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An Iranian Business Cycle?

(A Study of the Impacts of Oil Price Shocks)

Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Doctor in Philosophy (PhD)

By

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In the name of Allah, the Compassionate, the Merciful

In the name of Fatima Al-Zahraa (A.S)

Daughter of the Prophet Mohammed (pbuh)

In the name of Maryam (Mary)

TITLE: AN IRANIAN BUSINESS CYCLE? (A STUDY OF THE IMPACTS OF OIL PRICE SHOCKS)
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Abstract:

This research analyzes the effects of oil price shocks on the Iranian business cycle using the framework of real business cycle theory. A theoretical framework is modified to investigate cyclical behaviour of the economy in response to oil price shocks. Production function approach based on a real business cycle model that substitutes oil price shocks for technology shocks is developed to analyze the Iranian economy from 1959 to 2004. The strategy of this study is to set up a simple Cobb-Douglas production function model and explore the extent to which it can account for the observed behaviour of Iranian economy.

This study adds to an up-and-coming body of evidence supporting the hypothesis that business cycles are influenced by oil price shocks in the international oil market. This research also provides a platform increasing our understanding of the cyclical behaviour of Iran's economy, feeding into literature of primary commodity dependent economy. The observed cyclical behaviour of the Iranian economy seems to be influenced by the current shocks which seen an unexpected and unanticipated oil price shocks in the global oil market. This study provides an opportunity to identify to some extent to which macroeconomic fluctuations in a planned economy which are dominated by the oil sector and highly dependent on oil export earnings, can be explained by changes in the price of oil.

The Iranian economy has experienced several shocks, such as war, revolution and oil price shocks which had profound effects due to high dependence on foreign exchange revenues. The volatile nature of this source of revenue due to volatile oil prices in the international oil market together with the need for the government to smooth its spending meant that the government extensively resorted to financing its budget through external borrowing or seigniorage. Oil price shocks play a prominent role in business cycle fluctuations. It is shown that the increases in the relative price of oil generally have a significant negative effect on Iranian output.

The time series behaviour of oil prices is found to be crucial in explaining the patterns of the Iranian business cycle. Oil prices are found to influence other exogenous variables affecting the economy, thus augmenting the impact of an oil price shock on the economy. We find that the theoretical correlation between output and the price of oil is lower than its empirical counterpart. The empirical results show that the model can reproduce a business cycle path of the Iranian economy, especially in those periods when shocks in the price of oil were most dramatic. The results show that the model is able to mimic the Iranian response to shocks quite accurately but is less predictive of cyclical paths during periods of stability.

TABLE OF CONTENTS

List of Tables

List of Figures

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DECLERATION

I hereby declare that I am the author of this thesis; that the work of which this thesis is a record has been done by myself, and that it has been not previously been accepted for a higher degree.

CHAPTER 1

Introduction

> *"Business cycles are a type of fluctuation found in the aggregate economic activity of nations that organize their work mainly in business enterprise. A cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle" (Burns and Mitchell, 1946: 3)*

This chapter sets the stage for the thesis by introducing the research topic presenting the aim, research questions, and objective of thesis. This is followed by the rationale of the study. The research methodology and data analysis is provided next. Finally, the structure of the thesis along with the research outline and plan of the study is presented.

The topic of this Ph.D. dissertation is 'An Iranian business cycle'. The purpose of this thesis is to investigate the effects of oil price shocks on the Iranian economy. In order to do this, a modified version of the widely accepted real business cycle (RBC) model is developed. The proposed modification is designed to emphasize the specific nature of the oil market and the particular circumstances faced by Iran as a major oil producer.

Understanding and distinguishing the factors that affect the short and long-run behaviour of macroeconomic time series have been the main aim of real business cycle theory in quantitative macroeconomic analysis (Hughes, 1952). The aim of this research is to extend and develop a business cycle framework within the context of oil-exporting countries and to examine the impacts of oil price shocks on the macroeconomic behaviour of the Iranian economy within a framework offered by RBC theory. 'In economics a *shock* can be defined as an unexpected or unpredictable event that affects an economy, either positively or negatively' (Wikipedia[1], 2006). Oil price shocks are unexpected and unanticipated movements in the price of oil, which do have long history in the world economy. The research questions are:

1. Are there business cycles in Iran?

2. How can Iranian business cycles be explained by oil price shocks?

3. Can RBC theory be applied to oil dependent economies?

The objective of this research is to contribute to the literature of real business cycle by investigating cyclical fluctuations in planned economies that are dependent on oil. The approach of this thesis will be useful for understanding the cyclical behaviour of oil dependent economies like Iran. The goals of this study, within the framework of real business cycle theory, are as follows:

1. Analyzing the transmission channels of oil price shocks into the Iranian economy

2. Analyzing the importance of this source of fluctuation (oil price shocks) when characterising the cyclical path of Iran's economy

3. Evaluating the capacity of the model to explain other empirical features of the business cycle in oil dependent economies

4. Quantifying the effects of relative oil price changes on macroeconomic fluctuations of Iran's economy

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[1] See: http://en.wikipedia.org/wiki/Shock_%28economics%29. Accessed on 5/12/2006

Understanding the causes of aggregate economic fluctuations (business cycles) is the central goal (key objective) of macroeconomics (Romer, 1996). Understanding whether the fluctuations in the business cycles are due to monetary or real shocks (oil price shocks) is the turning point in the emergence of the real business cycle theory (Kaboub, 2003). This study adds to an emerging body of evidence supporting the hypothesis that business cycles are influenced by oil price shocks in the international oil market. This research also provides a platform increasing our understanding of the cyclical behaviour of Iran's economy, feeding into the literature of primary commodity dependent economies. The observed cyclical behaviour of the Iranian economy seems to be influenced by the current shocks which are seen as unpredicted and unanticipated oil price shocks in the global oil market.

The revival of interest in the macroeconomics of oil dependent economies and the lack of a satisfactory theoretical framework emphasizes the need for the explicit introduction of oil price impacts into macroeconomic models (Pesaran, 1984). This research examines an oil dependent economy. This is a systematic attempt to identify the extent to which fluctuations of macroeconomic aggregates in an economy can be explained by changes in the price of oil. It analyses the role of oil price shocks in causing fluctuations to the Iranian economy – an economy that is highly dependent on oil export revenues.

In order to empirically estimate a model of the Iranian business cycle, a simple Cobb-Douglas production function based approach is employed. On the basis of this, a model is developed which is subsequently tested using Iranian macroeconomic data for period 1959-2004. The Iranian economy is subdivided into oil and non-oil sectors for this purpose and the model is tested separately for each sector.

The remainder of this thesis is organised as follows:

Chapter Two explores the nature of the world oil market. The research looks specifically at the price of oil and its fluctuations and the behaviour of OPEC.

Chapter Three provides an initial discussion and analysis of characteristics, macroeconomic performance, and planning system of Iran between 1959 and 2004.

Chapter Four provides an overview of different analytical approaches to the study of the business cycle, leading to real business cycle theory and goes on to propose modifications of real business cycle model which is designed to capture the particular characteristics of oil dependent economies. As part of this analysis, we apply a standard filtering technique as suggested by Hodrick-Prescott (1980) (HP), to isolate the cyclical behaviour in both total GDP and separately for oil and non-oil sectors. The cyclical behaviour revealed in this initial analysis provides the subject matter to be explored in more detail in subsequent chapters.

Chapter Five explores an extension of the real business cycle model proposed by King, Plosser and Rebelo (1988) (KPR), with suitable modification, which can provide a useful framework for the empirical analysis of business cycles in primary commodity dependent economies.

Chapter Six identifies an estimable version of the modified RBC model developed in the previous chapter. It reports and discusses the empirical evidence obtained when the model is estimated using Iranian data for 1959-2004.

Finally, Chapter Six offers a summary and some concluding thoughts.

CHAPTER 2

Oil Price Changes and the World Oil Market

2.1 Introduction

This chapter sets out to explore the properties and long-run dynamics between the macroeconomy and oil price movements and volatilities in the world oil market. It first reviews this global market from the perspectives of producers, OPEC and non-OPEC, consumers and major traders. Then it attempts to define the main characteristics and features of oil-exporting developing countries and oil price determination and setting it in the context of trade in other primary commodities.

Economic theory states that markets send signals about the allocation of resources through the price mechanism. Price change is apparently the mechanism to adjust a difference between supply and demand. Changes in oil prices, namely volatility, can affect market variables such as production, inventories stocks, and even prices of other commodities (Adelman, 1999). The commodity traded is not only physical oil but also claims on future oil or expected price differentials. Volatility of oil prices presents many challenges for producers, consumers, and policymakers in the world economy (IEA/SLT, 2001).[1]

This chapter has six sections. Section 2.2 explores the nature of the world oil market follows by oil-exporting countries - OPEC and non-OPEC. Section 2.3 presents an analytical overview of the volatility of the price of oil. Section 2.4 presents a

[1] International Energy Agency and Organization for Economic Co-operation and Development

historical overview of the OPEC cartel. Section 2.5 discusses oil price instability and models of OPEC behaviour. Section 2.6 provides a summary.

2.2 The World Oil Market

The world oil economy has been through incredible changes in the past thirty years. These changes have affected the structure of the world market and led to significant fluctuations in price and output. There are two determinants in the oil market - production and price. By increasing production, price is reduced and vice versa. The price of oil, like any other goods in the market, is influenced by factors such as demand, supply and the degree of monopoly in the market which itself depends upon the market structure (Adelman, 1972). There is no single situation of competition or monopoly in the world oil market due to forces at work. The importance of the price of oil and its critical role in the world economy is interested of researcher because of forces outside the market structure, which at times impact the market (Libecap and Smith, 2001).

The long-run supply and price of oil are essential factors in the world oil market. This section pays particular attention to oil-exporting countries and the long-run relationship between oil price movements and macroeconomic activities in these countries. Several questions need to be answered in these countries, including:

1. What are the relations between these variables?

2. Whether these are mechanisms for transmission of shocks to other countries?

3. Whether it is possible to isolate the domestic economy from oil price movement?

World Oil Supply and Demand: Major Producers and Traders

Broadly, countries in the world oil market can be split into three groups:

1. The Organization of the Petroleum Exporting Countries (OPEC)

OPEC is made up of 11 developing nations which are heavily reliant on oil revenues as their main source of income. OPEC formed in 1960, the current members are Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates and Venezuela. OPEC members produce 40% of the world's crude oil and possess more than three-quarters of the world's total proven crude oil reserves. OPEC is enormously influential in the sector – raising their prices, increasing or decreasing production which can affect markets around the world. Some of the smaller countries are reliant on oil exports so low prices can have a devastating effect on their economies. Since oil revenues are vital for the economic development of these nations, they aim to bring stability and harmony to the oil market by adjusting their oil output to help ensure a balance between supply and demand (see Appendix 6 for more detail).

2. The Organisation for Economic Cooperation and Development (OECD)

OECD consists of 30 countries that share a commitment to democratic government and the market economy. Twenty countries originally signed the convention on OECD in 1960. Since then a further ten countries have become members of the organisation.[2] The OECD offers an opportunity to discuss common policies to help stabilise exchange rates and encourage growth.

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[2] The member countries of the organisation are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan,

3. Other Oil-Producing Countries

The oil-producing countries who are not members of either organisations include: Russia; China; Malaysia; India; Brazil; Argentina; Colombia; Ecuador; Oman; Syria; Yemen; Egypt; Angola; Gabon.[3]

Table 2.1 World Oil Supply and Demand (Million barrels per day)

Year	1998	1999	2000	2001	2002	2003	2004
OECD Demand	46.8	47.7	47.8	47.7	47.8	48.6	49.3
Non-OECD Demand	26.8	27.6	28.1	28.3	28.7	30.7	33.1
Total Demand	73.6	75.3	75.9	76.0	76.5	79.3	82.4
OECD Supply	21.9	21.4	21.9	21.8	21.8	21.6	21.2
Non-OECD Supply	21.4	21.8	22.4	23.1	24.1	25.6	27.1
Processing Gains	1.6	1.7	1.8	1.7	1.7	1.9	1.8
Total Non-OPEC	44.9	44.9	46.1	46.6	47.6	49.1	50.1
OPEC	30.8	29.4	30.8	30.2	28.3	30.7	33.1
Total Supply	75.7	74.3	76.9	76.8	75.9	79.8	83.2

Compiled by Author, data source: IEA (2002: http://omrpublic.iea.org/omrarchive/11jun02tab.pdf and 2006: http://omrpublic.iea.org/omrarchive/10nov06tab.pdf)

Table 2.1 shows the world oil supply and demand during 1998-2004. The OECD countries almost capture more than 60% of the world oil demand, whilst these countries capture less than 30% of world oil supply. So, they supply about 50% of their demand. The OPEC countries cover almost 40% of the world oil supply rather than non-OPEC countries supply the rest.

World Oil Market and Oil Price Changes

The influence of oil prices on oil market activity might be one of the most significant factors in terms of oil price movements in oil-producing economies.[4] Whilst there

Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States

[3] See also Appendix 6 for more detail about the countries with production, consumption. Source: http://www.prospects.ac.uk/cms/ShowPage/Home_page/Explore_job_sectors/Oil__gas_and_petroleum/a_world_view/p!ejFdcc.

[4] The ten largest oil-producing countries are: Saudi Arabia; Russia; United States; Iran; China; Mexico; Norway; Venezuela; United Kingdom; Canada. A growing percentage of the world's production is in offshore areas, such as the Gulf of Mexico, the North Sea, western Africa (Angola, Nigeria), Asia (China, Vietnam), and Australia. The number of countries involved in oil production is

have been studies of the effect of oil price volatility on economic variables in oil-importing countries, there has been very limited research into such phenomena in oil-exporting countries.

The literature on the effects of oil price shocks suggests that oil prices by themselves do not have significant macroeconomic effects (Bohi, 1991). Oil price increases matter if they are large enough relative to past experience (Hamilton, 1996) and the effects oil price increases are a function of their size relative to their current degree of variability (Lee, *et al.*, 1995). The variability of these macroeconomic aggregates is correlated with movements in oil prices. They are felt even in oil-exporting countries that produce oil and consume intermediate and final goods (Backus and Crucini, 2000).

Higher oil prices have the potential for damage to the world economy because they transfer resources away from oil-importing countries to oil-exporting countries. In reality, more oil-importing and consuming countries are more powerful than the oil-exporting countries. Oil exporters seek to increase their oil revenues, both by increasing production, prices, and sometimes by attempting to increase their share of the market. In addition to this, there is competition between the Western oil companies. Continued challenges between all groups during the last 30 years have resulted in increases and/or decreases in both oil production and prices (Adelman, 1993).

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growing – Turkmenistan, Vietnam, Azerbaijan, Kazakhstan, China and Russia are just some of the countries where, in recent years, new fields have been discovered.

Table 2.2 Selected Oil-Exporting and Transition Countries*

Country	Oil revenue as a % of total public sector revenue	Fiscal position Overall balance (% of GDP)	Estimated impact on government revenue (% of GDP)
Middle East			
Bahrain	51.5	-4.8	1.7
Egypt	7.1	-3.3	0.2
Iran	**41.0**	**-2.8**	**4.8**
Kuwait	58.5	7.0	3.2
Oman	69.5	-2.1	2.6
Qatar	69.8	-2.8	2.4
Saudi Arabia	63.9	-8.4	2.7
Syria Arab Rep.	43.4	-0.5	1.4
Africa			
Algeria	58.4	-2.2	4.6
Angola	78.8	-14.1	8.5
Cameroon	23.3	-1.2	0.6
Congo, Rep. of	64.2	-12.9	3.2
Gabon	49.9	-12.8	2.8
Nigeria	75.7	-7.5	8.2
Asia			
Brunei	77.3	-26.8	4.4
Western Hemisphere			
Mexico	34.4	-1.1	0.4
Trinidad and Tobago	11.2	-0.6	0.4
Venezuela	69.9	-2.5	1.8
Countries in Transition			
Azerbaijan	10.3	-4.3	0.4
Kazakhstan	2.4	-6.5	2.4
Russia	7.4	-5.7	0.6

*Five-Year Impact of 20% Increase in Oil Prices on Public Sector Revenues (1998-99 Averages)
Source: IMF (2000a), World Economic Outlook (2000).

The impact of higher oil prices on growth and activity in oil-exporting countries depends on a variety of factors, most importantly on how these higher oil revenues are spent, and on the degree of diversification of the economy.[5] In the long term, however, oil revenues are likely to be lower, as higher prices would not compensate fully for lower production. In many oil-exporting countries, a significant proportion of higher oil revenues will accumulate to the government (Table 2.2). The reaction of government, in turn, is likely to depend on the underlying financial situation of the country. For example, Saudi Arabia has been traditionally a net creditor, but Mexico and Venezuela are net debtors. So, an increase in oil price will not only increase export earnings, but could also decrease external borrowing costs (IMF, 2000a).[6]

However, the limitation of exports (capacity) in developing countries, which typically include primary goods such as oil, coffee, and sugar, has led to greater cycles in their economies, in which the primary exports tend to be most volatile and are prone to larger fluctuations in national income. For example, it can be seen that, oil as a single export in oil-exporting counties has comprised over 50% of gross national product (GNP), and 90% of government revenues and also generated more than 95% of foreign exchange income approximately (IMF, 2000a).[7]

Figure 2.1 shows the world oil price during the period 1947-2006. The Figure is a graph developed by WTRG Economics (2006) showing the price of oil for the period 1947-2006, with important events and averages highlighted. The first oil shocks happened in 1973, when oil prices tripled from around $3/bl to over $10/bl, and was followed by a second oil shocks between 1979 and 1981, when prices again tripled

[5] In many oil-exporting countries in which oil dominates production, the expansionary impact of additional expenditures induced by higher oil prices is quite small (Saez, and Puch, 2002).
[6] Saudi Arabia, for example, which has traditionally been a net creditor, may choose to refill reserves. For other oil exporters that have in the past been net debtors, such as Mexico and Venezuela, a rise in oil prices would not only increase export earnings but could also lower external borrowing costs, assuming the higher oil prices would reduce the risk premia charged to these countries as their future export earnings rise. See also (IMF, 2000b) http://www.imf.org/external/pubs/ft/oil/2000/oilrep.pdf
[7] See also Dargahi (1994). A number of developing countries can have a greater magnitude and periodicity of cycles, especially where primary commodity exports are the most volatile component.

towards $40/bl. After the oil price shocks of 1973-74 and 1979-80, a number of researchers explored the relationships between oil price shocks and periods of macroeconomic disturbance in the world economy.[8]

Since 1996, prices have tended to fluctuate much more on a monthly and annual basis. Between 1997 and 1999, oil prices fell from $23/bl to as low as $10/bl. Prices started to increase again in 1999, reaching $30/bl at the beginning of 2000. The main reasons for the price slump were an OPEC decision (in 1997) to increase its production quotas, the Asian financial crisis and warm winters in 1997 and 1998. OPEC production cutbacks in 1999, together with economic recovery in Asia and strong economic activity elsewhere in the world, led to sharply higher prices in 1999 and 2000, (World Energy Outlook, 2001). Until 2000, adoption of the $22-$28 per barrel (/bl) band for the OPEC basket of oil, oil prices only exceeded $22/bl in response to war or conflict in the Middle East and for only 50% of the time period between 1947 and 2003, have oil prices exceeded $15.25/bl.

Since 1970s, almost thirty years on from the first oil crisis, oil has become as a political and economical factors in the world economy. Oil has been subjected to further extreme price volatility, particularly during the Gulf War in 1991 and, more recently, the terrorist attacks of September 11th 2001. The price declined below the lower end of OPEC's target range under the uncertainty surrounding subsequent pressure around the world and the impact on the world economy. Also, uncertainty over the availability of Iraqi oil production in recent years has made worse the apparent reduction of oil supplies (Lynch, 2004).

[8] Apart from major changes in oil price in 1970's and large oil supply by Mexico in 1986, oil market experienced instability because of variations in demand and supply that caused the movement of the oil price (Adelman, 1999).

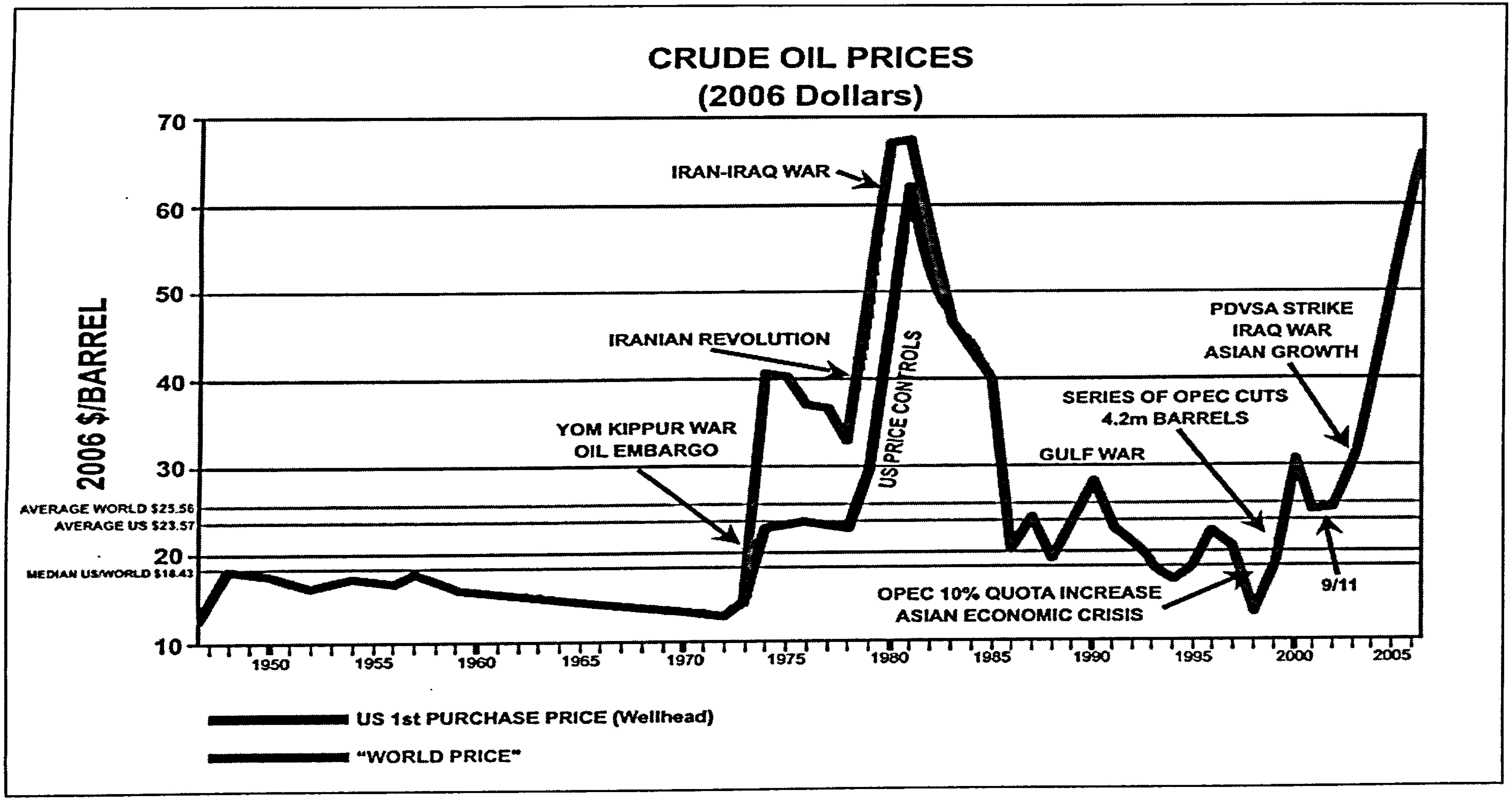


Figure 2.1 World Events and Oil Prices 1947-2006
Compiled by author, adopted from: WTRG Economics: http://www.wtrg.com

The literature shows that prior to 1986 the main focus was on the impact of oil price increases on macroeconomic variables. The oil price increase in the 1970s had serious impacts on the economies of most countries. With major attention focused on the negative impact of oil price increases in oil-importing countries. In this respect the role of OPEC, as a major cartel, was proven to be an important agent in controlling oil price volatility. Greene *et al.*, (1998)[9] assessed the impact of cartels such as OPEC on the US economy and they stated that the evidence from various econometric studies show that the sensitivity of US gross domestic product (GDP) to oil prices has changed during the last 30 years.

Green *et al.*, (1998) also identified three main, separate and additive types of economic losses resulting from oil price increases: the loss of the potential to produce, macroeconomic adjustment losses and the transfer of wealth from US oil consumers to foreign oil exporters. The transfer of wealth is exactly equal to the quantity of oil the country imports multiplied by the difference between the monopoly price and the competitive market price of oil.

The Role of OPEC and Non-OPEC

Oil price behave like any other commodities with wide price movements in times of shortage or surplus. The oil price cycle may extend over several years responding to changes in demand as well as OPEC and non-OPEC supply. If oil prices remains at

[9] They demonstrates that the evidence from various econometric studies show that the sensitivity of US gross domestic product (GDP) to oil prices has changed during the last 30 years. They also identified three main, separate and additive types of economic losses resulting from oil price increases: the loss of the potential to produce, macroeconomic adjustment loss and the transfer of wealth from US oil consumers to foreign oil exporters. The transfer of wealth is exactly equal to the quantity of oil the country imports multiplied by the difference between the monopoly price and the competitive market price of oil.

relatively low levels for the predictable future, the oil producing countries become to increase prices and/or production as much oil as possible. This causes instability in the world economy (Teece, 1982).

To control instability in the oil market, OPEC attempts to control the oil price by manipulating the level of production. The regulation of oil production depends upon maintaining the benefits to both supplier and consumer countries. OPEC as a major supplier attempts to control its own resources by preventing a reduction in oil prices, and the oil companies try to grant discounts to their oil customers. As a result of the implementation of these decisions, it would take both an increase in oil exports and an improvement in prices to satisfy both sides. It seems that OPEC as an efficient organisation will continue to influence the oil market and the structure of oil production to maintain oil prices at constant levels. The extraction decisions of OPEC show that it has played the game as a single oil producer under monopoly conditions (Adelman, 1982).

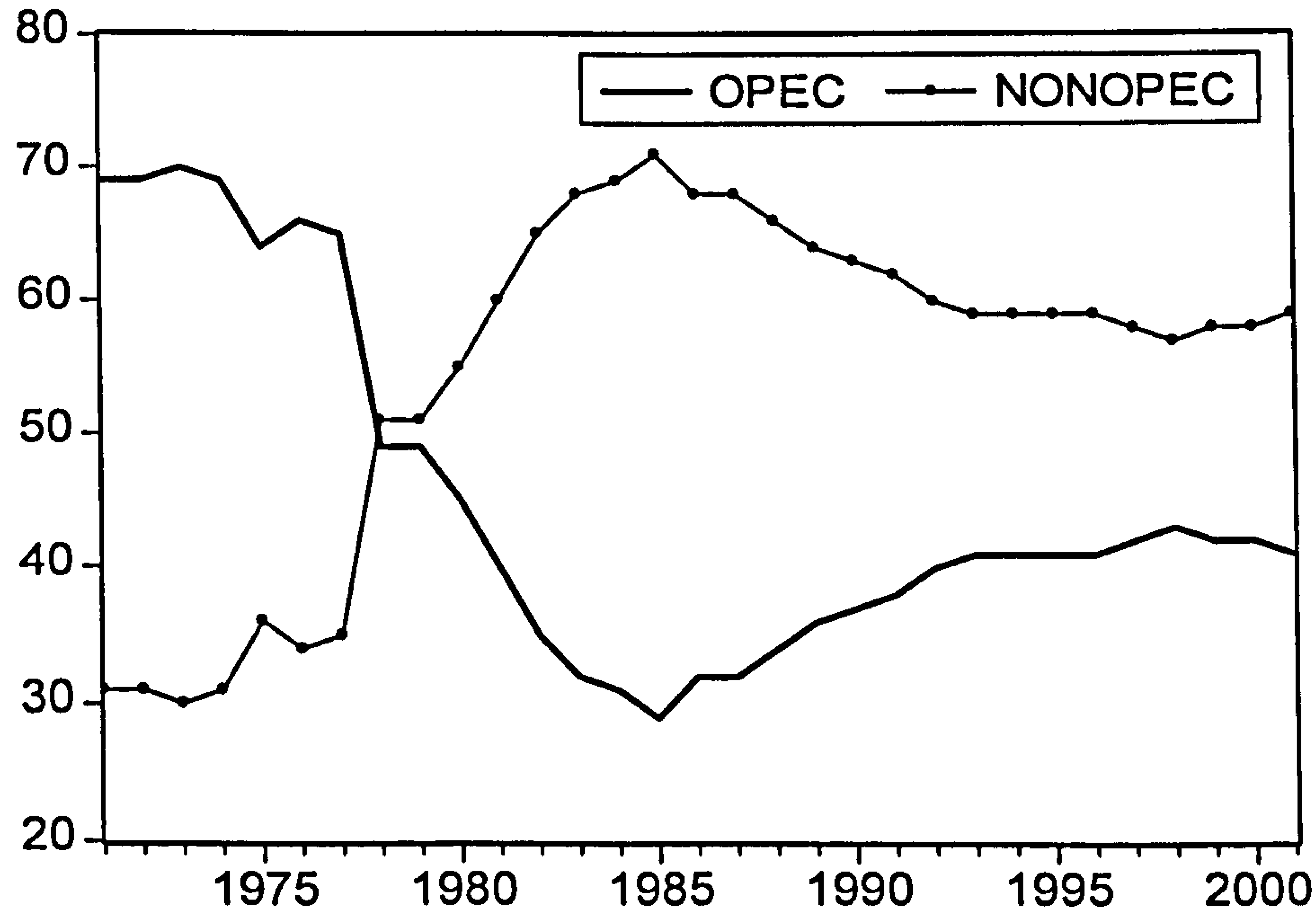
A major key to understanding why OPEC does not always do what seems obvious to the rest of the world is the internal political pressure between its members. The conflict for market share has caused problems and OPEC has encountered another major problem over the trade off between market share and price: OPEC cannot have both. To increase market share OPEC must increase production sufficiently. This drives prices down to the point where it is uneconomical for non-OPEC producers to maintain their current production rates.

OPEC, often in close collaboration with some non-OPEC countries, has played its part to the full in ensuring oil price stability in the oil market. For example, increases in oil prices in the 1970s encouraged non-OPEC countries to produce greater levels of oil. In an attempt to maintain oil prices, OPEC lowered its production of oil, and prices continued to decline, as a result of lower consumption and increased non-OPEC production, the market share for OPEC dipped below 30% by 1985 (Ramcharran, 2002).

Figure 2.2 shows the share of production of OPEC and non-OPEC in the world oil market. OPEC's share has decreased from 70% in 1971, when OPEC was in power, to about 30% in 1985, when OPEC was losing power. After 1986, the OPEC's share increased steadily and it continued to about 40% of market share in recent years.[10] The figure also shows that the changes in the OPEC share of global oil production went through a cycle in the period of 1974-2003. A significant increase in non-OPEC production at a time when world demand was either stagnant or growing very slightly was accompanied by an equivalent reduction in OPEC's production. The reason is that non-OPEC producers are volume maximizers while OPEC, having assumed the role of defending an administered price, became the residual oil supplier to the world (Mabro, 2004).[11]

[10] Data are taken from IEA, OPEC, and BP Statistical Review of World Energy.

[11] Note that the world oil market experienced substantial fluctuations in the price of oil between 1972 and 2004. The increase in the price of oil tends to result in an increase in non-OPEC production and consequently an increase of their share of the world oil market. When the oil prices was relatively high, the share of non-OPEC production increased significantly during 1974-85, and continued with steadily decrease market share for non-OPEC, with lower oil prices during 1986-2004 (Jalali-Naini and Asali, 2004).



Compiled by Author, data source: Data are obtained from IEA and OPEC

Figure 2.2 Shares of OPEC and Non-OPEC in the World Oil Market (Percent)

Important changes also occurred in the regional structure of non-OPEC production in past 30 years. In the second half of the 1970s, oil production rose by significant increases in the production of the UK, Norway, Mexico, Alaska, the Caspian, Angola, Russia, and other West Coast African countries by early 1980s. Analysis of the market share between OPEC and non-OPEC indicates that the increases in the price of oil create bigger benefits for non-OPEC rather than OPEC countries. Therefore, OPEC has an interest to follow a stable oil prices and a secure supply strategy due to non-OPEC supply. Current oil prices are a result of OPEC's successful development of its position as the world-leading producer: generally it meets 40% of world oil demand, and according to OPEC policy, non-OPEC countries will take a progressively reduced share of the world oil market.

2.3 Volatility of Oil Prices: An Analytical Framework

Oil prices have been more volatile during the last thirty years than at any time in the last 100 years, and concerns about the increase in price volatility rest on an unarguable fact, as was cited at International Energy Agency (IEA, 2001): 'We recognize the need for less volatility in oil prices in the interest of global economic growth.' It can be distinguished oil price volatility into price shocks and ongoing fluctuations. Shocks are caused by adjustments or threats to international supply and defined as unexpected or unpredictable events that affect an economy, while fluctuations are driven by changes in demand due to business cycles and the expectation of markets and hence more predictable.

Volatility is a measure of the change in the price of a commodity over a period of time. The normal measure for volatility is the standard deviation of price. It measures how widely actual values are dispersed from the average. The larger the difference between actual and average values, the higher the standard deviation and volatility will be. However, use of the standard deviation assumes that there is a normal distribution. Therefore, one should take the standard deviation of the logarithm of price changes (the percentage changes in prices) measured at regular intervals of time (World Energy Outlook, 2001).[12]

Economists traditionally assume that oil prices will forever remain volatile, because that is how all market commodities behave, even without political interference. However, volatility and related movements of macroeconomic aggregates respond to the nature and source of disturbances and one important source of macroeconomic

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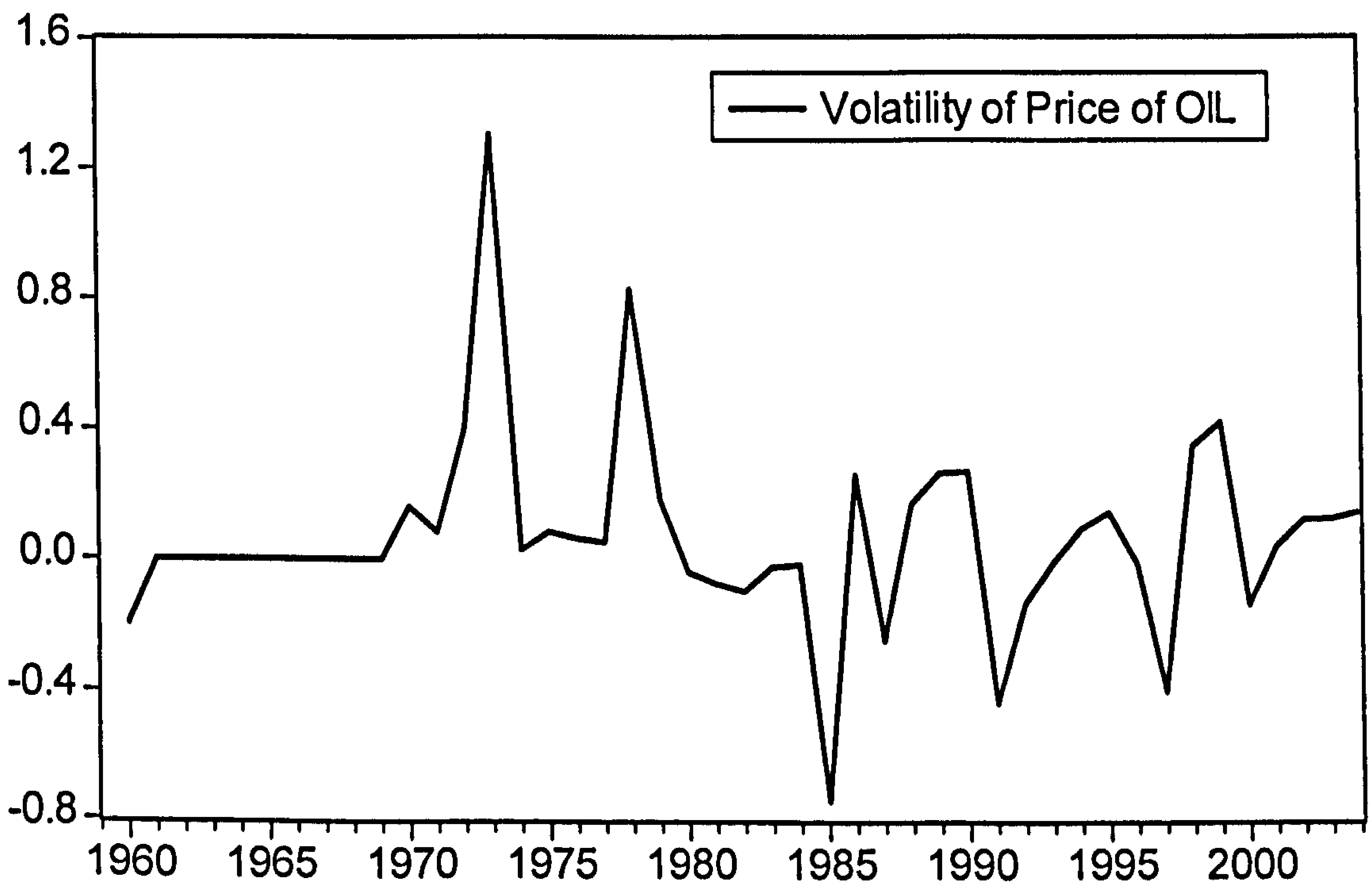
[12] Volatility is a characterization of price changes over time and can be defined as the standard deviation in a given period. An easy way to calculate volatility is simply to take the standard deviation of $\log(P_t/P_{t-1})$ over time, where P is price and t is the time index.

fluctuations is the oil price shock. Oil price shock is capable of generating highly persistent volatility in macroeconomic aggregates. Changes in the mean and volatility of oil price shocks, basically can account for different levels of movements in macroeconomic aggregates (Castillo, *et. al.* 2005).

This change in oil price movement can be attributed partly to the fact that OPEC changed strategy from setting the price and letting production fluctuate to setting production quotas and letting the price fluctuate. However, a number of other changes transformed this to a period of greater volatility (IEA, 2001). Until the oil price collapse in the mid-1980s, the major movement in oil prices was upward. Since then, the pattern has been of large price movements causing a substantial rise in volatility of oil prices (see Figure 2.3).



Compiled by Author, data source: CBI, OPEC

Figure 2.3 Volatility in the Price of Oil

The volatility in oil prices depends on two factors: firstly, that the current price of oil is highly correlated with its future market price, and secondly, that trade accounts are affected by expectations of future market share. Singer and Lutz (1994) argued that volatility is related to uncertainty, and a rise in the degree of volatility will result in an increase in macroeconomic fluctuations and produce errors in forecasting.[13] Yang *et al.* (2002) suggest that the volatility of oil prices creates uncertainty, and therefore an unstable economy for both oil-exporting and importing countries. It is also reflects the market structure of OPEC, and demand structure.[14]

The price of oil exhibits a high degree of volatility which varies significantly over time. Since the events of the 1970s, oil has been subjected to further extreme price volatility, particularly during the first oil shock in 1973, when oil prices tripled from around $3/bl to over $10/bl, and was followed by a second oil crisis between 1979 and 1981, when prices again tripled towards $40/bl. Since 1996, prices have tended to fluctuate more systematically-on a monthly and annual basis. Between 1997 and 1999, oil prices fell from $23/bl to as low as $10/bl. Prices started to increase again in 1999, reaching $30/bl at the beginning of 2000. More recently, the terrorist attack of 11th September 2001, created uncertainty over the availability of Iraqi oil production which was made worse by the apparent reduction of oil supplies.

Volatility of Oil and Non-oil Primary Commodities

Primary commodity prices are well known to be highly volatile. Indeed, they are not just subject to short boom and bust cycles driven by demand and supply shocks, but also longer term cycles and trends driven by more structural and evolutionary forces. The volatility of primary commodity prices appears to have increased quite dramatically in the past two decades. Oil prices are a special case because of the very different circumstances of global trade in energy, which have once again underlined

[13] See Sapsford and Morgan (1994). See also World Energy Outlook (2001).

[14] The literature on price volatility of oil price relates oil price shocks to the instability of market structure. The disruptions in oil market give rise to higher prices and increase oil price volatility.

the crucial role played by OPEC decisions in setting international prices in this sector. But it is worth noting that in general non-oil prices have certainly followed similar long-terms trends, and are now displaying similar volatility.

Undoubtedly, oil prices have been much more volatile than the prices of most other primary goods except perhaps metals and wheat (Adelman, 1999). From an economic perspective, in comparing oil price volatility with other commodities, three factors seem to stand out: First, inventory stocks tend to be proportionately smaller for oil than for other commodities that can play a smaller role in countering oil market disturbances to give rise to short-run price changes. Second, the geographical distribution of oil reserves is combined with transport costs, which are relatively higher than for other commodities. Finally, some of the world's refineries can process only certain types of crude oil (Plourde and Watkins, 1998).[15]

A comparative analysis of the price volatility of oil compared to nine non-oil commodities by Plourde and Watkins (1998) demonstrated oil's higher volatility. The non-oil commodities have two pricing mechanisms: producer prices set by major firms and prices determined on metal exchanges. Because of the stability of the market structure, prices also tend to be most stable. The selected non-oil widely traded commodities are: aluminium, copper, lead, nickel, tin, zinc, gold, silver, and wheat (See Table 2.3).[16]

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[15] This additional constraint on quantity adjustments means that market disturbances are more likely to give rise to price changes. The results show that the two oil series have the largest mean and median absolute rate of change, and the largest variance of monthly rates of price change (Plourde and Watkins, 1998).

[16] The economic literature have considerable interests of primary commodities from their importance in the world trade and in the trading activities of developing countries, and tendency of the quantity traded grow less rapidly than other commodities. http://www.twnside.org.sg/title/jb14.htm. There are studies for primary commodities such as coffee, sugar, cocoa, rice, tea, and cotton which show export dependency of related countries and their terms of trade (IMF, 2000a). Hughes Hallett (1984) compares the performance of price stabilization schemes and controls on production and provides empirical evidence for copper, coffee, and rubber (see Sapsford and Morgan, 1994).

Table 2.3 Monthly Rates of Price change and Absolute Values

	Monthly Rates of Price Change			Absolute Values	
Commodity	Mean	Median	Variance	Mean	Median
WTI-D	-0.0037	-0.0040	0.0082	0.0623	0.0463
WTI-W	-0.0036	-0.0064	0.0083	0.0629	0.0445
WTI-M	-0.0033	-0.0012	0.0111	0.0719	0.0489
Brent-D	-0.0044	-0.0057	0.0089	0.0662	0.0471
Brent-W	-0.0044	-0.0069	0.0091	0.0663	0.0467
Brent-M	-0.0042	0.0023	0.0132	0.0789	0.0487
Aluminium-M	0.0045	-0.0021	0.0050	0.0507	0.0365
Copper-D	0.0068	0.0101	0.0038	0.0461	0.0321
Lead-D	0.0035	0.0000	0.0050	0.0514	0.0374
Nickel-M	0.0047	-0.0103	0.0091	0.0634	0.0432
Tin-D	-0.0057	-0.0025	0.0025	0.0336	0.0235
Zinc-D	0.0022	0.0051	0.0042	0.0511	0.0464
Gold -D	0.0014	-0.0002	0.0011	0.0246	0.0176
Silver-D	-0.0028	-0.0084	0.0028	0.0365	0.0241
Wheat -M	0.0008	0.0030	0.0022	0.0354	0.0227

- WTI stands for West Texas Intermediate
- D (daily), W (weekly), M (monthly) average prices quotations
- Compiled by Author, data source: Plourde and Watkins (1998)
- All of the monthly data were collected for the period of 1985-1994.

2.4 OPEC: An Historical and Analytical Overview

In 1960, five major oil exporters, Iran, Saudi Arabia, Venezuela, Kuwait and Iraq joined together to form OPEC They had the following reasons for doing so. Firstly, they were aware of the substantial economic rents in the world oil market. There was a large gap between the low marginal cost of oil production and the market price which consumers paid for refined petroleum products and only a small mark-up could be added by transportation, refining, and marketing costs (Griffin and Teece, 1982).

Secondly, the reduction in oil revenues could be followed by the reduction in oil price, which resulted from the increasingly competitive nature of world oil market and due to the increase in oil demand by the entry of many new countries into the market.

Finally, in 1960, they faced up to the indisputable fact that conditions in the world economy, such as world supply and demand conditions were greatly limiting the possible actions for all countries. However, according to the limited capacity of oil production and reserves compared with the large demand, OPEC had supplied two-thirds of the world oil demand in 1960. The extraction decisions of OPEC show that it has played the game as a single oil producer under monopoly conditions.

By the end of 1971, six other countries had joined the group comprising: Qatar, Indonesia, Libya, United Arab Emirates, Algeria and Nigeria.

Table 2.4 OPEC Countries

Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, Venezuela

Table 2.5 Middle East Countries

Afghanistan, Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestinian Authority, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, Turkey, United Arab Emirates, Yemen

Any country-region or organization, as is the case with OPEC (11 countries-Table 2.4) or the Middle East (23 countries-Table 2.5)[17], is formed by a set of countries that are linked either by mutual interests to country-specific shocks or respond differently to similar economic circumstances. One of the most important tasks of the researcher is to test whether a set of variables from these countries, share any common

[17] See http://www.mideastinfo.com/countries.html-(Accounted September Accessed on 12/05/2006

characteristics such as large dependency on oil revenues, aside from any distinctive characteristic factors such as geographic location or political stability.

In the 1970s, OPEC countries achieved control of more than 55% of global oil supply and started to fix production quotas based on the oil reserves of each of its members. Members began a process of nationalising their domestic oil industries (Libya, 1971; Iraq, 1972; Iran, 1973; Venezuela, 1975). There were also indications that the remaining oil reserves were not as large as thought and officially reported. One reason for this behaviour was that OPEC's rules stated that oil quotas were determined by the size of reserves. In many countries there have been government efforts to reduce dependency on oil and the high oil prices ruling in the 1970s acted as a stimulus for this process (Greene, 1991).

OPEC faces further difficulties in trying to increase its strength and reduce its weakness. OPEC price control is based on competition. Johany (1978) and Mead (1979) show that oil price changes transfer control over production policies from oil-producing countries to other countries and are able to explain the changes in oil production ownership patterns that occurred in the early 1970s.[18] Subsequent research on OPEC supply behaviour (Griffin, 1985; Jones, 1990; Dahl and Yucel, 1991; Wirl 1991; Wirl 1990) has reinforced the interpretation of the events of oil market events of the 1970s and 1980s.

However, OPEC has shown its strength when faced with these adverse conditions. It maintained the solidarity of its members throughout the 1960s, 1975, 1978-79, and its members made valuable contributions to the world economy by reducing the gap between demand and supply in their attempts to control the price of oil. Since oil

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[18] See for more details. http://www.att.com/ehs/ind_ecology/articles/commoditization.html

prices are more volatile than other commodity prices, the competitive market lacks the ability to control oil prices. Therefore, OPEC output control might remain essential to price maintenance. This means that if demand falls and wells continue to produce oil, then the cartel has to decide who must cut output and by how much (Adelman, 1999).[19]

Another concern is the variable power of OPEC in the world oil economy. According to Suma (2000), current oil prices are only partially affected by OPEC's role and its position as the world-leading producer: generally it meets only 40% of world oil demand. Moreover, OPEC gains more power and has more influence on market price when there is a strong market demand, but loses control when market demand is weak: 'we may observe the volatile price to be related to the OPEC behaviour' (Liao and Lin, 2001).[20]

However, the rapid price increases of 1979-1980 caused several reactions among consumers: better insulation in new homes, increased insulation in many older homes, increases in the efficiency of industrial processes and improved automobile fuel consumption. These factors, along with the world recession, caused a reduction in demand, which led to a decrease in the price of oil.

Between 1982 and 1985, OPEC attempted to set production quotas low enough to stabilize prices. These attempts met with repeated failure because some members of the cartel produced outputs beyond their quotas. In 1986, the price of oil and the market share controlled by OPEC began to increase. The literature shows that prior

[19] See also Plourde and Watkins (1998). In comparing oil price fluctuations with other commodities, Verleger (1993) argued that oil prices are generally more volatile than the prices of other commodities, but did not undertake a precise analysis of that proposal.
[20] Note that when demand is strong in the oil market, OPEC wielded market power and may control the price of oil. Whilst demand is weak, OPEC may not able to affect in the price of oil. Therefore, the oil price change depends on two factors: First, the price of oil is highly correlated with the international oil market, and second, the share of exchange rate in the trade accounts.

to 1986 the main focus was on the impact of oil price fluctuations on macroeconomic variables. The price of oil increased in 1990 with the uncertainty arising from the Iraqi attack on Kuwait and the resultant Gulf War, but following it oil prices declined steadily until 1994. In 1998, OPEC attempted to reverse the decline in oil prices, but even it failed to extend the current quotas. It also had a further failure when it approved a 10% quota increase at a time when the Asian economies were encountering an extended economic crisis (Alhajji, and Huettner, 2000a).

Table 2.6 shows a comparison of market share of OPEC members during 1990 and 1998.

Table 2.6 Market Share of OPEC Members (percent)

Country	1990	1998
Algeria	5.03	2.89
Indonesia	5.67	4.98
Iraq	12.79	8.42
Iran	11.72	12.99
Kuwait	8.70	7.36
Libya	5.30	4.94
Nigeria	7.51	7.32
Qatar	1.69	2.36
Saudi Arabia	24.03	29.68
U.A.E	8.91	8.09
Venezuela	8.64	10.98

Compiled by Author, data source: WTRG Economics (1999)

2.5 An Overview of the Oil Price Instability and Models of OPEC Behaviour

A cartel is a group of sellers, either independent organizations or countries, formed to limit competition by controlling the price, production and distribution of a product or service. Cartels are agreements between all, or a majority of the major producers of a good, to either limit their production, and/or to fix prices and coordinate supply decisions so that the joint profits of the members will be maximized. In practice, a cartel may not find matters nearly so simple and some difficulties may arise in its operation.

The main purpose of a cartel is to exercise market power by pushing prices higher than they would be under market conditions and thus to obtain profits. OPEC is often indicted of curbing its production in order to raise prices. OPEC member countries own a high percentage of world oil reserves (69.8% in 1973 and 77.6% in 1992) and they supply almost half of world crude oil (56% in 1973 and 40.6% in 1992). It appears that they have the power to influence market conditions and the decrease in their share of production along with the increase in their share of reserves is consistent with cartel behaviour. Cartels provide the organizational structure within which necessary restrictive arrangements are accomplished and enforced. The failure of the organization to prevent prices from falling, especially in the output-rationing era, raised the question of whether OPEC was accomplished at regulating oil production among its members in its effort to control the market price of oil (Alhajji and Huettner, 2000).

The OPEC cartel can expect to control the capacity of production towards increasing its product price as well as market share among its members. This organization is often held liable for the increase of oil prices in 1974, but OPEC had no ability to prevent prices falling in the 1980s. This raises the question of whether OPEC was ever able to increase the market price of oil by curbing its production, or whether the organization simply took advantage of high prices caused by political problems and conflicts between some of its members (Gulen, 1996).

OPEC became an effective cartel in 1970s, sharing the market among its members and gained more influence following the Arab-Israeli War of 1973. There is a long-run equilibrium relationship between production of each member and total OPEC output. Subsequent restrictions and the nationalization of oil production in these countries enabled the cartel to raise the price of oil from $2/bl in 1971 to $34/bl in 1981. According to structural changes in market demand and instability in the oil market, the OPEC price increases of the 1970s helped push industrialized economies into recession. OPEC was able to impact negatively the economies of those importing countries compared with other countries that produced oil, combining to create a two-sided monopoly market. Following this, the 1980s witnessed a substantial decline in the demand for oil by industrialized countries (Alhajji, and Huettner, 2000b).

Hay and Morris (1979) argued that cartels are much more likely to avoid uncomfortable periods of price cutting, especially in cyclical industries, than by avoiding them by deliberately raising prices to full joint profit maximizing levels. Based on legal obstacles and limitations imposed by market condition, the problems of negotiations on market shares within the cartel are likely to prevent the full operation of a monopoly situation.

For example, the high oil price in the 1970's was not the result of OPEC policy but that an adjustment was needed to increase oil prices after the low oil price before 1973-4 (Gulen, 1996). OPEC has been accused of exercising market power by deliberately reducing its output in order to increase oil prices. For example, the 1982-93 period is the only time period during which the organization had the ability to impact prices.

There are two challenges facing OPEC in its attempts to control prices. The first is the determination and maintenance of oil production levels to prevent competition between members. Members are not permitted to compete on price against any other member. Based on a monopoly market, OPEC countries gave up sales volume for a higher price (Hnyilicza and Pindyck, 1976). There is, however, an incentive to cheat as members can increase their profit by supplying more than allowed. The second is controlling oil prices in the world to ensure the highest possible prices whilst at the same time preventing competition from new suppliers so that new entrants into the market do not interrupt the balance of the cartel, and cause increased supply that would lower prices. But the cartel tries to reduce such advantages by apportioning the shares in industry output on an agreed quota basis (Hay and Morris, 1979).

Griffin (1985) also noted the empirical tendency for parallel movement among OPEC members' production levels and argued that OPEC is a real cartel with at least partially effective output coordination. Furthermore, Gulen (1996) looked for indications that the output levels of individual OPEC members tend to move in parallel because, if OPEC is an effective cartel[21] sharing the market among its members. Although parallel movement theory shows that it is not consistent with the cartel hypothesis, it is inconsistent with the competitive hypothesis (Alhajji and Huettner, 2000b).

Models of OPEC Behaviour

There are various monopolistic and competitive models of the world oil market. According to the classification of models of the world oil market, they provide an understanding of OPEC behaviour. These models can be classified along two lines: models that assume oil producers follow wealth maximization principles (monopoly

[21] To the extent that the oil market had undergone a permanent change in 1973, that change seemed to be more one of effective cartel power centred in a politically unstable part of the world than one of a permanent shift into escalating scarcity of minerals.

and competition), and those that consider non-wealth maximizing behaviour – target revenue and political models (Dargahi, 1994).[22]

In the wealth maximization model, core producers set the price of oil and allow the other members of group to sell all they are able to supply to cover the remaining demand.[23] The entire production of an individual swing producer is vulnerable to relatively small percentage fluctuations in aggregate output from the rest of the group (Smith, 2002).[24] To distinguish the swing producer from the competitive producer, Dahl and Yucel (1991) suggest that low-cost producers in a profit-maximizing cartel are expected to produce more than high-cost producers, and that an indicator of marginal cost should therefore enter significantly (and negatively) into the production function for cartel members.

A further model of OPEC' behaviour is based on the target revenue model. OPEC makes decisions based on members' requirements over their own domestic budgets. Alhajji and Huettner (2000) have focused on the estimated price elasticity of demand for OPEC oil. They have examined the target revenue hypothesis and find it relatively easy to reject the extreme form, but much more difficult to reject the more plausible, weak forms of this model. In general, foreign exchange incomes are the main source of funding for a member countries domestic budget. In this case, total production or exports of oil are planned to achieve target revenue. Increases in world oil prices will tend to reduce production of oil in the current period and vice versa. In

[22] Griffin (1985) also highlights the behaviour of OPEC into four categories: cartel, competitive, the target revenue, and property rights models. The property right models can be created by using the concepts of the real discount rate and real oil price in the Hotelling theory.

[23] The residual demand is the critical variable for core producers. It argues that the oil price can not regulate residual demand as directly and effectively as cartel theory assume. Residual demand is the difference between global demand and supply.

[24] As a further example of the uncertainty of market predictions, Libecap (1989) considers a hypothesis, later employed by Dahl and Yucel (1991), that so-called swing producers are expected to exhibit larger proportionate changes in production than the rest of the market.

other words, each country tries to cover its budget, even by increasing oil prices or production, because of the imperatives of meeting national objectives (Ramcharran, 2002).

The final view of OPEC behaviour is the political model in which the members are simultaneously concerned to extend their political influence on the world oil market, by controlling the production level, and in maximizing the wealth from oil revenues. Moran (1982) has examined the political and security impacts on economic decisions by analyzing a specific characteristics and differing impacts shocks on each country.

The empirical studies on OPEC's behaviour argue that OPEC's behaviour varies over time, fluctuating between cooperative and competitive models, depending on circumstances. They conclude that such behaviour cannot be adequately described by any simple hypothesis (Smith, 2002).[25] Adelman (2002) argues that OPEC is an inconsistent, sometimes bumbling, sometimes consistent, but always vacillating, federation of producers.[26]

Fog (1956) has suggested that the differences in policy between cartel members, on short-run versus long-run profitability are important to the success of a cartel. Countries with large resources would like to keep prices at a low level to maintain market shares and to maximize their profits in the long-run, and vice versa. It is also possible for a cartel to promote competition between the cartel members by setting quotas and fixing prices for a given time. Orr and MacAvoy (1965) argued that the

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[25] Geroski, *et al.* (1987) specifies a partially selfish objective function for each OPEC member that incorporates variable weights on its own profits and the profits of other members. Within this framework, the authors are able to reject the constant behaviour hypothesis, and demonstrate that observed actions conform roughly to the 'tit-for-tat'[25] game strategy (an equivalent given in return at least during their sample period of 1966-1981), which is a time-varying combination of cooperative and competitive modes of behaviour.

[26] Kaufmann (1995) has characterized OPEC as a loosely cooperative oligopoly. Similarly, Griffin and Neilson (1994) find evidence that, subsequent to the oil price crash of 1985-1986, Saudi Arabia adopted a tit-for-tat production strategy that alternately disciplines and rewards other cartel members.

correct procedure for the cartel is to fix their price to maximize profits, given the defector's price.

OPEC may prefer to give up short-run profits in order to guarantee future profits. If OPEC has really been able to affect prices by decreasing (or increasing) production, they can be empirically verified using causality tests (Gulen, 1996). Again, causality in the reverse direction is not allowed, as production in the competitive fringe is not expected to have an effect on the market price of oil.[27] However, though some members might have such constraints, OPEC as a whole is not expected to be constrained in this way. There should also be causality from the price to non-OPEC production since non-OPEC nations are all price-taking members of the competitive fringe.[28]

Today it seems that competitive oil prices in the world oil economy will continue lurching unsteadily from their current levels. OPEC output control will be continued as it is essential to price maintenance, and has worked for more than 30 years (Kohl, 2002). However, the monopoly problem is considerably more complex if the extraction of monopoly outcomes requires cooperative behaviour among a number of producers. Coordination mechanisms are needed to control production and pricing decisions (Takian, 2003).

[27] There should be causality from OPEC production to the market price of oil and not in the reverse direction. If the producer country has a revenue absorption constraint, as in the target revenue models (Teece, 1982 and Cremer and Salehi-Isfahani, 1980, 1989), causality from price to production is plausible.

[28] Early 1999 in an effort to control the oil price increase, for example, OPEC policy reverted to one of periodic increases in production targets. Following this increase, and partly in response to concerns by some OPEC members on the long-term effect of high prices, including loss of market share to non-OPEC producers, OPEC informally defined a target price band of $22 to $28 a barrel and prescribed increases or decreases of one half million barrels per day.

2.6 Summary

An analysis of the world oil market has shown that OPEC has worked with non-OPEC countries to stabilize the volatile prices of this commodity. Oil price shocks since 1973 have been analyzed and it can be seen that oil price fluctuations are related to the structure of world oil market. Volatility may be related to primary commodity prices and export earnings. Changes in oil prices have a greater influence on the world economy than the effect of changes in production. Notwithstanding, it seems likely that oil prices will remain highly volatile for the foreseeable future. In fact, one can identify the main sources of volatility as economic factors such as production, consumption, and market structure and disturbances with political origins.

The formation of OPEC in 1960 as a cartel with control of 40% of the market introduced a new dynamic into the relationship between importer and exporter on both a political and economical level. OPEC's role varies according to different theoretical models. As a monopoly, it can pursue strategies for wealth maximization or revenue support and it is a price maker by controlling production levels. Another interpretation of OPEC's behaviour is based on competition and market determination of price.

According to oil price determination and OPEC behaviour, it is suggested that oil supply is consistent with the oil price target for any demand schedule. The oil residual demand, that depends on exogenous variables and partly correlated with oil price, is the critical variable for OPEC. Thus, the oil market is most competitive when the market is tight and OPEC plays an effective role when the market is weak by directing the oil prices towards a target level or zone.

To control instability in the oil market, OPEC attempts to organize the oil price by operating the level of production. The rule of oil production depends upon maintaining the advantages to both supplier and consumer countries. OPEC as a major supplier attempts to control its own resources by preventing a reduction in oil prices and stabilize it. These performances lead to increase in oil supply and an improvement in prices of oil to satisfy supply and demand sides.

Oil price has been more volatile during the last thirty year and has greater impact on macroeconomic fluctuations of primary commodity dependent economies. The real oil prices and oil price volatility, and the relationship between oil price changes and macroeconomic fluctuations, could be evaluated by time series analysis, which is a useful tool in the framework of business cycle theory, which is discussed in chapters four and five. However, the next chapter will examine the macroeconomic performance of Iranian economy in detail and specify the impacts of oil price shocks on it.

CHAPTER 3

Macroeconomic Performance of the Iranian Economy

3.1 Introduction

This chapter provides an initial discussion of the macroeconomic performance of the Iranian economy over the period 1959-2004 and reviews the macroeconomic fluctuations and policies, especially the implications of oil price shocks on the cyclical behaviour of the Iranian economy. The purpose of this chapter is to evaluate the importance of oil price shocks influencing macroeconomic fluctuations, and to increase our understanding of business cycles of a primary commodity dependent economy.

The revival of interest in the macroeconomics of oil dependent economies and the lack of a satisfactory theoretical framework emphasizes the need for the precise introduction of oil price impacts into macroeconomic fluctuations (Pesaran, 1984). Iran is the second largest member of OPEC and the fourth ranked oil producer in the world oil market. The effects of oil price shocks are particularly profound due to the dependence of this oil dependent economy and of the macroeconomic policies on oil revenue and its sensitivity to international disturbances in the world oil market, accentuated by its geographical position.

Section 3.2 reviews the literature. Section 3.3 starts with a review of the importance of geographical location and explores the characteristics of a small open oil dependent economy with an historical overview. Section 3.4 explores the main macroeconomic aggregates and indicators introducing growth rate, inflation, unemployment, exchange rate, the relationship between oil and non-oil sector, and oil and non-oil exports shares in the economy. This section concludes with a discussion of the consequences of oil price shocks and the policy responses in the Iranian economy. Section 3.5 reviews macroeconomic policies of a planned economy covering fiscal and monetary policy, trade and foreign exchange policy. Section 3.6 provides a summary.

3.2 Literature Review

None of the current literature addresses the role of oil price shocks in Iranian business cycles. Ghaffari (2000) has discussed the political economy of oil in Iran for the last century and argued that:

> *"Studies on Iran's oil are carried on a regular basis, comprehensive and interdisciplinary studies of the subject covering virtually the whole of the century are rather rare. It can be argued that one can only adequately discuss the issue of Iran's oil by relating it to the country's internal, regional, and international context."(P. XXVII)*

This discussion concentrates on political economy of oil in Iran rather than the economic view. Moradi (2000) has studied the determinants and behaviour of inflation on the macroeconomy of Iran, whilst Jalali-Naini (2000, 2003, 2005) addresses the volatility of fiscal policy in developing countries, and explains the macroeconomic features of the long-term Iranian growth rate. Salehi-Isfahani (2002) discussing the role of households in economic growth of Iran, identifies the impacts of fertility and investment in child education on economic growth, comparing them with Korean households. This study focuses on microeconomics issues rather macroeconomic. Dargahi (1994) discusses the impacts of stabilization policy in Iran under the rational expectations macroeconomic model, but without any discussion of business cycles. Hakimian (1999, 2000) and Hakimian and Karshenas (1999) studied the macrocosmic performance of Iran from 1979 to 1999, suggesting that the performance of non-oil sector was broad-based and driven by high domestic demand.

None of these cited works pay attention to the impact of oil price shocks on Iranian output or to business cycles. However, Pesaran (1984, 1992, 2000, 2004) discusses the role of oil price shocks on macroeconomic policies, especially exchange rates but neglects business cycles. Khalili-Araghi and Soltani (2002) also stress the importance of real shocks as sources of fluctuations in Iran's economy, based on the work of Boschen and Mills. They selected monetary variables affecting economic growth and used in a business cycle model in which the production function depends on the past and current value of real shocks. Their results show that the variables have a significant effect on the business cycles in Iran, but introducing the monetary variables into a model have not significantly increased the explanatory power of the model.

The most relevant study is that by Samadi and Abdolmajid (2004) who reviewed business cycles in Iran from 1959 to 2001 and focused on recognition of effective factors and its statistical characteristics. They first estimated the long-run trend of real GDP in linear form, measuring deviation of real GDP from trend. Then they concluded that there are serial correlations in the model and the period of a cycle is about 11 years, and that oil incomes, investment, budget deficit and liquidity are the most important factors in its formation. Whilst this does indeed demonstrate the existence of business cycles in Iran, the authors do not recognise the significance of oil price shocks.

There would appear to be a lack of comprehensive studies which bridge the gap between macroeconomic models and oil price shocks in the Iranian economy. Thus, this research offers a theoretical framework to analyse the impacts of oil price shocks on Iranian business cycles for the period 1959-2004. This research also contributes to the corpus on primary commodity dependent and planned economies, which are highly dependent on export earnings.

3.3 Characteristics of the Economy

Iran as a small open economy is located in the Middle East. Because of Iran's importance in the world economy as a second oil producer in OPEC and ranking fourth in the world oil market, it is necessary to trace its influence. Its high dependency on oil earnings, as a primary commodity dependent economy, brought an important consideration of the impact of oil price shocks on its macroeconomy.

3.3.1 Location and Importance of Iran

Geographically, Iran links central Asia and the Caspian Sea to the Persian Gulf and Indian Ocean. It has a strategic position in world trade, bridging the economies of many countries in the East and the West.[1] The brief outline of the special features of the Iranian economy has important implications which any study of business cycles in Iran must take into consideration.

In recent decades, Iran has experienced some important events in the economic, political, and social fields, which have affected the business cycle of the economy, and make it necessary to evaluate macroeconomic fluctuations. For example, the revolution of 1979 had significant structural effects such as the large-scale nationalisation in banking, international trade, and industry. Additionally, the Iran-Iraq war affected oil production, allocation of government revenues to defence

[1] Iran, covering 1,648,000 square kilometres, is located in South West Asia. It is bounded in the North by Turkmenistan, Azerbaijan, Armenia and the Caspian Sea, in the West by Iraq and Turkey, in the South by the Persian Gulf and the Sea of Oman and in the East by Pakistan and Afghanistan.

creating uncertainty and a decrease in investment, which had an impact on growth rate.

Table 3.1 uncovers the fact that growth performance in Iran and the Middle East has varied significantly during the last decade. Iran is the largest market in the Middle East, with a volume of imports considerably greater than that of other countries. A comparison between Middle Eastern countries shows that Iran's GDP has grown by an average of 5.8% in the last decade and has the highest growth rate of any Middle Eastern country. This growth has been based on the opening the economy to international investments and trade, economic reform of financial innovation, the continuance of high oil prices and improved macroeconomic conditions that together lead to more trust on the part of domestic and international investors (Mardoukhi, 2000).[2]

Table 3.1 Middle East Countries: GDP Growth Rate (Percent)

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Middle East	4.0	5.3	6.1	3.7	0.9	6.0	2.0	4.8	5.1	4.6
Bahrain	3.9	4.1	3.1	4.8	4.3	5.3	4.8	4.1	4.1	4.3
Egypt	4.5	4.9	5.9	4.5	6.3	5.1	3.5	2.0	2.8	3.0
Iran	**3.4**	**7.6**	**4.0**	**3.4**	**2.0**	**5.3**	**5.9**	**6.7**	**6.1**	**5.7**
Jordan	6.2	2.1	3.3	3.0	3.1	4.2	4.2	4.9	3.0	5.5
Kuwait	-2.0	5.1	2.3	2.4	-2.5	1.4	-1.1	-0.9	4.7	2.2
Lebanon	6.5	4.0	4.0	3.0	1.0	-0.5	2.0	2.0	2.0	3.0
Libya	-0.8	3.3	5.2	-3.6	0.7	2.8	0.5	-0.2	5.6	2.8
Oman	4.8	2.9	6.2	2.7	-0.2	5.5	9.3	2.3	2.2	4.8
Qatar	2.9	4.8	5.4	6.2	5.3	11.6	7.2	3.0	4.0	8.2
Saudi Arabia	0.5	1.4	2.6	2.8	-0.7	4.9	1.3	1.0	4.7	2.1
Syria	7.3	4.7	4.1	6.3	-0.9	0.6	7.2	2.7	1.0	2.9
United Arab Emirates	7.0	6.1	0.3	1.4	4.4	10.0	3.8	1.5	6.3	3.9

Compiled by Author, data source: International Monetary Fund (IMF, 2005)

Table 3.1 also show that growth in recent years (5.8% during 1995-2004) has been satisfactory, and was driven by economic reforms as well as by transitory factors, such as high oil prices and expansionary fiscal and monetary policies. Given the past

[2] See: http://www.irvl.net/iranian_economy_in_2000.htm

experience the Iranian economy can grow at relatively high rates over an extended period. One needs to examine the historical antecedents of growth and discuss the relevance of various factors, to provide an analytical framework of macroeconomic performance in Iran (IMF, 2004).

3.3.2 Small Open Economy

Iran is a typical small open economy, highly dependent on export earnings from a single primary commodity. As such, it is particularly sensitive to international disturbances, and the major determinants of oil price are likely to transmit external shocks into the economy.

An economy is said to be open if domestic households, firms and the government can trade goods, services and/or assets with the rest of the world (Catalan, 2003). An economy is said to be small with respect to trade in goods and services, if these actors are price takers in international markets for the relevant tradable goods and services, i.e. the size of the trade economy is small relevant to the rest of the world (Correia *et al.,* 1995). Although some countries are large producers and exporters of one or two commodities their economies are small. Whilst Iran has a substantial trade with the rest of the world economy, the country is conventionally considered as having a small open economy (Catalan, 2003).

One of the characteristic of a small open economy is that the prices of traded goods are determined by the international market. So, Iran is much more vulnerable than an industrialised economy when confronted with changes in the international oil market. However, it would typically have more control over variables such as the exchange rate, and can consequently use them to accommodate price shocks. For the Iranian economy it is the international market that largely determines the exchange rate for its currency.

This argument highlights the importance of considering the behaviour of relative oil prices when analysing aggregate fluctuations in small open economies. This high degree of interdependence with the rest of world and with its necessary intermediate and capital imports makes the economy open and vulnerable to fluctuations in the world economy. Therefore, an oil-exporting country as a small open economy is sufficiently small in the world oil market to be a price-taker and would be unable to influence the oil price (Motamen, 1983).

Thus, it can be assumed that foreign income and oil prices are influenced exogenously and that the majority of oil-exporting countries have strict foreign exchange control on oil incomes. Also, for a given level of foreign prices, which are measured in foreign currency, it is assumed that import prices measured in terms of the domestic currency vary proportionally with the nominal exchange rate, defined as units of domestic currency in terms of a unit of foreign currency.

3.3.3 Oil Dependent Economy

A vast majority of developing countries depend as a main source of revenue on primary commodities, which account for about half of the export revenues of these countries, many of whom continue to rely heavily on one or two primary commodities. Sapsford and Morgan (1994) argue that primary commodities not only have in the past and indeed still continue to account for a high proportion of the exports of many developing countries, but also the major source of export earnings for developed countries. They suggest that fluctuations in export earnings of these commodities have the potential to interrupt economic stability, domestic and macroeconomic policies, and the flow of finance for development.[3]

Claessens and Duncan (1994) also argue that primary commodities represent the majority of export earnings of many developing countries. The large fluctuations that can occur in the prices of such commodities are therefore a main economic difficulty for them. New financial techniques can lower the risk caused by these price changes over longer periods and allow financial obligations to be linked to commodity prices. But few developing countries have used these techniques.

Hughes Hallett (1994) argued that commodity market stabilization agreements have been a major policy issue since the mid-1970s, because of volatility in primary commodity prices and the importance of exports of primary commodities in generating foreign exchange in developing countries. Fluctuations in export earnings arise mainly because of volatile commodity price movements, which often cause booms and slumps in these countries' output and unemployment.

In Iran, as a developing primary commodity dependent country oil revenues covers over 90% of total exports, 50% of government revenues, and 20% of GDP. Since the early 1960s and particularly after the first oil shock of 1973-74, oil has also played an important role in government budget (Komijani, 2006).[4]

3.3.4 A Historical Overview of Oil in Iran

On 21st May, 1901 the rights to explore for oil throughout Iran except the North were conceded to William Darcy for a period of 60 years. In 1902, the first Iranian

[3] IMF (1981, 1984) shows that 70% of the world's 125 largest economies depended on primary commodities for in excess of 50% of their export earnings, while 43% relied on primaries for more than 75% of their export earnings (Sapsford and Morgan, 1994).

[4] Volatile commodity prices significantly affect the economy. The first oil shock drastically increased the dependence of Iran's economy on oil revenue. As a result of that, nominal wages increased and a large proportion of government budget was diverted to consumption expenditure.

oil company was established and Qasr-e-Shirin, a city in western Iran, was chosen as the first site for exploration activities. In 1908, the first oil well was exploited in Masjed-e-Soleyman followed in 1909, by the registration of the Anglo-Persian Oil Company in London.[5] In 1951, the Iranian government announced the nationalization of the oil industry throughout the country. It marked a great achievement of Iranian independence. Iran holds 90 billion barrels of confirmed oil reserves, or roughly 9% of the world total. The majority of Iran's oil reserves are located in the south western Khuzestan region near the Iraqi border and the Persian Gulf. The Ahwaz-Bangestan, Marun, Gachsaran, AghaJari, and BibiHakimeh oil fields account for most of Iran's current oil production.

The idea for the nationalization of Iran's oil industry came about in 1949 when the Majlis (parliament) approved its First Development Plan. The plan was to be financed largely from oil revenues. Iranian government had noted that the revenue of the British government from taxing the concessionaire, the Anglo-Iranian Oil Company (AIOC) was more than the revenue the Iranian government collected from royalties (Ghaffari, 2000).[6]

Since the oil sector has been nationalised, the government has received all of the oil revenue and this has increased its overall revenue. The downside is that government revenue now fluctuates with oil revenue. When the price of oil rises, the government uses most of the oil revenue for financing consumption. This has had potential inflationary effects on the demand side.

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[5] In 1935 it changed its name to the Anglo-Iranian Oil Company (AIOC).

[6] The oil issue had figured prominently during the election for the Majlis in 1949, and afterwards, nationalists in the new Majlis were determined to renegotiate the AIOC agreement. In 1950, the Majlis committee voted to nationalize the oil industry.

Although the dramatic rises in oil revenues that occurred in 1973 and 1974 highlighted the country's economic performance such achieving high growth rates. Publicly owned oil provided the capital required for economic growth. Despite the undeniable dominance of the oil sector, it is worth noting that the Iranian economy is relatively more diversified, at least in comparison with most Middle East oil-producing nations (Ghaffari, 2000).[7]

The National Iranian Oil Company (NIOC) formed in 1979 is the only operating oil company in Iran. In recent years the government has succeeded in attracting domestic and foreign investment for all sectors, and the highest level of the Iranian government has supported this ideal. The fall in the oil price in 1986 that was accompanied by increased production of oil by non-OPEC countries also created a shortage of foreign exchange revenues and inflationary pressures on the supply side, due to the effects of decreased oil production.

Furthermore, the eight-year war with Iraq, has affected the economy in various ways. The Iraqi army occupied oil fields in the west and southwest of the country and the war necessitated the allocation of major oil revenues for the defence of the nation. As the war coincided with the third oil shock of 1986, a significant reduction in the price of oil occurred and the existing economic depression worsened. Iran launched an economic reform programme after the end of the war. The programme aimed at reducing government control, encouraging private enterprise, and fostering greater reliance on competition. Since the war, the Iranian government has rebuilt its oil

[7] Compared to Iran, other single-product economies producing copper, tin, coffee, sugar and the like, are labour-intensive. They employ lower skilled labour and technology, and successfully integrate such industries into their economies. For example, in 1972 the relative contributions to GDP by each sector were agriculture 18.1%, oil 19.5%, industry and mining 22.3% and services 40.1%. By the end of the Fifth Plan period, 1977, these ratios were expected to be agriculture 8%, oil 48.7% industry and mining 16.1% and services 27.2%, still a comparatively more diversified structure.

production and export facilities. Significant gains resulting from oil price rises and oil revenues in these years have led to increased imports and domestic consumption (CBI, 2000).[8]

As a policy to promote development, the government announced in 1995 that foreign companies would be permitted to contribute to the exploration of new oil fields through buy-back deals. This strategy has led to new opportunities for foreign companies to invest in Iran.

The government has recently extended this policy to explore and develop petrochemical industries and great efforts have been made to attract foreign investment to Iran's oil and gas industries. In this respect, during recent years, heavy investment has been made in the Iranian petrochemical sector, though the resulting income from it has not been significant. Indeed, it is clear that as in any economic venture, it takes a number of years for such investments to yield sufficient returns.[9] The main strategy of this country is to increase its production capacity while gaining the best possible value-added from oil production.[10]

As a result of these events, fundamental changes have occurred in the Iranian economy. Analysis of macroeconomic data indicates that the country's dependence on oil-exports as a source of foreign exchange and government revenues has had a significant effect on its economy. Some of these changes might have been unavoidable and have been the result of forces outside the control of government.

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[8] The World Bank and the International Monetary Fund encouraged Iran to artificially maintain their parity rates against to the dollar at a high level (see CBI, 2000).

[9] It seems that in the petrochemical sector, the government needs to make fundamental changes. Establishment of suitable technology, injecting more capital are needed to prepare the infrastructure for the successful development of this industry.

[10] During 2001, Iran's current sustainable crude oil production capacity was estimated at around 3.85 MBD, which is more than 650,000 bpd above Iran (2002) OPEC production quota of 3.186 MBD. See also: http://www2.hawaii.edu/~spanning/factpage.htm

But they have played a significant role in macroeconomic fluctuations of the Iranian economy and have led to the development of business cycles (Moradi, 2002).[11]

3.4 Performance of Main Macroeconomic Indicators

This section provides an overview of main macroeconomic indicators of Iranian economy and discusses the consequences of oil price shocks and the related policy responses.

3.4.1 The Growth Rate of the Economy

To understand the underlying factors of the Iranian economy one needs to look closely at the movements of GDP. Three different growth episodes in Iran can be distinguished - 1959-77, 1978-88, and 1989-2004 (see also Jalali-Naini, 2003). Indeed, a brief look at the evidence from the literature suggests that during the period 1959-77 Iran experienced a period of relative price stability accompanied by a substantial rate of economic growth. During this period the growth rate of GDP was about 9.91% on average per annum (Table 3.2).[12]

Table 3.2 Average Growth Rate and Volatility (at constant 1998 prices-percent)

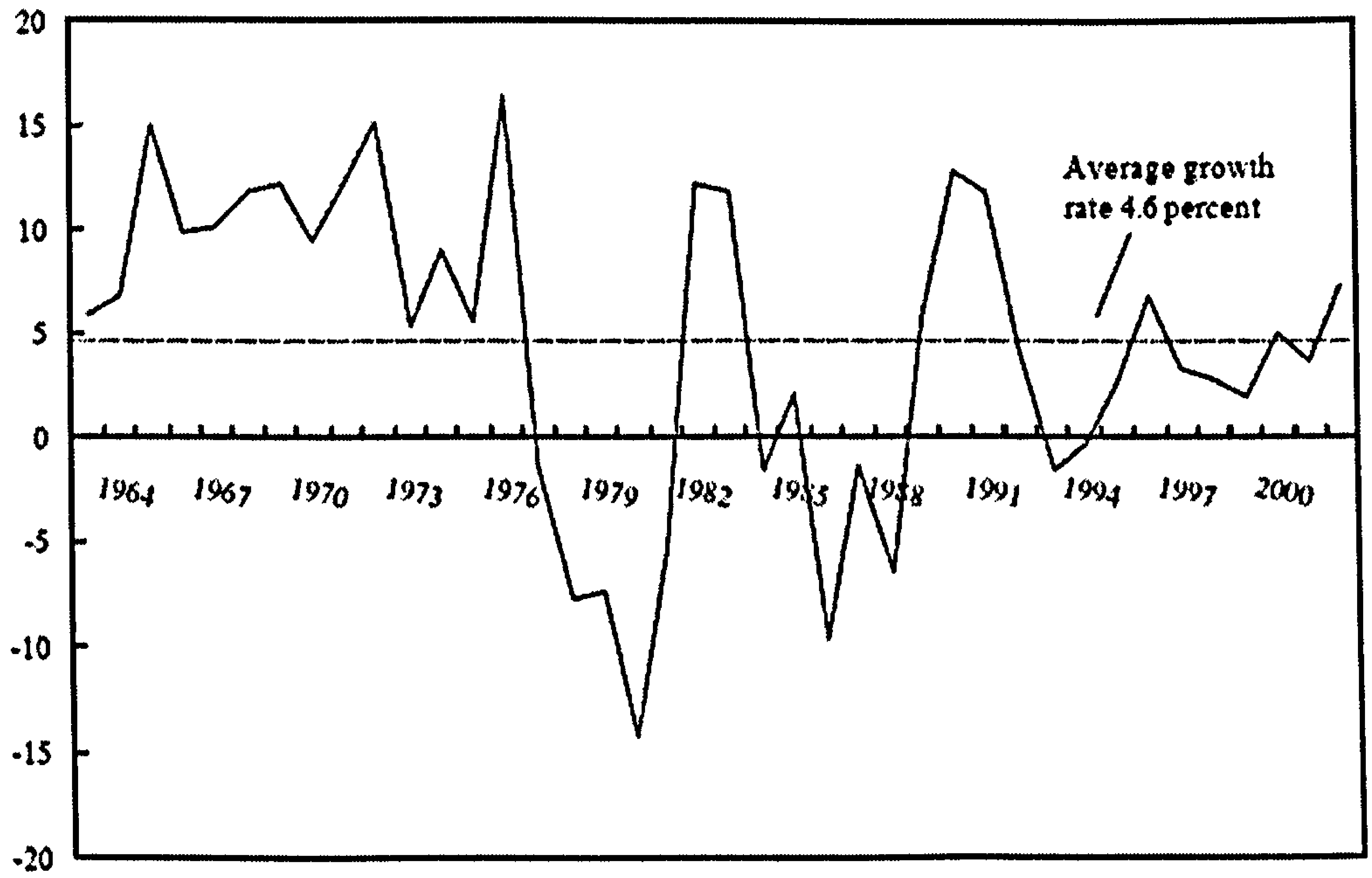
	GDP (Percent Per Annum)		Non-Oil GDP (Percent Per Annum)	
	Mean	SD*	Mean	SD
1959-77	9.91	4.8	10.2	6.65
1978-88	2.4	8.5	0.34	5.78
1989-2004	4.31	4.67	4.5	4.8

- Standard Deviation
- Compiled by Author, data source: Central Bank of Iran (2004)

Table 3.2 show the average growth rates and growth fluctuations (measured by the standard deviation of growth rates in each period). The results show that the structure

[11] Nevertheless the periodicity of business cycles, their magnitude is small relative to average GDP and trend growth. However, some fluctuations are evident during the 1970s, 1980s and 1990s.
[12] There were two distinct phases evident during this period: (1) 1959-63 characterized by a relatively low growth rate and a zero rate of inflation and (2) 1964-77 characterized by a high growth rate and minimum inflation (Vakil, 1977).

of production in Iran has changed significantly, during the period of this study. The non-oil GDP and wider export-based production produced significant growth over much of the period, but with restricted growth in subsequent years. Overall, the performance of non-oil sector was broad-based and driven by higher domestic demand. Recent economic performance has worsened significantly compared to international standards (Hakimian, 2000).



Source: Iranian authorities and IMF staff estimations (IMF, 2004)

Figure 3.1 Iran: GDP Growth Rate 1962-2002

Figure 3.1 shows that the average growth rate of GDP at constant 1998 prices. A break in the trend is observed during 1978-88. Since the 1979 Revolution, increased government involvement in the economy has actually depressed growth. Economic activity, severely disrupted by the Revolution, was further depressed by the war with Iraq, the decline of oil prices beginning in late 1985 and economic sanctions imposed by the US.[13] After the war ended, the situation improved: Iran's GDP grew for two

[13] The war years show the worst performance of the economy with GDP contracting by 0.1%. The growth rate of 6% before the revolution falls to 0.5% after it, except during the first economic plan (5.3%), (Hakimian, 1999).

years running, partly due to an oil windfall in 1990, and a substantial increase in imports.[14]

However, following the 1988 ceasefire substantial reconstruction projects, and an overvalued exchange rate, coupled with rationing and price controls, led to economic distortions. Economic growth increased in the early 1990s partially fuelled by short-term external borrowing. The consequent need for debt repayment restricted imports of crucial production inputs and contributed to weaker GDP growth in the mid-1990s. GDP growth was further affected by weak oil prices in 1997-98 and stimulated by reduction in oil exports to comply with OPEC quotas in 1999 and continued constantly in 2000. The average growth rate over the period 1989-2004 was 4.31%. In addition, high economic growth in 2001 and 2002 with real GDP growing by 4.8%, despite lower oil production, took place in an environment of declining inflation and an improving external position (see also Table 3.3).

Table 3.3 GDP Growth Rate in Iran 1959-1999 (Percent)

Era	Years	Real GDP growth Rate	Per Capita GDP Growth Rate
Before Revolution	1959-78	9.0	6.0
Oil-Boom	1973-77	8.6	5.6
Revolution	1979-97	2.4	-0.5
War years	1980-88	-0.1	-3.7
First plan	1989-94	7.3	5.3
2nd Plan	1995-99	3.7	2.2

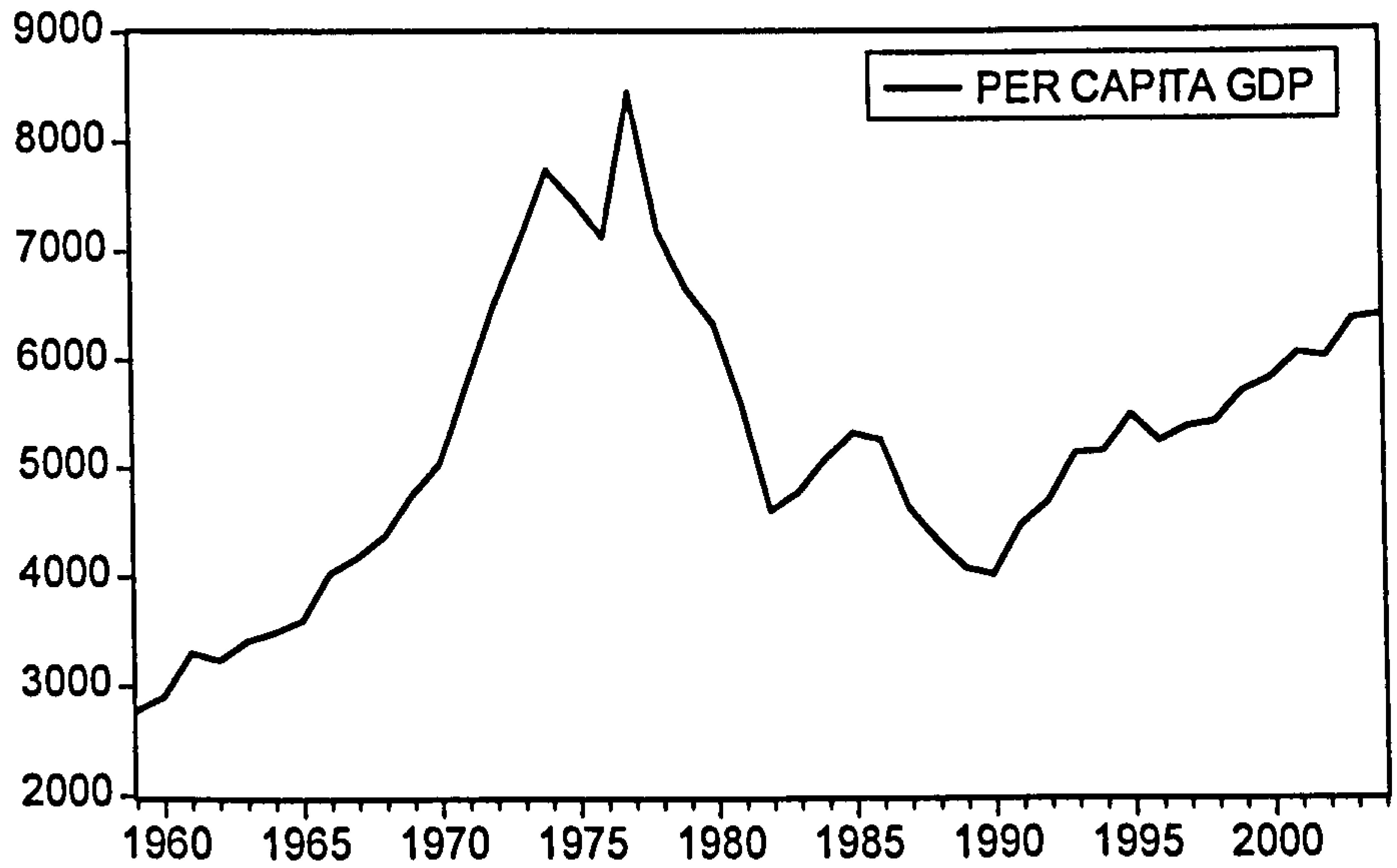
Compiled by Author, data source: MPO and CBI, 2003

Income Per Capita

Figure 3.2 shows a sharp increase in real GDP based on increases in oil revenues resulting from increases in the price of oil during the 1970s. The growth rate of real

[14] Since the end of the war, the rate of real GDP growth rose to an estimated 10.1% in 1990-91, mainly as a result of foreign investment, but also because of a 120% increase in government oil revenues in 1989. However, the sustained fall in oil revenues from 1992 has produced another period of economic stagnation. In 2001, Iran's real GDP grew by around 4.3%; for 2002 it grew at the slightly lower of rate 3.5%. Relatively high oil exports revenues in the past year or two have allowed Iran to set up an oil stabilization fund.

per capita GDP is characterized by wild fluctuations. Until 1976 it fluctuated between 4% and 14% whilst over the period 1978–88 it was persistently negative with the exception of the mini-boom of 1982-83. A more stable pattern is observed after the Iran-Iraq war, when GDP increased steadily after 1990 until 2004 (see also Table 3.2).



Compiled by Author, data source: Central Bank of Iran

Figure 3.2 Real GDP Per Capita at 2000 Constant Price in Iran (Rials)

Sectoral Economic Growth Rate

Differences in sectoral growth rates and changes in the inter-sectoral relative prices are the main causes of the significant fluctuations in the sectoral distribution of GDP (Jalali-Naini, 2005). During 1960–2002, the industrial sector exhibited the strongest performance and grew at 7.6% p.a. on average.

Table 3.4 Average Sectoral Growth Rate 1960-2002 (percent)

Sectors	1960-76	1977-88	1989-2002	1960-2002
Oil	10.0	-8.6	2.5	2.4
Agriculture	4.6	3.9	4.1	4.2
Industry	14.0	-1.3	7.3	7.6
Services	11.1	-1.9	4.8	5.4
Non-Oil	10.1	-0.5	5.0	5.5
GDP	9.8	-2.4	4.7	4.6

Compiled by Author, data source: Central Bank of Iran

In contrast, the oil sector grew by 2.4% and its relative weight decreased from one third of GDP to less than 13% in 2002. The agricultural output grew at 4.2% p.a. on average, a slightly slower pace than GDP, while the services sector grew at a faster rate than GDP (5.4% p.a. on average) (Table 3.4).

Share of Economic Sectors in GDP

Table 3.5 shows the distribution structure GDP of amongst different sectors. The significance of the oil sector can be determined by its share of GDP. However, the share of services, industry, and agriculture sectors is greater.

Table 3.5 Share of Economic Sectors in GDP (percent)

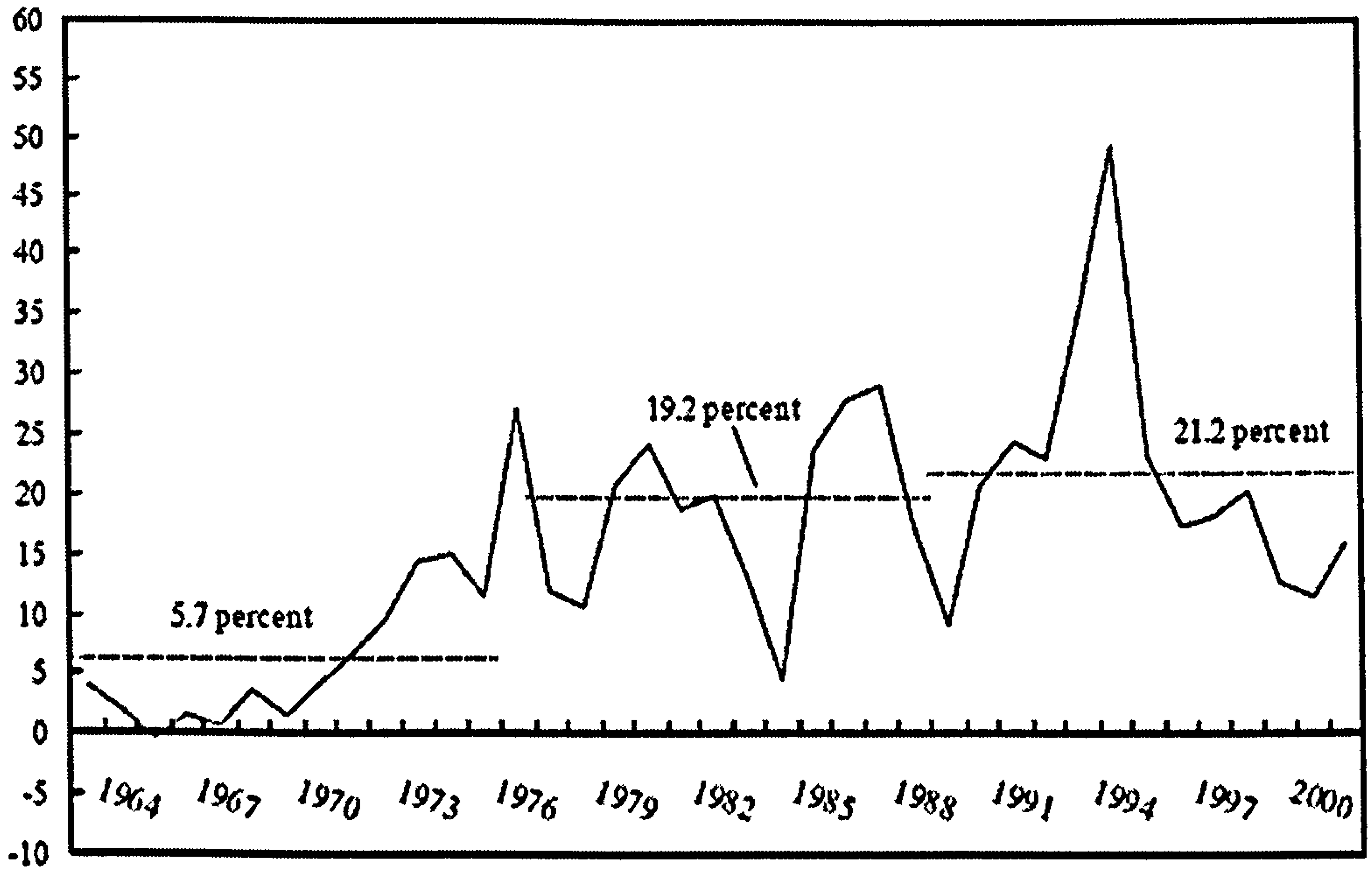
Sectors	1959	1963-64	1968-69	1971	1972-73	1976	1977-78	1988	2001
Oil	12.2	21.3	25.1	25.0	51.9	38.3	35.8	7.3	14.2
Agriculture	37.3	25.8	20.6	18.5	10.6	9.9	9.4	23.5	13.4
Industry	9.2	17.7	20.2	15.9	13.0	16.7	19.1	14.8	19.2
Services	41.3	35.2	34.1	40.6	24.5	35.1	35.7	54.4	53.2
GDP	100	100	100	100	100	100	100	100	100

Compiled by Author, data sources: Central Bank of Iran, National Accounts, Different years.

The oil sector's share declined from 30-40% in the 1970s to 10-20% in the 1980s, mainly as a result of war damage to production facilities, policy decisions to reduce production and exports and diversification of the production base of the country, a lack of investment in the oil sector, and the effect of OPEC's ceilings.

3.4.2 Inflation Rate

The time trend of inflation rate is shown in Figures 3.3. Throughout the 1960s the increase in oil prices was accompanied by strong price stability, and extremely low inflation, though towards the end of the decade it rose to 3.5% p.a. The rate rose to 6.5% in 1972 and in following year to over 10%. By the end of 1973 when OPEC unilaterally increased the price of oil, the structure of Iran's economy had changed, to extremely high growth rates and accelerating inflation. In 1975, prices rose partly due to imported inflation and partly due to excessive liquidity, so that urgent action was required. Strict price controls were implemented and succeeded in lowering the prices of most consumer goods to acceptable levels (Bagheri, 1996).[15]



Source: Iranian authorities and IMF staff estimations (IMF, 2004)

Figure 3.3 Iran: Inflation Rate 1962-2002

Figure 3.3 shows sharp fluctuations in inflation. The peaks in 1975, 1979, and 1987 can be attributed to the oil price shocks, whilst the 1993 peak can be related to the Asian economic crises. Until 1978, the economy grew impressively at a rate almost unparalleled in the Middle East (Karshenas, 1998; Hakimian and Karshenas, 1999). Inflation since 1979, peaking at 31.3% has never achieved the high level of earlier years. Following a sharp decline in output immediately after the revolution and a significant increase in oil prices in 1979, the economy experienced moderate growth up to 1985. Table 3.6 also shows that the 1989-94 economic reform programmes produced 18.8% inflation on average. The inflation rate increased further over the period following the structural adjustment program, reaching to 49.5% in 1995.

[15] Bagheri (1996) argued that the pattern of inflation in Iran is consistent with the neoclassical theory of money and inflation. Hooker (1999) argued that there has been little transmission from oil price changes to inflation by the 1980. Previous to this oil shocks contributed to inflation.

Table 3.6 Inflation Rate in Iran 1959-1999 (Percent)

Era	Years	Inflation Rate	Inflation Rate (Standard Deviation)
Before Revolution	1959-78	6.5	6.7
Oil-Boom	1973-77	15.6	5.9
Revolution	1979-97	21.6	9.8
War years	1980-88	19.8	7.6
First plan	1989-94	18.8	6.1
2nd Plan	1995-99	31.3	14.2

Compiled by Author, data Source: MPO and Central Bank of Iran, 2003

3.4.3 Unemployment Rate

Unemployment in Iran is a difficult topic because there is no consistent aggregate data series on it. However, from subjective data, one could make general observations that unemployment has a major problem even before the Revolution and may be caused by population growth, high minimum wage levels and other restrictive labour policies. During the first decade of the post-revolutionary period, unemployment rates stayed persistently higher than Iran's historical levels. Despite some progress in the immediate post-war period, the sluggish real GDP growth rates resulted in unemployment rates consistently above their pre-revolutionary levels. The 1997-98 recessions caused unemployment to increase at a time of reduced investment and the entry of young people into the labour market (Table 3.7).

Table 3.7 Unemployment Rate in Iran 1974-2000 (Percent)

Years	Unemployment Rate
1974-77	2.9
1979-80	11.8
1981-88	15.9
1989-92	9.7
1993-96	9.1
1997-2000	16.2

Compiled by Author, data source: CBI-http://www.irvl.net/six_snapshots.htm

3.4.4 Exchange Rate

A review of exchange rate during the pre-revolutionary period would clarify the role of the government in setting exchange rates. From 1959-72 the official and market exchange rate diverged little.[16] But after the revolution, the exchange rate appeared under different guises: preferential exchange rate (1979), export exchange rate (Import against export at 1982), competitive exchange rate (1989), floating exchange rate (1993), export exchange rate (1995), import certificate rate (1997), exchange deposit certificate rate and acceptable rate (2000). The basic official rate was applied to oil revenues, imports of basic necessities, and official debt repayments. The competitive rate was applied to intermediate and capital goods imports, not eligible for the official rate. The floating rate determined by the banks taking into account the parallel market rate, and applied to remaining transactions. In 1993, these three official rates were unified into a single measure at a far lower rate than the previous level of the basic and competitive official rates (Sundararajan *et al*, 1999).

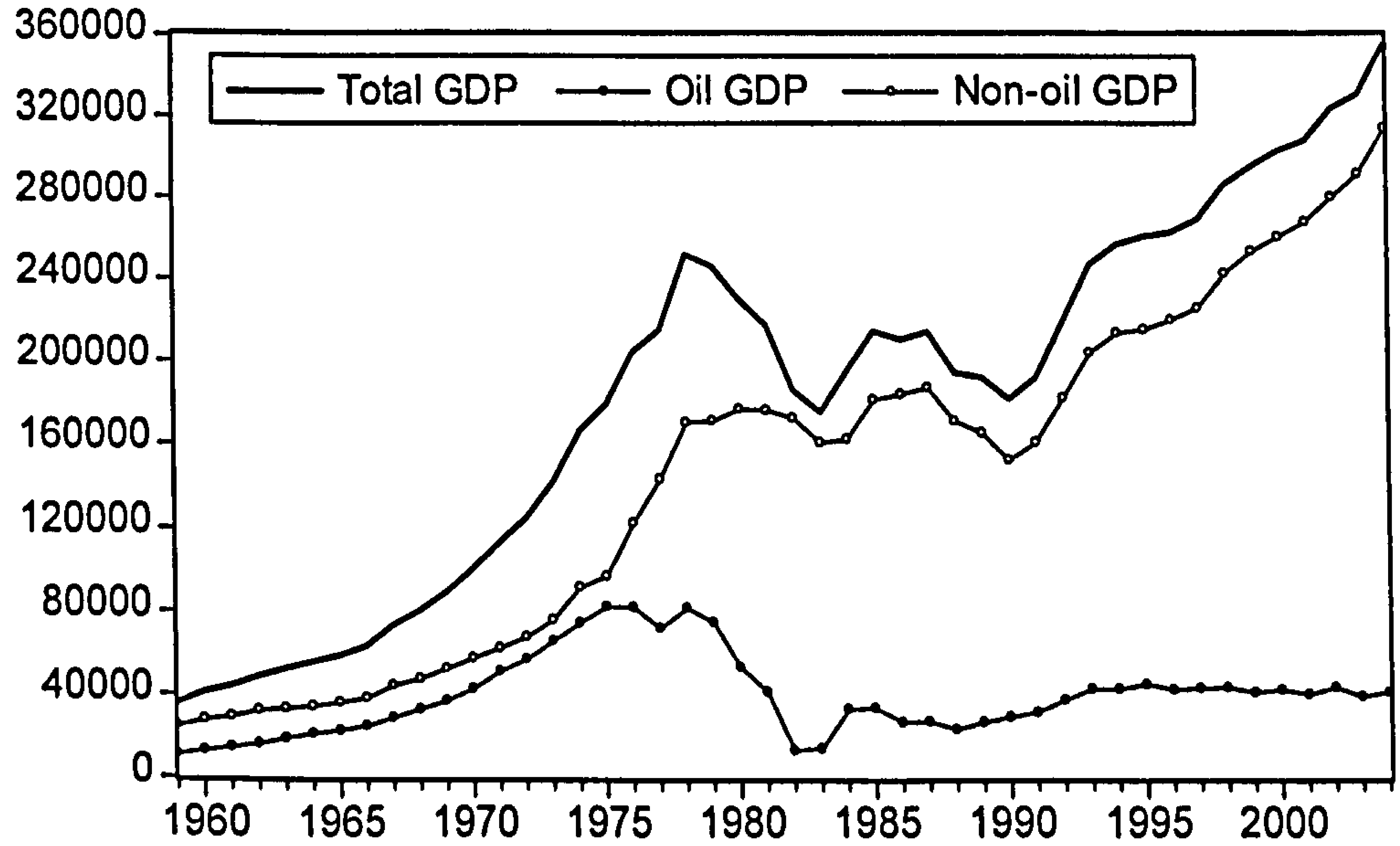
The most effective determination action of an appropriate exchange rate is the dependency on exchange earnings realized from the export of oil, and over which the government has monopoly power. This dependency is manifest in aggregate supply and demand, inflation, national product, employment level, and balance of payments. This implies the absence of an organized free market exchange rate (Samsamy, 2003).

3.4.5 Oil and Non-Oil Sector

The structural behaviour of GDP is inevitably influenced by its dependence on oil as the main source of hard currency, and it has passed through periods of boom and bust as oil prices have risen and fallen. With oil revenue providing some 80% of export earnings and 40-50% of government revenues, the government became and continues to be the dominant force in the economy (Hakimian and Karshenas, 1999).

[16] For example, the official exchange rate until 1972 was around 76 Rials, whilst the market rate fluctuated around 70-80 Rials.

Figure 3.4 shows output by sector in Iran during 1959-2004. The evolution of total GDP is seen to be closely associated with the evolution of the oil GDP until 1985. As one would expect total GDP and non-oil GDP follows each other closely. The oil GDP grew at a rate close to the non-oil GDP during 1959-72. Since 1959 as long as oil prices increased, the oil GDP increased and continued to rise until 1976. In 1976 as oil revenue reduced, both declined slightly causing the economy to move into recession.[17]



Compiled by Author, data source: Central Bank of Iran, Historical time series, 1959-2003, 2004

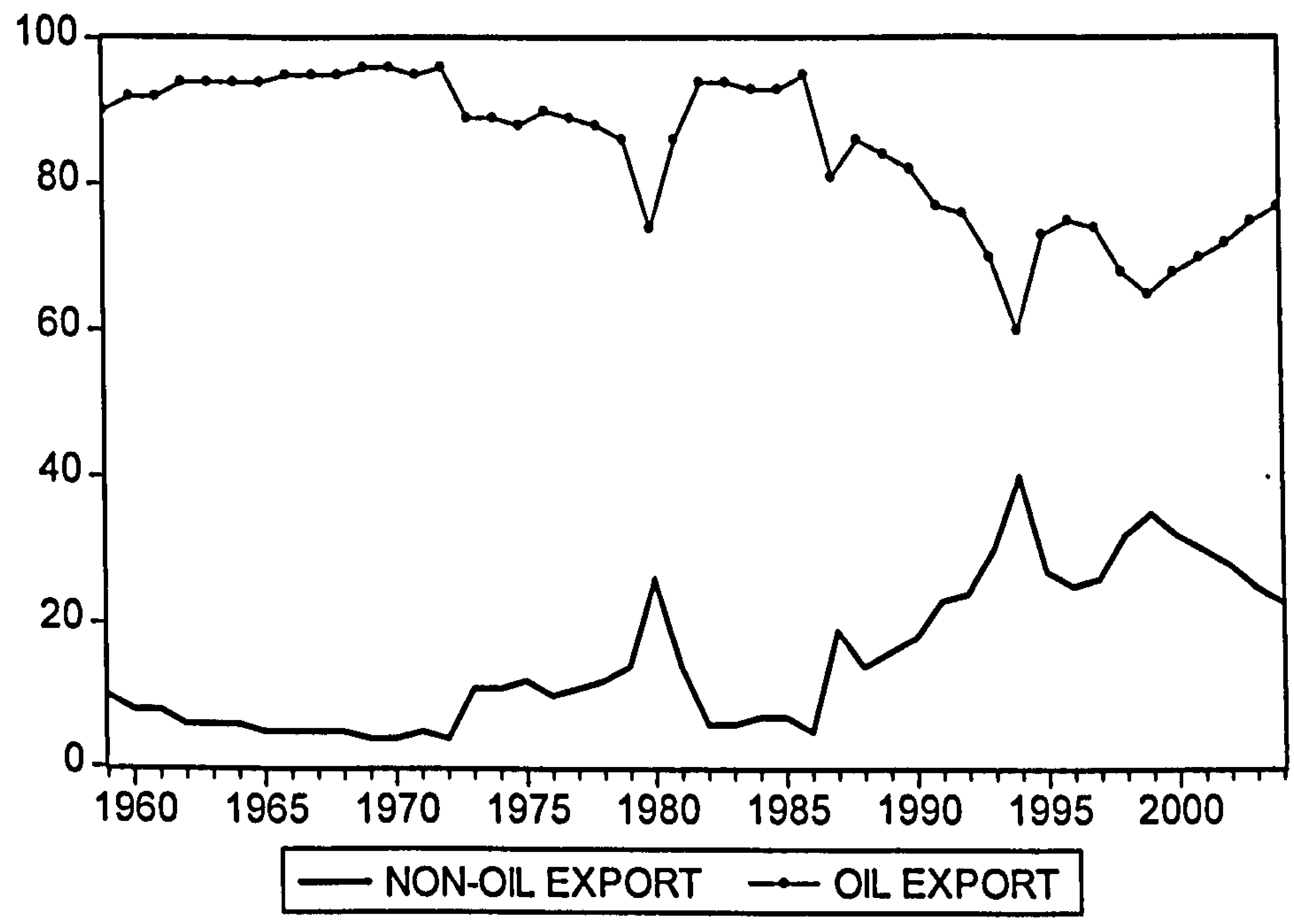
Figure 3.4 GDP in Iran (1998 Constant Price)

Following the fall in the price of oil in 1986, GDP again showed a decline. With the end of the war in 1988, GDP rose continuously until 1996 and boosted by an oil windfall in 1990. It can be seen, therefore, that the evolution of real GDP is closely associated with the evolution of the oil sector, despite the levelling off of the oil GDP.

[17] Economic activity, severely disrupted by the 1979 revolution, was further depressed by the war with Iraq; the decline of oil prices beginning in late 1985 and economic sanctions imposed by the US. This decline continued during 1979-80, but revived in the early 1980s following an increase in oil exports.

3.4.6 Oil and Non-Oil Exports

Figure 3.5 shows the dominating share of oil export in total export in the Iranian economy. The supportive policies of the government positively impact non-oil exports, which increased sharply as a ratio of total export in 1979/1980 as oil exports decreased (Jalali-Naini, 2005). However, the decline in non-oil exports from 1980-1985 was due to political uncertainties following the revolution, the effect of war with Iraq, and the rising official real exchange rate. When this depreciated and export restrictions were lifted, nominal non-oil exports rose after the cessation of conflict with Iraq, until 1994. However, after a change in the mix of economic policies in 1994, exports declined in both absolute and real terms. The devaluation of Rial and government export promotion policies helped non-oil export recovery during 1998–99. In recent years, it continued to increase because of oil price and production increases.



Compiled by Author, data source: Central Bank of Iran, Historical time series, 1959-2003, 2004

Figure 3.5 Shares of Oil and Non-Oil Export in Iran (Percent)

However, non-oil exports have always been the small part (at most 10%) of Iranian total exports. The upward trend continued in the 1990s with a strong base for economic growth by deliberately developing non-oil exports and reducing dependence on oil to meet foreign exchange requirements, reflecting a major goal of the government (CBI, 2000).[18] Taking into account the performance of all sectors, overall economic activity and the performance of the non-oil sector was strong and broad-based, and was driven by higher domestic demand and improved confidence following trade reform and the removal of foreign exchange constraints.[19]

The above underlines that the overall performance of the Iranian economy has been positive. As evidence from the macroeconomic policy initiatives implemented from 1997, Iran is moving from an inward-looking economic structure to an open market structure where the economy needs to interact with the rest of the world. From an economic point of view, while macroeconomic performance has been positive, current economic worries, especially over oil price changes may create social tensions. Therefore, one of the key signposts of economic improvement in Iran may be the government's handling of oil price changes. So, the next section provides an overview of these oil price shocks and the subsequent policy responses of the government.

3.4.7 Consequences of Oil Price Shocks and their Policy Response

The empirical literature on the macroeconomic impacts of oil price shocks suggests that the aggregate economy may respond to a sudden and/or permanent oil price

[18] The main difficulties obstructing the export of industrial products in Iran are related to the infrastructure of this country, e.g. dependence on the hard currency earned through oil exports, utilization of old machinery and equipment in certain industrial fields, lack of balance between the country's and the world's industrial development, relative instability of economic and administrative laws, regulations and policies.

[19] For example, a review of non-oil exports in 1998 indicates that industrial goods took the major share by holding 85% of the weight, and 51.5% of the value of non-oil exports, up by 41% and 15.2% from the previous year. During the same period however, mineral exports held a meagre 5.4% of the weight, and 1.5% of the value of non-oil exports (CBI, 2000).

shock. To some extent, the oil price shocks have been attributed with other issues such as government policies (Jones and Leiby, 1996).[20]

The importance of oil price shocks on macroeconomic aggregate of Iran's economy raised several issues to subsequent research focused on the contribution of macroeconomic policy and their responses on oil price shocks. The historical record includes two negative price shocks: the 1960s oil price drop and the collapse of world oil prices in 1986; and two positive oil price shocks in 1973 and the Iranian revolution 1979. This raised the issue of possible asymmetry in the macroeconomic response to oil price shocks. The dependency of primary commodity dependent economies, especially on oil export earnings, brought more attention of the routes of oil prices on the economy and business cycle transmission mechanisms (Jones and Leiby, 1996).[21]

The major sources of fluctuations in the Iranian economy are the Islamic Revolution, the Iran-Iraq war, debt crises, and most important of all, oil price shocks. The oil price fluctuations may extend over several years.[22] It may be that the reaction of the Iranian economy to oil price changes is likely to depend on the underlying financial situation of the country due to the dependence of the appropriate macroeconomic polices. After the Iran-Iraq war, the economic reform programme also implemented major changes with the removal of government control on prices, and subsidies,

[20] See also Mory (1933), Mork (1989), and Mork *et al.* (1994). These studies report statistically significant negative elasticities for oil price increase and insignificant positive elasticities for price decreases (Jones and Leiby, 1996).

[21] Economic shocks can cause unpredictable changes in aggregate demand and short-run aggregate supply, which respond outside macroeconomic models. The unpredictable nature of these shocks creates a fluctuating rate of economic growth and may require some sort of macroeconomic policy response (Jones and Leiby, 1996).

[22] The three major oil price shocks on 1973, 1979, and 1986, together with the large fluctuations in the price of oil, imply the possibility of impact of oil on the business cycles of Iran. For example, for only 50% of the given time period from 1947 to 1997, oil prices exceeded $15.26 per barrel. Prices have only exceeded $22 per barrel in response to war or conflict in the Middle East.

currency devaluation, and the deregulation of trade and tariffs. This means that there are different sources of fluctuations that may affect the economy.

Table 3.8 provides a chronology of major events in Iran and the economic policy response to them over the period 1959-2004. Over the period of study, there was no significant change in the oil price until 1972. But during 1973-80, following the first oil boom, the oil price steadily increased. The rise in oil prices clearly accelerated over this period. The Yom Kippur war triggered the first major oil production cut by OPEC. In response to the war, OPEC agreed to an oil embargo against the United States and others. As a result, oil prices sharply increased in subsequent years.[23]

Table 3.8 Events and Main Policy Measures in Iran during 1959-2004

Year	Events	Policy Response
1959-72	No trend and little change	Follows the OPEC's policy[24]
1973	First oil boom (Yom Kippur)	Price control by OPEC
1978	Revolution	Large scale nationalisation
1979	Second oil boom-Upward trend of oil price	Cut oil production
1980-88	Eight-year Iran-Iraq war	Borrowing from external sources
1980	Start of US embargo	Cutting oil export to US
1986	Third oil shocks-Downward trend of oil price	Governmental control on prices
1987-96	No trend but large changes	Subsidies, currency devaluation
1988	End of the war	Economic reform programme
1989-93	Debt Crisis	Devaluation and Deregulation of trade
1994	Financial pressure	Protectionism (price and exchange rate)
1996-98	Rapid increase in oil prices	Debt service payment
1998-2000	Downward trend of oil price	Non-oil export drive
2000-04	Upward trend of oil but little fluctuation	Reduction in oil production

Complied by Author

In the period 1981-86, the oil price declined until collapse in 1986, known as the third oil shock - in which the price of oil dropped to its lowest level between 1979 and 1996. This dramatic fall in prices was followed by sluggish growth in the economy (Shapiro and Watson, 1988).

[23] For example, the oil price had fallen to $11/bbl by the mid-1980s, remarkably, since inflation and oil prices effectively returned to their pre-1973 levels.

[24] Apparently, the oil price would never follow one single price determination rule. Apart from those big changes in 1960's when OPEC began to control world crude oil and, market instability occurred due to demand and supply variations (Adelman, 1999). http://web.mit.edu/ceepr/www/RN1-799b.pdf

In the period 1987-96, oil prices fluctuated frequently and with a large magnitude around a constant mean, but he strong oil market in 1996 helped to alleviate financial pressures. The financial situation worsened in 1997 and deteriorated further in 1998 because of lower oil prices. The subsequent rapid increase in oil prices in 1999 helped Iran to recover its fiscal situation but did not solve its structural economic problems.

The period from 1998 to 2000 witnessed a wide range of political, economic, and environmental events directly related to the world oil market. As the impact of the South East Asian and Latin American financial crises subsided, the world economy started to recover from the beginning of 1999 and by 2000 had managed to achieve a growth rate of 4.7%. In 2000, in order to sustain world economic growth and maintain the price of oil within the OPEC price range of $22-28/bl, OPEC members raised their production maximum amount by 3.7 MBD. Therefore the world demand for oil increased, and OPEC increased production to prevent a sharp rise. Despite the sustained rise in OPEC's production ceiling, the price of each barrel of the OPEC basket stood at a higher level than the OPEC preferred maximum price of $28 for 2000 (Mardoukhi, 2000).[25]

A combination of recession and a sharp drop in oil demand in 2001, led to a reduction in oil prices. In response, Iran and other OPEC member reduced oil production and non-OPEC countries followed this policy as well. Strong domestic demand helped increase liquidity, and fuelled inflation, which rose from 11.4% in 2001 to 15.8% in 2002. However, the Iranian economy continued to grow in 2002-

[25] Along with this improvement in the world economy, the world demand for oil increased, and OPEC raised its members' production maximum amount to prevent a sharp rise in oil prices. As a result of the 1998 Asian financial crisis, oil consumption dropped by approximately 0.5 MBD in Japan, Korea, Thailand, and Indonesia. Also in 1998, the OPEC and non-OPEC oil producers reduced their production until 1999.

03. Primary evidence indicates that employment rose during 2003-04, and for the first time for several years, the unemployment rate fell.

3.5 A Planned Economy

The Iranian economy combines central planning and state ownership of oil. Its structure continues to be determined by its dependence on oil, as it has been for most of the past 40 years. An oil producer since 1960, the state became and continues to be the dominant force in the economy. Over-ambitious development plans, fuelled by the 1973 oil price rise, served to concentrate power in the hands of the public sector, which was further enhanced by the 1979 revolution and restructuring for the 1980s Iran-Iraq war.

3.5.1 Oil and Importance of Planning

In the Iranian economy most macroeconomic activities depend on oil income. Jalali-Naini (2005) suggests that oil export revenues have been the main source of foreign exchange in the Iranian economy during the last five decades and this has exerted an effect on macroeconomic fluctuations. Oil incomes were spent on various projects such as economic planning. The government uses oil revenues for domestic expenditure and to import goods and services. Thus, opportunities for and limitations of economic development, and structural progress have been influenced by oil revenue.[26]

Since the 1950s, oil revenue has been the basis for major economic and social change in Iran. The politics of oil development within Iran during the 1960s and 1970s took place within the wider context both of the oil producing countries in OPEC and of

[26] With the growing realisation of the state of backwardness of the country the importance of oil export revenue to the Iranian economy has increased. These facts about the economic condition are sufficient to illustrate Iran's general difficulties during the period of study. Even the oil industry, despite its large commercial operations and substantial profits, employed a relatively small part of the labour force.

the international political and economic relations regarding oil supply. However, the structure of Iran's oil policy and the dependence of its economic development on oil income did not bring about any reductions in domestic or regional tensions.

The Iranian economy is centrally planned and follows five-year development plans, which have a 60-year long history. The development plan is a document in which favourable economic and social conditions within the framework of anticipated limitations and resources are drawn up and suitable policies adopted to obtain them. However, attention should be paid to the fact that drawing up the targets and policies in the plan documents will not necessarily lead to the realization of the goals and objectives of the plan. There might be a considerable gap between the performance of the economic and social development plans and their forecast targets as was evident in the first and second development plans.

The state sector includes all large-scale and strategic industries, foreign trade, major minerals, banking, insurance, power generation, dams, and large-scale irrigation networks, radio and television, post, telegraph and telephone services, aviation, shipping, roads, railroads. All these are publicly owned and administered by the State (Valadkhani, 2004). The existence of long history of planning and emphasising Five-Year Plans in the economy, and also high dependency of planning system on oil export earnings, leads to offer a strong suggestion to define oil price shocks, difference between the actual and planned oil price.

The First Plan (1949-1955) of the Iranian economy contained guidelines for the allocation of government expenditures to different sectors of the economy. The plan though it favoured agriculture over industry and transport, accomplished little, achieving no more than the setting up of a planning process for industries (Ghaffari, 2000).

The Second Development Plan (1956-62) emphasised agriculture, transport and communications systems by developing an economy based on the agricultural sector. The plan was also drafted on the basis of an agreement between Iran and the international oil companies in which, on average, 75% of oil revenues would be used to fuel the plan. This plan though was similar in many ways to the First Plan. It contributed to economic development and stimulated a degree of industrial development and rapid growth in a period characterised by balance of payments difficulties and inflation. Nevertheless the Second Plan did contribute to the expansion of an infrastructural network essential to raising the overall level of economic activity, whether private or public (Ghaffari, 2000).

The Third Plan (1963-67) was Iran's first effort at comprehensive planning. Its main purposes ware to achieve a rate of growth of 6% by promoting rapid import-substitution industrialisation, to enlarge employment possibilities, to achieve a more equal distribution of income, and to maintain relative price stability and equilibrium in the balance of payments (Valadkhani, 2001). The features of the plan were an investment programme for the public sector and some forecasts for the private sector (Ghaffari, 2000).

The Fourth Plan (1968-72) was more comprehensive and ambitious than any of the previous ones in terms of formulation and implementation. Iran had by this time become the leading oil producer in the Middle East and the third largest in the world. The vital role of oil revenues in financing the plan and in augmenting capital formation and growth raised the growth rate in GDP from 9% to 11% in real terms.

The objectives of the plan were directed at agriculture, heavy industry, oil and gas, water and power, and service industries (PBO, Fourth Plan)

In the Fifth Development Plan (1973-78) oil prices were assumed to be largely constant or even to marginally increase in real terms and existing levels of foreign growth and inflation were expected to continue. Imports were rising faster than oil revenues and non-oil exports seemed small (Ghaffari, 2000). This plan was revised almost immediately in the light of an oil revenue increase. This plan was larger than all previous plans put together. It brought about great changes in the social and economic structure of the economy (Komijani, 2006).

Ambitious five-year plans following the price explosion of 1973 were concentrated on the public sector and nationalisation of many large firms in the aftermath of the 1979 Iranian revolution, and the restructuring necessary for the 1980-88 Iraq-war that compounded this process. The first post-revolution economic, cultural and social development five-year plan (1989-94) was launched in 1989, followed by the second plan in 1995 with the latter failing to produce the needed results. One of the reasons for the failure of the second plan was the contradiction between the expectation and performance of the plan; lack of belief in planning on the part of policy makers, and lack of concentration and uncertainty in the role of government and other institutions. At first, the implementation of the plan dealt with national development projects (Ghaffari, 2000).

The second development plan (1995-99) focused on non-oil exports and on lowering the dependency of the economy on oil. The period of the second plan was characterized largely by declining economic growth and macroeconomic instability which forced government to shift from adjustment policies to control ones.

Significant success was achieved in regulating and managing of the external debt arrears, which had been largely repaid by mid-1999 (Komijani, 2006). In the course of the plan, the percentage of targets achieved stood at 60% annually, with half of development projects behind schedule. Iran had deviated from its targets in the course of the first and second development plans and none of the targets were attained as planned.

Assuming that favourable social and economic conditions in the country were correctly reflected by the goals of the Third Plan (2000-04), the reason for the contradiction between the target indexes and performance of the plan can be attributed to four groups of factors (CBI, 2005): (i) existence of factors that were out of the government's control or a lack of control over them, (ii) failure to implement the plan appropriately, (iii) effects of previous decisions on current economic and social policies, (iv) a possible mistake in properly understanding measures and decisions that should be taken in connection with the setting of targets on the part of policy makers or choosing contradictory goals.

As the assessment of the performance of the first and second development plans show, attainment of the targets of each development plan depends on harmony between the targets and policies of the plan; correct recognition of the effects of variables under the control of the country's social and economic administration, and precise evaluation of technological and resources limitations and of obligations made by previous policies.

In response to an oil price decline and worsening economic conditions in 1997-9, the third plan (2000-2004) involved restoring market-based prices, reducing the size of the public sector and encouraging private sector investment. Main objectives of the plan were: (a) liquidation, privatization, merging and restructuring of State Owned Enterprises, (b) raising the efficiency of the tax system and eliminating the existing organizational bottlenecks, (c) establishment of "Oil Stabilization Fund" to dampen the effects of fluctuation of oil proceeds (d) adjustment in the regulations of foreign trade: Introducing flexibility in the banking industry.[27]

It should be noted that during the third plan the region and Iran's international relations experienced a non-stable situation due to occupation of Iraq and its internal war and also issues related to Iran's nuclear energy industry. Development planning in Iran shows that there is a substantial relationship between oil revenue and planning with approximately 55%-90% of each plan's funding come from oil revenues (Komijani, 2006).

Iran is attempting to define its oil production policies within a national planning framework that is related to the foreign exchange and national requirements of the economy. This policy can affect the mechanism of decision making during a five-year plan period. However, while preparing its development plans, Iran's rulers looked for policies that could provide: a satisfactory level of growth rate during the plan's life, an optimum portfolio of assets at the end of the plan, and a possibility of decreasing the dependency of the economy on oil revenues over the long-term and a continuous objective of the economic plans, has been the growth of non-oil exports. But reaching this goal has been hindered by the availability of oil revenues, the nature of fiscal policy, the structure of the domestic economy, and relative prices (Jalali-Naini, 2005).

[27] The major objectives of the plan, such as appropriate economic growth, growth of capital formation, improvement in balance of payments and reductions in the unemployment rate have been achieved over the plan period. But the high rate of liquidity growth and inflation, size of government sector and unsuccessful privatizations of state owned enterprises are still weak points of the implemented plan.

3.5.2 Macroeconomic Policies in a Planned Economy

The fundamental aspects of a macroeconomic policy consistent with long-run growth in Iran are fiscal regulation and the separation of monetary policy from the government budget complemented by a reliable monetary policy. For instance, the management of oil revenue fluctuations can be part of macroeconomic policy in Iran (Jalali-Naini, 2005). The foreign reserves management as well as the behaviour of government expenditures are relevant to understand the channels through which this income is transferred to the economy. This section reviews macroeconomic polices: fiscal, monetary, trade and exchange rate.

Macroeconomic policy in Iran faces challenges arising from three characteristics of oil revenue: firstly, oil revenue is more volatile than revenue from other export commodities, because of international market conditions and the high fixed costs involved in exploration and production; secondly, oil revenue is a foreign exchange inflow, and thus its use can have large effects on macroeconomic stability; and thirdly, oil is an exhaustible resource with a finite revenue stream.

Macroeconomic policies aim to stabilize expenditures and sterilise excess revenue inflows. In a primary commodity dependent economy the cyclical behaviour of economy is driven by oil price developments, expansion of the non-oil sector, and real exchange rate volatility driven by monetary policy.

The macroeconomic situation during the period 1979-1988 forced the government to adopt direct administrative policies to deal with the exigencies of war. Such policies included import substitution policy along with strict foreign exchange control, imposition of foreign exchange allocations on government agencies at overvalued official exchange rate, domestic industry protection policies by explicit and implicit subsidies and direct allocation of the bank facilities primarily to the public sector.

3.5.2.1 Fiscal and Monetary Policy

The Iranian fiscal year runs from 21st March each year to 20th March the next. Fiscal policy is relatively stable during the period of study. Non-oil revenue grew broadly in line with economic growth and total expenditure rose by about 5% in real terms, with the growth in current expenditure more than offsetting the decline in capital outlays. The authorities continued to take advantage of the sustained high oil revenue by accumulating fiscal savings in the oil stabilisation fund (OSF) - an account at the Central Bank of Iran. The fund was to be financed from surplus foreign exchange oil revenues to fund annual budgets, and for the repayment of foreign debts. This performance has been facilitated by the policies of using the increased oil revenue to reduce external debt, to build international reserves, to accumulate savings in the OSF which smoothed the effect of fluctuations in oil-export revenues on government expenditures, and reduced trade and foreign exchange restrictions.[28]

Nonetheless, policymakers are faced with important challenges in the short and medium-term. The short-term challenges derive from the expansionary fiscal policy and high liquidity growth that increase the rate of inflation and weaken the competitiveness of the Iranian economy through a real appreciation of the exchange rate. The medium-term challenges relate to the need to deepen and accelerate structural reforms to sustain high growth rates, diversify the economy away from oil, and create employment.

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[28] The purpose of the Oil Stabilization Fund was to split the high correlation between the current oil revenues and current government expenditures, particularly government development expenditures. The government has frequently drawn heavily from the Oil Stabilization Fund. Thus, as in the previous years, government expenditures are still highly correlated with oil revenues. The experience shows that a high correlation is not satisfactory from a macro policy perspective (Jalali-Naini, 2005).

Fiscal policy changes should be implemented for two reasons. First, it seems unreasonable that the large increases in revenues were not totally spent during the high oil price period. In addition, the favourable financial position made it possible to undertake fiscal policy actions in order to smooth business cycles in the same period. The latter argument is strengthened by the fact that interest rates were constrained by exchange rate policy, making fiscal policy the only available stabilisation instrument (Torbjorn and Magnussenb, 2000).[29]

The general pattern of government revenue is affected by oil revenue directly or indirectly as follows: (a) when oil revenues increase, the windfall goes entirely to the government and directly affects its revenue; (b) the price of oil exports is determined by the international oil market and its quantity by OPEC; (c) the government has no real influence on its revenue.

Since the 1979 revolution, a large number of financially haemorrhaging state-owned enterprises have been exempted from taxation and/or have benefited from various types of government subsidies. As a result enormous pressure has been placed on the government budget. Given that the major source of financing the government budget deficit is through borrowing from the Central Bank, the monetary base and liquidity have increased substantially and as a result the Iranian Rial has become a declining currency (Moradi, 2002).[30]

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[29] The boom-and-bust cycles in oil-producing countries have been largely caused by unpredictable fiscal policies that depend heavily on oil price developments. Oil-price booms often result in an unsustainable expansionary fiscal policy. Because of an inelastic domestic supply, sudden expansion of aggregate demand generates inflationary pressures within a relatively short period of time (Jalali-Naini, 2005).

[30] The government budget deficit has been financed largely by printing money since both bond financing and external borrowing were insignificant, if not illegal, and tax revenue formed a small proportion of total government revenue (24.3% on average over the period 1959–1996). Increases in government expenditure, financed mainly through oil revenue, were accompanied by expansion in the money supply. Oil revenue made up 57.7% of the government revenue on average over the whole period but some fluctuations existed during 1970s, 1980s and 1990s in particular.

In recent years, the fiscal position has been expected to deteriorate significantly owing to the expansionary expenditure stance of the budget and the cost of exchange rate unification (IMF, 2002). Table 3.9 shows the components of government revenue, by including revenues received from the sale of foreign exchange through oil revenue sales, tax revenues, non-oil revenues, and others, where oil revenue covers almost 50% of total revenue. Nonetheless, the share of oil revenues in total general revenues fell from 23.6% in 1999 to 19.2% in 2000. This was largely caused by the annual adjustment of other components of the revenue, including tax and other revenues.[31] The increase in tax revenues in 2000 was mainly due to increases of 8.3% in the imports tax, and 7.2% in consumption tax.

Table 3.9 Government Revenues in Iran (Billion Rials)

	Revenue	Revenue	Change (%)	Change (%)	Share (%)	Share (%)
Year	1999	2000	1999	2000	1999	2000
Oil	44487.6	59448.5	96.7	33.6	48.2	56.8
Non-oil	47828.1	45192.3	54.3	-5.5	51.8	43.2
Tax	25831.3	32842.1	38.2	27.1	28.0	31.4
Other	21996.8	12350.2	78.6	-43.9	23.8	11.8
Total	92315.7	104640.8	72.1	13.4	100	100

Compiled by Author, data source: Central bank of Iran

Despite substantial oil-export revenues and an increase in tax revenues, the country has continued to face budgetary pressures in recent years. These were exacerbated by various factors, namely a rapidly growing young population with limited job prospects and high levels of unemployment, significant external debt (including a high proportion of short-term debt); high levels of poverty; extensive state subsidies on many basic goods; a large and inefficient public sector including state monopolies; international isolation and sanctions (Khataii, 2001). A reason for this

[31] Tax revenues were the main component of non-oil government revenues about 72.7% and the rest revenues received from government monopolies and ownership, sale of goods and services, return on loans and government investments abroad were 27.3%. For example, during the period 1975-78 tax revenue was only 18.5% of total government revenue, while the share of oil revenue was 75.5% (Amuzegar, 1983).

situation arising were the huge drawings by the government on financial resources of the Central Bank of Iran (CBI) to make up the budget deficit.[32]

Monetary policy is confronted with setting exchange rate unification, foreign exchange reserves, and subsidizing inflationary expectations.[33] The setting of monetary policy relies to a large extent on administrative controls in the context of fiscal dominance – with high liquidity growth and inflation, and a lack of market-based instruments.[34] A mixed policy of fiscal adjustment and monetary actions to remove excess liquidity would be essential to bring domestic liquidity growth under control, while administrative controls are used to improve the inflationary impact of fiscal dominance and to favour the redistribution of resources according to government priorities. The approach to monetary policy formulation gives the government a crucial influence in setting specific monetary targets. In particular, five-year plans set annual targets for monetary growth and inflation which are used as benchmarks for formulating monetary programmes by the Central Bank (IMF, 2004).

However, the Iranian economy has experienced some important external and internal shocks such as three oil price shocks, the 1979 revolution, and the Iran-Iraq war. In addition, significant government interventions such as nationalisation, liberalisation, and valuation of the domestic currency were placed. The effects of oil price shocks were particularly profound due to the heavy dependence of the economy on oil

[32]According to data published by CBI, there are two scales of data adjusted to constant prices of 1991 and 1998. See also: http://www.iraninternationalmagazine.com/text/imf%27s%20take%20on.htm

[33] Exchange rate unification and the establishment of a managed float exchange rate regime raised the issue of the appropriate nominal anchor, as well as the related supporting policies. Since Iran has chosen a managed float exchange rate regime, price stability should be an overriding objective of monetary policy, see Sundararaian *et al* (1999) and Celasun (2003).

[34] Exchange rate unification and the establishment of a managed float exchange rate regime raised the issue of the appropriate nominal anchor, as well as the related supporting policies. Since Iran has chosen a managed float exchange rate regime, price stability should be an overriding objective of monetary policy, see Sundararaian *et al* (1999) and Celasun (2003).

revenues which is influenced by macroeconomic policies. For instance, monetary policy involved printing money to convert oil revenue into domestic currency before being spent by the government. Fiscal policy was also linked to the oil sector as government expenditure was financed mainly through oil revenue.[35]

3.5.2.2 Trade and Foreign Exchange Policy

This section explores the relationship between macroeconomic fluctuations and changes in price and quantity variables that are relevant to international trade. The correlations of output fluctuations with fluctuations in merchandise trade and measures of both nominal and real effective exchange rates are examined. One measure of foreign trade transactions is the trade balance, construed as the difference between real exports and real imports and divided by real GDP in order to control for scale effects. In the absence of accessible data on price deflators for exports and imports, many authors use the ratio of the sum of nominal exports and imports to output. Since neither the private sector nor the government have enough reserves to provide the necessary level of capital, the issue of foreign investment surfaces.

Concerning the trade policy, oil exports constituted the main part of exports, with imports closely linked to oil revenue. The government has played an important role in the international trade, as an oil exporter, and the provider of foreign currency. However, the government not only affects the trade balance directly by exporting oil and importing goods and services but also uses an indirect control on the allocation of foreign currencies to private importers. The government has generally aimed at improving the competitiveness of the economy and devaluation of the domestic currency was implemented (Moradi, 2000).

[35] See also Moradi (2000).

Access to oil revenue has a major effect on both the exchange rate regime and trade policy. The effect of a devaluation of the exchange rate will differ over time. In recent years the distinction between nominal and real exchange rates has become increasingly important. Whereas the nominal exchange rate is a monetary concept that measures the relative price of two monies, the real exchange rate is a concept that measures the relative prices of two commodities. The real exchange rate (RER) is defined as the relative price of tradable goods with respect to non-tradable goods in the same currency (Edwards, 1989).[36]

The country's foreign trade (external) sectoral dependency on the exchange revenues of oil exports are exposed by studying the components of the import and export market as a whole. Export of oil during 1959-2004 constituted more than 90% of the country's total exports; and on average, 59% of the country's imports were raw material and intermediary goods, and in general more than 80% of imports included production inputs (raw material, intermediary and capital goods) (Samsamy, 2003).

The approach of the Iranian authorities to its exchange rate policy over past decades indicated a strong preference towards maintaining stable nominal exchange rates, as fixed official exchange rates until 1997. An obstruction to the maintenance of fixed official rates has been high inflation and the resulting appreciation of the official rate in real terms, as evidenced by large premiums over the official exchange rates on the parallel market, fuelled mainly by strong monetary expansion to finance the public

[36] An important point about the trend of RER is that the real appreciation started after the first oil price rise in 1973 and continued through to the post-revolutionary period when it was accompanied by the second oil price shock. There was an increase in import and export in 1989 due to the implementation of the economic reform programme that included liberalisation of trade, and the allocation of foreign currencies at the official floating rate.

sector.[37] The parallel market exchange rate itself has been determined in the formal market, which was itself influenced by the pricing system of the official market. Hence it cannot be considered as a suitable measure for exchange rate determination for the Iranian economy (Samsamy, 2003).

3.6 Summary

This chapter has discussed the implications of oil price shocks on the macroeconomic performance of Iranian economy as a primary commodity dependent economy that is centrally planned. It has found that the economy has been affected by internal and external disturbances over the last forty years due to a wide range of domestic, regional and international events, particularly fluctuations in oil prices. Iran as a small open economy has been highly dependent on oil export earnings and responsive to international disturbances. It was found that foreign exchange revenue and oil prices were determined exogenously in the international market. These brought Iran's economy as a price taker, vulnerable to oil price changes. Macroeconomic performance of the economy has shown that oil price and oil revenue have played an important role and influenced on main macroeconomic indicators. These impacts have brought the government attention to rule a decision to adjust and stabilize the price of oil as a dominant sector.

The structure of the economy is based on five-year development plans and government ownership. The role of the government has been highlighted in taking decisions and making policies in response to oil price fluctuations and the concentration of its efforts on restructuring the economy. The structural behaviour of

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[37] The exchange of dollar earnings on oil exports into domestic currency put pressure on the domestic currency to appreciate. A nominal appreciation is likely to lead to an appreciation of the real exchange rate. If the government uses the domestic currency and spends it on domestic goods, this will put upward pressure on the prices of non-traded goods and generate additional upward pressure on the real exchange rate (IMF, 2003).

the Iranian economy is predictably and largely influenced by fluctuating oil prices. As the recipient of oil revenue, the state as the dominant economic actor absorbs oil revenues from foreign exchange.

Experience gained from the expansion of non-oil exports has encouraged the government to adopt sustained policies to ease its heavy dependence on oil proceeds. In other words, economic policy on exports should be directed toward a sustained growth in non-oil exports, and toward the exploitation of the country's relative priorities in the world economic forums, with the private sector playing a major role. To determine the importance of oil revenues on economic activity a theoretical framework is needed for further examination.

Despite Iran's determination to reduce economic dependence on oil, it has a long and difficult road ahead of it. Iran may need to make enough investment in the oil industry to ensure continued supply for domestic use and export, and integrate oil, gas and petrochemical industries into the national economic structure so that these industries, as a whole, can serve as a dynamic vehicle for industrial development.

It was found that an oil price shock is one of the sources of business cycles in the Iranian economy. The apparent correlations between oil price shocks and the business cycle need to be analyzed more fully in the context of a real business cycle model. To define the cyclical behaviour of the Iranian economy, we refer to historical output data and the definition of business cycles, which will be explained in the next chapter.

CHAPTER 4

Business Cycle Theory

4.1 Introduction

This chapter introduces an overview of business cycle theory and its ability to explain the fluctuations in a primary commodity dependent economy. Special attention is paid to key assumptions and major policy implications of business cycle theory. Historically, fluctuations have taken place around a path of long-run growth. The relation between the forces contributing to growth and those making for fluctuations are one of the most important issues in the theory of the business cycle (Matthews, 1959). The objective of business cycle analysis is determination of the cyclical peaks and troughs in the time series, in particular GDP.

An alternative option would be to divide shocks into temporary or short-run effects and permanent or long-run effects. Understanding and distinguishing the factors that affect the short-and long-run behaviour of macroeconomic time series have been the main aim of recent research in quantitative macroeconomic analysis (Hughes, 1952).[1] The neoclassical theorists believe that GDP is moving along a path or long-run trend with some short-run fluctuations; whereas Nelson and Plosser (1982) argued that real shocks have a permanent effect on GDP, preventing it from regressing to its original path. Thus, the GDP is following a random walk (Kaboub, 2003). Nelson and Plosser (1982) argued that most macroeconomic time series are

[1] Mitchell (1951) gives a comprehensive summary of cyclical quantative analysis which contributes business cycle theory.

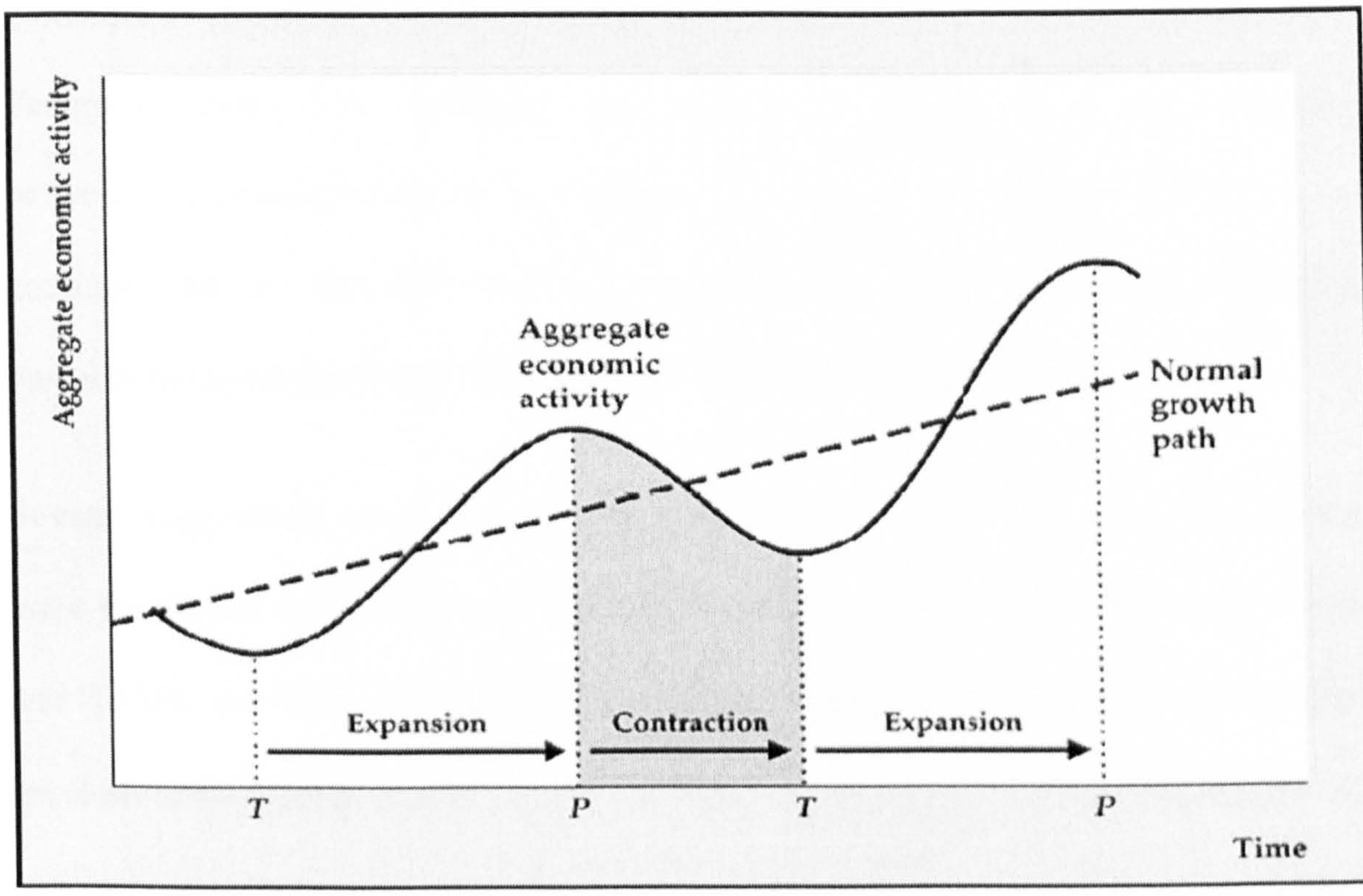
described as a random walk, rather than as fluctuations or deviation from deterministic trends.

Important empirical efforts have been concentrated on identifying the main characteristics of business cycle theory. Romer (1996) argued that the importance of understanding the cause of aggregate economic fluctuations is a central goal of macroeconomics. Understanding fluctuations in the level of economic activity is a main interest among economists.

This chapter has six sections. Section 4.2 explores the definition and analytical overview of the business cycles. Section 4.3 presents the classical behaviour of time series. Section 4.4 reviews the relationship between business cycles and oil price shocks. Section 4.5 presents a brief overview of business cycles in developing countries, while section 4.6 discusses Iranian business cycles based on oil price changes. Section 4.7 provides a summary.

4.2 Definition and Analytical Overview of Business Cycles

A business cycle is defined as a period of economic decline, or contraction, which often leads to a restriction of business activity and the compression of the profit margins of business firms, followed by a longer expansionary period (Figure 4.1). These cycles occur at regular intervals in a market economy when the rate of real economic growth exceeds the growth in the potential of the economy to produce goods and services. The business cycle refers to the ups and downs seen simultaneously in most parts of an economy. It involves shifts over time between periods of relatively rapid growth (expansion), alternating with periods of relative recession (contraction). A recession is usually defined in macroeconomics as a fall of country's GDP (Rand and Tarp, 2001). The business cycle peak and trough dates for each economy are chosen on the basis of the turning points in the coincident index and its components. This ensures that the same definition of recession is used for all countries, and business cycles are comparable across them (Bry and Boschan, 1971).



Source:http://www.courses.rochester.edu/guvenen/econ209/CH8.pdf#search='real%20business%20cycle%20and%20opec' Accessed on 10/10/2006

Figure 4.1 Business Cycle Definitions

Economic Cycle Research Institute (ECRI) identifies business cycle recessions and expansions and their turning points (peaks and troughs), and used an algorithm codifying the judgmental procedures, which was used by business cycle analysts (Bry and Boschan, 1971).[2] The cyclical movements associated with these common turning points are sufficiently persistent and widespread across sectors, then an aggregate business cycle is identified and its peaks and troughs are dated (Taylor and Woodford, 1999:8).

[2] The National Bureau of Economic Research (NBER) defined recession as a persistent period of decline in total output, income, employment, and trade, usually lasting from six months to a year, and marked by widespread contractions in many sectors of the economy.

Politicians are mainly interested in the level of economic activity and focus on turning points and the alternating periods of recessions and expansion phases while academic economists in the last two decades have mainly focused on second moments of real GDP and its components after the removal of its trend component Pedersen (2002). This difference in perspective corresponds to the difference between the classical business cycle analysis of Burns and Mitchell (1946) that is continued by the National Bureau of Economic Research (NBER) and modern business cycle research with its focus on trend adjusted variables.

Several suggestions have been put forward pertaining to cycles. The best known were developed by Samuelson, Hicks, Goodwin, Phillips and Kalecki in the 1940s and 1950s, combines the multiplier with the accelerator theory of investment-accelerator-multiplier model. Some theories of the cycle include the notion of national expectations or the idea that expectations are more forward looking (Matthews, 1959).

Kaboub (2003) argued that Keynesians and monetarists focused their macroeconomic analysis with respect to the business cycle on the traditional aggregate demand approach introduced by Keynes in 1936. The traditional view that business cycles simply represent a continuous sequence of positive and negative growth is deeply entrenched in the minds of economists and policy makers. However, Kontolemis (1997) define business cycles as temporary disturbances of normal or potential growth, with a three-phase model of the business cycle: Hicks's ceiling model (1950), Friedman's plucking model (1969, 1993), and the output gap model (De Long and Summers, 1988).[3]

Burns and Mitchell (1946) define business cycle as follows.[4]

> *"Business cycles are a type of fluctuation found in the aggregate economic activity of nations that organize their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle The sequence of cyclical changes is recurrent but not periodic and in duration cycles vary from more than one year to ten, even twelve years."*

The definition of business cycle by Burns and Mitchell highlights two key features. First is the co-movement among individual economic variables, which take into account possible leads and lags in timing. The second is deviation of business cycles into separate phases: expansions and contractions (Diebold and Rudebusch, 1996). To identify the definition of Burns and Mitchell, some researchers claim that business cycles are similar to comovements. Lucas (1977) argued that is suggests the possibility of unified explanation of business cycles grounded in the general laws governing market economies.

Nelson and Plosser (1982) have challenged the traditional view by testing whether macroeconomic time series are better characterized as stationary fluctuations around a deterministic trend or as non-stationary processes that have no tendency to return to a deterministic path. Their alternative view stated that most macroeconomic variables

[3] Hicks (1952:102) explained four phases over the business cycle. The model includes a slump and recovery period within each contraction and boom phase. This description follows business cycles definition by Burns and Mitchell (1946:7) which argued that expansion is followed by recession, recession by contraction, contraction by revival, and revival by a fresh expansion.
[4] See Burns and Mitchell (1946) page 4 and also Snowdon *et al* (1994).

do not possess a tendency to return to deterministic trend. The tendency is better described as non-stationary stochastic rather than deterministic.[5]

Generally, business cycle models as separate from models of economic growth and to characterize business cycles as the deviations from some smooth, usually deterministic, trend that proxies growth. Theories of business cycle models are then constructed to explain these deviations. Plosser (1989) argued that tests of business cycle theories are actually joint tests of the model for growth (the trend) and the model for the cycle. He highlighted some important characteristics that should be taken into account in defining the business cycle:

> *'When we think in business cycles, we frequently think about notions of persistence or serial correlation in economic aggregates; co-movement among economic activities; leading or lagging variables relative to output; and different amplitudes or volatilities of various series'.(page 53)*

Plosser (1989) argued that business cycles are often related to the idea of persistence and serial correlation in economic activities. The fluctuations do not exhibit any single regular or cyclical pattern. They occur at random intervals and the strength of fluctuations also varies.

Although Abel and Bernanke (1992) argued that to be completely successful, a theory of the business cycle should be able to explain not just the cyclical behaviour of the few variables such as output but also the cyclical patterns found in other important economic variables.

With respect to the dynamics of economic fluctuations, Romer (2001) pointed out that:[6]

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[5] Business cycle explains the difference between stochastic and deterministic trends that can be used to decompose a series into its temporary and permanent components (Enders, 1995). The trend is the nonstationary component of growth and the cyclical and irregular component are stationary.

'Because output movements are not regular, modern macroeconomics has generally turned away from attempts to interpret fluctuations as combinations of deterministic cycles of different lengths. Instead, the prevailing view is that the economy is perturbed by disturbances of various types and sizes at more or less random intervals, and those disturbances then propagate through the economy'.(page 169)

Business cycles are irregular fluctuations of output around trend. Lucas (1977) argued that the movements of any single economic aggregate are irregular. However, there are regularities, which are observed in the co-movements among different time series. According to a review of the literature, an economic time series consist of a trend and cyclical component (Goodwin, 1993).[7] This tendency to follow a smooth path (or natural rate of growth) is fixed by economic determinants. For example, in the case of output, factors such as capital accumulation, population growth and technology are assumed to be the source of the growth.

Interest in business cycle theory is itself cyclical (Mullineux *et al.*, 1993). Stiglitz (1992) has argued that it is possible to recognize four major theories of the business cycle. The first is based on asymmetries of information; the second is a standard real business cycle model; the third is the New Classical model of price forecast errors, and the fourth concerns models of imperfect competition.[8]

The long-run history of empirical analysis of business cycles was introduced by the classical techniques of business cycle analysis. Using a variety of econometric

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[6] Two theoretical approaches have been used to study business cycles: deterministic cycles, and stochastic cycles. The more modern and widely accepted view is that cycles represent the simulation of random shocks over time.

[7] The size of a contraction importantly influences the size of the following expansion with major expansions tending to follow major contractions; the size of an expansion, however, has no stable relationship to the size of the following contraction. Friedman offers theoretical reasons for the existence of these regularities.

[8] Imperfect competition provides a more satisfactory framework to evaluate the need for and effects of macroeconomic policy (Walrasian framework). Whilst the subject of imperfect competition has been developed during the last two decades in the scope of closed economies, it's implications for open economies have received little attention. Imperfect competition improves the behaviour of a standard model driven by technology and government shocks (Ubide, 1999).

techniques, a substantial body of literature has documented a wide range of empirical features in macroeconomic fluctuations and business cycles across countries. However, there is general agreement that cyclical fluctuations in national income are caused by changes in the level of aggregate demand. Changes in supply conditions may also play a significant part in the cycle, but it is the rise and fall in demand that is of major importance (Matthews, 1959).

4.3 Business Cycles: The Classical Behaviour of Time Series

This section, by using statistical techniques, provides a time series analysis of cyclical behaviour of macroeconomic fluctuations. A time series is a set of numbers that measures the status of some activity over time and may be stationary or exhibit a trend over time. The value of time series analysis is defining stationarity and using econometric methods to estimate this unique process[9] under assumed conditions; and using econometrics to forecast variables. The classical view of a time series is that it is made up of four distinct components: secular trend, cyclical variation, seasonal variation, and random or irregular variation (Burns and Mitchell, 1946).

Secular trend is typically modelled as a linear, quadratic or exponential function. The secular trend component captures the long-run movement of a time series. An example of secular trend is the long-run growth of gross domestic product (GDP) in Iran, over the last 40 years. It has averaged approximately 3% during the period 1960-2000, but has been volatile since (CBI, 2000).[10]

The second component of a time series is the cyclical variation that is an increase or decrease in the level of the variable around the trend line. A cycle may be

[9] Consider a time series x_t that is covariance-stationary in the sense that it has a time-invariant expected value and auto-covariance structure. Then there exists a unique representation of this series as a realization of stationary, stochastic time series process.
[10] Central Bank of Iran (CBI), Economic Report (2000)

characterized in terms of its period and amplitude. The period is the length of the cycle and by definition is constant for each movement through peak, downswing, trough, and upswing. The amplitude is the distance from the mean level of the series (after detrending) to the peak or trough and is also assumed to remain constant over time. Some economists believe that several cycle wavelengths exist, perhaps simultaneously. For example, the Kondratieff cycle [50 to 60 years], the Juglar cycle [7 to 12 years], and the Kitchen cycle [3 to 4 years] may operate simultaneously (Harrison and Tamaschke, 1984).

Seasonal variation is the third component of a time series and is a short-term movement often associated with the result of climate, and social customs. In other words, seasonality is a pattern that repeats regularly through a year. For example, oil prices reflect changes in demand and supply between summer and winter; agricultural crops are only harvested in summer and autumn; when a repetitive pattern is observed over some time horizon, the series is said to have seasonal behaviour.

The final component of a time series is the random or irregular variation, which cannot be predicted, such as episodic and residual variation. Randomness is irregular, unpredictable noise causing high frequency fluctuations in the data. It might be seen as an irregular component of the cycle and reflects persistent economic and social factors, such as oil price shocks that can have an effect on such time series.

There are two models used to analyze time series - additive and multiplicative[11]. The additive model can be written as:

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[11] Both models perform decomposition on a time series. They calculate and display the components of the time series. See also: http://espse.ed.psu.edu/statistics/statlets/usermanual/sect6_3_2.htm#top

$$X_t = T_t + C_t + S_t + I_t \tag{4.1}$$

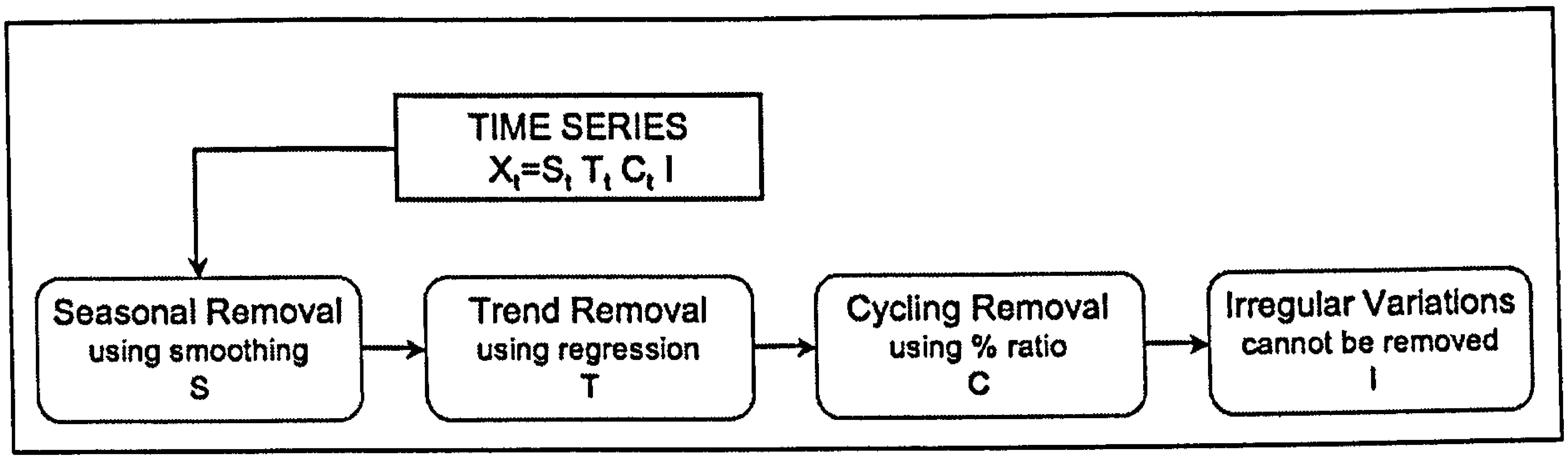
where X_t is the observed value and T_t, C_t, S_t, I, are the trend, cyclical, seasonal, and irregular time series components, respectively. Whereas the multiplicative model can be written as:

$$X_t = T_t * C_t * S_t * I_t \tag{4.2}$$

The first three components (T, C, S) are deterministic and are called 'signals', while the last component (I) is a random variable. Techniques of time series analysis, used in solving these equations are:

- The measurement of trend in which the trend itself may be the main concern, and then removing the trend from the cyclical component.
- Using a moving average which is the simplest mechanical method of obtaining an indication of the general trend in a series. Here positive and negative variations are pooled together and tend to cancel each other out.
- Cyclical analysis in which a cycle may be characterized in terms of its period and amplitude. Each cycle within a series has its own period and amplitude, and in general cycles differ in phase (or timing of their peaks) (Harrison and Tamaschke, 1984).

The crucial questions in modern empirical business cycle research are how to define the trend and how to extract the trend component from the underlying economic time series, so that what is left is something that can be interpreted as the business cycle component.



Source: Arsham, 2004- Adopted by Author

Figure 4.2 Time Series Decomposition

Decomposition analysis is used to identify from the four components that appear simultaneously in a time series. Figure 4.2 shows the three signals decomposition and its reversal processes for forecasting time series. To understand and measure these components, the forecast procedure involves decomposing the component effects from the data. After the effects are measured, making a forecast involves reconstructing forecast estimates (Arsham, 2004).[12] The first step of time series decomposition is to remove seasonal effects in the data that repeat continually with similar timing and strength.

The second step is the measurement of trend (T) in which the trend itself may be the main concern. The cycles can be easily studied if the trend itself is removed. If the effects of trend are removed it may be easier to identify the tendencies of data to increase or decrease. Since the work of Hodrick and Prescott (1980)[13], a large number of statistical methods have been developed for filtering the stochastic trend from a macroeconomic time series. Fluctuations in the economy are assumed to dissipate over time and the trend is assumed to be an independent component that follows a natural rate of growth that varies slowly with time (Pedersen, 2002).

[12] Lucas (1981a) distinguished cycle from trend. See in the link: http://home.ubalt.edu/ntsbarsh/stat-data/Forecast.htm#rhowtrend

[13] Prescott (1986) and King and Rebelo (1993) developed a statistical definition of the business cycle component (or growth cycle) and developed a widely used method for summarizing the dynamics of empirical facts about growth cycles in the form of sample second moments summarizing the variation and serial correlation between economic variables.

The third step requires the cyclical removals that are general up-and-down data changes due to changes in the recession and expansion. The general effect of cycle on data levels can be calculated by a series of cycle. Predicted data levels using the trend equation may represent pure trend effects.

The final step, irregularities (I) are any fluctuations not classified as one of the above. This component of the time series is unexplainable and unpredictable. Estimation of irregularities can be anticipated only when its variance is small. Otherwise, it is not possible to decompose a series. If the magnitude of variation is large, the projection for the future values may be inaccurate. The best one can do is to give a probabilistic interval for the future value with a known probability of irregularities (Arsham, 2004).

The extent to which each of these components (trend, cyclical, seasonal and random) is represented in a particular series depends on the nature of the variable and the time horizon over which the data are recorded. Various procedures to measure or isolate these components have been presented; the choice of procedure depends in part on whether an additive or multiplicative model is assumed. Often the motivation for time series analysis is a desire to predict the future (Harrison and Tamaschke, 1984). Time series models forecast future quantities or prices on the basis of past movements in the given series alone. The processing of time series data is relevant to econometric theory, in which some time series are modelled exclusively in terms of their own past behaviour as the only systematic information available.

An argument is that the business cycle is caused not only by fluctuations in aggregate demand, but also by random shocks such as wars, weather disturbances, new technological developments and new social developments in the conditions under which producers supply their products (supply side economics)[14] as evidenced by the oil shocks of the 1970s.

4.4 Business Cycles and Oil Price Shocks

Bruno and Sachs (1982) argued that one of the identifiable sources of shocks that have claimed the attention of many economists is oil price shocks. Oil price shocks have shown that business cycles are repeatable phenomena but they might be different in terms of their domain movement and cycling period.[15] The empirical literature on the macroeconomic impacts of oil supply shocks developed gradually after 1973. One of the initial beliefs, following the 1973-74 oil price shock, was that the new, higher price of oil might be a permanent feature of a changed natural resource regime. An assumption is made by adjusting supply shocks in an economy and circumstances after oil price shock (Bruno and Sachs, 1985).

Darby (1982) estimated the impact of the 1973-74 oil price shocks on real income in eight OECD countries. He was dissatisfied with the ability of the limited data to distinguish among three factors that might have contributed to the recession: oil price shocks; a largely independent course of monetary policy fighting inflation in the wake of the 1973 collapse of the Bretton Woods system; and a partly statistical, partly real effect, of the imposition and subsequent elimination of price controls over the period 1971-75.

[14] Price shock is one of the main sources of macroeconomic fluctuations in primary dependent economy and exporting country and needs to be investigated as a real shock in the supply side of economy. Other kinds of supply shocks are wars, weather disturbances such as drought, new technological developments and new social developments such as industrialization.

[15] The fluctuations in the economy, commonly observed through changes in real GDP and unemployment. In the 1930s, economists attempted to forecast major macroeconomic variables such as GDP, price levels, and unemployment. In this regards, the structure of the combined indicators was studied in particular and econometric techniques were effectively employed in diversifying and explaining such indices.

Darby (1982) looked at the availability of internationally comparable data, that would permit a similar investigation into the 1979-80 oil price shock, but this line of research has not been pursued consistently since the early 1980s. Hamilton's (1983) has shown the important role of oil price shocks in business cycles of United States and its considerable influence on the macroeconomics of this country. He explained an inverse relationship between oil prices and aggregate economic activity. Mork (1994) reviewed the methods of integrating oil price shocks into macroeconomic models before discussions on the relationships between real business cycle (RBC) models and oil price shocks were developed. Jones and Leiby (1996) argued that an oil price shock can be a believable mechanism that yielded the unanticipated, temporary supply shocks needed by the RBC models.

Mork (1994) explained the theoretical relationship between macroeconomics and oil price shocks using various econometric techniques. He argued that typically RBC models contain common circulation mechanisms for the effects of shocks: consumption smoothing, lags in the investment process, intertemporal substitution of leisure.[16]

Kim and Loungani (1992), Rotemberg and Woodford (1996), and Finn (2000) have studied the effects of energy price shocks in RBC models. They concluded that these shocks had significant explanatory power on the performance of real business cycle models, but that they are not a major cause of output fluctuations. Rebelo (2005) argued that energy prices are highly volatile; energy costs are too small as a fraction of value added for changes in energy prices to have a major impact on economic activity.

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[16] See also Jalali-Naini and Asali (2004).

The 1986 decline of the oil price, despite the two shocks of the 1970s, caused researchers to reconsider the origins and the probable future of oil price shocks. Hamilton (1983) shifted the macroeconomic analysis of oil shocks from demand-side phenomena to the supply side and relied on the statistical concept of Granger causality to test for directions of effect in a business cycle setting of shocks. Watkins (1992) has reinforced interpretation of oil market events of the 1970s and 1980s on the predictive capability of the Hotelling (1933)[17] exhaustible resource model.

The effects of oil price shocks on the economies of industrialized countries have been widely recognized in the literature (Kilian, 2005). Authors such as Pindyck (1979), Hamilton (1983) and Olson (1988) suggest that these shocks affect growth as well as the business cycle, thereby creating an additional source of economic fluctuation. Mork 1989 (1994) argue that there is an extensive empirical literature that offers evidence of an asymmetric relationship between oil prices changes and aggregate economic activity. Mork (1994) show that an upward price shock may negatively influence the level of economic activity, but a decline does not lead to an increase in output. Clements and Krolzig (2000) show that the asymmetries identified in the business cycles do not appear to be understandable by changes in the real price of oil.[18] Such asymmetry has been attributed to a wide range of explanations: adjustment costs, financial stress, monetary policy (See Balke *et al.* 2002 for a discussion about the origin of this asymmetry).[19]

Mork *et al.* (1994) have explained general grouping of approaches as follows:

[17] The Hotelling role for oil assumes that oil is an asset of the economy. If kept under ground it is a valuable asset. Otherwise, producing and exporting oil creates income for the economy. Assuming oil is an asset it would bring into play analysis of long-run changes in oil price (Jones and Leiby, 1996).

[18] See also Jalali-Naini and Asali (2004).

[19] Using a model of asymmetric price responses, Smyth (1993) finds an alternative concept of asymmetry that implemented by Mory (1994) and Mork *et al.* (1994), a process in which only oil price increases above the previous maximum price reduce aggregate production and price changes below that range have no effect.

- First the macroeconomic response to oil price shocks examines whether an asymmetric response is expected theoretically and whether the asymmetric response reveals that the impacts of the positive oil price shocks of the 1970s were substantially overstated, having been confused with other events?

- Secondly close association with the business cycle literature brought to oil-macroeconomic research a well-developed (although still evolving) body of thought on business cycle transmission mechanisms.

Subsequent literatures on the macroeconomics of oil shocks have addressed different issues for a number of developed countries. These studies report a statistically significant negative elasticity for oil price increases and non-significant positive elasticity for price decreases on output. However, fluctuations in the world prices of primary, capital, and intermediate goods could have an important impact on the business cycles of developing countries.[20] International oil price shocks play an important role in identifying business cycles in small open developing countries, as primary commodity dependent economies. Generally 88% of aggregate output fluctuations, in these economies, can be explained by international price shocks (Kose, 2002).

Kose (2002) also argued that there are three main reasons for the impacts of world price shocks in these economies. First, is the direct effect of world price shocks on both primary and non-traded final goods sectors. The second is that world price shocks have a greater impact on the import of capital and intermediate goods.[21] The

[20] He examined 28 non-oil exporting developing countries, based on annual data, and also the G7 countries for comparison. See also Agenor and Montiel (1996).
[21] Prebisch and Singer (1950) argued that developing countries with primary export commodities are able to import less for a given level of exports because of the demand for manufactured goods increases more rapidly than demand for primary products (Wikipedia, 2006).

final reason is volatility in the relative world price shocks is higher than terms of trade and productivity shocks.[22]

Understanding the sources of business cycles and transmission of oil price shocks is crucial in the design and conduct of macroeconomic policies. In particular, analysis of the implications of government policies aiming to stabilize business cycles generated by oil price shocks seems to be an abundant research avenue (Kose, 2002).

4.5 An Overview of Business Cycles in Developing Countries

Kose (2002) argued that developing countries differ from developed economies along several structural dimensions such as being heavily dependent on unstable export earnings of primary commodities, vulnerable to fluctuations in the relative primary commodity prices, large foreign debt compared with their export revenues, and heavily dependent on imported capital and intermediate goods for domestic production.

A key issue concerning business cycle fluctuations in developing countries is whether aggregate fluctuations are similar to those observed in developed countries.[23] As business cycles in developing countries show different properties relative to those of developed countries, an alternative definition of the business cycle is proposed in respect of the former. This alternative definition is useful not

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[22] Apart from the existing literature, (Koutparitsas, 1997); (Backus and Crucini, 1998) on the role of oil price fluctuations which has mainly focused on industrialized countries or models of international trade, few attempts have been made to analyze the impact of the volatility in oil resource revenue on growth business cycle behaviour from the point of view of the producing country. Indeed, a large amount of trade in these economies comes from oil exports and is largely influenced by oil price shocks. Aggregate fluctuations in developing countries exhibit a high volatility of the terms of trade McCallum (1989), Mendoza (1995), and Kose and Riezman (2001).

[23] A simple way of approaching this issue is to examine summary statistics for the stationary components of industrial output (Greenway and Chris, 1993).

only in understanding the phenomenon, but also in identifying and extracting the cyclical component from a set of economic time series (Lama, 2005).[24]

There are issues dealing with business cycle in developing countries:

- The standard procedure and methodological restrictions: These restrictions are: limited availability of data, short length of the time series, and recurrent structural changes.

- The data: In selecting the data, it is important to consider that most of the developing countries are highly vulnerable to shocks in the prices of export commodities or primary commodities like oil. Also the data may have some problems with stationarity process that differentiate by using unit root test process.

- Statistical robustness: It can be shown that statistical robustness in estimation is an ideal and desirable objective. Unfortunately, most time series from developing countries are not long enough to guarantee such robustness.

However, there are at least two factors that may account for analysing business cycles in developing countries. The first concerns limitations of the quality and frequency of data. For instance, quarterly data on national accounts are available for only a few of the developing countries and cover only a few years. Even where they are available, they are considered to be of significantly lower quality than annual data. Second, the developing countries tend to face unexpected crises and marked

[24] Structural shocks are identified as the main sources behind the developing countries as well as the Middle Eastern business cycles. Economic crises and political changes may be the factors behind the differences in volatility, timing, direction, and persistence associated with the economic fluctuations in developing countries.

fluctuations in macroeconomic variables, often making it difficult to differentiate any type of cycle of economic activities (Agenor *et al.* 1999).

Rand and Tarp (2002) investigated business cycles in 15 developing countries, covering 19 macroeconomic variables. They argued that supply shocks are the main sources of short-run fluctuations and supply side models are most useful in explaining these fluctuations. They found that business cycles in developing countries were influenced by the 1979 oil price shock and subsequent recession in the developed countries.[25] They argued that business cycles in developing countries are different in duration and turning points compared with developed countries. So, understanding the causes of business cycles is the key objective of macroeconomics to design an appropriate stabilization policy in developing countries.

The following section show Iran's economy can satisfactorily demonstrate the impacts of oil price shocks on cyclical behaviour of output for a small open oil-dependent economy.

4.6 Business Cycle in the Iranian Economy

The identification and measurement of macroeconomic fluctuations can be analysed by examining common elements in the behaviour of aggregate time series representing different sectors of the economy. Aggregate measures such as real GDP, oil and non-oil GDP are typically used in place of individual output series in the analysis of short-run fluctuations. Romer (1991) suggests that the main focus of the dependency of aggregate analysis on output is changes in the cyclical behaviour of output over time. Pedersen (2002) argued that economists in the last two decades

[25] Kouparitsas (2001) supported this issue by evaluating the extent to which macroeconomic fluctuations in developing non-oil exporting countries are caused by shocks in developed countries. Lucas (1981) argued that understanding the characteristics of short-run macroeconomic fluctuations is the first step in designing appropriate stabilization policies.

have focused on identifying turning points and investigating alternating periods of recession and expansion in real GDP.

This section examines the effects of oil price shocks on cyclical behaviour of output - oil and non-oil output. Since the GDP includes cyclical behaviour, it is necessary to decompose the observed series into trend and cyclical components (Apergis, 1996). Kydland and Prescott (1990) suggest that one commonly used approach to extract cycles is to use the Hodrick-Prescott (HP) (1980) filter. The HP filter is used to obtain a smooth estimate of the long-term trend component of historical data (Baldini, 2005). This filter is constructed based on the idea that the trend and cycles can be separated and that not all frequencies observed in a variable are a business cycle frequency (Jalali-Naini and Asali, 2004).[26]

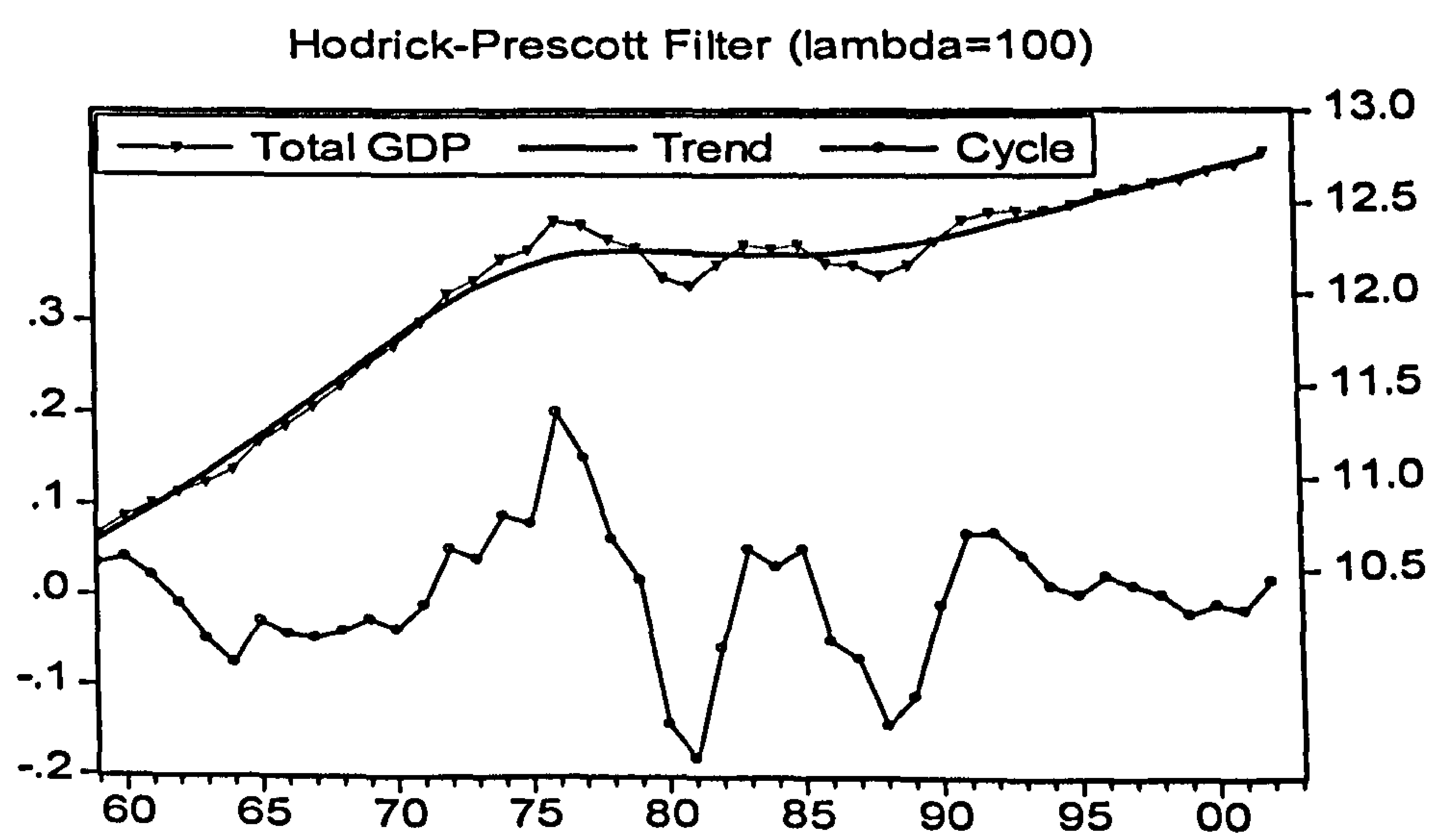
The HP-Filter has been used extensively for the purpose of detrending real output in order to obtain a stationary cyclical component (Khashadourin and Grammy, 2004). The detrending method[27] can be measured by estimating the actual business cycle after filtering with HP-filter which is the distance between the actual and the predicted business cycle (Pedersen, 2002). It extracts a stochastic trend, which for a given value of λ, moves smoothly over time and is correlated with the cycle. λ is

[26] Hartley *et al* (1997) suggest that methods of detrending are required to isolate trend from the cycle, its specification, and the producers employed to reach the solution, can help to explain the nature of macroeconomic fluctuations in an economy. The HP- filter removes the trend component of a time series (Cogley and Nason, 1991 and King and Rebelo, 1993).

[27] There are three approaches to detrending macroeconomic aggregates in order to observe the business cycle facts. The first implies removing the steady state level of the variable in logarithms without exception a higher variability in the variables, and a higher autocorrelation and cross-correlation of the variables with GDP. The second is the Hodrick-Prescott Filter (1980) on the logarithm of the variables. The third is using first difference. Methods of detrending are required to isolate trend from the cycle, its specification, and the procedures employed to reach the solution, can help to explain the nature of macroeconomic fluctuations in an economy (Hartley *et al,* 1997).

the smoothing parameter, which penalizes the variation in the growth rate of the trend.[28]

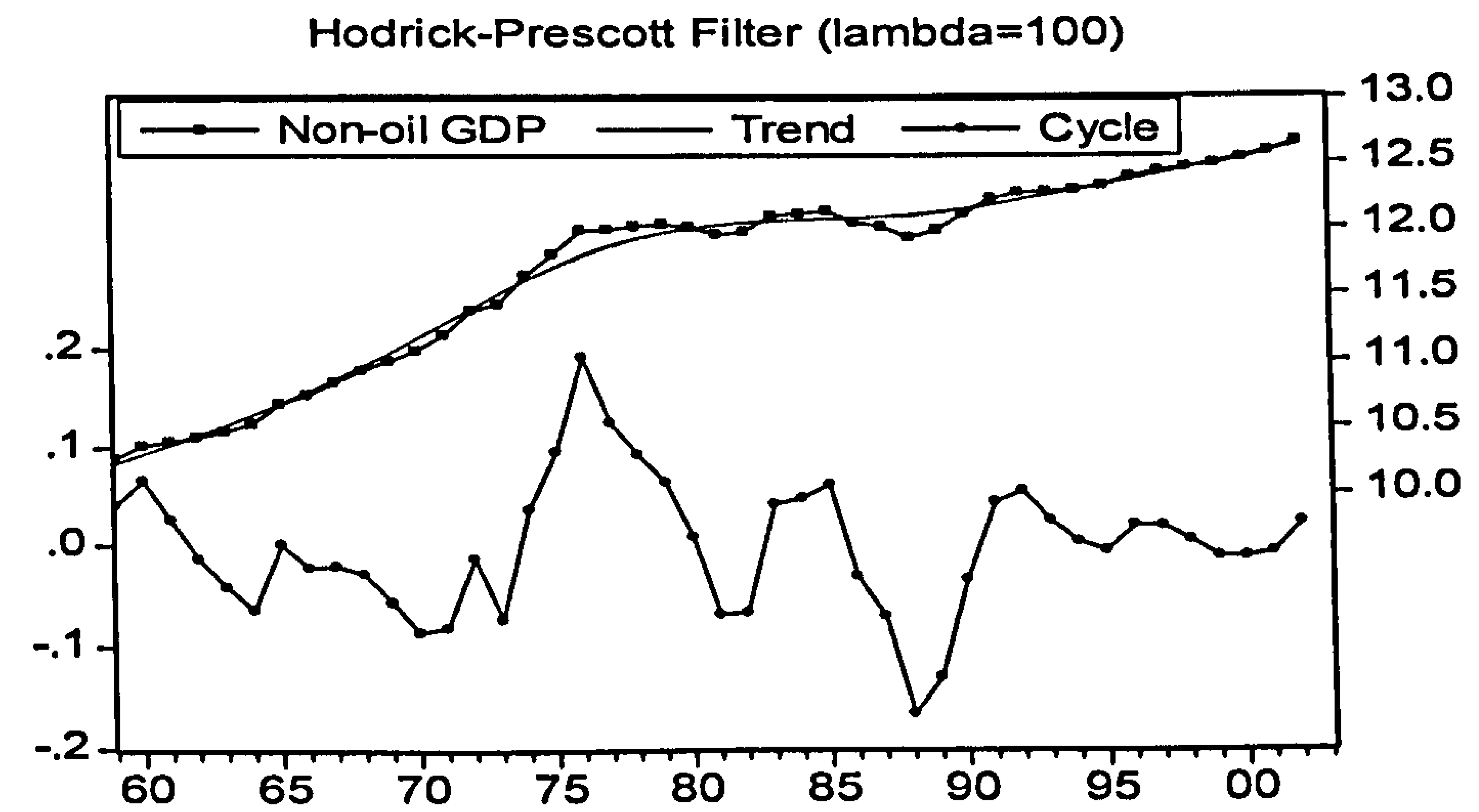
Figures 4.3 to 4.5 provide a snapshot of GDP and trend component for the Iranian business cycles during the period 1959-2004. They also display GDP and its HP trend with detrended oil and non-oil GDP. By using the HP filter to extract trend from cycle, the non-oil GDP appears to be more volatile than oil GDP, with the former displaying greater amplitude. Note that the Figures indicate a sharp increase in growth rate during 1974-76, as a result of performance of economy to sharp increase in 1973-74 oil prices, which followed by rapid increase in the oil export earnings at the same time. Figure 4.3 and 4.4 clearly demonstrate the existence of two business cycles – 1976-1984 and 1986-1991). However, Figure 4.5 shows only cycle -1979-1985, which roughly equates with the first cycle of Figure 4.3 and 4.4. So, it would appear that oil GDP did not demonstrate cyclical behaviour, except during the period which was dominated by the Revolution and Iran-Iraq war.



Compiled by Author, data source: Central Bank of Iran, Historical time series, 1959-2003, 2004

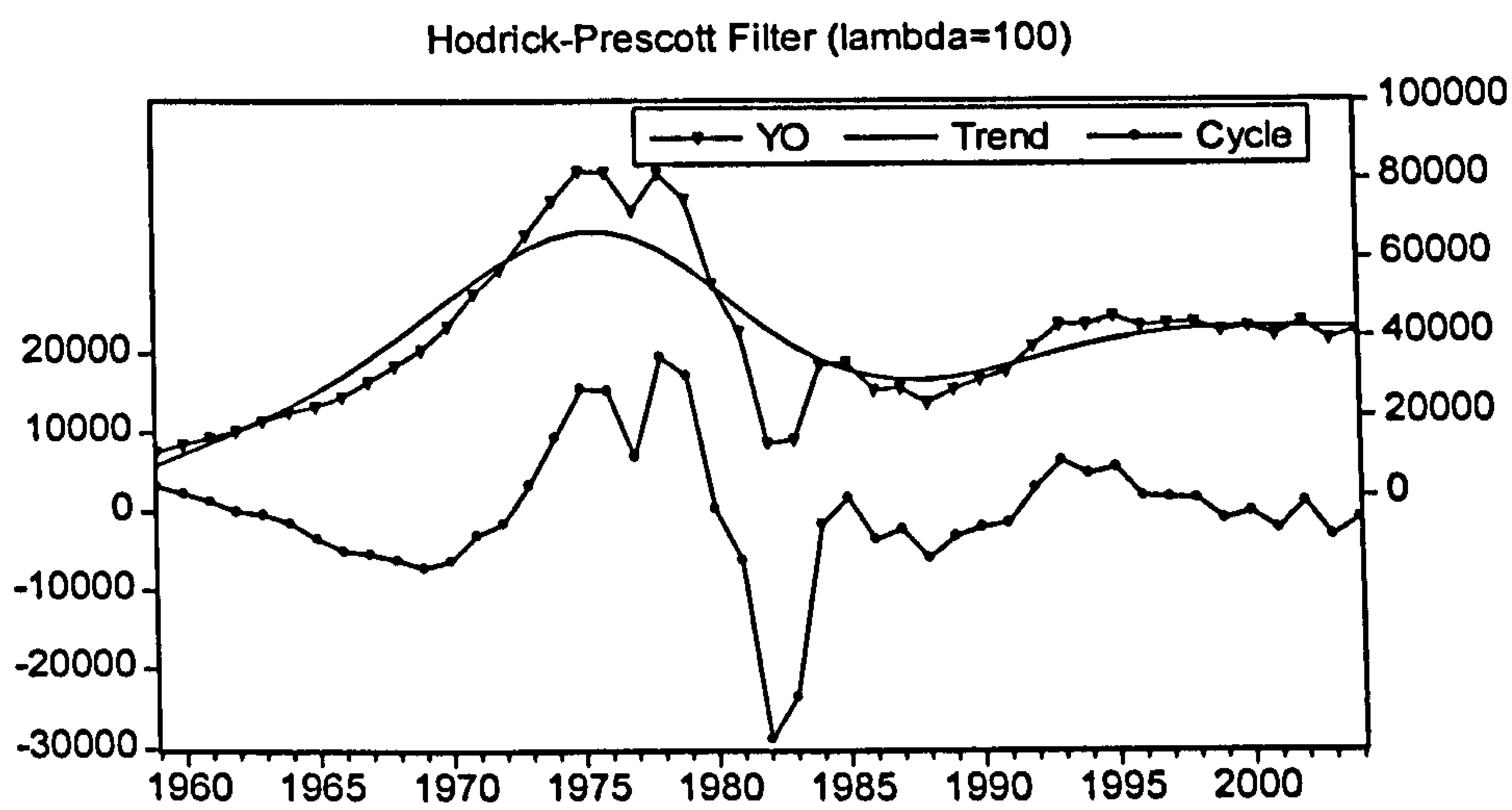
Figure 4.3 Extracted Trend from Cycle (Total GDP)

[28] The HP-filter decomposes a time series into two components: trend and cycle (Hodrick and Prescott, 1980), Kydland and Prescott (1990), and Prescott (1986). For annual data, the value of λ=100 which is used by Backus and Kehoe (1992), Giorno *et al.* (1995), and European Central Bank (2000), (see Maravall, 2001).



Compiled by Author, data source: Central Bank of Iran, Historical time series, 1959-2003, 2004

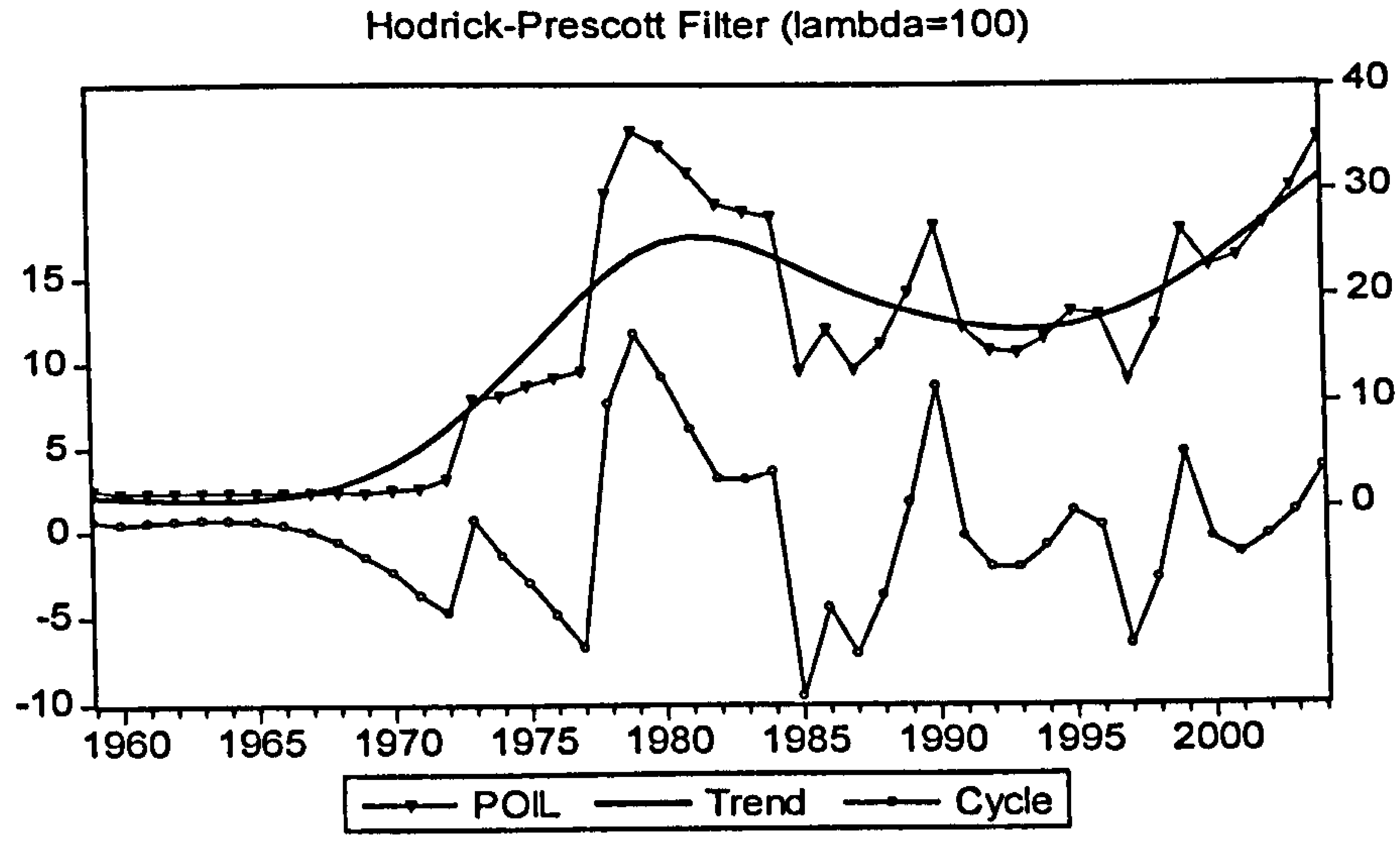
Figure 4.4 Extracted Trend from Cycle (non-oil GDP)



Compiled by Author, data source: Central Bank of Iran, Historical time series, 1959-2003, 2004

Figure 4.5 Extracted Trend from Cycle (Oil GDP)

In order to show the impact of the oil price fluctuations on business cycles, the HP filter was applied here to expose cyclical behaviour of the oil price.



Compiled by Author, data source: Central Bank of Iran, Historical time series, 1959-2003, 2004

Figure 4.6 Extracted Trend from Cycle (oil price)

Figure 4.6 provides extracted trend from cycle for the price of oil and reveal that the price of oil exhibited substantial cyclical behaviour during 1959-2004.[29] In addition to indicating possible changes in the behaviour of the economy, this analysis provided incontrovertible evidence of cyclical behaviour. The main finding is that the evolution of total GDP is closely associated with the evolution of the non-oil GDP, and the fluctuations may be related to the effects of oil price shocks. I n addition, while there has been little change in the behaviour of oil GDP over time, there were fluctuations during Revolution and Iran-Iraq war (1979-88).

The Iranian business cycle was tested by using the Hodrick-Prescott techniques on historical output data, and it was found that the cyclical component of the price of oil is related to the cyclical components both total and non-oil GDP, but it is not related to the cyclical component of oil GDP, which fluctuated only from 1979-88.

[29] The cycles have greater amplitude and higher frequency than the GDP cycles (Jalali-Naini and Asali, 2004:125). For instance, a positive oil price shocks tends to have a negative effect on the output. However, this negative effect may not happen, if the positive oil price shock is compensated by an accommodating an increase in production of oil. We could not test the compensatory effect, because it was not coordinated in response to the oil price shocks.

This suggests that macroeconomic fluctuations are generated by factors other than those related to the oil GDP. On the characteristics of the business cycle, a strong dominance of short-term cyclical components is observed for both the oil and the non-oil sector. However, the evidence shows that the trend of the oil GDP is more volatile than its cycle, indicating that the primary source of fluctuations in oil GDP seems to originate from shocks to the trend rather than from the business cycle.

4.7 Summary

This chapter has defined business cycles as advances and declines in aggregate output and has indicated that the purpose of the study is to improve economic performance. The history of business cycle theory from the 19th century shows that movement in output is a new phenomenon. There are a number of economists who have classified cycles according to their duration.

In recent years economic theory has moved towards the study of economic fluctuation rather than a business cycle - though some economists use the phrase business cycle. These views led to the formulation of the idea that observed economic fluctuations could be modelled as shocks to a system.

This chapter introduced an overview of the way that economy has business cycle, which business cycles are a type of fluctuation found in the aggregate economic activity of nations that organize their work mainly in business enterprises. Statistical techniques provide a time series analysis of cyclical behaviour of macroeconomic fluctuations with four distinct components: secular trend, cyclical variation, seasonal variation, and random or irregular variation. T ime series models forecast future quantities or prices on the basis of past movements in the given series alone.

The processing of time series data is relevant to econometric theory, in which some time series are modelled exclusively in terms of their own past behaviour as the only systematic information available. Econometric theory argues a suitable development real business cycle approach can be useful to understand the nature and characteristics of the business cycles in developing countries.

The results have shown that the evolution of total GDP is closely associated with the evolution of the non-oil GDP, and macroeconomic fluctuations may be related to the effects of oil price shocks due to fluctuations during Revolution and Iran-Iraq war. It also was found that the trend of the oil GDP is more volatile than its cycle, indicating that the primary source of fluctuations in oil GDP seems to originate from shocks to the trend rather than from the business cycle.

To understand the nature of macroeconomic fluctuations and to develop a theoretical framework for consideration of oil price shocks in causing cyclical behaviour in oil-exporting economies, a standard approach needs to test and examine the component of data series. The real business cycle theory is useful because it is an easy way to introduce a number of macroeconomic fluctuations, including the adjustment process that remains central in macroeconomics. Real business cycle theory will be explained in the next chapter and their value in illustrating macroeconomic variables will be advocated.

CHAPTER 5

Real Business Cycle Theory

5.1 Introduction

Understanding whether the fluctuations in the business cycle were due to real shocks, was a turning point in the emergence of the real business cycle (RBC) theory (kaboub, 2003). Real business cycle literature provides an explanation of business cycles which characterize macroeconomic fluctuations (Snowdon *et al.*, 1994). This theory is extended to explain the distinctive characteristics of primary dependent commodity economies. The aim of this chapter is to explore more detail of the RBC model. The main element underlying RBC theory is one particular model developed by King, Plosser and Rebelo (1988) (KPR) model, is argued to be especially useful in the context of primary commodity dependent economies facing external shocks. However, the nature of shocks here is more general, so the original model needs to be extended to make it more relevant to the specifics of these economies.

RBC theory has developed rapidly since research in this area began in the early 1980s with new refinements of the theory currently being developed to understand the causes of macroeconomic fluctuations (Abel and Bernanke, 1992). RBC models are essentially extensions of the neoclassical growth model, and provide the foundations for understanding business cycles based on theoretic analysis (Plosser, 1989). These models contribute to understanding business cycles and the construction of technology shocks within these models. These models also provide an opportunity to investigate the impacts of oil price shocks in the business cycles of a primary dependent economy.

This chapter has five sections. Section 5.2 explores an overview of real business cycle theory. Section 5.3 traces the development of the real business cycle model and looks at the work of King, Plosser, and Rebelo (1988) (KPR) which uses Kydland and Prescott (1982). Section 5.4 presents an explanation of the value of real business cycle theory. Section 5.5 provides a summary.

5.2 An Overview of Real Business cycle Theory

In the last three decades, macroeconomic research has attempted to construct a model of the aggregate variables, which is theoretically consistent with past observations and which can be used for policy planning and analysis. An influential group of classical macroeconomists, led by Kydland and Prescott (1982), have developed a theory that takes a strong stand on the sources of shocks that cause cyclical fluctuations. This theory, known as the RBC theory, argues that real shocks to the economy are the primary cause of the business cycle. Real shocks are disturbances to the real side of the economy; for example, those shocks that affect the production function, the size of the labour force, real government expenditure, and the spending and saving decisions of consumers (Abel and Bernanke, 1992).[1]

The central prediction of the theory is that real phenomena, and not nominal ones, cause the business cycle. Real shocks are contrasted with nominal shocks, which are

[1] A common approach is to specify the production function is: $Y_t = AK_t^{\alpha} N_t^{\beta} e^{u_t} e^{z_t}$ where A is a constant at the country level, t is a time index, e is the natural logarithm base and α, β are the parameters. Taking log from both sides, consider the Cobb-Douglas production function as: $y_t = a + \alpha k_t + \beta n_t + z_t + u_t$ where y_t is the log of output, n_t is the log of labour, and k_t is the log of capital. There are two terms in this equation that are unobservable, z_t and u_t. The distinction between these two is important. The u_t represents difference between observed and expected output, which is known as error term. In contrast, the z_t represent shocks to production function that is not only potentially observable (or predictable) but also unexpected and unanticipated such as productivity or oil price shocks (Ackerbery *et al.*, 2005).

shocks to money supply or money demand, and fiscal shocks to aggregate supply and demand.

Kydland and Prescott (1982) seek to model a competitive general equilibrium theory which is essentially the Ramsey-Solow Neoclassical model of economic growth.[2] It is attractive to say that the Solow residual represents the growth of knowledge as technology shocks in the short-run. The neoclassical model of capital accumulation, augmented by shocks to productivity, is the basic framework for RBC analysis (Stadler, 1994). Plosser (1989) argued that the basic neoclassical model of capital accumulation can provide an important framework for developing our understanding of economic fluctuations.[3]

RBC theory assumes that exogenous technology shocks are the main source of aggregate fluctuations in the economy. Kydland and Prescott (1982) stress the importance of technology shocks as a source of business cycle fluctuations, the shock that drives the business cycle is the same as the shock that generates economic growth and in this respect technological change is seen as the main driving force. Technology is assumed to evolve as a stochastic process.

Employing Kydland and Prescott (1982) methodology requires two steps. The first concerns measurement, data series must be consistent with model series. The second step concerns reporting, the same statistics should be computed for the model and the

---

[2] Recall that as an accounting identity output is produced by some combination of capital and labour, $Y \equiv AK^{\alpha}L^{1-\alpha}$ Log differentiation and rearrangement yields the Solow Residual, $R = \frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \alpha\frac{\dot{K}}{K} - (1-\alpha)\frac{\dot{L}}{L}$ This is defined as the difference between actual and expected output (Plosser, 1986).

[3] RBC theorists argued that the same theory that can explain long-run growth, should also explain business cycles. Following Gas (1965), Koopmans (1965), and Solow (1956), Hicks (1965) argued that it is natural to consider the neoclassical model as the benchmark model for understanding of economic cycles as well as growth (Plosser, 1989). It is purely real model, driven by technology or productivity shocks, and hence, following Long and Plosser (1983), it has been labelled a real business cycle model.

revised data. In order to achieve the dynamics required to statistically mach the data, it is necessary for the postulated technology shocks to be highly persistent (King and Rebelo, 1988). Kydland and Prescott (1991) also stress that the RBC model is impracticable in the sense that it aims only to capture only certain features of the data rather than to provide a complete explanation of them.[4]

Danthine and Donaldson (1993) suggested that RBC approach implies a methodology for the study of business cycles, which involves two components: an empirical review and quantitative theory. It also comprises the dynamic general equilibrium models, which can be evaluated either quantitatively or qualitatively in terms of their ability to reproduce the basic features of business cycles. Such comparisons are useful in highlighting similarities and deviations, which are both necessary ingredients to further the development of good theory. A 'good' theory of the business cycle is quantitative as well as qualitative (McGrattan, 2006).[5]

The RBC approach suggests that growth and business cycles can be treated within an integrated theory. Kydland and Prescott (1982) and Prescott (1986), argued that one cannot separate growth from business cycle issues, which need to be within an integrated theory. Nevertheless the RBC model can explain a great part of the fluctuations in an economy.

King and Plosser (1988) also suggested alternative specifications and extensions to the basic neoclassical framework. First, they show how to incorporate stochastic

[4] The lack of discussion on the nature of technological shocks has often been criticized, on the basis that they are just the result of the convergence of other factors that are not specified in the model. The problem is that of estimating the actual impact of technology shocks on the RBC model. In this sense, specifying identifiable sources of fluctuations allows unobservable sources to be reduced in the explanation of the business cycle (Danthine and Donaldson, 1993). It is difficult to identify technology shocks in the actual economy Summers (1986), Mankiw (1989) and the most illustrations of oil shocks are not technology fluctuations but actually factor price changes (McCallum, 1989).

[5] It has been recognized that most RBC models have not used formal testing procedures when comparing their theoretical and empirical results, so that there may be disagreement as to model rejection criteria.

growth into the model so that the shock that drive the growth process also drives the cyclical properties of the model. Second, following Romer (1986), Lucas (1988), and King and Rebelo (1987), they consider models that generate endogenous growth. The idea of using endogenous growth elements to study business cycles argues that many authors have successfully incorporated endogenous sources of growth in dynamic statistical general equilibrium models and shown that this line of research can lead to substantial improvement over simple RBC models (Matheron, 2003).[6] Third, they show how one can incorporate government actions into the framework. This opens up an important area of research for these models because it enables them to begin the analysis of government policies that are thought to be important in evaluating business cycles (King and Plosser, 1988).[7]

It seems the standard RBC analysis is based on a stochastic growth model with complete markets in which productivity shocks are the main force behind business cycles (Obstfeld and Rogoff, 1999).[8] Stochastic general equilibrium growth models have become a framework for trying to understand business cycles. Real business cycle theory regards stochastic fluctuations in productivity as the source of fluctuations in economic activity (Stadler, 1994).[9]

[6] See also Einarsson and Marquis (1997), Maffezzoli (2000), and Ozlu (1996), have shown that introducing an endogenous source of growth in RBC models helps reproduce some key comovements unaccounted for by standard RBC models.

[7] In RBC models the government plays an extremely passive role if it is present at all. An exception is Eichenbaum and Christano (1990) where uncertainty in government purchases is one of the principal determinants of model dynamics; they do not consider stabilization policies. This state of relationships is a reflection of the dominant RBC approach, which views cyclical fluctuations as the result of agents' optimal responses to exogenous uncertainty.

[8] There have been a number of other important methodological developments: RBC models with analysis of data for some area by Hansen and Heckman (1996), Kydland and Prescott (1996), and Sims (1996). In particular, Hansen (1997) has shown that if real business cycle models are to give a satisfactory picture of the business cycle, they need to incorporate persistent yet stationary shocks.

[9] This theory follows the approach of Frisch (1933, 1965) and Slutzky (1937). Solow (1956, 1957) suggested exogenous productivity shocks on the neoclassical growth models.

In addition to the empirical studies investigating exceptional features of business cycles of various countries by proceeding only on structural econometric methods such as vector autoregression (VAR) analysis, a considerable study has studied the sources of macroeconomic fluctuations by examining the business cycle characteristics within the framework of stochastic dynamic general equilibrium business cycle theory (Baxter, 1995). A vast majority of the studies focused on the cross-country differences and similarities of business cycle characteristics of major developed economies.[10] While a limited number of studies consider developing countries, there exists no comparative study that examines the sources of macroeconomic fluctuations and business cycle characteristics in the oil-exporting countries using the methods of the stochastic dynamic general equilibrium business cycle theory (Sayan and Kose, 2003).[11]

The starting point of our analysis is a standard dynamic general equilibrium model for a small open economy in which oil is included as a productive input. The oil price and the exchange rate are initially assumed to be those determined by the international markets. Hence our starting point is taking those prices as given. Oil price shocks are considered to be one of the possible sources of fluctuations in an economy and follow a stochastic process. They influence significantly the size and path of aggregate fluctuations and illuminate other features of business cycle. This

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[10] Backus and Kehoe (1992) examine the characteristics of business cycles in 10 OECD countries, Christodulakis, Dimelis and Kollintzas (1995) study the business cycles in the EU. These studies find that business cycles in major industrialized economies are quite similar. Kose, Otrok, and Whiteman (2000) investigate the common dynamic properties of business cycle fluctuations across countries, regions and the world using a comprehensive data set. Kose and Yi (2001) study the role of trade linkages in transmitting business cycle fluctuations across developed countries in a multi country business cycle model.

[11] Mendoza (1995) compares business cycle characteristics of developed economies with developing countries. Kose (2001) investigates the regularities observed in several small open developing countries. Kim, Kose and Plummer (2000, 2001) provide an extensive analysis of the similarities and differences across the business cycle characteristics of the countries in the Asia-Pacific region.

analysis allows us to prove the extent to which oil price shocks can account for the Iranian business cycle.

The RBC model can be applied to a partially linearized version of the stochastic growth model, derived from Kydland and Prescott (1982) and Hansen (1985), by taking into account the stochastic process for technology shocks. To verify the ability of the model and to explain empirical characteristics of the Iranian business cycle, we adopt an approach in which the only source of fluctuations comes from the stochastic process estimated for oil price.

The RBC model is a stochastic general equilibrium model for a small open oil-dependent economy augmented to incorporate the oil income as a pure rent associated to transfer from abroad. It is assumed that the oil output is entirely sold in an international market and oil prices are taken exogenously. Furthermore, oil revenue fluctuations come mainly from variations in oil prices rather than any quantity changes and could be affected on aggregate fluctuation because most oil income finances public expenditure.

Basically, the equilibrium allocation can be assumed by solving the social planner's problem. The problem is maximizing utility function subject to constraints. In other words, because all agents are identical, one can solve for the equilibrium quantities and prices by solving the agent's optimization problem. The representative household maximizes its expected lifetime utility defined over stochastic sequences of consumption (c_t) and labour (n_t) subject to the household budget constraint:

$$
\begin{aligned}
&U_t = Max\mathrm{E}_t\sum_{t=0}^{\infty}\beta^t u(c_t,l_t)\\
&S.t.\\
&l_t + h_t = 1\\
&Y_t = z_t f(k_t,n_t) = e^{z_t}k_t^{\alpha}(\lambda^t n_t)^{\beta}\\
&z_t = \rho z_{t-1} + \varepsilon_t\\
&K_{t+1} = (1-\delta)K_t + I_t\\
&Y_t = C_t + I_t + G_t + NX_t
\end{aligned}
\tag{5.1}
$$

The Lagrangian method to solve the optimization problem is:

$$L = \left\{\sum_{t=0}^{\infty}\beta^t u(c_t,l_t)\right\} + \sum_{t=0}^{\infty}\mu_t\left[e^{z_t}k_t^{\alpha}\lambda^{t\beta}N_t^{\beta} - C_t - G_t - NX_t - k_{t+1} + (1-\delta)k_t\right] \tag{5.2}$$

where μ_t is the Lagrange multiplier, which is introducing as the shadow price of unit of marginal utility of consumption. By assuming the consumption function is as follows:

$$U(c,l) = \frac{\left[C_t^{1-\alpha}(l_t)^{\alpha}\right]^{1-\delta}-1}{1-\delta} \text{ for } 0<\delta<1 \tag{5.3}$$

Then, it can be shown: $U(c,\overline{n}-n) = \frac{\left[C_t^{1-\alpha}(\overline{n}-n)_t^{\alpha}\right]^{1-\delta}-1}{1-\delta}$ for δ=1 (5.4)

Therefore, we can write: $U(c,\overline{n}-n) = (1-\alpha)\log c_t + \alpha\log(\overline{n}-n_t)$ (5.5)

The first-order conditions are follows:

$$
\begin{aligned}
&\frac{\partial L}{\partial c_t} = \beta^t\frac{(1-\alpha)}{c_t^{\alpha}} - \mu_t = 0\\
&\frac{\partial L}{\partial n_t} = -\beta^t\frac{\alpha}{(\overline{n}-n_t)} + \mu_t(1-\theta)\left[e^{z_t}k_t^{\theta}\lambda^{t(1-\theta)}n_t^{-\theta}\right] = 0\\
&\frac{\partial L}{\partial k_t} = -\mu_t + \mu_{t+1}\left\{\theta_t\left[e^{z_t}k_t^{\theta-1}\lambda^{t(1-\theta)}n_t^{(1-\theta)}\right] + (1-\delta)\right\} = 0\\
&\frac{\partial L}{\partial \mu_t} = e^{z_t}k_t^{\theta}\lambda^{t(1-\theta)}n_t^{(1-\theta)} - c_t - k_{t+1} - g_t - NX_t + (1-\delta)k_t = 0
\end{aligned}
\tag{5.6}
$$

where $c_t \geq 0, 0 \leq n_t \leq \overline{n}, i_t \geq 0, c_t = C_t, i_t = I_t, k_t = K_t, n_t = N_t$

The first order condition can be linearized around the steady state, as a first-order autoregressive linear system (Arango-Thomas, 1997):[12]

$$(\hat{x}_t - \hat{x})/\hat{x} = \ln \hat{x}_t - \ln \hat{x} = \tilde{x}_t \tag{5.7}$$

where $\hat{x}$ represents the steady state of variable $\hat{x}_t$.

King, Plosser, and Rebelo (1998 a, b) (KPR) use the neoclassical model of capital accumulation for the investigation of economic fluctuations. KPR develop four main issues in the framework of RBC theory. First, they investigate the implications for the business cycle - the role of economic growth in economic fluctuations. Second, they use an analytical method to study the time series implications of the neoclassical model. Third, they extend the methods of RBC analysis to include the study of the dynamic characteristics of the basic neoclassical model in response to technology shocks. Finally, they explore the RBC model to emphasis the important features of macroeconomic time series (KPR, 1988b).[13] This concept is developed in the next section.

5.3 The King, Plosser, Rebelo Model

This section attempts to present the methods currently utilized to analyze macroeconomic fluctuations in the RBC framework. The stochastic growth model of King, Plosser, and Rebelo (1998) (KPR) is derived from Kydland and Prescott (1982) and Hansen (1985). This model studied by Cooley and Prescott (1995) and

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[12] The equations are linear zed by using a first order Taylor series expansion as follows: let us assume that the function X (Y, Z) is continuously differentiable, where Y and Z are variables in logarithms with steady state denoted by $\bar{y}$ and $\bar{z}$ The linear approximation of $x(o)$ around the steady state of the variables is $x(o) = x(\bar{y},\bar{z}) + x_y(\bar{y},\bar{z})(y-\bar{y}) + x_z(\bar{y},\bar{z})(z-\bar{z})$, where $x_y(\bar{y},\bar{z})$ and $x_z(\bar{y},\bar{z})$ stand for the derivative of the function $x(o)$ with respect to Y and Z respectively, evaluated at steady state.

[13] These issues are developed in the KPR (1988a:195-196).

Hansen and Wright (1992). The KPR model of growth presents the best-known extension of the basic RBC model to a growth environment. It has become established as one of the leading analyses of growth in the context of business cycles.[14] The reason for using this model which is widely used in the literature is to justify the particular case of shocks that it is a relatively simple real business cycle textbook model (Bierens, 2003).[15] It is also useful in the analysis of similar primary commodity dependent economies such as the Colombian economy (Arango-Thomas, 1997)[16].

KPR (1988a) model provides an introduction to the neoclassical model of capital accumulation and shows how it can be used as an integrated model of economic growth and of business fluctuations. The basic framework of the KPR model is able to address a wide variety of issues that are commonly thought to be important for understanding business cycles. The method considers technology shocks or exogenous factor such as government polices and terms of trade (KPR, 1988). They argued that the predetermined state variable in their model is the capital stock. The variability of GDP and other aggregates are replicated well with determination of data and parameterisation with RBC models (KPR, 1988a, b). This method also explains the optimal decision rules by applying the necessary and sufficient first-order condition for a constrained maximum (Arango-Thomas, 1997).

KPR model was the modification of the basic neoclassical model that is compatible with endogenous steady state growth that considered implications for the model response to shocks (KPR, 1988b). It is a moderate departure from the standard

[14] See also Summers (1986), and Rotemberg and Woodford (1996).

[15] It is not impossible to link the parameters of their linearized model to the deep parameters; it is more complicated than in my approach. Consequently, KPR (1988a) do not provide this link, except for a deterministic version of their model with fixed labour. (See KPR (1988a, Footnote: 17. P.4)

[16] See Ph.D. thesis at the University of Liverpool.

neoclassical growth model and used log-linearization techniques to compute the solution to stochastic growth model (Gangopadhyay *et al.*, 2003).

The Initial Model

The economy consists of a large number of identical and homogenous households. The representative household has preferences that can be defined as stochastic sequences of consumption (c_t) and leisure (l_t), described by the utility function (U):

$$U = \sum_{t=0}^{\infty} \beta^t u(c_t, l_t) \qquad \beta \prec 1 \tag{5.8}$$

where β the discount factor and β∈(0, 1).

The basic neoclassical model is built with a constant returns to scale (Cobb-Douglas) production function relating output (Y_t) in period (t) to labour (N_t), and capital stock (K_t). Thus (KPR, 1988: 200):

$$Y_t = A_t F(K_t, N_t X_t) \Leftrightarrow Y_t = A_t K_t^{1-\alpha} (N_t X_t)^{\alpha} \quad 0 \prec \alpha \prec 1 \tag{5.9}$$

where A_t is temporary changes in total factor productivity, X_t is permanent technology shocks that is restricted to be in labour productivity, N_t is the labour input in period t, K_t is the predetermined capital stock (chosen at t-1) and the economy's initial capital stock (K_0) is given.

The capital stock evolves according to:

$$K_{t+1} = (1-\delta)K_t + I_t \tag{5.10}$$

where I_t is gross investment and δ is the rate of depreciation for capital.

In each period, an individual faces two resource constraints given by

$$L_t + N_t \leq 1, \quad C_t + I_t \leq Y_t \tag{5.11}$$

These restrict allocations of commodities and time available between hours of work (N_t) and leisure (L_t). There are also non-negativity constraints associated with $L_t, N_t, C_t, and\, K_t$.

Suppose that the economy exhibits steady state growth of output, consumption, capital, and investment that all are per capita, but time devoted to work is restricted by the endowment. Thus it can not grow in the steady state. These conditions imply that the utility function must be restricted to be consistent with steady state growth as:

$$\begin{aligned} u(C,L) &= \frac{1}{(1-\sigma)} C^{1-\sigma} v(1-N) \quad for\ 0 \prec \sigma \prec 1 \quad and\, \sigma \succ 1 \\ u(C,L) &= Log(C) + vLog(1-N) \quad for \quad \sigma = 1 \end{aligned} \tag{5.12}$$

where σ is the elasticity of the marginal utility of consumption with respect to consumption (KPR, 2001). The constant intertermporal elasticity of substitution in consumption is $1/\sigma$ for these utility functions (KPR, 1988).

Thus, this is based on a neoclassical model that considers that variations in work effort are associated with intertemporal substitution made in equilibrium by capital accumulation. The standard method of analysing models with steady state growth is to transform the economy into a stationary one where the dynamics are more agreeable to analysis.[17]

The equilibrium allocation can be determined by solving this equation for utility. The problem is maximizing the utility function subject to constraints. In other words, because all agents are identical, one can solve for the equilibrium quantities and prices by solving the agent's optimization problem. The representative agent's decision problem is (Bierens, 2003):

$$\begin{aligned} &U_t = Max\sum_{t=0}^{\infty}\beta^t u(C_t, 1-N_t) \\ &subject\ to \\ &A_t K_t^{1-\alpha}(N_t X_t)^{\alpha} - C_t - K_{t+1} + (1-\delta)K_t = 0 \end{aligned} \tag{5.13}$$

The Lagrangian method to solve the optimization problem is:

$$\ell = \left\{\sum_{t=0}^{\infty}\beta^t u(C_t, 1-N_t)\right\} + \sum_{t=0}^{\infty}\lambda_t\left[A_t K_t^{1-\alpha}(N_t X_t)^{\alpha} - C_t - K_{t+1} + (1-\delta)K_t\right] \tag{5.14}$$

where (λ_t) is the Lagrange multiplier. In particular KPR linearize the first order condition of the Lagrangian (5.8) around the steady state solution. The first-order conditions are follows:

$$\begin{aligned} &\beta^t \frac{1-\sigma}{C_t^{\sigma}} - \lambda_t = 0 \\ &-\beta^t \frac{\sigma}{1-N_t} + \lambda_t \alpha\left[A_t K_t^{1-\alpha} N_t^{\alpha-1} X_t^{\alpha}\right] = 0 \\ &-\lambda_{t+1} + \lambda_t\left\{(1-\alpha)\left[A_t K_t^{-\alpha}(N_t X_t)^{\alpha}\right] + (1-\delta)\right\} = 0 \\ &A_t K_t^{1-\alpha}(N_t X_t)^{\alpha} - c_t - K_{t+1} + (1-\delta)K_t = 0 \end{aligned} \tag{5.15}$$

[17] As described in KPR, we can transform this economy to a stationary economy, by dividing all variables $K_t, C_t, and\ I_t\ by\ X_{t-1}$, expressed as $k_t, c_t, and\ i_t$, respectively.

Overall, RBC theory is still in its development stage and the progress to date has a significant impact on research in macroeconomics. The original KPR model suggests that technology shocks affect the production function of the neoclassical growth model and the common argument employed is that business cycles are caused not only by fluctuations in aggregate demand, but also in the supply side.

5.4 The Value of Real Business Cycle Theory

The objective of the real business cycle (RBC) approach is to understand the character of real fluctuations. This approach attempts to explain booms and recessions in the economy as responses to random external shocks. Overall, the RBC approach has generated many new insights and techniques that assist in modelling the macroeconomy. RBC literature stresses the importance of technology shocks as a potential source of business cycle fluctuations. Technology shock is the real shock in the real business cycle theory. Romer (1996) argued that the importance of understanding the causes of aggregate economic fluctuations is the central goal of macroeconomics.

RBC models contribute to understanding of business cycles and the construction of unexpected technology shocks within these models. An oil price shock as an alternative can be accounted in the real business cycle theory as a real shock.[18] Rebelo (2005) suggests that an oil price shock provides evidence to be a believable mechanism which yielded the unanticipated, temporary supply shocks needed by the RBC models. These models provide an opportunity to investigate the impacts of oil price shocks in the business cycles of a primary dependent and planned economy,

[18] Understanding the dynamics of the international oil market has been a major concern for economists for at least the last three decades (Gao *et al.*, 2006).

such as the Iranian economy, to identify the oil price shocks over the different periods of planning.

A business cycle is apparently observable, but understanding the nature of the cycle and its causes needs more investigation. The conventional view was that business cycles were temporary deviations from trend. This idea provided the justification for involvement of monetary and fiscal policies to stabilise the economy and reduce the effects of cyclical fluctuations in economic activity. It is supposed that the conventional view such as real business cycle theory offer more convincing explanation of the business cycle. This approach implies that deviations from the trend change in output are a sign of cycles and present useful information on the economy (Harrison, 1999).

There are issues that RBC models have been used widely elsewhere and with potentially useful adjustment can be applied for the Iranian economy as an opportunity to analyze and explain unexpected shocks. The observed cyclical behaviour of the Iranian economy seems to be influenced by the current shocks which seen an unanticipated oil price shocks in the international oil market. The RBC model provides a platform to increase our understanding of the output behaviour of the Iranian economy, and attempts to find the nature of these shocks based on historical time series data due to movements in GDP and oil price and examine the relationship between oil price and business cycles. Jones and Leiby (1996) argued that research effort has gone into introduce oil price shocks in RBC models and statistically testing their importance as a contributor to business cycles. Lama (2005) identified and extracted the cyclical behaviour component of economic time series in developing countries using RBC approach.

5.5 Summary

Real business cycle theory has developed rapidly since research in this area began in the early 1980s, with new refinements of the theory currently being developed. RBC theorists argue that a plausible theory of the business cycle should be quantitative as well as qualitative. The central calculation of the RBC theory is real phenomena, which cause business cycles. This theory assumes that technology shocks are the main source of macroeconomic fluctuations and technology shocks evolve a stochastic process. The purpose of this study was using endogenous sources of growth in dynamic statistical general equilibrium models which can lead to considerable enhancement over RBC models.

An extension of RBC model, as a linearized version of the King, Plosser, and Rebelo model is able to address a wide variety of issues that are though to be vital for understanding business cycles. These models provide an opportunity to investigate the impacts of oil price shocks in the business cycles of a primary dependent and planned economy. Oil price shocks are considered to be one of the possible sources of fluctuations in an economy and influence significantly the size and path of growth and clarify other features of business cycle.

The next chapter will demonstrate the use of the RBC model to explain and test the properties under alternative specification for preferences of the cyclical behaviour of the Iranian economy, namely one that recognises oil exports as an important source of economic fluctuations. The chapter will show how a modified model is appropriate for testing for the effects of oil price shocks in an oil-dependent economy. It also will consider the key question that how RBC theory can help to understand the issue of relationship between oil price shocks and the Iranian experience.

CHAPTER 6

Modelling Iran's Business Cycles

6.1 Introduction

The aim of this chapter is to explain the factors affecting the Iranian business cycles, and to provide a suitable framework for the analysis of macroeconomic fluctuations. A common argument is that the business cycle is caused not only by fluctuations in aggregate demand, but also by random shocks in the supply side of economics. Within the real business cycle (RBC) fr amework, the factors, such as oil price shocks, affecting the business cycle of the Iranian economy and supply side are identified and estimated.

This chapter explores the ability of a modified RBC model to explain the time profile of Iran's real output. We specify and estimate a model which is an extension of the RBC model and which is designed to explain determinants of the time path of real GDP. It also attempts to model output and looks at its ability to identify the turning points of Iranian business cycles. The model, in short, explains the movements of real output.

This chapter also examines how unforeseen shocks have an impact on the path of output. To achieve this, the production function approach[1] is used to test hypotheses about various types of shock. The shock is unanticipated and is defined in terms of

[1] Formally a production function expresses the output of a commodity as a function of all its inputs. Desai (1976) argued that the production function is a technological relationship between output and inputs. The popularity of the Cobb-Douglas production function stems from its simplicity and flexibility as well as the empirical support it has received from data for various industries and countries.

the price of oil and the exchange rate. We generally have to proxy this shock because it is not directly observable. The chapter has seven sections. Section 6.2 presents a justification of methodology used to analyze business cycles. The following section explores the model to be tested for the Iranian business cycle. Section 6.4 presents the hypotheses to be tested. Section 6.5 describes data issues and Section 6.6 reports the results of empirical estimation of the model. Finally, the results are discussed in the final section.

6.2 Justification for the Approach and Methodology used

In order that the modified RBC has utility in accounting for aggregate fluctuations in Iran's economy, it has to be tested and the model properties under alternative have to be computed. Three issues of the RBC model can account for business cycle variability. First the model assesses the role of the price of oil in business cycles and how changes in the variability of oil shocks alter the characteristics of them. The second feature requires the modification of the RBC model which was originally developed to analyze technology shocks, by substituting oil price shocks for technology shocks. The third issue is that Iran's economy is separated into two sectors, the oil and non-oil sector, and the nature of shocks provides an opportunity for an analytical level of consideration.

To examine the effects of oil price shocks on the business cycles of the Iranian economy, real business cycle methodology, which is usefully modified in this context, as an appropriate methodology must be employed to explain and evaluate the effects of oil price shocks on the economy. To assess the ability of the model to account for aggregate fluctuations, we consider the role of oil price shocks and compute the properties of the RBC model under alternative specifications for preferences which is a plausible method to account for the cyclical patterns in driving aggregate fluctuations in Iran. Two approaches were considered - Vector Autoregression modelling and structural modelling.

Empirically, causal relationships between GDP and aggregate data cannot be identified from empirical analysis and causality tests are not accurate and may produce inconclusive result. Dadkhah (1987) suggested that tests of causality are valid asymptomatically. They require a relatively large sample, due to the lagging of variables - about 50 observations. Most of these tests end up concluding that there is no causality between the variables they examined. However, if enough changes in policy rules have occurred during the observation period, it is possible to identify causal relationships from policy instruments to target variables.[2]

Hungnes (2002) suggests an estimation procedure to distinguish between causal effects of expected policy changes and (unexpected) shocks. The causality approach probably is specified in simultaneous equations with or without the vector autoregression (VAR) analysis. The method therefore takes the complexity of that process for granted and always attempts to allow for it (Driehuis, 1976).[3] In addition, most of the literature on the effect of oil price shocks on macroeconomic fluctuations

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[2] The causality method is based on the simultaneous and successive relationships between the determinants of the economic process, in the case of primary commodity markets. Hungnes (2002) argued that the idea of understanding causality as an indication of controllability makes it important for macroeconomics. For example, the causal relationship shows the effects of changes in government policy on economic variables. Identifying a causal relationship is therefore necessary in order to understand how policy changes affect the economy. However, to identify the causal effect of the policy changes on the target variables, it is possible only when there are structural changes in the policy variables.

[3] This method involves diagnostic process and the econometric model approach that can be used for diagnostic and forecasting purposes. Many researchers argue that causality analysis is wasting time and it just explains correlation across time, but not generally explain the causality of it. They also argue that methodologically to understand the future; it needs to find the structure of the present by understanding the present. A n alternative feature of the causality method is that it allows the calculation of alternative values of the endogenous variables under alternative assumptions of the exogenous variables.

has employed VAR models in their analysis.[4] This method promises a dynamic process, but minimizes the excluded relevant variables, which causes bias estimation and low efficiency because of the infinite number of lags and large degree of freedom. Thus, this approach is inappropriate because the limitation of the period of study reduces the available number of lags.

The alternative approach of this study is using a structural approach which is mutually exclusive with the causality approach. The structural approach is more appropriate, arguably, because one of the clear points is that the effect of unexpected shocks, by their nature, is not usually straightforward enough to include the Granger and/or causality framework. The risk of structural model approach is more likely misspecified model than in the case of VAR model, because VAR model is, in general, less misspecified. Because of the limitation of sample data, the structural model is the best model to apply, because it gives a good estimation of variables in the economy. It interprets dummy variables, their definition and the results, and analyses all shocks in the same manner. A structural equation expresses the endogenous variables as being dependent on the current realization of another endogenous variable.[5] It also can be used as a reduced form.[6]

The usual way to apply real business cycle theory is to use the production function approach which is consistent with the Cobb-Douglas function and growth theories.

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[4] For example, Deaton and Miller (1996) employ a vector autoregression (VAR) model to examine the importance of commodity price shocks in African countries. Hoffmaister, Roldos, and Wickham (1998) estimate a structural VAR model, where identifying restrictions are derived from a long-run small open economy model, to study the role of terms of trade and world real interest rate shocks in several African countries.

[5] Production functions relate inputs to outputs with the limits arise from identification and estimation. An econometric issue in estimating production function is the possibility of some unobserved inputs, which may cause an endogeneity problem and OLS estimates become biased (Ackerbery *et al.*, 2005).

[6] A reduced form equation is one expressing the value of a variable in terms of its own lags, lags of other endogenous variables, current and past values of exogenous variables, and disturbance terms (Enders, 1995).

To develop and understand the relationships between oil price shocks and business cycles, using a production function approach, the analysis is undertaken from a viewpoint, which considers that there is a country production function – an approach that assumes a relatively efficient and given oil prices at the international oil market.[7] We analyse the impact of oil price shocks on primary commodity dependent economies such as Iran.

6.3 The Model to be Estimated

This section presents a model that can be empirically tested and explained the effects of oil price shocks on Iranian business cycles by using a production function approach developing real business cycle methodology. The production function approach is applied to a linearized version of the stochastic growth model of King, Plosser and Rebelo (KPR) (1988a,b) which was discussed in chapter five. The linearization procedure is different from the (deterministic) Lagrange multiplier solution proposed by KPR (Bierens, 2003). The model is modified firstly by expressing the variables as first difference and logarithms. Second, we replace the technology shock variable in the KPR model by one defined in terms of oil price shocks. The model will be further modified for the structure of the Iranian economy and will allow us to analyze the effect of oil price shocks on macroeconomic fluctuations.

Formally a production function expresses the output of economy as a function of all its inputs. Econometricians have concentrated on the utilization of the production function, because of its ability to explain returns to scale, resource allocation, elasticity of substitution between inputs, and so it is possible to employ it at the

[7] As McCallum (1989) points out, the production function of most RBC models (including Kydland and Prescott, 1982) employ is essentially Cobb-Douglas (Stadler, 1994).

macroeconomic level by using the Cobb-Douglas production function and economic growth. The notion of an aggregate production function has been used to provide empirical description of intertemporal differences in the economic growth. Desai (1976) argued that the importance of the Cobb-Douglas production function comes from its simplicity and flexibility as well as the empirical support it has received from data for various industries and countries. Ackerbery *et al.* (2005) suggest that production functions are a fundamental component of all economies, and have a long history in applied economics.

A Cobb-Douglas production function relating output (Y_t) in period (t) to labour (n_t), and capital stock (k_t) is defined as follows:

$$y_t = Ae^{\lambda_t} k_t^{\alpha} n_t^{\beta} \tag{6.1}$$

where A is the temporary change in total factor productivity, e is the exponential; α *and* β are returns to scale, λ is the trend parameter, and t is the time index. Taking logarithms and first differencing:

$$\log y_t = \log A + \alpha \log k_t + \beta \log n_t + \lambda_t \tag{6.2}$$

$$\Delta \log y_t = \Delta\lambda + \alpha\Delta \log k_t + \beta\Delta \log n_t \tag{6.3}$$

$$\dot{y} = \dot{\lambda} + \alpha\dot{k} + \beta\dot{n} \tag{6.4}$$

The steady state equation of the production function defines the rate of growth of output ($\dot{y}$) as a function of growth of capital ($\dot{k}$); growth of labour ($\dot{n}$), and trend ($\dot{\lambda}$). Equation (6.4) has often been used to analyze the relationship between the growth of output, capital and labour.

To adopt the framework of the production function approach to the Iranian economy, we need to make a number of further assumptions. It is assumed that oil price shocks are a linear function of lags of past data.[8] Under this approach oil price shocks are defined as the deviation of oil prices from those predicted in each five-year plan. The predicted oil price for each five-year plan is derived by taking the deviation between the actual oil price and the expected planned oil price for the previous period.[9] The mechanism to find movements of oil price shocks is obtained by calculating the deviation between the actual price of oil in the current time period and the average price of oil over the previous plan period ($P_s = P_t - P_A$) - where P_s is the oil price shocks, P_t is the actual oil price, and P_A is the anticipated (planned) oil price.

We define an exchange rate shock as the difference between the actual exchange rate for the current time period and the average exchange rate over the previous time period ($X_s = X_t - X_A$) - where X_s is the exchange rate shocks, X_t is the actual exchange rate, and X_A is the anticipated (planned) exchange rate.

It is also assumed that the growth rate of the price of oil in the previous five-year plan can be used as an estimate of the price of oil for the current plan. The expected price in the current plan is equal to the actual closing price at the end of previous plan plus the average change over that period. So, oil price shocks are related to either the plan's expectation or are extrapolated from the previous five-year plan for some periods while there was no plan in operation. Therefore, given the structure of

[8] Using a lag produces the relationship between income and consumption that business cycle theories also apply. The existence of lags also makes government attempts to control the economy more difficult.

[9] A shock is an unanticipated deviation. This has been widely discussed in the macroeconomic literature. For instance, the heart of Friedman's permanent income theory uses it. The evidence shows that the planned oil price changed significantly between plans (Ghaffari, 2000). For example, for 1973 the actual oil price was much higher than the planned price due to effective action by OPEC.

the Iranian economy, the system of planning in Iran seems to provide an opportunity to proxy the shock. This approach captures unanticipated oil prices for each plan period and is in accordance with RBC theory that makes its statements on the bases of unanticipated shocks.

It is also assumed that the effect of OPEC is partially captured through the planned oil price of the five-year plans. Iran as a major member has the ability to influence OPEC policies on supply and its prices. Oil production is periodically controlled by the OPEC cartel, and the operation of it is a very important issue. OPEC can set the price of oil by controlling oil production levels. Oil prices are defined by a price rule based on changes in market conditions and OPEC behaviour. When the demand side expects an increase in the price of oil, demand will shift and the price of oil will increase. So as OPEC becomes less powerful, Iran becomes more powerful. However, when OPEC fails to specify the price of oil, Iran has to impute it from the previous five-year plan. As a result, real business cycle theory can incorporate the influence of the OPEC cartel during periods when it wielded market power.[10]

The model is based on a key feature of the Iranian economy where output is divided between the oil sector (oil-GDP) (Y_t^o) and the non-oil sector (non-oil-GDP) (Y_t^{no}).

$$GDP \Leftrightarrow Y_t = Y_t^o + Y_t^{no} \tag{6.5}$$

The two sub-sectors have production functions:

$$Y_t^o = F(k_t^o, n_t^o, z_t) \tag{6.6}$$

$$Y_t^{no} = G(k_t^{no}, n_t^{no}, z_t) \tag{6.7}$$

[10] In particular, OPEC acts according to a cooperative behaviour and ensures the global equilibrium at the price determined by the price rule. The role of OPEC in the oil market would be tested later here.

where z_t defined as technology shocks in the RBC model are replaced with oil price shocks here.[11] It is assumed that oil price shocks generate an externality effect on output in both sectors. Note that the nature of z_t is different in the oil and non-oil sector and will be explained in more detail later.

Equation (6.6) shows that output for the oil sector is a function of the share of capital and labour in the oil sector; and oil price shocks, whilst equation (6.7) shows that output for the non-oil sector is a function of the share of capital and labour in the non-oil sector, and oil price shocks.

First, consider the production function in equation (6.6) which uses the rat e of change in each variable modified for the oil sector. Three models are considered. The null hypotheses are presented as follows:

Model (A) $$y_t^o = \lambda + \mu_1 poil_t + \alpha k_t^o + \beta n_t^o + u_{1t} \quad (6.8)$$

Model (B) $$y_t^o = \lambda + \mu_2 er_t + \alpha k_t^o + \beta n_t^o + u_{2t} \quad (6.9)$$

Model (C) $$y_t^o = \lambda + \mu_1 poil_t + \mu_2 er_t + \alpha k_t^o + \beta n_t^o + u_{3t} \quad (6.10)$$

where y_t^o is output (GDP) of the oil sector, $\mu_i, \lambda, \alpha, and\ \beta$ are parameters and assumed constant, $poil$ is the price of oil (in US dollars), k_t^o is capital, n_t^o is labour, er is the exchange rate (nominal or real), and u_{it} is a classical error term.

[11] It is assumed that the 1970s' oil shocks are similar to technology shocks because in both cases the slope of the production function varies with capital and labour. This interpretation explains why RBC theory drew interest in economics in the 1970s after the oil shocks had a dramatic impact on oil-importing economies. However, oil price shocks are different in nature between exporter and importer. For example, the 1973 oil price increase was followed by an increase in economic growth of oil-exporting countries. The oil price shocks in 1979 also changed the slope of the trend of the economy.

Model (A) relates oil output in terms of a change in the price of oil. Model (B) relates oil output in terms of a change in the exchange rate. Model (C) relates oil output to both.[12]

The production function in equation of (6.7) uses the rate of change in each variable modified for the non-oil sector. Here, shocks enter from the government sector. Government expenditure is largely based on oil revenue that may fluctuate exogenously.[13] The non-oil production function can be defined as follows:

Model (D) $$y_t^{no} = \lambda + \mu_3 g_t + \alpha k_t^{no} + \beta n_t^{no} + u_{4t} \quad (6.11)$$

Model (D) shows that output growth in the non-oil sector (y_t^{no}) is related to the share of capital (k_t^{no}) and labour (n_t^{no}) in the non-oil sector, and government expenditure. It is assumed that the oil sector impacts on the non-oil sector via government expenditure.

Based on the time series literature, before regression analysis take place, it needs to test stationarity of variables using unit root test, which is part of estimation process in production function approach. A unit root test is performed using Dickey-Fuller (DF) (1979), Augmented Dickey Fuller (ADF), and Phillips and Perron (1988) tests.

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[12] Despite considerable development in macroeconomic theory in recent decades, the impact and magnitude of exchange rate on real economic variables is an argument. Exchange rate is conducted by making an arbitrary change in the official exchange rate. The devaluation of the Rial against the US dollar causes a fall in GDP. Although imports fall, surprisingly there is no significant improvement on non-oil exports. This causes the price level to rise and thus creates stagflation. Resource balance of foreign oil income is the main source of real exchange rate fluctuation. Exchange rate is an important key macroeconomic variable which plays a role in policymaking in each economy.

[13] The exogeneity assumption is used as a device to remove the influence of these shocks from the error term (Perron, 1989).

The results reported in the Appendix 3 show that all variables are I(0) variable when they are first differenced.[14] In such a case, econometric theory suggests that the production function can be estimated with OLS. However, whilst using this approach, the literature suggests that there may be further problems of endogeneity and multicollinearity. The data is tested by employing the Hausman-Wu test[15] to evaluate how important is the deviation of endogeneity; and by using variance inflation factor (VIF) and Tolerance techniques to identify multicollinearity.[16]

6.4 The Hypotheses to be Tested

Evidence suggests that two sectors exist in Iran; one is the oil sector, the other is the non-oil sector. Oil revenues fluctuate over time in order with changes in the price of oil and/or exchange rate. The non-oil sector depends upon the government policy and five-year plans. The planning system is designed by the government to allocate revenues for public expenditure. Government expenditure is largely based on foreign exchange revenues (about 60%) and the government operates a budgeting system to allocate the resources for the non-oil sector. This opportunity allows us to take into account any changes in the price of oil, exchange rate, and probably OPEC policy in the five-year planning system. The production function approach is modified for Iran's economy to allow for this.

In view of the foregoing observations the following are the main hypotheses to be investigated in the study:

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[14] It is often recommended that the regression equation be estimated in first differences if the data are non-stationary and the variables are integrated in the same order and the residuals contain a stochastic trend. So, if the variables have unit roots, then the first difference of each is stationary (Enders, 1995). It is argued that the variables in first difference offer the real results and it can transform a non-stationary series into a stationary one (Verbeek, 2004). See Appendix 3 for more detail.

[15] See Hausman (1978) and Wu (1973). The results are reported in the Appendix 4.

[16] If VIF is greater than five, then the variable is highly correlated with the other explanatory variables. Tolerance has a range from zero to one. The closer the tolerance value is to zero relates a level of multicollinearity (Wooldridge, 2000). Appendix 5 provides further detail.

1. The coefficient of capital and labour are positive.

2. The shock variable has an adverse effect on output.

3. Asymmetrical positive shocks have more significant effects on the economy than negative shocks. The positive shocks are deviations between actual and planned oil price/exchange rate where it is bigger than zero. These shocks are expected to have more impact on the output rather than negative shocks which are the deviation between actual and planned oil price/exchange rate where it is negative.

4. The quadratic form of the shock variable captures negative shocks better than positive shocks.

5. There is a significant relationship between shocks and output.

6.5 Data

For the purpose of estimation our main source of the data is the database of the Central Bank of Iran (CBI), which has been used widely by other researchers, for example, Ahmadian (1986), Badiei and Bina (2002), Celasun (2003), Dargahi (1994), Ghaffari (2000), Jalali-Naini (2003), Khalili and Soltani (2002), Khataii (2001), Mardoukhi (2000), Pahlavani (2006), Valadkhani (2004, 2006), and IMF (2004). Full detail of definitions and sources are set out in the Appendix 1.

The data are collected from CBI and we justify its use by fact that it is the only data available and has been widely used elsewhere. The coverage of the data is very short; quarterly data is also unavailable. The models are estimated using annual data for 1959-2004. Given the limited availability of macroeconomic data and the lack of macroeconomic empirical studies, the shock variable has been estimated on the basis of the Iranian Five-Year Plans for the period of study. With regard to the lack of data on capital and labour, we use data collected by the Management and Planning Organisation (MPO). The statistical Centre of Iran (SCI), OPEC, Heston and Summers database, IMF, and WTRG data sources are also utilised.

6.6 Empirical Estimation

As noted earlier, output in Iran involves two sectors: oil and non-oil. The purpose of this specially developed production function model is to analyse and evaluate the impact of oil price shocks on the Iranian business cycle. This information and information obtained from the initial analysis of the study is used to specify and examine the hypotheses for the production function approach. The hypotheses are defined in order to investigate the nature of shocks and how they impact on output.

The first stage assumes that the shock variable enters the model of oil output in terms of the price of oil. The second stage assumes the shock variable enters the model of oil output though the exchange rate. The third stage adds both simultaneously. Then we turn over our attention to the effect of the shock variable in the model of non-oil output. The final stage is to analyze and evaluate the selected models for oil and non-oil sector and use them to explain the cyclical behaviour of the Iranian economy.

6.6.1 The Oil Sector Production Function

The first stage in using the specified production function in Model (A) for oil output is to define the shock variable that enters as the price of oil. There are a number of possible hypotheses for (z_t).

Hypothesis (1): The shock variable is defined in terms of changes in the price of oil ($\Delta \log(poil_t)$). Our production function for oil output takes the form:

Model (1) $$\Delta Log(y_t^o) = \lambda + \alpha\Delta Log(k_t^o) + \beta\Delta Log(n_t^o) + \mu_1\Delta Log(Poil_t) + \mu_2 D_2 + \mu_3 D_2\Delta Log(Poil_t) \quad (6.12)$$

where D_2 is a dummy variable for the sub-period of 1979-88 which allows for the effect of political instability caused by the revolution and the Iran-Iraq war. The results of estimating this model show that most of the coefficients, especially the coefficient of the change in the price of oil are insignificant. So, the results reported in column 1 of Table 6.1, shows that the model (1) is poor fitting.

Hypothesis (2): When the shock variable is defined as changes in the price of oil in hypothesis 1, it was found that movements in the price of oil did not explain oil price shocks. Therefore, we suggest a new shock variable, namely deviations between the actual and predicted (that is the price of oil upon which Five-Year plans are based) of the price of oil. This is proxy for shock variable of the price of oil (PS). There are two possible approaches. The first defines the shock variable as difference between actual and expected price of oil. This was tested and the results were found to be statistically insignificant. The second approach uses a quadratic form. Here, the squared deviation introduces a bigger penalty for deviations and includes two elements: the difference between actual price with expected price, and the quadratic form of oil price shocks ($PS2$). The model is:

Model (2) $$\Delta Log(y_t^o) = \lambda + \alpha\Delta Log(k_t^o) + \beta\Delta Log(n_t^o) + \mu_4 PS2 + \mu_2 D_2 \quad (6.13)$$

The estimated equation is reported in column 2 of Table 6.1 and shows that the variables have better explanatory power than those of model 1, but are statistically insignificant and the model still has a poor fit.[17]

Hypothesis (3): Another possibility is that oil price shocks can be divided into two separate shocks: ($PSPO$) where the deviation between actual and planned oil price is positive ($PS \succ 0$), whilst ($PSNE$) the deviation to the case where is negative ($PS \prec 0$).[18] This is called a dummy track in the price of oil where oil price shocks capture positive or negative effects of shocks. The model as follows:

Model (3)
$$\Delta Log(y_t^o) = \lambda + \alpha \Delta Log(k_t^o) + \beta \Delta Log(n_t^o) + \mu_5 PSPO_t + \mu_2 D_2 + \mu_6 D_2 PSPO_t \qquad (6.14)$$

We estimated both positive and negative oil price shocks separately. The results show that positive oil price shocks have a statistically significant effect on oil output but still the model has a poor fit.[19] The result of this final equation is reported in column 3 of Table 6.1.

Table 6.1 summarizes the results of the OLS regressions that are obtained from the three different hypotheses. In general, the results show that all three models are poor fitting; though the DW test shows an absence of autocorrelation. Only the dummy variable (D2) for the period of the Iranian revolution and Iran-Iraq war, in either intercept or slope form has any significance with a negative effect on oil output.

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[17] Note that the initial estimate in model 2 was obtained by using the difference between the actual and expected planned price of oil (PS). The estimated equation has a poor fit and is not reported here.

[18] In economics, information asymmetry occurs when a positive shock has more effect than a negative shock. Information asymmetry models assume that at least one positive shock has more effect than the negative. It is often observed that upward movements in the price of oil are followed by higher volatility than downward movements of the same magnitude. To account for this phenomenon, Engle and Ng (1993) describe a news impact curve with asymmetric response to positive and negative shocks (QMS, Eviews 4, 2000). The estimated equation has a poor fit and is not reported here.

[19] To distinguish the effects of positive from negative shocks model (3) only considers the positive shocks. The positive shocks also show that when the price of oil in US dollars increases, given a constant exchange rate, oil revenue and then oil output will decrease.

Table 6.1 Oil Price Shocks in the Oil Sector

Variable	Model 1	Model 2	Model 3
Dependent (DLOG(YO))	β (t-ratio)	β (t-ratio)	β (t-ratio)
Intercept	0.07 (1.96)	0.06 (1.58)	0.07(1.93)
Capital (DLOG(KO))	0.32 (0.76)	0.80 (1.75)	0.65 (1.34)
Labour (DLOG(NO))	-0.11 (-0.22)	0.23 (0.44)	-0.01 (0.02)
Price of Oil (DLOG(POIL))	-0.04 (-0.39)		
Quadratic form of oil price shock (PS2)		-0.0004 (-1.36)	
Positive oil price shocks (PSPO)			-0.008 (-1.16)
Intercept Dummy (D2)	-0.50 (-5.20)	-0.55 (-5.41)	-0.66 (-5.21)
Slope Dummy (D2*DLOG(POIL))	2.34 (2.64)		
Slope Dummy (D2*PSPO)			0.31 (1.99)
R-Squared (R^2)	0.50	0.44	0.49
Adjusted R-squared ($\overline{R}^2$)	0.44	0.38	0.43
Number of Observations	46	46	46
D.W	2.08	2.02	2.12

Compiled by Author, data source: Central bank of Iran

The second stage is to use the production function specified in Model (B) allowing the shock variable to enter through the exchange rate. Again we can consider a range of hypotheses for (z_t).

Hypothesis (1): The shock variable is defined in terms of changes in exchange rate ($\Delta\log(er_t)$). Model (4) relates oil output to changes in the exchange rate as follows:

Model (4)
$$\Delta Log(y_t^o) = \lambda + \alpha\Delta Log(k_t^o) + \beta\Delta Log(n_t^o) + \mu_7\Delta Log(er_t) + \mu_2 D_2 + \mu_8 D_2\Delta Log(er_t) \quad (6.15)$$

The result reported in column 1 of Table 6.2 show that the model is a poor fit.

Hypothesis (2): The shock is defined as the squared difference between the actual and expected planned exchange rate (QXX). The model becomes:

Model (5) $$\Delta Log(y_t^o) = \lambda + \alpha \Delta Log(k_t^o) + \beta \Delta Log(n_t^o) + \mu_9 QXX_t + \mu_2 D_2 + \mu_{10} D_2 QXX_t \quad (6.16)$$

The estimated equation is reported in the column 2 Table 6.2 and has a poor fit.

Hypothesis (3): The shock variable relates to observations ($XXPO$) where the deviation between the actual and expected planned exchange rate is positive ($XX \succ 0$). Model (6) defines oil output as follows:

Model (6) $$\Delta Log(y_t^o) = \lambda + \alpha \Delta Log(k_t^o) + \beta \Delta Log(n_t^o) + \mu_{11} XXPO_t + \mu_2 D_2 \quad (6.17)$$

Hypothesis (4): The shock variable relates to the case ($XXNE$) where this deviation is negative ($XX \prec 0$). The model (7) is:

Model (7) $$\Delta Log(y_t^o) = \lambda + \alpha \Delta Log(k_t^o) + \beta \Delta Log(n_t^o) + \mu_{12} XXNE_t + \mu_2 D_2 \quad (6.18)$$

The estimated results are reported in the column 3 and 4 of Table 6.2 and show that both models produce poor fits.

Table 6.2 summarizes the results of the OLS regressions that are obtained from the four different models of exchange rate shocks in the oil sector. In general, the result of the DW statistic shows that autocorrelation is not a problem. Only the dummy variable (D2) for the period of the Iranian revolution and Iran-Iraq war, in either intercept has any significance with a negative effect and slope form has positive effect on oil output, respectively.

Table 6.2 Exchange Rate Shocks in the Oil Sector

Variable	Model 4	Model 5	Model 6	Model 7
Dependent (DLOG(YO))	β (t-ratio)	β (t-ratio)	β (t-ratio)	β (t-ratio)
Intercept	0.07 (1.87)	0.07 (1.92)	0.06 (1.55)	0.06 (1.69)
Capital (DLOG(KO))	0.17 (0.40)	0.45 (1.22)	0.49 (1.21)	0.42 (1.05)
Labour (DLOG(NO))	-0.18 (-0.31)	0.05 (0.10)	0.06 (0.11)	0.17 (0.32)
Exchange Rate (DLOG(ER))	-0.04 (-0.20)			
Quadratic Form of exchange rate shocks (QXX)		-0.0000001 (-0.77)		
Positive exchange rate shocks (XXPO)			-0.00001 (-0.68)	
Intercept Dummy (D2)	-1.03 (-5.57)	-0.97 (-5.88)	-0.53 (-5.21)	-0.54 (-5.29)
Slope Dummy (D2*DLOG(ER))	2.08 (3.07)			
Slope Dummy (D2*QXX)		0.002 (3.16)		
Negative exchange rate shocks (XXNE)				0.0002 (0.98)
R-Squared (R^2)	0.53	0.55	0.42	0.43
Adjusted R-Squared ($\overline{R}^2$)	0.47	0.49	0.36	0.37
Number of Observations	46	46	46	46
D.W	2.04	1.88	2.06	2.07

Compiled by Author, data source: Central bank of Iran

So far, we have estimated the production function for the oil sector in terms of either oil price shocks or exchange rate shocks. To find a comprehensive model for oil output, we can also allow changes in the price of oil and the exchange rate to take place simultaneously.

The third stage is to take the production function specified in Model (C) to allow the shock variable to enter through the price of oil and/or exchange rate. We can consider a range of hypotheses for (z_t).

Hypothesis (1): The shock is defined as the change in the price of oil multiplied by the nominal exchange rate ($NPER$). Model (8) is defined as follows:

Model (8) $$\Delta Log(y_t^o) = \lambda + \alpha \Delta Log(k_t^o) + \beta \Delta Log(n_t^o) + \mu_{13} \Delta Log(NPER_t) + \mu_2 D_2 \quad (6.19)$$

Hypothesis (2): The shock is defined as the change in the price of oil multiplied by the real exchange rate ($RPER$).[20] Model (9) is defined as follows:

Model (9) $$\Delta Log(y_t^o) = \lambda + \alpha \Delta Log(k_t^o) + \beta \Delta Log(n_t^o) + \mu_{14} \Delta Log(RPER_t) + \mu_2 D_2 \quad (6.20)$$

Hypothesis (3): The shock is defined as the changes in the price of oil ($Poil$) and the exchange rate (er). Model (10) is defined as follows:

[20] To find out real exchange rate, it may be necessary to consider a foreign currency which plays a major role in the economy. The US dollar captures a major market share of exchange rate. There is also a strong relationship between the US dollar and the Iranian Rial in the long-term, which transfers the effects of exchange rate changes into other currencies. Therefore, based on the above implications, the consumer price index (CPI) of the US is used to measure Iranian real exchange rate (RER). It can be measured as follows:

$$RER = \frac{NER / P}{1\$ / P^*} = NER . \frac{P^*}{P}$$

where RER is the real exchange rate, NER is the nominal (official) exchange rate, (P) is the consumer price index in Iran, and (P^*) is the consumer price index in the United States. There is no significant difference between the nominal and real term.

Model (10) $$\Delta Log(y_t^o) = \lambda + \alpha \Delta Log(k_t^o) + \beta \Delta Log(n_t^o) + \mu_1 \Delta Log(Poil_t) + \mu_7 \Delta Log(er_t) + \mu_2 D_2 \quad (6.21)$$

Hypothesis (4): The shock is defined as the square of the deviation between the actual and expected planned price of oil ($PS2$) and the square of the deviation between the actual and expected planned exchange rate (QXX). Model (11) is defined as follows:

Model (11) $$\Delta Log(y_t^o) = \lambda + \alpha \Delta Log(k_t^o) + \beta \Delta Log(n_t^o) + \mu_4 PS2_t + \mu_9 QXX_t + \mu_2 D_2 \quad (6.22)$$

Hypothesis (5): The shock is defined as the deviation between actual and planned oil price where is positive ($PSPO$) and the deviation between actual and planned exchange rate where is positive. Model (12) is defined as follows:

Model (12) $$\Delta Log(y_t^o) = \lambda + \alpha \Delta Log(k_t^o) + \beta \Delta Log(n_t^o) + \mu_5 PSPO_t + \mu_{11} XXPO_t + \mu_2 D_2 \quad (6.23)$$

Hypothesis (6): The shock is defined as the deviation between the actual and expected planned oil price where is negative ($PSNE$) and the deviation between the actual and expected planned exchange rate where is negative ($XXNE$). Model (13) is defined as follows:

Model (13) $$\Delta Log(y_t^o) = \lambda + \alpha \Delta Log(k_t^o) + \beta \Delta Log(n_t^o) + \mu_{15} PSNE_t + \mu_{12} XXNE_t + \mu_2 D_2 \quad (6.24)$$

Table 6.3 summarizes the results of OLS regression of models (8) to (13) for the oil sector based on hypotheses for shock variable based on the price of oil and exchange rate. The results show poorly fitting models and only the dummy variable has any statistically significant effect. Based on the significance of its coefficients and taking other considerations into account model (11) have been selected as "best".[21] However, the results of trend coefficient show that oil output is steady growth rate about 0.06. Therefore, oil sector introduce the trend and it is trend dominated. Results from the initial analysis of data for the oil sector shows that the oil output is growing steadily. Therefore, whatever changing the price of oil, changes the oil revenue and it is not possible to differentiate exchange rate dimension and oil price changes for steady trend behaviour of the oil sector.[22]

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[21] The selected model is based on comparison the t-statistic and R-squared between estimated models. In econometric literature, formal F-test is also applied for comparison.

[22] If the oil GDP is trend stationary, current economic shocks (oil price shocks) will not have any long-run effects on the series. Shocks to a stationary time series are necessarily temporary; over time, the effects of shocks will dissolve and the series will revert to its long-run mean level (Enders, 1995).

Table 6.3 Oil Price and Exchange Rate Shocks in the Oil Sector

Variables	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13
Dependent (DLOG(YO))	β (t-ratio)	β (t-ratio)	β (t-ratio)	β (t-ratio)	β (t-ratio)	β (t-ratio)
Intercept	0.049 (1.31)	0.051 (1.32)	0.038 (0.88)	0.073 (1.89)	0.064 (1.71)	0.095 (1.94)
Capital (DLOG(KO))	0.47 (1.16)	0.48 (1.19)	0.64 (1.34)	0.87 (1.87)	0.89 (1.81)	0.23 (0.50)
Labour (DLOG(NO))	0.11 (0.22)	0.09 (0.18)	-0.17 (-0.26)	0.17 (0.32)	0.19 (0.37)	0.26 (0.49)
Nominal (DLOG(NPER))	0.01 (0.28)					
Real (DLOG(RPER))		0.0009 (0.02)				
Price of Oil DLOG(POIL))			-0.03 (-0.27)			
Exchange Rate (DLOG(ER))			0.15 (0.65)			
Quadratic of Oil price shocks (PS2)				-0.0005 (-1.51)		
Quadratic of ER shocks (QXX)				-0.000001 (-0.85)		
Positive Oil Price shocks (PSPO)					-0.01 (-1.38)	
Negative Oil Price shocks (PSNE)						0.009 (1.00)
Positive exchange rate shocks (XXPO)					-0.00001 (-0.64)	
Negative exchange rate shocks (XXNE)						0.0003 (1.19)
Intercept Dummy (D2)	-0.53 (-5.13)	-0.53 (-5.12)	-0.55 (-5.12)	-0.57 (-5.45)	-0.56 (-5.44)	-0.55 (-5.36)
R-Squared (R^2)	0.42	0.41	0.42	0.46	0.45	0.44
Adjusted R-Squared ($\overline{R}^2$)	0.36	0.36	0.35	0.39	0.38	0.37
Number of observations	46	46	46	46	46	46
D.W	2.02	2.03	2.05	2.08	2.10	2.06

Compiled by Author, data source: Central bank of Iran

6.6.2 The Non-Oil Sector Production Function

Suppose that the non-oil sector captures the cyclical behaviour of business cycles. The oil sector is regulated by the government and can affect the non-oil sector. This effect is captured through two channels:

1. The oil sector affects the non-oil sector by generating petrodollars that substantially impact on the economy's capacity to import capital and intermediate goods that are employed in non-oil sector production.[23]

2. The oil sector and its output are totally exogenous as oil prices are determined in the world oil market, and the quantity of oil that Iran can export is set by OPEC.

Based on planning system in Iran, oil revenues transfer to the government budget. Oil revenues in excess of the budgeted amount are transferred to the oil stabilization fund (OSF). If the realized oil revenue is less than the annual budget allocation, the government draws from the OSF the amount required to compensate for the shortfall in its expenditure.[24] In this way the government can smooth the expenditure in order to oil revenue fluctuations.

The final stage to use the production function specified in Model (D) and to allow entry of the shock variable through government expenditure. We can consider a range of hypotheses for (z_t).

Hypothesis (1): The shock variable is defined as the proportion of government expenditure in total GDP (SG). Model (14) is defined as:

Model (14) $$\Delta Log(y_t^{no}) = \lambda + \alpha \Delta Log(k_t^{no}) + \beta \Delta Log(n_t^{no}) + \mu_{16}(SG_t) + \mu_2 D_2 \qquad (6.25)$$

[23] See Valadkhani (1997) for more details. See also Aghvli and Sassanpour (1982).
[24] See IMF (2004) for more details.

Estimation of this model shows that most coefficients, especially the coefficient of the government expenditure variable are significant. The results reported in column 1 of Table 6.4, also show that the model still has a poor fit.

Hypothesis (2): The shock variable is d efined as the proportion of government expenditure in total GDP (SG) and the first difference of oil GDP with a one period lag (Y^{o}_{t-1}). Model (15) is defined as:

Model (15)
$$\Delta Log(y_t^{no}) = \lambda + \alpha \Delta Log(k_t^{no}) + \beta \Delta Log(n_t^{no}) + \mu_{16}(SG_t) + \mu_{17}\Delta Log(Y^{o}_{t-1}) + \mu_2 D_2 \qquad (6.26)$$

The results show that most of the coefficients, especially the coefficient of the government expenditure in total GDP and the first difference of logarithm of oil GDP variable are significant. The result reported in column 2 of Table 6.4, show that this model is a better fit than Model (14). The results show that the role of government in the non-oil sector is positive and significant, and that the dummy variable for the Iranian revolution and war has a negative effect on the intercept of output.

Table 6.4 Shocks in Non-Oil Sector

Variables	Model 14	Model 15
Dependent (DLOG(YNO))	β (t-ratio)	β (t-ratio)
Intercept	-0.03 (-1.26)	-0.05 (-1.94)
Capital (DLOG(KNO))	0.83 (6.98)	0.76 (6.78)
Labour (DLOG(NNO))	0.02 (0.74)	0.03 (0.86)
Government Expenditure Share (SG)	0.002 (1.43)	0.003 (2.21)
GDP in Oil Sector (DLOG(YO(-1))		0.08 (2.74)
Intercept Dummy (D2)	-0.08 (-2.94)	-0.08 (-2.99)
R-Squared (R^2)	0.59	0.66
Adjusted R-Squared ($\overline{R}^2$)	0.55	0.61
Number of observations	46	46
D.W	2.05	2.02

It has been shown that the coefficients on the capital variable show that capital has a positive effect on output; the results of a t-test reveal that these coefficients are significant for the non-oil sector, and insignificant for the oil sector. It has also been shown that for all models the coefficients of the labour variable are insignificant and have no effect on output.

The price of oil shock has a small, negative effect on oil output and is insignificant statistically. Moreover, the coefficient of the price of oil in all regressions is not significantly different from zero. The coefficients of the exchange rate variable are insignificant and show it has a negative effect on oil GDP. As a result, we reject the hypothesis that there is a significant statistical relationship between the oil price shocks and output for Iran.

The results show that the role of government in the economy is positive and significant, but that the sign of the coefficient of dummy variable indicate that there is a significant downward shift and negative effect on output.

6.6.3 OPEC, Oil Crises, and Interaction Dummies

Economic theories often incorporate qualitative, rather than quantitative, explanatory variables; such as war and oil shocks. In such cases a quantative proxy is constructed to represent qualitative variables in the corresponding econometric model, and such proxy variables are known as dummy variables. The simplest form of dummy variable is one which takes the value of one when the qualitative effect is in place, and zero otherwise (Darnell, 1994).

This section attempts to evaluate the impacts of dummy variables such as OPEC behaviour and policy, oil crises, and Iran-Iraq war on Iranian economy. Here the assumptions about the impacts on these events are based on the results of chapter two and three. Nevertheless, OPEC as a cartel has major influence on the oil market because it dominates the supply side and can reduce or increase supply on a significant scale to affect the oil price towards target revenue. As a result of this behaviour when the oil market is tight the oil price is set by the supply and demand, otherwise OPEC has the power to set the oil prices.[25]

In addition, the oil crises of 1973 and 1979 had a positive effect on the oil prices, while the oil crisis of 1986 had a negative effect on oil prices. The role of the 1979 revolution which was followed by the war (1980-88) had a large effect on oil prices and the economy. These phenomena can be tested by using a Chow test and evaluating interaction between dummies to find their significance on oil and non-oil output.

In many economic applications a critical question arises as to whether the same model is appropriate for two potentially different sub-samples. Is there a historical relationship between GDP and oil price shocks? In what year did oil price shocks/OPEC/Iran-Iraq war shift the production function? These are some questions to which the Chow test and related statistical procedures could provide valuable insight. The idea of the Chow test is to fit the equation separately for each sub-sample and to see whether there are significant differences in the estimated equations.[26]

[25] Gulen (1996) suggested that the 1982-93 period is the only time period which OPEC had the ability to impact oil prices.

[26] The Chow test compares the sum of squared residuals obtained by fitting a single equation to the entire sample with the sum of squared residuals obtained when separate equations are fit to each sub-sample of the data. A significant difference indicates a structural change in the relationship. There are two test statistics - the F-statistic is based on the comparison of the restricted and unrestricted sum of squared residuals, and the log likelihood ratio statistic is based on the comparison of the restricted and unrestricted maximum of the log likelihood function. The LR test statistic has a Chi-Squared distribution with degrees of freedom equal to (m-1) k under the null hypothesis of no structural change, where m is the number of sub-samples and k is the number of parameters in the equation.

There are several structural break points in the Iranian economy, which can be dated. These are 1973 (first oil shock), 1979 (second oil shock and Revolution), 1980-88 (war with Iraq), 1982-93 (OPEC power), and 1986 (third oil shock).To explore the importance of these events on the Iranian economy, it is necessary to introduce dummy variables and test the significance of the estimated coefficients. The dummy variables are reported in Table 6.5.

Table 6.5 Dummy Variables in the Iranian Economy

Dummy Variables	Break Point	Null Hypothesis	Alternative Hypothesis
D1: First oil shock	1973	$0\ for\ t \prec 1973$	$1\ for\ t \geq 1973$
D3: Second oil shock/Revolution	1979	$0\ for\ t \prec 1979$	$1\ for\ t \geq 1979$
D4: Iran-Iraq War	1980-88	$0\ for\ t \prec 1980\ and\ t \succ 1988$	$1\ for\ t \geq 1980-88$
D5: OPEC power	1982-93	$0\ for\ t \prec 1982\ and\ t \succ 1993$	$1\ for\ t \geq 1982-93$
D6: Third oil shock	1986	$0\ for\ t \prec 1986$	$1\ for\ t \geq 1986$

The results of Chow test are shown in Table 6.6.

Table 6.6 Results of Chow Test for Oil Sector

Chow Breakpoint Test: 1973 (First oil price shock)

F-statistic (2.15)	0.306512	Probability	0.905482
Log likelihood ratio	1.951993	Probability	0.855747

Chow Breakpoint Test: 1979 (Second oil price shock)

F-statistic (1.99)	0.468868	Probability	0.796611
Log likelihood ratio	2.951121	Probability	0.707521

Chow Breakpoint Test: 1980-1988 (Iran-Iraq War)

F-statistic (2.19)	3.933744	Probability	0.002004
Log likelihood ratio	37.73301	Probability	0.000042

Chow Breakpoint Test: 1982-93 (OPEC power)

F-statistic (2.61)	0.734375	Probability	0.686638
Log likelihood ratio	10.01544	Probability	0.439140

Chow Breakpoint Test: 1986 (Third oil price shock)

F-statistic (2.07)	3.638850	Probability	0.009884
Log likelihood ratio	18.88215	Probability	0.002022

The empirical results based on Chow test show that there was not enough evidence against the null hypothesis of 1973, 1979, and 1982-93 for oil output. The computed break dates correspond closely with the expected dates associated with the effect of the Iran-Iraq war. We found that the most significant structural breaks occurring over the last four decades, correspond with the 1980-88 (Iran-Iraq war), and 1986 (third oil price shock).

Table 6.7 Results of Chow Test for Non-Oil Sector

Chow Breakpoint Test: 1973

F-statistic (2.15)	1.801287	Probability	0.138990
Log likelihood ratio	10.33953	Probability	0.066167

Chow Breakpoint Test: 1979

F-statistic (1.99)	4.515203	Probability	0.002906
Log likelihood ratio	22.40588	Probability	0.000438

Chow Breakpoint Test: 1980-1988

F-statistic (2.19)	1.939707	Probability	0.080053
Log likelihood ratio	22.53431	Probability	0.012602

Chow Breakpoint Test: 1982-93

F-statistic (2.61)	1.144183	Probability	0.361095
Log likelihood ratio	11.01642	Probability	0.200771

Chow Breakpoint Test: 1986

F-statistic (2.07)	2.785243	Probability	0.032608
Log likelihood ratio	15.10530	Probability	0.009922

The empirical results based on a Chow test show that there was not enough evidence against the null hypothesis of 1973, 1980-88, 1982-93, while there are significant structural breaks occurring over the period 1979 and 1986 for non-oil output. This provides complementary evidence to the model employing exogenously imposed structural breaks in the Iranian macroeconomy.

One possibility is that the various events discussed above (namely, oil crises, war, and OPEC policy) may be subject to interaction effect. To evaluate these, we consider the following models – specifically 6.13, which allows for multiplicative interaction.

$$Y_t = \alpha_1 + \alpha_2 D_{1t} + \alpha_3 D_{3t} + \beta X_t + u_t \qquad (6.27)$$

where Y is output, D1, and D3 are first and second oil shock (qualitative), and X includes all quantitative explanatory variables. To allow for interaction effects, we specify 6.13. According to 6.13 the possibility exists of interaction between the two qualitative variables D1 and D3. Therefore, their effect on mean Y may not be simply additive as in (6.12) but multiplicative as well, as in the following model (Gujarati, 2003):

$$Y_t = \alpha_1 + \alpha_2 D_{1t} + \alpha_3 D_{3t} + \alpha_4 (D_{1t} D_{3t}) + \beta X_t + u_t \qquad (6.28)$$

From the (6.13), we obtain:

$$E(Y_t / D_{1t} = 1, D_{3t} = 1, X_t) = (\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4) + \beta X_t + u_t \qquad (6.29)$$

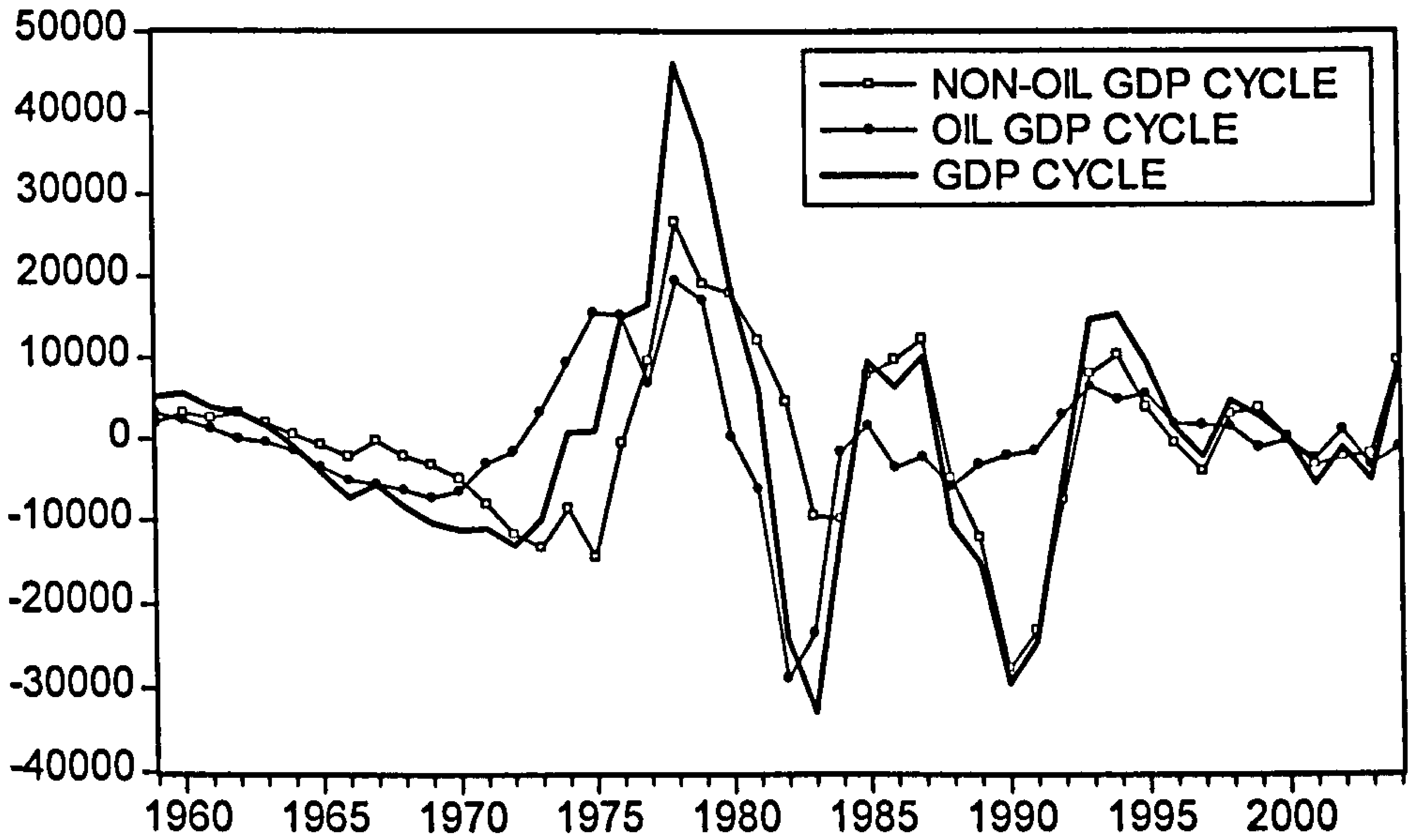
where α_2, α_3, and α_4 are the differential effects of being first oil shock, second oil shock, and first and second oil shock, respectively. According to the model (6.14), the interaction dummies for the war, oil shocks, and OPEC in the oil and non-oil output are estimated and available by author upon request.

Overall, the results of interaction dummies in the oil sector show that all the differential intercept coefficients, additive and interaction, are statistically insignificant, except for interaction dummies between second oil shock/Revolution and third oil shock, and between war and OPEC policy. The interaction effect between second and third oil shock (0.02), and between war and OPEC (0.06) show that holding other explanatory variables constant, they increase the mean of oil output.

The results of interaction dummies in the non-oil sector show that all the coefficients of additive and interaction dummies are statistically insignificant, and only the interaction effect between war and third oil price shock is significant (0.07), which may increase the mean of non-oil output.

6.6.4 Cyclical Behaviour of the Iranian Economy

In this section, we evaluate the cyclical behaviour of aggregate economic activity level in oil and non-oil output, based on the results obtained. Given the limitations of available data and plausible transmission channels of the effects of the oil price shocks on the economic activity, we use simple models which empirically test the inverse relationship between oil price shocks and economic cycles. In order to do this, we discuss our empirical results on the effect of oil price shocks for selected models of the oil and non-oil sectors. We used the HP-filter in Chapter 4 and decomposed trend from cycle. Thus the result shows the underlying cyclical behaviour of the Iranian economy.

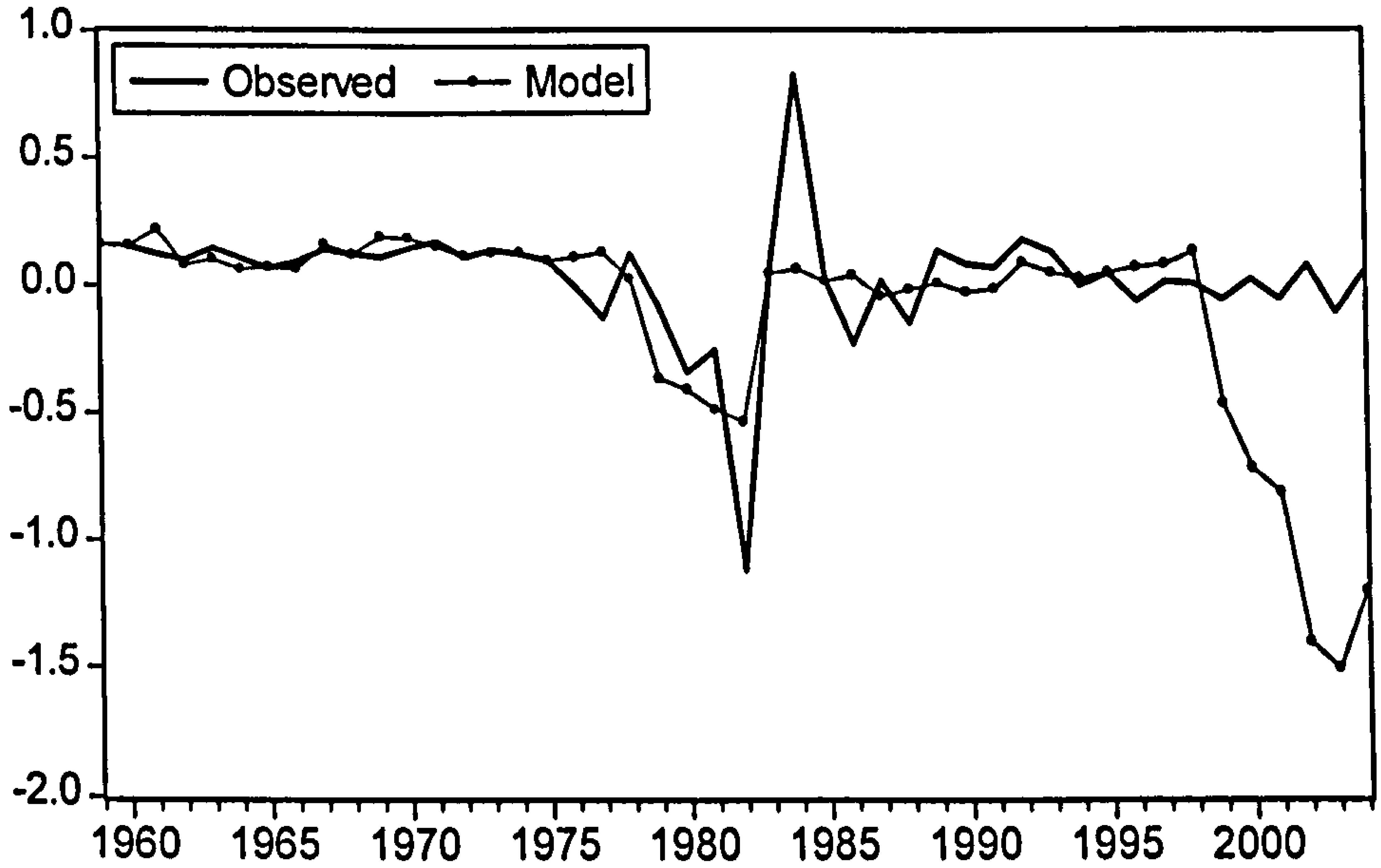


Compiled by Author, data source: Central Bank of Iran, Historical time series, 1959-2003, 2004

Figure 6.1 Cyclical Output

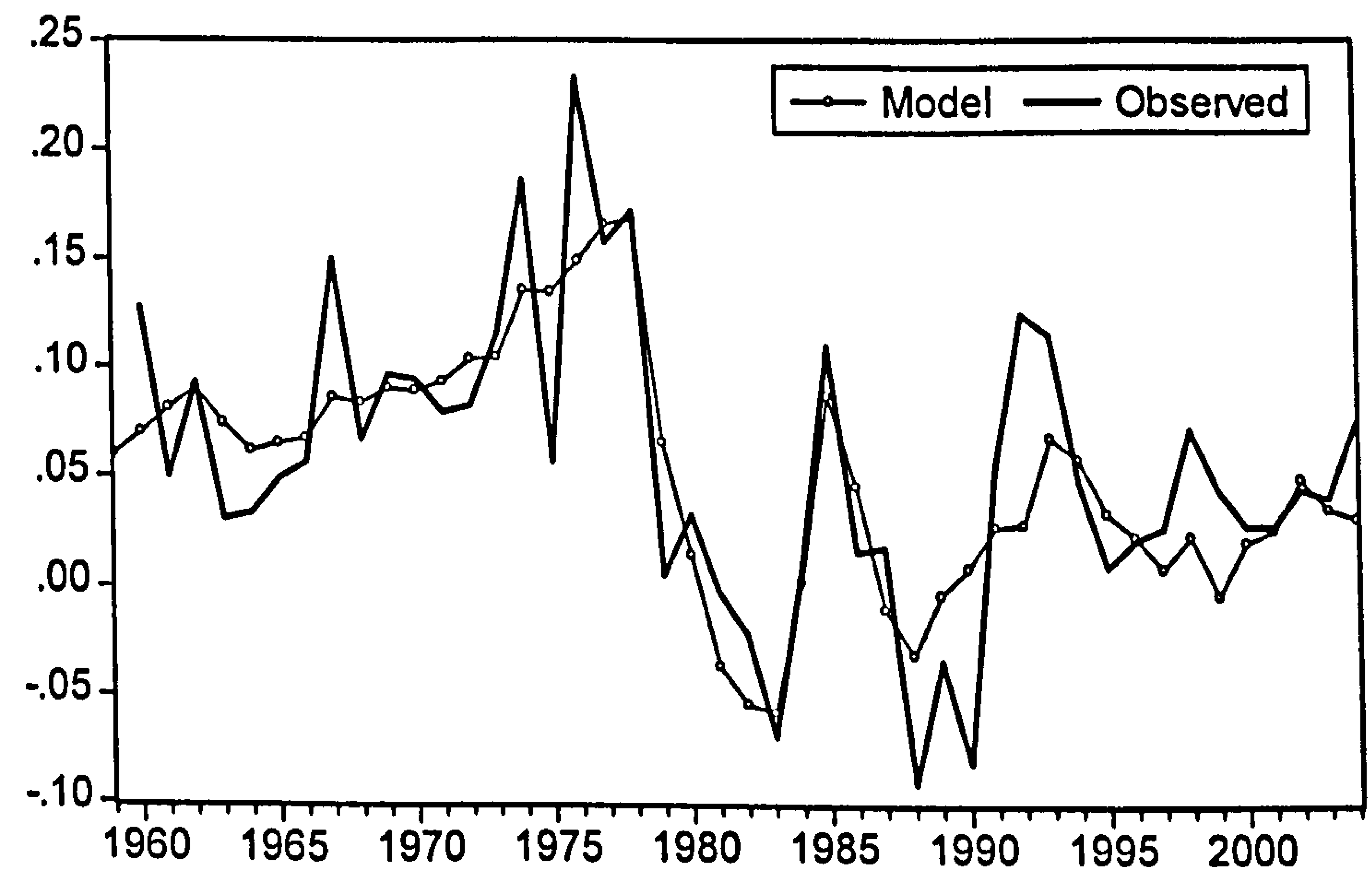
Figure 6.1 shows cyclical behaviour of oil, non-oil, and total GDP for the Iranian economy and provides a snapshot of the Iranian business cycles during the period 1959-2004. This cyclical component, obtained from the HP-filter, is defined as the deviation of actual from trend. As we might have expected, total GDP, oil and non-oil GDP follow each other closely over the business cycle in Iran. The Figure also show that the fluctuations in the prediction of oil GDP are much smaller than those historically observed. We can also see that the economy has experienced several business cycles during the period of study, three turning points - 1978, 1987, and 1994 all of which are shown in Figure 6.1.

In order to understand the cyclical behaviour of the Iranian economy, we investigate the behaviour of the fitted values of the estimated models against their known historical values. We use the "best" fitting models for oil (model 11) and for non-oil (model 15) to generate the fitted values based on the historical data. The two selected models for oil and non-oil output were replicated using the parameter values of each model. The actual (observed) and fitted (model) values for the two sectors are illustrated in Figures 6.2 and 6.3. The Figures suggest that the predictions of the selected models are consistent with the observed patterns for oil and non-oil sectors in accounting for the response of these sectors, except during the second oil price shock.



Compiled by Author, data source: Central Bank of Iran, Historical time series, 1959-2003, 2004

Figure 6.2- Real and Predicted Oil GDP in Iran



Compiled by Author, data source: Central Bank of Iran, Historical time series, 1959-2003, 2004

Figure 6.3- Real and Predicted Non-Oil GDP in Iran

These Figures also show that the instability in replicated data is somewhat underestimated at the beginning of the sample. For example, averaging this period of positive fluctuations between oil price changes and output growth together with the

1974-75 and 1979-81, periods of negative fluctuations misses the possibility that the dynamic response of the variables in the model is different for oil price decreases than it is for oil price increases. Throughout the early 1980s, oil prices were important negative factors affecting output. Finally increasing political instability, accompanied by a debt crises in the later years are features the model is obviously demonstrating. Saez and Puch (2002) using a similar model for developing countries came to conclusions consistent with this research.

6.6.5 Lag Modelling: Developing a Dynamic Model

Overall, the estimated models show the results of a static model for the Iranian economy. The revival of interest in economic dynamics has given a new emphasis to time series by using lagged dependent variable. Enders (1995) suggests that stochastic difference equations can take place quite naturally from dynamic economic models. An important issue in econometrics is the need to integrate short-run dynamics with long-run equlibria. The traditional approach to the modelling of short-run disequilibria is the partial adjustment model (PAM).[27] The analysis of short-run dynamics is often done by eliminating trends in the variables, usually by differencing (Maddala, 2001). Some studies include a lagged dependent variable as a regressor, giving as a justification the argument that an economy may be able to immediately and fully adjust towards the equilibrium value which is consistent with the values of all the independent variables in the regression.[28]

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[27] Partial adjustment models have established extraordinarily useful in empirical work and uncertainty as to the precise quantitative effect of manipulating a policy variable is widespread (Startz, 2005). Chow (1975) presents a general analysis of dynamic systems under uncertainty. Indeed, the principal involvement of a dynamic model is to show that under a particular, reasonable specification, the optimal policy is to follow the partial adjustment model.

[28] The inclusion of lagged values of the dependent variable as regressor is a means of simplifying the form of the dynamic model by placing restrictions on how current Y_t adjusts to the lagged values of explanatory variables with a one period lag (Harris, 1995).

The economic theory suggests that the production function needs to produce a given output under the amount of technology. Gujarati (2003) argues that to transform a static production function to a dynamic model, an adjustment or partial adjustment model may be used. Following Griliches (1979), a simple production function can be specified as $Y_t = F(K_t, N_t, u_t)$ relating some measure of output (Y_t), at the macro (country) level, to the inputs K_t, N_t, and u_t; where N_t stands for labour, K_t is capital stock, and u_t represents all other unmeasured determinants of output (see also Crespi and Geuna, 2005).

The argument is based on a Cobb-Douglas production function relating output (Y_t) in period (t) to labour (N_t), and capital stock (K_t) is defined as follows:

$$Y_t = Ae^{u_t}K_t^{\alpha}N_t^{\beta} \tag{6.30}$$

where A is the temporary change in total factor productivity, e is the exponential; α *and* β are returns to scale, u_t is the error term, and t is the time index. Taking logarithms from both sides:

$$\log Y_t = \log A + \alpha \log K_t + \beta \log N_t + u_t \tag{6.31}$$

where:

$$\log Y_t = y_t^*,\ \log A = \mu_0,\ \alpha \log K_t = \mu_1 k_t,\ \beta \log N_t = \mu_2 n_t \tag{6.32}$$

To simplify, suppose the following Cobb-Douglas production function in logs that the desired level (planned level/optimal value) of output (y_t^*) is a linear function of inputs capital (k_t) and labour (n_t) as follows:

$$y_t^* = \mu_0 + \mu_1 k_t + \mu_2 n_t + u_t \tag{6.33}$$

where n_t is the log of labour, k_t is the log of capital, u_t is the random error term, and y_t^* is the log of optimal/desired (long-run) value of output (y), but that the economy chooses only partially to adjust the value of y towards this equilibrium within the current period.[29] This model is named the long-run or equilibrium, production function for output.

Since the desired level of output is not directly observable, we follow the partial adjustment hypothesis, which suggests that output adjusts slowly towards its desired value (Gujarati, 2003).[30] In particular suppose the actual adjustment ($y_t - y_{t-1}$) is only a proportion (δ) of the desired change $(y_t^* - y_{t-1})$. The partial adjustment mechanism is:[31]

$$y_t - y_{t-1} = \delta(y_t^* - y_{t-1}) \qquad 0 \prec \delta \leq 1 \tag{6.34}$$

where δ is the coefficient of adjustment, $y_t - y_{t-1}$ is the actual output change between two periods, $(y_t^* - y_{t-1})$ is the desired change.

Equation (6.30) suggests that the actual change is output in any given time period t is some fraction (δ) of the desired change for that period. If δ=1, the actual output is equal to the desired output, the actual output adjusts to the desired output in the same

[29] The economic litterateur generally requires an explanation for the determination of the unobservable y_t^*. For example, the optimum output might depend on the prices of its output and the factors of production, which can be observed (Stewart and Wallis, 1981).
[30] A simple model incorporating adjustment lags is the partial adjustment model, e.g., an economy adjusts output only partially toward its desired levels (Maddala, 2001:405). See also Stavrinos (1987).
[31] The partial adjustment model has been used widely and successfully in various econometric investigations. In PAM, current values of the independent variables not only determine the desired value of the dependent variable (Equation 6.4) but also determine some fraction of the desired adjustment within one particular time period (Equation 6.5) (Griliches, 1967).

time period, completely; whereas if $\delta = 0$, nothing ever changes.[32] Note that rearranging the partial adjustment model can be written as:

$$y_t = \delta y_t^* + (1-\delta) y_{t-1} \tag{6.35}$$

This equation shows that the observed output at time t is a weighted average of the desired output at the same time (δ) and the output existing in the previous time period (1-δ). Substituting the long-run equation (6.29) into (6.31) equation for y_t^* we obtain:

$$\begin{aligned} y_t &= \delta(\mu_0 + \mu_1 k_t + \mu_2 n_t + u_t) + (1-\delta) y_{t-1} \\ &= \delta\mu_0 + \delta\mu_1 k_t + \delta\mu_2 n_t + (1-\delta) y_{t-1} + \delta u_t \end{aligned} \tag{6.36}$$

This model called a partial adjustment model that is the short-run production function for output, which is not necessarily equal to the long-run level.[33] Once we estimate the coefficients of equation (6.32), the coefficients of equation (6.29) can also be obtained as follows:

$$y_t = b_0 + b_1 k_t + b_2 n_t + b_3 y_{t-1} + v_t \tag{6.37}$$

where:

$$\begin{aligned} &b_0 = \delta\mu_0, \quad b_1 = \delta\mu_1 \\ &b_2 = \delta\mu_2, \quad b_3 = 1-\delta, \quad v_t = \delta u_t \end{aligned} \tag{6.38}$$

[32] Once y_t is below y_t^*, all the maximising equations are similarly affected since y_t enters the production function and not y_t^*. We can not thus derive desired output by assuming the economy to be continuously in equilibrium and then assume it to be adjusting actual to desired output. The adjustment process has to be integrated with the maximising procedure, which we must add, is not easy task (Desai, 1976).

[33] The short-run (estimating) equation is a combination of the long-run (equilibrium) relationship and the partial adjustment mechanism. Estimates of the long-run parameters (the μ_i s) can be assumed once the short-run parameters (the b_i s) have been estimated (Stavrinos, 1987). Note that $0 \prec b_i \prec 1$ and the properties of the error terms are the same. Thus the partial adjustment model does not change the properties of the error term (Maddala, 2001).

The equation 6.32 contains the dependent variable with one period lagged as an explanatory variable. This is called an autoregressive model or a dynamic model (Gujarati, 2003). The dynamic model is easily generalised to allow for more complicated, and often more realistic, adjustment processes. However, there are several potential problems with this form of the dynamic model. The first is the likely high level of correlation between current and lagged values of a variable that may lead to multicollinearity. The second is that some of the variables in the dynamic model are likely to be nonstationary, in terms of levels. This leads to the potential problem of common trends and thus spurious regression (Harris, 1995).[34]

Suppose that the error term (ν_t) is subject to first-order autocorrelation and follows:[35]

$$\upsilon_t = \rho\upsilon_{t-1} + \varepsilon_t \tag{6.39}$$

Now we can rewrite the equation (6.33) as:

$$y_t = b_0 + b_1 k_t + b_2 n_t + b_3 y_{t-1} + \rho\nu_{t-1} + \varepsilon_t \tag{6.40}$$

But it also holds that y_{t-1} depends on υ_{t-1}, since if (6.33) true for t, it is also true for (t-1).

$$y_{t-1} = b_0 + b_1 k_{t-1} + b_2 n_{t-1} + b_3 y_{t-2} + \nu_{t-1} \tag{6.41}$$

[34] It means that while t- and F-statistics do not have standard distributions and the usual statistical inference is invalid. However, if the right hand side variables in the model are weakly exogenous, invalid inference and potential bias will not be a problem. See Harris (1995)

[35] Assuming $E\{k_t\upsilon_t\} = 0$, $E\{n_t\upsilon_t\} = 0$, $E\{y_{t-1}\upsilon_t\} = 0$ for all t, the ordinary least square (OLS) estimator for b_is is consistent. However, an incorrect dynamic specification, for instance, the correlation between error terms (ν_t) and y_{t-1} may lead to autocorrelation in OLS residuals, which OLS no longer yields consistent estimator for the regression parameters (Gujarati, 2003).

from which it shows that the error term (v_t) is correlated with y_{t-1}, and $\rho \neq 0$. Thus OLS becomes inconsistent and biased. Verbeek (2004) suggests that a possible solution is the use of maximum likelihood or instrumental variables techniques.[36] We estimated static and dynamic regression of oil GDP. The results of static and dynamic models are reported in Table 6.8.

Table 6.8 Static and Dynamic Model of Oil GDP

Variables/Models	Static	Dynamic (-1)
Dependent (DLOG(YO))	β (t-ratio)	β (t-ratio)
Intercept	0.073 (1.89)	0.07 (1.77)
Capital (DLOG(KO))	0.87 (1.87)	0.85 (1.69)
Labour (DLOG(NO))	0.17 (0.32)	0.17 (0.31)
Quadratic of Oil price shocks (PS2)	-0.0005 (-1.51)	-0.0005 (-1.39)
Intercept Dummy (D2)	-0.57 (-5.45)	-0.56 (-5.05)
Quadratic of ER shocks (QXX)	-0.000001(-0.85)	-0.0000001 (-0.79)
Dependent (DLOG(YO(-1))		0.03 (0.24)
R-Squared (R^2)	0.46	0.46
Adjusted R-Squared ($\overline{R}^2$)	0.39	0.37
Number of observations	46	46
D.W	2.08	2.10
F-Statistic		0.06
Chi-Square		43.29

- F-test statistic is based on a modified ratio of the sum of squares residuals. To test the significance (goodness of fit) of estimators, one could apply in economic theory is using Chi-Square (χ^2) methodology. All results are reported here and found that χ^2 lies between the critical value of 5% significance level and the data support null hypothesis (the detail of results available on request).

Overall the results of t-statistics of dynamic regression with one period lagged dependent variable show that the coefficient of y_{t-1} is insignificant and there is no difference between R^2 of static and dynamic model. So, it can be suggested that the

[36] In some applications, the inclusion of lagged dependent variable in the model will eliminate the autocorrelation problem. In such cases the finding of autocorrelation is an indication that the model is misspecified, and we have to decide whether the model is supposed to be static or dynamic (Verbeek, 2004). See also Dougherty (1992).

dynamic model does not improve the results and the static model can be used for this case. The relation between lagged dependent variable and cyclical fluctuations can cause the output to fluctuate. Dependent variable (y_t) varies directly with y_{t-1}. The direct dependence of y_t on y_{t-1} gives the output behaviour to cumulative movement up or down (Matthews, 1966).

However, in a dynamic model with a lagged dependent variable, the Durbin-Watson test is an inappropriate test, because the condition that the explanatory variables can be treated as deterministic is violated (Verbeek, 2004). Assuming that the explanatory variables are non-stochastic, their values are fixed in repeated sampling. So, one could argue that the Durbin-Watson test may not be useful in econometrics involving time series data with lagged dependent variable (Gujarati, 2003).

An alternative test is provided by the Breusch (1978)-Godfrey (1978) Lagrange Multiplier (LM) test for test of autocorrelation.[37] The LM test statistic is asymptotically distributed as a $\chi^2(p)$ with p degrees of freedom. This test statistic can be computed as T multiplied by R^2 of a regression of the least squares residuals v_t on v_{t-1} and all included explanatory variables (including the relevant lagged dependent variable) (Verbeek, 2004).[38]

Breusch-Godfrey precedes the test by assuming the following equation:

[37] In general, this test allows for (1) non-stochastic regressor such as the lagged values of the dependent variable; (2) higher-order autoregressive schemes such as AR(1), AR(2); and (3) simple or higher-order moving average of white noise error terms (Gujarati, 2003).

[38] The null hypothesis of the LM test is that there is no serial correlation up to lag order p, where p is equal to 1 in this case. Under null hypothesis, the test statistics asymptotically has a Chi-squared distribution with one degree of freedom $\chi^2(1)$. The Obs*R-squared statistic is the Breusch-Godfrey LM test statistic. If the sample size is large, then LM statistic is computed as the number of observations and p times the R^2 from the test regression $(n-p)R^2 \approx \chi^2_p$ (Gujarati, 2003).

$$y_t = b_0 + b_1 k_t + b_2 l_t + b_3 y_{t-1} + v_t \qquad (6.42)$$

Assume that the error term v_t pursues the pth-order autoregressive, AR(P) as follows:

$$v_t = \rho_1 v_{t-1} + \rho_2 v_{t-2} + ... + \rho_p v_{t-p} + \varepsilon_t \qquad (6.43)$$

where ε_t is a error term. The null hypothesis $H_0 : \rho_1 = \rho_2 = ... = \rho_p = 0$ shows there is no serial correlation of any order (Gujarati, 2003).

The Lagrange Multiplier (LM) test is conducted for oil GDP; the results are shown in Table 6.9.

Table 6.9 Breusch-Godfrey Serial Correlation LM Test for Oil GDP

Variables/Models	Dynamic (-1)
Dependent (Residual)	β (t-ratio)
Intercept	0.03 (0.79)
Capital (DLOG(KO))	-0.56 (-1.09)
Labour (DLOG(NO))	0.08 (0.17)
Quadratic of Oil price shocks (PS2)	0.00005 (0.17)
Intercept Dummy (D2)	0.0009 (0.009)
Quadratic of ER shocks (QXX)	-0.00000001 (-0.82)
Dependent (DLOG(YO(-1))	-0.21 (-1.52)
Residual (-1)	-0.24 (-1.29)
R-Squared (R^2)	0.13
Adjusted R-Squared ($\overline{R}^2$)	-0.05
Number of observations	46
D.W	1.79
F-Statistic [Probability]	5.04 [0.03]
Chi-Square (Obs*R-squared) [Prob.]	5.42 [0.02]

To determine whether the null hypothesis can be rejected in this case, it is necessary to determine the critical $\chi^2(1)$ value from χ^2 Table (the critical χ^2 value is 6.34).

Since the calculated Breusch-Godfrey LM test statistic of 5.42 less than the critical $\chi^2(1)$ value, we cannot reject the hypothesis of no serial correlation up to lag order 1 at the 99% confidence level for oil sector.[39]

The same procedure described above can be applied for the non-oil sector and the results are reported in Table 6.10.[40]

Table 6.10 Static and Dynamic Model of Non-Oil GDP

Variables/Models	Static	Dynamic (-1)	Dynamic (-2)
Dependent (DLOG(YNO))	β (t-ratio)	β (t-ratio)	β (t-ratio)
Intercept	-0.05 (-1.94)	-0.05 (-2.26)	-0.05 (-2.04)
Capital (DLOG(KNO))	0.76 (6.78)	0.94 (5.59)	0.99 (4.90)
Labour (DLOG(NNO))	0.03 (0.86)	0.02 (0.63)	0.02 (0.65)
Government Expenditure Share (SG)	0.003 (2.21)	0.004 (2.51)	0.003 (2.25)
Intercept Dummy (D2)	-0.08 (-2.99)	-0.08 (-3.19)	-0.08 (-2.99)
GDP in Oil Sector (DLOG(YO(-1))	0.08 (2.74)	0.08 (2.97)	0.08 (2.82)
Dependent (DLOG(YNO(-1))		-0.20 (-1.39)	-0.19 (-1.25)
Dependent (DLOG(YNO(-2))			-0.07 (-0.50)
R-Squared (R^2)	0.66	0.68	0.68
Adjusted R-Squared ($\overline{R}^2$)	0.61	0.62	0.67
Number of observations	46	46	46
D.W	2.02	1.64	1.73
F-Statistic		1.95	0.50
Chi-Square		40.98	41.21

- F-test statistic is based on a modified ratio of the sum of squares residuals. To test the significance (goodness of fit) of estimators, one could apply in economic theory is using Chi-Square (χ^2) methodology. All results are reported here and found that χ^2 lies between the critical value of 5% significance level and the data support null hypothesis (the detail of results available on request).
- Compiled by Author, data source: Central bank of Iran

[39] The probability printed to the right of the Obs*R-squared statistic in the EViews output (i.e., 0.019899) represents the positive correlation in the error term and the probability that you would be incorrect if you rejected the null hypothesis of no serial correlation up to lag order 1 at the 95% confidence level (QMS, 2000). There is another method to do LM test. If in an application, $(n-p)R^2$ exceeds the critical chi-square value at the chosen level of significance, we reject the null hypothesis, in which case at least one ρ is statistically significantly different from zero (Gujarati, 2003:474). In this case $(n-p)R^2$ is equal 18.86 which exceeds 3.84.

[40] The higher order lagged dependent variable is estimated and available by author. Because of serial correlation in second, third, and fourth order lag, they are not reported here.

Overall, the coefficients of lagged dependent variable are statistically insignificant and they cannot improve the model. Dependent variable (y_t) varies inversely with y_{t-1}, and y_{t-2}. This shows that all lag orders are capable of leading to a cycle.

Following Matthews (1966), and based on the result of dynamic equations and the cyclical behaviour of the Iranian economy, it can be suggested that non-oil GDP (output) fluctuates in cycles of diminishing amplitude, which converge upon equilibrium. These are called damped cycles that depend on the size and value of the coefficients of lagged dependent variables in the equations. Damped cycles could result from a fair range of values of the parameters, so the extreme coincidence required to produce a long period of cycles of constant amplitude is avoided.

Since cyclical fluctuations of economic activity have persisted with unexpected shocks, the non-oil GDP model (Table 6.7) can make damped cycles. These fluctuations caused by war, technology changes or oil price shocks occur quite frequently and at random intervals. Their continued occurrence maintains the cyclical behaviour when it would otherwise disappear. The behaviour of output related these disturbances are cyclical, even though the shocks themselves occur at random intervals (Matthews, 1966).

To follow an identical procedure to that organized for the oil sector a Lagrange Multiplier (LM) test for non-oil sector is applied and the results are shown in Table 6.11.[41]

[41] The higher order lagged dependent variable is estimated and available by author. Because of serial correlation in second, third, and fourth order lag, they are not reported here.

Table 6.11 Breusch-Godfrey Serial Correlation LM Test for Non-Oil GDP

Variables/Models	Dynamic (-1)	Dynamic (-2)
Dependent (Residual)	β (t-ratio)	β (t-ratio)
Intercept	-0.02 (-0.80)	0.01 (0.49)
Capital (DLOG(KNO))	0.03 (0.19)	-0.26 (-1.31)
Labour (DLOG(NNO))	0.004 (1.10)	0.001 (0.36)
Government Expenditure Share (SG)	0.001 (0.86)	-0.0005 (-0.27)
Intercept Dummy (D2)	-0.03 (-1.34)	0.01 (0.36)
GDP in Oil Sector (DLOG(YO(-1))	-0.03 (-1.09)	0.009 (0.31)
Dependent (DLOG(YNO(-1))	-0.007 (-0.05)	0.11 (0.69)
Dependent (DLOG(YNO(-2))		0.07 (0.52)
Residual (-1)	0.18 (1.11)	0.14 (0.76)
Residual (-2)		-0.07 (-0.37)
R-Squared (R^2)	0.12	0.09
Adjusted R-Squared ($\overline{R}^2$)	-0.06	-0.16
Number of observations	46	46
D.W	1.97	2.09
F-Statistic [Probability]	4.70 [0.04]	1.65 [0.21]
Chi-square (Obs*squared) [Prob.]	5.08 [0.02]	3.92 [0.14]

To determine whether the null hypothesis can be rejected in this case, it is necessary to determine the critical $\chi^2(1)$ value from χ^2 Table (the critical χ^2 value is 3.84). Since the calculated Breusch-Godfrey LM test statistic of 5.08 exceeds the critical $\chi^2(1)$ value, we can reject the hypothesis of no serial correlation up to lag order 1 at the 95% confidence level for non-oil sector.[42] But the results of second order lag show there is no serial correlation ($\chi^2(2) = 5.99 \succ 3.92$) at the 95% confidence level for non-oil sector.

Following the studies of Eckaus (1957), dynamic difference-equation models of economic fluctuations have been found useful tools for a complete description of

[42] The probability printed to the right of the Obs*R-squared statistic in the EViews output (i.e., 0.024134) represents the probability that you would be incorrect if you rejected the null hypothesis of no serial correlation up to lag order 1 at the 95% confidence level (QMS, 2000).

aggregate economic activity. The models here have led to a better appreciation of cycle-producing forces and the character of cyclical movements. These models have been developed in a variety of forms based on different assumptions about time sequences and using different types of production functions as components.

6.7 Discussion of the Results

This research has modelled business cycles in Iran during the period 1959-2004. The hypotheses tested here were that oil price shocks have an adverse effect on output, that asymmetrical positive shocks are more significant than negative, that the quadratic form captures negative shocks better than positive ones and that, overall, there is a significant relationship between shocks and output. The models used to test these hypotheses have been modified from real business cycle theory, using a production function approach which is consistent with the Cobb-Douglas production function.

The conception of a production function has been used to provide empirical explanation of intertemporal differences in the economic growth. To adopt the framework of the production function approach to the Iranian economy, a number of assumptions have been made. Oil price shocks are a linear function of lags of past data which are defined as the deviation of oil prices from those predicted in each five-year plan. OPEC can also set the price of oil by controlling oil production levels based on changes in the oil market conditions.

A structural approach was preferred over a vector autoregression approach because of the limited period of data. Econometric analyses were performed, and these included OLS regression, unit root tests, Hausman-Wu test, variance inflation factor test, LM test, Chow test, Chi-square test, and F test were used to evaluate the models for both oil and non-oil output.

Results of the econometric analyses provided a degree of support for a number of the hypotheses, in particular, that the shock variable has an adverse effect on output. Results show that there is a negative relationship between oil price shocks and output in Iran's economy.

The positive and significant coefficient for capital in the non-oil sector, but partly insignificant in oil sector lends support to our hypothesis that the coefficient of capital is positive. The negative and insignificant labour coefficient was not able to support our hypotheses that the labour is positively related to output. This may reflect the problem that the quality of data for labour is poor.

However, econometric literature argues that in the case of a Cobb-Douglas production function the sum of $\alpha + \beta$ gives information about returns to scale, that is, the response of output to a proportionate change in the inputs. From theoretical view of economic, we would expect constant returns to scale. Here, we find that $\alpha + \beta \cong 1$ which suggests constant returns to scale though it is not tested here.[43]

The estimated models explain how the oil shock variable impacts on the macroeconomic fluctuation and cyclical behaviour of the Iranian economy. The production function approach is applied within the theoretical framework of RBC theory for the macroeconomic level and uses OLS regression technique to model the GDP of the entire economy, which is conventionally divided into oil and non-oil sectors. The production function in each sector is specified and estimated. The model

[43] Classical technique would be to run a F-test imposing the restrictions and comparing against the model where the restriction is not enforced.

was used to test the significance of hypotheses using various definitions of the shock variable to capture unanticipated oil prices shocks.

The distinction between the exchange rate and the price of oil after converting it into the local currency explains the issue of the relative inflation rate and purchasing power parity between the nominal and real exchange rate used to evaluate the price of oil in nominal or real term.[44] It was found that neither positive nor negative effects of exchange rate shocks have any significant effect on oil output. Therefore, it can be concluded that positive shocks that are unforeseen have a greater effect on output rather than negative shocks. However, the results show that both nominal and real exchange is not significant and there is not much difference to choose between them.

The model used dummy variables to allow for the Iranian revolution and the Iran-Iraq war. The estimation results showed that the effect of the dummy variable is significant for the war period. The coefficient on the intercept dummy was seen to be highly significant and the effect of oil price shocks was negative on the intercept of the model. The results also show that the shocks caused by high oil prices during 1979-1986 had a persistent effect on Iran's business cycles. In general, it was found that the dummy variables were statistically significant. The slope dummy had positive effects on the economy, whilst the effects of the intercept dummy were negative. The interaction effects between dummy variables found that there are different effects of interaction dummies in the oil and non-oil sector. In general, the results show that all the coefficients of dummies are statistically insignificant, and only second oil shock/Revolution and third oil shock on oil output, and war and OPEC have significant effects on both oil and non-oil output.

[44] Positive shocks were shown to cause an increase in the value of dollar and so the Rial was seen to increase. Given the price of oil in dollar constant, an increase in exchange rate was shown to produce an increase in the output of the economy.

OPEC cartel has major power on the oil market because it rules the supply side and can reduce or increase supply on a significant level to affect the oil price towards target revenue. The effect of OPEC on the Iranian economy was found indirectly through its effect on the price of oil in the five-year plans, and controlling oil production levels, when acting as a cartel. It was noted that when OPEC was less powerful and the demand side expected an increase in the price of oil, then Iran became more powerful.

The results revealed that both government expenditure and oil GDP with a one period lag had a significant and positive effect on the non-oil sector. So, the government can play an important role in the economy by designing five-year plans and making plausible policies when the oil prices changes by adjusting the shocks in the oil sector, and smoothing government expenditure in the non-oil sector.

The results suggest that predictions based on the model are consistent with the observed patterns for oil and non-oil sectors. In particular, the model does particularly well in accounting for the response of these variables during the second major oil price shock (1979-88). This shock not only accounts for macroeconomic fluctuations but also satisfactorily explains the cyclical behaviour of the economy.

Macroeconomic fluctuations may occur if the movement of output is controlled from proceeding beyond a certain point or if some lags of the dependent variable are present in the model. The lag hypothesis by itself is not capable of explaining the recurrence of cycles of constant amplitude such as oil output, except non-oil output which indicates a damp cycle using second order lag of dependent variable. However, when the model is subject to continually external disturbances such as unexpected shocks, fluctuations may result in steady state.

CHAPTER 7

Conclusions

This chapter concludes the thesis by presenting the research findings. The research questions asked in the outset are finally answered here. The general conclusion and finding can be presented as follows.

- The aim of the study was to investigate the effects of oil price shocks on the Iranian economy. To understand the nature of macroeconomic fluctuations and to develop a theoretical framework of the relationship between oil price shocks and the business cycle, the research was conducted using a modified version of the widely accepted real business cycle (RBC) model. In order to model the Iranian business cycle, a modified version of the production function approach was developed and employed to evaluate cyclical behaviour of the economy for period 1959-2004.

- This developed model has provided a platform - significant contribution - increasing our understanding of output behaviour of primary commodity dependent economies, which could have considerable implications for these countries in number of ways. It was shown that the RBC model can be usefully extended in such a way as to provide an opportunity to empirically evaluate the hypotheses mechanism in the context of oil dependent economies.

- Notwithstanding the limitation of a simple Cobb-Douglas based approach to estimation of specified models for the oil and non-oil sectors, a portrait of the

Iranian economy is presented. It allows us to investigate the wider issue of the planning system which provides a valuable research opportunity and offers fundamental analysis and how oil impacts on it. It also provides some estimation of the expected elements by careful analysis of the nature and outcome of Iran's five-year plans process.

- The state of the world oil market has been affected by changes in the price and/or production, which is also related to OPEC behaviour. OPEC has the largest share of the oil market, and as a cartel, plays an important role with its control over output levels and/or prices. The complicated role of OPEC policies in oil price fluctuations was found to be its ability in controlling oil supply. These polices have been influenced by its members decisions and world oil market conditions. At the time, it has the potential to influence its members and world oil market.

- Given the high volatility of oil prices, it is particularly important to ensure that government spending is not increased rapidly to levels which may become unsustainable if oil prices fall in the future. By assuming oil price instability as one of the main sources of shocks, OPEC need to concern to consider focusing exclusively on the current state of the oil market to limit the scope of the policy to *ad hoc* changes in price or production. This can be taken into account to anticipate the impacts of certain exogenous factors such as changes in ceiling, the future of effects of energy and macroeconomic policies of consuming and producing countries on the market. Of course, there are events such as wars, oil price shocks, and disturbances which cannot be easily anticipated.

- The Iranian economy is highly dependent on a single primary commodity namely oil and its export earnings. It has been demonstrated that the Iranian economy has long been dominated by the oil sector, and by the global oil market. Oil exports take up a large share of Iran's international trade, and the revenues from them constitute the main source of country's foreign exchange earnings. The economy was centrally planned and government dominated on whole economy.

- Oil price shocks are one of the main sources of disturbances that have seriously affected the world economy since the 1970s. An oil price shock has also a greater impact on macroeconomic fluctuations of oil dependent economies. Oil price shocks are related to the state of the world oil market. The disruption caused by an oil price shock depends on the state of the business cycle, the response of macroeconomic policies, and the flexibility of the underlying economies. Large fluctuations in the price of oil in the last four decades have substantially affected the Iranian economy. The macroeconomic consequences of oil price shocks were influenced the government revenue and so government expenditure, because of high dependency on oil export revenues.

- Macroeconomic performance of the Iranian economy has shown that oil revenue is still the major source of its foreign exchange and was used to support a large number of planned projects. It was found that there are business cycles in the Iranian economy as evidenced by the cyclical behaviour of total, oil and non-oil output over time. An analysis and discussion transmission channels and interrelationship between the oil and non-oil sector has shown that oil price shocks were affected on non-oil sector by government expenditure.

- The observed cyclical behaviour of the Iranian economy appears to be influenced by unanticipated oil price shocks in the international oil market. The results show that the model is able to mimic the Iranian response to shocks quite accurately but it is less predictive of cyclical paths during periods of stability. Oil price shocks have been defined as unexpected and unanticipated movements in the price of oil, nominal and real exchange rate. The results have shown oil price shocks have negative effects on Iranian output over the period of study.

- The relationship between the Iranian business cycle and oil price shocks was tested using the Hodrick-Prescott techniques on historical output data. We found that the cyclical component of the price was related to the cyclical components both total and non-oil GDP. More generally, the cycles of total GDP and non-oil GDP were clearly related. However, it was not related to the cyclical component of oil GDP. Oil output was found to have grown steadily except for the Revolution and Iran-Iraq war periods where it saw large fluctuations.

- It was found that the allowed dummy variables - the Iranian Revolution and the Iran-Iraq war - had statistically significant and positive effects on the slope and a negative effect on the intercept of output. The interaction effect between purposed dummies was found that they were statistically insignificant, except between second oil shock/Revolution and third oil shock in oil output, and between war and OPEC which was significant on both oil and non-oil output.

- To transform a static model to a dynamic model, a partial adjustment model was applied by using lagged dependent variables, which can cause fluctuations in output. The dynamic model was generalised to allow for more complicated and often more realistic adjustment processes. It was found that the lag modelling by itself was not able to explain the reappearance of constant amplitude oil output cycles, whilst non-oil output was specified a damp cycle using second order lag of dependent variable.

Limitations

- Inevitably these results must be approached with a degree of caution reflecting the simplicity of modelling technique applied and limitation of available data. Despite these limitations, it has been argued that these findings do carry some potentially interesting policy implications.

- Understanding the sources of business cycles and transmission of oil price shocks is crucial in the design and conduct of macroeconomic policies. In particular, analysis of the implications of government policies aiming to stabilize business cycles persuaded by oil price shocks seems to be successful research avenue. One implication of this thesis is that the government may need to design price stabilization scheme and/or smoothing schemes to reduce the impact of oil price fluctuations on the economy.

- The macroeconomic policy implications for oil-exporting developing countries with appropriate macroeconomic response to oil price shocks depend upon the cyclical situation, existing policy position, planned or free market, and exchange rate regime, which may have similar or different empirical results comparing to the current study.

Further Scope of Research

- It would be necessary to study in detail the five-year plans, specific sectors and their relationship to the foreign exchange earnings of oil exports.

- An extension of this research would be useful to identify the source of fluctuations in other oil-exporting economies by running cross country comparisons if we are to understand fully the main factors that drive business cycles in these countries.

- Economic performance has been volatile in developing countries and so further research on the determinants and characteristics of economic fluctuations in these countries is needed. Many other issues needed to be taken into account to enhance our understanding of the process of structural changes in developing countries which are highly dependent on a single primary commodity export earnings.

- A study of oil-exporting developing countries with similarities to the studied economy and with considerable differences, such as Mexico and Venezuela can be suggested for further research. For instance, Mexico is one of the major non-OPEC oil producers, whose oil exports are not large enough. Whilst the oil sector is a crucial component of Mexico's economy, Venezuela is one of the OPEC members, is highly dependent on - and vulnerable to - the oil sector. The oil sector plays a dominant role in Venezuela as it contributes a significant amount of GDP, public sector revenues, and exports. The similarity and differences of these countries are considered because of their location, dependence on oil, and the structure of economy.

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Appendices:

Appendix 1: List of Data Sources: Definitions and Measurements

The source of the data is the Central Bank of Iran. The time period chosen was 1959-2004. The parameters of the model are estimated so that the model economy produces values for the stationary variables that match the corresponding averages of actual data during the period of study.

Real Gross Domestic Product (RGDP) (Y_t): The time series data on the gross domestic product (GDP) for the entire period of 1959-2004 are obtained from the Central Bank of Iran (Annual report). These data are based on 1998 constant prices and kept in Iranian currency. This data set based on 1998 constant prices is divided into oil sector GDP (Y_t^o) and the non-oil sector GDP (Y_t^{no}).

Capital Stock (K_t): Data for this variable was originally collected by the Management and Planning Organisation (MPO), and is divided into capital stock of the oil sector (K_t^o), and non-oil sector (K_t^{no}). The definition of capital is gross fixed capital formation in Iran.

Labour Force (N_t): This data is also provided by the MPO, comprises labour force in the oil sector (N_t^o) and the non-oil sector (N_t^{no}). The labour force comprises the number of educated people who are employed.

Price of Oil $(Poil_t)$***:*** The data for the price of oil is obtained from OPEC and CBI that refers to the Iran's crude oil price corresponding in US dollars.

Exchange rate (ER_t)***:*** These data are collected from CBI and defines as official exchange rate in Iran.

Oil Price Shocks (PS_t)***:*** The oil price shock is defined as the difference between the actual price of oil in the current period and the average oil price over the previous planning period. The expected oil price in the current plan is equal to the actual closing price at the end of previous plan plus the average change over that period. So, oil price shocks are related to either the plan's expectation or are extrapolated from the previous five-year plan for some periods while there was no plan in operation.

Consumer Price Index (CPI): The US consumer price index data is obtained from the Federal Reserve Bank of Minneapolis, which is available online: http://woodrow.mpls.frb.fed.us/research/data/us/calc/hist1913.cfm

Dummy Variables $(D2)$***:*** This variable is used as an intercept and/or slope dummy. It is assumed that using dummy variables for the period of Iranian revolution and Iran-Iraq war is the best way to model the events of 1979-88. This period is problematic though, due to a lack of data, a changing economic structure, and OPEC is effects on the price of oil. A solution for this is to divide the period into two sub-periods: 1979-84 and 1985-88 which give two distinct periods of oil price changes.

Table A1. List of Data Sources: Definitions and Measurements

Variable	Definition	Source and Measurement
$Y_t = Y$	Real Gross Domestic (GDP) Production	CBI, At 1998 constant prices
$Y_t^o = YO$	Real Oil GDP	CBI, At 1998 constant prices
$Y_t^{no} = YNO$	Real Non-Oil GDP	CBI, At 1998 constant prices
$K_t = K$	Capital Stock	MPO At 1998 constant prices
$L_t = L$	Labour Force	MPO, Employed People
$K_t^o = KO$	Capital Stock in the Oil Sector	Share of capital stock in the oil sector
$K_t^{no} = KNO$	Capital Stock in the Oil Sector	Share of capital stock in the non-oil sector
$L_t^o = LO$	Labour Force in the Non-Oil Sector	MPO, Employed People in the oil sector
$L_t^{no} = LNO$	Labour Force in the Non-Oil Sector	MPO, Employed People in the non-oil Sector
$Poil_t$	Price of oil	OPEC, CBI, MPO, Price of oil in UD dollar
ER_t	Exchange Rate (Nominal)	CBI, official exchange rate $I=XRls
PS_t	Oil Price Shock	Deviation between Actual and Planned oil price
XX_t	Exchange Rate Shock	Deviation between Actual and Planned Exchange Rate
$PS2_t$	Oil price Shock in Quadratic form	The Squared Deviation between Actual and Planned oil price
$PSPO_t$	Positive Oil Price Shock	Deviation between Actual and Planned oil price where it is positive
$PSNE_t$	Negative Oil Price Shock	Deviation between Actual and Planned oil price where it is Negative
$D2_t$	Intercept Dummy variable	Spick Dummy for the period of 1979-84
QXX_t	Exchange Rate Shock in Quadratic	The Squared Deviation between Actual and Planned Exchange rate
$XXPO_t$	Positive exchange rate Shock	Deviation between Actual and Planned exchange rate where it is positive
$XXNE_t$	Negative exchange rate Shock	Deviation between Actual and Planned exchange rate where it is positive
$NPER_t$	Price of Oil in Rial term	The multiplication of the price of oil and nominal exchange rate
$RPER_t$	Price of Oil in Real term	The multiplication of the price of oil and real exchange rate
SG_t	Ratio of Government Expenditure	Government Expenditure divided by GDP
$Y_{t-1}^o = YO(-1)$	Oil GDP with a one period lag	The value of Oil GDP in the previous Period in the current period
$YOPE_t$	Predicted Oil GDP	Oil GDP based on Estimated parameters
$YNOPE_t$	Predicted Non-Oil GDP	Non-Oil GDP based on Estimated parameters
$RESYO_t$	Residual of GDP	Deviation between real and predicted Oil GDP
$RESYNO_t$	Residual of GDP	Deviation between real and predicted Non-Oil GDP
$RESKO_t$	Residual of Capital in the Oil Sector	Deviation between real and predicted Capital in the Oil Sector
$RESLO_t$	Residual of Labour in the Oil Sector	Deviation between real and predicted Labour in the Oil Sector
$RESKNO_t$	Residual of Capital in the Non-Oil GDP	Deviation between real and predicted Capital in the Non-Oil Sector
$RESLNO_t$	Residual of Labour in the Non-Oil GDP	Deviation between real and predicted Labour in the Non-Oil Sector

Appendix 2: Reduced-Form of Cobb-Douglas Production Function

Assuming output as a homogenous production function, at the macroeconomic the price of inputs such as capital and labour cannot be determined, which argued by Angrist *et al.*, (2000), Goldberger (1991), and Manski (1995). So, it is necessary to take the price of capital and labour as given in the competitive economy. It is assumed that capital (k_t) and labour (n_t) are exogenously given in the economy (See also Lin, 2005). Markets are assumed to clear, which means that the transaction (k_t, n_t) is assumed to be an equilibrium outcome.

$$Y_t^o = Y_t^{no} \Rightarrow q_t^o(k_t, n_t) = q_t^{no}(k_t, n_t) \qquad \text{(A.2.1)}$$

It can be assumed that both oil and non-oil functions are in Cobb-Douglas form with fixed coefficients and additive residuals. These assumptions simplify the estimation techniques and provide a useful benchmark of the structural form of the equilibrium condition which is given by:

Oil: $$q_t^o = AK_t^{\alpha} N_t^{\beta} \qquad \text{(A.2.2)}$$

Non-oil: $$q_t^{no} = AK_t^{\alpha_1} N_t^{\beta_1} \qquad \text{(A.2.3)}$$

Market clearing: $$q_t^o = q_t^{no} = q_t \qquad \text{(A.2.4)}$$

which simplifies to:

Oil: $$q_t = AK_t^{\alpha} N_t^{\beta} + \varepsilon_1 \qquad \text{(A.2.5)}$$

Non-oil: $$q_t = AK_t^{\alpha_1} N_t^{\beta_1} + \varepsilon_2 \qquad \text{(A.2.6)}$$

These equations are the structural equations of the economy. Because economic theory predicts that capital and labour have a positive effect on the production function, it can be expected that $(0 \geq \alpha, \alpha_1, \beta, \beta_1 \geq 1)$. Solving the structural equations for capital and labour, one obtains the following reduced-form equations for the economy:

Capital: $$k_t = k_t^{\gamma_1} n_t^{\gamma_2} + u_t^k \quad \text{(A.2.7)}$$

Labour: $$n_t = k_t^{\gamma_1} n_t^{\gamma_2} + u_t^n \quad \text{(A.2.8)}$$

Where $\gamma_1 = {}^{\alpha_1}\!/_{\alpha}$ and $\gamma_2 = {}^{\beta_1}\!/_{\beta}$

A reduced-form equation is one that expresses an endogenous variable only in terms of the predetermined variables and the stochastic disturbances. Equations (A.2.7) and (A.2.8) are a reduced-form equations; γ_1 *and* γ_2 are the associated reduced-form coefficients. Note that these reduced-form coefficients are non-linear combinations of the structural coefficients (Gujarati, 2003). Econometric analysis seeks to efficiently identify the structural parameters $(\alpha, \alpha_1, \beta, \beta_1)$. To do this, it can be estimated the production function by replacing capital and labour in the original production function:

Oil: $$q_t^o = AK_t^{\alpha} N_t^{\beta} = A(k_t^{\gamma_1} n_t^{\gamma_2})^{\alpha} (k_t^{\gamma_1} n_t^{\gamma_2})^{\beta} \Leftrightarrow q_t^o = AK_t^{\lambda_1} N_t^{\lambda_2} \quad \text{(A.2.9)}$$

Non-oil: $$q_t^{no} = AK_t^{\alpha_1} N_t^{\beta_1} = A(k_t^{\gamma_1} n_t^{\gamma_2})^{\alpha_1} (k_t^{\gamma_1} n_t^{\gamma_2})^{\beta_1} \Leftrightarrow q_t^{no} = AK_t^{\delta_1} N_t^{\delta_2} \quad \text{(A.2.10)}$$

where $$\lambda_1 = {}^{\alpha_1}\!/_{\alpha}(\alpha + \beta), \qquad \lambda_2 = {}^{\beta_1}\!/_{\beta}(\alpha + \beta)$$

$$\delta_1 = {}^{\alpha_1}\!/_{\alpha}(\alpha_1 + \beta_1), \qquad \delta_2 = {}^{\beta_1}\!/_{\beta}(\alpha_1 + \beta_1)$$

The reduced-form coefficients $\lambda_1, \lambda_2, \delta_1, \beta_2$ are also known as short-run multipliers, because they measure the immediate impact on the endogenous variable of a unit change in the value of the exogenous variable.

Notice an interesting feature of the reduced-form equations. Since only the predetermined variables and stochastic disturbances appear on the right hand sides of these equations, and since the predetermined variables are assumed to be uncorrelated with the error terms, the OLS method can be applied to estimate the coefficients of the reduced-form equations (Gujarati, 2003).

One of the estimateable reduced-form type equations which economic theory may suggest is that the coefficients in the regression model satisfy some linear equality restrictions. For example, consider the Cobb-Douglas production function:

$$Y_t = AK_t^{\alpha} N_t^{\beta} e^{u_t} \qquad \text{(A.2.11)}$$

Written in log form, the equation becomes

$$\ln Y_t = a + \alpha \ln K_t + \beta \ln N_t + u_t \qquad \text{(A.2.12)}$$

Suppose that there are constant returns to scale, then economic theory would suggest that:

$$\alpha + \beta = 1 \Leftrightarrow \alpha = 1 - \beta \Leftrightarrow \beta = 1 - \alpha \qquad \text{(A.2.13)}$$

The simple procedure is to estimate (A.2.12) in the normal way without the restriction (A.2.13) explicitly. This is called original or unrestricted regression. Having estimated parameters, a test of hypothesis or restriction can be identified by t-test. A direct approach to test linear equality restrictions (A.2.13) into the estimating procedure can be written the Cobb-Douglas production function as:

$$\ln Y_t = a + \alpha \ln K_t + (1-\alpha)\ln N_t + u_t \\ = a + \ln N_t + \alpha(\ln K_t - \ln N_t) + u_t \tag{A.2.14}$$

$$\ln Y_t - \ln N_t = a + \alpha(\ln K_t - \ln N_t) + u_t \\ \ln(Y_t / K_t) = a + \alpha \ln(K_t / N_t) + u_t \tag{A.2.15}$$

where $\ln(Y_t/N_t)$ is output/labour ratio, $\ln(K_t/N_t)$ is capital/labour ratio. Equation (A.2.15) is called a restricted least square one.

Given two regression models, one of which constrains one or more of the regression coefficients according to the null hypothesis, the general F-test statistic is then based on a modified ratio of the sum of squares of residuals of the two models as follows:[1]

$$F = \frac{(RSS_R - RSS_{UR})/m}{RSS_{UR}/(n-k)} \tag{A.2.16}$$

where RSS_R is sum squared residual of restricted regression, RSS_{UR} is sum squared residual of unrestricted regression, m is number of restricted regression, k is number of parameters in the unrestricted regression, n is number of observations.

The estimated reduced-form for the oil and non-oil sectors (unrestricted and restricted equations in first difference log) is shown in Tables (A.2.1) and (A.2.2).[2]

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[1] The F-test can be applied the hypothesis that the standard deviations of two normally distributed populations are equal, and thus that they are of comparable origin, for example, oil and non-oil GDP in Iran, separately. Note that F distribution follows with m, (n-k) df. See Gujarati (2003).

[2] Note that since the reduced-form coefficients can be estimated by the OLS method, and since these coefficients are combinations of the structural coefficients, the possibility exists that the structural coefficients can be "retrieved" from the reduced-form coefficients, and it is in the estimation of the structural parameters (Gujarati, 2003).

Table A.2.1 Oil Output (Unrestricted and Restricted Model)

Variables	Unrestricted Model	Reduced-Form Model
Parameters	β (t-ratio)	β (t-ratio)
Dependent	DLOG(YO)	DLOG(YO/LO)
Intercept	0.073 (1.89)	0.073 (2.08)
Capital (DLOG(KO))	0.87 (1.87)	
Labour (DLOG(NO))	0.17 (0.32)	
Capital/Labour (DLOG(KO/LO))		0.86 (2.59)
Quadratic of Oil price shocks (PS2)	-0.0005 (-1.51)	-0.0005 (-1.69)
Quadratic of ER shocks (QXX)	-0.000001 (-0.85)	-0.0000001 (-0.86)
Intercept Dummy (D2)	-0.57 (-5.45)	-0.57 (-5.63)
R-Squared (R^2)	0.46	0.51
Adjusted R-Squared ($\overline{R}^2$)	0.39	0.46
Number of observations	46	46
D.W	2.08	2.08

Table A.2.2 Non-Oil Output (Unrestricted and Restricted Model)

Variables	Unrestricted Model	Reduced-Form Model
Parameters	β (t-ratio)	β (t-ratio)
Dependent	(DLOG(YNO))	(DLOG(YNO/LNO))
Intercept	-0.05 (-1.94)	-0.06 (-2.59)
Capital (DLOG(KNO))	0.76 (6.78)	
Labour (DLOG(NNO))	0.03 (0.86)	
Government Expenditure Share (SG)	0.003 (2.21)	0.003 (2.11)
GDP in Oil Sector (DLOG(YO(-1))	0.08 (2.74)	0.07 (2.39)
Intercept Dummy (D2)	-0.08 (-2.99)	-0.08 (-2.98)
Capital/Labour (DLOG(KO/LO))		0.96 (32.15)
R-Squared (R^2)	0.66	0.96
Adjusted R-Squared ($\overline{R}^2$)	0.61	0.96
Number of observations	46	46
D.W	2.02	1.82

Since the dependent variable in the proceeding two regressions are different, we have to use the F-test given in equation (A.2.16). We have the necessary data to obtain the F-value.

$$F = \frac{(1.356714 - 1.356596)/1}{1.356595/(37)} = 0.0032$$

The resulting test statistic value would then be compared to the corresponding entry on a table of F-test critical values. The F value follows the F distribution with 1 and 37 from the F distribution table for even 25% level is 1.38, which is not significant. It can be concluded that the oil sector in Iran's economy was presumably characterised by constant returns to scale over the period of study.

This can be tested for non-oil output and the results show that F-value for 5% level in the table of F-test critical values (4.17) is greater that estimated F=3.29, which is insignificant and suggests that the non-oil sector of Iran's economy may characterised as constant returns to scale over the period of study.

$$F = \frac{(0.071193 - 0.065515)/1}{0.065515/(38)} = 3.29$$

Appendix 3: Unit Root Test: Stationary or Nonstationary

Macroeconomic time series often appear to have a stochastic trend, suggesting that, the mean of GDP has been changing and it makes them nonstationary. Since many statistical procedures assume stationarity, it is often necessary to transform data before beginning analysis. There are a number of familiar transformations, including deterministic detrending, stochastic detrending, and differencing. A large number of statistical methods have been proposed for filtering a stochastic trend out of macroeconomic time series.[3]

Macroeconomic time series are often trended or affected by statistical processes and these can produce some problems for regressions involving the series that can falsely imply the existence of a significant economic relationship.[4] To understand these effects, it is common to test whether series are stationary or nonstationary by applying a unit-root test.[5] A test of stationarity (or non-stationarity) that has become widely popular over the past several years is the unit root test (Gujarati, 2003). This issue is especially important since many economic time series appear to have a nonstationary component.

Enders (1995) argued that stationarity implies the absence of a trend and long-run mean reversion. The distinction between stationary and nonstationary processes has a crucial impact on whether the trend observed in the actual economic time series is

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[3] In economic theory it is important to test the order of integration of each variable to set up whether it is nonstationary and how many times the variable needs to be differenced to become a stationary series (Harris, 1995). An alternative terminology refers to series that is itself nonstationary or has a unit root, but is stationary after first differencing.

[4] This also leads to problems with forecasting. Forecasts of a series with a stochastic trend converge to a steady level (see Gujarati, 2003).

[5] Normally in economic theory, time series data are modelled exclusively in terms of their own past behaviour. A stationary series tends to return to its mean value and fluctuate around it within a constant range, while a nonstationary series has a different mean at different points in time and its variance increases with the sample size (Harris, 1995). A time series is stationary if its mean, variance and autocovariances are independent of time (Rao, 1994).

deterministic or stochastic. If the trend is completely predictable and not variable, it can be called a deterministic trend that implies steady increase (or decrease) into the infinite future; otherwise it is a stochastic trend (Gujarati, 2003). Thus, the two types of trend can be distinguished - difference-stationary and trend-stationary. The presence of a stochastic trend (which is nonstationary) as opposed to deterministic trend (which is stationary) can used to test for unit roots (Harris, 1995).[6]

A common transformation of time series variable involves first differencing. However, the level of a variable and its first difference will typically vary in terms of mean and variation (Rao, 1994). Macroeconomic data seem to show to a stochastic trend that can be removed by differencing the variables. The variables in first difference are largely stationary (Gujarati, 2003).[7] It is argued that all the variables in first difference or proportion rate offer the valid results and first differencing can quite often transform a nonstationary series into a stationary one.[8] In particular, this may be the case for aggregate economic series or their natural logarithms (Verbeek, 2000).

There are several ways of testing for the presence of a unit root, and the basic approach is the Dickey-Fuller (1979) (DF) test for null hypothesis that a series does contain a unit root (nonstationary) against the alternative of stationarity (Harris,

[6] Rao (1994) suggests that the time series is said to have a stochastic trend or being integrated of order 1 or I (1). In contrast, a series that is stationary, without first differencing, is said to be integrated of order zero or I (0). See also Nelson and Plosser (1982).

[7] The transformation method depends on whether the time series are difference stationary (DSP) or trend stationary (TSP). In order to do this, Gujarati (2003) argued that most macroeconomic time series are DSP rather than TSP. Therefore, if a time series has a unit root, the first differences are stationary. For example, if a time series is I(1), has unit root, the first difference is I(0).

[8] Most variables are I(1) and can be considered stationary. Another traditional implication is that the misspecification of the trend component leads to the estimation of a spurious cyclical component. Given this fact, business cycle derived from these spurious transitory components could be misleading.

1995). An important assumption of DF test is that the error terms are independently and identically distributed. To do this, consider:

$$y_t = \rho y_{t-1} + u_t \quad -1 \le \rho \le 1 \quad and \quad u_t \approx I(0) \quad iid \approx (0, \delta^2) \tag{A.3.1}$$

where u_t is, a white noise error term. The process in equation (A.3.6) is stationary when ρ less than one in absolute value, i.e. $-1 \succ \rho \succ 1$. By subtracting y_{t-1} from both sides of (A.3.6) it can be obtained:

$$y_t - y_{t-1} = \rho y_{t-1} - y_{t-1} + u_t = (\rho - 1) y_{t-1} + u_t \tag{A.3.2}$$

which can be written as: $\Delta y_t = \delta y_{t-1} + u_t$ (A.3.3)

where $\delta = (\rho - 1)$ and Δ is the first difference operator.

The null and alternative hypotheses are:

Null hypothesis (H_0): If $\rho = 1 \Leftrightarrow \delta = 0$, y_t has a unit root and is nonstationary. This implies a random walk without drift that the series is $y_t = y_{t-1} + u_t$.[9] Assuming $\rho = 1$, then $y_t - y_{t-1} = \Delta y_t = u_t$ and u_t defines a stationary process (Rao, 1994).[10] This process has been known as difference stationary since the first difference of y_t is stationary. Of course, testing the hypothesis $\rho = 1$ is equivalent to testing the hypothesis $\delta = 0$, which means that the first difference of a random walk time series are stationary, and can be written as follows:

$$\Delta y_t = (y_t - y_{t-1}) = u_t \tag{A.3.4}$$

[9] See also Rao (1994:51) for more detail.
[10] See also Nelson and Plosser (1982).

The alternative hypothesis should be chosen to maximise the power of the test against the null hypothesis. A two-sided alternative $\delta \neq 0$, comprising $\delta \prec 0$ and $\delta \succ 0$, is not chosen in general because $\delta \succ 0$ corresponds to $\rho \succ 1$ and in that case the process generating y_t is a nonstationary process and not stable; instead the one-sided alternative is chosen because departures from the null are expected to be in this direction corresponding to an I(0) process (Patterson, 2000).

Alternative hypothesis (H_1): If $\rho \prec 1 \Leftrightarrow \delta \prec 0$, y_t has a root outside unit circle and is stationary and implies AR (1) process. This is the general idea behind the unit root test of stationarity (Gujarati, 2003). Thus critical values are negative, and sample with higher negative values than the critical values leading to rejection of the null hypothesis in the direction of the one-sided alternative (Patterson, 2000).

To test for the existence of a unit root and to find the best form of null hypotheses, Dickey-Fuller (1979, 1981) suggested three different regression equations that can be used to test for presence of a unit root (Gujarati, 2003):

Model A) y_t is a random walk: $\Delta y_t = \delta y_{t-1} + u_t$ (A.3.5)

Model B) y_t is a random walk with drift: $\Delta y_t = \beta_1 + \delta y_{t-1} + u_t$ (A.3.6)

Model C) y_t is a random walk with drift around a stochastic trend:

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + u_t \qquad \text{(A.3.7)}$$

The difference between the three regressions concerns the presence (existence) of the deterministic elements β_1 and $\beta_2 t$. The parameter of interest in all regressions is estimating δ by using OLS in order to obtain the estimated value of δ and associated standard error. Comparing the resulting t-statistic with the appropriate value of τ from the Dickey-Fuller tables allows us to determine to accept or reject the null hypothesis $\delta = 0$ (Enders, 1995).

We estimated three regressions and the results are presented in Table A.3.1. It is clearly important that the t-value for y_{t-1} coefficient and its critical values that are reported in Table A.3.1 for three models separately. To test the values of δ, one can statistically compare the critical values in 1% and 5% with the estimated t-statistic in the regression. The results of the Dickey-Fuller (DF) test for GDP show that determining the underlying properties of the process that generates the time series variables shows whether they are stationary or nonstationary.

The results of model A show that the coefficient of y_{t-1} is positive and imply $\rho \succ 1$, which theoretically is out of the case of unit root test, because in this case the GDP time series would be unpredictable (Gujarati, 2003). Then we can select the models B and/or C, which show that the estimated δ is negative, implying that the estimated value of ρ is less than 1. However, for the Models B and C, the critical values[11] show that the test statistic is bigger than the critical values of 10%, 5%, and 1% significance level and therefore the comparison for both models show that GDP has a unit root and is nonstationary and we cannot reject the null hypothesis of non-stationarity in level terms for real GDP in Iran. Therefore, we prefer to follow the case of Model C, which includes intercept and trend to test for stationarity.

[11] See, e.g. Table D.7 of Gujarati (2003). In some cases the Model B is also seen to be unacceptable.

Table A.3.1 The Results of Dickey-Fuller Test For Real GDP

Variables		Model A	Model B	Model C
Dependent DLOG(Y)		β (t-ratio)	β (t-ratio)	β (t-ratio)
LOG(Y(-1))		0.002 (1.82)	-0.03 (-1.77)	-0.06 (-1.85)
Constant (C)			0.36 (1.87)	0.71 (1.96)
Trend (T)				0.002 (1.15)
Critical	1%	-2.62	-3.59	-4.18
Value[12]	5%	-1.95	-2.93	-3.51
	10%	-1.61	-2.60	-3.18
R-Squared (R^2)		0.31	0.36	0.38
Adjusted R-Squared ($\overline{R}^2$)		0.29	0.33	0.33
D.W		2.05	1.97	2.02

However, Enders (1995), Harris (1995) suggest that Dickey and Fuller (1981) provide three additional non-standard F-statistics ($\Phi_1, \Phi_2, and\ \Phi_3$) to test joint hypothesis on the coefficients, concerning the unit root and the significance of constant and/or trend in terms of the critical values, using appropriate Dickey-Fuller distribution. To allow for the possibility of data generation process contains deterministic components, the test for the null hypotheses of a stochastic trend (non-stationarity) against the alternative of deterministic trend (stationarity), three models are based:

A) $y_t = \rho y_{t-1} + \sum_{i=1}^{k} \beta_i \Delta y_{t-i} + u_t$ (A.3.8)

B) $y_t = \alpha + \rho y_{t-1} + \sum_{i=1}^{k} \beta_i \Delta y_{t-i} + u_t$ (A.3.9)

[12] The critical values obtained from Table D.7 (Gujarati, 2003). Note that the critical values of the t-statistics depend on whether an intercept and/or time trend is included in the regression equation, and sample size (Enders, 1995). As in most hypothesis tests, for any given level of significance, the critical values of the t-statistics decrease as sample size increases.

C) $Y_t = \alpha + \beta t + \rho y_{t-1} + \sum_{i=1}^{k} \beta_i \Delta y_{t-i} + u_t$ (A.3.10)

whether the distributed lag on the Δy_t term specified, in the usual way, to deal with potential serial correlation. Comparing the calculated value of Φ_i to the appropriate value reported in Dickey and Fuller (1981) allows us to determine the significance level at which the restriction is required. The null hypothesis is based on restricted model and the alternative hypothesis is that the data are generated by the unrestricted model. If the calculated value of Φ_i is smaller than that reported by Dickey and Fuller, we can accept the restricted model (null hypothesis), otherwise we can reject the null hypothesis (Enders, 1995).

Given two regression models, one of which constrains one or more of the regression coefficients according to the null hypothesis, the general F-test statistic is then based on a modified ratio of the sum of squares of residuals of the two models as follows:[13]

$$F = \frac{(RSS_R - RSS_{UR})/m}{RSS_{UR}/(n-k)} \Leftrightarrow \Phi_i = \frac{(RSS_R - RSS_{UR})/m}{RSS_{UR}/(n-k)}$$

where RSS_R is sum squared residual of restricted regression, RSS_{UR} is sum squared residual of unrestricted regression, m is number of restricted regression, k is number of parameters in the unrestricted regression, n is number of observations.

Following Rao (1994) which suggested Dickey-Fuller Procedure for Unit Root Testing, seven steps, we conducted the same procedure for analysis of unit root in this study. Here is the detail of discussion and results of these steps we find for each

[13] The $\Phi_1, \Phi_2, and\ \Phi_3$ statistics are constructed in exactly the same way as ordinary F-tests (Enders, 1995).

variable in the model which are summarised in the Table 1. Replication of the analysis for other variables is estimated by author and available on request.

Step (1): First, we estimate the equation (C) with sufficient lags of Δy_t to eliminate serial correlation in the regression residuals. The null hypothesis is:

$$H_0 : \beta_1 = \beta_2 = ... = \beta_p = 0 \Rightarrow y_t = \alpha + \beta t + \rho y_{t-1} + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + u_t$$

Dependent Variable: LOG(Y)
Method: Least Squares
Sample (adjusted): 1962 2004
Included observations: 43 after adjustments
LOG(Y)=C(1)+C(2)*TREND+C(3)*LOG(Y(-1))+C(4)*DLOG(Y(-1))+C(5)
*DLOG(Y(-2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.843726	0.382000	2.208705	0.0333
C(2)	0.002239	0.001665	1.344374	0.1868
C(3)	0.926912	0.034837	26.60736	0.0000
C(4)	0.474840	0.154777	3.067906	0.0040
C(5)	0.066979	0.155377	0.431071	0.6689

R-squared	0.989911	Mean dependent var	12.05770
Adjusted R-squared	0.988849	S.D. dependent var	0.554008
S.E. of regression	0.058503	Akaike info criterion	-2.730518
Sum squared resid	0.130061	Schwarz criterion	-2.525727
Log likelihood	63.70613	Durbin-Watson stat	1.982760

where:

DLOG(Y(-2)) is real GDP in Iran in first difference log with a two period lag

DLOG(Y(-1)) is real GDP in Iran in first difference log with a one period lag

LOG(Y(-1)) is real GDP in Iran in log level with a one period lag[14]

[14] To choose the number of lags in the equation of unit root test, Campbell and Perron (1991) suggest starting with some upper bound on k. if the last included lag is significant based on the standard normal distribution, the k is optimum. If not, the lag must be reduced until the coefficient is significant. Here we applied and used Schwarz Information Criterion from Eviews.

Trend is the time trend, and LOG(Y) is real GDP in Iran in log level

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.451832	Probability	0.100398
Obs*R-squared	5.154980	Probability	0.075964

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 03/05/07 Time: 13:45
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.001312	0.007477	0.175409	0.8617
C(2)	0.000468	0.000918	0.509541	0.6135
C(3)	-0.002312	0.002321	-0.996242	0.3258
C(4)	0.019839	0.157077	0.126304	0.9002
C(5)	0.270081	0.155273	1.739402	0.0905
RESID(-1)	-0.048917	0.164032	-0.298214	0.7673
RESID(-2)	0.106452	0.164635	0.646590	0.5220

R-squared	0.119883	Mean dependent var	-1.07E-15
Adjusted R-squared	-0.026803	S.D. dependent var	0.055648
S.E. of regression	0.056389	Akaike info criterion	-2.765195
Sum squared resid	0.114469	Schwarz criterion	-2.478488
Log likelihood	66.45170	Durbin-Watson stat	2.451850

To determine whether the null hypothesis can be rejected in this case, it is necessary to determine the critical $\chi^2(2)$ value from χ^2 Table (the critical χ^2 value is 5.99). Since the calculated Breusch-Godfrey LM test statistic of 5.15 less than the critical $\chi^2(2)$ value, we cannot reject the hypothesis of no serial correlation up to lag order 1 at the 95% confidence level for real GDP.[15]

Step (2): We use Φ_3 to test null and alternative hypothesis as follows:

$$H_0:(\alpha,\beta,\rho)=(\alpha,0,1) \quad against \quad H_A:(\alpha,\beta,\rho)\neq(\alpha,0,1)$$

[15] The probability printed to the right of the Obs*R-squared statistic in the EViews output (i.e., 0.075964) represents the positive correlation in the error term and the probability that you would be incorrect if you rejected the null hypothesis of no serial correlation up to lag order 2 at the 95% confidence level (QMS, 2000).

$H_0 : y_t = \alpha + \rho y_{t-1} + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + u_t$
$H_A : y_t = \alpha + \beta t + \rho y_{t-1} + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + u_t$

Dependent Variable: LOG(Y)
Method: Least Squares
Sample (adjusted): 1962 2004
Included observations: 43 after adjustments
LOG(Y)=C(1)+C(2)*LOG(Y(-1))+C(3)*DLOG(Y(-1))+C(4)*DLOG(Y(-2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.408118	0.204403	1.996634	0.0529
C(2)	0.968082	0.016776	57.70510	0.0000
C(3)	0.466114	0.156233	2.983457	0.0049
C(4)	0.019428	0.152856	0.127098	0.8995

R-squared	0.989431	Mean dependent var	12.05770
Adjusted R-squared	0.988618	S.D. dependent var	0.554008
S.E. of regression	0.059106	Akaike info criterion	-2.730564
Sum squared resid	0.136247	Schwarz criterion	-2.566732
Log likelihood	62.70713	Durbin-Watson stat	1.972954

$$\Phi_3 = \frac{(0.136247 - 0.130061)/1}{0.130061/(43-5)} = \frac{0.006186}{0.003423} = 1.81$$

The calculated value for Φ_3 is 1.81 which is located between the critical value of Φ_3 from Table VI Dickey-Fuller (1981) at 5% critical value is (1.11-6.73). Thus the null hypothesis can be rejected (see also Table C, Enders, 1995), and real GDP includes intercept and trend.

Step (3): Assuming rejection of null hypothesis in step 2, the next step is to test for $\rho = 1$ using t-statistic obtained from estimating the augmented version of equation in step 1, with the critical values taken from the standard normal tables. The results show that the standard t-statistic of ρ is highly significant ($t_{\hat{\rho}}$=26.607 compared with the critical value 1.684 at 5% significance) and $\rho = 1$ is accepted. It can be concluded that β is non-zero ($t_{\hat{\beta}}$=1.344) and $\rho = 1$. So, the series has a unit root and a linear trend (and possibly non-zero intercept α). This outcome is highly implausible for an economic time series.

Step (4): If we reject the null hypothesis $\beta = 0$, the series is stationary with a linear trend and possibly with an intercept, a conventional t-test can be used to establish whether or not the intercept (α) is zero. To support the conclusion, we need to compare the t-statistic from step (3 and 4) with critical values from the non-standard normal tables in Dickey-Fuller (1981).

We follow the procedure to test for α, it is possible to test hypotheses concerning the significance of the drift term α. To test these hypotheses we can use the $\tau_{\alpha\mu}$ statistic based on the estimated equation. The critical values can be obtained from the Table I Dickey-Fuller (1981). The calculated t-statistic for α (2.21) is smaller than the critical value 2.56 at 5% level. So, we can not reject null hypothesis and the series includes intercept.

Step (5): We use a t-statistic to test for $\rho = 1$, assuming β is zero so that non-standard critical values are required. However, it is also possible to test hypothesis concerning the significance of the time trend $\beta = 0$ given $\rho = 1$. Under the null hypothesis the test for presence of the time trend is given by the $\tau_{\beta\tau}$ statistic from the Table III (Dickey-Fuller, 1981). The critical value for 95% (2.81) is larger than the calculated t-statistic is $t_{\hat{\beta}}$=1.34, which is out of the confidence intervals at the 5% level and it cannot be rejected the null hypothesis ($\beta = 0$) and the series includes trend.

To test the hypothesis $\alpha = 0$, it also can be used the $\tau_{\alpha\tau}$ statistic if the estimated equation is $y_t = \alpha + \beta t + \rho y_{t-1} + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + u_t$. The critical values can be obtained from the Table II Dickey-Fuller (1981). The calculated t-statistic for α ($t_{\hat{\alpha}}$=2.21) is smaller than the critical value 3.14 at 5% level. So, we can not reject null hypothesis and the series includes intercept.

Step (6): Assuming that $(\beta, \rho) = (0,1)$, we might carry out the F test Φ_2 in Dickey-Fuller (1981) with the following hypotheses.

$$H_0 : (\alpha, \beta, \rho) = (0,0,1) \quad against \quad H_A : (\alpha, \beta, \rho) \neq (0,0,1)$$

If Φ_2 suggests that α is zero then it can be concluded that the series is a random walk without intercept. Otherwise the series is a random walk with intercept. To do this, first we estimate the appropriate equation as follows:

$$y_t = \rho y_{t-1} + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + u_t$$

Dependent Variable: LOG(Y)
Method: Least Squares
Sample (adjusted): 1962 2004
Included observations: 43 after adjustments
LOG(Y)= C(1)*LOG(Y(-1))+C(2)*DLOG(Y(-1))+C(3)*DLOG(Y(-2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.001526	0.000976	1026.655	0.0000
C(2)	0.529721	0.158558	3.340873	0.0018
C(3)	0.070462	0.156228	0.451022	0.6544

R-squared	0.988350	Mean dependent var	12.05770
Adjusted R-squared	0.987768	S.D. dependent var	0.554008
S.E. of regression	0.061273	Akaike info criterion	-2.679750
Sum squared resid	0.150174	Schwarz criterion	-2.556876
Log likelihood	60.61463	Durbin-Watson stat	1.954850

Now we can estimate Φ_2 as follows:

$$\Phi_2 = \frac{(0.150174 - 0.130061)/2}{0.130061/(43-5)} = \frac{0.010056}{0.003423} = 2.94$$

The calculated value for Φ_2 is 2.94 which is located between the critical value of Φ_2 from Table VI Dickey-Fuller (1981) at 5% critical value is (0.91-5.94), and the null hypothesis can be rejected (see also Table C, Enders, 1995). Thus, the series is a random walk with intercept.

Step (7): Suppose the null and alternative hypotheses are as follows:

$$H_0 : (\alpha, \rho) = (0,1) \quad \textit{against} \quad H_A : (\alpha, \rho) \neq (0,1)$$

Assuming β is actually zero ($\beta = 0$) then tests on α and/or ρ should have greater power once this restriction is required. This may use an augmented version of estimated equation by using the Φ_1 statistic to test the null hypothesis of a unit root and zero intercept (Rao, 1994).

$$H_0 : y_t = \delta y_{t-1} + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + u_t \text{ v.s. } H_A : y_t = \alpha + \delta y_{t-1} + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + u_t$$

Now we can estimate Φ_1 as follows:

$$\Phi_1 = \frac{(0.150174 - 0.136247)/1}{0.136247/(43-4)} = \frac{0.013927}{0.003494} = 3.99$$

The calculated value for Φ_1 is 3.99 which is located between the critical value of Φ_1 from Table IV Dickey-Fuller (1981) at 5% critical value is (0.50-4.86), thus the null hypothesis can be rejected (see also Table C, Enders, 1995). Thus, the series is a random walk with time trend.

Table A.3.2 The Results of Joint Dickey-Fuller (1981) Test for Variables Model

Variables	k	$\chi^2(k)$	Φ_1	Φ_2	Φ_3	τ_α	τ_β	Constant (C) & Trend (T)
Real GDP	2	5.15	3.99	2.94	1.81	2.21	1.34	C&T
Oil-GDP	1	1.16	7.22	3.52	0.001	2.59	0.03	C
Non-Oil GDP	2	5.82	2.71	2.40	2.03	1.99	1.42	C&T
Exchange Rate	1	3.62	0.02	3.07	6.13	1.73	2.48	C
Government Spending	1	2.97	6.04	2.95	0.002	1.93	0.05	C
Capital (OIL)	5	8.36	3.66	2.53	1.35	2.09	1.16	C&T
Labour (Oil)	5	0.08	5.39	10.68	0.44	3.19	3.26	-
Labour (Non-Oil)	7	11.36	1.71	1.41	1.11	1.28	1.05	C&T
Capital (Non-OIL)	11	23.72	5.30	3.51	1.58	2.43	1.26	C

- $H_0:(\alpha,\rho)=(0,1)$, *against* $H_A:(\alpha,\rho)\neq(0,1)$. The critical value of Φ_1 is between 0.50 and 4.86.
- $H_0:(\alpha,\beta,\rho)=(0,0,1)$ *against* $H_A:(\alpha,\beta,\rho)\neq(0,0,1)$. The critical value of Φ_2 is between 0.91 and 5.94.
- $H_0:(\alpha,\beta,\rho)=(\alpha,0,1)$ *against* $H_A:(\alpha,\beta,\rho)\neq(\alpha,0,1)$. The critical value of Φ_3 is between 1.11 and 6.73.
- All variables are valid for $\chi^2(k)$ at 5% significance, except capital and Labour in Non-oil sector at 1% significance. k is the number of lags of variable.
- More detail is available by author upon request.

Overall, the results of Dickey-Fuller test in Table A.3.2 show that we can apply further tests for time series with drift and/or drift and time trend. Of course, there are time series which may indicate different results for Dickey-Fuller test. In general we use the time series in log level and first difference (FD) for appropriate unit root test. Gujarati (2003) argued that the Augmented Dickey Fuller (ADF) test adjusts the Dickey-Fuller test to take care of possible serial correlation in the error term by adding the lagged difference terms of dependent variable. Also, using the Dickey-Fuller test, Phillips and Perron (1988) have developed a comprehensive theory of unit root non-stationarity similar to the Augmented Dickey Fuller (ADF).[16] Table A.3.3 gives the unit root test for all the time series, using the conventional Augmented Dickey Fuller test (ADF) and Phillip-Perron test (PP).[17]

Table A.3.3 The Results of ADF and Phillips-Perron Unit Root Test

Variable	Constant (C) and Trend (T)	ADF statistics	Optimal lag	Phillips-Perron statistics
Log (Y_t)	C & T	-2.09	2	-1.79
Δ Log (Y_t)	C&T	-3.22	2	-3.75
Log (YNO_t)	C & T	-1.88	2	-1.31
Δ *Log* (YNO_t)	C&T	-3.47	2	-4.07
Log (YO_t)	C	-2.66	1	-2.52
Δ log (YO_t)	C	-5.18	1	-5.22
Log (ER_t)	C	-1.49	1	-1.82
Δ *Log* (ER_t)	C	-3.26	1	-4.66
Log (G_t)	C	-2.32	1	-2.55
Δ *Log* (G_t)	C	-2.35	1	-3.67
Log (KO_t)	C & T	-1.96	5	-1.33
Δ *Log* (KO_t)	C&T	-3.42	5	-3.46
Log (KNO_t)	C	-2.26	11	-2.99
Δ *Log* (KNO_t)	C	-1.54	11	-1.54
Log (LNO_t)	C & T	-1.28	7	-2.67
Δ *Log* (LNO_t)	C&T	-7.87	7	-7.87

- The data used in the present research are expressed in 1998 constant prices and have been collected from the Central Bank of Iran (CBI), Management and Planning Organisation (MPO).
- The detail of analysis is available by author upon request.
- The optimal lag is obtained from Table A.3.2.

[16] Philips and Perron (1988) also developed a generalization of the Dickey-Fuller procedure that allows for fairly mild assumptions concerning the distribution of the errors (Enders, 1995:239).

[17] These tests include a constant and/or constant and a time trend (Table A.3.1), as recommended by Dickey and Fuller (1986). See also Olomola and Adejumo (2006). However, different unit root tests can lead to different results. This limitation certainly does not highlight without any serious reason, placing all their confidence in a single method or model (Laszlo, 2004).

Appendix 4: Hausman-Wu Test and Endogeneity

Endogeneity is important in defining endogenous and exogenous variables in the production function. The production function can be estimated by applying OLS, assuming that all the right hand side variables are exogenously given or predetermined. However, the econometric literature suggests that there is a risk of the endogeneity problem appearing in estimating the production function that OLS regression may become biased and inconsistent and capital and labour are related to the error term.

In such cases it is useful to consider the reduced form of the production function,[18] in which the endogenous variables Y, K, and L are related to the error term. The reduced form parameters, that are nonlinear functions of the structural form parameters, can then be estimated consistently by applying OLS (Verbeek, 2000).[19] In principle, OLS can be replaced by instrumental variables (IV) methods in order to test endogeneity. A general method of obtaining consistent estimates of the parameters in simultaneous equations models is the instrumental variable (IV) method. An IV is a variable that is uncorrelated with the error term but correlated with the explanatory variables in the equation (Maddala, 2001).

Hausman (1978) originally proposed a test statistic for endogeneity based on upon a direct comparison of coefficient values. The underlying idea of the Hausman test is to compare two tests of estimates, one of which is consistent under both the null and the alternative and another which is consistent only under the null hypothesis. A

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[18] The inconsistency is important because it is correlated with the error term and correlation does not disappear unless sample size increases. For more details about reduced forms see Appendix 4.

[19] In special case, one of the problems of production function is under-identified and so cannot be estimated by OLS regression, because K and L are jointly dependent with Y, which means that OLS is biased and cannot identify error term (Desai, 1976).

large difference between the two sets of estimates is taken as evidence in favour of the alternative hypothesis (QMS, 2000).[20]

Two OLS regressions are applied to test: the first is regressing, for example, K and/or L on all exogenous and instrument variables and also retrieve residuals; the second is re-estimating the production function including the residual from the first regression as additional regressor. If the OLS estimates are consistent, then the coefficient on the first stage residuals should not be significantly different from zero. The results show that there is no problem with endogeneity and OLS estimate seems to imply satisfactory.

The results of Hausman-Wu test are reported in the Tables A.4.1 to A.4.2. Hausman-Wu test suggested that there was no problem with endogeneity and OLS estimate seems to imply satisfactory. The results show that the calculated value support null hypothesis for all estimated models and Hausman-Wu test suggests no endogeneity problem here.

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[20] The OLS method has been employed via Eviews (version 4) in this study. The estimated coefficient of capital for the whole period is significant (and positive) at 5% level while the coefficient of labour shows no statistical significance.

Table A.4.1 Hausman-Wu Test for the Oil Sector

Variables	Unrestricted Model	Capital Model	Restricted Model	Labour Model	Restricted Model
Parameters	β (t-ratio)	β (t-ratio)	β (t-ratio)	β (t-ratio)	β (t-ratio)
Dependent	DLOG(YO)	DLOG(KO)	DLOG(YO)	DLOG(LO)	DLOG(YO)
Intercept	0.073 (1.89)	0.002 (0.23)	0.07 (1.74)	0.01 (1.10)	0.07 (1.34)
Capital (DLOG(KO))	0.87 (1.87)		0.88 (1.08)	-0.17 (-0.88)	0.88 (1.73)
Labour (DLOG(LO))	0.17 (0.32)	-0.12 (-0.88)	0.17 (0.31)		0.17 (0.08)
DLOG(KO(-1))		0.58 (5.39)		0.15 (0.89)	
DLOG(LO(-1))		0.05 (0.32)		0.26 (1.56)	
Quadratic of Oil price shocks (PS2)	-0.0005 (-1.51)	0.0003 (4.52)	-0.0005 (-1.15)	0.00009 (0.89)	-0.0005 (-1.22)
Quadratic of ER shocks (QXX)	-0.000001 (-0.85)	0.0000001 (0.20)	-0.00000001 (-0.82)	-0.00000003 (-0.49)	-0.00000001 (-0.79)
Residual (YO)		-0.02 (-0.53)		-0.01 (-0.23)	
Residual (KO)			-0.003 (-0.003)		
Residual (LO)					0.001 (0.0005)
Intercept Dummy (D2)	-0.57 (-5.45)		-0.57 (-4.55)		-0.57 (-4.71)
R-Squared (R^2)	0.46	0.60	0.46	0.12	0.44
Adjusted R-Squared ($\overline{R}^2$)	0.39	0.53	0.37	-0.04	0.37
Chi-square (χ^2)			43.34		43.34
D.W	2.08	1.76	2.07	1.92	2.06

Table A.4.2 Hausman-Wu Test for the Non-Oil Sector

Variables	Unrestricted Model	Capital Model	Restricted Model	Labour Model	Restricted Model
Dependent	β (t-ratio)	β (t-ratio)	β (t-ratio)	β (t-ratio)	β (t-ratio)
Dependent	DLOG(YNO)	DLOG(KNO)	DLOG(YNO)	DLOG(LNO)	DLOG(YNO)
Intercept	-0.05 (-1.94)	0.02 (1.56)	-0.05 (-1.78)	0.02 (0.18)	-0.05 (-1.51)
Capital (DLOG(KNO))	0.76 (6.78)		0.76 (5.89)	-0.06 (-0.04)	0.76 (6.55)
Labour (DLOG(LNO))	0.03 (0.86)	-0.0007 (-0.04)	0.03 (0.85)		0.03 (0.03)
DLOG(KNO(-1))		0.91 (13.52)		0.10 (0.07)	
DLOG(LNO(-1))		0.009 (0.51)		-0.03 (-0.19)	
Government Expenditure Share (SG)	0.003 (2.21)	-0.0009 (-1.26)	0.003 (2.10)	0.00002 (0.004)	0.003 (2.18)
GDP in Oil Sector (DLOG(YO(-1))	0.08 (2.74)	0.02 (1.20)	0.08 (2.68)	-0.02 (-0.14)	0.08 (2.18)
Intercept Dummy (D2)	-0.08 (-2.99)		-0.08 (-2.58)		-0.08 (-2.93)
Residual (YNO)		0.14 (1.45)		0.003 (0.004)	
Residual (KNO)			0.00000000007 (0.0000002)		0.00000000007 (0.0000002)
Residual (LNO)					-0.0000000001 (-0.0000002)
R-Squared (R^2)	0.66	0.84	0.66	0.002	0.66
Adjusted R-Squared ($\overline{R}^2$)	0.61	0.81	0.60	-0.16	0.60
Chi-square (χ^2)			43.13		43.13
D.W	2.02	1.97	2.02	2.00	2.02

To support the findings and evaluate and test the significance of an estimator verses an alternative estimator, one could apply in economic theory is Chi-Square methodology. Consider an alternative methodology for testing significance such as Chi-square as follows:

$$\chi^2 = (n-2)\frac{\hat{\delta}^2}{\delta^2} \tag{A.4.1}$$

where Chi-square follows χ^2 distribution with n-2 degree of freedom.

Suppose that the null and alternative hypotheses are as follows:

Null hypothesis $H_0 : \delta^2 = \delta_0^2$

Alternative hypothesis $H_1 : \delta^2 \neq \delta_0^2$

Substituting the appropriate values of estimated variances in (A.4.1), it can be found the value of χ^2. All results are reported here and found that χ^2 lies between the critical value of 5% significance level and the data support null hypothesis. So, there is not enough evidence to reject it (Gujarati, 2003).[21]

Critical value: $24.43 \succ \chi^2_{5\%/2,41} \succ 59.34$

Oil output: $\chi^2 = (43-2)\frac{(0.196875)^2}{(0.19148)^2} = 43.34$

Non-oil output: $\chi^2 = (44-2)\frac{(0.042079)^2}{(0.041522)^2} = 43.13$

[21] The variance can be obtained by square of standard error of regression, or sum of squared residual divided by degree of freedom. The critical value can be obtained from Chi-square distribution, e.g. Table D.4 of Gujarati (2003: 968).

Appendix 5: Multicollinearity and Variance Inflation Factor Test

Multicollinearity (MC) occurs when one explanatory variable is, or nearly is, a linear combination of one of the other explanatory variables. Accordingly, the partial regression coefficients are unstable and constitute unreliable estimates (Maddala, 2001). Multicollinearity occurs when one explanatory variable is correlated above |0.80|. For this model, both variance inflation factor (VIF) and Tolerance tests were undertaken and it was found that there was multicollinearity in the levels of data, but not when first differences were used.

MC is when variables are highly correlated (0.80 and above). With MC the effects are additive, the independent variables are interrelated, yet affecting the dependent variable differently. Accordingly, the partial regression coefficients are unstable and unreliable. Large standard errors due to MC result in both a lessened probability of rejecting the null hypothesis and wide confidence intervals. Consequently, even extreme MC does not break OLS assumptions. OLS estimates are still unbiased and BLUE (Best Linear Unbiased Estimators).

Nevertheless, the greater the MC, the greater the standard errors. When high MC is present, confidence intervals for coefficients tend to be very wide and t-statistics tend to be very small. Coefficients will have to be larger in order to be statistically significant. However, large standard errors can be caused by things besides MC.[22] MC can be caused by inappropriate use of dummy variables, including a variable that is computed from other variables in the equation, including the same or almost the same variable twice. These factors imply some sort of error on the regression model. But, it may just be that variables really and truly are highly correlated. Before

[22] See also: http://www.nd.edu/~rwilliam/stats2/l11.pdf

developing the concepts, it should be noted that the variance of the OLS estimator for a typical regression coefficient (say β_i) can be shown to be the following.[23]

$$Var(\hat{\beta}_i) = \frac{\delta^2}{S_{ii}(1-R_i^2)}$$

Where $S_{ii} = \sum_{j=1}^{n}(X_{ij} - \overline{X}_i)^2$ and (R_i^2) is the unadjusted (R^2) when you regress (X_i) against all the other explanatory variables in the model, that is, against a constant, $(X_2, X_3, \ldots, X_{i-1}, X_{i+1}, \ldots, X_k)$. Suppose there is no linear relation between (X_i) and the other explanatory variables in the model. Then (R_i^2) will be zero and the variance of $\hat{\beta}_i$ will be $\frac{\delta^2}{S_{ii}}$. Dividing this into the above expression for $Var(\hat{\beta}_i)$ it can obtained the variance inflation factor and tolerance as:

$$VIF(\beta_i) = \frac{1}{1-R_i^2} \text{ and Tolerance } (\hat{\beta}_i) = 1/VIF = 1 - R_i^2$$

It is readily seen that the higher VIF or the lower the tolerance index, the higher the variance of $\hat{\beta}_i$ and the greater the chance of finding (β_i) insignificant, which means that severe MC effects are present. Thus, these measures can be useful in identifying MC. The procedure is to choose each right hand side variable (that is, explanatory variable) as the dependent variable and regress it against a constant and the remaining explanatory variables. It would get k–1 values for VIF. If any of them is high, then MC is indicated. Unfortunately, however, there is no theoretical way to

[23] See Wooldridge (2000), Chapter 3 (Appendix for proof).

say what the entrance value should be to judge that VIF is "high." Also, there is no theory that tells you what to do if MC is found.[24]

To identify Multicollinearity, there are several warning signals:

(a) Look at pair wise relationships between variables, if (r_{ij}) correlation values are greater than |0.80| the variables are strongly interrelated and should not be used. Calculate matrix of correlation coefficients or scatter plot matrix of explanatory variables

(b) For analysis of MC in regression analysis results some packages, such as SPSS, generate a VIF and tolerance value the VIF, or variance inflation factor, will reflect the presence or absence of MC. A high VIF, larger than one, the variable may be affected by MC. The VIF has a range 1 to infinity. The mutual of the tolerance is known as the VIF. The VIF shows how much the variance of the coefficient estimate is being inflated by MC. The square root of the VIF explains how much larger the standard error is, compared with what it would be if that variable were uncorrelated with the other variables in the equation.[25]

Tables A.6.1 to A.6.28 shows the results of multicollinearity and VIF tests for the Iranian Economy.

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[24] See the main source: http://www.econ.ucsd.edu/~rramanat/MoreonMC.pdf See also: Greene, W.H., *Econometric Analysis*, Fourth Edition, Prentice-Hall, Upper Saddle River, New Jersey, 2000. Wooldridge, J. M., *Introductory Econometrics: A Modern Approach*, South Western, 2000.

[25] To Solve for Multicollinearity: turn variables to rates, reduce data set; remove variables which are redundant due to a very high relationship with one another.

A.5.1 Oil Output and Multicollinearity Test*

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.073	.038		1.89	.067	-.005	0.150					
	DLKO	.874	.468	.263	1.87	.070	-.074	1.822	.141	.294	.225	.732	1.365
	DLLO	.167	.524	.040	0.32	.752	-.895	1.229	-.092	.052	.038	.931	1.074
	PS2	.000	.000	-.217	-1.51	.140	-.001	0.000	.006	-.240	-.181	.701	1.427
	QXX	-1.70E-009	.000	-.104	-0.85	.400	.000	0.000	-.017	-.139	-.103	.971	1.029
	D2	-.568	.104	-.679	-5.45	.000	-.778	-0.357	-.634	-.667	-.656	.933	1.072

*Dependent Variable: DLYO

A.5.2 Oil Output and Multicollinearity Test

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	38023.773	8914.680		4.26	.00	19976.94	56070.60					
	PS2	65.294	30.614	.376	2.13	.03	3.32	127.26	.34	.327	.32	.722	1.39
	QXX	.000	.000	.103	.55	.58	.00	.01	.03	.090	.08	.659	1.52
	D2	10900.549	12671.545	.161	.86	.39	-14751.65	36552.75	.09	.138	.12	.644	1.55
	KO	-.044	.326	-.036	-.13	.89	-.70	.61	.12	-.022	-.02	.329	3.04
	LO	-.022	.164	-.035	-.13	.89	-.35	.31	-.03	-.022	-.02	.325	3.07

* Dependent Variable: YO

A.5.3 Non-Oil Output and Multicollinearity Test *

Model		Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-.047	.023		-2.053	.047	-.093	-.001					
	DLKNO	.797	.113	.679	7.036	.000	.567	1.026	.697	.756	.656	.932	1.073
	DLLNO	.027	.030	.085	.908	.370	-.033	.087	.072	.148	.085	.999	1.001
	SG	.003	.001	.247	2.159	.037	.000	.006	-.005	.334	.201	.664	1.507
	DLYO1	.084	.028	.308	3.059	.004	.029	.140	.404	.449	.285	.858	1.165
	D2DLYO1	-.208	.120	-.211	-1.737	.091	-.452	.035	.180	-.275	-.162	.591	1.692
	D2	-.106	.031	-.460	-3.466	.001	-.168	-.044	-.247	-.495	-.323	.493	2.030

* Dependent Variable: DLYNO

A.5.4 Non-Oil Output and Multicollinearity Test *

Model		Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	11711.132	4898.207		2.391	.022	1795.230	21627.034					
	D2	-765.977	14935.100	-.003	-.051	.959	-31000.506	29468.553	.100	-.008	-.001	.060	16.739
	YO1	.572	.078	.135	7.348	.000	.414	.729	.255	.766	.093	.479	2.087
	KNO	.214	.004	.997	50.479	.000	.206	.223	.991	.993	.640	.413	2.421
	LNO	-.001	.001	-.021	-1.103	.277	-.002	.000	.716	-.176	-.014	.435	2.301
	SG	-580.373	307.255	-.038	-1.889	.067	-1202.378	41.633	.293	-.293	-.024	.397	2.519
	D2YO1	-.050	.227	-.011	-.220	.827	-.510	.410	.097	-.036	-.003	.061	16.480

- Dependent Variable: YNO

A.5.5 Model Summary*

Model	R	R-Squared	Adjusted R- Squared	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.681**	0.464	0.392	0.19148	0.464	6.413	5	37	0.000	2.082

** Predictors: (Constant), D2, DLKO, QXX, DLLO, PS2 * Dependent Variable: DLYO

A.5.6 Coefficients and Multicollinearity Test*

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.073	.038		1.889	.067	-.005	.150					
	DLKO	.874	.468	.263	1.869	.070	-.074	1.822	.141	.294	.225	..732	1.365
	DLLO	.167	.524	.040	.319	.752	-.895	1.229	-.092	.052	.038	.931	1.074
	PS2	.000	.000	-.217	-1.506	.140	-.001	.000	.006	-.240	-.181	.701	1.427
	QXX	-1.70E-009	.000	-.104	-.852	.400	.000	.000	-.017	-.139	-.103	.971	1.029
	D2	-.568	.104	-.679	-5.452	.000	-.778	-.357	-.634	-.667	-.656	.933	1.072

*Dependent Variable: DLYO

A.5.7 Collinearity Diagnostics*

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions					
				(Constant)	DLKO	DLLO	PS2	QXX	D2
1	1	2.372	1.000	.07	.06	.04	.05	.02	.02
	2	1.118	1.457	.00	.03	.16	.03	.17	.33
	3	.989	1.549	.03	.02	.01	.14	.51	.10
	4	.735	1.797	.00	.08	.65	.00	.07	.29
	5	.442	2.317	.81	.01	.03	.17	.23	.21
	6	.344	2.628	.09	.81	.10	.60	.01	.05

A.5.8 Coefficient Correlations*

Model			D2	DLKO	QXX	DLLO	PS2
1	Correlations	D2	1.000	-.107	.098	-.188	.183
		DLKO	-.107	1.000	-.088	.081	-.516
		QXX	.098	-.088	1.000	.072	.095
		DLLO	-.188	.081	.072	1.000	-.183
		PS2	.183	-.516	.095	-.183	1.000
	Covariances	D2	.011	-.005	2.05E-011	-.010	5.84E-006
		DLKO	-.005	.219	-8.24E-011	.020	-7.41E-005
		QXX	2.05E-011	-8.24E-011	4.00E-018	7.50E-011	5.82E-014
		DLLO	-.010	.020	7.50E-011	.275	-2.95E-005
		PS2	5.84E-006	-7.41E-005	5.82E-014	-2.95E-005	9.45E-008

*Dependent Variable: DLYO

A.5.9 Model Summary*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.382**	0.146	0.034	19397.68679	0.146	1.302	5	38	0.284	0.326

* Dependent Variable: YO ** Predictors: (Constant), LO, PS2, D2, QXX, KO

A.5.10 Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	38023.773	8914.680		4.265	.000	19976.947	56070.600					
	PS2	65.294	30.614	.376	2.133	.039	3.320	127.268	.345	.327	.320	.722	1.386
	QXX	.000	.000	.103	.556	.582	.000	.001	.035	.090	.083	.659	1.518
	D2	10900.549	12671.545	.161	.860	.395	-14751.653	36552.750	.099	.138	.129	.644	1.552
	KO	-.044	.326	-.036	-.136	.893	-.705	.616	.124	-.022	-.020	.329	3.040
	LO	-.022	.164	-.035	-.133	.895	-.355	.311	-.034	-.022	-.020	.325	3.076

A.5.11 Collinearity Diagnostics*

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions					
				(Constant)	PS2	QXX	D2	KO	LO
1	1	3.382	1.000	.01	.01	.01	.01	.01	.00
	2	1.021	1.820	.00	.01	.20	.36	.00	.00
	3	.941	1.896	.00	.39	.18	.06	.00	.00
	4	.544	2.492	.03	.32	.31	.22	.00	.01
	5	.083	6.385	.66	.04	.16	.08	.32	.02
	6	.029	10.848	.30	.23	.14	.28	.67	.97

* Dependent Variable: YO

A.5.12 Coefficient Correlations*

Model			LO	PS2	D2	QXX	KO
1	Correlations	LO	1.000	.391	.432	-.448	-.714
		PS2	.391	1.000	.384	-.005	-.514
		D2	.432	.384	1.000	.017	-.583
		QXX	-.448	-.005	.017	1.000	.066
		KO	-.714	-.514	-.583	.066	1.000
	Covariances	LO	.027	1.965	900.470	-1.81E-005	-.038
		PS2	1.965	937.196	148788.158	-3.89E-005	-5.137
		D2	900.470	148788.158	160568049.608	.052	-2409.295
		QXX	-1.81E-005	-3.89E-005	.052	6.04E-008	5.29E-006
		KO	-.038	-5.137	-2409.295	5.29E-006	.106

A.5.13 Model Summary*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.824	0.679	0.627	0.04085	0.679	13.023	6	37	0.000	1.998

** Predictors: (Constant), D2, DLLNO, DLKNO, DLYO1, SG, D2DLYO1
* Dependent Variable: DLYNO

A.5.14 Coefficients*

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-.047	.023		-2.053	.047	-.093	-.001					
	DLKNO	.797	.113	.679	7.036	.000	.567	1.026	.697	.756	.656	.932	1.073
	DLLNO	.027	.030	.085	.908	.370	-.033	.087	.072	.148	.085	.999	1.001
	SG	.003	.001	.247	2.159	.037	.000	.006	-.005	.334	.201	.664	1.507
	DLYO1	.084	.028	.308	3.059	.004	.029	.140	.404	.449	.285	.858	1.165
	D2DLYO1	-.208	.120	-.211	-1.737	.091	-.452	.035	.180	-.275	-.162	.591	1.692
	D2	-.106	.031	-.460	-3.466	.001	-.168	-.044	-.247	-.495	-.323	.493	2.030

* Dependent Variable: DLYNO

A.5.15 Collinearity Diagnostics*

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions						
				(Constant)	DLKNO	DLLNO	SG	DLYO1	D2DLYO1	D2
1	1	2.997	1.000	.01	.03	.00	.01	.00	.01	.02
	2	1.613	1.363	.00	.02	.00	.00	.15	.12	.06
	3	.987	1.742	.00	.00	.97	.00	.01	.00	.00
	4	.749	2.000	.00	.01	.02	.00	.76	.08	.08
	5	.371	2.843	.01	.01	.00	.00	.02	.68	.60
	6	.246	3.488	.03	.91	.00	.05	.03	.10	.01
	7	.037	8.972	.95	.03	.00	.94	.02	.01	.23

* Dependent Variable: DLYNO

A.5.16 Coefficient Correlations

Model			D2	DLLNO	DLKNO	DLYO1	SG	D2DLYO1
1	Correlations	D2	1.000	-.023	-.120	-.016	-.463	.519
		DLLNO	-.023	1.000	-.003	.028	.004	-.021
		DLKNO	-.120	-.003	1.000	-.155	-.034	-.175
		DLYO1	-.016	.028	-.155	1.000	.160	-.194
		SG	-.463	.004	-.034	.160	1.000	-.008
		D2DLYO1	.519	-.021	-.175	-.194	-.008	1.000
	Covariances	D2	.001	-2.05E-005	.000	-1.32E-005	-2.01E-005	.002
		DLLNO	-2.05E-005	.001	-1.11E-005	2.29E-005	1.86E-007	-7.56E-005
		DLKNO	.000	-1.11E-005	.013	.000	-5.46E-006	-.002
		DLYO1	-1.32E-005	2.29E-005	.000	.001	6.29E-006	-.001
		SG	-2.01E-005	1.86E-007	-5.46E-006	6.29E-006	2.02E-006	-1.31E-006
		D2DLYO1	.002	-7.56E-005	-.002	-.001	-1.31E-006	.014

A.5.17 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.997**	0.994	0.993	6968.85976	0.994	1029.027	6	38	0.000	0.993

** Predictors: (Constant), D2YO1, LNO, YO1, SG, KNO, D2 * Dependent Variable: YNO

A.5.18 Coefficients*

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	11711.132	4898.207		2.391	.022	1795.230	21627.034					
	D2	-765.977	14935.100	-.003	-.051	.959	-31000.506	29468.553	.100	-.008	-.001	.060	16.739
	YO1	.572	.078	.135	7.348	.000	.414	.729	.255	.766	.093	.479	2.087
	KNO	.214	.004	.997	50.479	.000	.206	.223	.991	.993	.640	.413	2.421
	LNO	-.001	.001	-.021	-1.103	.277	-.002	.000	.716	-.176	-.014	.435	2.301
	SG	-580.373	307.255	-.038	-1.889	.067	-1202.378	41.633	.293	-.293	-.024	.397	2.519
	D2YO1	-.050	.227	-.011	-.220	.827	-.510	.410	.097	-.036	-.003	.061	16.480

* Dependent Variable: YNO

A.5.19 Collinearity Diagnostics

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions						
				(Constant)	D2	YO1	KNO	LNO	SG	D2YO1
1	1	4.967	1.000	.00	.00	.00	.00	.00	.00	.00
	2	1.605	1.759	.00	.01	.00	.00	.00	.00	.01
	3	.237	4.575	.01	.00	.10	.27	.01	.02	.00
	4	.100	7.045	.14	.01	.33	.20	.06	.00	.00
	5	.045	10.535	.01	.14	.19	.05	.14	.44	.22
	6	.025	14.234	.12	.68	.30	.15	.27	.12	.66
	7	.022	15.135	.72	.15	.07	.34	.52	.42	.10

* Dependent Variable: YNO

A.5.20 Coefficient Correlations

Model			D2YO1	LNO	YO1	SG	KNO	D2
1	Correlations	D2YO1	1.000	-.024	-.326	.178	.038	-.955
		LNO	-.024	1.000	.080	.028	-.746	.040
		YO1	-.326	.080	1.000	-.613	-.050	.315
		SG	.178	.028	-.613	1.000	-.156	-.302
		KNO	.038	-.746	-.050	-.156	1.000	-.036
		D2	-.955	.040	.315	-.302	-.036	1.000
	Covariances	D2YO1	.052	-2.74E-006	-.006	12.404	3.70E-005	-3240.844
		LNO	-2.74E-006	2.63E-007	3.18E-006	.004	-1.62E-006	.308
		YO1	-.006	3.18E-006	.006	-14.660	-1.66E-005	366.473
		SG	12.404	.004	-14.660	94405.841	-.203	-1383670.0
		KNO	3.70E-005	-1.62E-006	-1.66E-005	-.203	1.80E-005	-2.280
		D2	-3240.844	.308	366.473	-1383670.0	-2.280	223057216.806

A.5.21 Model Summary*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.862**	0.742	0.700	0.03898	0.742	17.755	6	37	0.000	2.088

** Predictors: (Constant), DLYO1, DLL, DLER, D2, DLK, DLG * Dependent Variable: DLY

A.5.22 Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.002	.012		.144	.886	-.023	.026					
	DLK	.633	.122	.504	5.197	.000	.386	.880	.560	.650	.434	.741	1.349
	D2	-.123	.022	-.501	-5.460	.000	-.168	-.077	-.561	-.668	-.456	.828	1.208
	DLL	-.041	.049	-.070	-.839	.407	-.142	.059	-.090	-.137	-.070	.993	1.007
	DLER	.059	.040	.143	1.478	.148	-.022	.139	-.268	.236	.123	.741	1.350
	DLG	.112	.058	.192	1.917	.063	-.006	.230	.541	.301	.160	.692	1.446
	DLYO1	.067	.026	.229	2.575	.014	.014	.119	.468	.390	.215	.884	1.132

*Dependent Variable: DLY

A.5.23 Collinearity Diagnostics

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions						
				(Constant)	DLK	D2	DLL	DLER	DLG	DLYO1
1	1	2.538	1.000	.03	.03	.02	.01	.02	.03	.01
	2	1.554	1.278	.00	.00	.14	.01	.07	.10	.12
	3	.965	1.622	.00	.01	.02	.80	.00	.02	.09
	4	.824	1.755	.00	.01	.00	.17	.16	.05	.53
	5	.621	2.022	.02	.00	.69	.00	.18	.00	.21
	6	.357	2.665	.05	.20	.10	.01	.18	.81	.01
	7	.140	4.259	.90	.74	.03	.00	.39	.00	.03

* Dependent Variable: DLY

A.5.24 Coefficient Correlations*

Model			DLYO1	DLL	DLER	D2	DLK	DLG
1	Correlations	DLYO1	1.000	-.051	-.110	.193	-.139	-.173
		DLL	-.051	1.000	-.017	-.021	-.011	.053
		DLER	-.110	-.017	1.000	-.226	.290	.245
		D2	.193	-.021	-.226	1.000	-.222	.209
		DLK	-.139	-.011	.290	-.222	1.000	-.299
		DLG	-.173	.053	.245	.209	-.299	1.000
	Covariances	DLYO1	.001	-6.54E-005	.000	.000	.000	.000
		DLL	-6.54E-005	.002	-3.24E-005	-2.34E-005	-6.33E-005	.000
		DLER	.000	-3.24E-005	.002	.000	.001	.001
		D2	.000	-2.34E-005	.000	.001	-.001	.000
		DLK	.000	-6.33E-005	.001	-.001	.015	-.002
		DLG	.000	.000	.001	.000	-.002	.003

* Dependent Variable: DLY

A.5.25 Model Summary*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.997**	0.993	0.992	7638.62736	0.993	963.564	6	38	0.000	1.756

** Predictors: (Constant), ER, YO1, D2, G, L, K * Dependent Variable: Y

A.5.26 Coefficients*

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	15453.875	5365.539		2.880	.006	4591.910	26315.840					
	D2	-22323.959	4906.071	-.073	-4.550	.000	-32255.780	-12392.138	.114	-.594	-.060	.665	1.503
	K	.176	.012	.800	15.216	.000	.152	.199	.946	.927	.199	.062	16.098
	L	-.001	.001	-.033	-.997	.325	-.002	.001	.797	-.160	-.013	.152	6.561
	G	.358	.253	.066	1.416	.165	-.154	.870	.847	.224	.019	.079	12.610
	YO1	1.334	.137	.296	9.715	.000	1.056	1.611	.440	.844	.127	.185	5.408
	ER	3.474	1.074	.115	3.235	.003	1.300	5.648	.738	.465	.042	.135	7.407

* Dependent Variable: Y

A.5.27 Collinearity Diagnostics

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions						
				(Constant)	D2	K	L	G	YO1	ER
1	1	5.191	1.000	.00	.00	.00	.00	.00	.00	.00
	2	1.061	2.212	.00	.39	.00	.00	.00	.00	.02
	3	.496	3.236	.01	.32	.00	.00	.00	.01	.08
	4	.122	6.525	.12	.08	.00	.02	.02	.11	.03
	5	.106	6.983	.04	.04	.06	.00	.03	.05	.12
	6	.016	18.092	.69	.00	.04	.97	.00	.01	.33
	7	.007	27.301	.14	.16	.89	.00	.95	.83	.41

* Dependent Variable: Y

A.5.28 Coefficient Correlations

Model			ER	YO1	D2	G	L	K
1	Correlations	ER	1.000	-.521	.335	.586	-.532	-.568
		YO1	-.521	1.000	-.431	-.884	-.023	.768
		D2	.335	-.431	1.000	.309	.105	-.415
		G	.586	-.884	.309	1.000	.013	-.877
		L	-.532	-.023	.105	.013	1.000	-.268
		K	-.568	.768	-.415	-.877	-.268	1.000
	Covariances	ER	1.153	-.077	1764.911	.159	.000	-.007
		YO1	-.077	.019	-290.077	-.031	-2.03E-006	.001
		D2	1764.911	-290.077	24069531.267	383.024	.330	-23.521
		G	.159	-.031	383.024	.064	2.03E-006	-.003
		L	.000	-2.03E-006	.330	2.03E-006	4.08E-007	-1.97E-006
		K	-.007	.001	-23.521	-.003	-1.97E-006	.000

Appendix 6: World Oil Market

Table A.6.1 Countries Dependent on a Single Primary Commodity for Export Earnings (Annual average of exports, in dollar, 1992-97)

Countries	For 50% or more of export earnings	For 20%-49% or more of export earnings	For 10%-19 or more of export earnings
Oil	Bahrain, Iran, Iraq, Kuwait, Libya, Oman, Qatar, Saudi Arabia, Yemen, Angola, Congo, Gabon, Nigeria, Venezuela	Syria, UAE, Cameron, Equatorial Guinea, Ecuador, Trinidad and Tobago, Azerbaijan, Brunei, Darussalam, Norway, Papua New Guinea, Russia	Egypt, Colombia, Mexico, Indonesia, Kazakhstan, Vietnam
Aluminium		Tajikistan	Bahrain
Bananas		Honduras, St. Vincent	Costa Rica, Ecuador, St. Lucia
Fishmeal			Peru
Natural gas	Turkmenistan	Algeria	
Iron ore		Mauritania	
Copper	Zambia	Chile, Mongolia,	Congo , Peru, Kazakhstan, Papua New Guinea
Gold		Ghana, South Africa, Papua New Guinea	Mali, Zimbabwe, Guyana, Uzbekistan
Timber		Equatorial Guinea, Lao PDR, Solomon Islands	Central African, Gabon, Ghana, Swaziland, Cambodia, Indonesia, Myanmar, Papua New Guinea, Latvia, New Zealand
Cotton		Benin, Chad, Mali, Sudan, Pakistan, Uzbekistan	Burkina Faso, Paraguay, Azerbaijan, Tajikistan, Turkmenistan
Tobacco	Malawi	Zimbabwe	
Arabica Coffee	Burundi, Ethiopia	Rwanda	Colombia, Salvador, Guatemala, Honduras, Nicaragua
Robusta Coffee	Uganda		Cameron
Cocoa		Ghana	Cameron
Tea			Kenya, Rwanda
Sugar		Mauritius, Guyana, St. Kitts and Nevis	Swaziland, Belize
Rice			Guyana

Compiled by Author, data source: International Monetary Fund (1999)

Table A.6.2 CONSUMPTION OF OIL BY COUNTRY (1980-2003)
(Thousand Barrels per Day)

Year	USA	UK	TUNISIA	JAPAN	NEW ZEALAND	CHINA
1980	17002.6	1597.1	1735.5	59862.4	2362.3	521.0
1981	16224.2	1871.6	1653.2	58198.6	2747.5	515.6
1982	15552.1	2065.5	1638.0	56971.8	2970.7	512.4
1983	15268.1	2361.4	1680.6	56683.7	3209.8	543.0
1984	15735.2	2287.0	1735.1	57354.4	3078.7	546.9
1985	15662.3	2326.2	1848.4	57192.0	3115.3	541.4
1986	16175.3	2277.9	1963.4	58628.3	3087.8	573.8
1987	16564.8	2379.3	2094.1	60119.3	3210.4	601.0
1988	17115.4	2449.5	2227.3	61888.6	3341.6	715.4
1989	17140.5	2476.7	2328.7	62758.5	3421.9	824.2
1990	16662.6	2582.4	2279.3	63035.1	3590.3	1017.0
1991	16402.5	2646.5	2443.8	63248.1	3619.5	1216.5
1992	16674.0	2950.8	2615.1	63637.8	3971.9	1468.3
1993	16926.0	3121.5	2926.1	63804.1	4069.4	1612.5
1994	17439.6	3158.4	3005.0	64672.6	4084.3	1763.9
1995	17409.7	3191.5	3179.2	65976.1	4128.8	1921.7
1996	17992.8	3279.6	3487.5	67718.3	4276.9	2003.3
1997	18375.3	3314.2	3899.9	69614.5	4388.6	2145.4
1998	18663.7	3787.8	3742.9	70183.1	4817.9	1799.7
1999	19215.9	3735.6	4103.3	71439.6	4720.8	1959.0
2000	19426.0	3838.5	4606.3	72105.3	4899.7	2025.9
2001	19513.6	3956.3	4614.1	72719.1	5089.4	2019.2
2002	19891.0	4074.3	4958.1	73272.0	5192.2	2072.3
2003	20195.0	4199.9	5483.6	74900.9	5437.1	2078.7

Source: http://www.opec.org/library/annual%20statistical%20bulletin/interactive/2003/filez/XL/T50.HTM

1. These countries are selected out of other countries in the world by large oil consumption.
2. The largest consumption belongs to USA, JAPAN, TUNISIA, and NEW ZEALAND with more than 5000 (Thousand Barrels per Day) in 2003.

Table A.6.3 Oil Production by Country (1980-2003)

(Thousand Barrels per Day)

Year	USA	Mexico	Russia	Norway	UK	Iran	Saudi Arabia	China
1980	8,596.6	1,936.7	12,009.8	522.7	1,611.2	1,816.6	9,900.5	2,169.1
1981	8,571.6	2,313.1	12,174.5	501.4	1,803.2	1,565.0	9,808.0	2,012.4
1982	8,648.5	2,749.1	12,280.2	490.4	2,068.2	2,420.6	6,483.0	2,008.4
1983	8,687.7	2,691.1	12,328.0	609.9	2,260.5	2,441.7	4,539.4	2,101.6
1984	8,879.0	2,684.8	12,234.5	692.2	2,505.8	2,032.4	4,079.1	2,262.4
1985	8,971.4	2,630.8	11,638.7	796.0	2,532.1	2,192.3	3,175.0	2,442.9
1986	8,680.1	2,427.7	11,968.4	878.6	2,499.8	2,037.1	4,784.2	2,553.1
1987	8,349.0	2,541.0	12,118.6	1,018.6	2,457.2	2,297.6	3,975.2	2,666.2
1988	8,139.7	2,507.5	12,067.8	1,152.7	2,273.8	2,478.5	5,100.1	2,720.3
1989	7,613.1	2,513.1	11,766.1	1,501.6	1,814.9	2,814.1	5,064.5	2,760.3
1990	7,355.3	2,547.7	11,030.0	1,645.8	1,834.9	3,135.3	6,412.5	2,766.0
1991	7,416.5	2,675.8	9,928.4	1,882.0	1,811.0	3,406.8	8,117.8	2,804.6
1992	7,171.1	2,667.8	8,643.3	2,102.8	1,851.1	3,431.6	8,331.7	2,814.5
1993	6,846.7	2,673.4	7,738.7	2,268.8	1,943.0	3,425.2	8,047.7	2,924.3
1994	6,661.6	2,685.4	6,986.3	2,538.0	2,397.4	3,596.0	8,049.0	2,941.9
1995	6,559.6	2,617.8	6,855.3	2,697.6	2,488.2	3,595.0	8,023.4	2,996.2
1996	6,464.5	2,858.2	6,743.8	3,030.8	2,517.8	3,596.0	8,102.3	3,173.2
1997	6,451.6	3,022.4	6,912.1	3,062.9	2,494.0	3,603.4	8,011.7	3,254.4
1998	6,251.8	3,070.6	6,907.5	2,908.0	2,560.2	3,714.0	8,280.2	3,207.3
1999	5,881.5	2,906.1	7,044.9	2,880.7	2,649.4	3,439.0	7,564.7	3,211.9
2000	5,821.6	3,012.1	7,459.1	3,182.8	2,427.1	3,661.3	8,094.5	3,228.3
2001	5,801.4	3,127.1	8,070.4	3,118.0	2,269.3	3,572.0	7,888.9	3,297.2
2002	5,745.5	3,177.2	8,880.9	2,992.4	2,254.3	3,248.0	7,093.1	3,393.1
2003	5,737.0	3,370.8	9,766.0	2,852.5	2,062.6	3,741.6	8,410.3	3,407.2

Source: http://www.opec.org/library/annual%20statistical%20bulletin/interactive/2003/filez/XL/T39.HTM

1. These countries are selected out of other countries in the world by large oil production.

2. The largest production belongs to Russia, Saudi Arabia, USA, Iran, and China/ Mexico with more than 3000 (Thousand Barrels per Day) in 2003.

Table A.6.4 Crude Oil Exports by Country (1980-2003)
(Thousand Barrels per Day)

Year	Canada	RUSSIA	Iran	Saudi Arabia	UAE	Nigeria	Mexico	Norway
1980	194.6	2,390.6	796.7	9,223.2	1,697.3	1,960.2	817.2	492.2
1981	163.6	2,357.9	714.6	9,017.9	1,439.0	1,228.4	1,087.0	435.1
1982	209.4	2,383.4	1,623.2	5,639.4	1,167.0	1,002.8	1,491.9	439.7
1983	285.2	2,507.2	1,718.7	3,920.8	1,077.3	935.2	1,536.8	545.1
1984	356.3	2,563.1	1,521.8	3,186.9	1,036.7	1,094.1	1,538.4	609.1
1985	487.1	2,298.9	1,568.3	2,150.7	977.7	1,333.3	1,429.8	656.9
1986	585.2	2,534.7	1,454.0	3,265.8	1,132.0	1,221.2	1,283.7	734.5
1987	620.8	2,683.8	1,710.0	2,416.5	1,250.0	1,065.2	1,347.2	866.4
1988	709.5	2,821.7	1,696.0	3,030.1	1,345.0	1,110.5	1,305.4	991.6
1989	647.0	2,501.3	2,120.0	3,335.5	1,650.0	1,525.9	1,276.0	1,353.4
1990	654.4	2,132.9	2,220.0	4,499.8	1,895.0	1,550.0	1,279.4	1,416.9
1991	762.4	1,215.0	2,420.0	6,526.3	2,195.0	1,610.0	1,374.9	1,718.3
1992	837.4	1,479.0	2,528.0	6,581.9	2,060.0	1,585.0	1,373.3	1,939.9
1993	917.0	1,718.5	2,600.0	6,292.9	1,970.0	1,557.0	1,356.5	2,098.5
1994	982.3	1,874.0	2,650.0	6,233.6	1,955.0	1,590.0	1,307.3	2,381.0
1995	1,057.6	1,884.0	2,621.0	6,290.8	1,925.0	1,665.0	1,300.8	2,482.7
1996	1,072.0	2,067.0	2,630.0	6,109.3	1,943.2	1,812.9	1,607.4	2,803.9
1997	1,042.9	2,174.0	2,587.0	6,184.5	1,949.0	1,855.5	1,793.0	2,818.0
1998	1,146.4	3,042.2	2,512.0	6,390.4	2,039.0	1,832.8	1,807.4	2,699.1
1999	1,047.4	3,438.7	2,291.0	5,719.7	1,919.0	1,705.1	1,671.7	2,681.4
2000	1,175.2	4,142.9	2,492.2	6,253.1	1,814.9	1,986.4	1,848.5	2,887.0
2001	1,130.2	4,592.2	2,184.6	6,035.9	1,786.7	2,089.4	1,882.5	2,962.6
2002	1,426.8	5,581.7	2,093.6	5,284.6	1,614.0	1,798.2	1,902.7	2,833.0
2003	1,553.6	6,479.5	2,396.3	6,522.9	2,048.0	2,303.5	2,102.9	2,694.2

Source: http://www.opec.org/library/annual%20statistical%20bulletin/interactive/2003/filez/XL/T52.HTM

1. These countries are selected out of other countries in the world by large oil export.
2. The largest export belongs to Saudi Arabia, RUSSIA, Norway, Iran, and Nigeria with more than 2000 (Thousand Barrels per Day) in 2003.

Table A.6.5 Imports of Crude Oil by Country, 1980-2003
(Thousand Barrels per Day)

Year	USA	France	Germany	Spain	Italy	India	Japan	South Korea
1980	5,188.1	2,188.0	2,368.1	970.4	1,663.6	332.4	4,337.0	499.2
1981	4,342.8	1,764.4	1,974.1	937.1	1,621.1	313.8	3,847.6	500.4
1982	3,474.8	1,474.6	1,850.3	879.8	1,497.0	355.5	3,529.8	488.3
1983	3,321.8	1,333.1	1,688.6	857.7	1,306.1	319.0	3,457.0	528.0
1984	3,412.1	1,363.7	1,707.5	836.7	1,239.5	299.1	3,595.4	545.1
1985	3,200.9	1,343.4	1,658.9	888.7	1,190.4	303.8	3,341.1	542.9
1986	4,168.2	1,322.7	1,708.4	947.0	1,346.4	298.2	3,290.6	629.8
1987	4,654.7	1,244.0	1,661.1	909.1	1,263.1	370.1	3,144.4	591.7
1988	5,082.6	1,317.3	1,804.9	943.3	1,216.2	362.4	3,286.1	712.7
1989	5,814.6	1,315.8	1,711.7	1,014.0	1,261.0	388.1	3,558.0	811.4
1990	5,870.9	1,393.9	1,748.0	1,038.7	1,399.7	426.6	3,845.5	844.1
1991	5,779.7	1,462.0	1,778.4	1,044.6	1,368.4	447.5	4,077.7	1,093.0
1992	6,079.8	1,418.8	1,979.6	1,105.5	1,456.7	613.3	4,211.2	1,390.5
1993	6,783.8	1,496.2	1,995.4	1,054.4	1,446.2	621.8	4,300.0	1,537.9
1994	7,063.6	1,495.7	2,129.2	1,103.6	1,409.0	572.3	4,599.0	1,574.0
1995	7,715.7	1,542.5	2,025.8	1,103.1	1,474.5	602.5	4,502.2	1,701.7
1996	8,128.5	1,667.7	2,080.6	1,085.9	1,487.6	668.8	4,433.5	1,967.0
1997	8,873.1	1,756.1	2,019.1	1,118.0	1,583.9	684.3	4,554.4	2,401.3
1998	9,326.5	1,803.6	2,196.5	1,199.8	1,718.0	788.6	4,261.0	2,302.2
1999	9,326.5	1,803.6	2,196.5	1,199.8	1,718.0	925.9	4,261.0	2,302.2
2000	9,722.2	1,705.1	2,082.2	1,154.2	1,679.9	964.3	4,222.0	2,446.8
2001	9,929.3	1,703.9	2,112.1	1,140.5	1,659.4	974.0	4,179.1	2,356.9
2002	9,715.5	1,606.9	2,106.5	1,133.6	1,610.0	954.7	3,953.6	2,143.0
2003	10,348.8	1,708.0	2,138.8	1,150.7	1,686.3	1,574.1	4,162.7	2,166.1

Source: http://www.opec.org/library/annual%20statistical%20bulletin/interactive/2003/filez/XL/ T56.HTM

1. These countries are selected out of other countries in the world by large oil import.
2. The largest import belongs to USA, JAPAN, South Korea, and Germany with more than 2000 (Thousand Barrels per Day) in 2003.

Appendix 7: Table A.7.1 An Overview of the Studies on Oil Price and their Principal Results

Authors and period studied	Objective / General idea	Results	Comparison to other studies
Hamilton (1983) 1948-1980	Demonstrates that historic correlation between oil price increases and economic recessions is not a statistical coincidence.	Oil price increase was followed 3-4 quarters later by slower output growth with a recovery beginning after 6-7 quarters. Nominal oil price increase could be expected to lead to a minor output effect during inflationary times than in non-inflationary times	
Gisser, Goodwin (1986) 1961-1982		Show that oil price effects on economic output cannot be explained only by monetary and fiscal policy. The relationship between oil price shocks and U.S. economy didn't change after 1973.	Confirm Hamilton's observation (1983) regarding a similar relationship before and after 1973
Loungani (1986) 1947-1982	Assumes that disruptions in the world oil market generate significant unemployment through sectoral shifts.	Oil price increases in the 1950s and 1970s appear to account for disturbing the labor reallocation process (Quarterly employment data for 28 industries).	
Mork (1989) 1948-1988		Analyses if Hamilton's results remain correct when the oil market collapse of the 1980s and the real oil price are considered as well. Shows an even stronger negative correlation between oil price increase and output growth than Hamilton. Despite of oil price declines in the 1980s, economic output growth is slowed down by oil price changes → asymmetry in effects.	Confirms Hamilton's (1983) observation of a negative correlation between output growth and oil price increases and extends data until 1988.
Lee et al. (1995) 1950-1992	Objective: Examining causality of real oil price to the macroeconomy through 1992	In a long period of stability, oil price shocks (= surprise) have a greater impact than in a volatile environment. - For output growth in a 24-quarter horizon the largest negative impulse appears 4 quarters after the oil price shock, recovery begins about 6 quarters after the shock. - Unemployment begins to rise 4 quarters after the oil shock through 8 quarters after the shock that is not offset at later dates.	The important point of this study is the inclusion of the variable oil price shock, that means the measure of how a change in the given oil price differs from the historical pattern.
Ferderer (1996) 1970-1990 daily spot market oil prices	To explain the asymmetry in effects Ferderer finds evidence that volatility has a greater impact than the oil price level	- Volatility and oil price changes have a stronger and more significant impact on economic activity than monetary policy variables - Oil price increases are accompanied by greater volatility - Oil price volatility and the Federal funds rate dominate the oil price level in terms of explaining fluctuations in industrial production - Volatility has a negative and significant impact on output growth immediately and again eleven months later. - Oil price changes have a significant impact on output growth after about one year.	U.S. economy is affected by oil market disruptions from the 1970s until the 90s through sectoral shocks and uncertainty as shown by Lee et al.

Rotemberg and Woodford (1996) 1948-1980		Imperfectly competitive market models can explain the great effect of oil price changes on output growth and real wages. - A 1% increase in oil prices results in a reduction in output of about -.25 percent after 5 - 7 quarters - After an oil price increase of 10%, real wages fall by 1% after 5 or 6 quarters after this increase The decline in output and real wages gains importance in the second year after the oil price shock.	The period chosen seems to weaken the qualitative results because oil price declines and volatility occur in the 1980s.
Hooker (1996) 1948-1994		1948-1972: 10% increase in oil prices led to GDP growth roughly 0.6 % lower in the third and fourth quarters after the shock 1973-1994: Neither unemployment nor GDP growth can be predicted by oil prices levels. However, GDP growth could be predicted sometimes by volatility.	Refutes the linear relation between oil prices and output (Hamilton 1983) and the asymmetric relation based on oil price increases (Mork 1989).
Hamilton (1996) 1973-1994		Relation between GDP growth and net oil price increase (NOPI) remains statistically significant for the full period from 1948:1 to 1994:2. Due to the oil price volatility since 1986, the period of the previous year has to be considered rather than only the previous quarter when analyzing oil price development	Hamilton agrees completely with Hooker refuting linearity and asymmetry in the oil price macroeconomy relationship.
Hamilton (2000) 1949:1999		Oil price increases matter substantially more than oil price decreases. Increases that occur after a long period of stable prices have a bigger impact than those that simply correct previous decreases. From 1949 to 1980 a 10% increase in oil prices resulted four quarters later in a level of GDP growth that was 1.4% lower. But today, there is not enough historical experience to choose one particular functional form unambiguously over another.	
Chaudhuri (2000) 1973-1996		Real oil prices have an influence on real commodity prices, even if oil is not being used directly in the production of commodities. An oil price change may affect the prices of primary commodities.	

Source: Sauter and Awerbuch (2003)