arising from this for the short-run models will be discussed further, after discussion of the long-run models. Table 3.1 provides a summary of the similarities and differences between the short-run models discussed in this sub-section.

<table>
<thead>
<tr>
<th></th>
<th>E-V</th>
<th>B-M</th>
<th>N-W</th>
<th>B-P</th>
</tr>
</thead>
<tbody>
<tr>
<td>a2 (in equation (3.1b))</td>
<td>0</td>
<td>0</td>
<td>&gt;0</td>
<td>&gt;0</td>
</tr>
<tr>
<td>( \mu_1 = 1 )</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>( \mu_2 = 0 )</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Distinction between non-oil output and real income</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>In equation (3.2a), ( y^p ) is replaced by actual oil production (( o^p ))</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Equation (3.7) is dropped</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Equation (3.8) is replaced by ( y^p = o^p + e + po - pn )</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 3.1
A Summary of the Alternative Assumptions of the Short-Run Models
3.4.2 Long-run models

The short-run models identified and discussed above are subject to two main deficiencies (Harvie, 1994). First, they ignore additional wealth effects such as foreign asset stock accumulation arising from developments in the current account. Second, they assume that oil production will have no long-run sustainable impact on non-oil output. In other words, they ignore physical capital stock accumulation in the non-oil sector. These two deficiencies, beside others, are considered in the long-run models.

The long-run models of relevance mentioned earlier are the H-G (1993), H-T (1993), and, more recently, C-H (2010) models. They extend the short-run models by adding up to six extensions. These are the inclusion of the physical capital stock, the current account, an expansion of the components of wealth, inclusion of the supply side of the economy, budgetary stance and its funding and inclusion of additional sticky quantity adjustment in non-financial markets.

The key assumptions underlying the long-run models are as follows. First, like the short-run models, they assume that the economy is an oil producer and net oil exporter. Second, economic agents are assumed to possess rational expectations with complete information, equivalent to the case of perfect foresight. Third, financial markets are assumed to be in continual equilibrium, whilst non-financial markets do not clear continuously as they are subject to sticky price and quantity adjustment\(^35\). Fourth, unlike the short-run models, four financial assets are considered in the long-run models. These are domestic money, domestic bonds, foreign bonds and equity claims on the domestic physical capital stock in the non-oil sector. The three non-money assets are assumed to be perfect substitutes. Finally, oil production is assumed to affect the economy through

\(^{35}\) The short-run models only consider price stickiness in the adjustment process.
five distinct channels. These being an income effect, a revenue effect, a spending (wealth) effect, a current account effect and exchange rate effect.

In analysing the effects of oil shocks the three models, H-G, T-H, and C-H argue that emphasis should be placed upon the long-run nature of the adjustment process. This emphasis, and hence the link between the short and long runs, can be achieved by the following model extensions. First, incorporation of capital stock accumulation in the non-oil sector, and hence investment and increased non-oil productive capacity of the economy over the long term. Second, incorporation of foreign asset stock accumulation via developments in the current account, and the inclusion of budgetary financing requirements.\(^{36}\) Equilibrium in the current account and fiscal budget is required for long-run steady state to be achieved.

The C-H model (2010) contains all the extensions mentioned above; therefore the approach adopted here is to focus upon the C-H model, then to contrast it with the H-G and H-T models. The equations of the model, where all of the variables are in log form except that of the domestic nominal interest rate \((r)\) and the world interest rate \((r^*)\), are categorised under the headings of product market, asset markets, aggregate supply and wage/price nexus, overseas sector and definitions, as shown in Table 3.2.

\(^{36}\) The incorporation of budgetary financing requirements is only considered in the C-H model.
Table 3.2: the C-H Model

**Product Market**

\[ No^d = a_1c^p + a_2i^p + a_3g + a_4T \]  \hspace{1cm} (3.1)

\[ c^p = b_1No^s + b_2w^p \]  \hspace{1cm} (3.2)

\[ i^p = k^p = \eta q \]  \hspace{1cm} (3.3)

\[ c^s = \tau^s \]  \hspace{1cm} (3.4)

\[ i^s = k^s = \varphi(k^s - k^s) \]  \hspace{1cm} (3.5)

\[ g = \beta_1c^s - \beta_2No^i + \beta_3i^g \]  \hspace{1cm} (3.6)

\[ bd = g - r^s = \sigma_1(m - pc) + \sigma_2(b - pc) \]  \hspace{1cm} (3.7)

\[ r^s = \gamma No^s + (1 - \gamma)(o^p + po + e - pc) \]  \hspace{1cm} (3.8)

\[ T = \lambda_1(e - p^* - pc) - \lambda_2y + \lambda_3y^* \]  \hspace{1cm} (3.9)

\[ y = \nu No^s + (1 - \nu)o^p + (1 - \nu - \mu_1)(po + (\mu_1 - \nu)(e - w)) - (1 - \mu_1 - \mu_2)p^* \]  \hspace{1cm} (3.10)

\[ y^p = \nu No^{sp} + (1 - \nu)o^p + (1 - \nu - \mu_2)po + (\mu_1 - \nu)(e - w) - (1 - \mu_1 - \mu_2)p^* \]  \hspace{1cm} (3.11)

**Asset Market**

\[ m - pc = \varepsilon_1y - \varepsilon_2r \]  \hspace{1cm} (3.12)

\[ R = \theta_1No^s - \theta_2k^p + \theta_3k^g \]  \hspace{1cm} (3.13)

\[ \dot{q} = \delta^{-1}_3[q - \delta_1R + \delta_2(r - \bar{m})] \]  \hspace{1cm} (3.14)

\[ w^p = \Omega_2(f + e - pc) + \Omega_3(k^p + q) + \Omega_4(m - pc) + \Omega_5(b - pc) + \Omega_6y^p \]  \hspace{1cm} (3.15)

\[ \bar{m} = \tau(\bar{m} - m) \]  \hspace{1cm} (3.16)

**Aggregate Supply and Wage/Price Nexus**

\[ pc = \mu_1w + \mu_2(e - po) + (1 - \mu_1 - \mu_2)(e - p^*) \]  \hspace{1cm} (3.17)

\[ \dot{w} = \psi_1(No^d - \overline{No}^d) + \psi_2\bar{m} \]  \hspace{1cm} (3.18)

\[ No^i = \phi_1k^p + \phi_2k^g - \phi_3(w - pc) \]  \hspace{1cm} (3.19)

**Overseas Sector**

\[ \dot{f} = \alpha_1T + \alpha_2r^*f + \alpha_3(o^s + po) - (1 - \alpha_2 - \alpha_3)(e - pc) \]  \hspace{1cm} (3.20)

\[ o^* = \zeta(o^* - \overline{y}) \]  \hspace{1cm} (3.21)

**Definitions**

\[ c = e - w \]  \hspace{1cm} (3.22)

\[ l = m - w \]  \hspace{1cm} (3.23)
\[ B = b - w \]  
\[ \dot{e} = r - r^* \]

A dot above a variable signifies its rate of change.

The notation utilised here is the same as that for the short-run models. The model consists of 26 endogenous variables and 10 exogenous variables. The endogenous variables are: real income \((y)\), permanent income \((y_p)\), aggregate demand for non-oil output \((No^d)\), the nominal exchange rate \((e)\), domestic price level \((pc)\), nominal domestic interest rate \((r)\), real exchange rate \((c)\), real money balances \((l)\), wage rate \((w)\), which is equivalent to that of \((pn)\) used in the short run models, non-oil output supply \((No')\), domestic private sector wealth \((w^p)\), private capital stock \((k^p)\), public capital stock \((k^s)\), private investment \((i^p)\), government investment spending \((i^s)\), foreign asset stocks \((f)\), Tobin’s \(q\) \((q)\), real profit \((R)\), total government expenditure \((g)\), non-oil trade balance \((T)\), private consumption spending \((c^p)\), government consumption spending \((c^g)\), total tax revenues \((t)\), nominal domestic bonds \((B)\) and net oil exports \((o^+).\) The exogenous variables are: actual oil production \((o^a)\), permanent oil income \((o^p)\), oil price \((po)\), world price level of the non-oil good \((p^*)\), permanent non-oil income \((No^{p})\), desired government consumption expenditure \((\bar{c}^g)\), desired public capital stock \((k^{s*})\), the money stock \((m)\), and the world nominal interest rate \((r^*)\) as in the short-run models, and the rest is: world real income \((y^*)\). The parameter in front of each variable indicates its partial elasticity.

The product market equilibrium consists of eleven equations, which are represented by equations \((3.1) - (3.11).\) Equation \((3.1)\) describes the total demand for non-oil output \((No^d)\) as comprising private consumption expenditure \((c^p)\), investment
spending \((i^p)\), government spending \((g)\) and the non-oil trade balance \((T)\). Equation (3.2) indicates that private consumption spending \((c^n)\) depends positively upon the production of non-oil output and private sector wealth. Equation (3.3) indicates that private investment spending, which equals the change in the stock of private capital, is determined by Tobin’s \(q\) ratio. Government spending, equation (3.4), shows that government consumption expenditure is assumed to be exogenous.

Equation (3.5) describes government investment spending, which arises from a gradual adjustment of the actual public capital stock to its policy determined level. Total government spending \((g)\) is identified by equation (3.6). It depends positively on two components of expenditure; government consumption expenditure \((c^g)\) and government investment expenditure \((i^g)\), and depends negatively on the supply of non-oil output\(^{37}\).

Equation (3.7) identifies the budgetary stance, which is government expenditure \((g)\) less tax revenues \((t^*\)). It shows that the budget deficit can be financed in two ways, through money accommodation or government liabilities (bonds). Tax revenues are generated from two sources, non-oil production and oil production (equation (3.8)). Equation (3.9) specifies the non-oil trade balance, which depends upon the real exchange rate \((e - p^* - pc)\), domestic real income and world real income \((y^*)\).

Real and permanent income definitions, as first used by Buiter and Purvis (1982), are shown by equations (3.10) and (3.11). Real income, as identified in equation (3.10), depends upon non-oil output \((No^*)\), oil production \((o^\prime)\) that is assumed exogenous, the world price of oil \((po)\) that is also exogenous, the real exchange rate as emphasised here

\(^{37}\) It is worth noting here that there is another part of government consumption expenditure which depends upon the supply of output. This arises due to social welfare spending. When output is high, unemployment is low and therefore welfare expenditure is low and vice versa.
and the exogenously determined price of non-oil imported goods ($p^*$). Equation (3.11) represents permanent income, which is a function of exogenous permanent non-oil output ($No^p$), exogenous permanent oil output ($o^p$), the world price of oil, the real exchange rate and price of non-oil imported goods (see also Harvie, 1993).

Asset market equilibrium is given by equations (3.12) – (3.16). Four financial markets are addressed in this model, these being domestic money, domestic bonds, foreign bonds and equities which determine the $q$ ratio. The three non-money assets are assumed to be perfect substitutes with arbitrage between them resulting, instantaneously, in the same expected real rate of return. The conventional money market equilibrium, abstracting from permanent income or wealth, is identified by equation (3.12), in which the demand for real money balances depends upon real income and the nominal interest rate.

Equation (3.13) represents the real return on private capital, which depends positively on the level of non-oil production (as measured by output supply), negatively on the stock of private capital due to diminishing marginal returns, and positively on the stock of public capital. The latter holds true because public and private capital are assumed to be complementary in nature.$^{38}$

The change in Tobin’s $q$ ratio is identified by equation (3.14). As mentioned above the three non-money assets are assumed to be perfect substitutes with arbitrage between them resulting instantaneously and continuously in the same expected rate of return. The real return on foreign bonds, in domestic currency terms, is equivalent to $r^*+\dot{e}-\dot{\pi}$, which must equate continuously with the return on domestic bonds $r-\dot{m}$ (for example Harvie & Gower, 1993; Harvie & Thaha, 1994).

\[ r - \dot{m} = r^* + \dot{\varepsilon} - \dot{\pi} \]

where \( \dot{m} = \dot{\pi} \) represents inflationary expectations.

These expected rates of return will be equated instantaneously, through arbitrage, with the expected real return on domestic equities. Equities are assumed to be held only domestically. The expected real return on holding equities is given by equation (3.14a):

\[ \dot{q} / q + R / q \]

(3.14a)

where \( q \) is the value (real) of these equities, and \( R \) the real profit stream derived from capital services as given by equation (3.13). That is the expected return depends upon the expected capital gain/loss from holding equity capital \( \dot{q} / q \), where \( \dot{q} = 0 \) in steady state, plus \( R \) relative to \( q \). Continual and instantaneous arbitrage between the three non-money assets implies:

\[ \dot{q} / q + R / q = r - \dot{m} = r^* + \dot{\varepsilon} - \dot{\pi} \]

(3.14b)

By ignoring capital gains/losses, this must be equivalent to \( r - \dot{m} \), and taking a log linear approximation to solve for \( q \), the following can be obtained:

\[ q = \delta_1 R - \delta_2 (r - \dot{m}) + \delta_3 \dot{q} \]

(3.14c)

Or rearranging, and solving for \( \dot{q} \), equation (3.14) can be obtained.

Domestic private sector real wealth is given by equation (3.15), depending positively on the real domestic currency value of domestically held foreign assets (bonds), on the real value of the capital stock held by the private sector, consisting of a physical quantity \( k \) and its market valuation \( q \), on real money balances, on real bond
holdings\(^{39}\) and permanent income (oil wealth). Equation (3.16) shows the money growth equation, which is the difference between the policy targeted money supply and the current money supply.

Equations (3.17)-(3.19) define the wage/price nexus and aggregate non-oil output supply. Equation (3.17) defines the domestic price level, which is a weighted average of nominal wage cost, the domestic cost of oil and the domestic cost of the world non-oil imported good. Equation (3.18) indicates that the adjustment of the nominal domestic wage is generated by an expectations augmented Phillips curve. Such adjustment arises from excess demand for non-oil goods relative to its available supply, as given by its natural level of output or full employment level, and inflationary expectations. Equation (3.19) shows that aggregate non-oil output supply, derived from a simple production function relationship, depends positively on the private capital stock, public capital stock (see Aschauer, 1989), and negatively on the real wage rate.

The overseas sector consists of the current account and the oil trade balance. Developments in the current account are given by equation (3.20a) (see Harvie, 1994; Harvie & Gower, 1993).

\[
\dot{f} + e - pc = \alpha_1 T + \alpha_2 (r^* f + e - pc) + \alpha_3 (o^* + po + e - pc)
\] (3.20a)

where \((o^*)\) represents net exports of oil. Rearranging (3.20a) and expressing this in terms of foreign asset (bond) holdings, equation (3.20) is obtained. This shows that changes in domestic holdings of foreign assets, as reflected in the current account balance \((f)\), depends positively upon the trade balance \((T)\), foreign interest income \((r^* f)\), net oil exports and on the real exchange rate \((e - pc)\). In long-run steady state the current

\(^{39}\)This variable is not included in the private sector wealth equation in the H-G and H-T models.
account balance must be zero, otherwise further wealth effects will arise requiring further macroeconomic adjustment (Harvie, 1994; Harvie & Gower, 1993). Net oil exports are identified by equation (3.21). It indicates that net oil exports depend positively upon the actual production of oil and negatively upon domestic real income.

Finally, equations (3.22)-(3.25) contain definitions utilised in the model. Equation (3.22) defines the real exchange rate, equation (3.23) defines real money balances, equation (3.24) defines real bond balances, and equation (3.25) defines the uncovered interest parity condition.

From the equations of the C-H model, the major differences between the C-H, H-T and H-G models can be identified as follows:

1. The first distinction can be found in equations (3.1) and (3.2). The C-H model incorporates private consumption expenditure as depending on non-oil output and private wealth, which has a direct effect upon the demand for non-oil output. However in the H-T and H-G models private consumption expenditure has no direct role to play in the determination of the demand for non-oil output.

2. Both the C-H and H-T models incorporate an equation for total government spending, and they also distinguish between routine or consumption government expenditure and development expenditure. The demand for domestic non-oil output can be stimulated by consumption expenditure, whereas the demand and supply side can be enhanced by development expenditure. No such thing is found in the H-G model.

3. The link between the short and long-run in the C-H model is found from capital stock accumulation in the non-oil sector, foreign asset stock accumulation via
developments in the current account, and the requirement that the budget must be in balance in steady state. However, budgetary financing requirements is not considered in either the H-G or H-T models.

3.4.3 Fundamental differences and similarities between the basic models

Harvie (1994) conducted a comparative simulation analysis of the E-V, N-W, B-M, B-P and H-G models by imposing numerical values upon the coefficients of the models. Also, Cox & Harvie (2010) and Harvie & Thaha (1994) conducted a numerical simulation analysis of their long-run models. A program known as “Saddlepoint”, developed by Austin and Buiter (1982), was used to generate such numerical simulations. This programme was designed for solving linear rational expectations models with constant parameters. It is the continuous time analogue of the solution to linear difference equation models with rational expectations studied in Blanchard and Kahn (1980). The dynamic stability of each model is a necessary condition before conducting the simulations. That is, the control variables must adjust in a fashion which is consistent with the underlying behavioural assumptions of the model.

Harvie (1994) conducted three oil shock simulation scenarios, with a 10 percent increase from base level assumed in each scenario. These are an increase in permanent oil output (wealth), an increase in oil production and an increase in the price of oil. Also, Harvie and Thaha (1994) conducted various oil shock simulation scenarios based upon an increase of oil production and the oil price. Moreover, Cox and Harvie (2010) conducted two simulations relating to increases in the oil price. The first case is an immediate and permanent increase in the price of the resource by 10 percent and the second case is a transient and gradual increase in the resource price. One oil shock

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40 This programme is based upon the solution provided by Blanchard and Kahn (1980) for systems of linear difference equations.
simulation scenario is highlighted here, that of a 10 percent increase in the oil price \((p_o)\). The analysis emphasised the adjustment of a number of key macroeconomic variables including that of the real exchange rate \((e)\), real income \((y)\), non-resource output \((N_o^*)\), physical capital stock \((k)\), foreign asset stock \((f)\), the non-oil trade balance \((T)\), domestic private sector real wealth \((w^\rho)\) and price level \((p_c)\). The steady state results\(^{41}\) derived for a 10 percent increase in the oil price are presented in Table 3.2\(^{42}\).

Table 3.3 summarises the directional change from an initial equilibrium to the new steady state, resulting from a 10 percent increase in the world oil price. All dynamic models suggest an appreciation of the real exchange rate in steady state, leading to a loss of competitiveness for non-oil exports. That is, the existence of Dutch Disease consequences is possible from this result.

In the short-run models, with the exception of the B-P model, non-oil output, which is equivalent to real income, remains unchanged, whilst the long-run models show an increase in real income due to the accumulation of physical capital stock. The latter models suggest a higher level of non-oil output in steady state. Only the C-H model departs from this result, where it suggests that non-oil output is adversely affected by a decline in the capital stock, a lower \(q\) ratio and reduced returns on the capital stock (Cox & Harvie, 2010).

The physical capital stock, foreign asset stock, non-oil trade balance, and domestic private sector real wealth are not included in the short-run models and therefore they have nothing to say about these. However, the long-run models include these variables and suggest that the positive oil price shock results in an accumulation of

\(^{41}\) See Cox & Harvie (2010), Harvie (1993), and Harvie & Thaha (1994).
\(^{42}\) These results were derived through numerical simulations. Thus, they are sensitive to the numerical values used in the simulations.
physical capital stock and foreign asset stock, which contributes to an accumulation of domestic private sector real wealth. In addition, they suggest a deterioration in the non-oil trade balance due mainly to an appreciation of the real exchange rate.

Both the short- and long-run models show that an increase in the world price of oil has no sustained impact upon inflation.

Table 3.3
A Summary of the Steady States Properties of the Models
The Case of a 10% Increase in the Oil Price

<table>
<thead>
<tr>
<th>Variables</th>
<th>c</th>
<th>y #</th>
<th>No^s</th>
<th>k</th>
<th>T</th>
<th>f</th>
<th>w^e</th>
<th>(\dot{p})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-run models</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-V</td>
<td>-</td>
<td>?</td>
<td>0</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>0</td>
</tr>
<tr>
<td>B-P</td>
<td>-</td>
<td>?</td>
<td>0</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>0</td>
</tr>
<tr>
<td>Long-run models</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H-G</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>H-T</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>C-H</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes:
- Increase (depreciation) of the variables
- Decrease (appreciation) of the variables
? Change in the variable is not known, as not explicitly identified
# A distinction between y and No\^s is not made in the B-M, E-V, and N-W models, as they placed emphasis upon the demand for non-oil output (No\^d)

Sources:

To sum up, the adjustment process derivable from the short-run models diverges from that of the long-run models. That is, the incorporation of capital stock accumulation in the non-oil sector, and hence investment and development of the economy over the long term, and incorporation of foreign asset stock accumulation via developments in the
current account and budgetary financing requirements, significantly extend the period of time over which the new steady state equilibrium is achieved.

### 3.5 Possible amendments for the Libyan economy

The basic models discussed above, particularly the long-run models of H-G, H-T and C-H, are able to identify the influences of oil production and price shocks upon key macroeconomic variables such as the real exchange rate, real income, non-oil output, capital stock, oil and non-oil trade balances, foreign asset stock, wealth and domestic price level. Throughout the adjustment process some of these macroeconomic variables might be better or worse off than in the steady state equilibrium. For that reason, awareness of the consequences of the adjustment process may be important to economic units such as government, producers and consumers in order either to know the potential benefits from an oil boom or to avoid its adverse effects. These implications are particularly important for a developing country such as Libya, which depends heavily upon the oil sector.

The long-run dynamic macroeconomic models, in particular that of the C-H model, are quite analogous to developed economies such as that of Australia and the UK. However, such models need to be amended to be more applicable for the analysis of the case of a net oil-exporting developing economy like Libya. That is, various amendments are required to this model in order to make it more applicable to the case of the Libyan economy, particularly to analyse the impact of oil related shocks on macroeconomic variables, and identifying optimal policies that can be implemented by policymakers to mitigate the impact of exogenous oil related shocks. There are four major amendments required for the case of Libya.
1. The majority of oil production and its revenue is produced and generated by government owned entities. Therefore, the government is assumed to allocate all of the oil production for either domestic usage or export, and spends the oil revenue in the form of consumption and investment expenditure. The latter expenditure being equivalent to government investment spending upon physical capital stock and human capital stock, which is anticipated to enhance the productivity potential of the private sector, and, hence, stimulate non-oil output supply.

2. The earlier models assume that domestic private sector wealth plays an important role through its effect upon the demand for both financial assets and non-oil output. Such an assumption may not be appropriate for the Libyan economy. In particular in terms of the influence of the private sector upon the supply side, as the public sector has dominated economic activities since the early 1970s.

3. As in most developing economies, both financial and capital markets are highly controlled by the monetary authority. The Libyan economy has experienced both fixed and managed floating exchange rates. However, the former has remained without any noticeable change over most of the period of study. At the same time the monetary authority exercises control over the domestic interest rate. Thus the assumption of perfect capital mobility is not fully appropriate for the Libyan economy.

4. As in the C-H model the budget stance should be incorporated in the Libyan model, and emphasis should be placed upon money accommodation (pure monetary policy) to finance the budget deficit. As mentioned in the previous chapter the government resorted to printing money as a result of the absence of an
effective private sector, the inefficiency of public enterprises, and the expansion of the public sector.

5. Finally, Libyan oil exports have been a major source of foreign exchange and such revenue can play another crucial role in the economic development process by financing various imports, particularly capital imports, technology and services essential to economic development. Therefore, it is assumed that oil revenue will have a further long-run sustainable impact upon non-oil output growth through providing the foreign exchange required for financing capital imports.

The details of these amendments, amongst other assumptions, and the development of the model for the Libyan economy, will be further discussed in the next chapter.

3.6 Summary and conclusions

In summary, this chapter has reviewed the literature analysing the macroeconomic adjustment process of key macroeconomic variables arising from resource (oil) related shocks, concentrating on both a static and dynamic analysis. It has presented a basic model that can be used to develop a general equilibrium macroeconomic model for a net oil-exporting economy such as Libya with suitable amendments for a developing economy.

In general, the key outcome from both the static and dynamic studies presented in this chapter is that Dutch Disease effects arising from resource related shocks appear in resource abundant economies. Regarding the static analysis the well-known economic model developed by Corden and Neary (1982) was considered. It can be utilised to
analyse the booming sector and Dutch Disease hypothesis, in particular for the case of resource abundant economies like Libya. It clearly suggests that there are Dutch Disease effects as indicated by the contraction of non-booming tradable output arising from movement of production factors out of the non-booming tradable sector, and the real exchange rate appreciation induced by the booming sector revenue, which in turn makes this sector less competitive resulting in a deterioration of the non-booming trade balance.

The dynamic models considered here were divided into two categories; short-run and long-run models. Regarding the short-run models the contribution of each model was discussed, and then the fundamental differences and similarities between the short-run models were taken into account. The models considered are the B-M, E-V, N-W, and B-P models. Afterwards, the long-run model developed by Cox and Harvie (2010) was outlined and then contrasted and compared with the H-G and H-T models. Both the short and long dynamic models show the adjustment process of the economy towards steady state equilibrium in response to an oil related shock, whereas this is obviously not possible with a static model. A dynamic framework is more useful for policy analysis.

The major difference between the short- and long-run models is that the short-run models ignore additional wealth effects, such as from foreign asset stock accumulation arising from developments in the current account. Also, they ignore capital stock accumulation in the non-resource (oil) sector, which means that resource (oil) production will have no long-run sustainable impact on the non-resource sector. These two deficiencies were considered in the long-run models, and this in turn resulted in a divergence in the adjustment process derived from the short-run models from those derived from the long-run models. The analysis suggests that with the inclusion of the physical capital stock, foreign asset stocks, and budgetary financing requirements the
effects of the resource (oil) related shocks upon the key macroeconomy variables are greater, and are more useful for policy analysis than are the short-run models. During the adjustment process some of these macroeconomic variables might be better or worse off than in the steady state equilibrium. Therefore, knowledge of the consequences of the adjustment process during the long term is important to the government and economic agents to identify alternative policies that can be implemented in order to overcome some of the undesirable features of the adjustment process, and thereby boost the benefits from resource (oil) related shocks.

A dynamic and long-run model, in particular that of the C-H model, is the most appropriate for analysis of the economic effects of oil related shocks upon the Libyan economy. The assumptions underlying such a basic model regarding domestic private sector wealth, financial and capital markets, interest rate and exchange rate can be amended to make it more applicable for the analysing of the case of a net oil-exporting developing economy like Libya. This will be conducted in the following chapter.
Chapter 4

Theoretical Framework and the Macroeconomic Model for Libya

4.1 Introduction

Having presented the characteristics of the Libyan economy and the basic theoretical framework in Chapters 2 and 3, the main objectives of this chapter are to develop a long-run and dynamic model for the Libyan economy in order to analyse the effects of oil related shocks, and to identify its key underlying assumptions. The model will explicitly incorporate the fundamental features of the Libyan economy as highlighted in Chapters 2 and 3. The model emphasises the long term nature of the dynamic adjustment process, recognising the contribution of the oil sector, and in turn oil revenues, to the development of the Libyan economy. The economic variables emphasised are those of real income, real oil income itself, non-oil output, private physical capital stock, public physical capital stock, human capital stock, imported capital stock, foreign asset stock, non-oil trade balance, real exchange rate, the domestic inflation rate and private sector real wealth. The oil related macroeconomic model adopted here for the Libyan economy has its foundation in the C-H model for the case of a flexible exchange rate (see Chapter 3). Thus, the approach of this model will be similar to that of the C-H model, however; estimation of the C-H model requires relevant data, some of which may not be readily available for the Libyan economy. As a consequence proxy variables will be used where necessary.

The model developed here is based upon key characteristics of the Libyan economy. These being as follows: a net oil exporting economy, the existence of a fixed nominal exchange rate without any noticeable change for a long time, changing to a managed floating exchange rate with the recent development of the economy, a high
degree of control over international capital mobility by the monetary authority and control of the interest rate, the domination of the government over the economy, the importance of government spending of oil revenue either upon investment or consumption and the weak contribution of the private sector in economic activities.

The model developed is capable of incorporating alternative government policy responses toward the allocation of oil production for either domestic usage or export, the spending of the oil revenue either upon consumption or investment, and budget financing. The spending of oil revenue, in particular development expenditure in the form of government investment spending upon infrastructure, human capital formation and technology acquisition, is a key policy issue, which has important implications for the development of the Libyan economy.

The model is also capable of incorporating different degrees of control over the capital market, along with the adoption of either a fixed or flexible exchange rate regime. These are highly relevant for the Libyan economy which has experienced considerable development since it started its transition to a market economy in 2002, and through its gradual integration into the global market economy.

This chapter is structured as follows; section 4.2 discusses in detail the assumptions underlying the model. Section 4.3 presents the model developed for the Libyan economy, which consist of five subsections; product market, asset market, aggregate supply and prices nexus, overseas sector, and definitions. Section 4.4 presents alternative versions of the basic model. Section 4.5 describes limitations of the theoretical model, while section 4.6 provides specific summary and conclusions derivable from this chapter.
4.2 The Assumptions underlying the model

The assumptions underlying the theoretical model are discussed in this section, and can be summarised as follows: the model is dynamic and focuses upon the long-run; economic agents possess forward looking or rational expectations with complete information, equivalent to the case of perfect foresight; the economy is an oil producer and net oil exporter; the domestic economy produces one composite non-oil good that can be consumed domestically and is an imperfect substitute for the imported good; oil production is assumed to affect the economy through five distinct channels. These being an income effect, revenue effect, a spending (wealth) effect, a current account effect, and real exchange rate effect. These assumptions are similar to that of the C-H model (2010), and will, for that reason, not be discussed further here.

However, a number of amendments to the C-H model are required in order for it to be more applicable for the analysis of the case of Libya. These are as follows:

First, the majority of oil production and its revenue is produced and generated by government owned entities; hence oil production and revenue generated from this production is under government control. Therefore, only non-oil production takes place principally in the private sector, generating what is equivalent to private sector real income. This assumption is considered as the first extension to the C-H model which was discussed in Chapter 3. Most significantly, this assumption has important implications for modelling the oil boom effects on an economy such as Libya.

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43 The non-oil good produced domestically is a composite good that can be consumed domestically or exported. It consists of both non-oil tradable goods and non-tradable goods. For simplicity, these two goods are combined as in other theoretical models (e.g. the H-C model, the H-T model, and the C-H, model).

44 It is worth mentioning here that even the majority of non-oil output is generated by the public sector.
In this model oil production for either domestic usage or export is assumed to be allocated by the government, and spending of the oil revenue is assumed to be in the form of consumption and investment expenditure and determined by the government as well. Consumption spending stimulates aggregate demand for domestic non-oil output. Government investment spending on physical capital, human capital and imported capital are likely to benefit the private sector due to the fact that public capital spending on infrastructure results in substantial external positive effects by reducing the costs of private production, and hence raising the productivity of private factors of production (Aschauer, 1989a, 1989b; Morrison & Schwartz, 1996), stimulating both aggregate supply of non-oil output and aggregate demand for non-oil output. That is, on every occasion the government raises (lowers) its investment\textsuperscript{45}, there will, accordingly, be a direct rise (fall) on the demand side, as well as indirect increase (decrease) in the supply side of non-oil output due to additional physical, human capital and imported capital stock from the flow of investment. The allocation of the oil revenue to either consumption or investment expenditure is mainly politically determined, and in the context of this model is assumed to be exogenous. Alternative spending options can be adopted to enhance the level of aggregate demand for non-oil output, and aggregate supply of non-oil output.

Other benefits from the oil sector also directly arise from the foreign exchange generated from oil exports, as it embodies the majority of total exports, and also indirectly via the spending of oil revenue. These will have further implications for non-oil output, foreign asset stocks and private sector real wealth.

\textsuperscript{45} For the case of Libya the government increases (decreases) its investment with increases (decreases) in the oil price. See Table 2.3 in Chapter 2.
Second, another major assumption, as in the C-H model, is found in the dynamic long-run nature of the framework. It is assumed that the oil sector, during its production and boom periods, will have a long-run sustainable impact on non-oil output. The oil boom generates both physical capital stock accumulation in the non-oil sector and human capital stock accumulation which are induced by government capital expenditure, foreign asset stock accumulation via developments in the current account, acquisition of technology through capital imports, and budgetary financing requirements via the tax revenues generated from oil production. This will essentially contribute to boosting the productivity capacity of non-oil output, in particular in the post oil boom period. *The inclusion of human capital and imported capital stock are considered as a second amendment to the C-H model*, and of the other models discussed in Chapter 3.

Allocation of the oil revenue between government consumption and investment spending in the form of government investment spending upon physical capital, human capital and foreign capital stock, along with the distribution of oil production between domestic usage and for exports are principally politically determined, and in the context of the model are assumed to be determined by government. These suggest two policy issues which will be simulated and analysed in Chapter 7. That is, alternative spending options of oil revenue between investment spending and consumption spending, as well as the allocation of oil between domestic usage or for export, allow the identification of suitable policies that would enhance the level of aggregate demand for non-oil output and aggregate supply of non-oil output, and hence reduce the possible Dutch Disease effects and maximise the benefits from an oil boom.

Third, the model developed assumes that the nominal exchange rate is fixed, since it has remained noticeably unchanged over most of the period of study, and
international capital mobility is highly controlled by the government\textsuperscript{46}. As a consequence of this, international capital mobility is considered to be negligible in the base model. Under a fixed nominal exchange rate regime the exchange rate is not capable of adjusting so that capital flows will have an effect upon foreign exchange reserves. As a result, the nominal exchange rate is exogenous, and growth of the money stock is endogenous. Thus, the domestic price level will be influenced by the difference between non-oil output demand and supply, and growth of the money stock. \textit{This is the third amendment of the C-H model.}

The assumption of a fixed exchange rate combined with zero capital mobility will be relaxed later with the aim of conducting equivalent simulations under a flexible nominal exchange rate policy, combined with perfect international capital mobility. This will allow the identification of appropriate policies and their implications for the adjustment process arising from oil shocks for Libya. Under a flexible nominal exchange rate regime the exchange rate is capable of adjusting so that the balance of payments is balanced. As a consequence the nominal exchange rate is endogenous, and growth of the money stock is exogenous. Therefore, the domestic price level will only be temporarily influenced by the difference between non-oil output supply and demand.

Fourth, in the C-H model there are assumed to be four financial assets available in the economy. These are domestic money, domestic bonds, foreign bonds and equities. The equities represent claims to the ownership of the physical capital stock used in the non-oil sector. In the case of Libya there is assumed to be only one financial asset

\textsuperscript{46} Libyan financial markets are immature and still in the process of being liberalised, as the Libyan economy only started its transition to a market economy in 2002. The monetary authority still exercises control over the domestic interest rate, as the interest rate was only changed in February 2004, the first change since 1994, (IMF, 2005). IMF Staff advice to the monetary authority in 2005 was to ease interest rate controls with the aim of full liberalisation of Libyan interest rates.
available in the economy, which is a money asset. This assumption is due to the immaturity of financial assets in the economy and the lack of data on additional financial assets.

Fifth, the earlier models assume that the domestic private sector plays an important role through its effect upon the demand for both financial assets and non-oil output. Such an assumption may not be appropriate for the Libyan economy. In addition, the influence of the private sector upon the supply side is also limited, as the public sector has dominated economic activities since the early 1970s. In the early 1970s all foreign companies, including those operating in the oil industry were nationalised, and most productive sectors such as heavy industry, the agricultural sector, banking sector and services sector were also nationalised (Fayad, 2000). Moreover, macroeconomic policies from the early 1970s to the mid 1990s imposed several restrictions upon the private sector, such as laws relating to the banning of rent and private ownership. In brief, government became the unique investor and producer of goods and services in the economy. Hence the public sector has played a crucial role though its dominance upon economic activities during the period of study.

However, due to modest oil prices and the negative impacts of the USA trade embargo and UN sanctions imposed upon the economy in the 1980s and 1990s, respectively, the authorities realised the need for reform and to reduce the role of the public sector and the size of the government deficit. They recognised the limitations of state-led development financed by oil revenue, and also recognised that the economy would not generate sufficient growth to absorb growth of the labour force. As a consequence, they sought solutions on how to promote private sector activities in the
economy (IMF, 2003). As a result, since the suspension of UN sanctions in 1999\(^47\), the Libyan government has engaged in substantial deregulation and development of the private sector, and started a privatisation programme. Nevertheless, the pace and effectiveness of these reforms has been slow.

Sixth, as in the C-H model, the budget stance is incorporated in the Libyan model, with emphasis placed upon money accommodation (pure monetary policy) to finance budget deficits as well as sales of government bills and securities to the Central Bank of Libya (borrowing from the central bank of Libya). As mentioned in Chapter 2 the government resorted to printing money as a result of the absence of an effective private sector, the inefficiency of public enterprises, and expansion of the public sector.

Seventh, as discussed in Chapter 2, Libyan oil exports have been a major source of foreign exchange, and such revenue can play another crucial role in the economic development process by financing various imports, particularly capital imports, technology and services essential to economic development. It is worth mentioning that capital imports, which comprise capital goods and raw material goods, increased during the oil boom periods (the period of the late 1970s and early 1980s, and then since 2000). This can be attributed to the vastly ambitious development programme conducted by government during these periods. Therefore, it is assumed that oil revenue will have a further long-run sustainable impact upon non-oil output growth through providing the foreign exchange required for financing capital imports\(^48\). Thus, capital imports are included in the aggregate supply equation for non-oil output. The inclusion of capital

\(^{47}\) UN sanctions were suspended in April 1999 and finally lifted in September 2003 after Libya accepted responsibility for the Lockerbie bombing.

\(^{48}\) Capital imports constitute more than 65% of the total imports of the Libyan economy (see CBL, 2005).
imports in the aggregate supply of non-oil output equation is considered as a fourth amendment and contribution to the C-H model discussed in the previous chapter.

Eighth, the model emphasises both the demand and supply of non-oil output, as in the C-H model. The long-run nature of the model indicates that non-oil output supply is not fixed (at some natural level), but can vary with both private and public physical capital stock, human capital stock and imported capital stock accumulation/decumulation in the non-oil sector. Developments in the supply of non-oil output can be interpreted to represent a change in the potential output supply in this sector.

Ninth, the non-oil export and non-oil import equations, rather than only the non-oil trade balance equation, will be modelled. The reason for conducting this is to examine the major factors influencing non-oil exports and imports, rather than only the non-oil trade balance. Furthermore, the non-oil import equation will be disaggregated into non-oil capital imports and non-oil consumption imports in order to examine the influence of non-oil capital imports on non-oil output supply. This can be considered as the Fifth Amendment to the C-H model discussed in the previous chapter.

Tenth, the model assumes a deterministic framework, in which economic agents possess rational or forward looking expectations and complete information, as in the C-H model. This is equivalent to the case of perfect foresight. Such an assumption implies that economic agents are rational and do not make consistent forecasting errors. Non-financial markets do not clear continuously, since they are subject to sticky price and quantity adjustment. This assumption can be justified on the basis of the existence of adjustment costs. On the other hand, financial markets are assumed to be in continual equilibrium. That is, financial variables can make discontinuous jumps so as to ensure
such financial equilibrium\textsuperscript{49}. In the C-H model, such sticky adjustment in non-financial markets can rise from both sticky prices, such as nominal wages, and quantity adjustment. In the case of Libya the assumption of sticky wage adjustment may not be important as wages and salaries are fixed by Law No.15 declared by the government in January 1981\textsuperscript{50} (see section 2.5.4.2), and also the labour market is not explicitly modelled here\textsuperscript{51}. Therefore, the lack of physical capital, human capital and technology, and hence the stickiness of their adjusting to increase production in the domestic market are more important. Consequently, physical capital stock, human capital stock and technology acquisition, which is represented by capital imports, are explicitly modelled, and hence they are constraints to the development of non-oil output. The development of non-oil output will subsequently be associated with the accumulation/decumulation of the physical private capital stock, physical public capital stock, human capital and imported capital stock.

Finally, oil developments affect the Libyan economy through six distinct channels. These are an income effect (arising from the production of oil itself), a revenue effect (arising from revenue generated by government owned entities), a spending effect (arising from current and future income (wealth) generated from the production of the oil, with the latter described as permanent oil revenue), a current account effect (arising from an increase in oil exports), the real exchange rate effect, as in the C-H model, and a technology acquisition effect (arising from imported capital). The spending effect will not only influence the economy through government investment spending upon the

\textsuperscript{49} The assumption of rational expectations, associated with non-continual equilibrium in non-financial markets and continual equilibrium in financial markets, was first introduced by Dornbusch (1976). Such assumptions imply that the effect of any shock is transmitted firstly through financial markets, and then to non-financial market.

\textsuperscript{50} In this context, increasing the amount of salaries and wages reflects only an increase in the number employed in the economy.

\textsuperscript{51} It is well known that there are two inputs available for the production of non-natural resource output. These are labour and capital. In this model, however, only the private and public physical capital stocks are modelled.
infrastructure, as in other models, but also through government investment spending upon human capital.

The main objective of the model developed is to identify the implications of aforementioned alternative policies, such as financial liberalisation, represented by a movement from a fixed nominal exchange rate to a more flexible exchange rate, and expansion of public development spending, represented by alternative spending options of oil revenue as well as oil exports, upon overall macroeconomic performance. These policy implications will be discussed in Chapter 7.

Incorporating these assumptions into the model leads to an extensive modification of the modelling of the effects of oil related shocks, and in turn oil revenue, for the Libyan economy, in comparison to that of the C-H model. The model is developed and presented in the following section.

4.3 A general equilibrium macroeconomic model for the Libyan economy

The model presented in this section is developed to capture the key characteristics of the Libyan economy where there is a fixed exchange rate, and the government exercises considerable control over capital markets. This is considered as the base model. Other versions of the model can be adopted to allow for the possibility of moving from a fixed to more flexible nominal exchange rate regime. Identification of alternative suitable policies could enhance the level of aggregate demand for non-oil output and aggregate supply of non-oil output, and expand the role of the private sector; hence reducing the possible Dutch Disease effects, and maximising the benefits from an oil boom.
The equations of the model are presented in Table 4.1. The model is divided into five sub headings: product market, assets market, aggregate supply and prices, foreign trade sector and definitions.

### Table 4.1 the Macroeconomic Model

#### Product market

\[ No^d = \beta_1 c^p + \beta_2 i^p + \beta_3 g_1 + \beta_4 (x^n - m^n) \]  
\[ c^p = \beta_5 No^s + \beta_7 w^p \]  
\[ i^p = k^p = \gamma (k^{p^*} - k^n) \]  
\[ k^{p^*} = \delta No^s \]  
\[ g = \beta_8 c^e + \beta_9 i^g + \beta_{10} i^h + \beta_{11} i^{cap} \]  
\[ c^e = (1 - \theta_1 - \theta_2 - \theta_3) (o^a + p_o + e - p) \]  
\[ i^g = k^g = \phi (k^{g^*} - k^g) \]  
\[ i^h = k^h = \sigma (k^{h^*} - k^h) \]  
\[ i^{cap} = \dot{k}^{cap} = \lambda (k^{cap^*} - k^{cap}) \]  
\[ k^{g^*} = \theta_1 (o^a + p_o + e - p) \]  
\[ k^{h^*} = \theta_2 (o^a + p_o + e - p) \]  
\[ k^{cap^*} = \theta_3 (o^{cap} + p_o + e - p) \]  
\[ bd = g - t^s = \beta_{12} (m - \dot{p}) \]  
\[ t^s = \beta_{13} (o^a + p_o + e - p) + (1 - \beta_{13}) No^s \]  
\[ x^n = \beta_{14} (e + p^{* \prime} - p) + \beta_{15} y^* \]  
\[ m^{con} = \beta_{16} y - \beta_{17} (e + p^{* \prime} - p) \]  
\[ y = v No^s + (1 - v) o^a + (1 - v - \mu_1) p_o + (\mu_4 - v) (e - w) - (1 - \mu_2 - \mu_2) p^* \]  
\[ y^p = v No^{o_p} + (1 - v) o^{p^*} + (1 - v - \mu_2) p_o + (\mu_4 - v) (e - w) - (1 - \mu_1 - \mu_2) p^* \]

#### Asset market

\[ m - p = \varepsilon_1 No^s - \varepsilon_2 x - \varepsilon_3 r \]  
\[ w^p = \varepsilon_4 k^p + \varepsilon_6 (m - p) + \varepsilon_7 y^p \]
\[ \dot{m} = d\dot{c}e + \dot{f} \quad (4.21) \]

**Aggregate supply and prices**

\[ p = \mu_1w + \mu_2(e + po) + (1 - \mu_1 - \mu_2)(e + p^*) \quad (4.22) \]

\[ \dot{w} = \psi_1(No^d - No^*) + \psi_2\dot{m} \quad (4.23) \]

\[ No^d = \phi_1k^p + \phi_2k^s + \phi_3k^h + \phi_4k^{cop} + \phi_5em \quad (4.24) \]

**Overseas sector**

\[ \dot{f} = \alpha_1(x^o - m^n) + \alpha_2r^*f + \alpha_3(o^* + po) - (1 - \alpha_2 - \alpha_3)(e - p) \quad (4.25) \]

\[ o^* = \zeta o^u \quad (4.26) \]

**Definitions**

\[ c = e - w \quad (4.27) \]

\[ l = m - w \quad (4.28) \]

\[ T = x^o - m^n \quad (4.29) \]

\[ m^n = m^{con} + i^{cop} \quad (4.30) \]

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

The model consists of 30 equations, 33 endogenous variables, and 10 exogenous variables. All variables in the model are in log form except that of the domestic nominal interest rate and world interest rate, and the parameter in front of each variable indicates its elasticity. The definitions of endogenous and exogenous variables are presented in Table 4.2. Equilibrium in the model depends upon equilibrium in the product market, assets market, and overseas or foreign trade sector. The product market is discussed first.

**Table 4.2 Explanation of Symbols Used in the Model**

**Endogenous variables**

- \( No^d \) Aggregate demand for non-oil output
- \( c^p \) Private consumption
- \( i^p \) Private investment
$k^*$  Desired private capital stock
$g$  Total government spending
$c^e$  Government consumption expenditure
$x^n$  Non-oil exports##
$m^n$  Non-oil imports##
$T$  Non-oil trade balance
$No^r$  Aggregate supply of non-oil output
$w^p$  Real private sector wealth
$k^p$  Private capital stock
$k^{cap}$  Imported capital stock#
$k^f$  Actual public capital stock
$k^h$  Human capital stock#
$k^g$  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
$t^*$  Total tax revenue
$m$  Nominal money supply¹
$\pi$  Inflation rate**
$p$  Consumer price level
$w$  Domestic nominal wage
$m^{con}$  Consumption of non-oil imports#
$y$  Total real income²
$y^p$  Permanent real income
$f$  Foreign asset stocks
$o^i$  Oil exports
$c$  Real exchange rate
$l$  Real money balance
Exogenous variables

\[
e \quad \text{Nominal exchange rate}^3
\]

\[
o^o \quad \text{Oil production}
\]

\[
po \quad \text{World oil price (in foreign currency)}
\]

\[
p^* \quad \text{Price of non-oil imported goods}
\]

\[
y^* \quad \text{World real income}
\]

\[
No^p \quad \text{Permanent non-oil income}
\]

\[
o^p \quad \text{Permanent oil-income}
\]

\[
r^* \quad \text{World nominal interest rate}
\]

\[
r \quad \text{Domestic nominal interest rate}
\]

\[
em \quad \text{Employment}
\]

---

1. Exogenous if the nominal exchange rate is flexible.
2. Which is equivalent to total real domestic production.
3. Endogenous if the nominal exchange rate is flexible.
4. Not included in the C-H model.
5. \((x^o \text{ less } m^n)\) used to represent non-oil trade balance \(T\).
6. Used as a proxy to the nominal interest rate in the base model.

4.3.1 Product market

Product market equilibrium consists of eighteen equations, which are represented by Equations (4.1) – (4.18). Equation (4.1) describes the total demand, or spending, on non-oil output \((No^d)\). It is a log linear approximation of total spending in the form of private consumption spending, private investment spending, government spending (which is given by equation (4.5) and is comprised of a weighted average of both government consumption and government investment spending) and the non-oil trade balance consisting of non-oil exports \((x^o)\) and non-oil imports \((m^n)\). The parameters \((\beta_i)\) represent the elasticities of spending in each category.

In line with the C-H model, private sector consumption is given by equation (4.2). 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. Equation (4.3) describes private sector gross investment, which equals the change in the stock of private capital, capturing the partial adjustment hypothesis. This partial adjustment arises from costs of adjusting the actual physical capital stock \((k)\) to the desired capital stock \((k^*)\), as in equation 4.3a:

\[
\dot{k}^p = \gamma(k^* - k)
\]  

(4.3a)

this shows that 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 desired capital stock is assumed to depend upon non-oil output (equation (4.4)).

Total government spending \((g)\) is identified by equation (4.5). 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 (4.6) and government development expenditure, which will directly influence the production of non-oil output as given by equation (4.24). Government development spending is divided into three parts; government development spending on physical capital \((i^p)\), government development spending on human capital \((i^h)\), and that devoted to imported capital \((i^{cap})\). Government development expenditure on human capital consists of government spending

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52 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.

53 In the C-H model the change in the stock of private capital is determined by Tobin’s q ratio, which is the ratio of the marginal market valuation of capital relative to the replacement cost of the capital.
on the education sector and health sector\textsuperscript{55}, where the public sector in Libya plays an important role in providing free education and healthcare necessary to build human capital\textsuperscript{56} (World Bank, 2006). In this context, Lederman and Maloney (2007) argue that natural resources such as oil can contribute positively to stimulating growth and economic development, when it is transformed to human capital and knowledge innovation. Whilst government spending on imported capital represents technological acquisition from overseas.

Equations (4.7), (4.8), and (4.9) 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, therefore; determined by oil revenue, which are given by equations (4.10), (4.11), and (4.12). The parameters of $\theta_1$, the proportion of government spending allocated towards desired physical public capital stock, $\theta_2$, the proportion of government expenditure allocated towards human capital stock, and $\theta_3$, the proportion of government spending directed towards imported capital stock are considered as policy parameters. This is another major difference between this model and that of the C-H model and other models discussed in Chapter 3.

\textsuperscript{55} The inclusion of health services can be justified by the fact that a healthy person can not only work more effectively and efficiently, but also devote more time to productive activities, see (Baldacci et al., 2004).

\textsuperscript{56} In this context, Libya has achieved essential improvements in terms of primary, secondary, and tertiary school enrolments. For example, secondary school enrolment substantially increased from 21 percent in 1970 to 95 percent in 2002. Also, tertiary enrolment recorded a significant increase from 3 percent to 53 percent in the same period. However, there are concerns about the quality of the content and the actual access to up-to-date knowledge and expertise. These concerns are attributed mainly to Libya’s isolation for more than a decade due to the embargo and the sanctions imposed upon the country by the US and UN, and the ban on foreign languages from the curricula. Regarding the health sector, life expectancy has increased from 52 years in 1970 to 72 years in 2002 as a result of improvement in health care services (for more detail, see World Bank, 2006, p.7-8).
Equation (4.13) identifies the budgetary stance, which is government expenditure (g) less tax revenues (t). The budget deficit can be financed in three ways; through money accommodation (sales of government bills and securities to the CBL), by borrowing domestically from the private sector, or by borrowing from abroad. In Libya the government issues bonds to the Central Bank only, and does not issue bonds to the public. The public are not able to buy treasury bills and bonds due to the lack of financial institutions in the economy. Also, the Libyan government has not, as yet, borrowed from abroad. Therefore, equation (4.13) shows that any excess of real total expenditure (g) over real total tax revenue (t*) must be financed by borrowing domestically from the CBL. Tax revenues are generated from two sources, oil production and non-oil production (equation (4.14)).

Unlike the C-H model the non-oil trade balance is disaggregated further into non-oil exports less non-oil imports as shown in equation (4.15) and identity as shown in equation (4.30). Equation (4.15) specifies that non-oil exports depend positively upon the real exchange rate and world real income. Non-oil imports are also disaggregated into consumption non-oil imports (m^con) and capital non-oil imports (i^cap).

Equation (4.16) identifies non-oil consumer imports, which depend negatively upon the real exchange rate and positively on domestic real income. Equation (4.9) identifies capital imports which are assumed to be endogenously determined, arising from a gradual adjustment of actual imported capital spending to its policy determined level. As mentioned earlier, Libyan capital imports, which comprise capital goods and raw material goods, increased during the oil boom periods. This is attributed to the highly ambitious development programme conducted by government during the oil boom periods. Thus, a large share of oil revenue is being used directly for the purchase of
capital imports containing advanced technology in particular. This is another departure from the C-H model, and in addition is considered as one of the main contributions of this model.

Real and permanent income definitions, first used by Buiter and Purvis (1982), are given by equations (4.17) and (4.18) as in the C-H model. Real income, as identified in equation (4.17), depends upon non-oil output ($No'$), oil production ($o^o$) that is assumed to be exogenous, the world price of oil ($po$), that is also exogenous, the real exchange rate as emphasised here and the exogenously determined price of non-oil imported goods ($p^*$). However, in the C-H model such income goes to the private sector, whereas in this model only real non-oil income, generated from real non-oil output, accrues directly to the private sector, and real oil income generated from real oil production goes directly to government. This is another major departure from the C-H model. Real oil output (government oil revenue) will directly affect government income and in turn its spending, as in equations (4.5), (4.6), (4.7), (4.8) and (4.9). It will also affect non-oil output supply as in equation (4.24) through imported, human and physical capital accumulation, and the allocation of oil production as in equation (4.26). Non-oil output will directly influence private sector consumption and the money market, as in equations (4.2) and (4.19).

Equation (4.18) is the same as in the C-H model. It represents permanent income, which is a function of exogenous permanent non-oil output ($No^{p}$), exogenous permanent oil output ($o^{p}$), the world price of oil, the real exchange rate and price of non-oil imported goods (see also Harvie, 1994). It is assumed that $v$, which is the share of non-oil production in total value added, does not change as a result of oil production and is treated as being the same in real and permanent income, and is constant through time.
If the share of oil production in domestic real income \((1 - \nu)\) is larger than its share in domestic consumption \((\mu_2)\), then the economy will be an oil exporter during its period of production.

### 4.3.2 Assets market

Assets market equilibrium is given by equations (4.19) – (4.21). Unlike the C-H model and other long-run models discussed in Chapter 3, there is only one financial asset (money assets) modelled in this model. According to conventional money market equilibrium the demand for real money balances depends upon real income, and the nominal interest rate as the opportunity cost of holding real balances. However, the special characteristics of Libya, like most other developing countries, should be considered when specifying the functional form of money demand. Libyan financial markets are immature and still in the process of being liberalised, and capital is restricted due to the constant nominal interest rate. Thus, there is a limited range of alternative financial assets. Furthermore, the interest rate does not reflect the increase in price levels. As a consequence the interest rate does not reflect the true opportunity cost of holding money in Libya. In addition, since the interest rate is subject to regulation by policymakers it is no longer a good proxy for the costs of holding money but, rather, tends to show the restrictiveness of monetary policy. Therefore, the rate of inflation will be utilised as a proxy variable for the opportunity cost of holding money.

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57 Tobin’s \(q\) and the real return on private capital services are omitted from this model due to lack of data and adequate information.

58 In this respect many researchers have used alternative variables to that of the interest rate in the demand for money equation in developing countries. For instance, Usui (1996) used the rate of inflation as a proxy for the opportunity cost of holding money beside the interest rate in the demand for money for the Indonesian economy. He found that the inflation rate is significant and negatively related to money demand, reflecting the opportunity cost of holding money, while the interest rate is not significantly related to money demand.
For this reason the alternative specification of money market equilibrium, as given by equation (4.19), incorporates real non-oil income and the rate of inflation as alternative explanatory variables in place of the interest rate. The nominal money supply is assumed to be endogenous as the nominal exchange rate is fixed. The demand for real money balances (the nominal money stock \( m \) deflated by the consumer price level \( p \)) depends positively upon real non-oil income \( (No') \), representing a transactions demand, and negatively upon the inflation rate. It is assumed that the money market always clears, so this equation always holds.

Domestic private sector real wealth is given by equation (4.20) as in the C-H model, except that real bond holdings by the private sector are excluded from equation (4.20). This is because of the fact that the Libyan government does not issue bonds to the public. Domestic private sector real wealth consists of three components. The first major component is real money balances, which consists of cash, deposits, and savings of the private sector. The second major component is the private capital stock assumed to be owned entirely by the private sector. The private capital stock is produced from private investment spending where the annual rate of depreciation is assumed to be at 5 percent. The final component is permanent non-oil income, equivalent to that of permanent non-oil output\(^59\).

Equation (4.21) shows the money growth equation. It indicates the assumption of a fixed exchange rate combined with zero capital mobility. Since a fixed exchange rate is assumed for the case of Libya, the money supply, and hence growth of it, is endogenously determined, and depends upon exogenously determined changes in domestic credit expansion \( (dèe) \) and the accumulation of foreign exchange reserves

\(^{59}\)This is a proxy for the present value of future income streams for the private sector.
through balance of payments surpluses/deficits ($f_{es}$) as shown in equation (4.21a) (Harvie, 1993; Harvie & Thaha, 1994).

\[ m = dce + f_{es} \]  

(4.21a)

$dce$ is exogenously determined by government, and hence in this study it is assumed for simplicity that the change in it is zero. $f_{es}$ indicates changes in foreign exchange reserves arising from balance of payments surpluses or deficits, which arise from developments in the current account ($\dot{f}$) and capital flows arising from the differential between the domestic and foreign nominal interest rate ($r - r^*$), as shown in equation (4.21b), 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 (Frenkel & Rodriquez, 1982).

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

(4.21b)

However, capital flows are not driven by the market in the Libyan economy, but, rather, determined by the government. The government also controls the interest rate and, therefore, exerts substantial control over capital mobility (see section 2.5.4.2)\(^{60}\). Thus, in the context of the Libyan economy, capital mobility is assumed to be negligible in the base model scenario. Accordingly, we assume that foreign exchange reserves depend only upon developments in the current account ($\dot{f}$).

\[ f_{es} = \dot{f} \]  

(4.21c)

\(^{60}\) A government cannot control both the exchange rate and the interest rate without controlling capital flows.
Given that a fixed nominal exchange rate is assumed, and hence unable to adjust, there will be balance of payments surpluses or deficits arising from developments in the current account, leading to accumulation/decumulation of foreign exchange reserves \((fes)\). As a consequence this will have an impact upon the domestic money supply, resulting in changes in the consumer price level. By substituting equation (4.21b) into equation (4.21a), equation (4.21) is obtained.

### 4.3.3 Aggregate supply and prices

Equations (4.22)–(4.24) define the price level and aggregate non-oil output supply. Price and inflationary expectations developments are given by equations (4.22), (4.23), and (4.24). Equation (4.22) defines the domestic 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 last one is represented by the imported goods price index in foreign currency multiplied by the exchange rate.

Adjustment of nominal wages is generated by an expectations augmented Phillips curve, as given by equation (4.23). Two possible adjustment sources are considered, these being excess demand for non-oil goods relative to its available supply \((No^d – No)\) and core inflation \((\pi)\). Core inflation depends upon developments in the monetary growth rate (equation (4.21)).

Aggregate non-oil output supply is endogenously determined, as given by equation (4.24). It depends positively on the public physical capital stock\(^{61}\), 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

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\(^{61}\) The reason for including government development expenditure is to capture the effects of government-led development strategies, in particular during oil boom periods.
capital stock accumulation \( (k^g) \), capital that affects non-oil output through human capital formation \( (k^h) \)\(^{62}\) and imported capital accumulation \( (k^{cap}) \). Appendix 4.1 provides the method of defining human capital formation, and Appendix 4.2 provides the method of calculation of physical and imported capital stock.

Inclusion of the public capital stock is attributed to the assumption that it is complementary to that of the private capital stock in nature. For example, Aschauer (1989a, 1989b) argues that public capital spending, especially on infrastructure such as highways, streets, water and sewerage systems and airports, operates as a complement to private sector inputs, and “crowds in” private capital accumulation and enhances its efficiency. In addition, Morrison and Schwartz (1996) examine the relationship between public capital and costs of private production. Their results indicate the importance of public infrastructure investment to the private sector’s productivity. They find that public infrastructure investment reduces the cost of private production, and hence leads to an increase in productivity performance. Hence it has a potentially positive and significant effect on aggregate supply. Furthermore, like other typical oil-exporting countries in the Middle East and North African regions, Libya is dependent on imports of industrial inputs, in the form of physical capital and technology, from developed countries. Importation of capital goods and raw materials, which contribute more than 65 percent of total imports (CBL, 2005), are crucial for the production of non-oil output, hence they play an important role in the economic development process. Thus, unlike the C-H model and other long-run models, the stock of capital imports \( (k^{cap}) \) is vital for the supply of goods and services and are also included in equation (4.24). Also, unlike the C-H model, the real wage is excluded from equation (4.24) due to technical difficulties in its

\(^{62}\) Baldacci et al. (2004) present panel data evidence of a significant and direct impact of education and spending on the accumulation of human capital in developing countries.
estimation (see page 157 Chapter 5). In addition, the nominal wage was fixed for most of the study period due mainly to wage and salaries freeze imposed in 1981.

4.3.4 Overseas sector

The overseas sector consists of the current account and the oil trade balance. Developments in the current account are given by equation (4.25a) (see Harvie, 1994; Harvie & Gower, 1993).

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

(4.25a)

where \((o^*)\) represents net exports of oil. Re-arranging equation (4.25a) and expressing this in terms of changes in foreign exchange reserves, equation (4.25) 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 (4.29)), 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 (4.25) is as in the C-H model.

Equation (4.26) indicates that net oil exports are exogenously determined, dependent upon government policy towards the domestic usage of oil production or for export. The distribution of the oil production between domestic usage and exports is an alternative government policy that will be discussed in Chapter 7.

4.3.5 Definitions

Finally, equations (4.27)-(4.30) define four variables which are used extensively throughout this study. Equation (4.27) defines the real exchange rate, equation (4.28)
defines real money balances, equation (4.29) defines the non-oil trade balance, and equation (4.30) defines non-oil imports.

4.4 Alternative Exchange Rate Policy and other Government Policies

Alternative exchange rate policy is considered in this section. It is concerned with moving the nominal exchange rate from a fixed to a flexible exchange rate regime, combined with perfect international capital mobility. Equation (4.21) is utilised in the base model to represent the assumption of a fixed exchange rate. Also, as the domestic interest rate is constant and is not significant in Libya, the capital flow, which depends upon the interest differential between the domestic and foreign nominal interest rate \( (r - r^*) \), will have no notable influence upon foreign exchange reserves. Hence foreign exchange reserves are determined mainly by developments in the current account.

The change in the nominal exchange rate from a fixed to flexible exchange regime will affect the development of the overseas sector. Under a flexible exchange rate regime the exchange rate is capable of adjusting so that either capital inflows or outflows will have no effect upon foreign exchange reserves. As a consequence growth of the money stock is exogenous, and the nominal exchange rate is endogenous. Since the assumption of a flexible exchange rate is combined with imperfect capital mobility, an amendment is required. That is, equation (4.21) is replaced by equation (4.21d). The assumption of imperfect capital mobility results in a discrepancy between the return on domestic financial assets and foreign financial assets, which can persist for a prolonged period of time. This divergence between the domestic and foreign interest rate is eliminated slowly, after allowing for exchange rate expectations, resulting in a gradual outflow or inflow of foreign assets. Therefore, equation (4.21d) is relevant to represent a flexible exchange rate regime, combined with highly controlled international capital
mobility. Regarding the case of a flexible exchange rate and perfect capital mobility, which can be considered as an alternative policy for the case of the Libyan economy, equation (4.21e) can be utilised. This equation represents the assumption of perfect capital mobility and perfect foresight in the foreign exchange market.

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

Other alternative government policies concerned with the allocation of the spending of the oil revenue in the form of consumption and investment expenditure; allocation of the oil production for either domestic usage or export; and that of budget financing can be adopted in alternative versions of the model by merely altering some of the parameters without requiring any modifications to the base model.

The model will be estimated using the ARDL approach, using the Microfit 5 package. Then the coefficient parameters obtained from the estimation along with those calculated from available data, those set as adjustment coefficients, those obtained from other studies, and those imposed due to data limitation or in order to ensure model stability, will be utilised in the simulation analysis to examine the impact of oil related shocks upon the macroeconomic adjustment process. The method of estimation, as well as the details of the properties of this estimation, will be discussed in Chapter 5. The simulation scenarios for the base model will be conducted in Chapter 6 by using the estimated parameter values derived from the model and other parameters, so as to analyse exogenous shocks arising from increased/decreased oil production and oil prices and their impact upon key macroeconomic variables such as government real oil revenue,

\[63\text{ For more detail about the case of a flexible exchange rate and perfect capital mobility see Harvie (1993).}\]
real income, non-oil output, physical capital stock, human capital stock, imported capital stock, private capital stock, foreign asset stock, non-oil trade balance, real exchange rate, the domestic inflation rate, and private sector real wealth. The simulation results for all alternative policy implications will be presented in Chapter 7.

4.5 Limitation of the Theoretical Model

Even though the model presented in this chapter has attempted to capture the main features of the economy, there are still some limitations related to its representation of the Libyan economy as a developing country. These being as follows:

1. The model for the Libyan economy analyses the adjustment of non-oil output only, and does not take into account adjustment in key sub sectors in the economy such as agriculture, manufacturing and service production. However, developments in Libya’s non-oil output by sector show some of the major structural changes that have taken place over the period of study (see section 2.5.2). Therefore, the structural adjustments can be more clearly identified by disaggregating non-oil output into its key sub-sectors.

2. The theoretical model emphasises the operation of a fixed and a flexible exchange rate regime, whereas the Libyan economy operates under a system of a managed floating exchange rate.

3. The model developed here, which has its foundation in the C-H, assumes that adjustment of financial markets plays a crucial role in the model. However, Libya’s financial markets like other developing countries, are not yet that developed. This assumption may not be appropriate for the case of Libya as its financial markets are regulated by the authorities.
4. The labour force is not explicitly modelled. As is well known in the literature there are two inputs available for the production of non-natural resources output. These are labour and capital. In this model, however, only the private capital stock, physical public capital stock, human capital stock, representing education and training, and imported capital stock are modelled.

5. Other limitations related to the assumptions underlying the model are that it is a linear deterministic framework in which economic agents possess rational expectations, which is in turn equivalent to the case of perfect foresight. This is a very strict assumption and unlikely to be satisfied in a developing country like Libya. Such an assumption implies that economic agents are rational, and do not make consistent forecasting errors.

6. Some parameters of the model cannot be estimated. This is because there is no data available; hence some parameters will be imposed.

These limitations of the model will be taken into account in the next chapter as results from the model are derived.

4.6 Summary and Conclusions

The main focus of this chapter has been upon discussing the assumptions underlying the long-run dynamic model developed to analyse the effects of oil related shocks for the Libyan economy. The model explicitly incorporates the fundamental features of the Libyan economy and recognises the important contribution of oil production, and in turn oil revenues, to the economic development of the economy. The economic developments emphasised here relate to that of real income, real oil income itself, non-oil output, physical capital stock, human capital stock, foreign asset stock,
non-oil trade balance, real exchange rate, the domestic inflation rate, and private sector real wealth.

The model incorporates the fact that oil production and its revenues are under the control of government owned entities. Therefore, the allocation of oil production to either domestic usage or for export, and the spending of oil revenues either in the form of consumption, infrastructure, education and technology acquisition are determined by the government.

The model emphasises the long-run nature of the dynamic adjustment process, as oil production has a long-run sustainable impact on non-oil output. This impact arises from physical capital stock accumulation in the non-oil sector induced by government capital spending, human capital accumulation, technology acquisition through capital imports, foreign asset stock accumulation via developments in the current account and budgetary financing requirements.

The inclusion of public physical capital stock accumulation in the non-oil sector, human capital stock accumulation and imported capital stock will essentially contribute to boosting the productivity capacity of non-oil output, in particular during the non-oil boom period. The inclusion of human capital is considered as a second main extension of this model to the C-H model and other models outlined in Chapter 3. Also, the inclusion of developments in the current account, which captures developments in oil exports and the non-oil trade balance, will have a further impact upon developments in non-oil output. Furthermore, oil revenue has a short and long-run sustainable impact upon non-oil output through providing the foreign exchange required for financing capital imports and acquisition of foreign technology. Accordingly, capital imports will also contribute
to boosting the productivity capacity of non-oil output, in particular during the non-oil boom period.

A fixed exchange rate combined with zero capital mobility is assumed in the base model developed in this chapter. This assumption can be relaxed and a flexible exchange rate can be considered as an alternative exchange rate policy in the Libyan economy. This is necessary for the private sector and the Libyan government so as to offset possible Dutch Disease effects, and maximise the potential benefits from an oil boom during the adjustment process to long-run steady state. This policy alternative requires an amendment of the base model. The key difference between the fixed and flexible nominal exchange rate regimes is in relation to the money stock. With a fixed exchange rate the money supply, and hence growth of it, is endogenously determined, and depends upon changes in domestic credit expansion and changes in foreign exchange reserves. Whilst under a flexible exchange rate regime the exchange rate is capable of adjusting so that either capital inflows or outflows will have no effect upon foreign exchange reserves. As a consequence, growth of the money stock is exogenous.

Other government policy responses, in relation to oil shocks, are emphasised. These are government policy responses toward the allocation of oil production for either domestic usage or export, the spending of the oil revenue either upon consumption, infrastructure, human capital formation and technology acquisition, and budget financing. The spending of oil revenue, in particular development expenditure on physical capital, human capital and that dedicated for imported capital is a key policy issue, which has important implications for the development of the Libyan economy as mentioned earlier. Unlike the policy alternative of a flexible nominal exchange rate, these
alternative policies do not require an amendment of the base model but only changing of some of the parameters of the model. These policies will be analysed in Chapter 7.
Appendix 4.1: The Computation of Human Capital Accumulation

Human capital formation is defined in discrete time as:

$$k^h = \frac{(1-\delta_h)}{(1+g)} h_{t-1} + i^h_t$$  \hspace{1cm} (4.1.1)

where \(\delta_h\) and \(g\) are depreciation of human capital and a constant rate of population growth, respectively, and \(i^h_t\) is the investment in human capital. Equation (4.1.1) represents the fact that population growth reduces per capita human capital over time. The investment in human capital is assumed to be determined by government spending on education and health services \((G_{h,i})\) as follows:

$$i^h_{t,i} = \bar{w}^* \left( \sum_{i=t-6}^{i=t-1} G_{h,i} \right) = \frac{1}{20} \left( \sum_{i=t-6}^{i=t-1} G_{h,i} \right)$$  \hspace{1cm} (4.1.2)

where \(\bar{w}\) is the share of each school-graduating cohort in the labour force. It is assumed that the human capital of a cohort about to enter the labour force is approximately the sum of government spending on education and health \((G_{h,i})\) over the last five years.

Appendix 4.2: The Computation of Physical Capital and Imported Capital Stock Accumulation

The physical capital stock and imported capital stock are generated as follows:

$$K = I + (1-d)K_{t-1}$$  \hspace{1cm} (4.2.1)

where \(d\) denotes a constant annual depreciation rate. Since the initial capital stock is unknown the following procedure is used to assess \(K_0\). Assuming further that

$$K_t = K_0 g^t$$  \hspace{1cm} (4.2.2)

and substituting (4.2.2) into (4.2.1) for \(K_t\) and \(K_{t-1}\) obtains equation (4.2.3)

$$K_0 = \frac{I_t}{g^{t-1} \left[ g - (i-d) \right]}$$  \hspace{1cm} (4.2.3)

where \(g\) is equal to 1 plus the unknown accumulation rate of capital stock. By recalling that (4.2.3) holds for \(t\) and for \(t-1\)

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64 For a more detailed discussion about how to calculate human capital formation see Mongardini and Samake (2009), and Farah et al. (2009).
\[
\frac{I_i}{g^{i-1}} = \frac{I_{i-1}}{g^{i-2}}
\]

(4.2.4)

and hence

\[
g = \frac{I_i}{I_{i-1}}
\]

(4.2.5)

Since different values of \( g \) are likely to be obtained for any arbitrary choice of two consecutive values of \( I \) the sample average of the right-hand side of equation (4.2.5) is considered, which is an unbiased estimator of \( g \):

\[
\hat{g} = \frac{1}{T} \sum_{t=1}^{T} \frac{I_t}{I_{t-1}}
\]

(4.2.6)

and then by substituting \( t = 1 \) into equation (4.2.3) to obtain

\[
\hat{K}_0 = \frac{I_1}{\hat{g}(i-d)}
\]

(4.2.7)

and computed \( \hat{K}_0 \) for the time series with the first (1969) observed value of gross investment, the estimated value of \( g \) from equation (4.2.6), and predetermined value of \( d \). Subsequently, by substituting the computed initial capital stock in equation (4.2.1) to obtain the projected level of capital stock for the following year and by subsequent substitutions, the time-series of capital stock is produced.
Chapter 5

Estimation of the Macroeconomic Model and Empirical Results

5.1 Introduction

The purpose of this chapter is to empirically estimate the behavioural equations of the Libyan macroeconomic model developed in the previous chapter. As mentioned earlier, the aim of this study is to develop and estimate a long-run and dynamic macroeconomic model to analyse the effects of oil related shocks, and in turn oil revenues and production changes upon key macroeconomic variables in the Libyan economy.

The Microfit 5 package (Pesaran & Pesaran, 2009) will be used here to estimate the behavioural equations of the model. Yearly data from 1970 to 2007 will be utilised for the estimations. However, before the macroeconomic model for the Libyan economy is estimated, it is necessary to define whether the key macroeconomic variables in the behavioural equations contain a trend or not, and whether the trend is deterministic or stochastic. In other words, it is essential to check each time series for stationarity. Furthermore, it is crucial to accurately identify structural breaks in the data for any economy. The importance of this is; firstly, to avoid misspecification of the model considered; secondly, to obtain unbiased coefficients. In the context of the Libyan economy, and as already noted in Chapter 2, during the last four decades, the Libyan economy has experienced several severe business cycles, marked by periods of expansion and periods of recession. These business cycles reflect structural changes in the Libyan economy, which are attributed to several events. These events include increasing oil prices during the late 1970s, early 1980s, and then since 2000; the collapse of oil prices during the mid 1980s to the 1990s; the changing of the economic regime in
1977 which prohibited the private sector; the USA embargo, which started in the early 1980s; the UN sanctions in the early 1990s; the lifting of sanction in 2003, the change of the official exchange rate in 1999; the unification of the exchange rate in 2002; amongst others.

In order to test if the time series are non-stationary, the traditional unit root tests (Dickey & Fuller, 1979, 1981; Phillips & Perron, 1988), and the two-break minimum LM unit root test (Lee & Strazicich, 2003) will be used in order to examine the hypothesis that the variables in each equation have a unit root. Subsequently, the Auto-regression Distributed Lag (ARDL) Model developed by Pesaran and Shin (1998), Pesaran, Shin and Smith (1996, 2001) and Pesaran and Smith (1998), will be used in this study to examine the long-run relationship between variables which are included in the behavioural equations, and the relevant structural breaks as well as to estimate the short-run and long-run elasticities.

The parameters that will be derived from estimation of the macroeconomic model will be used in Chapter 6 to conduct a numerical simulation analysis to analyse exogenous shocks arising from increased/decreased oil production and oil prices, and their impact upon key macroeconomic variables such as real income, real oil income itself, non-oil output, physical capital stock, human capital stock, imported capital stock, foreign asset stock, non-oil trade balance, real exchange rate, the domestic inflation rate and private sector real wealth.

The remainder of this chapter proceeds as follows. Section 5.2 describes the data sources. Section 5.3 presents the concept of stationary and non-stationary time series. Section 5.4 discusses the method of the unit root tests and empirical results of unit root tests applied to Libyan data. Section 5.5 presents the ARDL approach and the empirical
results of the estimation, while section 5.6 provides a summary and conclusions derivable from this chapter.

5.2 Data Sources

The study covers the period 1970–2007, which captures both the oil boom and non-oil boom periods. Also, during this period, the exchange rate changed from fixed to more flexible, which means that the implications of such a change for the effects of oil related shocks upon the economy needs to be re-evaluated. The relevant data was obtained from different sources (international and local publications). International publications such as the International Financial Statistics Yearbook (IFS) issued by the International Monetary Fund (IMF), World Tables issued by the World Bank (WB), and Annual Statistical Bulletin issued by OPEC were used as sources of data for this study.

Also, local publications, such as that of the Central Bank of Libya (Economic Bulletin and Annual Report), Secretariat of the General People's Committee for Planning, and National Authority for Information and Documentation, were extensively used as sources of data. The data from these different sources for the entire time series from 1970 to 2007, except that of monetary data, is only available in the form of annual data. Consequently, this study has chosen annual data instead of quarterly data. Like many other developing countries, some of the data is either not available or may be available but not always in the form of a consistent time series.

5.3 Stationary and non-stationary time series

It is necessary, before starting to perform any empirical estimations of the model, to analyse the time series data as to whether they are stationary or non-stationary. The method of estimation, using the Ordinary Least Squares (OLS) method, is based on the assumption that the means, variances, and autocovariances (at various lags) of the
variables being tested are constant over time. Stationary data refers to the condition in which the means, variances and autocovariances of the variables remain the same over the length of the series; that is, they are time invariant. Variables whose means and variances change over time are known as non-stationary or unit root variables. A non-stationary time series can be transferred into a stationary time series by differencing. Accordingly, if the time series $y_t$ has to be differenced one time to make it stationary, then $y_t$ is said to be integrated of order 1, denoted by $y_t \sim I(1)$. Similarly, if $y_t$ has to be differenced $d$ times, then the time series $y_t$ is said to be integrated of order $d$, denoted by $y_t \sim I(d)$. However, if the time series $y_t$ does not require any differencing (i.e. it is stationary), then it is said to be integrated of order zero, denoted by $y_t \sim I(0)$.

The stationarity properties of a time series (the absence of trend and long-run mean reversion) are scrutinised by carrying out the unit root test to avoid spurious or nonsense regressions. There are a number of methods available for conducting a unit root test. These methods are discussed briefly below.

5.4 Methods of the unit root test.

This section briefly discusses the methods of the unit root test and empirical results. Besides the traditional unit root tests the subject has attracted a remarkable amount of work in the economics literature (Perron, 1989; Christiano, 1992; Zivot & Andrews, 1992; Perron & Vogelsang, 1992; Perron, 1997; Lumsdaine & Pappel, 1997; Lee & Strazicich, 2003). These are unit root tests with one exogenous structural break, unit root tests with one unknown structural break, unit root tests with two unknown structural breaks, minimum Lagrange Multiplier (LM) unit root test with two endogenous structural breaks, and, finally, new Perron-type Innovational outlier tests with a break(s) at an unknown time. The conventional unit root tests are discussed and applied first.
5.4.1 Traditional unit root tests

The most popular and widely used tests in the economics literature to examine the stationarity of a time series, in the absence of a structural break, are the Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979, 1981), and Phillips and Perron (PP) test (1988). In the following model, Dickey and Fuller test the null hypothesis against the alternative hypothesis:

$$\Delta y_t = \mu + \beta t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \epsilon_t$$ (5.1)

where $\Delta$ denotes the first difference, $\mu$ is an intercept, $t$ is the time trend variable, and $k$ is the number of lags which are included in the model to ensure that the error term $\epsilon_t$ is serially uncorrelated, hence obtaining an unbiased estimate of $\alpha$ (i.e. $\epsilon_t$ is white noise with zero mean and constant variance). The null hypothesis of the ADF test is $\alpha = 0$ (non-stationary series) against the alternative hypothesis of $\alpha < 0$ (stationary series), where $\alpha = \rho - 1$. Non-rejection of the null hypothesis implies that the time series $y_t$ is non-stationary, and in this case the usual $t$-statistic cannot be used, hence the ADF statistic is used. On the other hand rejection of the null hypothesis signifies the time series is stationary.

The second traditional unit root test is the PP test. Phillips and Perron use the same asymptotic distribution as for the ADF test statistic, but they use non-parametric statistical methods to ensure that the error term is serially uncorrelated without adding lagged difference terms as in the ADF test. To test the unit root hypothesis PP used the following specification:

$$\Delta y_t = \mu + \rho y_{t-1} + u_t$$ (5.2)
where $\Delta$ denotes the first difference, $\mu$ is an intercept, $u$ is an error term with zero mean and constant variance. The null hypothesis of the PP test is $\rho = 0$ (non-stationary series) against the alternative hypothesis of $\rho < 0$ (stationary series). Rejection of the null hypothesis implies that the time series $y_t$ is stationary.

5.4.1.1 Empirical results for the ADF and PP unit root tests

The regression results of the ADF and PP unit root tests applied to Libyan data used in this study, with an intercept term and a linear trend, are revealed in Table 5.1. The inclusion of the trend can be justified in that most of the time series considered here have a trend. The graphs of the time series of interest are revealed in Appendix 5.1. The Schwarz Bayesian Criterion (SBC) and Newey-West Bandwidth are utilised to select the optimum lags in ADF and PP, respectively. The null hypothesis of a unit root is rejected if the value of the ADF test statistic and/or PP test statistic is greater than the critical value. The time series tested here are those of the behavioural equations of the model developed in the previous chapter. The findings in Table 5.1 show that both the ADF and PP tests reject the null hypothesis of a unit root for real non-oil exports ($x^n$), aggregate demand for non-oil output ($No^d$), private capital stock ($k^p$), imported capital stock ($k^{cap}$), inflation rate ($\pi$), non-oil capital imports ($m^{cap}$), and the current account ($f$). However, the null hypothesis of a unit root for imported capital stock is rejected only by the PP unit root test, whilst the null hypothesis of a unit root for world income is rejected by the ADF test.

The computed test statistics obviously show that the following fifteen variables i.e. real private consumption ($c^p$), aggregate supply of non-oil output ($No^s$), actual

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66 The maximum lag is set to be four in the ADF and PP tests because of the sample size constraining the degrees of freedom.
67 The critical value used in Table 5.1 is at the 5 percent significance level.
public capital stock \((k^s)\), human capital stock \((k^h)\), consumption of non-oil imports \((m^c)\), total real income \((y)\), foreign interest income \((r^* f)\), real private wealth \((w^p)\), domestic real wages \((w - p)\), oil exports \((o^x)\), real money balances \((m - p)\), real exchange rate \((e - p)\), oil production \((o^p)\), world oil price \((p^o)\), and world real income \((y^*)\) are non-stationary.

In general, results from the ADF and PP model are able to reject only 7 out of the 22 series, representing about 32 per cent of the variables of interest. These results may be biased towards the non-rejection of the unit root test, and the observed unit root behaviour, as Perron (1989) suggested, resulting from failure to account for a structural beak in the data. Perron (1989) argues that the traditional unit root hypothesis tests may not be reliable in the presence of structural breaks. Hence ignoring structural break(s) in the trend function leads to considerable power reduction of the traditional unit root tests. Therefore, applying the traditional unit root tests in the absence of structural changes is insufficient, since significant structural breaks are very likely to have occurred in the Libyan economy time series. The methods to test the null hypothesis of a unit root in the presence of structural break(s) in the trend function are discussed in the following section.
ADF and PP Unit Root Tests for Stationarity (Includes an Intercept and a Linear Trend)

<table>
<thead>
<tr>
<th>Variables</th>
<th>ADF Test Statistics</th>
<th>PP Test Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real non-oil exports ($x^o$)</td>
<td>-3.87782[0]</td>
<td>-3.87706</td>
</tr>
<tr>
<td>Aggregate supply of non-oil output ($NO^s$)</td>
<td>-2.19562[2]</td>
<td>-3.65521[0]</td>
</tr>
<tr>
<td>Aggregate demand for non-oil output($NO^d$)</td>
<td>-3.80429[0]</td>
<td>-3.87127</td>
</tr>
<tr>
<td>Private capital stock ($k^p$)</td>
<td>-3.77823[0]</td>
<td>-3.93580</td>
</tr>
<tr>
<td>Actual public capital stock ($k^e$)</td>
<td>-1.60393[0]</td>
<td>-5.17063[0]</td>
</tr>
<tr>
<td>Imported capital stock ($k^{ow}$)</td>
<td>-1.49326[2]</td>
<td>-13.5293[0]</td>
</tr>
<tr>
<td>Inflation rate ($\pi$)</td>
<td>-5.63131[0]</td>
<td>-5.70369</td>
</tr>
<tr>
<td>Consumption of non-oil import ($m^{on}$)</td>
<td>-2.70916[0]</td>
<td>-8.03595[0]</td>
</tr>
<tr>
<td>Capital non-oil imports ($m^{ow}$)</td>
<td>-4.51661[0]</td>
<td>-4.53670</td>
</tr>
<tr>
<td>Total real income ($y^s$)</td>
<td>-1.09208[0]</td>
<td>-4.15272[0]</td>
</tr>
<tr>
<td>Developments in the current account ($\hat{f}^s$)</td>
<td>-6.04392[0]</td>
<td>-6.04383</td>
</tr>
<tr>
<td>Foreign interest income ($r^*f$)</td>
<td>-1.71064[1]</td>
<td>-4.62666[0]</td>
</tr>
<tr>
<td>Real private weal ($w^p$)</td>
<td>-1.85296[1]</td>
<td>-3.73483[0]</td>
</tr>
<tr>
<td>Domestic real wage ($w^r - p$)</td>
<td>-0.19438[0]</td>
<td>-4.87631[0]</td>
</tr>
<tr>
<td>Oil exports ($O^x$)</td>
<td>-3.10335[0]</td>
<td>-5.85773[1]</td>
</tr>
<tr>
<td>Real money balances ($m - p$)</td>
<td>-2.65701[0]</td>
<td>-4.88840[0]</td>
</tr>
<tr>
<td>Real exchange rate ($e^r - p$)</td>
<td>-2.37287[0]</td>
<td>-7.73441[0]</td>
</tr>
<tr>
<td>Oil production ($O^{on}$)</td>
<td>-2.53294[0]</td>
<td>-5.68400[0]</td>
</tr>
<tr>
<td>World oil price (in foreign currency) ($p^o$)</td>
<td>-0.95766[0]</td>
<td>-6.64650[0]</td>
</tr>
<tr>
<td>World real income ($y^w$)</td>
<td>-3.46981[1]</td>
<td>-4.37657[0]</td>
</tr>
</tbody>
</table>

(1) All variables in the Table are in log form. (2) Critical value of I(0) at the 5 percent level is -3.536601, whereas critical value of I(1) at the 5 percent level is -3.540328. The critical values are obtained directly from the empirical results generated by Eviews 6. (3) Figures in square brackets besides each ADF test represent optimum lags, selected automatically using Schwarz Bayesian Criterion (SBC).

5.4.2 Unit root test in the presence of structural break(s) in the trend function

The traditional view of the above unit root tests is that current shocks merely have a temporary effect, and that the long-run movement in the series is unchanged by such shocks. This view is challenged by Nelson and Plosser (1982) who argued, using the ADF technique, that current shocks have a permanent effect on the long-run level of most macroeconomic and financial variables. They found evidence in favour of the unit root hypothesis (non-stationary) for 13 out of 14 macroeconomic and financial aggregates for
the United States\textsuperscript{68}. The study by Nelson and Plosser was followed by a number of empirical analyses, most notably by Wasserfallen (1986) among others, which basically applied a similar ADF technique and confirmed their outcomes. However, Perron (1989) questioned this interpretation, suggesting that the observed unit root behaviour may have resulted from failure to account for a structural break in the Nelson and Plosser data. He argued that most macroeconomic time series are not characterised by the presence of a unit root and fluctuations are in fact transitory (i.e. stationary around a deterministic trend function). According to Perron, the only two exogenous shocks that have had a permanent effect upon macroeconomic variables are the Great Crash of 1929 and the oil price shock of 1973. As a consequence, ignoring such events or structural changes in the trend function leads to considerable power reduction of traditional unit root tests.

In order to overcome this problem Perron (1989) re-examined the Nelson and Plosser data by developing an ADF test, and showed that the result derived by Nelson and Plosser (1982) could be reversed for most of the time series variables. Perron allows for a break in the trend function by simply including dummy variables in the ADF test regression, and assuming that the timing of the break points was known a priori, i.e., that the points selected were uncorrelated with the data\textsuperscript{69}. By doing so he reversed the Nelson and Plosser results in 11 of the 14 macroeconomic variables for the USA, which implies that the series were stationary once one known structural break, such as the Great Crash of 1929 and the oil price shocks of 1973, is included.

The primary assumption of a known exogenous break point i.e., the dates selection are uncorrelated with the data, is criticised because of its tendency to favour the

\textsuperscript{68} The time series considered by Nelson and Plosser are real GNP, nominal GNP, real per capita GNP, industrial production, unemployment rate, GNP deflator, consumer prices, wages, money stock, velocity, bond yield, and common stock prices.

\textsuperscript{69} The exogeneity assumption is utilised by Perron as a device to remove the influence of the shocks from the noise function.
alternative hypothesis. Therefore, subsequent literature, most notably Christiano (1992); Perron (1997); Perron and Vogelsang (1992); Zivot and Andrews (1992); among others, have incorporated an endogenous single break time into the model specification. Specifically, Zivot and Andrews (1992) develop a unit root testing procedure that allows for an estimated break in the trend function under the alternative hypothesis. Unlike Perron (1989), Zivot and Andrews determine the structural break endogenously by estimating every potential break date (\( T_B \)) sequentially. By doing so, the authors argue that the results of the unit root hypothesis earlier suggested by traditional tests such as the ADF test could be reversed. From amongst all possible breakpoints, the break date \( T_B \) is chosen as the value which minimises the Dickey-Fuller \( t \)-statistic for testing \( \hat{\alpha} = 1 \). In other words, the break date will be selected where the evidence is least favourable for the null hypothesis.

Using Nelson and Plosser (1982) data, Zivot and Andrews (1992) found that their result is somewhat different from the result of Perron (1989). They reversed his conclusion by rejecting the unit root for only 3 out of 13 series at the 5 percent significance level. Therefore, the findings of Zivot and Andrews confirm Nelson and Plosser’s findings. According to Zivot and Andrews (1992, p.258) this difference is attributed to two reasons. First, the break year defining dummy variables are estimated endogenously instead of being fixed at a particular time, such as the Great Crash of 1929 and the oil price shocks of 1973. Second, Zivot and Andrews did not impose a structural break under their null hypothesis.

The debate regarding the relationship between the unit root hypothesis and structural breaks has been resumed by several studies (Clemente et al. 1998; Lee & Strazicich, 2003; Lumsdaine & Pappel, 1997; among others). Once again, the assumption
of an unknown or endogenous break point, i.e. the dates selection are correlated with the
data, is criticised because of a loss of information from ignoring two or more breaks in
the one break test. In the words of Lee and Strazicich (2003, p.1082) “…given a loss of
power from ignoring one break, it is logical to accept a similar loss of power from
ignoring two, or more, breaks in the one-break test”. In this context, Lumsdaine and
Papell (1997) proceed in this direction and expand the pervious literature by including
two structural breaks. In particular, they extend the minimum Zivot and Andrews’s unit
root test, allowing for two structural breaks. They re-examine the unit root hypothesis for
the Nelson and Plosser data, introducing a procedure to capture two structural break
points over the relevant time period. They found more evidence against the unit root
hypothesis than Zivot and Andrews (1992), but less than Perron (1989). Specifically,
using finite-sample critical values, they reject the unit root hypothesis at the 5 percent
significance level for seven of the 13 series and at the 10 percent significance level for
two additional variables. Results from different methods of the unit root tests utilising the
Nelson and Plosser data set are summarised in Table A in Appendix 5.2.\textsuperscript{70}

5.4.3 Minimum LM unit root test with two endogenous structural breaks

Extensions of the seminal work of Perron (1989) have been made by Perron
(1997); Perron and Vogelsang (1992); and Zivot and Andrews (1992); among others,
through accounting for one endogenous structural break, and by Lumsdaine and Papell
(1997); among others, through accounting for two structural breaks. This literature
assumes no break(s) is allowed under the null hypothesis and derive their critical values
in view of that\textsuperscript{71}. However, Lee and Strazicich, 2001, 2003; and Nunes, Newbold, and

\textsuperscript{70} The Lee and Strazicich (2003), Popp (2008), and Narayan and Popp (2009) studies are considered in the
following sections.

\textsuperscript{71} The exception to those tests is Perron’s (1989) exogenous break unit root test, which allowed for a break
under both the null and alternative hypothesis.
Kuan, 1997; indicate that the above unit root tests, based on the ADF test, suffer from spurious rejection in finite samples when a break is present under the null hypothesis.

Lee and Strazicich (2003) continue in this direction and state that:

“...the rejections of the null hypothesis in the above endogenous unit root tests does not necessarily imply rejection of a unit root hypothesis \textit{per se}, but may imply rejection of a unit root without breaks. Similarly, the alternative does not necessarily imply trend stationarity with breaks, but may indicate a unit root with breaks” (Lee & Strazicich, 2003, p.1082).

Lee and Strazicich (2003) extend the LM test procedure of Schmidt and Phillips (1992) and provide a remedy to the limitations noted in the above tests, assuming a break(s) under the null and alternative hypothesis. They introduce a two breaks minimum LM unit root test\footnote{Their testing methodology is expanded from the LM unit root test that was primarily proposed by Schmidt and Phillips (1992).} in which the alternative hypothesis unambiguously implies trend stationarity. The main advantages of the minimum LM unit root test suggested by Lee and Strazicich are as follows:

1. in line with Zivot and Andrews (1992) and Perron (1997) amongst other, the break points are determined endogenously from the data.
2. the structural breaks are allowed under both hypotheses.
3. avoids the problem associated with the previous tests of bias and spurious rejections.
4. the LM test corresponds to the exogenous structural break test of Perron (1989).
5. the Lee and Strazicich LM test enables accurate break point estimation.

As an alternative to the Lumsdaine and Papell (1997) test, Lee and Strazicich consider the data-generating process (DGP) (or parameterisation) as follows:
\[ y_t = \delta'Z_t + e_t, \quad e_t = \beta e_{t-1} + \varepsilon_t \]  

(5.3)

where \( Z_t \) consists of exogenous variables and \( \varepsilon_t \) is an error term with mean zero and variance \( \sigma^2 \). Two structural breaks models are considered by Lee and Strazicich. Model (A) allows for two shifts in level and is given by \( Z_t = [1, t, D_1, D_2, \ldots] \), where \( D_\mu = 1 \) if \( t \geq T_{\mu j} + 1, j = 1, 2, \ldots, \) and 0 otherwise. The term \( D_\mu \) represents a dummy variable for a mean shift accruing at \( T_{\mu j} \). \( T_{\mu} \) denotes the time period when the break occurs. Model (C) allows for two changes in the level and trend and is described by \( Z_t = [1, t, D_1, D_2, DT_1, DT_2, \ldots] \), where \( DT_\mu = t - T_{\mu j} \) for \( t \geq T_{\mu j} + 1, j = 1, 2, \ldots, \) and 0 otherwise. The term \( DT_\mu \) is an indicator dummy variable for a trend shift accruing at time \( T_{\mu j} \). According to Lee and Strazicich (2003) the following regression can be used to obtain the LM unit root test statistic:

\[ \Delta y = \delta'\Delta Z + \phi \tilde{S}_{t-1} + u_t \]  

(5.4)

where \( \tilde{S}_t = y_t - \tilde{\psi}_x - Z_t \tilde{\delta}, \) \( t = 2, \ldots, T \); \( \tilde{\delta} \) are coefficients in the regression of \( \Delta y \) on \( \Delta Z_t \); \( \tilde{\psi}_x \) is described by \( y_1 - Z_1 \tilde{\delta} \); and \( y_1 \) and \( Z_1 \) denote the first observations of \( y_t \) and \( Z_t \) respectively. The unit root null hypothesis is given by \( \phi = 0 \), and the LM test statistics are described by \( \tilde{\chi} = t - \text{statistic testing the null hypothesis } \phi = 0 \). The critical values for the two break case are tabulated in Lee and Strazicich (2003).

Lee and Strazicich (2003) applied the two-break minimum LM unit root test to Nelson and Plosser’s data, and compared their results with the two-break minimum Lumsdaine and Papell (1997) test. They found stronger rejections of the null hypothesis utilising the Lumsdaine and Papell test than with the LM test. At the 5 percent
significance level, the null is rejected for six series with the Lumsdaine and Pappel test and four series with the LM test (see Table A, appendix 5.2).

5.4.3.1 Empirical results of the Lee and Strazicich unit root model with two structural breaks.

In this sub-section the two-break minimum LM unit root test is applied to Libyan data to analyse whether the time series is stationary or non-stationary, as well as to determine the major structural breaks that can be used in the regression of the behavioural equations. The regression results for the two-break minimum LM unit root test are contained in Table 5.2. One model is considered here; Model (C), which allows for two changes in the level and trend. This can be justified in that most of the time series considered here have a trend (see Appendix 5.1). All variables of interest are in log form. Due to the small sample size, a maximum of 4 lags was specified in GAUSS. The results of the LM test show a rejection of the unit root null hypothesis for 11 out of the 22 series. These are $c^p$, $x^n$, $k^p$, $k^h$, $\pi$, $m^{cap}$, $f^*$, $w^p$, $\alpha^x$, $o^x$, and $y^*$. On the contrary, the rest of the variables are revealed to be non-stationary series. That is, applying the LM test apparently indicates that the following eleven variables: i.e., $No^t$, $No^d$, $k^g$, $k^{cap}$, $m^{con}$, $y$, $r^*f$, $w−p$, $m−p$, $e−p$, and $po$ are non-stationary.

Overall, while the traditional ADF and PP unit root tests suggest that $c^p$, $k^h$, $w^p$, and $w−p$ are non-stationary, results from the LM method suggests that these time series are trend stationary when the structural breaks are considered under both the null and alternative hypotheses at unknown time in trend function\textsuperscript{73}. The two-break points in

\textsuperscript{73}The Narayan and Popp (2010) model for a unit root test with two structural breaks was also applied to Libyan data. The results of the Narayan and Popp unit root test show a rejection of the unit root null hypothesis for only 3 out of the 22 series. However, when the break points were traced, the method of Lee and Strazicich (2003) is found to be more appropriate and precise than the Narayan and Popp unit root test for the case of Libya. Moreover, the Narayan and Popp test captures small structural breaks, whereas our
the level and/or trend for the time series are significant for 13 time series. However, for the remainder of the time series the break points are not statistically significant in the first and/or in both breaks. These being $c^p, k^p, k^s, k^h, \pi, m^{con}, m^{sup}, y, w^p, o^x, e - p, o^a$, and $po$. Regarding the stationary time series the break dates were consistent with the changing of the economic regime in 1977 when the private sector was prohibited; increasing oil prices during the period of the late 1970s, early 1980s, and then since 2000; the collapse of oil prices during the mid 1980s until the 1990s; the economic reforms during the late 1990s and the beginning of this century in which the restrictions upon the private sector were alleviated, the embargo imposed by the USA in the early 1980s where part of foreign assets were frozen; the UN sanctions in the early 1990s; the depreciation of the official exchange rate in 1999 as well as the lifting of sanctions imposed by the United Nations; the unification of the exchange rate in 2002; and the lifting of the embargo imposed by the USA in 2003.
Table 5.2: Results of Two-Break Minimum LM Unit Root Test, Model C: Breaks in Intercep and Slope.

<table>
<thead>
<tr>
<th>Variable</th>
<th>t-Statistic</th>
<th>( T_{B1} )</th>
<th>( T_{B2} )</th>
<th>k</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real private consumption (( c^p ))</td>
<td>-6.4180*</td>
<td>1983</td>
<td>2000</td>
<td>4</td>
<td>Stationary</td>
</tr>
<tr>
<td>Real non-oil exports (( x^\alpha ))</td>
<td>-6.4417*</td>
<td>1978</td>
<td>2000</td>
<td>4</td>
<td>Stationary</td>
</tr>
<tr>
<td>Aggregate supply of non-oil output (( N_o^x ))</td>
<td>-3.6777</td>
<td>1976</td>
<td>1989</td>
<td>2</td>
<td>Unit Root</td>
</tr>
<tr>
<td>Aggregate demand for non-oil output (( N_o^x ))</td>
<td>-4.2819</td>
<td>1977</td>
<td>1989</td>
<td>2</td>
<td>Unit Root</td>
</tr>
<tr>
<td>Private capital stock (( k^p ))</td>
<td>-5.9800*</td>
<td>1976</td>
<td>2000</td>
<td>0</td>
<td>Stationary</td>
</tr>
<tr>
<td>Actual public capital stock (( k^x ))</td>
<td>-5.6212</td>
<td>1980</td>
<td>1991</td>
<td>4</td>
<td>Unit Root</td>
</tr>
<tr>
<td>Imported capital stock (( k^{op} ))</td>
<td>-4.7665</td>
<td>1976</td>
<td>1999</td>
<td>0</td>
<td>Unit Root</td>
</tr>
<tr>
<td>Human capital stock (( k^h ))</td>
<td>-6.7033*</td>
<td>1982</td>
<td>2002</td>
<td>0</td>
<td>Stationary</td>
</tr>
<tr>
<td>Inflation rate (( \pi ))</td>
<td>-8.0248*</td>
<td>1976</td>
<td>1999</td>
<td>0</td>
<td>Stationary</td>
</tr>
<tr>
<td>Consumption of non-oil import (( m^{con} ))</td>
<td>-5.1373</td>
<td>1987</td>
<td>2003</td>
<td>3</td>
<td>Unit Root</td>
</tr>
<tr>
<td>Capital non-oil imports (( m^{con} ))</td>
<td>-7.8678*</td>
<td>1987</td>
<td>2003</td>
<td>2</td>
<td>Stationary</td>
</tr>
<tr>
<td>Total real income (( y ))</td>
<td>-5.1194</td>
<td>1980</td>
<td>1994</td>
<td>3</td>
<td>Unit Root</td>
</tr>
<tr>
<td>Developments in the current account (( f ))</td>
<td>-7.2376*</td>
<td>1976</td>
<td>1980</td>
<td>0</td>
<td>Stationary</td>
</tr>
<tr>
<td>Foreign interest income (( r^* f ))</td>
<td>-4.7006</td>
<td>1982</td>
<td>1999</td>
<td>1</td>
<td>Unit Root</td>
</tr>
<tr>
<td>Real private weal (( w^p ))</td>
<td>-5.9864*</td>
<td>1982</td>
<td>1999</td>
<td>2</td>
<td>Stationary</td>
</tr>
<tr>
<td>Oil exports (( o^x ))</td>
<td>-7.0671*</td>
<td>1983</td>
<td>2001</td>
<td>3</td>
<td>Stationary</td>
</tr>
<tr>
<td>Domestic real wage (( w-p ))</td>
<td>-4.9416</td>
<td>1979</td>
<td>1993</td>
<td>3</td>
<td>Unit Root</td>
</tr>
<tr>
<td>Real money balances (( m-p ))</td>
<td>-4.8823</td>
<td>1976</td>
<td>1997</td>
<td>0</td>
<td>Unit Root</td>
</tr>
<tr>
<td>Real exchange rate (( e-p ))</td>
<td>-4.7717</td>
<td>1994</td>
<td>2000</td>
<td>3</td>
<td>Unit Root</td>
</tr>
<tr>
<td>Oil production (( o^{\alpha} ))</td>
<td>-8.0949*</td>
<td>1988</td>
<td>1997</td>
<td>4</td>
<td>Stationary</td>
</tr>
<tr>
<td>World oil price (in foreign currency) (( p_o ))</td>
<td>-4.9327</td>
<td>1985</td>
<td>1998</td>
<td>3</td>
<td>Unit Root</td>
</tr>
<tr>
<td>World real income ( y^* )</td>
<td>-6.8167*</td>
<td>1977</td>
<td>1991</td>
<td>4</td>
<td>Stationary</td>
</tr>
</tbody>
</table>

The critical values at the five percent significance level are as follows: for \( c^p, k^h, m^{con}, m^{op}, r^* f, w^p, o^x, o^{\alpha}, p_o \), \( \lambda = (0.4, 0.8) = -5.56; \) for \( x^\alpha, k^p, k^{op}, \pi, y, (m-p), y^* \) is \( \lambda = (0.2, 0.8) = -5.71; \) for \( N_o^x, N_o^x, k^x, (w-p) \) is \( \lambda = (0.2, 0.6) = -5.74; \) for \( f \) is \( \lambda = (0.2, 0.4) = -5.59; \) and for \( (e-p) \) is \( \lambda = (0.6, 0.8) = -5.73. \)

5.5 The Autoregressive Distributed Lag (ARDL) cointegration approach

To empirically analyse the long-run relationships and dynamic interactions between the variables of interest, the behavioural equations of the model are now estimated by utilising the ARDL (or bounds testing) cointegration approach\(^{74}\). Numerous

\(^{74}\) Several tests for cointegration have been introduced since the seminal work of Engle and Granger (1987) proposed the concept. The most widely used method for testing cointegration in the literature are the residual-based Engle and Granger (1987) and Phillips and Ouliaris (1990) approaches, the residual-based test for the null hypothesis of cointegration by Shin (1994), the maximum likelihood-based Johansen (1988, 1991, 1995) and Johansen and Juselius (1990), and the ARDL method proposed by Pesaran (1997), Pesaran and Shin (1998), Pesaran, Shin, and Smith (1996, 2001) and Pesaran and Smith (1998). In
studies have used the ARDL cointegration technique to determine the long-run relationships among variables of interest and to estimate the long-run and short-run elasticities. This is due to a number of advantages that ARDL has over other cointegration techniques, such as that of the residual-based Engle and Granger and cointegrating rank test by Johansen methods. The advantages of the ARDL approach are as follows.

First, the main advantage of the ARDL approach is that it can be applied regardless of whether the variables are $I(0)$, $I(1)$, or mutually cointegrated (Pesaran et al, 2001, p.290). That is, the ARDL approach, unlike other multivariate cointegration techniques such as the maximum likelihood-based Johansen, and Johansen and Juselius approaches, does not require the pre-testing of the variables included in the model for unit roots. In regard to this study, as we are not certain about the stationarity properties of the variables in the Libyan model, using the ARDL approach would be the more appropriate approach for empirical analysis.

A second advantage of the ARDL procedure is that it is relatively unbiased, and hence, a more statistically significant approach to determine the cointegration relationship for a small sample size as is the case for this study (Ghatak & Siddiki, 2001). This study has a relatively small number of annual observations (1970 – 2007).

Third, a dynamic error correction model (ECM) can be obtained from the ARDL model via simple linear transformation. The ECM integrates the short-run dynamics with other cointegration techniques proposed by Carrion-i-Silvestre and Sanso (2006), Gregory and Hansen (1996), and the Westerlund and Edgerton (2007) test for cointegration with one structural break. However, in this chapter we test for unit roots to eliminate the possibility of $I(2)$ variables, and also to identify the main structural breaks. The unit root test was conducted for all variables in the behavioural equations. First the ADF and PP unit root tests were conducted, where only 7 of the 22 time series were rejected. However, when the LM unit root test with two structural breaks was applied, 13 of the variables under investigation were revealed to be stationary.
the long-run equilibrium without losing long-run information. That is, the short-run 
model and long-run model can be estimated simultaneously, removing problems 
associated with excluding variables and autocorrelation (Narayan & Narayan, 2006, 
p.471).

Fourth, the ARDL approach avoids the difficulties experienced by the Johansen 
cointegration technique such as deciding the number of exogenous and endogenous 
variables to be included, the treatment of deterministic components, and the order of 
VAR and the optimal number of lags to be identified. The estimation procedures are very 
sensitive to such choices and decisions (Pesaran & Smith, 1998). Finally, the ARDL 
method is able to distinguish dependent and independent variables when cointegration 

As has been shown by the unit root tests, in particular the results derived from the 
LM method, the time series of the behavioural equations in this study are a combination 
of stationary and non-stationary variables, i.e., the variables consist of a mix of \( I(0) \) and 
\( I(1) \) series with structural breaks\(^{77}\). For this reason, and the advantages mentioned above, 
the ARDL cointegration approach is utilised in this study to analyse the long-run 
relationships and dynamic interactions between the variables in the behavioural equations 
of the model developed in the previous chapter.

According to Pesaran \textit{et al}. (2001), and Pesaran and Pesaran (2009) the 
augmented ARDL \((p, q_1, q_2, \ldots, q_k)\) is given by the following equation:

\[
\Omega(L, p) y_t = \alpha_0 + \sum_{i=1}^{k} \beta_i(L, q_i) x_{it} + \delta w_t + \varepsilon_t \quad \text{(5.5)}
\]

where \( \Omega(L, p) = 1 - \Omega_1 L - \Omega_2 L - \cdots - \Omega_p L^p \quad \text{(5.6)} \)

\(^{77}\) Because of this reason all cointegration procedures are ruled out except for that of ARDL.
and $\beta_i(L,q_i) = \beta_{i0} + \beta_{i1}L + \beta_{i2}L^2 + \cdots + \beta_{iq_i}L^{q_i}$ \quad i = 1,2,\ldots,k \quad (5.7)

$y_t$ is the dependent variable; $L$ is a lag operator such that $L^t y_t = y_{t-1}$; $\alpha_0$ is a constant term; and $w_t$ is a $s \times 1$ vector of deterministic variables such as the intercept term, time trend, dummy variables and other exogenous variables with fixed lags. The $x_{it}$ in equation (5.5) is the $i$ independent variable where $i = 1,2,\ldots,k$. In the long-run, we have $y_t = y_{t-1} = \cdots = y_{t-p}; x_{it} = x_{i,t-1} = \cdots = x_{i,t-q}$ where $x_{i,t-q}$ denotes the $q$th lag of the $ith$ variable.

The long-run coefficient for a response of $y_t$ to a unit change in $x_{it}$ is estimated by:

$$\beta_i = \frac{\hat{\beta}_i(1,\hat{q}_i)}{\Omega(1,\hat{p})} = \frac{\hat{\beta}_{i0} + \hat{\beta}_{i1} + \cdots + \hat{\beta}_{iq_i}}{1 - \hat{\Omega}_1 - \hat{\Omega}_2 - \cdots - \hat{\Omega}_p}, \quad i = 1,2,\ldots,k \quad (5.8)$$

$\hat{p}_i$ and $\hat{q}_i,i = 1,2,\ldots,k$ are the selected (estimated) values of $p$ and $q_i,i = 1,2,\ldots,k$.

Likewise, the long-run coefficients associated with the intercept term, time trend, dummy variable, or exogenous variables with fixed lags are estimated by:

$$\delta_i = \frac{\hat{\delta}(\hat{p},\hat{q}_1,\hat{q}_2,\ldots,\hat{q}_k)}{1 - \hat{\Omega}_1 - \hat{\Omega}_2 - \cdots - \hat{\Omega}_p} \quad (5.9)$$

where $\hat{\delta}(\hat{p},\hat{q}_1,\hat{q}_2,\ldots,\hat{q}_k)$ denotes the OLS estimate of $\delta$ in equation (5.5) for the selected ARDL model. The error correction (ECM) representation of the ARDL ($\hat{p},\hat{q}_1,\hat{q}_2,\ldots,\hat{q}_k$) model can be obtained by rewriting equation (5.5) in terms of the lagged levels and first differences of $y_t,x_{i1},x_{i2},\ldots,x_{iq_i}$ and $w_t$. First note that:

$$y_t = \Delta y_t + y_{t-1}, \quad y_{t-s} = y_{t-1} - \sum_{j=1}^{s-1} \Delta y_{t-j}, \quad s = 1,2,\ldots,p$$

and similarly

$$w_t = \Delta w_t + w_{t-1}$$

$$x_{it} = \Delta x_{it} + x_{i,t-1}, \quad x_{i,t-s} = x_{i,t-1} - \sum_{j=1}^{s-1} \Delta x_{i,t-j}, \quad s = 1,2,\ldots,q_i \quad (5.10)$$
Substituting the relations in (5.10) into (5.5), and after some rearrangements, we have

$$\Delta y_i = \Delta \alpha_0 - \Omega(1, \hat{p})ECM_{t-1} + \sum_{i=1}^k \beta_{0i}y_{it} - \sum_{j=1}^{i-1} \Omega^j y_{t-j} - \sum_{i=1}^k \sum_{j=1}^{d_i} \beta_{ij}^j \Delta x_{t-j} + \delta' \Delta w_i + \epsilon_i \quad (5.11)$$

where \( ECM_i \) is the correction term determined as follows:

$$ECM_i = y_i - \hat{\alpha} - \sum_{i=1}^k \hat{\beta}_i x_{it} - \delta' w_i \quad (5.12)$$

and \( \Delta \) is the first difference operator, \( \Omega^j \), \( \beta_{ij}^j \) and \( \delta' \) are the coefficients which are related to the short-run dynamics of the model convergence to equilibrium whilst \( \Omega(1, \hat{p}) \) measures the speed of adjustment.

The ARDL requires a two-step procedure for estimating the long-run relationships. The first step is to investigate the existence of a long-run relationship among the variables in the equation of interest. This can be done by using the F-test. Once a long-run cointegrating relationship is found to exist the second step is to estimate the long and short-run elasticities. Applying ECM determines the short-run adjustment to its long-run equilibrium.

### 5.5.1 Specification of behavioural equations

The logarithmic version of the Libyan macroeconomic model is shown in Chapter 4. Following Pesaran et al. (2001), and without having any prior knowledge about the direction of the relationship among the variables, the behavioural equations, i.e., equations (2), (15), (16), (19), (23), (24), and (25) in the model, can be expressed in the form of an unrestricted error correction model (UECM) format as follows:

$$\Delta c^p = \alpha_0 + \sum_{j=1}^a b_j \Delta c_{t-j} + \sum_{j=0}^c c_j \Delta N_t^p + \sum_{j=0}^d d_j \Delta w_{t-j} + \delta_1 c_{t-1} + \delta_2 N_{t-1} + \delta_3 w_{t-1} + \delta_4 D_{83} + \delta_5 D_{2000} + \epsilon_i \quad (5.13)$$
\[
\Delta x^n = \alpha_0 + \sum_{j=1}^{n} b_j \Delta x^n_{-j} + \sum_{j=0}^{n} c_j \Delta (e + p^* - p)_{-j} + \sum_{j=0}^{n} d_j \Delta y^*_{-j} + \delta x^n_{-1} + \delta_2 (e + p^* - p)_{-1} + \delta_3 y^*_{-1} + \delta_4 D_{78} + \delta_5 D_{2000} + \varepsilon,
\]

\[
\Delta m^{com} = \alpha_0 + \sum_{j=1}^{n} b_j \Delta m^{com}_{-j} + \sum_{j=0}^{n} c_j \Delta y^*_{-j} + \sum_{j=0}^{n} d_j \Delta (e + p^* - p)_{-j} + \delta m^{com}_{-1} + \delta_2 y^*_{-1} + \delta_3 (e + p^* - p)_{-1} + \delta_4 D_{87} + \delta_5 D_{2003} + \varepsilon,
\]

\[
\Delta (m - p) = \alpha_0 + \sum_{j=1}^{n} b_j \Delta (m - p)_{-j} + \sum_{j=0}^{n} c_j \Delta No^d - No^*_{-j} + \sum_{j=0}^{n} d_j \Delta \pi^*_{-j} + \delta_2 No^d - No^*_{-1} + \delta_3 No^d - No^*_{-1} + \delta_4 \pi^*_{-1} + \delta_5 D_{61} + \varepsilon,
\]

\[
\Delta \psi = \alpha_0 + \sum_{j=1}^{n} b_j \Delta \psi_{-j} + \sum_{j=0}^{n} c_j \Delta (No^d - No^*_{-j}) + \sum_{j=0}^{n} d_j \Delta \pi^*_{-j} + \delta_2 (No^d - No^*_{-1}) + \delta_3 \pi^*_{-1} + \varepsilon,
\]

\[
\Delta No^d = \alpha_0 + \sum_{j=1}^{n} b_j \Delta No^d_{-j} + \sum_{j=0}^{n} c_j \Delta k^p_{-j} + \sum_{j=0}^{n} d_j \Delta k^e_{-j} + \sum_{j=0}^{n} e_j \Delta k^h_{-j} + \sum_{j=0}^{n} f_j \Delta m_{-j} + \sum_{j=0}^{n} g_j \Delta k^{cap}_{-j} + \delta_2 No^d_{-1} + \delta_3 k^p_{-1} + \delta_4 k^e_{-1} + \delta_5 k^h_{-1} + \delta_6 em_{-1} + \delta_7 k^{cap}_{-1} + \delta_8 D_{69} + \varepsilon,
\]

\[
\Delta \tilde{f} = \alpha_0 + \sum_{j=0}^{n} c_j \Delta T_{-j} + \sum_{j=1}^{n} b_j \Delta \tilde{f}_{-j} + \sum_{j=0}^{n} c_j \Delta r^* f_{-j} + \sum_{j=0}^{n} d_j \Delta (o^* + po)_{-j} + \sum_{j=0}^{n} e_j \Delta (e - w)_{-j} + \delta_1 \tilde{f}_{-1} + \delta_2 T_{-1} + \delta_3 r^* f_{-1} + \delta_4 (o^* + po)_{-1} + \delta_5 (e - w)_{-1} + \varepsilon,
\]

where \( \alpha_0 \) is a drift component, \( \varepsilon \) is white noise error, \( \delta_i, \ i = 1, 2, 3, 4, ... \) are the long-run multipliers, and \( b, c, d, ... \) are the corresponding short-run dynamic coefficients of the ARDL models. To investigate the existence of a long-run relationship among the variables, unrestricted error correction model (UECM) regressions are estimated considering each of the variables in turn as a dependent variable. That is, the null hypothesis is tested by considering the UECM for the behavioural equations, restricting all the lagged variables. Specifically, the null hypothesis of cointegration amongst the variables \( H_0 : \delta_1 = \delta_2 = \delta_3 = ... = \delta_i \) is tested against the alternative hypothesis
\( H_1 : \delta_1 \neq \delta_2 \neq \delta_3 \neq \ldots \neq \delta_i \neq 0 \) by means of an F-test with an asymptotic non-standard distribution. This can also be expressed as \( F(c^p / N \sigma^i, w^p, D_{83}, D_{2000}) \) for equation (5.13). Similarly, the null hypothesis of non-existence of a long-run relationship in equations (5.14), (5.15), (5.16), (5.17), (5.18), and (5.19) can be expressed in the same manner, respectively.

The computed F-statistic value will be compared with the critical values reported in Pesaran and Pesaran (2009, p.544). Two sets of critical values are tabulated; lower bound critical values assuming the regressors are \( I(0) \) and upper bound critical values assuming the regressors are purely \( I(1) \). If the computed value is above the upper critical value the null hypothesis of no long-run relationship is rejected, irrespective of the orders of integration for the time series. On the contrary, if the computed value falls below the lower critical value the null hypothesis is not rejected, and the conclusion is that there is no long-run relationship between the independent variable and its determinants. On the other hand, if the F-statistic falls between the lower and upper critical values the result is inconclusive. In the last case conclusive inference cannot be made without knowing the order of integration of the regressors. Once the long-run relationship is established the long-run and short run elasticities can be estimated. The order of the lags in the ARDL model is selected by either the Akaike Information criterion (AIC) or the Schwartz Bayesian criterion (SBC).

5.5.2 The parameters

The model consists of 30 equations four of which are definitions, 33 endogenous variables, and 10 exogenous variables. All variables in the model are in log form except that of the domestic interest rate and the world interest rate, and the parameter in front of each variable indicates its elasticity. The definitions of endogenous and exogenous
variables are presented in Table 4.2 in Chapter 4. These equations are grouped into three categories, as follows: behavioural, identities, and adjustment equations, respectively. Equations (4.2), (4.15), (4.16), (4.19), (4.23), (4.24) and (4.25) are behavioural equations and their parameters are estimated by the ARDL cointegration approach. Equations (4.1), (4.5), (4.14), (4.17), (4.18), (4.20), and (4.22) are identity equations. The parameters of these equations can be determined by either using available data for the Libyan economy or values attained from other studies. The third category consists of equations (4.3), (4.7), (4.8), (4.9), (4.13), and (4.21). The policy adjustment parameters of these equations are also imposed by either using values obtained from other studies (where available) or by utilising a priori beliefs.

In regard to the behavioural equations the trend term is included in the equations as this coincides with the LM unit root test of Lee and Strazicich (2003), which captures two structural breaks in the intercept and trend. Therefore, in line with Pesaran et al. (2001), the general error correction model with unrestricted intercept and unrestricted trend is estimated.

As mentioned earlier the first stage in the ARDL bounds testing approach is to estimate the equations by OLS, so as to investigate the existence of a long-run relationship between the variables of interest by conducting an F-test. In the second stage, once the existence of cointegration is established, the long-run and short-run elasticities can be estimated by using the ARDL technique proposed by Pesaran et al. (2001). The empirical results for behavioural equations (4.2), (4.15), (4.16), (4.19), (4.23), (4.24) and (4.25) of the model are now presented.
5.5.3 Testing for the existence of a long-run relationship among the variables

Because the sample size is small, the Akaike Information Criterion (AIC) lag specification was chosen to be between 1 and 3 as maximum to produce the best results (see section 5.5.4). The results presented in Table 5.3 indicate conclusive outcomes for the dependent variables $c^p, x^n, m^{cap}, m - p, \hat{w}, \hat{N}o^t$ and $\hat{f}$, 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 and 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.

Table 5.3: Testing for the Existence of a Long-Run Relationship among the Variables*

<table>
<thead>
<tr>
<th>Equation</th>
<th>95% Lower bound</th>
<th>95% Upper bound</th>
<th>90% Lower bound</th>
<th>90% Upper bound</th>
<th>The computed $F$-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F(c^p / No^t, w^p, D_{53}, D_{2000})$</td>
<td>7.1331</td>
<td>8.1223</td>
<td>5.9643</td>
<td>6.8483</td>
<td>8.5036</td>
</tr>
<tr>
<td>$F(x^n / (e + p^*-p), \hat{y}, D_{78}, D_{2000})$</td>
<td>7.2027</td>
<td>8.0224</td>
<td>5.9599</td>
<td>6.8090</td>
<td>9.5687</td>
</tr>
<tr>
<td>$F(m^{con} / y, (e-p^*-p), D_{87}, D_{2003})$</td>
<td>6.8999</td>
<td>7.9831</td>
<td>5.7676</td>
<td>6.7289</td>
<td>6.9717</td>
</tr>
<tr>
<td>$F(m - p / No^t, r, \hat{\pi}, D_{81})$</td>
<td>4.9827</td>
<td>5.9803</td>
<td>4.1361</td>
<td>5.0154</td>
<td>6.1426</td>
</tr>
<tr>
<td>$F(w/(No^d - No^t), \hat{\pi})$</td>
<td>2.8906</td>
<td>4.1355</td>
<td>2.2636</td>
<td>3.3349</td>
<td>6.7978</td>
</tr>
<tr>
<td>$F(No^t / k^p, k^n, k^h, em, k^{cap}, D_{80})$</td>
<td>3.4346</td>
<td>4.8073</td>
<td>2.9059</td>
<td>4.0535</td>
<td>5.9323</td>
</tr>
<tr>
<td>$F(\hat{f} / T, r^f, (o^t + po),(e - p))$</td>
<td>4.0285</td>
<td>5.3829</td>
<td>3.3851</td>
<td>4.627</td>
<td>5.9057</td>
</tr>
</tbody>
</table>

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

The following step is to estimate the long-run parameters using the ARDL approach, and then the short-run parameters using an ECM. The two significant and relevant structural breaks determined endogenously by the LM model will be taken into account by inclusion of break date dummy variables in the ARDL model. The break points for $c^p$ are 1983 and 2000; for $x^n$ 1978 and 2000; for $m^{con}$ and $m^{cap}$ 1987 and

---

78 The two dummy variables take the value of 0 until the break date and then 1 afterwards.
2003; and for \( m - p \) it is 1981. The empirical results of the long-run and short-run coefficients of the behavioural equations are presented in the next sub-section.

### 5.5.4 Estimation results of the behavioural equations based on the ARDL model

Several specifications of the equations were tried so as to obtain better results in terms of higher \( R^2 \), t-statistics, and accepted value of the Durbin-Watson statistic (DW)\(^79\); however, efforts were made to keep the specifications as simple as possible. The results for behavioural equations of the model (4.2), (4.15), (4.16), (4.19), (4.23), (4.24) and (4.25) in Chapter 4 are presented in Tables 5.4 to 5.10.

Equation (5.13), which is equivalent to equation (4.2) in Chapter 4, represents the private sector consumption function. The Akaike Information Criterion (AIC) lag specification is ARDL (3, 0, 0) and the long-run and short-run coefficient estimates are reported in Table 5.5. The results indicate that the long-run estimated coefficient of non-oil real income elasticity has the correct positive sign (0.66), and is significant at the 1 percent level. This means that a 1 percent increase in non-oil real income will result in an increase in real private consumption by 0.66 percent, which is consistent with economic theory’s view that income is crucial in the consumption function. Also, the long-run estimated coefficient of the wealth elasticity has the right sign (0.54) and is significant at the 5 percent level. This indicates that individuals whose wealth increased during the oil boom increased their consumption level as well.

The trend and structural change for 1983 are also significant. The dummy variable for 1983 has a negative sign indicating that it has a negative long-run and short-

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\(^{79}\) To ascertain the appropriateness of the ARDL models, various diagnostic analyses for serial correlation, heteroskedasticity, normality of residuals and model adequacy (RESET) were conducted and are reported in Appendix 5.3.
run impact upon real private consumption. The structural change of 1983 is consistent with the introduction of Law No.15 in the early 1980s, when wages were frozen.

The short-run elasticities tell a similar story to the long-run where non-oil real income and private real wealth have a positive effect upon real private consumption, and both are significant at the 5 percent level. The empirical results also show that lagged private consumption by two periods positively affects the current private consumption behaviour of individuals.

The result for the error correction term for private consumption indicates that the coefficient of ECM (-0.56) has the correct sign and is statistically significant at the 1 percent level and is moderately large, showing a strong and significant tendency for private consumption to return back to long-run equilibrium when shocks occurred in the short-term. In other words, significant error correction confirms the existence of a stable long-run relationship among the significant explanatory variables and real private consumption expenditure.
Table 5.4: Estimated Long-Run Coefficients and Short-Run Error Correction Model (ECM) for the Real Private Consumption Equation (Equation 4.2)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistics</th>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>$No^s$</td>
<td>0.6636</td>
<td>2.9561</td>
<td>$\Delta c_{t-1}^p$</td>
<td>0.5767</td>
<td>3.1175</td>
</tr>
<tr>
<td>$w^p$</td>
<td>0.5438</td>
<td>2.1632</td>
<td>$\Delta c_{t-2}^p$</td>
<td>0.5859</td>
<td>3.8735</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.6310</td>
<td>-0.8602</td>
<td>$\Delta No^s$</td>
<td>0.7668</td>
<td>2.3359</td>
</tr>
<tr>
<td>Trend</td>
<td>-0.0533</td>
<td>-4.2839</td>
<td>$\Delta w^p$</td>
<td>0.6313</td>
<td>2.2949</td>
</tr>
<tr>
<td>D1983</td>
<td>-0.1423</td>
<td>-1.6100</td>
<td>Trend</td>
<td>-0.0619</td>
<td>-3.8767</td>
</tr>
<tr>
<td>D2000</td>
<td>0.0872</td>
<td>0.9116</td>
<td>$\Delta D1983$</td>
<td>-0.1651</td>
<td>-1.4176</td>
</tr>
<tr>
<td>$\Delta D2000$</td>
<td>0.1012</td>
<td>0.9694</td>
<td>ecm(-1)</td>
<td>-0.5607</td>
<td>-2.9309</td>
</tr>
</tbody>
</table>

$R^2 = 0.74$  
D-W = 2.10

Equation (5.14), which is equivalent to equation (4.14) in Chapter 4, identifies non-oil exports. The lags of the variables are given by AIC as ARDL (1, 0, 0). The long-run and the short-run coefficient estimates are reported in Table 5.5. It can be seen from Table 5.5 that the long-run coefficient of the real exchange rate is not significant. The elasticity of world real income, as measured by the GDP of North Africa and Middle East countries, is elastic and significant at the 5 percent level.

The trend and structural break for 2000 are also significant at the 5 percent level. The structural change for 2000 coincided with the freezing of sanctions imposed by the United Nations and with the depreciation of the official exchange rate.

The short-run elasticity of the real exchange rate (0.35) is significant at the 10 percent level, whereas the elasticity of world real income experienced a slight decrease but is still significant at the 5 percent level. Table 5.5 also shows that the ECM coefficient is (-0.75) and highly significant. This implies that deviations from the long-
term rate of non-oil exports are corrected by 0.75 percent in the next period, which is a relatively fast pace of adjustment back to equilibrium.

Table 5.5: Estimated Long-Run Coefficients and Short-Run Error Correction Model (ECM) of Real Non-Oil Exports Equation (Equation 4.14)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistics</th>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>(e + p *−p)</td>
<td>0.4735</td>
<td>1.4607</td>
<td>Δ(e + p *−p)</td>
<td>0.3556</td>
<td>1.6807</td>
</tr>
<tr>
<td>y *</td>
<td>7.0362</td>
<td>2.3759</td>
<td>Δy *</td>
<td>5.2843</td>
<td>2.1526</td>
</tr>
<tr>
<td>Constant</td>
<td>-113.30</td>
<td>-2.3044</td>
<td>Trend</td>
<td>-0.1618</td>
<td>-2.1484</td>
</tr>
<tr>
<td>Trend</td>
<td>-0.2154</td>
<td>-2.0094</td>
<td>ΔD1983</td>
<td>-0.07598</td>
<td>-0.1883</td>
</tr>
<tr>
<td>D1978</td>
<td>-0.1012</td>
<td>-0.1869</td>
<td>ΔD2000</td>
<td>1.5552</td>
<td>2.3150</td>
</tr>
<tr>
<td>D2000</td>
<td>2.0708</td>
<td>2.0416</td>
<td>ecm(-1)</td>
<td>-0.7510</td>
<td>-4.4940</td>
</tr>
<tr>
<td>R² = 0.60</td>
<td></td>
<td></td>
<td>D-W = 2.03</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The long-run and short-run coefficients of non-oil imports consumption, equation (5.15) which is equivalent to equation (4.16) in Chapter 4, are reported in Table 5.6. The lags of the variables are given by AIC as ARDL (1, 0, 0). The elasticity of real income in the long-run has the right sign 0.74 and is highly significant at the 1 percent level. This result implies that a 1% increase in real income will result in a 75 percent increase in imported consumption goods from overseas. It can also be seen from Table 5.6 that the long-run coefficient of the real exchange rate (0.25) has a negative sign and is significant at the 5 percent level.

The constant, trend and structural changes are all significant during the long-term. The break point of 1987 coincided with the decrease of oil prices, while the break point of 2003 is consistent with the lifting of the embargo imposed by the USA and the continuous increase of oil prices.
The elasticities of both variables experienced a considerable decrease during the short-term, but were still significant at the 1 percent level. Also, the ECM shows a high speed of adjustment and reconfirms the long-run relationship between the variables. It indicates that more than 0.65 percent of disequilibrium in the consumption of non-oil imports in the previous year is corrected in the current year.

**Table 5.6: Estimated Long-Run Coefficients and Short-Run Error Correction Model (ECM) for the Consumption of Non-Oil Imports Equation (Equation 4.16)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistics</th>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>0.7438</td>
<td>3.5753</td>
<td>$\Delta y$</td>
<td>0.4853</td>
<td>3.6452</td>
</tr>
<tr>
<td>$(e + p^* - p)$</td>
<td>-0.2565</td>
<td>-2.2490</td>
<td>$\Delta (e + p^* - p)$</td>
<td>-0.1673</td>
<td>-2.9166</td>
</tr>
<tr>
<td>Constant</td>
<td>2.4202</td>
<td>1.4721</td>
<td>Trend</td>
<td>-0.0232</td>
<td>-2.2521</td>
</tr>
<tr>
<td>Trend</td>
<td>-0.0355</td>
<td>-2.0950</td>
<td>$\Delta D1987$</td>
<td>0.4245</td>
<td>2.5530</td>
</tr>
<tr>
<td>D1987</td>
<td>0.6507</td>
<td>2.1544</td>
<td>$\Delta D2007$</td>
<td>-0.4309</td>
<td>-2.4118</td>
</tr>
<tr>
<td>D2003</td>
<td>-0.6605</td>
<td>-1.9677</td>
<td>ecm(-1)</td>
<td>-0.6524</td>
<td>-4.3951</td>
</tr>
<tr>
<td>$R^2 = 0.67$</td>
<td>D-W = 2.31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equation (5.16), which is equivalent to equation (4.19) in Chapter 4, represents the demand for real money balances, defined as the nominal money stock deflated by the consumer price index $m - p$. The AIC lag specification for $(m - p)$ is ARDL (1, 0, 1, 0). The results reported in Table 5.7, where the deterministic time trend was excluded, suggest that the long-run estimated parameter of the real non-oil income elasticity (0.41) has the right sign and is highly significant at the 1 percent level. The inflation rate elasticity (0.36) is negative and also significant at the 1 percent level, supporting the theoretical specification identified in Chapter 4. This means that a 1 percent increase in the inflation rate will bring about a decrease in real money demand by 36 percent. However, the long-run coefficient of the domestic interest rate is not significant;
indicating that the interest rate does not reflect the increase in price levels. As a consequence, the interest rate does not reflect the true opportunity cost of holding money in Libya. In other words, the interest rate does not have an important effect on real money demand.

The structural breaks for 1987 and 2003 are significant at the 5 percent and 10 percent levels, respectively. The results show that both breaks have a long-run negative effect on real money demand.

The elasticity of non-oil real income experiences a slight decrease during the short-run, while the elasticity of the inflation rate experiences a considerable increase. However, although the short-run coefficient of the domestic interest rate is significant at the 10 percent level the elasticity of the domestic interest rate is very low indicating that a 1 percent decrease increases the demand for money in Libya by only 7 percent.

Table 5.7 shows that the ECM coefficient has the right sign and is highly significant. This confirms the existence of the cointegration relationship among the variables. The coefficient of ECM is equal to (-0.69), which implies that 0.69 percent of disequilibrium in the previous year is corrected in the current year. This result indicates that the speed of adjustment is really high in the demand for money function in the Libyan economy.
Table 5.7: Estimated Long-Run Coefficients and Short-Run Error Correction Model (ECM) for the Real Money Balances Equation (Equation 4.19)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistics</th>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>$No'$</td>
<td>0.4102</td>
<td>10.1153</td>
<td>$\Delta No'$</td>
<td>0.2870</td>
<td>2.9367</td>
</tr>
<tr>
<td>$\pi$</td>
<td>-0.3624</td>
<td>-3.1979</td>
<td>$\Delta \pi$</td>
<td>-1.3338</td>
<td>-2.6810</td>
</tr>
<tr>
<td>$r$</td>
<td>-0.0987</td>
<td>-1.5171</td>
<td>$\Delta r$</td>
<td>-0.0690</td>
<td>-1.8387</td>
</tr>
<tr>
<td>Constant</td>
<td>1.3204</td>
<td>1.8935</td>
<td>$\Delta D1987$</td>
<td>-0.5162</td>
<td>-2.0614</td>
</tr>
<tr>
<td>$D1987$</td>
<td>-0.0738</td>
<td>-1.6851</td>
<td>$\Delta D20007$</td>
<td>-0.0815</td>
<td>-1.7877</td>
</tr>
<tr>
<td>$D2003$</td>
<td>-0.1166</td>
<td>-1.6537</td>
<td>$ecm(-1)$</td>
<td>-0.6994</td>
<td>-3.6216</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.76</td>
<td></td>
<td>D-W</td>
<td>2.14</td>
<td></td>
</tr>
</tbody>
</table>

The Phillips Curve is identified by equation (5.17), which is equivalent to equation (4.23) in Chapter 4. Two possible adjustment sources were considered; the excess demand for non-oil goods relative to its available supply ($No'^d - No$) and core inflation ($\pi$). Core inflation depends upon developments in the monetary growth rate. The AIC lag specification for $\dot{w}$ is ARDL (1, 0, 1). The results reported in Table 5.8 indicate that the long run coefficients of excess demand for non-oil goods and core inflation are (0.68), and (0.65) respectively, have positive signs and are significant at the 10 percent and 5 percent levels, respectively.

The trend and the constant were omitted to obtain a better result. The break points of 1979 and 1993 were not significant, as indicated by the LM unit root test; hence they were also excluded from the specification of equation (5.17)\(^80\).

---

\(^80\) The Lee and Strazicich (2004) unit root test with one structural break was also conducted, but the break date was not significant.
The short-run coefficient of excess demand for non-oil goods decreased to 0.49 percent, while the short-run coefficient of core inflation considerably increased to 1.06 percent and is very significant at the 1 percent level.

The ECM coefficient has the right sign and is highly significant. This confirms the existence of a cointegration relationship among the variables. The coefficient of the ECM is equal to (-0.72), which implies that 0.72 percent of disequilibrium in the previous year is corrected in the current year. This result indicates that the speed of adjustment is significantly high in the Phillips equation for the Libyan economy.

Table 5.8: Estimated Long-Run Coefficients and Short-Run Error Correction Model (ECM) for the Phillips Equation (Equation 4.23)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistics</th>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>((No^d - No^s))</td>
<td>0.6778</td>
<td>1.6985</td>
<td>(\Delta (No^d - No^s))</td>
<td>0.4903</td>
<td>1.7325</td>
</tr>
<tr>
<td>(\hat{\pi})</td>
<td>0.6509</td>
<td>2.2924</td>
<td>(\Delta \hat{\pi})</td>
<td>1.0667</td>
<td>4.7325</td>
</tr>
<tr>
<td>(ecm(-1))</td>
<td>-0.7234</td>
<td>-4.4947</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R\(^2\) = 0.73  D-W = 2.13

Equation (5.18), which is equivalent to equation (4.24) in Chapter 4, gives the supply of non-oil output. The AIC lag specification for \(No^s\) is ARDL (2, 0, 1, 2, 0, 0). As can be seen from Table 5.9 the elasticity of the real private capital stock in the long-term is small (0.06), and is not significantly different from zero. This finding supports the theoretical description that the private sector has an ineffective role in the economy. As mentioned in Chapter 4 the private sector in the Libyan economy was marginalised in the late 1970s. The elasticity of the real public capital stock is 0.20 and is highly significant at the 1 percent level. This result supports the claim that the public capital stock plays an important role in the economy.
The interesting and innovative results in Table 5.9 are that the long-run coefficients of human capital stock (0.53) and imported capital stock (0.45) are significant at the 5 percent level. These findings support the earlier assumption that not only does the public physical capital stock have a long-run effect upon non-oil output supply in the Libyan economy, but also upon the human capital stock and imported capital stock. The long-run coefficient of employment has a positive sign and is significant at the 5 percent level. This outcome can be interpreted as follows. More than 65 percent of the labour force is employed in the public sector, in which employees are unlikely to be fired when real wages increase. Therefore, an increase in wages will most likely lead to an increase in the demand for non-oil goods and services, which in turn enhances non-oil supply. It is worth mentioning here that the real wage was excluded from the non-oil output equation due to technical difficulties in its estimation.

Again, and like the previous equation, the break dates of 1976 and 1989 were not included in the specification of the non-oil supply equation, as the LM unit root test indicated that they were not significantly different from zero.

The elasticities of the explanatory variables slightly decreased in the short-term. The ECM coefficient has the right sign and is highly significant. This confirms the existence of a cointegration relationship among the variables. The coefficient of ECM is equal to -0.35 which is highly significant, has the correct sign, and suggests a moderate speed of convergence to equilibrium. A significant error correction confirms the existence of a stable long-run relationship among the significant regressors and the dependent variable, No\textsuperscript{*}.
Table 5.9: Estimated Long-Run Coefficients and Short-Run Error Correction Model (ECM) for the Real Non-Oil Output Equation (Equation 4.24)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistics</th>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>$k^p$</td>
<td>0.0566</td>
<td>0.9019</td>
<td>$\Delta N^o_{t-1}$</td>
<td>-0.2534</td>
<td>-1.7346</td>
</tr>
<tr>
<td>$k_g$</td>
<td>0.2061</td>
<td>4.2342</td>
<td>$\Delta k^p$</td>
<td>0.0201</td>
<td>0.9904</td>
</tr>
<tr>
<td>$k_h$</td>
<td>0.5325</td>
<td>2.4162</td>
<td>$\Delta k^g$</td>
<td>0.1106</td>
<td>3.7522</td>
</tr>
<tr>
<td>$k_{cap}$</td>
<td>0.4505</td>
<td>2.0154</td>
<td>$\Delta k^h$</td>
<td>0.4810</td>
<td>1.0003</td>
</tr>
<tr>
<td>$em$</td>
<td>0.5914</td>
<td>2.1358</td>
<td>$\Delta k_{t-1}$</td>
<td>0.7316</td>
<td>1.8514</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.4822</td>
<td>-2.1223</td>
<td>$\Delta k_{cap}$</td>
<td>0.1596</td>
<td>2.4143</td>
</tr>
<tr>
<td>D1996</td>
<td>0.0416</td>
<td>0.3905</td>
<td>$\Delta em$</td>
<td>0.2095</td>
<td>1.5089</td>
</tr>
<tr>
<td>$R^2 = 0.87$</td>
<td>D-W = 1.93</td>
<td></td>
<td>$\Delta D1996$</td>
<td>0.1476</td>
<td>0.4089</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$ecm(-1)$</td>
<td>-0.3542</td>
<td>-4.2061</td>
</tr>
</tbody>
</table>

Equation (5.19), which is equivalent to equation (4.25) in Chapter 4, represents the development of the current account balance. The AIC lag specification for $\hat{j}$ is ARDL (2, 0, 2, 0, 0). As can be seen from Table 5.10 the estimated long-run coefficient of the non-oil trade balance was unsatisfactory because it is not significantly different from zero. The results also indicate that the long-run estimated coefficients of foreign interest income (0.57) and oil exports (0.34) have the correct positive sign and are significant at the 1 percent level and 5 percent level, respectively. The elasticity of the real exchange rate has a negative sign but is not significant even at the 10 percent level.

The results from Table 5.11 suggest that in the short-run the change in the current account depends upon the previous position of the current account which is highly significant at the 1 percent level. Another interesting result from Table 5.10 is that the short-run elasticities of the explanatory variables are almost the same as those for the long-run. The error correction mechanism for the current account development, with a
value of (-1.1881), has the correct sign and is significant at the 1 percent level. This large elasticity magnitude indicates extraordinary overshooting behaviour for the current account during the short-term equilibrium process.

Table 5.10: Estimated Long-Run Coefficients and Short-Run Error Correction Model (ECM) of Development of the Current Account Equation (Equation 4.25)

<table>
<thead>
<tr>
<th>Variable</th>
<th>coefficient</th>
<th>t-statistics</th>
<th>Variable</th>
<th>coefficient</th>
<th>t-statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T$</td>
<td>0.1506</td>
<td>1.1327</td>
<td>$\Delta \hat{f}_{r-1}$</td>
<td>0.5415</td>
<td>2.9384</td>
</tr>
<tr>
<td>$r^*f$</td>
<td>0.5775</td>
<td>4.1594</td>
<td>$\Delta T$</td>
<td>0.1789</td>
<td>1.1136</td>
</tr>
<tr>
<td>$(o^* + po)$</td>
<td>0.3250</td>
<td>2.0135</td>
<td>$\Delta r^*f$</td>
<td>0.5555</td>
<td>4.9177</td>
</tr>
<tr>
<td>$(e - p)$</td>
<td>-0.3787</td>
<td>-1.2976</td>
<td>$\Delta (o^* + po)$</td>
<td>0.3862</td>
<td>2.2228</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.9352</td>
<td>-1.3189</td>
<td>$\Delta (e - p)$</td>
<td>-0.4500</td>
<td>-1.3419</td>
</tr>
<tr>
<td>Trend</td>
<td>0.0058</td>
<td>1.8155</td>
<td>Trend</td>
<td>0.0069</td>
<td>1.6612</td>
</tr>
<tr>
<td>$R^2 = 0.86$</td>
<td>D-W = 2.16</td>
<td></td>
<td>ecm(-1)</td>
<td>-1.1881</td>
<td>-5.4502</td>
</tr>
</tbody>
</table>

5.6 Summary and Conclusions

The main purpose of this chapter has been to empirically estimate the behavioural equations of the model developed in Chapter 4, taking into account two relevant structural breaks. To do so the key macroeconomic variables in the behavioural equations were tested for stationarity and non-stationarity, and the major structural breaks were endogenously defined.

To test for the stationarity of the Libyan time series data the ADF and PP test were conducted for 22 time series. The regression results for the ADF and PP tests with an intercept term and a linear trend indicates that the traditional unit root tests were able to reject 7 out of the 22 series, representing about 32 per cent of the variables considered. Following the traditional unit root tests the LM unit root test, proposed by Lee and Strazicich (2003), was used to determine the most significant structural breaks in the
data. The interesting features of the LM unit root test are that the break points are determined endogenously from the data; it does not exhibit spurious rejections in the finite sample when breaks occur under the null hypothesis; and the critical values of the test corresponds to the exogenous structural break test of Perron (1989).

The results obtained from the LM unit root test indicate a rejection of the unit root null hypothesis for 13 out of 22 variables. These results confirmed the claim of Perron (1989) that the observed unit root behaviour by traditional unit root tests may have resulted from failure to account for a structural break in the data.

Given the break points determined by the LM model, the bounds testing approach to cointegration was utilised to test for the long-run relationship among the variables of interest and to estimate the coefficients of the long-run and short-run behavioural equations. Regarding the long-run relationship among the variables, the F-test indicates conclusive results for most of the variables.

After the long-run relationship was established the long-run and short-run coefficients were estimated by the ARDL approach. The estimates of the coefficients of the behavioural equations, where most of the parameters of the long-run and short-run were satisfactory in terms of signs and significance level, bring about some interesting conclusions. First, the oil sector has stimulated real private consumption through inducing non-oil output and real wealth. Non-oil output is induced mainly by the physical public capital stock, human capital stock, and imported capital stock, which in turn is stimulated by government investment spending arising from oil revenue. On the other hand, real wealth is stimulated by the private capital stock, real money balances and permanent income. Consequently, stimulating real private consumption along with an increase in total government spending will lead to an increase in the demand for non-oil
output. Since the excess demand for non-oil goods relative to their available supply exerts a positive and significant impact upon nominal wages, the domestic price level will also increase.

Second, the real exchange rate exerts a significant impact, particularly during the short term, upon non-oil exports and non-oil imports. Therefore, an increase in the domestic price level, arising from more private and government spending, will result in a real exchange rate appreciation, and this will potentially bring about a combination of increasing non-oil imports and declining non-oil exports; consequently, a deterioration of the non-oil trade balance will occur.

Third, current account developments are influenced positively by foreign interest income and oil exports, since the short and long-run coefficients of these variables are significant. Because the nominal exchange rate is fixed, foreign asset stocks will increase and stimulate money growth. Since the short and long-run coefficients of the monetary growth rate have positive signs and are significant in relationship with money wages, a further appreciation of the real exchange rate is likely to occur if prices subsequently rise.

Finally, the imported capital stock, generated from non-oil capital imports, and human capital stock generated from government spending on education and health services, have positive long-run and short-run effects upon non-oil output supply. These results support the author’s earlier claim that it is not just the public physical capital stock and private capital stock that have a long-run effect upon non-oil supply, but also the imported capital stock and human capital stock can stimulate non-oil supply in both the long and short-run.
Appendix 5.1: Plot of the Time Series

\[ c^p \]

\[ x^n \]

\[ No^i \]

\[ No^j \]

\[ k^p \]

\[ k^s \]
$k^\text{op}$

$\pi$

$m^{\text{in}}$

$m^{\text{op}}$

$y$
*The vertical axis in each graph measures the values of variable in log form.
Appendix 5.2: The Results of Different Methods of Unit Root Tests Utilising the Nelson and Plosser Data Set

Table A: Unit root test with the Nelson and Plosser’s data-set (1982)

<table>
<thead>
<tr>
<th>Empirical Studies</th>
<th>Type of Model</th>
<th>Unit Root</th>
<th>Stationary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nelson and Plosser (1982)</td>
<td>ADF test without break</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>Perron (1989)**</td>
<td>Exogenous with one break</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Zivot and Andrews (1992)*</td>
<td>Endogenous with one break</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Lumsdaine and Papell (1997)*</td>
<td>Endogenous with two breaks</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Lee and Strazicich (2003)**</td>
<td>Endogenous with two breaks</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Popp (2008)**</td>
<td>Endogenous with one break</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Narayan and Popp (2010)**</td>
<td>Endogenous with two breaks</td>
<td>8</td>
<td>6</td>
</tr>
</tbody>
</table>

* Assume no break(s) under the null hypothesis unit root.
** Assume break(s) under both the null and alternative hypothesis.
### Appendix 5.3: Diagnostic Tests Results

#### Table 5.3.1: Real Private Consumption (\(c^p\))

<table>
<thead>
<tr>
<th>Diagnostic test statistics (LM version)</th>
<th>(\chi^2) Statistics</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial correlation(^1) (\chi^2 (1))</td>
<td>2.3619</td>
<td>[0.124]</td>
</tr>
<tr>
<td>Functional form(^2) (\chi^2 (1))</td>
<td>0.2289</td>
<td>[0.632]</td>
</tr>
<tr>
<td>Normality(^3) (\chi^2 (2))</td>
<td>0.0086</td>
<td>[0.996]</td>
</tr>
<tr>
<td>Heteroscedasticity(^4) (\chi^2 (1))</td>
<td>2.3758</td>
<td>[0.123]</td>
</tr>
</tbody>
</table>

\(^1\) Lagrange multiplier test of residual serial correlation; \(^2\) Ramsey’s RESET test using the square of the fitted values; \(^3\) Based on a test of skewness and kurtosis of residuals; \(^4\) Based on the regression of squared residuals on squared fitted values

#### Table 5.3.2: Real Non-Oil Exports (\(x^\alpha\))

<table>
<thead>
<tr>
<th>Diagnostic test statistics (LM version)</th>
<th>(\chi^2) Statistics</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial correlation(^1) (\chi^2 (1))</td>
<td>0.0004</td>
<td>[0.084]</td>
</tr>
<tr>
<td>Functional form(^2) (\chi^2 (1))</td>
<td>3.0143</td>
<td>[0.083]</td>
</tr>
<tr>
<td>Normality(^3) (\chi^2 (2))</td>
<td>0.1835</td>
<td>[0.912]</td>
</tr>
<tr>
<td>Heteroscedasticity(^4) (\chi^2 (1))</td>
<td>3.8455</td>
<td>[0.050]</td>
</tr>
</tbody>
</table>

\(^1\) Lagrange multiplier test of residual serial correlation; \(^2\) Ramsey’s RESET test using the square of the fitted values; \(^3\) Based on a test of skewness and kurtosis of residuals; \(^4\) Based on the regression of squared residuals on squared fitted values

#### Table 5.3.3: The Consumption of Non-Oil Imports (\(m^{con}\))

<table>
<thead>
<tr>
<th>Diagnostic test statistics (LM version)</th>
<th>(\chi^2) Statistics</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial correlation(^1) (\chi^2 (1))</td>
<td>1.5870</td>
<td>[0.208]</td>
</tr>
<tr>
<td>Functional form(^2) (\chi^2 (1))</td>
<td>0.3434</td>
<td>[0.558]</td>
</tr>
<tr>
<td>Normality(^3) (\chi^2 (2))</td>
<td>0.6080</td>
<td>[0.738]</td>
</tr>
<tr>
<td>Heteroscedasticity(^4) (\chi^2 (1))</td>
<td>0.0195</td>
<td>[0.889]</td>
</tr>
</tbody>
</table>

\(^1\) Lagrange multiplier test of residual serial correlation; \(^2\) Ramsey’s RESET test using the square of the fitted values; \(^3\) Based on a test of skewness and kurtosis of residuals; \(^4\) Based on the regression of squared residuals on squared fitted values
Table 5.3.4: Real Money Balances ($m - p$)

<table>
<thead>
<tr>
<th>Diagnostic test statistics (LM version)</th>
<th>$\chi^2$ Statistics</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial correlation</td>
<td>$\chi^2 (1)$</td>
<td>0.49681</td>
</tr>
<tr>
<td>Functional form</td>
<td>$\chi^2 (1)$</td>
<td>0.0113</td>
</tr>
<tr>
<td>Normality</td>
<td>$\chi^2 (2)$</td>
<td>1.7146</td>
</tr>
<tr>
<td>Heteroscedasticity</td>
<td>$\chi^2 (1)$</td>
<td>0.8224</td>
</tr>
</tbody>
</table>

1 Lagrange multiplier test of residual serial correlation; 2 Ramsey’s RESET test using the square of the fitted values
3 Based on a test of skewness and kurtosis of residuals; 4 Based on the regression of squared residuals on squared fitted values

Table 5.3.5: Phillips Equation ($\psi$)

<table>
<thead>
<tr>
<th>Diagnostic test statistics (LM version)</th>
<th>$\chi^2$ Statistics</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial correlation</td>
<td>$\chi^2 (1)$</td>
<td>2.6872</td>
</tr>
<tr>
<td>Functional form</td>
<td>$\chi^2 (1)$</td>
<td>3.3806</td>
</tr>
<tr>
<td>Normality</td>
<td>$\chi^2 (2)$</td>
<td>2.1855</td>
</tr>
<tr>
<td>Heteroscedasticity</td>
<td>$\chi^2 (1)$</td>
<td>0.6855</td>
</tr>
</tbody>
</table>

1 Lagrange multiplier test of residual serial correlation; 2 Ramsey’s RESET test using the square of the fitted values
3 Based on a test of skewness and kurtosis of residuals; 4 Based on the regression of squared residuals on squared fitted values

Table 5.3.6: Real Non-Oil Output ($No'$)

<table>
<thead>
<tr>
<th>Diagnostic test statistics (LM version)</th>
<th>$\chi^2$ Statistics</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial correlation</td>
<td>$\chi^2 (1)$</td>
<td>0.1113</td>
</tr>
<tr>
<td>Functional form</td>
<td>$\chi^2 (1)$</td>
<td>0.2957</td>
</tr>
<tr>
<td>Normality</td>
<td>$\chi^2 (2)$</td>
<td>5.3014</td>
</tr>
<tr>
<td>Heteroscedasticity</td>
<td>$\chi^2 (1)$</td>
<td>0.0165</td>
</tr>
</tbody>
</table>

1 Lagrange multiplier test of residual serial correlation; 2 Ramsey’s RESET test using the square of the fitted values
3 Based on a test of skewness and kurtosis of residuals; 4 Based on the regression of squared residuals on squared fitted values
Table 5.3.7: Development of the Current Account ($\hat{f}$)

<table>
<thead>
<tr>
<th>Diagnostic test statistics (LM version)</th>
<th>$\chi^2$ Statistics</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial correlation$^1$ $\chi^2$ (1)</td>
<td>0.6455</td>
<td>[0.422]</td>
</tr>
<tr>
<td>Functional form$^2$ $\chi^2$ (1)</td>
<td>0.0573</td>
<td>[0.811]</td>
</tr>
<tr>
<td>Normality$^3$ $\chi^2$ (2)</td>
<td>0.2570</td>
<td>[0.879]</td>
</tr>
<tr>
<td>Heteroscedasticity$^4$ $\chi^2$ (1)</td>
<td>2.7148</td>
<td>[0.099]</td>
</tr>
</tbody>
</table>

1 Lagrange multiplier test of residual serial correlation; 2 Ramsey’s RESET test using the square of the fitted values; 3 Based on a test of skewness and kurtosis of residuals; 4 Based on the regression of squared residuals on squared fitted values.
Chapter 6

Simulation Analysis

6.1 Introduction

The aim of this chapter is to conduct numerical simulations to analyse possible macroeconomic effects on the Libyan economy arising from exogenous shocks from increased oil production and oil prices. The macro variables focused upon are real income, real oil income itself, non-oil output, physical capital stock, human capital stock, imported capital stock, private domestic capital stock, foreign asset stock, non-oil trade balance, real exchange rate, domestic inflation rate, and private sector real wealth. Dynamic adjustment of these variables is emphasised as well as identification of their long-run steady state values.

With the assumption of a fixed exchange rate and control over capital mobility, the dynamic equations of the model developed in Chapter 4 are presumed to comprise a number of dynamic endogenous control variables, i.e. private capital stock \( \dot{k}^p \), public physical capital stock \( \dot{k}^g \), human capital stock \( \dot{k}^h \), imported capital stock \( \dot{k}^{cap} \), nominal wages \( \dot{w} \), foreign asset stock \( \dot{f} \), and money growth \( \dot{m} \). The first six control variables are non-jump variables, or predetermined, because of the assumption of stickiness of price and quantity adjustment in non-financial markets. However, money growth, where money is the only financial asset variable assumed here, is the only jump or non-predetermined variable.

A simulation analysis is conducted using a program called “Dynare”, which is designed for solving and simulating deterministic and stochastic dynamic general equilibrium models (see Adjemian, et al. 2011). From this, optimal policies that can be
implemented by policymakers to mitigate the impact of exogenous oil related shocks upon the non-oil sector with the objective of maximising economic growth and development as well as conducting policy reform scenarios, will be identified and discussed in more detail in Chapter 7.

This chapter is organised into five sections. Section 6.2 identifies the parameter values used to conduct the simulation analysis. Section 6.3 presents the simulation analysis, analysing the macroeconomic consequences arising from two kinds of oil shocks. Section 6.4 compares the simulation results arising from an oil production and oil price shock, and section 6.5 provides a summary and conclusion of the major findings from this chapter.

6.2 Parameter values used for the simulation analysis

In this section the base macroeconomic model developed in Chapter 4 is utilised to conduct two numerical simulations. Given the size and complexity of the model under analysis, derivation of analytically unambiguous results for both the steady state and dynamic properties of the model is very difficult to achieve and to analyse. This difficulty is overcome by conducting a numerical solution or calibration of the model. The nominal exchange rate is assumed to be fixed in this base model in line with the Libyan situation. Also, the government exercises significant control over capital mobility into and out of the economy. Thus, capital mobility is assumed to be negligible in the base model scenario. As a consequence, changes in foreign exchange reserves arise only from developments in the current account.

In order to identify the steady state properties of the model as well as the adjustment process towards the long-run steady state arising from oil related shocks, it is essential to determine the numerical values of the parameters of the model. As mentioned
previously in Chapter 4 the equations of the base model can be grouped into three
categories, behavioural, identities, and adjustment equations respectively. The parameter
values utilized are those obtained from:

1. the estimation procedure conducted in Chapter 5 using the ARDL
cointegration technique,
2. those calculated from available data,
3. those set as adjustment coefficients,
4. those obtained from other studies, and
5. those imposed due to data limitation or in order to ensure model stability.

Table 6.2 shows that the 19 estimated parameters for behavioural equations (4.2),
(4.15), (4.16), (4.19), (4.23), (4.24) and (4.25), were mostly significantly different from
zero, and are used in the simulation analysis conducted in this chapter. The remaining
parameters were chosen from previous studies and/or calculated from available data, and
are also utilised in the simulation analysis. For adjustment equations (4.3), (4.7), (4.8)
and (4.9) the adjustment coefficients were selected to be 0.50, indicating moderate
adjustment of the independent variables. In equation (4.26) the parameter has been
selected as 0.70, indicating a more export oriented policy. The distribution of oil
production between domestic usage and for exports under alternative government policy
will be discussed in Chapter 7.

The parameters for equations (4.6), (4.10), (4.11), and (4.12) 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. The allocation of the oil
revenue in the form of consumption and investment expenditure under alternative
government policy will be also analysed in Chapter 7.

For the identities (4.1), (4.5), (4.14), (4.17), (4.18), (4.20) and (4.22) the
parameter values were calculated from the available data or from similar previous
studies. Equation (4.1) demonstrates the share of private consumption and investment,
government total spending as shown in equation (4.5), non-oil exports and non-oil
imports to total demand for non-oil output. In line with the C-H model the parameters are
set to 1.

The parameters in identities (4.17) and (4.18) are calculated as a share of current
and permanent oil output to 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 output is treated as being the same in real and permanent income, and is
constant through time (see Buiter & Purvis, 1982). In the base model, as well as the
alternative models the share of oil output in domestic real income \((1-v)\) is set to be
larger than its share in domestic consumption \((\mu_z)\). This implies that the Libyan
economy is a net oil exporter during its period of production. The parameter \((\beta_{13})\) in
equation (4.14) 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 (see Table 2.2 in Chapter 2). Also, corresponding to the C-H
model, the parameters in (4.20) are set to 1. The weights used in the consumer price
index in (4.22) are approximated as in the H-T model.

It is important to mention here that the macroeconomic model developed in
Chapter 4 is sensitive to changes in the parameter values shown in Table 6.1. Therefore,
for simplicity and in order to maintain model stability, some parameters were slightly
scaled up or down. Specifically, the parameters in price and wage inflation equations (4.22) and (4.23) were marginally scaled down. The form of the macroeconomic model developed in Chapter 4, including the numerical coefficients, is presented in Table 6.1.

Table 6.1: The Macroeconomic Model Including the Numerical Coefficients

<table>
<thead>
<tr>
<th>Product market</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( No^d = c^p + i^p + g + (x^p - m^p) )</td>
<td>(4.1)</td>
</tr>
<tr>
<td>( c^p = 0.66No^s + 0.54w^p )</td>
<td>(4.2)</td>
</tr>
<tr>
<td>( i^p = \dot{k}^p = 0.5(k^{ps} - k^p) )</td>
<td>(4.3)</td>
</tr>
<tr>
<td>( k^{ps} = 0.8No^s )</td>
<td>(4.4)</td>
</tr>
<tr>
<td>( g = 0.4c^s + 0.3i^s + 0.15i^h + 0.15i^{cop} )</td>
<td>(4.5)</td>
</tr>
<tr>
<td>( c^s = 0.2(o^a + po + e - p) )</td>
<td>(4.6)</td>
</tr>
<tr>
<td>( i^s = \dot{k}^s = 0.5(k^{ss} - k^s) )</td>
<td>(4.7)</td>
</tr>
<tr>
<td>( i^h = \dot{k}^h = 0.5(k^{hs} - k^h) )</td>
<td>(4.8)</td>
</tr>
<tr>
<td>( i^{cop} = \dot{k}^{cop} = 0.5(k^{cop} - k^{cop}) )</td>
<td>(4.9)</td>
</tr>
<tr>
<td>( k^{ss} = 0.3(o^a + po + e - p) )</td>
<td>(4.10)</td>
</tr>
<tr>
<td>( k^{hs} = 0.3(o^a + po + e - p) )</td>
<td>(4.11)</td>
</tr>
<tr>
<td>( k^{cop} = 0.2(o^a + po + e - p) )</td>
<td>(4.12)</td>
</tr>
<tr>
<td>( bd = g - t^s = (\dot{m} - \dot{p}) )</td>
<td>(4.13)</td>
</tr>
<tr>
<td>( t^s = 0.7(o^a + po + e - p) + 0.3No^s )</td>
<td>(4.14)</td>
</tr>
<tr>
<td>( x^p = 0.47(e + p^<em>-p) + 7y^</em> )</td>
<td>(4.15)</td>
</tr>
<tr>
<td>( m^{con} = 0.74y - 0.26(e + p^*-p) )</td>
<td>(4.16)</td>
</tr>
<tr>
<td>( y = 0.6No^s + 0.4o^s + 0.3po + 0.1(e-w) - 0.2p^* )</td>
<td>(4.17)</td>
</tr>
<tr>
<td>( y^p = 0.6No^{cop} + 0.4o^p + 0.3po + 0.1(e-w) - 0.2p^* )</td>
<td>(4.18)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Asset market</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( m - p = 0.41No^s - 0.36\pi - 0.1r )</td>
<td>(4.19)</td>
</tr>
<tr>
<td>( w^p = k^p + (m - p) + y^p )</td>
<td>(4.20)</td>
</tr>
<tr>
<td>( \dot{m} = dce + \dot{f} )</td>
<td>(4.21)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aggregate supply and prices</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( p = 0.7w + 0.1(e + po) + 0.2(e + p^*) )</td>
<td>(4.22)</td>
</tr>
<tr>
<td>( \dot{w} = 0.68(No^d - No^s) + 0.65,\dot{m} )</td>
<td>(4.23)</td>
</tr>
<tr>
<td>( No^s = 0.05k^p + 0.21k^s + 0.53k^h + 0.45k^{cop} + 0.59em )</td>
<td>(4.24)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Overseas sector</th>
<th></th>
</tr>
</thead>
</table>

81 The model is particularly sensitive to the parameters \( \mu_2 \) and, \( \psi_2 \).
\[
\dot{f} = 0.15(x^n - m^n) + 0.57r^* f + 0.32(o^* + po) - 0.11(e - p) \quad (4.25)
\]
\[
o^* = 0.7o^n \quad (4.26)
\]

**Definitions**

\[
c = e - w \quad (4.27)
\]
\[
l = m - w \quad (4.28)
\]
\[
T = x^n - m^n \quad (4.29)
\]
\[
m^n = m^{con} + i^{cap} \quad (4.30)
\]

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

### 6.3 Simulation Analysis

The simulation analysis conducted emphasises the long-run steady state of the model and the dynamic adjustment process of a number of key macroeconomic variables arising from oil related shocks. These variables are real income, real oil income, non-oil output, physical private capital stock, physical public capital stock, human capital stock, imported capital stock, foreign asset stock, non-oil trade balance, real exchange rate, the domestic inflation rate and private sector real wealth\(^{82}\). These variables were chosen since a change in any of them, arising from an increase in oil production or oil price, will influence the development of other variables, hence the development of the domestic economy as a whole.

Two simulation scenarios arising from oil related shocks, and their impact upon twelve macroeconomic variables, are conducted\(^{83}\):

a) An instantaneous, unanticipated and permanent 15 percent increase in oil production.

b) An instantaneous, unanticipated and permanent 15 percent increase in oil price.

---

\(^{82}\) Adjustment of a number of macroeconomic variables can be obtained from the simulation analysis. However, to keep the discussion tractable, focus is placed on only a few key variables as emphasised here.

\(^{83}\) A number of possible scenarios could have been conducted. However, these scenarios were chosen in order to keep the discussion of the model tractable as well as demonstrating key outcomes derivable from it.
Table 6.1: Estimated, Chosen and or/Imposed Parameters for the Simulation Analysis

<table>
<thead>
<tr>
<th>Equation</th>
<th>Parameters</th>
<th>LR Estimated Coefficients</th>
<th>SR Estimated Coefficients</th>
<th>Chosen/Imposed Parameters for Simulation</th>
<th>Source of Imposed Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>$\beta_1$</td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\beta_2$</td>
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<td></td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\beta_3$</td>
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</tr>
<tr>
<td></td>
<td>$\beta_4$</td>
<td></td>
<td></td>
<td>1.00</td>
<td>A</td>
</tr>
<tr>
<td>(2)</td>
<td>$\beta_6$</td>
<td>0.66</td>
<td>0.76</td>
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<tr>
<td></td>
<td>$\beta_7$</td>
<td>0.54</td>
<td>0.63</td>
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</tr>
<tr>
<td>(3)</td>
<td>$\gamma$</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(4)</td>
<td>$\delta$</td>
<td></td>
<td></td>
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<tr>
<td>(5)</td>
<td>$\beta_8$</td>
<td></td>
<td></td>
<td>0.40</td>
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</tr>
<tr>
<td></td>
<td>$\beta_9$</td>
<td></td>
<td></td>
<td>0.30</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>$\beta_{10}$</td>
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<td></td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\beta_{11}$</td>
<td></td>
<td></td>
<td>0.15</td>
<td></td>
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<tr>
<td>(7)</td>
<td>$\varphi$</td>
<td></td>
<td></td>
<td>0.50</td>
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</tr>
<tr>
<td>(8)</td>
<td>$\sigma$</td>
<td></td>
<td></td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>(9)</td>
<td>$\lambda$</td>
<td></td>
<td></td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>(10,11)</td>
<td>$\theta_1, \theta_2$</td>
<td></td>
<td></td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\theta_3$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(12)</td>
<td>$\beta_{12}$</td>
<td></td>
<td></td>
<td>1.00</td>
<td>*</td>
</tr>
<tr>
<td>(13)</td>
<td>$\beta_{13}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(14)</td>
<td>$\beta_{14}$</td>
<td></td>
<td></td>
<td>0.70</td>
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<td></td>
<td>$\beta_{16}$</td>
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<td></td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\beta_{17}$</td>
<td></td>
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<td>7.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\beta_{18}$</td>
<td></td>
<td></td>
<td>5.28</td>
<td></td>
</tr>
<tr>
<td>(16)</td>
<td>$\beta_{19}$</td>
<td></td>
<td></td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\beta_{20}$</td>
<td></td>
<td></td>
<td>0.48</td>
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</tr>
<tr>
<td></td>
<td>$\beta_{21}$</td>
<td></td>
<td></td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\beta_{22}$</td>
<td></td>
<td></td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>(17,18)</td>
<td>$\nu$</td>
<td></td>
<td></td>
<td>0.60</td>
<td>*</td>
</tr>
<tr>
<td>(19)</td>
<td>$\epsilon_1$</td>
<td></td>
<td></td>
<td>0.41</td>
<td></td>
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</tr>
<tr>
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<td>$\epsilon_5$</td>
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</tr>
<tr>
<td></td>
<td>$\epsilon_6$</td>
<td></td>
<td></td>
<td>0.69</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\epsilon_7$</td>
<td></td>
<td></td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>(20)</td>
<td>$\epsilon_8$</td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\epsilon_9$</td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\epsilon_{10}$</td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>(21)</td>
<td>$\mu_1$</td>
<td></td>
<td></td>
<td>0.70</td>
<td>B</td>
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<tr>
<td>(22)</td>
<td>$\mu_2$</td>
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### Table 6.2: Continued

<table>
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<tr>
<th>Equation</th>
<th>Parameters</th>
<th>LR Estimated Coefficients</th>
<th>SR Estimated Coefficients</th>
<th>Chosen/Imposed Parameters for Simulation</th>
<th>Source of Imposed Parameters</th>
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<td>$\psi_1$</td>
<td>0.68</td>
<td>0.49</td>
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<td></td>
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<td>0.70</td>
<td>0.70</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

* Calculated by the author based on available data.
** Estimated coefficients obtained from Chapter 5, using the ARDL model.
A: Cox and Harvie (2010)
B: Harvie and Thaha (1994)

A summary of the long-run steady state properties of the Libyan macroeconomic model, focussing upon the more important macroeconomic variables mentioned earlier, for both scenarios, is included in Table 6.3. Both scenarios assume an immediate and permanent increase in oil production and oil price by 15 percent\(^8\). The numbers in Table 6.3 display the long-run deviations of the steady state values of the aforementioned 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 Figures 6.1 to 6.14. The horizontal axis measures

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\(^8\) Libya’s economy has experienced huge revenue during the last ten years arising from an increase in oil price and oil production. The increase in oil production between 1997 and 2007 was about 20% (see Table 2.1); however, the increase in oil price was much greater than that. Therefore, we assumed 15% increase in both scenarios just as representative of that positive oil shock, and also to be able to compare the macroeconomic impact arising from both scenarios upon the key macroeconomic variables. It is worth mentioning here that assuming oil related shock greater than 15% does not affect the directions of changes of the macroeconomic variables of interest arising from both oil related shocks; however it will affect the magnitude of the deviation of each variable from its baseline only.
the time periods, whilst the vertical axis, for each diagram, measures the percentage deviation of each variable from its initial or base value. These figures indicate that the adjustment path arising from oil related shocks lasts 40 periods, by which time all variables have reached their long-run steady state equilibrium. Each figure contains the two cases; Case (A) represents an oil production shock increase, and Case (A1) represents an oil price shock increase. A detailed analysis of the simulation results arising from an oil production and oil price shock is discussed in the following section.

Table 6.3: Steady State Properties of the Model for the Base Case (Percentage Deviation from Baseline)

<table>
<thead>
<tr>
<th>Variable/ Shock</th>
<th>f</th>
<th>T</th>
<th>g</th>
<th>c</th>
<th>w^p</th>
<th>y</th>
<th>No^x</th>
<th>k^x</th>
<th>k^h</th>
<th>k^cop</th>
<th>k^p</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>15% Oil Production</td>
<td>7.0</td>
<td>-3.5</td>
<td>1.62</td>
<td>0.0</td>
<td>8.0</td>
<td>7.1</td>
<td>5.2</td>
<td>4.5</td>
<td>3.0</td>
<td>3.0</td>
<td>5.8</td>
<td>0</td>
</tr>
<tr>
<td>15% Oil Price</td>
<td>12.3</td>
<td>-2.5</td>
<td>1.62</td>
<td>0.0</td>
<td>7.0</td>
<td>5.0</td>
<td>5.0</td>
<td>4.5</td>
<td>3.0</td>
<td>3.0</td>
<td>4.0</td>
<td>0</td>
</tr>
</tbody>
</table>

6.4 Simulation results arising from an oil production and oil price shock

The findings presented in Table 6.3 show that the directions of changes of the macroeconomic variables of interest arising from two oil related shocks are analogous. However, the magnitudes of the deviations differ, although they are comparable for most of the variables. The similarities and differences arising from both shocks for the variables of interest are now discussed.

6.4.1 Real government income

The simulation results in Table 6.3 and Figure 6.1 show that a 15 percent increase in oil price and oil production initially increase the real oil revenue of government during the adjustment process. However, real government oil revenue increases more in Case
(A) than in Case (A1) as a result of a smaller inflation rate in the former case during the early stage of adjustment (Figure 6.14). That is, an increase in the oil price leads to an initial higher consumer price level in Case (A1) (see equation (4.22)). Real government income increases immediately in the early stage of adjustment in both cases, which implies that the larger is government real income the larger will be government capital spending upon public physical capital, human capital formation and imported capital, and hence the larger will be the benefits to the private sector. Consequently, this stimulates development in the non-oil sector. Real government income slightly declines thereafter to a level where it is higher than its base value by 1.62 percent in both Cases A and A1.

Developments in government real oil revenue (revenue effect) affects total real income directly since government spending increases, and indirectly via expansions in non-oil supply as can be observed from equation (4.24). The indirect effect is induced, as mentioned above, by the public physical capital stock, human capital stock and imported capital stock, which benefit the private sector and further influences the development of the private capital stock and non-oil output supply. Also, an increase in government real income arising from oil related shocks will have a significant impact upon the real exchange rate (exchange rate effect). During oil boom periods government increases its spending to maintain its balanced budget policy, resulting in an increased demand for both non-oil as well as imported goods (see equation 4.1). Consequently, increasing the demand for non-oil output (spending effect) will lead to a higher domestic price during the short-run as well as an appreciation of the real exchange rate. An appreciation of the real exchange rate will have a significant influence upon the adjustment of a number of key macroeconomic variables, particularly non-oil exports, non-oil imports, non-oil trade balance, and consequently upon the domestic economy as whole.

85 This explains the continual increase in non-oil output in the early stage of adjustment (Figure 6.10)
### 6.4.2 Foreign asset stocks

Figure 6.2 shows developments in the foreign asset stock arising from both shocks. It shows that an increase in either oil production or the oil price by 15 percent initially leads to an accumulation of foreign asset stocks, arising from current account surpluses (*current account effect*) during the early stage of the adjustment path, but the initial accumulation is larger in Case (A1). This current account surplus arises from an immediate increase in oil exports and surplus in the oil trade balance, and higher foreign interest income (see equations (4.25) and (4.26)).

In addition, as indicated in Table 6.3 and Figure 6.2, foreign asset stocks increase continuously throughout the adjustment process towards long-run steady state in both cases, signifying continual current account surpluses. Foreign asset stocks accumulate by 7 percent in the long-run steady state in Case (A), and by 12.3 percent in Case (A1). This is despite a deficit in the non-oil trade balance arising from increasing non-oil imports\(^{86}\) and decreasing non-oil exports (Figures 6.3-6.5). That is, since positive and permanent

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\(^{86}\) Increased non-oil imports, in particular non-oil capital imports, deteriorate the non-oil trade balance and reduce the accumulation of foreign asset stocks. However, imported capital has a positive impact on the supply side upon non-oil output.
oil production and oil price shocks are assumed, the surpluses in the current account during the adjustment to long-run steady state can be explained by the fact that the non-oil trade balance deficit is entirely offset by the continual surpluses in the oil trade balance. This is brought about by a combination of larger oil export volumes and revenue, where oil production or the oil price has increased as well as an increase in foreign interest income.

Figure 6.2: Foreign Asset Stocks

Case A: 15% permanent oil production increase
Case A1: 15% permanent oil price increase

6.4.3 Non-oil trade balance

The non-oil trade balance initially deteriorates during the adjustment process for both cases, with a noticeably larger deterioration for Case (A1) as can be seen from Figure 6.3. The primary reason for the deterioration in the non-oil trade balance is a combination of increasing non-oil imports and declining non-oil exports throughout the adjustment path, as indicated in Figures 6.4 and 6.5. Increasing non-oil imports is stimulated by an appreciation of the real exchange, an increase in real domestic income and government spending on capital imports (see Figures 6.6 and 6.9, and equation (4.16)). However, the adjustment of non-oil exports is strongly influenced by the initial sizeable appreciation of the real exchange rate, particularly in Case (A1).
Dutch Disease consequences are likely to occur in terms of deterioration in the non-oil trade balance during the early stage of the adjustment process toward long-run steady state from the above results. As the real exchange rate appreciates this results in a loss of competitiveness for non-oil exports (*exchange rate effect*), and higher domestic demand, stimulated by an increase in real income, increases the demand for non-oil imports.

During the medium-run to long-run steady state the non-oil trade balance experiences a slight improvement as a result of an improvement in non-oil exports and decline in non-oil imports. This arises from a depreciation of the real exchange rate, as can be observed from Figure 6.5. The non-oil trade balance declines by almost 3.5 percent in the long-run steady state for the case of an increase in oil production, and deteriorates by 2.5 percent for an oil price increase (see Table 6.3).

**Figure 6.3: Non-Oil Trade Balance**

Case A: 15% permanent oil production increase
Case A1: 15% permanent oil price increase
Figure 6.4: Non-Oil Imports

Case A: 15% permanent oil production increase
Case A1: 15% permanent oil price increase

Figure 6.5: Non-Oil Exports

Case A: 15% permanent oil production increase
Case A1: 15% permanent oil price increase
6.4.4 Real exchange rate

The simulation results indicate that a permanent 15 percent increase in oil production and oil price leads initially to an appreciation of the real exchange rate, which overshoots its long-run steady state level. The initial appreciation of the real exchange rate is larger in Case (A1) in comparison with that of Case (A), resulting in a larger initial deterioration of the non-oil trade balance as can be observed in Figure 6.3. The main factor contributing to a different development in magnitude of the real exchange rate is the adjustment of the domestic price level throughout the short and medium-run periods (Figure 6.14). As mentioned earlier an increase in either oil production or oil price leads to an increase in government oil revenue and increase in the demand for non-oil output (see equations (4.1), (4.5), (4.7), (4.8) and (4.9)), and in particular for non-oil tradable goods thereafter. As a result the domestic non-oil output price increases due to a spending effect, resulting in an appreciation of the real exchange rate. The domestic price level is essentially influenced by the difference between non-oil output supply and demand. Also, it is influenced by money growth throughout the adjustment path (not shown here) arising from accumulation of foreign asset stocks induced by persistent balance of payments surpluses, as the nominal exchange rate is assumed to be fixed. Subsequently, the real exchange rate depreciates gradually towards its long-run steady state for both cases.
6.4.5 Private sector real wealth

The simulation results for private sector real wealth indicate that it increases continuously throughout the adjustment process toward its long-run steady state for either an increase in oil production or oil price, where it accumulates by almost 8 percent in Case (A), and 7 percent in Case (A1) as can be observed in Table 6.3 and Figure 6.7. Increased private sector real wealth in both cases arises due to an accumulation in private capital stock (Figure 6.8), an increase in permanent income and an increase in real money balances (not shown here). An increase in private capital stock is induced by an increase in non-oil output (see equations (4.3) and (4.4)), which in turn is further enhanced by increased government investment spending on physical, human and imported capital (technology effect), which is of further benefit to the private sector. This is due to the fact that public capital spending on infrastructure, human capital formation and technological acquisition through imported capital results in positive externalities that raise the productivity of private factors of production, stimulating both aggregate supply of non-oil output and also aggregate demand for non-oil output.
6.4.6 Real income

Figure 6.9 indicates that for either an increase in oil production or oil price, real income increases continuously throughout the adjustment process (income effect). It is noticeably larger for Case (A), with most of the increase in real income occurring very early on in the adjustment process. It is induced directly by the 15 percent increase in either oil production or oil price and also by subsequent changes in non-oil output (see equation (4.17)). In long-run steady state for Case (A) real income is approximately 7 percent higher than its base value, while it is 5 percent above its base value in Case (A1).
as indicated in Table 6.3. On the demand side an increase in real income stimulates non-oil imports, which in turn contributes to a deterioration of the non-oil trade balance through an increase in non-oil imports. However, an increase in non-oil capital imports enhances non-oil output supply, which in turn contributes positively to non-oil output supply and in turn to real income.

Figure 6.9: Real Income

Case A: 15% permanent oil production increase
Case A1: 15% permanent oil price increase

6.4.7 Non-oil output supply

Non-oil output supply improves continuously throughout the adjustment process to its long-run steady state for either the case of an oil production increase or oil price increase (Figure 6.10). The major contributory factors to this development throughout the adjustment process include a continuously increased level of private physical capital stock, public physical capital stock, human capital stock, and imported capital stock (Figures 6.10, 6.11, 6.12, and 6.13). An increase in non-oil output supply stimulates demand via private consumption and private investment. Also, an increase in non-oil output increases the nation’s real income and induces imports to rise, thereby possibly leading to a non-oil trade balance deficit. Thus, the positive effects of an increase in non-oil output are offset partially by deterioration in the non-oil trade balance.
The Dutch Disease effect upon non-oil output is not likely to occur during the early stage of the adjustment process toward long-run steady state based upon the above results. On the demand side there are two effects. The windfall revenue arising from the oil sector brings about increased domestic demand for non-oil output, while a real exchange rate appreciation reduces the demand for non-oil output (spending effect and an exchange rate effect). The latter contributes to a loss of competitiveness of the non-oil tradables sector. In this model the former effect dominates the latter effect and non-oil output demand increases overall. On the non-oil output supply side a Dutch Disease effect during the early periods of adjustment is also not observed, due to the gradual accumulation in physical, human and imported capital stocks (Figures 6.11, 6.12, and 6.13, and equation (4.24)).

In long-run steady state non-oil output supply is found to be higher than its base value by 5.2 percent in Case (A), and 5 percent in Case (A1) (see Table 6.3). This is again due to continual accumulation of public physical capital stock (infrastructure), human capital stock, imported capital stock as well as private capital stock in the long-run steady state.

87 A possible explanation for this result is that the real wage is not included in Equation (4.24) due to technical difficulties in its estimation. When the real wage was included in the simulation procedure, an initial decline in non-oil output supply was observed. However, to keep consistency with the estimation procedure conducted in Chapter 5 the real wage was excluded from the simulation procedure as well. Therefore the absence of this variable from Equation (4.24) appears to mitigate the Dutch disease effect upon non-oil output supply.
6.4.8 Physical, human and imported capital stock

The overall capital stock that can be influenced directly by government policy can be divided into three categories; public physical capital stock, human capital stock and imported capital stock. The simulation results in Table 6.3 and Figures 6.11, 6.12 and 6.13 show that public physical capital stock, human capital stock, and imported capital stock increase permanently throughout the adjustment process toward their long-run steady state. They are higher in Case (A) throughout the early periods of adjustment. An increase in the overall capital stock is stimulated directly by government development spending (spending effect) upon the physical capital stock (i.e. infrastructure), human capital stock (education and training), and imported capital stock (technological acquisition) (see equations (4.10), (4.11) and (4.12)).

A permanent increase in either oil production or oil price by 15 percent leads to an increase in the public physical capital stock by 4.5 percent in the long-run steady state, whilst the human capital stock and imported capital stock end up at 3 percent above their base value in steady state.
It is apparent that the oil sector during its boom period will have a sustainable impact upon non-oil output not only in long-run steady state, but also during the early periods of the adjustment process. The oil boom generates both physical capital stock accumulation in the non-oil sector and human capital stock accumulation, which are induced by government capital expenditure due to higher revenue generated to government, and acquisition of technology through spending on capital imports (technology effect). The public capital stock is complementary to that of the private capital stock in nature (Aschauer 1989a, 1989b). Therefore, these factors, as mentioned earlier, stimulate non-oil output supply which in turn stimulates the private capital stock (see equations (4.3), and (4.4)) and real income (see equation (4.17)).

**Figure 6.11: Physical Capital Stock**

Case A: 15% permanent oil production increase  
Case A1: 15% permanent oil price increase
6.4.9 Price level

Figure 6.14 indicates that the price level also increases initially because non-oil output demand increases by more than non-oil output supply, particularly in the case of an oil price shock, Case (A1), during the adjustment process before it declines to its long-run steady state level. This difference is mainly attributed to the fact that the increase in the oil price has an immediate effect upon the overall price level (see equation (4.22)), resulting in a higher price level throughout the adjustment process. Besides this, the oil related shocks lead to an accumulation of foreign asset stocks throughout the adjustment
process toward its long-run steady state, resulting in a higher money stock during the early stage of adjustment since the exchange rate is fixed.

During the oil boom period the government has to spend its oil revenue to maintain its balanced budget policy. Spending the oil revenue either in the form of consumption expenditure or development expenditure results in an initial increase in non-oil demand over non-oil supply, leading to an initial higher domestic price level (see equation (4.22) and (4.23)). In addition, the oil trade balance surplus generates balance of payments surpluses and an increase in the accumulation of foreign exchange reserves. This ultimately leads to a temporarily higher money stock so as to maintain the fixed nominal exchange rate policy, leading to an increase in the domestic price level in the short term (see equations (4.21), (4.22), (4.23) and (4.25)), as shown in Figure 6.14.

**Figure 6.14: Price Level**

Case A: 15% permanent oil production increase
Case A1: 15% permanent oil price increase

The results derived from the above simulation analysis are summarised in Table 6.4. The table shows the directional change from an initial equilibrium to the long-run steady state, resulting from a 15 percent increase in oil production and the world oil price. It shows that during the early periods of adjustment there is an increase in foreign asset stocks, real government oil revenue, private capital stock, private sector wealth, real
income, domestic physical capital stock, human capital stock, imported capital stock and non-oil output supply (demand). However, results from the simulation analysis indicate an appreciation of the real exchange rate in the early stage of adjustment, leading to a loss of competitiveness for non-oil exports and deterioration of the non-oil trade balance. That is, the existence of Dutch Disease consequences for the non-oil trade balance is likely from this result. In the long-run steady state most of the key macroeconomic variables, with the exception of the non-oil trade balance, increase towards the long-run steady state equilibrium, indicating vital development of the economy over the long-term.

In brief, the adjustment process derivable from the short-run to the long-run steady state indicates an important result, particularly for the non-oil production sector in the case of Libya. That is, the incorporation of human capital stock and imported capital stock accumulation besides public physical capital stock, in the non-oil output supply equation, stimulate the development of the economy over the short and long terms. Also, incorporation of foreign asset stock accumulation via developments in the current account and budgetary financing requirements, significantly extend the period of time over which the new steady state equilibrium is achieved.

### Table 6.4

A summary of the Adjustment Process in the Short-Run and Long-Run Steady State: The Case of a 15% Increase in Oil Production and Oil Price

<table>
<thead>
<tr>
<th>Variables/periods</th>
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<th>( T )</th>
<th>( g )</th>
<th>( c )</th>
<th>( w^p )</th>
<th>( y )</th>
<th>( No' )</th>
<th>( k^g )</th>
<th>( k^h )</th>
<th>( k^{cap} )</th>
<th>( k^p )</th>
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<td>+</td>
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<td>+</td>
<td>+</td>
<td>+</td>
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<td>+</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes: + Increase (depreciation) of the variables
- Decrease (appreciation) of the variables
The discussion of the simulation analysis of the base model in this chapter, as emphasised in the theoretical framework of the model in Chapter 4, indicates that the oil sector influences the Libyan economy through six channels, as follows: First, a revenue effect (arising from revenue generated by the government from the production of the oil sector). Second, an income effect (arising from production of the oil sector). Third, a spending or wealth effect which arises when lucrative oil resources increase demand and, hence, inflation in other sectors of the economy (both tradable and non-tradable). Fourth, an exchange rate effect which is associated with the spending or wealth effect. Additional revenue generated by the government from the oil production sector increases government consumption and investment spending, resulting in an initial increase in non-oil demand over non-oil supply, causing an initial higher domestic price level and an appreciation of real exchange rate. In addition, the huge inflow of foreign exchange, which comes from oil exports during the boom period, causes a temporarily higher money stock in an attempt to maintain the fixed nominal exchange rate policy, leading to a further increase in the domestic price level and further appreciation of the real exchange rate. Consequently, domestic production becomes less attractive than imports contributing to a deterioration of the non-oil trade balance and undermining the growth rate of the tradables sector (such as agriculture and manufacturing) (see Table 2.5). The fifth effect is a current account effect arising from balance of payment surpluses, bringing about an accumulation of foreign asset stocks. The last effect is the technology effect arising from imported capital. This latter effect has been inadequately identified in previous studies of developing economies with oil resources. Consequently, capturing and modelling the macroeconomic effects from this is a major novelty of this study.
6.5 Summary and Conclusions

The main focus of this chapter has been to simulate the Libyan macroeconomic model developed in Chapter 4, and to analyse the dynamic adjustment process and long-run steady state properties arising from two oil related shocks. Given the complexity of the theoretical model, the attainment of analytically unambiguous results is not possible. Therefore, an analysis of the steady state and dynamic adjustment processes of the model was implemented by utilising a numerical simulation procedure, or calibration of the model, using a dynamic stochastic general equilibrium framework. The simulation analysis takes into account the impact of additional oil revenue upon foreign asset stock accumulation, physical capital accumulation, human capital accumulation, and imported capital accumulation, which in turn influences non-oil output supply. The simulations also allow for the possible effect of oil revenue upon the real exchange rate, and hence upon the non-oil trade balance, and thereby enable analysis of Dutch Disease effects on the non-oil trade balance and non-oil output.

Simulation of the base case of the model was conducted by utilising the parameter values identified in Table 6.1, assuming a fixed exchange rate and highly controlled capital mobility. The adjustment of twelve key macroeconomic variables was emphasised and analysed. These are foreign asset stocks, non-oil trade balance, real exchange rate, private sector real wealth, private capital stock, real income, non-oil output, public physical capital stock, human capital stock, imported capital stock, and the price level. These variables were selected as the change in these variables, arising from an increase in oil production or oil price, will influence the development of other variables, and the subsequent development of the domestic economy. They are also key variables of particular interest to policy makers. Two simulation scenarios arising from oil related
shocks were conducted assuming an instantaneous and unanticipated permanent 15 percent increase in oil production or oil price.

It was apparent from the simulation results that either a positive oil production shock or oil price shock exert a significant influence upon the variables under consideration, and the domestic economy throughout the adjustment process to long-run steady state.

The major conclusion that can be derived from this chapter is that a permanent and unanticipated increase in oil production and/or oil price by 15 percent will potentially result in an increase in private capital stock, private sector wealth, real income, domestic physical capital stock, human capital stock, imported capital stock and non-oil output supply (demand). However, the oil sector boom also has the potential to deteriorate the non-oil trade balance through a loss of competitiveness from a real exchange rate appreciation.

Moreover, the benefits for the non-oil sector arising from physical capital stock, human capital stock, and imported capital stock accumulation induced by the boom in the oil sector could be of substantial importance in terms of employment and growth generation and overall development of the economy. An increase in non-oil output will likely lead to an increase in the demand for labour, and hence reduce unemployment. The potentially positive effect from public and private capital stock accumulation is not only beneficial in terms of generating more employment, but also to the long-run economic growth and development of the economy. The allocation of government spending is, therefore, critical in the case of Libya.
Dutch Disease consequences for an oil exporting country such as that of Libya, are likely to occur throughout the adjustment process toward long-run steady state. This is due to the fact that the real exchange rate appreciates resulting in a loss of competitiveness of non-oil exportable goods, in conjunction with increased real income increasing non-oil imports, which deteriorates the overall non-oil trade balance. However, despite a loss of competitiveness of the non-oil tradable sector, non-oil output supply increases throughout the early periods of adjustment. This arises for two reasons. First, the Dutch Disease effect upon non-oil output is offset by increased government development spending on physical, human and imported capital stocks from higher oil revenues. Second, the real wage was excluded from equation (4.24) in Chapter 4 due to technical problems in its estimation. When the real wage was included in the simulation procedure, an initial decline in non-oil output supply was noticed. However, to keep consistency with the estimation procedure conducted in Chapter 5 the real wage was excluded from the simulation procedure as well.

Another major conclusion from this chapter is that an increase in oil production exerts a greater influence upon key macroeconomic variables such as real income, private sector real wealth, private capital stock, overall public capital stock and the non-oil trade balance, and hence upon the whole domestic economy, during the adjustment process in comparison to that of a proportional oil price increase case. The major factors affecting developments in the adjustment process and long-run steady state for these variables are: price level developments, where it was higher in the case of an oil price shock; the real exchange rate; and government capital spending, as a response to the increased oil revenue. Overall, the economy benefits from both scenarios, but in particular from an increase in oil production in long-run steady state.
The chapter also emphasised that the oil sector influences the Libyan economy through six channels, these being a revenue effect (arising from revenue generated by the government from the production of the oil sector and from higher prices for oil), an income effect (arising from the production of the oil sector), the spending or wealth effect which increases domestic demand, and hence inflation for both tradable and non-tradable goods, an exchange rate effect which is associated with the spending and wealth effect, a current account effect (oil production generates an increase in exports and enhances the current account), and the last effect is a technology effect (arising from imported capital).

This chapter has presented simulation results from the base model where the exchange rate is fixed and substantial restriction on capital mobility is assumed. The model can be modified with the aim of conducting equivalent simulations under alternative exchange rate policies, combined with different degrees of international capital mobility. A change in the nominal exchange rate from a fixed to flexible exchange rate regime could affect the development of the overseas sector; therefore the government may further alleviate the adverse effects of the oil boom upon the non-oil trade balance by moving to a more flexible exchange rate system. Under a flexible exchange rate regime the exchange rate is capable of adjusting so that either capital inflows or outflows will have no effect upon foreign exchange reserves. As a consequence, growth of the money stock becomes exogenous and policy determined and the nominal exchange rate becomes endogenous. This situation can be derived for the base model by amendment of equation (4.21).

Moreover, the government could improve productivity and increase the availability and type of capital available for the non-oil tradable sector, such as the manufacturing and agricultural sectors, by increasing or changing the composition of
government investment in infrastructure (physical capital), human capital formation, and technology acquisition in these sectors. This will eventually improve the competitiveness of these sectors, firstly and most importantly, in the regional market and, secondly, in the world market.

Exploration of the above alternative policies relating to exchange rate policy, allocation of the oil revenue to consumption and investment spending, and other policy issues such as the distribution of oil production between export and domestic usage will be conducted and discussed further in the following chapter.
Chapter 7

Oil Revenue, Macroeconomic Policy Responses and Economic Development Outcomes

7.1 Introduction

The objective of this chapter is to simulate and analyse the results from a number of alternative government policies by amending the base model for the Libyan economy as developed in Chapter 4. A major conclusion from the simulation analysis of the base model conducted in Chapter 6 is that the private sector, such as that in Libya, can potentially benefit from natural resource sector booms, and the extent and nature of this depends upon the government’s policy response. Non-oil output supply increased throughout the early periods of adjustment due to the rapid increase in physical, human and imported capital stocks, which induced an increase in private capital stock. Moreover, the results also pointed to the existence of Dutch Disease consequences upon the non-oil trade balance, in particular during the dynamic adjustment process. The adverse effects are larger for the oil price shock case compared with that of the oil production shock throughout the adjustment process.

The government has an important role to play in maximising the benefits from the oil sector boom and in alleviating and/or eliminating the adverse effects of the oil boom upon key macroeconomic variables. This crucial role can be in the form of increasing productivity in the non-oil output sector, such as the manufacturing and agricultural sectors, by increasing government investment in infrastructure (physical capital), human capital formation (education and training), and capital imports (technology acquisition) in these sectors. In addition, the government could alleviate the adverse effects of the oil boom upon the non-oil trade balance by applying an alternative exchange rate policy. It is
not advisable for the government to use trade restrictions in this case such as that of import tariffs, import quotas and other quantitative restrictions on the flow of international trade, as they result in both higher prices and a larger appreciation of the real exchange rate. Most importantly, the imposition of import tariffs or import quotas upon capital imports may harm the growth of non-oil output, since the technological acquisition that the economy can gain through capital imports has a positive effect upon the growth of non-oil output\textsuperscript{88}. Trade restrictions would also harm the integration of the economy with the global market. Therefore, alternative government policies can potentially enhance non-oil exportable sectors, improve private sector real wealth, private sector real income and lead to higher future economic growth and development\textsuperscript{89}. Exploring the impact of these alternative policies and policy responses on the macro-economy is the primary objective of this chapter.

Overall, there are various scenarios that can be implemented by policymakers in an oil-exporting nation such as Libya to enhance the non-oil output sector and to mitigate the adverse effects of the oil boom sector. These scenarios can be in the form of the allocation of oil revenue between government consumption and government investment spending, the allocation of oil production between domestic usage and for export, and moving from a fixed nominal exchange rate to a flexible exchange rate system combined with a higher degree of capital mobility. These scenarios can be conducted, or captured, by either altering some of the parameter values or by modifying some equations. Changing the allocation of oil revenue between government consumption and government investment, and the allocation of oil production between domestic usage and

\textsuperscript{88} Estimation of the non-oil output equation indicates that the long-run and short-run coefficients of imported capital stock with respect to non-oil output are significant at the 5\% level (see Chapter 5).

\textsuperscript{89} Analysis of alternative policies can be conducted by merely altering some of the parameters without requiring any modifications to the base model. However, other alternative policies such as that for the exchange rate require a modification to one equation of the base model and will have broader implications upon the remaining equations and outcomes from the model.
for export, can be done by merely altering some parameters values such as that of $\theta_1$, $\theta_2$, $\theta_3$ and $\zeta$ in the model developed in Chapter 4. However, other policies related to the exchange rate and development of financial markets requires the modification of some equations. Scenarios that require only altering some parameters values will be discussed first in the next section.

In this chapter the effects of policy actions, in conjunction with changes in exogenous variables such as oil production and oil prices, are examined. The policy analysis will emphasise alternative allocations of oil revenue between government investment and government consumption spending in section 7.2. Section 7.3 discusses the distribution of oil production between domestic usage and that for export. Section 7.4 deals with analysing the economic implications arising from adoption of an alternative nominal exchange rate policy, that is, a flexible exchange rate combined with perfect capital mobility. Section 7.5 provides a summary and conclusions of the major results from this chapter.

7.2 Alternative policy allocation of oil revenue

The policy responses emphasised here relate to the allocation of oil revenue in the form of consumption or capital investment and its impact on the Libyan macroeconomy for two cases, namely (Case 1) an increase in oil production and (Case 2) an oil price increase. In the former case, an increase in oil production and four related scenarios, B, C, D and E are conducted and compared with scenario (A), which represents the base model as outlined in Chapter 6. In the latter case of an increase in oil price, four scenarios, F, G, H and I are simulated and compared with the base model, scenario (A1), as outlined in Chapter 6. The relevant parameters capturing these government responses are $\theta_1$, the proportion of government spending allocated towards the desired physical
capital stock, $\theta_2$ the proportion of government expenditure allocated towards human capital stock, $\theta_3$ the proportion of government spending directed towards imported capital stock, and then the remainder $(1-\theta_1-\theta_2-\theta_3)$ which is directed to government consumption expenditure. The four scenarios emphasised for the case of a positive oil production shock and oil price shock, are as follows\textsuperscript{90}.

1. An instantaneous and unanticipated 15 percent increase in oil production or oil price with an expansion in the share of government spending on public physical capital (infrastructure) from 30 percent to 40 percent (scenarios B and F).

2. An instantaneous and unanticipated 15 percent increase in oil production or oil price with an expansion in the share of government spending on human capital from 20 percent to 30 percent (scenarios C and G).

3. An instantaneous and unanticipated 15 percent increase in oil production or oil price with an expansion in the share of government spending on imported capital from 20 percent to 30 percent (scenarios D and H).

4. An instantaneous and unanticipated 15 percent increase in oil production or oil price in conjunction with an expansion in the share of government consumption spending from 30 percent to 40 percent (scenarios E and I).

The two cases with four different scenarios conducted in this section are summarised in Table 7.1 below.

\textsuperscript{90} The values of the $\theta$'s in the base scenarios conducted in Chapter 6, scenarios A and B, are as follows: $\theta_1 = 0.30$, $\theta_2 = 0.20$, $\theta_3 = 0.20$, and $(1-\theta_1-\theta_2-\theta_3) = 0.30$. Note that the sum of $\theta_1+\theta_2+\theta_3+(1-\theta_1-\theta_2-\theta_3)$ must always equal 1.
Table 7.1: Alternative Policy Allocation of the Oil Revenue

<table>
<thead>
<tr>
<th>Case 1: An instantaneous and unanticipated 15% Oil production increase</th>
<th>Case 2: An instantaneous and unanticipated 15% Oil price increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters*</td>
<td>A**</td>
</tr>
<tr>
<td>( \theta_1 )</td>
<td>0.3</td>
</tr>
<tr>
<td>( \theta_2 )</td>
<td>0.2</td>
</tr>
<tr>
<td>( \theta_3 )</td>
<td>0.2</td>
</tr>
<tr>
<td>( (1-\theta_1-\theta_2-\theta_3) )</td>
<td>0.3</td>
</tr>
</tbody>
</table>

* Note that the sum of \( \theta_1 + \theta_2 + \theta_3 + (1-\theta_1-\theta_2-\theta_3) \) must always equal 1 for each scenario.

** Represents base model scenarios conducted in Chapter 6.

Case 1: Oil production increase (altering \( \theta_1 \), \( \theta_2 \) and \( \theta_3 \))

This case analyses a positive oil production shock in conjunction with a change in the allocation of spending by government of the oil revenue arising from such a shock. The relevant parameters to be changed in this case are \( \theta_1 \), \( \theta_2 \) and \( \theta_3 \). The steady state properties of the model for this case, compared with that of base model scenario (A) conducted in the previous chapter, for selected macroeconomic variables are summarised in Table 7.2. Also, the adjustment paths of each variable of interest during the early periods toward long-run steady state are shown in Figure 7.1. The simulation results show that the government plays an essential role in the way that the additional oil revenues are spent and the macroeconomic outcomes arising from this, and hence in promoting alternative economic development outcomes.

In all scenarios the nominal exchange rate is still assumed to be fixed, and capital mobility is negligible. The analysis focuses on the impact of oil related shocks in tandem

\(^{91}\) Note that the consumption spending share always declines by the increase in government investment spending share on infrastructure, human capital or imported capital.
with government responses upon the development of key macroeconomic variables throughout the dynamic adjustment process and in long-run steady state.

Table 7.2: Steady State Properties of the Model for Different Government Response Scenarios (B, C, D and E) and the Base Model Scenario (A) Arising from a 15% Increase in Oil Production

(Percentage Deviation from Baseline)

<table>
<thead>
<tr>
<th>Variable</th>
<th>$f$</th>
<th>$T$</th>
<th>$c$</th>
<th>$w$</th>
<th>$y$</th>
<th>$N_o$</th>
<th>$k^g$</th>
<th>$k^h$</th>
<th>$k^{cap}$</th>
<th>$k^p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>7.0</td>
<td>-3.5</td>
<td>-1.0</td>
<td>8.0</td>
<td>7.1</td>
<td>5.2</td>
<td>4.5</td>
<td>3.0</td>
<td>3.0</td>
<td>5.8</td>
</tr>
<tr>
<td>B</td>
<td>8.9</td>
<td>-2.5</td>
<td>3.2</td>
<td>9.2</td>
<td>8.9</td>
<td>7.0</td>
<td>7.8</td>
<td>3.4</td>
<td>3.4</td>
<td>7.0</td>
</tr>
<tr>
<td>C</td>
<td>7.9</td>
<td>-3.0</td>
<td>1.1</td>
<td>8.2</td>
<td>8.2</td>
<td>5.9</td>
<td>4.9</td>
<td>4.8</td>
<td>3.1</td>
<td>6.6</td>
</tr>
<tr>
<td>D</td>
<td>8.0</td>
<td>-3.1</td>
<td>1.2</td>
<td>8.1</td>
<td>8.1</td>
<td>5.8</td>
<td>4.9</td>
<td>3.1</td>
<td>4.8</td>
<td>6.5</td>
</tr>
<tr>
<td>E</td>
<td>4.0</td>
<td>-4.2</td>
<td>-2.9</td>
<td>6.4</td>
<td>6.4</td>
<td>3.5</td>
<td>2.3</td>
<td>2.6</td>
<td>2.6</td>
<td>5.1</td>
</tr>
</tbody>
</table>

The simulation results in Figure 7.1 show that a permanent increase in oil production by 15 percent leads to an accumulation of foreign asset stocks throughout the adjustment path in all scenarios, indicating current account surpluses. This accumulation is greater in scenarios B, C and D, and particularly so in scenario B (the larger is $\theta_1$) and obviously increasing by less in scenario E (increased government consumption spending scenario). These results arise from an immediate increase in oil exports and surplus in the oil trade balance which offsets the deficit in the non-oil trade balance, as well as from an increase in foreign interest income.

Figure 7.1 and Table 7.2 also show that an accumulation of foreign asset stocks persists towards the long-run steady states, indicating current account surpluses in scenarios B, C and D, but again mostly in B. However, it increases by less in scenario E to a level of 4 percent above baseline, which is below that of the base scenario conducted in the previous chapter, scenario A. In general, developments in the current account in long-run steady state, in particular in scenarios B, C and D, are due to; a surplus in the oil
trade balance; an improvement in the non-oil trade balance as a result of a depreciation of the real exchange rate towards its long-run steady state (where it improves in scenario B to -2.5 percent relative to baseline compared to that of the base scenario of -3.5 percent relative to baseline); and due to an increase in foreign interest income arising from higher foreign asset stocks *per se*. The increase of foreign asset stocks in scenario E to below that of scenario A is due to a deterioration of the non-oil trade balance by 4 percent from baseline.

The real exchange rate initially appreciates in all scenarios, but appreciates slightly more in scenario E (increased government consumption spending). Without an increase in government capital spending the real exchange rate appreciates by approximately 6.3 percent from its initial base value, overshooting its long-run rate throughout the adjustment process. This is because of a higher price level (not shown in Figure 7.1), which contributes to a greater loss of competitiveness for non-oil exportable goods and deterioration of the non-oil trade balance in comparison with the other three scenarios (B, C, and D), where the real exchange rate appreciates by less. Consequently, the real exchange rate depreciates faster in scenarios B, C and D than that of E toward its long-run steady state, indicating a more competitive situation for the non-oil export sector and alleviating Dutch Disease consequences during adjustment to long-run steady state. On the other hand the real exchange rate appreciates by 2.9 percent in long-run steady state in scenario E, indicating that a Dutch Disease effect on the non-oil trade balance is more likely to exist not only during the early stage of adjustment but also in long-run steady state equilibrium.

The above results suggest that Dutch Disease effects can be mitigated through a more investment oriented policy by government. That is, more development spending on
infrastructure, human capital formation and technological acquisition will improve the competitiveness and performance of the non-oil tradable sector and the non-oil trade balance overall. Hence, Dutch Disease effects are likely to be exacerbated without an increase in government investment spending.

The simulation results also show that during the dynamic adjustment process an increase in \( \theta_1, \theta_2 \) and \( \theta_3 \) bring about a higher and continuous increase in non-oil output, mainly in scenario B. On the other hand, without an increase in government development spending, as in scenario E, non-oil output increases but it is below the other three scenarios and it is even below the level of the base scenario conducted in Chapter 6. Dutch Disease consequences are less likely to occur during the early stage of the adjustment process on non-oil output supply where an investment oriented strategy is adopted, as this leads to an accumulation of physical capital stock, human capital stock, imported capital stock and private capital stock increasing non-oil output supply (Figure 7.1). In long-run steady state non-oil output increases considerably in comparison with the base model, by 7 percent, 5.9 percent and 5.9 percent in scenarios B, C and D respectively. It visibly increases by more the larger is \( \theta_1 \) \(^92\), as in scenario B, where non-oil output supply increases by 7 percent, i.e. by 1.8 percent above the base scenario. However, in scenario E non-oil output increases to a level below that of the base model, increasing by only 3.5 percent compared to that of 5.2 percent for the base model. That is, stimulating government consumption spending, which implies less government development spending, would result in an increase in non-oil production, but by 1.7 percent less than the base case. On the demand side a substantial improvement in non-oil output supply, arising from a development oriented policy, contributes to an increase in

\(^92\) An increase in investment in the economy increases the productivity of the non-oil sector, and hence real income. This would induce imports to rise, thus possibly resulting in a deficit in the non-oil trade balance.
both private consumption and private investment (see equations (4.2), (4.3) and (4.4)) and in overall domestic non-oil demand.

There is a significant accumulation of physical capital stock, human capital stock, and imported capital stock during the adjustment process towards long-run steady state in scenarios B, C and D, where they accumulate by more than their levels in the base scenario (scenario A). This in turn augments non-oil output supply during the early stage of adjustment, offsetting the Dutch Disease effect on the non-oil output supply. However, without an increase in government capital spending, as in scenario E, they remain lower than their levels in the base model. It can be said that the larger the size of government development expenditure the larger is the accumulation of public physical capital stock, human capital stock and imported capital stock and thereby the physical capital stock in the private sector. Such a strategy (i.e. a more investment oriented policy) brings about a noticeable improvement on the supply side. On the other hand, a development oriented policy enhances the demand side via the increase in government investment spending, and also via a smaller appreciation of the exchange rate, as alluded to earlier, which reduces the loss of competitiveness of non-oil exports and thereby the non-oil trade balance deteriorates by less.

Private sector real wealth increases throughout the adjustment process towards long-run steady state, mainly in scenario B. Specifically, altering $\theta_1$, $\theta_2$ and $\theta_3$ in scenarios B, C and D, has noticeable effects upon private sector real wealth. This can be attributed to an increase in the private capital stock arising from the initial accumulation of public physical capital stock, human capital stock and imported capital stock, as public

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93 Even though more spending on technology acquisition from overseas will have adverse effects upon the non-oil trade balance in the form of increased non-oil capital imports, it improves domestic non-oil supply through an accumulation of imported capital stock.
investment is considered to be complementary to that of the private capital stock in nature (Aschauer 1989a, 1989b). Other factors which contribute to an initial increase in real private wealth include: an anticipated increase in future income (permanent income); and in real money balances. This increase in private sector real wealth will stimulate the private consumption and result in positive economic welfare\(^\text{94}\). While private sector real wealth increases in scenario E it does so by less than in the base scenario, as it accumulates by only 6.4 percent instead of 8 percent as in the base scenario. An increase in private sector real wealth induces private consumption and in turn domestic non-oil demand (see equation (4.2)).

The important conclusion that can be derived from these results is that a development oriented policy aimed at increasing \(\theta_1\), \(\theta_2\) and \(\theta_3\), should be adopted by policymakers in Libya to improve the performance of the economy. This can be seen from the improvement in non-oil output supply arising from a larger accumulation of physical capital stock, human capital stock, and imported capital stock, which in turn enhances private sector real wealth and real income. The results indicate the existence of Dutch Disease consequences during the adjustment process from a deterioration of the non-oil trade balance, arising from an appreciation of the real exchange rate. However, Dutch Disease effects are likely to be less during the medium to long-run steady state where a development oriented policy is adopted, especially where this is aimed at increasing the physical capital stock. Stimulating government consumption spending, as in scenario E, will lead to less favourable results during the adjustment process and in long-run steady state for all the variables of interest.

\(^{94}\) An increase in private sector real wealth will stimulate the private consumption through Equation (4.2). Thus, while there is no explicit measure of economic welfare in this study, the effects of oil revenue on private sector real wealth is considered to be a rough approximation to welfare.
Figure 7.1:
Case 1: Oil Production Increase (Altering $\theta_1$, $\theta_2$ and $\theta_3$)
Case 2: Oil price increase (altering $\theta_1$, $\theta_2$ and $\theta_3$)

The simulation results for Case 2, presented in Table 7.3 and Figure 7.2, indicate that the way in which government allocates the additional oil revenue between investment and consumption spending will produce similar results to that of Case 1 throughout the adjustment process, and in long-run steady state. However, the magnitudes of the deviations are not the same, although they are comparable for most of the variables. The steady state properties of the model for selected macroeconomic variables for Case 2, compared with that of base model scenario (A1) conducted in Chapter 6, are summarised in Table 7.3, and the adjustment path of each variable of interest during the early periods toward long-run steady state are shown in Figure 7.2. Once again the simulation results reveal that government plays an essential role in the way that additional oil revenue is spent, and hence in promoting alternative economic development outcomes.

Table 7.3: Steady State Properties of the Model for Government Response Scenarios (F, G, H and I) and the Base Model (A1), Arising From a 15% Increase in the Oil Price (Percentage Deviation from Baseline)

<table>
<thead>
<tr>
<th>Variable</th>
<th>$f$</th>
<th>$T$</th>
<th>$c$</th>
<th>$w^b$</th>
<th>$y$</th>
<th>$No^t$</th>
<th>$k^t$</th>
<th>$k^h$</th>
<th>$k^{cap}$</th>
<th>$k^p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case: A1</td>
<td>12.3</td>
<td>-2.5</td>
<td>-0.5</td>
<td>7.0</td>
<td>5.0</td>
<td>5.0</td>
<td>4.5</td>
<td>3.0</td>
<td>3.0</td>
<td>4.0</td>
</tr>
<tr>
<td>F</td>
<td>13.0</td>
<td>-2.5</td>
<td>2.2</td>
<td>8.0</td>
<td>6.2</td>
<td>6.5</td>
<td>7.2</td>
<td>3.2</td>
<td>3.1</td>
<td>5.0</td>
</tr>
<tr>
<td>G</td>
<td>12.1</td>
<td>-3.1</td>
<td>1.0</td>
<td>7.5</td>
<td>5.8</td>
<td>5.6</td>
<td>4.8</td>
<td>4.8</td>
<td>3.0</td>
<td>4.6</td>
</tr>
<tr>
<td>H</td>
<td>12.0</td>
<td>-3.0</td>
<td>1.0</td>
<td>7.4</td>
<td>5.6</td>
<td>5.5</td>
<td>4.8</td>
<td>3.1</td>
<td>4.9</td>
<td>4.5</td>
</tr>
<tr>
<td>I</td>
<td>7.6</td>
<td>-4.5</td>
<td>-2.7</td>
<td>6.2</td>
<td>4.5</td>
<td>3.2</td>
<td>2.1</td>
<td>2.5</td>
<td>2.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

The results derived from Case 2 show that altering government capital spending has a similar impact upon the adjustment of foreign asset stocks to that of an increase in oil production during the early stage of adjustment. An increase in government
investment spending in scenarios F, G and H have a larger positive effect on the adjustment of foreign asset stocks relative to that of scenario I\textsuperscript{95}. The accumulation of foreign assets stock is noticeably larger the larger is $\theta_1$ and then $\theta_4$ and $\theta_5$ relative to that of scenario I. In long-run steady state, foreign asset stocks accumulate by 13 percent in scenario F, 12.1 percent in scenario G, 12 percent in scenario H, and 7.1 percent in scenario I. This indicates that during the long-run adjustment to steady state the current account remains in surplus throughout all scenarios.

The real exchange rate initially appreciates and then depreciates throughout the remainder of the adjustment process in all scenarios. It appreciates by approximately 9 percent in all scenarios in Case 2, compared with 6 percent in Case 1, in the early stage of adjustment from its initial base value, overshooting its long-run rate throughout the adjustment process. The difference with Case 1 arises from the adjustment in the price level, where it is higher in the case of the oil price increase, Case 2. The larger initial appreciation of the real exchange rate brings about a larger deterioration in the non-oil trade balance of 7.5 percent relative to baseline, compared with 6 percent in Case 1. This clearly exacerbates the Dutch Disease effect during the adjustment process. The real exchange rate depreciates rapidly during the medium-run towards long-run steady state, overshooting its initial value in scenarios F, G and H. This depreciation improves competitiveness and the non-oil trade balance. In other words there is a reversal of the Dutch Disease consequences occurring in the short-run, with subsequent adjustment to long-run steady state. On the other hand, without a government development spending increase, as in scenario I, the real exchange rate depreciates towards its long-run steady

\textsuperscript{95} In order to avoid repetition and for brevity, see section 7.2 and Table 7.1 above for more detail about scenarios F, G, H and I.
state where it has appreciated overall by 2.2 percent. As a result of this the non-oil trade balance deteriorates by 4.5% in steady state instead of 2.5 percent as in the base model.

During the early stage of adjustment non-oil output increases in all scenarios, but increases more in scenarios F, G and H and mainly in F. This is due to the large accumulation of physical capital stock, human capital stock, and imported capital stock in the early stage of adjustment. Non-oil output increases in scenario I, but by less than for the three other scenarios. This implies that a more development oriented policy aimed at increasing $\theta_1$, $\theta_2$ and $\theta_3$ would stimulate the accumulation of physical, human, and imported capital stocks, and hence non-oil output supply, offsetting the possible decline in non-oil output supply that could result from an appreciation of the real exchange rate. While non-oil output supply increases in the case of increasing government consumption spending, this is less than for the other three scenarios and even by less than the base scenario, scenario (A1) as outlined in Chapter 6. In long-run steady state non-oil output supply increases by more the larger are $\theta_1$, $\theta_2$ and $\theta_3$, reaching a level higher than that of the base model. The largest increase is 6.5 percent in scenario F, compared to 5 percent in the base scenario and 3.2 percent in scenario I. The major factors affecting the development of non-oil output supply are the accumulation of physical capital stock, human capital stock, and imported capital stock, which all positively influence non-oil output supply. Equally, an investment oriented policy augments the demand side via the increase in government investment spending, and in turn private sector wealth and consumption spending.

The results derived from Case 2 are similar to that of Case 1 throughout the early periods of adjustment and in long-run steady state equilibrium for key macroeconomic variables. Generally speaking the results for Case 2 suggest that a development oriented
policy, as indicated by higher values for $\theta_1$, $\theta_2$ and $\theta_3$, result in Dutch Disease consequences, as indicated by the development in the non-oil trade balance in the early stage of the adjustment process. This can be seen from the deterioration of the non-oil trade balance arising from a larger real exchange rate appreciation. However, it reduces the Dutch Disease effects throughout the medium to long-run steady state, as indicated by improvement in the non-oil trade balance during this same period. On the other hand the Dutch Disease effect does not take place in the early period of adjustment for non-oil output supply. This is mainly due, as mentioned earlier, to the gradual increase in the physical capital stock, human capital stock and imported capital stock induced by more government investment spending, arising from a positive oil price shock. The larger are $\theta_1$, $\theta_2$ and $\theta_3$ the greater the benefit of the oil price increase on the variables of interest, particularly non-oil output supply, and therefore the better is macroeconomic performance. On the other hand, motivating government consumption spending will result in less favourable results during the early periods of the adjustment process, operating primarily upon increasing non-oil output demand rather than supply, for key variables throughout the adjustment process and in long-run steady state equilibrium, thereafter.

Figure 7.2:
Case 2: Oil Price Increase (altering $\theta_1$, $\theta_2$ and $\theta_3$)

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96 For more details see footnote 5 in Chapter 6.
7.3 Alternative policy allocation of oil production

The purpose of this section is to analyse macroeconomic outcomes from alternative government allocation of oil production between domestic usage and that for export, for one case and two scenarios, namely scenarios A and J. Scenario A represents the base model outlined in Chapter 6. The relevant parameter for this government policy is $\zeta$, the proportion of oil production which is exported. The larger is $\zeta$ the larger the amount of oil production exported and *vice versa* (see equation (4.26)). A simulation and
policy analysis will be conducted only for the case of a positive oil production shock. In this section only two scenarios will be emphasised, which are as follows:

**Scenario A**: an instantaneous and unanticipated 15 percent increase in oil production with a more export oriented policy ($\zeta = 0.70$)

**Scenario J**: an instantaneous and unanticipated 15 percent increase in oil production with a less export oriented policy ($\zeta = 0.40$)

**Case 3: Oil Production Increase (altering $\zeta$)**

In order to analyse the impact of a changed allocation of oil production between domestic usage and that for export this case is compared with the base scenario conducted in Chapter 6, scenario A, where $\zeta$ was larger ($\zeta = 0.70$). The steady state properties of the model for scenario J, compared with that of base model scenario (A), are summarised in Table 7.4. The results derived from this case suggests notable disparities from that of Cases 1 and 2, as discussed earlier, in terms of the dynamic adjustment process and the deviation of each variable from baseline. This is because of the real exchange rate response to the change in oil exports.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$f$</th>
<th>$T$</th>
<th>$c$</th>
<th>$w^o$</th>
<th>$y$</th>
<th>$No'$</th>
<th>$k^g$</th>
<th>$k^h$</th>
<th>$k^{cap}$</th>
<th>$k^p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 3*: A</td>
<td>7.0</td>
<td>-3.5</td>
<td>0.0</td>
<td>8.0</td>
<td>7.1</td>
<td>5.2</td>
<td>4.5</td>
<td>3.0</td>
<td>3.0</td>
<td>5.8</td>
</tr>
<tr>
<td>J</td>
<td>1.4</td>
<td>-4.0</td>
<td>-1.1</td>
<td>7.0</td>
<td>6.5</td>
<td>3.2</td>
<td>3.0</td>
<td>1.8</td>
<td>1.8</td>
<td>4.8</td>
</tr>
</tbody>
</table>

*Oil production increase

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97 The simulation result for the case of a positive oil price shock indicates that the adjustment path and long run steady state of the variables of interest are identical to that of the base model (the case of an oil price increase as in case A1 of Chapter 6), irrespective of the value of $\zeta$. 

220
The simulation results in Figure 7.3 indicate that the adjustment of foreign asset stocks in scenario J differs noticeably from that of base scenario A. Foreign asset stocks slightly de-cumulate during the early periods of adjustment the smaller is $\zeta$, while they initially accumulate in the base case (i.e. the larger is $\zeta$). This is simply because of the decline in oil exports in scenario J, which is the main source of foreign exchange in the Libyan economy. Foreign asset stocks increase somewhat towards its long-run steady state thereafter in scenario J, indicating small current account surpluses, whereas in scenario A foreign asset stocks increase more substantially in long-run steady state. The accumulation of foreign asset stocks in scenario A is more substantial due to larger surpluses in the oil trade balance, arising from more oil exports, and an increase in foreign interest income. In long-run steady state foreign asset stocks accumulate by 7 percent in the base scenario, the larger is $\zeta$, whilst it accumulates by only 1.4 percent in scenario J, the smaller is $\zeta$. These results suggest that if policymakers adopt a less export oriented policy, $\zeta = 0.40$, the accumulation of foreign asset stocks would inevitably be less, which could harm the ability of the government to induce non-oil supply via more technology acquisition from overseas, and vice versa for a more export oriented policy.

The price level initially increases by almost 4.5 percent during the adjustment process for the base scenario (scenario A), and remains above the base line for a period of time before achieving its long-run steady state equilibrium. The adjustment of the price level in the early periods is essentially influenced by larger government consumption and investment spending (a larger spending (demand) effect), which results in a larger increase in non-oil demand over non-oil supply. In addition, the more oil export oriented policy, as in scenario A, generates larger balance of payments surpluses
and a larger accumulation of foreign exchange reserves. This eventually leads to a primarily higher money stock so as to maintain the fixed nominal exchange rate policy, leading to an increase in the domestic price level in the short term. The price level initially increases by only 1.8 percent in scenario J, induced by a smaller spending (demand) effect relative to output supply, and a smaller accumulation of foreign asset stocks (Figure 7.3). The adjustment path of the price level contributes to developments of the real exchange rate as the nominal exchange rate remains fixed. As can be seen from Figure 7.3 the real exchange rate appreciates in both scenarios, but is larger with a more oil export oriented policy (the larger is $\zeta$).

Developments in the non-oil trade balance show that a more oil export oriented policy, scenario A, will lead to a larger deterioration of the non-oil trade balance in the early periods of adjustment, indicating larger Dutch Disease effects. This mainly arises from a larger appreciation of the exchange rate by 7 percent (Figure 7.3) induced by additional oil revenue, larger current account surpluses and also from a larger initial increase in real income throughout the early periods of adjustment. The non-oil trade balance deteriorates by less in scenario J, due to the smaller $\zeta$, as the real exchange rate initially appreciates by only 2.5 percent. The non-oil trade balance improves rapidly thereafter in scenario A as the real exchange rate depreciation towards its long-run steady state results in improved competitiveness and from a slight decline in non-oil imports.

Overall, the larger is oil exports the greater is the likelihood that the non-oil trade balance will deteriorate during the early stage of adjustment, but it will improve over the long-run to steady state and end up at 3.5 percent below baseline. However, with a less oil export oriented policy the non-oil trade balance will deteriorate by 4 percent in long-run steady state in comparison to baseline.
Non-oil output supply increases initially throughout the early stage of adjustment in both scenarios, but it obviously increases by more when more oil is exported as in scenario A. The initial increase in non-oil production is due mainly to the faster accumulation of productive capital stock in the form of public capital stock, human capital stock, imported capital stock and private capital stock (Figure 7.3), which increases by more in scenario A (where $\zeta$ is larger). Specifically, oil exports generate foreign asset stocks which boost the ability of government to induce non-oil supply through more technology acquisition from overseas, and the attainment of skill and knowledge from overseas via sending workers for training and students for education. This development offers the prospect of offsetting the potential adverse effect of real exchange rate appreciation upon non-oil output supply through improving private sector productivity, expanding the capacity of non-oil output supply and achieving faster economic growth. Non-oil production increases continuously throughout the dynamic adjustment path towards long-run steady state equilibrium, and in particular in the scenario of more oil exports (the base scenario) where it ends up at 5.2 percent above baseline while it reaches only 3.2 percent above baseline in scenario J. This implies that the increase in non-oil production is 2 percent less as a result of increasing the domestic usage of oil production.

In terms of private sector real wealth the simulation results indicate that it increases rapidly throughout the dynamic adjustment process for either scenario, but it increases by more the larger is oil exports. This is due to the larger accumulation of private capital stock (Figure 7.3) and increase in permanent income (not shown in Figure 7.3) in the early periods of adjustment. In long-run steady state real private wealth increases in either scenario, but it increases more in the base case scenario as a result of more accumulation of private capital stock, an increase in real money balances and
permanent income. This increase in private sector real wealth will eventually stimulate the private consumption and bring about positive economic welfare effects (see Equation 4.2).

From these results it can be concluded that a positive oil production shock in combination with more oil exports can bring about beneficial outcomes for the Libyan economy. It contributes to more foreign asset stock accumulation, which in turn enhances accumulation of productive capital stock in the form of human capital stock, imported capital stock and private capital stock, and, therefore, boosts non-oil production throughout the adjustment process and in long-run steady state. However, the larger are oil exports the larger is the likelihood that the non-oil trade balance will deteriorate during the early stage of adjustment, indicating a Dutch Disease effect, but it will slightly improve over the long-run to steady state due mainly to a more rapid depreciation of the real exchange rate towards its long-run steady state. In general, a more oil export oriented policy in a period of increasing oil production can result in advantageous developments throughout the adjustment process to long-run steady state for some key macroeconomic variables, such as real income, private real wealth, foreign asset stocks, physical capital, human capital and imported capital stocks, and therefore non-oil output. However, it leads to less favourable results for the non-oil trade balance during the early periods of the adjustment path.
Figure 7.3:
Case 3: Oil Production Increase (Altering $\zeta$)

- **Foreign asset stocks**
- **Price level**
- **Real exchange rate**
- **Non-oil trade balance**
7.4 Alternative nominal exchange rate policy

The policy responses discussed in the previous sections were concerned with the allocation of additional oil revenue between government consumption and investment spending, and the distribution of oil production between domestic usage and for export, assuming a fixed exchange rate. The simulation results derived from these policies pointed out the ability of the government to enhance productivity of non-oil output supply by increasing government investment spending on infrastructure (physical capital), human capital formation, and technology acquisition, and also by increasing oil exports. However, despite the stimulation of non-oil output supply, particularly during the early periods of the adjustment path via the aforementioned policies, the results suggested the existence of Dutch Disease consequences, and deterioration in the external sector. Key factors driving this development are the appreciation of the real exchange rate, the inflation rate, increased real income, a loss of competitiveness of non-oil exportable goods and increased non-oil imports, and overall deterioration of the non-oil trade balance.

It is of interest to identify if the adverse effects of the oil boom upon the non-oil trade balance could be alleviated by adopting an alternative nominal exchange rate policy. That is, in order to mitigate the adverse effects of the oil boom upon the non-oil 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 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 only be temporarily influenced by the difference between non-oil output supply and demand.

Equation (4.21) was utilised in the base model developed in Chapter 4 to represent the assumption of a fixed nominal exchange rate combined with zero capital mobility. However, moving from a fixed to flexible nominal exchange rate combined with perfect capital mobility requires replacement of equation (4.21) by equation (4.21e) in the model presented in Chapter 4.

\[ m = dce + \dot{f} \]  
\[ \dot{e} = r - r^* \]

Equation (4.21e) is the uncovered interest parity condition. It represents the assumption of perfect capital mobility and perfect foresight in the foreign exchange market. It assumes that in the foreign exchange market agents have rational expectations and anticipate that when the economy is out of steady state it will ultimately converge to a new steady state.

This section analyses the consequences of alternative exchange rate regimes upon the Libyan macroeconomy for two cases. That is, an oil production and oil price increase. Two different nominal exchange rate regime scenarios will be conducted for each case as shown in Table 7.5. In the case of an oil production increase, Case 4, scenario K assumes a fixed nominal exchange rate combined with zero capital mobility, whilst scenario L
presumes a flexible nominal exchange rate regime combined with perfect capital mobility. Similarly, in the case of an oil price increase, Case 5, scenario M assumes a fixed nominal exchange rate combined with zero capital mobility, whilst scenario N presumes a flexible nominal exchange rate regime combined with perfect capital mobility. The four scenarios are summarised in Table 7.5.

**Table 7.5**

**Alternative Nominal Exchange Rate Policy and Capital Market Policies**

<table>
<thead>
<tr>
<th>Case 4: 15% Oil production increase</th>
<th>Case 5: 15% Oil price increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario K</td>
<td>Scenario M</td>
</tr>
<tr>
<td>Nominal Exchange Rate Regime</td>
<td>Nominal Exchange Rate Regime</td>
</tr>
<tr>
<td>fixed</td>
<td>fixed</td>
</tr>
<tr>
<td>flexible</td>
<td>flexible</td>
</tr>
<tr>
<td>Degree of Capital mobility</td>
<td>Degree of Capital mobility</td>
</tr>
<tr>
<td>zero</td>
<td>zero</td>
</tr>
<tr>
<td>perfect</td>
<td>perfect</td>
</tr>
</tbody>
</table>

**Case 4: Oil production increase (fixed exchange rate with zero capital mobility versus flexible exchange rate with perfect capital mobility)**

In this section results derivable from a simulation of the model involving movement from a fixed to a flexible exchange rate regime in the case of a positive oil production shock, are analysed. Two scenarios are conducted in this case, scenario K and scenario L.

Generally, as indicated in Table 7.6 and Figure 7.4, moving from a fixed to flexible nominal exchange rate regime brings about different outcomes during the dynamic adjustment process, and in particular for the non-oil trade balance. The key variables that contribute to this difference are the inflation rate and 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 can also enhance the supply of, and demand for, non-oil output.

Table 7.6: Steady State Properties of the Model for Alternative Nominal Exchange Policy Regimes (K and L) (Percentage Deviation from Baseline)

<table>
<thead>
<tr>
<th>Variable</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^v</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 4*: K</td>
<td>6.0</td>
<td>-4.0</td>
<td>-1.0</td>
<td>8.0</td>
<td>7.0</td>
<td>5.0</td>
<td>4.3</td>
<td>2.9</td>
<td>2.9</td>
<td>5.8</td>
</tr>
<tr>
<td>L</td>
<td>6.0</td>
<td>-3.5</td>
<td>-0.0</td>
<td>9.0</td>
<td>8.0</td>
<td>5.9</td>
<td>5.0</td>
<td>3.4</td>
<td>3.4</td>
<td>6.7</td>
</tr>
</tbody>
</table>

*Oil production increase

Simulation outcomes for foreign asset stocks, as shown in Figure 7.4, show that they initially increase in both scenarios, but this is more rapid in scenario L signifying higher current account surpluses during the early stage of adjustment. Foreign asset stocks decline slightly for scenario L thereafter, before returning to long-run steady state where it has accumulated by 6 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 non-oil 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 non-oil trade balance is less in scenario L compared to that of K during the early periods of adjustment (Figure 7.4).

The price level initially increases by almost 4.5 percent during the adjustment process for the fixed nominal exchange rate regime scenario (scenario K), 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 which 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. As can be seen from Figure 7.4 the price level slightly increases in the early periods of the adjustment process, and returns quickly to its initial value thereafter.

Developments in the domestic price level affect the development 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 K), overshooting its long-run steady state. Also the appreciation of the real exchange rate for scenario K is larger and is more prolonged before it depreciates towards long-run steady state. The main reason for this being that the higher domestic price level for scenario K, induced by money growth and the difference between non-oil demand and non-oil 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 slightly appreciates, induced by a smaller increase in the domestic price level for scenario L. 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 K towards its initial value as the price level returns quickly to its initial value.
Development of the non-oil trade balance is influenced by the adjustment path of the real exchange rate in both scenarios. The non-oil trade balance deteriorates throughout the dynamic adjustment process in both scenarios, with a noticeably larger deterioration in scenario K where it initially deteriorates by almost 6.5 percent. The deterioration of the non-oil trade balance in the case of a fixed exchange rate, scenario K, is due to a combination of increasing non-oil imports arising from an increase in real income and a decline in non-oil 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 non-oil trade balance in the case of a flexible exchange rate, scenario L, is due only to an increase in non-oil imports stimulated by a larger increase in real income. Non-oil exports experience a minor decline in the early stage of adjustment in scenario L, influenced by a smaller appreciation of the real exchange rate and a prompt return to its base value thereafter. The smaller deterioration of the non-oil trade balance in scenario L means that the competitiveness of non-oil exports is better with the flexible nominal exchange rate regime combined with perfect capital mobility.

Non-oil production increases continuously in both scenarios throughout the adjustment path towards long-run steady state, but it increases more in the case of the flexible exchange rate regime (scenario L). The main contributory factor for this difference is an increase in non-oil production in scenario L 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 non-oil exports arising from a smaller appreciation of the real exchange rate as compared with that of scenario K. As can be seen from Table 7.6, and Figure 7.4, public physical capital stock, human capital stock, imported capital stock and private capital stock accumulate in the early periods of adjustment towards 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; 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 non-oil production arising from scenario L (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 towards long-run steady state. It increases more in scenario L, where it increases by 9 percent compared with 8 percent in scenario K. Developments in real private wealth are induced mainly by a significant accumulation of private capital stock, real money balances and permanent income. This will eventually lead to positive economic welfare.

The overall conclusions from the above results are that 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 non-oil 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 non-oil trade balance was due to the larger increase in non-oil imports stimulated by a larger increase in real income.
Therefore, it can be said that Dutch Disease consequences can be minimised by moving from a fixed to flexible exchange rate regime. In addition, a flexible nominal exchange rate policy provides greater benefits for non-oil 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 non-oil exports. Moreover, private sector benefits from the flexible exchange rate regime are induced mainly by an increase in the private capital stock.

Figure 7.4: Case 4: Oil Production Increase

Figure showing the impact of flexible exchange rate regime on foreign assets and price level over periods.
Case 5: Oil price increase (fixed exchange rate with zero capital mobility versus flexible exchange rate regime with perfect capital mobility)

This case is concerned with a policy analysis of an oil price shock for two scenarios; scenario M, which represents the case of a fixed nominal exchange rate in conjunction with zero capital mobility, and scenario N which represents the case of a flexible exchange rate combined with perfect capital mobility (where $\tau = 0$).
In general, as indicated in Table 7.7 and Figure 7.5, the results derived from Case 5 are similar to that obtained for Case 4. Moving from a fixed to flexible nominal exchange rate regime produces different results, in particular throughout the dynamic adjustment process. Again the key variables that drive this difference are the inflation rate and exchange rate. Once again, a flexible exchange rate policy enhances non-oil production and also reduces the Dutch Disease consequences for the current account; in particular during the early part of the adjustment path.

**Table 7.7: Steady State Properties of the Model for Alternative Nominal Exchange Policy Regimes (M and N)**

(Percentage Deviation from Baseline)

<table>
<thead>
<tr>
<th>Variable</th>
<th>f</th>
<th>T</th>
<th>c</th>
<th>w</th>
<th>y</th>
<th>No</th>
<th>k^s</th>
<th>k^h</th>
<th>k^cap</th>
<th>k^p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 5*: M</td>
<td>10.0</td>
<td>-3.9</td>
<td>-0.08</td>
<td>7.5</td>
<td>5.1</td>
<td>4.5</td>
<td>4.0</td>
<td>2.6</td>
<td>2.6</td>
<td>4.0</td>
</tr>
<tr>
<td>N</td>
<td>11.0</td>
<td>-3.7</td>
<td>0.0</td>
<td>8.5</td>
<td>6.0</td>
<td>5.2</td>
<td>4.5</td>
<td>3.0</td>
<td>3.0</td>
<td>4.8</td>
</tr>
</tbody>
</table>

*Oil price increase

For foreign asset stocks the simulation results in Table 7.7 and Figure 7.5 indicate that it initially increases in both scenarios, but it increases more rapidly in scenario N, demonstrating larger current account surpluses in the early periods of adjustment. The increase in foreign assets stocks continues to long-run steady state for both scenarios, indicating that the current account is in persistent surplus, where foreign asset stocks accumulate by 11 percent in scenario N (flexible exchange rate scenario). Once again this result clearly indicates that the flexible nominal exchange rate policy provides a larger accumulation of foreign asset stocks, specifically in the early stage of the adjustment process.
In regards to the domestic price level it initially increases by almost 7.5 percent in the early stage of the adjustment process for the fixed nominal exchange rate regime scenario (scenario M), and remains above base line for a period of time before it returns to its long-run steady state. The adjustment of the price level during the early stages is essentially influenced by the difference between non-oil demand and non-oil supply, and also by money growth arising from an accumulation of foreign asset stocks which itself is primarily driven by an improvement in the oil trade balance (see equations (4.21), (4.22) and (4.23)). This result is similar to that of base scenario B conducted in Chapter 6 with negligible capital mobility.

Once again the results are different with a flexible exchange rate since an increase in oil revenue would not influence the monetary growth rate, but, rather, appreciate the nominal exchange rate. In other words the adoption of a flexible exchange rate insulates the country from inflation arising from growth of the money supply. Thus the development in the domestic price level results primarily from the adjustment of the nominal exchange rate. As can be seen from Figure 7.5 the price level increases slightly in the early part of the adjustment process, and returns quickly to its initial value.

The real exchange rate initially appreciates and then depreciates throughout the remainder of the adjustment process with the adoption of a fixed nominal exchange rate regime (scenario M), overshooting its long-run steady state by almost 10 percent on impact. The appreciation of the real exchange rate for scenario M is larger and more prolonged before it depreciates towards long-run steady state. This mainly results from a higher domestic price level for scenario M induced by money growth and a spending effect. With a flexible nominal exchange rate regime, scenario N, the real exchange rate barely appreciates in the early periods of adjustment, induced by a smaller appreciation
of the nominal exchange rate, and rapidly depreciates towards its long-run steady state thereafter.

The non-oil trade balance is influenced by the adjustment process of the real exchange rate in both scenarios. It deteriorates throughout the adjustment path in both scenarios. There is a larger deterioration in scenario M where it deteriorates by approximately 8 percent in the early periods of adjustment, compared with just about 3 percent in the case of a flexible exchange rate, scenario N. The deterioration of the non-oil trade balance in the case of a fixed exchange rate is due to a combination of increasing non-oil imports arising from an increase in real income and an appreciation of the real exchange, and decline in non-oil exports throughout the dynamic adjustment process which is affected by the initial sizeable appreciation of the real exchange rate. On the other hand the deterioration of the non-oil trade balance in the flexible exchange rate case, scenario N, is due primarily to an increase in non-oil imports stimulated by a larger increase in real income and smaller decrease in non-oil exports. Non-oil exports experience a minor decrease in the early stage of adjustment in scenario N, influenced by a smaller appreciation of the real exchange rate.

Non-oil output supply increases continuously in both scenarios throughout the adjustment path towards long-run steady state, but it increases more in the case of flexible exchange rate scenario N. Increased non-oil production is stimulated by an accumulation of physical capital stock, human capital stock, imported capital stock and private capital stock. Also, the Dutch Disease effects upon non-oil output supply are offset by the aforementioned factors, where the increase in non-oil output supply in the early periods of adjustment and in long-run steady state is larger in scenario N.
As can be seen from Table 7.7 and Figure 7.5 public physical capital stock, human capital stock, imported capital stock and private capital stock accumulate in the early periods of adjustment towards their long-run steady state. All of these capital stocks accumulate by more with a flexible exchange rate regime. This implies that the major benefits of a positive oil price shock upon all capital stocks and in turn upon non-oil production occur in scenario N (flexible exchange rate regime with perfect capital mobility). In long-run steady state non-oil output supply reaches approximately 5.2 percent above baseline in scenario N, compared with about 4.5% above baseline for scenario M.

Furthermore, the simulation results indicate that private real wealth increases continually in both scenarios throughout the adjustment path towards long-run steady state, but it obviously increases by more in scenario N where it has increased by 8.5 percent from baseline compared to 7.5 percent above baseline in scenario M. Developments in real private sector wealth are induced mainly by the significant accumulation of private capital stock, real money balances and permanent income. The developments in real private sector wealth will ultimately induce the private consumption and, in turn, result in positive economic welfare.

The major conclusion from the above results is similar to that of Case 4. A flexible nominal exchange rate policy combined with perfect capital mobility provides a significant accumulation of foreign asset stocks, particularly in the early stage of adjustment, and improves the competitiveness of non-oil exports as the real exchange rate only slightly appreciates. Thus, the deterioration of the non-oil trade balance was due to the larger increase in non-oil imports stimulated by a larger increase in real income. Consequently, despite the higher inflation rate in the case of an oil price increase
compared with that of an oil production increase, it can be concluded that Dutch Disease consequences can be diminished by moving from a fixed to a flexible exchange rate system. In addition, a flexible nominal exchange rate policy provides greater benefits to non-oil production, arising from a larger accumulation of public physical capital stock, human capital stock, imported capital stock and private capital stock. Moreover, the private sector benefits from the flexible exchange rate regime, mainly induced by an increase in private capital stock.

**Figure 7.5:**

*Case 5: Oil Price Increase*
7.5 Discussion of the results

The aforementioned alternative policies have revealed the important role of government in promoting economic development through enhancing non-oil production and minimising the adverse effect of oil related shocks upon the non-oil trade balance and non-oil output. The government can enhance the private sector and non-oil output supply through a development oriented policy in the form of increased government investment spending on public physical capital (infrastructure), human capital formation and imported technological acquisition, and also through a more oil export oriented policy. Specifically, human capital formation and imported capital (technology), besides physical capital, have been identified as key determinants in promoting the private sector, non-oil output supply and hence sustainable economic development. However, promoting government consumption at the expense of government investment spending
upon physical capital, human capital formation or imported capital retards economic development.

The key issue here is which of the government capital spending options is the best in fostering non-oil production and economic development. In fact these government expenditure options cannot be separated. That is, building a good infrastructure requires educated and skilled workers and also capital imports (technology). The preferences here depend upon the needs of the economy for infrastructure, human capital or technological acquisition. Thus, the government can alter the proportion of government spending allocated towards physical capital stock, the proportion of government spending allocated towards human capital stock, and the proportion of government spending directed towards imported capital stock according to the priorities (and bottlenecks) of the economy. This is also an empirical issue. The impact of these various forms of expenditure on the macro-economy depends upon the value of the model’s parameters and particularly those in the output supply equation (equation (4.24)).

The discussion also revealed that Dutch Disease effects arising from oil related shocks, particularly upon the non-oil trade balance, can be alleviated during the medium to long-run adjustment process through a development oriented policy. However, the flexible nominal exchange rate policy appears to be a more effective policy in minimising the adverse consequences upon the non-oil trade balance throughout the short and medium-runs towards long-run steady state equilibrium.

However, a key issue in regard to stimulating economic development via the aforementioned alternative policies is the ability and transparency of existing Libyan institutions and government agencies in adopting and implementing such policies. In the absence of institutions and government agencies with high efficiency, large revenue
generated from the oil sector may create rent-seeking behaviour by interested groups, such as government officials and local or foreign investors, resulting in corruption and inefficiency. This behaviour may result in economic failure including a collapse of the non-oil production sector, capital flight, higher inflation, poor institutional quality and hence lower growth and development. On the other hand, the existence of well established institutions and government agencies will enable the economy to execute alternative sound policies in response to oil related shocks, stimulating economic development via enhancing non-oil output supply and avoiding adverse effects such as that of Dutch Disease effects. Incorporating the role of well established institutions would represent a significant extension of the current macroeconomic dynamic model. This extension is left for future studies.

7.6 Summary and conclusions

Policies that can be undertaken by government in order to enhance the sustainable benefits from an oil boom and to reduce the adverse consequences of such a boom upon key macroeconomic variables have been highlighted and analysed in this chapter. Several simulation scenarios using a program called Dynare were conducted so as to analyse the economic consequences of alternative policies or government responses, and to provide policymakers with advice as to how to administer the additional oil revenue arising from an increase in oil production and oil price. In this context, three alternative policies have been analysed. In the first alternative policy emphasis was placed upon the allocation of additional oil revenue between government investments in the form of infrastructure (physical capital), human capital formation, and technology acquisition, and government consumption. For this alternative policy two cases and five scenarios, including that of the base model conducted in Chapter 6, were analysed. The focus of the second alternative policy was placed upon the distribution of oil production between domestic
usage and that for export. For this sort of government policy one case and two scenarios, including that of the base model, were conducted. In the third alternative policy scenario focus was placed upon a different nominal exchange rate policy, a flexible exchange rate combined with different capital mobility. In this cluster, two scenarios were simulated for the case of an oil production and oil price increase.

The analysis emphasised the adjustment paths as well as the long-run steady states of eleven key macroeconomic variables. These being foreign asset stocks, non-oil trade balance consisting of non-oil exports and non-oil imports, real exchange rate, inflation rate, non-oil production, physical capital stock, human capital stock, imported capital stock, private capital stock, private sector real wealth and real income. These variables were selected because the change in these variables, arising from an oil related shock, will influence the development of other variables, and hence the development of the domestic economy as one.

The results derived from Case 1 are similar, in terms of direction but not in magnitude, to that of Case 2 throughout the early periods of adjustment and towards long-run steady state equilibrium for key macroeconomic variables. The most important result derived from the first alternative policy is that a development oriented policy in the form of increased government investment on public physical capital, human capital formation, and technological acquisition results in an improvement of non-oil output supply and positive economic welfare. It also leads to Dutch Disease consequences, as indicated by developments in the non-oil trade balance, in the early stage of the adjustment process; however, Dutch Disease effects are mitigated throughout the medium to long-run adjustment path. On the other hand Dutch Disease effects do not take place in the early period of the adjustment process towards long-run steady state for
non-oil output supply. This is mainly due to the gradual increase in the physical capital stock, human capital stock and imported capital stock induced by more government investment spending, arising from positive oil related shocks. On the contrary, increasing government consumption spending will produce less favourable results during the early periods of the adjustment process for key variables and throughout the remainder of the adjustment process to long-run steady state equilibrium.

For the second alternative policy, which is related to the distribution of oil production between domestic usage and exports, the simulation results suggest that a more export oriented policy contributes to a larger foreign asset stock accumulation, which in turn enhances imported capital stock (technological acquisition from overseas) and human capital stock (through sending students and local workers for education and training overseas), and therefore boosts non-oil production and real income throughout the adjustment process and in long-run steady state. However the greater are oil exports the larger is the likelihood that the non-oil trade balance will deteriorate during the early stage of adjustment, exacerbating the Dutch Disease effect, but it will slightly improve over the long-run to steady state due mainly to a depreciation of the real exchange rate towards its long-run steady state. Overall, a more oil export oriented policy during a period of increasing oil production can result in advantageous developments throughout the adjustment process to long-run steady state for some key macroeconomic variables, such as real income, private real wealth, foreign asset stocks, physical capital, human capital and imported capital stocks, and therefore non-oil output. However, it leads to less favourable results for the non-oil trade balance during the early periods of adjustment.
For the alternative policy concerning the nominal exchange rate, outcomes suggest that a flexible exchange rate policy in the case of an oil production increase, Case 4, and for the case of an oil price increase, Case 5, provides a large accumulation of foreign asset stocks, particularly during the early stage of adjustment. The competitiveness of non-oil exports improves with a flexible nominal exchange rate system as the real exchange rate only slightly appreciates during the adjustment path. The deterioration of the non-oil trade balance was primarily due to the larger increase in non-oil imports stimulated by an increase in real income. Therefore, the Dutch Disease effects are potentially reduced by moving from a fixed to flexible exchange rate regime. In addition, the flexible nominal exchange rate offers larger benefits to non-oil production, influenced by a larger accumulation of public physical capital stock, human capital stock, imported capital stock, and private capital stock. In addition, the private sector benefits from the flexible exchange rate regime, induced mainly by an increase in private capital stock.

The aforementioned alternative policies require well established institutions to be implemented effectively by policymakers. Countries with well established institutions will be able to implement sound policies in response to positive oil related shocks, and hence will be able to stimulate their economic development and avoid the adverse effects arising from Dutch Disease effects. On the other hand a lack of such institutions would lead to poor policy choices, and hence a deepening and extending of the negative effects arising from an oil shock.

A number of alternative government policies have been discussed and analysed throughout this chapter. In order to maximise the benefits from the oil sector boom and minimise the adverse effects of the oil boom upon key macroeconomic variables, there is
a clear recommendation for policymakers and government agencies to adopt a more development oriented policy, a more oil export oriented policy, and an alternative nominal exchange rate regime. However, the adoption of such policies requires well-established institutions with a high degree of transparency and credibility. These results, alongside the other major results derived from this study will be summarised and discussed in Chapter 8.
Chapter 8

Summary, Conclusion, Policy Implications and Further Studies

8.1 Introduction

This study has focused upon the role of resource (oil) production and its implications for economic growth and development. The focus was placed upon the macroeconomic adjustment process of key macroeconomic variables arising from resource (oil) related shocks, emphasising both a static and dynamic analysis, and applied specifically to the case of Libya. Four objectives have been identified in the conduct of this study. First, to study the historically fundamental role of oil revenues in the economic development of the Libyan economy and the potential adverse consequences of the oil boom sector upon the non-oil sector. Second, to develop a long-run dynamic general equilibrium macroeconomic model for Libya, and then empirically estimate its short-run and long-run parameter elasticities. Third, to simulate this dynamic macroeconomic model developed with the objective of analysing the effects of oil related shocks for the Libyan economy. Fourth, to identify optimal policies implementable by policymakers and government agencies to mitigate the impact of exogenous oil related shocks upon non-oil sectors with the objective of maximising economic growth and development, as well as to conduct policy experiments.

Four analytical approaches have been utilised in this study to achieve the above objectives and answer the research questions and sub-research questions corresponding to the objectives of the study. First, a descriptive analytical approach was used in Chapter 2 to identify and review oil developments and its impact upon a number of key macroeconomic variables for the Libyan economy. These include government revenue and spending, real GDP, exports, current account, monetary variables (money supply,
inflation, interest rate and exchange rate) and investment. Second, in Chapter 3, this study reviewed the literature to further understand the macroeconomic adjustment process of key macroeconomic variables arising from resource (oil) related shocks, emphasising both a static and dynamic analysis. It reviewed basic models that can be used to develop a macroeconomic model for a net oil-exporting economy such as Libya, with suitable amendments for a developing economy. Third, a quantitative analytical approach was used in Chapters 4 and 5 to develop and quantitatively estimate, using robust and contemporary estimation procedures, a long-run dynamic model incorporating key fundamental features of the Libyan economy, and its oil production. Fourth, a numerical simulation approach using a Dynare was utilised in Chapters 6 and 7 to evaluate the macroeconomic consequences, arising from oil related shocks, upon key macroeconomic variables in the Libyan economy, as well as to simulate and analyse the results from a number of alternative government policies.

8.2 Main innovations and contribution to the literature

There is extensive literature devoted to analysing the effects of natural resource production upon the growth performance of resource-abundant economies over the short and long terms. This so called Dutch Disease literature places attention on how resource production affects the economy, specifically during the short-run, through a number of channels including: resource movement; spending; income; and exchange rate effects (for example, Buiter & Purvis, 1982; Corden, 1984; Corden & Neary, 1982; Eastwood & Venables, 1982; Harvie, 1989; Neary & van Wijnbergen, 1984). Other literature has placed emphasis on long-run effects arising from: capital stock accumulation in the non-oil sector, and hence investment and increased non-oil productive capacity of the economy over the long term; foreign asset stock accumulation via developments in the current account; and budgetary financing implications (see, Cox & Harvie, 2010; Harvie,
1991; Harvie, 1992a, 1992b, 1992c; Harvie & Gower, 1993; Harvie & Maleka, 1992; Harvie, 1993; Harvie & Thaha, 1994; Harvie & Tran Van Hoa, 1994a, 1994b; Harvie & Verrucci, 1991). Furthermore, this literature has also taken into account implications for adjustment arising from different exchange rate regimes (fixed or flexible) and the identification of optimal policy responses in a dynamic context with the objective of minimising the adverse effects of a resource boom on the non-resource sector.

However, no model in the relevant literature identified the way in which exogenous oil related shocks transmit their effects to the domestic oil-developing economy via human capital formation and imported capital stock accumulation (technological acquisition). Also, in this sense, recent studies for the case of Libya cannot be found. Thus, this study has emphasised both the short- and long-run effects identified above but also extended the existing relevant literature in different aspects, considered as a unique extension, specifically to that of the C-H model outlined in Chapter 3 as follows.

First, this study takes into account the long-run effects upon non-oil production, arising from human capital stock accumulation via government investment spending on education and health services (another additional wealth effect).

Second, it captures the long-run effects arising from imported capital stock accumulation in the non-oil sector via capital imports (a technology effect).

Third, it takes into account the allocation of additional oil revenue between different sorts of expenditure (spending options), emphasising the supply side in a dynamic long-run macroeconomic model.
Fourth, it uses a program called Dynare designed for solving and simulating Dynamic Deterministic and Stochastic General Equilibrium Model, a very substantial and contemporary advanced modelling technique, to evaluate the macroeconomic consequences arising from oil related shocks upon key macroeconomic variables in the Libyan economy. It is a robust approach to analysing macroeconomic relationships and for analysis of economic policy decision-making.

8.3 Major research question conclusions

This study has attempted to descriptively and empirically investigate three major research questions and three sub-research questions corresponding to the objectives of this study. The three main research questions relate to the historically significant role of oil revenues in the economic development of the Libyan economy, the positive and negative impacts of additional oil revenue arising from increased oil related shocks upon key macroeconomic variables, and optimal policies that can be implemented by policymakers and government agencies to enhance and/or to mitigate the impact of exogenous oil related shocks upon the non-oil sectors with the objective of maximising economic growth and development. The major results for these research questions are summarised as follows.

8.3.1 What is the historical role of oil revenue in the economic development of the Libyan economy?

In order to answer this question this study reviewed historical oil sector developments over the period 1970-2007 and its impacts upon a number of key macroeconomic variables for the Libyan economy, including government real oil revenue and spending, real GDP by sector, current account, investment and monetary variables,
including money supply, inflation and the exchange rate in Chapter 2. The main results for this research question are as follows:

1. The oil sector has been pivotal in affecting the development of key macroeconomic variables in the Libyan economy. This is despite the fact that oil production was adversely impacted by the trade embargo imposed by the United States in the early 1980s, and sanctions imposed by the United Nations in the early 1990s as well as oil price fluctuations.

2. In relation to the impact of the oil sector upon government revenue and spending, oil revenue, which has mainly accrued to the government, has enabled the government to expand both its administrative (consumption) and development (investment) expenditure. Oil revenue has, therefore, brought about an increase in demand for tradable and non-tradable goods such as that for services and construction (spending effect). This led to a higher domestic price level and, in turn, an appreciation of the real exchange rate of the Libyan Dinar (exchange rate effect). The spending effect is dominated by government policy decisions, and is most likely to have been the main channel in transmitting the effects of oil production to the overall macroeconomy. This is because the oil sector is an extremely capital-intensive activity with a high level of labour productivity, which means the resource movement effect has been negligible.

3. The share of oil output in real GDP is still significant in the Libyan economy, and may have had an adverse impact on the development of the non-oil tradeable sector. Developments in Libya’s GDP by sector indicate slight structural changes that have taken place over the period of study. That is, the contribution of the non-tradable sector, such as that of services and construction in real gross domestic product has experienced an increase, implying that the oil boom was followed by expansion in the non-oil tradable
sector; however it has undermined the growth of the non-oil tradable sector such as that of the manufacturing and agriculture sectors. In other words the oil sector may have had an adverse effect on the development of the non-oil tradable sectors, arising from the existence of the so called Dutch Disease effect.

4. Oil production has generated an increase in exports and enhanced the current account. Accordingly, oil production and price developments exert a major influence upon the economy through foreign asset accumulation via the current account (current account effect). Since the economy operated with a fixed nominal exchange rate for most of the period of the study, the money supply had to increase as a result of foreign asset accumulation. This resulted in further domestic inflation which was reflected in a higher price for tradable and non-tradable goods, causing a further appreciation of the real exchange rate. The accumulation of foreign asset stocks also exercises a major impact upon non-oil output supply through financing capital imports, a technology effect, particularly technology and services necessary for economic development. Furthermore, the boom in the oil sector, particularly during the period of the late 1970s and early 1980s and then since 2000, contributed positively to gross fixed capital formation, which enhanced non-oil output supply.

8.3.2 What are the positive and negative impacts of additional oil revenue, arising from increased oil production and oil prices upon key macroeconomic variables in the Libyan economy?

The second main research question focused on examination of the dynamic adjustment process and the long-run steady state of the base model, arising from two oil related shocks. In order to answer this question the parameters obtained from the estimation procedure conducted in Chapter 5, along with those calculated from available
data, those set as adjustment coefficients, those obtained from other studies and those imposed due to data limitation or in order to ensure model stability, were then used to conduct a simulation analysis in Chapter 6. The simulation analysis of the dynamic deterministic general equilibrium model was conducted using “Dynare”, which is suitable for a small open oil-exporting economy such as Libya. Simulation of the base model case was conducted, where a fixed exchange rate and highly controlled capital mobility was assumed. Twelve key macroeconomic variables were analysed. These are government real oil revenue, foreign asset stocks, non-oil trade balance, real exchange rate, private sector real wealth, private capital stock, real income, non-oil output, public physical capital stock, human capital stock, imported capital stock and inflation. Two simulation scenarios arising from a 15 percent increase in oil production and oil price and their impact upon the above twelve macroeconomic variables, were conducted. The major results derived from this research question are as follows:

1. An increase in government revenue (revenue effect) increased government spending upon consumption and investment in the domestic economy to maintain its balanced budget policy. Also, real income increased continuously throughout the adjustment process to long-run steady state (income effect) which increased the demand for non-oil imports.

2. A larger inflow of foreign exchange occurred during the oil boom (current account effect) which played a pivotal role in the economic development process through financing capital imports (technology effect), and acting as a buffer stock against any future financial or economic crises.

3. On the demand side an increase in government consumption and development expenditure increases the demand for both domestic non-oil and imported goods
(spending effect). Consequently, this brings about a higher domestic price level during the short-run and an appreciation of the real exchange rate (exchange rate effect). In addition, the huge inflow of foreign exchange, arising from balance of payments surpluses during the boom period causes a temporarily higher money stock in an attempt to maintain the fixed nominal exchange rate policy, also leading to an increase in the domestic price level and a further appreciation of the real exchange rate.

4. In the context of the macroeconomic model developed in this study, as the real exchange rate appreciated and real income increased Dutch Disease consequences occurred throughout the adjustment process toward long-run steady state, but only for the non-oil trade balance. The non-oil trade balance deterioration resulted from a loss of competitiveness of non-oil exportable goods, and increased non-oil imports.

5. On the supply side non-oil output did not behave according to the Dutch Disease hypothesis. The Dutch Disease hypothesis predicts a decline in the output of the non-oil tradable sector and then overall non-oil output through spending and/or resource movement effects. However, in the context of the Libyan model the consequences of the oil boom were in contrast to this hypothesis. This is because increased government development spending results in an accumulation of physical capital, human capital stock and imported capital stock, which benefits the private sector and stimulates non-oil output supply as well as increasing overall demand in the economy. The extent and nature of expansion of output in the private sector depends upon the government’s policy response.

8.3.3 How can policy makers (government agencies) minimise the adverse effects and/or maximise the positive effects, arising from oil related shocks?
Optimal policies that could be implemented by policymakers (or government agencies) to minimise the adverse impact of exogenous oil related shocks, and to maximise the benefits from exogenous oil related shocks upon the non-oil sectors with the objective of maximising economic growth and development, were highlighted and conducted in Chapter 7. Three alternative policies were emphasised so as to enable the government to manage properly the additional oil revenue, arising from an increase in oil production and oil price: (i) the allocation of additional oil revenue between different government investments, in the form of infrastructure (physical capital), human capital formation, and technology acquisition spending, and government consumption spending; (ii) the distribution of oil production between domestic usage and that for export; (iii) the last alternative policy focused upon a different nominal exchange rate policy combined with perfect capital mobility. The analysis of these alternative policy options emphasised the adjustment path and the long-run steady state of the key macroeconomic variables analysed in Chapter 6, except that of government real oil revenue. The answer to this research question is included in the major results of the following three sub-research questions.

8.3.3.1 What is the impact of the development oriented policy, in the form of increased government expenditure on infrastructure, human capital formation, and imported technological acquisition, on economic development in Libya?

For the development oriented policy and its impact upon economic development in Libya, two cases, namely the case of an oil production increase and the case of an oil price increase, and four scenarios were conducted and compared with the base model scenario in Chapter 6. The results derived from both cases are similar in terms of direction but not in magnitude throughout the early periods of adjustment, and in long-
run steady state equilibrium for key macroeconomic variables. The findings of the analysis of these policies indicated:

1. An improvement of economic performance occurred in both cases. This was seen from the improvement in non-oil output supply, arising from a larger accumulation of physical capital stock, human capital stock, and imported capital stock, which in turn enhanced private sector real wealth and result in a positive economic welfare. Specifically, and most importantly, for this study the accumulation of skill and knowledge of human beings and technological acquisition from overseas, besides the accumulation of infrastructure, are the most fundamental sources of non-oil output supply growth.

2. A development oriented policy in the form of increased government spending (spending effect) on public physical capital, human capital formation, and technological acquisition fails to prevent Dutch Disease consequences, as indicated by developments in the non-oil trade balance, in the early stage of the adjustment process; however, it mitigates Dutch Disease effects on the non-oil trade balance throughout the medium to long-run adjustment path. This can be seen from the deterioration of the non-oil trade balance arising from a larger initial real exchange rate appreciation.

3. The Dutch Disease effect, however, does not take place in the early period of the adjustment process for non-oil output supply. This is mainly due to the gradual increase in the physical capital stock, human capital stock and imported capital stock induced by more government investment spending, arising from positive oil related shocks. The larger is government development spending the better is the macroeconomic performance in the short-run and long-run steady state.
4. Increasing government consumption spending leads to less favourable results during the early periods of the adjustment process for key variables and throughout the adjustment process to long-run steady state equilibrium. In other words, increasing government consumption spending at the expense of government investment spending upon physical capital, human capital formation or imported capital retards economic development.

8.3.3.2 What is the impact of the alternative policy of distribution of oil production between domestic usage and exports upon key macroeconomic variables in the Libyan economy?

For the alternative policy of distribution of oil production between domestic usage and exports and its impact upon key macroeconomic variables in the Libyan economy, one case, i.e. oil production increase, and two scenarios were conducted. The outcomes of the analysis of this policy suggested that:

1. A more export oriented policy contributed to more foreign asset stock accumulation, particularly in the early periods of adjustment, which in turn enabled the government to increase its development spending and enhance the human capital stock and imported capital stock, strengthening non-oil production throughout the adjustment process and to long-run steady state.

2. However, larger oil exports increase the probability that the non-oil trade balance will deteriorate during the early stage of adjustment, enhancing the Dutch Disease effect, but it will slightly improve towards the long-run steady state due mainly to a depreciation of the real exchange rate towards its long-run steady state.
3. Overall, a more oil export oriented policy in a period of increasing oil production results in advantageous development throughout the adjustment process to long-run steady state for some key macroeconomic variables, such as real income, private real wealth, foreign asset stocks, physical capital, human capital and imported capital stocks, and therefore non-oil output; however, it leads to less favourable results for the non-oil trade balance during the early periods of the adjustment process due to a larger real exchange rate appreciation.

The major findings derived from the above policy analysis pointed to the ability of government agencies to improve productivity in non-oil output supply by increasing government investment on infrastructure (physical capital), human capital formation, and technology acquisition, and also by increasing oil exports. Conversely, despite stimulating non-oil output supply, particularly during the early periods of adjustment via the aforementioned policies, the results suggest the existence of Dutch Disease consequences, which took place in the early period of the adjustment process towards long-run steady state for the non-oil trade balance. In order to minimise the adverse effects of the oil boom upon the non-oil trade balance another alternative policy in the form of moving from a fixed to a flexible nominal exchange rate policy, combined with perfect capital mobility, was considered and simulated.

8.3.3.3 What is the impact of an alternative nominal exchange rate policy (a flexible nominal exchange rate regime) upon key macroeconomic variables in the Libyan economy?

Regarding the case of an alternative nominal exchange rate policy two scenarios were simulated for the case of an oil production and oil price increase. Both cases produced similar results in terms of direction but not in magnitude throughout the early
periods of adjustment and in long-run steady state equilibrium for key macroeconomic variables of interest. The outcomes suggested that:

1. The flexible exchange rate policy, combined with perfect capital mobility in both cases, offered significant accumulation of foreign asset stocks, and the competitiveness of non-oil exports improved as the real exchange rate slightly appreciated throughout the adjustment path and subsequently returned quickly to its initial value.

2. The results also indicate that the deterioration of the non-oil trade balance in the case of a flexible exchange rate was mainly due to the larger increase in non-oil imports induced by a larger increase in real income. This was due to the fact that the flexible exchange system offers a larger accumulation of international reserves that can be utilised for imports, particularly capital imports, which may deteriorate the non-oil trade balance, but will also have a positive impact upon non-oil production. Thus, Dutch Disease consequences upon the non-oil trade balance could be minimised by moving from a fixed to flexible exchange rate. Furthermore, the alternative nominal exchange rate policy provided greater benefits to non-oil production, induced by a larger accumulation of public physical capital stock, human capital stock, imported capital stock and private capital stock.

3. Private sector real wealth benefits from the flexible exchange rate regime, which is induced primarily by an increase in private capital stock. The latter is stimulated by accumulation of productive capital stock in the form of public physical, human and imported capital stock, as they are considered as complimentary to private capital stock (Aschauer 1989a & 1989b). The developments in private real wealth will bring about positive economic welfare.
8.4 Policy implications from the major findings

The above discussion of the major results demonstrate the significant potential role of government responses in promoting economic development via strengthening non-oil output supply, real income and private sector real wealth, and mitigating the adverse effects of oil related shocks upon the non-oil trade balance and non-oil output. The implications of the development oriented policy in the form of increased government expenditure, particularly upon public infrastructure, technology acquisition and human capital formation, appear to be the most appropriate policy for the Libyan economy in order to enhance the private sector, non-oil output supply and real income during the dynamic adjustment process and also in long-run steady state. Also, the benefits for the non-oil sector arising from physical capital stock, human capital stock, and imported capital stock accumulation induced by the boom in the oil sector could be of substantial importance in terms of employment and growth generation. An increase in non-oil output supply will possibly lead to an increase in the demand for labour, and hence reduce unemployment. However, these policy options resulted in Dutch Disease consequences, as indicated by developments in the non-oil trade balance, particularly in the early stage of the adjustment process. The extent of Dutch Disease effects primarily depends upon the price level, the appreciation of the real exchange rate and the increase in real income.

The oil export oriented policy under a fixed exchange rate regime will have a very crucial influence upon the development of key macroeconomic variables during the adjustment process and in long-run steady state, particularly for foreign asset stock, human capital stock, imported capital stock and, in turn, upon non-oil output supply. However, this policy also resulted in Dutch Disease consequences, as indicated by deterioration of the non-oil trade balance, mainly in the early stage of the adjustment process. Oil export revenue, as a main foreign exchange source, should primarily be
allocated to the importation of machinery and other imported capital necessary to generate domestic economic development as well as the accumulation of skill and knowledge of human capital from overseas.

Consequently, the government can alter the proportion of government development spending allocated towards physical capital stock, the proportion of government spending allocated towards human capital stock, and the proportion of government spending directed towards imported capital stock according to the priorities and needs of the economy so as to promote the private sector, non-oil output supply and hence to achieve sustainable economic development.

Economic performance appears to improve with a flexible exchange rate system combined with perfect capital mobility. This has been seen through minimising the adverse effects arising from additional oil revenue upon the non-oil trade balance. Thus, moving to a more flexible exchange rate system is recommended by this study to minimise or eliminate the Dutch Disease effects, particularly upon the development of the overseas sector. It produces improved macroeconomic outcomes not only in terms of the non-oil trade balance, but also in terms of non-oil output supply. A flexible exchange rate regime offers more foreign exchange reserves, which can be used for technological acquisition as well as the accumulation of skill and knowledge of human capital from overseas necessary to enhance non-oil output supply and sustainable economic development.

The above policy options recommended in this study bring about fostering an expansion of non-oil output supply, and minimising the adverse consequences arising from oil-related shocks. That is, the accumulation of real asset forms such as that of physical, human and imported capital as well as financial assets will ensure long term
economic sustainability by compensating for any decrease or depletion in oil revenue and oil production in the future, respectively. This implies that these policies will increase the ability of the Libyan economy to withstand shocks in the future by promoting diversification of the economy apart from the oil sector towards other tradable and more domestic labour-intensive sectors, such as that of agriculture and manufacturing.

Broadly speaking, the short and long-run feasible strategy of sustainable development for Libya is to utilise the oil revenue not only to develop its infrastructure, but also to accumulate foreign technology acquisition and to achieve a highly skilled and well-educated labour force. This strategy, in conjunction with an alternative nominal exchange rate policy, will offer Libya the capacity to use and absorb the imported capital and ultimately develop its own economy and technological capacity. Accordingly, accumulating physical, human and foreign technology would transform the economy into a well-equipped one able to maintain and improve its competitive advantages, and, therefore, to diversify and build a viable non-oil economy. This will not be an easy task. It will require well-established government institutions and well-skilled and informed policy-makers to implement expeditiously and efficiently this strategy. Well-established institutions will enable skilled policy-makers to carry out sound policies in response to positive oil related shocks, and hence stimulate economic development and avoid the adverse effects such as that of Dutch Disease effects. On the other hand the lack of such institutions would lead to poor policy choices, and hence a deepening and extension of the negative effects of the external shock. In the context of the Libyan economy, large revenue generated from the oil sector may create rent-seeking behaviour by government officials and local or foreign investors, resulting in corruption and inefficiency. This behaviour may result in economic failure, including a collapse of the non-oil production sector, capital flight, higher inflation, poor institutional quality and, hence, lower growth
and development indicators. Therefore, well-established institutions and government agencies with high efficiency are necessary to manage oil revenue effectively and to ensure efficient investment of this revenue.

8.5 Suggestions for further studies

It is essential to recognise that there are further features or policy options, such as reform of financial markets and privatisation, available to the Libyan government to consider, and they might be valuable to improve economic performance in the future. But due to the limitation of the data available, time devoted to this study on the one hand, and complexity of the model in order to accomplish policy analysis on the other, these features have been left for further studies.

1. The model of the Libyan economy developed in this thesis analyses the adjustment of non-oil output as a whole, and does not take into account the adjustment of key sub-sectors in the economy such as agriculture, manufacturing, and service production. However, developments in Libya’s non-oil output by sector show some of the structural changes that have taken place over the period of study (see Chapter 2). Therefore, the structural adjustments can be more clearly identified by disaggregating and modelling non-oil output into its key sub-sectors. Moreover, such disaggregating and modelling will enable any further research to analyse the role that could be played by small and medium enterprises (SMEs), lead by the private sector, in economic development. This is because SMEs dominate the other non-oil sectors.

2. The theoretical model emphasised the operation of a fixed and a flexible exchange rate regime, whereas the Libyan economy has recently operated under a system of a managed floating exchange rate. The major advantage of a managed floating exchange rate regime with respect to a flexible exchange rate is that it mitigates exchange
rate fluctuations, whilst its main advantage with respect to a fixed exchange rate system is that it corrects balance of payments disequilibrium by gradual exchange rate changes rather than requiring changes in all internal prices in the economy. Thus modelling a managed floating exchange rate system for the case of the Libyan economy should be considered.

3. The model developed here, which has its foundation in that developed by Cox and Harvie (2010), assumes that adjustment in financial markets plays a crucial role in the transmission process arising from exogenous shocks. However, Libya’s financial markets, like other developing countries, are not yet well developed. This assumption may not be appropriate for the case of Libya as its financial markets are regulated by the authorities. Therefore, in the future it would be important to develop and simulate a macroeconomic model, which includes additional and more sophisticated financial markets. That is, including domestic bonds, foreign bonds and equities besides domestic money, and the implications of doing so for alternative policy analysis.

4. The labour force is not explicitly modelled. As is well known in the literature there are two inputs available for the production of non-natural resource outputs. These are labour and capital. In this model, however, only the capital stock, which consists of physical public capital stock, human capital stock, imported capital stock, and private capital stock are modelled, with labour assumed to be predetermined. Almost 65 percent of the labour force is employed by the public sector, and the labour market does not function well.

5. The model is a deterministic framework in which economic agents’ possess rational expectations, which is in turn equivalent to the case of perfect foresight. This is a very strict assumption and unlikely to be satisfied in a developing country like Libya.
Such an assumption implies that economic agents are rational, and do not make consistent forecasting errors.

6. Incorporating the role of institutions would represent a significant extension of the current dynamic macroeconomic model. Including a measure of the ability and transparency of existing Libyan institutions and government agencies in adopting and implementing the policy options would bring about a remarkable extension to the current model. In the case of Libya the absence of institutions and government agencies with high efficiency may have led to mismanagement of oil revenue. The large revenue generated from the oil sector may have created rent-seeking behaviour by interested groups, such as government officials and local or foreign investors, resulting in corruption and inefficiency. This behaviour may have resulted in economic failure including capital flight, higher inflation, poor institutional quality and hence lower growth and development. Therefore, the lower social and economic indicators may not have resulted merely from Dutch Disease effects, but also from poor quality institutions.

Overall, this thesis has identified the prominent effects arising from oil related shocks for a small oil exporting economy such as that if Libya via developing and simulating a dynamic long-run general equilibrium macroeconomic model, incorporating the main characteristics of the economy. It has also provided some indications of the most likely economic outcomes arising from conducting alternative government policies for Libya. The framework of the model developed in this study, and the policy prescriptions derived from it, is also likely to be applicable to other oil-exporting economies in the Middle East region, which also suffer from Dutch Disease consequences and the so called resource curse.
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