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A Macroeconometric Model of Saudi Arabia
For
Economic Stabilisation and Forecasting

by

Ahmed B.M. Al-Teraiki

A Doctoral Thesis
Submitted in partial fulfilment of the requirements
for the award of
Doctor of Philosophy

Department of Economics
Loughborough University
August 1999

Supervisor: Professor John R. Presley

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IN THE NAME OF ALLAH
THE COMPASSIONATE
THE MERCIFUL
Dedication

To the sunshine of my life:
Those who taught me the principles of this life
through their teaching and reading their works,
my mother, father, brothers, sisters,
my wife, her parents,
my children
and all my teachers throughout my education
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Abstract

The purpose of this study is to construct a macroeconometric model for the Saudi Arabian economy in order to assess the effects of external shocks through such variables as the price of (oil) exports, real (oil) exports, and the price of imports. This model follows the methodology of the aggregate demand and supply. Due to the absence of interest rates, the formulation of the aggregate demand, following the monetary approach to the income determination, is done by combining the equations from the monetary sector in addition to the government and foreign sectors of the economy. The aggregate supply side of the economy is formulated by combining the equations from the oil and non-oil production sectors. The model determines the behaviours of such important endogenous variables as the real absorptive capacity, real oil and non-oil GDP, real imports, velocity of money, money supply, balance of payments, government oil and non-oil revenues, government expenditure, government deficit, and non-oil GDP and general price inflation rates.

The estimated model satisfactorily simulates the reality of the economy for the estimation period of 1971-1994. This, therefore, justifies the use of the model for both multiplier and scenario analyses. The multiplier analysis evaluates the effects of a 10% change in the price of (oil) exports, real (oil) exports, and the price of imports on the endogenous variables. The scenario analysis, however, examines the behaviours of the endogenous variables for 1999-2005 based on several scenarios on the price of (oil) exports, real (oil) exports, and the price of imports. Concentrating on three sets of scenarios corresponding to low, moderate, and high level of oil prices, our study concludes that a sound economy into the next century requires more aggressive privatisation policies. That is, the government policies should drastically limit the government expenditure and, instead, encourage the private sector to invest and participate more aggressively in the economic development projects.
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Chapter 1.

Introduction

Economic diversification through a strong agricultural and industrial structure has long been the main macroeconomic objective of Saudi Arabia. In the pursuit of this goal, the government short-term strategy has been to direct a large portion of development expenditures toward the creation of social and economic infrastructure such as good roads and schools, adequate health care, transportation, communications, and many other essential facilities. The government longer-term strategy has been to limit its economic involvement to regulatory and promotional functions while encouraging the participation of the private sector to invest on a profitable basis in economic diversification projects.\footnote{For a general economic background, see Presley and Westaway (1989)} Specifically, to increase economic efficiency and to promote sustainable economic growth, the Saudi government is committed to the eventual realisation of indigenous private ownership of all sectors of the economy except oil extraction.

A stable domestic economy is essential for the success of such strategies. The fact that Saudi Arabia relies heavily on the export of crude oil for foreign exchange earnings has made her vulnerable to the world events outside her control. The sharp decline in oil production since 1982 and the sudden decline in oil prices in 1986, for example, resulted in the oil revenues by the late 1980s to be a quarter of what they were in the early 1980s.\footnote{See Presley and Wilson (1991, p. 4) and Ghanem (1986, pp. 165 - 183)} As a result, some development projects had to be cut and others stretched out over a longer period of time than originally planned in order to avoid destabilising the domestic economy. In addition, government payments to Saudi (and foreign) contractors had to be slowed down, creating an uncertain environment for private investment among Saudi businessmen.

Given such recent experiences, this study attempts to provide a framework for analysing macroeconomic problems facing the Saudi economy today. Specifically, a macroeconometric model is constructed to assess the effectiveness of implemented fiscal policies toward the development process in light of the unfavourable fluctuations in international demand for oil and oil prices. Based on this assessment and what we have
learned for the last twenty-five years, our study aims at formulating a more comprehensive fiscal policy that promotes economic stability and growth in the case of the Saudi Arabian economy.

The outline of this chapter is as follows: The development process of the Saudi economy before and after 1970 will be reviewed, respectively, in Sections 1.1 and 1.2. Emphasising the period after 1970, the purpose of this study will be stated in more detail in Section 1.3. Section 1.4 will discuss the relevant methodological issues. Section 1.5 will conclude this chapter by explaining the organisation of this study.

1.1 General economic background before 1970

The unification of Saudi Arabia on 18 September, 1932, marked the beginning of movement toward an integrated national economy. Prior to 1932, the Saudi economy was based almost entirely on agriculture. Dates and livestock constituted among important exported commodities in trade with the neighbouring countries. The 3 March, 1938, discovery and exploitation of crude oil in commercial quantities opened an opportunity for economic development. World War II, however, became an obstacle in the development of the oil industry. However, soon after the war, the oil industry witnessed substantial expansion, with an increase in production from 60 million barrels in 1946 to 200 in 1950 and then to 481 million barrels in 1960.

For the period up to 1960, the oil industry became the dominant sector providing 82 percent of government revenue, 90 percent of the country's foreign exchange, and an important source of the national income. The oil revenue was largely spent on consumption, mostly on foreign goods, rather than on productive domestic investment. No productive investment under any long-range development plan was sponsored. The government had invested and planned only in a random fashion. Around three-fourths of the population was engaged in agriculture, and only a small fraction became directly engaged in the boom generated by oil production. As an important new feature, the

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3 For more details, see Mostyn (1983, pp. 12 - 13)
5 Saudi Arabian Monetary Agency (SAMA) Annual Reports (1963, pp. 23, 38; 1965, p. 6)
Saudi economy became almost entirely dependent on the oil industry which, in turn, was vulnerable to the international market conditions for crude oil. This vulnerability was soon recognised by:

(a) the sluggish demand but abundant supply of oil in the world market which kept oil prices from rising, and
(b) short-term disturbances such as the 1956 - 1957 Suez Canal crisis. Such events were partly responsible for a substantial accumulation of foreign debts during the 1950s.6

The need for directing government disbursements from oil revenues toward creating self-sustaining methods of raising the standard of living of the whole population led to the establishment of the Committee for Economic Development in 1959.7 This event marked the beginning of national economic planning in Saudi Arabia. Accordingly, in the early 1960s the government sector witnessed a transformation in functions both in the level of its operations and administrative capabilities.

Oil production continued to increase from 481.4 million barrels in 1960 to 1386.7 million barrels in 1970.8 As a result, oil government revenues increased from SR 1.502 billion in 1960 to SR 5.193 billion in 1970,9 which led to a balanced budget during most of the 1960s and to the repayment of foreign debts that had been incurred during the 1950s.

In addition, during 1960 - 1970 appropriations increased more rapidly for development than for consumption. For example, appropriations for development increased from less than SR 0.06 billion in 1959 to SR 2.655 billion in 1970; for this same period appropriations for consumption increased from SR 1.140 billion to SR 3.285 billion.10 However, while consumption expenditures were the same or sometimes

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6 For more information on the basic features of the economy including organisation and use of manpower, financial sector, and the government budget during the period up to 1958, the reader is referred to Lipsky (1959)
7 See Said Isa (1986, p. 118)
above the appropriations, development expenditures lagged behind due to administrative delays in receiving bids and implementing contracts, and considerable fluctuations in oil revenues. The development expenditures were only 50 percent of the appropriations in the mid-1960s. This was improved to 88 percent by 1970.\(^\text{11}\) Considerable fluctuations in oil revenue, with an average of 20 percent annual rate of increase up to 1964, a decline by 13.9 percent in 1964, and an annual average increase of 14.5 percent from 1964 to 1970 were perceived as the source of difficulty for the formulation and implementation of a comprehensive national development plan.\(^\text{12}\)

During the 1960s, the nominal GDP increased by an annual average rate of 10.6 percent and the real GDP increased by an annual average rate of 9.5 percent, most of which can be explained by growth in the oil sector.\(^\text{13}\) The relatively slow increase in oil revenues during the 1967 Arab-Israeli war, however, resulted in the GDP increasing at a reduced annual rate of 11.5 percent and 9 percent, respectively, in 1968 and 1969. The contribution of the non-oil sector to the national output was small. By the end of the 1960s, the contribution of agriculture was 6 percent, construction 6 percent, oil refining 6 percent, manufacturing (excluding oil refining) 2 percent, transportation and communication 7 percent, wholesale and retail trade 5.8 percent, and public administration and defence 5.6 percent.\(^\text{14}\)

Increased uncertainty about the flow of oil revenues and its adverse effect on the development process experienced throughout the 1960s, in addition to the depletion of reserves because of subsidy payments to Egypt and Jordan during the Arab-Israeli war, called for more aggressive actions towards foreign oil companies in obtaining more control over production and pricing. Operating within the framework of the Organisation of Petroleum Exporting Countries (OPEC), the control over oil prices was taken away from the oil companies, and OPEC started raising the price of oil by 1970.\(^\text{15}\)

\(^{11}\) Saudi Arabian Monetary Agency (SAMA) Annual Reports (1965, p. 7; 1971, p. 39). Also see Wells (1976, p. 22)

\(^{12}\) Saudi Arabian Monetary Agency (SAMA) Annual Report (1971, p. 88)

\(^{13}\) Kingdom of Saudi Arabia Third Development Plan 1980 - 1985 (1980, p. 9)

\(^{14}\) Saudi Arabian Monetary Agency (SAMA) Annual Report (1973, pp. 93, 112 - 113)

\(^{15}\) For a more detailed explanation on the history of OPEC and the oil-exporting countries' negotiations with oil companies prior to 1973, see Knauerhase (1975). Also see El Mallakh (1982a)
1.2 General economic background after 1970

National planning in the 1960s was limited partly by financial constraints. With the easing of financial constraints in 1970, the continued dominant share of oil output in the GDP called for urgent action toward the diversification of the economy. Accordingly, the Central Planning Organisation, which took the place of the Committee for Economic Development in 1965, submitted to the Council of Ministers its first five-year formal development plan on August 16, 1970, with subsequent five development plans following up to the present. In what follows, we discuss the goals and achievements of the first through the fifth five-year development plans in such fields as agriculture, non-oil mining and manufacturing, construction, utilities, and services. Special attention is given to the factors affecting the performance of the non-oil sectors in the process of economic diversification. We conclude our analysis by discussing the goals and targets set by the sixth development plan.

In our analysis below, we repeatedly refer to Tables 1.1 and 1.2. Table 1.1 reports the allocations of the planned government civilian development expenditures under the first through the fifth five-year development plans. Table 1.2 summarises the actual average annual and planned rates of growth of overall GDP, oil sector, and major non-oil sectors for these five-year development plans.

1.2.1 The first five-year development plan: 1970/71 - 1974/75

The first five-year plan covers the period from 1970/71 to 1974/75. The aim was mainly to develop a firm infrastructural foundation for future development including public utilities, extending government services, and enhancing human resources through education and training. Most of the planned government expenditures at SR 12.8

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Note: Amounts are in (nominal) billions of Saudi riyals (SR) and exclude transfer payments, foreign aid, and non-civilian expenditures.

Source: Ministry of Planning, various documents.
### Table 1.2.

**Annual real rate of growth in oil and non-oil sectors**

<table>
<thead>
<tr>
<th></th>
<th>First Plan 70/71-74/75</th>
<th>Second Plan 75/76-79/80</th>
<th>Third Plan 80/81-84/85</th>
<th>Fourth Plan 85/86-89/90</th>
<th>Fifth Plan 90/91-94/95</th>
<th>Sixth Plan 95/96-2000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>P</td>
<td>A</td>
<td>P</td>
<td>A</td>
<td>P</td>
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<tr>
<td>Total GDP</td>
<td>13.0</td>
<td>9.8</td>
<td>7.0</td>
<td>10.2</td>
<td>-1.6</td>
<td>3.3</td>
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<tr>
<td>Oil Sector</td>
<td>14.8</td>
<td>9.1</td>
<td>4.6</td>
<td>9.7</td>
<td>-14.4</td>
<td>1.3</td>
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<td>10.6</td>
<td>10.5</td>
<td>14.7</td>
<td>13.3</td>
<td>6.2</td>
<td>6.2</td>
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<td>Government</td>
<td>7.8</td>
<td>7.0</td>
<td>6.5</td>
<td>12.9</td>
<td>7.3</td>
<td>7.2</td>
</tr>
<tr>
<td>Private</td>
<td>11.3</td>
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<td>14.1</td>
<td>13.4</td>
<td>6.0</td>
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<td>3.6</td>
<td>4.6</td>
<td>6.9</td>
<td>4.0</td>
<td>9.5</td>
<td>5.4</td>
</tr>
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<td>15.0</td>
<td>7.3</td>
<td>9.8</td>
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<td>15.4</td>
<td>14.0</td>
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<td>18.8</td>
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<td>-2.4</td>
<td>-2.5</td>
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<td>Transport</td>
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<td>15.0</td>
<td>7.1</td>
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<tr>
<td>Finance</td>
<td>17.1</td>
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<td>14.3</td>
<td>9.5</td>
<td>2.5</td>
<td>7.3</td>
</tr>
<tr>
<td>Others</td>
<td>6.0</td>
<td>10.0</td>
<td>11.8</td>
<td>14.0</td>
<td>4.4</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**Notes:** Mining and manufacturing excludes oil-related products or refining. In the text, we refer to these sectors as the non-oil mining and manufacturing sectors. "A" stands for actual average annual rate of growth, and "P" stands for the planned or projected rate.

*Includes government contributions to all sectors listed above.

**Sources:** *Saudi Arabia: Recent Economic Developments (1995)*, prepared for International Monetary Fund, p. 15.
billion were allocated for physical infrastructure and economic resource development with the shares of 44.5 percent and 43.8 percent, respectively (see Table 1.1).

Traditionally, government services were limited to minor road building and national safety due basically to financial constraints. Such constraints were removed following the unexpected fourfold increase in oil prices in 1973 and the expansion of oil production. Consequently, actual government development expenditures turned out to be almost 2.5 times as large as the planned expenditures at SR 32.7 billion. Government services were drastically increased in the areas of economic development, public health and education, and national public works.

According to Table 1.2, the annual rate of growth in real GDP averaged 13.0 percent which was above the planned rate of 9.8 percent. This was partly due to the growth in oil production by an average annual rate of 14.8 percent which surpassed the target rate of 9.1 percent. The 10.6 percent average annual rate of growth in the non-oil sector was in line with the 10.5 percent target rate. The construction sector grew at an average annual rate of 21.4 percent, far above the planned rate of 10.4 percent. Agricultural, non-oil mining, and manufacturing sectors grew, but at rates below the planned rates. For example, the average annual rate of growth in agriculture was 3.6 percent compared to the 4.6 percent target rate. Non-oil mining and manufacturing averaged annual rates of 11.8 percent and 10.8 percent compared to, respectively, 23.3 percent and 14.0 percent target rates.

Agriculture, non-oil mining, and manufacturing are considered vital sectors in the process of diversification. The performance of these non-oil sectors, however, was not encouraging, given the fact that actual government expenditures were almost 2.5 times as large as planned expenditures. It is often argued that the growth targets were too optimistic in relation to the initially allocated government expenditures. This argument may seem reasonable due to the lack of necessary and strong physical infrastructure at the outset of the plan period.

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1.2.2 The second five-year development plan: 1975/76 - 1979/80

The Central Planning Organisation was converted to the Ministry of Planning in 1975. In this same year, the Ministry of Planning submitted the second development plan for the 1975/76 - 1979/80 period. In the absence of financial constraints, the second plan was almost nine times larger than the first plan in financial terms, with actual expenditures once again well above the planned expenditures. For example, the planned government development expenditure of SR 239.3 billion turned out to be SR 318.4 billion by the end of the plan period.23

In addition to such barriers as manpower shortages and the inability to absorb the increased expenditures in physical infrastructure, the economy faced a very high inflation problem during the second plan. In spite of shortages in housing, electricity, water supply, and the need for the completion of infrastructural projects, the government froze budgetary appropriations for 1976/77 at the 1975/76 level. Such an action in addition to the improvement of the country's seaports, reducing drastically the waiting periods of incoming ships loaded with essential imported goods, put an end to high inflation. Consequently, this allowed the government to increase budgetary appropriations and introduce subsidisation for the last two years of the plan. In addition to accelerating the development of the physical infrastructure of the economy, the second plan aimed at diversifying the economy through the utilisation of the country's agriculture, mining, and industry.24

Road, port, and airport construction, development of telecommunication, housing, the establishment of new industries, and building of schools were among the accomplishments in the 1970s. For example, the total cumulative length of asphalted roads increased from 2,000 kilometres in 1968 to more than 20,000 in 1979. In the field of education, the number of students enrolled in schools increased from 42,000 in 1952 to 1.35 million in 1979. In the area of industrialisation, despite the lack of skilled and semiskilled Saudi workers hindering private industrial development, the substantial increase in privately owned factories was impressive. A total of 1,035 industrial


24 See El Mallakh (1982b, pp. 171 - 172)
establishments with a total of SR 16,780 million were licensed in the period from 1975 to 1978 alone.\(^{25}\)

During the second plan period, the 7.0 percent average annual rate of growth in the overall real GDP was less than the 10.2 percent planned rate, due to a lower than expected growth in oil production. For example, the oil sector growth averaged an annual rate of 4.6 percent compared to the 9.7 percent target rate. The real non-oil GDP, however, grew at the average annual rate of 14.7 percent which was above the planned rate of 13.3 percent. Agriculture, manufacturing, construction, utilities, transport, trade, and finance all exceeded their targets. Non-oil mining and other services also grew but at less than their projected rates (see Table 1.2).\(^{26}\)

### 1.2.3 The third five-year development plan: 1980/81 - 1984/85

The economic situation at the beginning of the third plan submitted in June 1980 for the 1980/81-1984/85 period was far more favourable than the previous two plans. For example, major physical constraints to development, while not totally eliminated, had been significantly reduced; financial constraints were virtually non-existent, inflation was under control at an average of 10.5 percent in 1979, and absorptive capacity was also much improved with a dramatic increase in imports during the second plan. The third plan differed from the first and second plans in several areas. The overall aim of the first two plans was high growth rates in all sectors while allowing relatively free importation of foreign labour to meet manpower requirements. The third plan, in contrast, was much more selective, targeting high growth in non-oil sectors that had shown proven potential, with a great emphasis on significantly reducing the size of the foreign labour force. Specifically, the third plan put a greater emphasis on economic resource development as opposed to infrastructure, along with the development of a national labour force through vocational and technical training. For example, as seen in Table 1.1, the share of physical infrastructure decreased from 49.6 percent to 35.5

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percent, while the share of economic resource development increased from 25.1 percent to 37.3 percent of total planned development spending. The share of human resource development also increased from 15.9 percent to 18.5 percent. Decentralisation to ensure a more even geographic distribution of wealth, continued development of agriculture in pursuit of self-sufficiency in food, and improving social services to achieve a better quality of life for Saudi citizens were among the goals of the third plan.27

The performance of the third plan must be evaluated in light of the tremendous fluctuations in government revenues due to the reduction in oil production since 1982 (e.g., the annual production of crude oil from 3579.9 million barrels in 1981 fell to 2366.4 in 1982 and to 1158.8 in 1985).28 Such instability in the government's earning power translated itself into repeatedly revising the scale of the third plan. More importantly, fluctuations in government expenditures and the promptness of government payments were dictated by relatively short-term political and financial concerns. This, in addition to the apparent instability of the long-term government's earning power, made long- and even medium-term planning difficult and threatened the domestic economic stability. By the end of the third plan, it was recognised that unstable conditions in international energy markets, partly due to the Iran-Iraq war, adversely affected progress toward economic diversification.

The sharp decline in Saudi oil production resulted in a 14.4 percent average annual rate of decline in the oil sector during the third plan period. Consequently, the overall GDP declined by an average annual rate of 1.6 percent compared to the 3.3 percent planned annual rate of increase. The non-oil sector, however, scored a 6.2 percent average annual rate of growth due mainly to the continuing infrastructure and industrial projects with relatively few cutbacks in government development expenditures, despite the declining oil revenues. The agricultural sector averaged a rapid growth of 9.5 percent annually, well above the 5.4 percent planned rate. As was expected the construction sector declined, mainly because most ongoing construction projects were completed. Non-oil mining and manufacturing, utilities, transport, and finance all grew, but at less than their corresponding target rates (see Table 1.2 for more details).

The labour force increased by an 8 percent annual rate which was far above the

27 See Kingdom of Saudi Arabia Third Development Plan 1980 - 1985 (1980, pp. 3 - 4)
planned rate of 1.2 percent. A significant portion of this rapid growth was in trade and financial services employment. Compared to the non-Saudi average annual growth rate of 11.7 percent, the Saudi labour force grew only at 3.7 percent. Accordingly, the share of Saudis in the total labour force dropped from 49.4 percent in 1980 to 40.2 percent in 1985. More importantly, productivity declined by an average annual rate of 2.7 percent during the third plan period. This, of course, was in a sharp contrast to the plan's strategy of promoting higher productivity through imported technology and rapid growth in the non-oil sectors, and at the same time reducing significantly the size of the foreign labour force.

1.2.4. The fourth five-year development plan: 1985/86 - 1989/90

The fourth five-year development plan for 1985/86 – 1989/1990 was released in March 1985. The goals of this plan were:

(a) reducing dependence on oil production and exports by continuing the process of economic diversification through the development of agricultural and non-oil manufacturing sectors,
(b) expanding and improving the quality of the domestic labour force,
(c) encouraging discovery and development of mineral resources,
(d) completing the development of physical infrastructural facilities, and
(e) promoting an idea exchange for solving economic and social problems among the member states of the Gulf Cooperation Council (GCC).

The strategy of the fourth plan was to give greater emphasis than previous plans to the role of the private sector, with the government limiting its economic involvement to regulatory and promotional functions.

Chapter I: Introduction

The oil price crash of 1986 from a high of US $28 per barrel in January 1986 to a low of US $8 per barrel by mid-year resulted in a huge decline in oil revenues and a serious depletion of foreign assets. The depreciation of the US dollar was another adverse factor. Since oil exports were largely denominated in US dollars, but most Saudi imports came from countries whose currencies appreciated relative to the US dollar, these events led to a serious revision of development programs. The urgent task was to stabilise government finances by cutting capital expenditures, delaying some development projects, and cancelling others.32

The increase in oil production later in the period, however, resulted in an average annual growth rate of 5.1 percent in the oil sector. The overall GDP growing at 1.3 percent annual rate was well below the planned rate of 4.0 percent. In addition, economic diversification was hindered as the non-oil sector experienced a low rate of growth due to cutbacks in development projects following the sharp decline in oil revenues during the fourth plan. For example, the non-oil sector declined by an average annual rate of 1.1 percent compared to the 2.9 percent planned rate of increase. Construction continued to fall by 7.7 percent. Non-oil manufacturing showed an average annual growth rate of 0.5 percent, well below the 15.5 percent planned rate. Non-oil mining, transport, trade, and finance all fell, respectively, by average annual rates of 0.9 percent, 0.8 percent, 1.5 percent, and 4.6 percent. Surprisingly, however, both the agricultural sector and utilities showed growth well above their target rates. The agricultural sector grew by a 13.4 percent average annual rate compared to the 6.0 percent planned rate. Utilities grew by a 5.9 percent average annual rate compared to the 5.0 percent planned rate (see Table 1.2).

During the fourth plan period, expenditure retrenchment, depletion of foreign assets, and the sales of development bonds helped the government deal with severe budget deficits and stabilise its financial situation. This, in addition to the recovery in the world's demand for oil by 1989 and 1990, renewed optimism among the Saudi policy-makers. Plans were made to resume development expenditures in order to promote growth in the oil and non-oil sectors of the economy.

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32 See Banafe (1993, pp. 59 - 60) on this issue.

33 Saudi Arabia: Recent Economic Developments (1995, pp. 8 - 14). Also see Metz (1993, p. 125). We have relied on Metz (1993) for the review of the social and economic events during both the fourth and fifth plan periods.
1.2.5 The fifth five-year development plan: 1990/91 - 1994/95

The fifth development plan for the period of 1990/91 - 1994/95 was formulated in 1990 when international oil markets were stabilising and the national economy was showing signs of recovery. The goals of this plan included:

(a) development of human resources,
(b) diversification of the economy to reduce dependence on oil,
(c) provision of employment to the population,
(d) completion of infrastructure,
(e) encouragement of the private sector's participation in the economic diversification process,
(f) attainment of balanced growth in different regions of the country, and
(g) improvement of social services including education and health care.

In the light of constrained resources, committed funds for civilian programs fell by almost 28.5 percent from SR 500 billion for the fourth plan to SR 357.7 billion for the fifth plan (see Table 1.1). Despite the cutbacks in government investments in economic resources, transportation and communication, health and social services, and municipality and housing, those for human resources development were kept at the fourth plan levels. The general strategy, early in the period, was to move the process of economic diversification forward by encouraging private sector investment more aggressively. For example, the government opened the way for the private sector to buy shares in the larger industrial complexes and utilities. In addition, in order to protect domestic private investment, the government began a policy of protectionism by enforcing restrictive tariff and non-tariff barriers already initiated in the mid-1980s. This policy took place through GCC negotiations with the European Economic Community (EEC).

Such government actions resulted in a mini-boom. The mini-boom, however, was ended by the Iraqi invasion of Kuwait in August 1990. Massive outflow of assets from the domestic banking sector, loss of confidence of foreign creditors, and loss of

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35 See Metz (1993, p. 131)
confident in the Saudi riyal were among the immediate problems that the government had to deal with. In addition, in order to calm the international oil market, the Saudi government was compelled to raise oil output to 8.5 million barrels per day to make up for the 5 million barrels of Iraqi and Kuwaiti oil embargoed by the United Nations. This, however, did not prevent oil prices from doubling by December 1990. The Saudi government's commitment in support of the multinational forces in Saudi Arabia, however, resulted in a record high deficit by 1991. To finance this deficit, once again the government started using up foreign assets, selling development bonds, and borrowing from external commercial banks, which was unprecedented. External borrowing soon became an important tool in financing even the development programs. Saudi Aramco, Saudi Basic Industries Corporation (Sabic) and Saudi Consolidated Electric Company (Secco), for example, all sought external financing, instead of cutting back expansion plans. Accordingly, the fiscal crisis did not cause problems for the private sector because the government's reduction of its budgeted expenditures was slight. Moreover, domestic government spending in support of the war effort was substantially increased, and, consequently, many Saudi companies benefited from war-related contracts. Accordingly, the mini-boom that was interrupted by the Iraqi invasion of Kuwait was once again revived. This revival was further enhanced by:

(a) the US long-term commitment to the protection of Saudi Arabia which restored private sector confidence in the economy,
(b) the Saudi government's regional policy changes to further encourage the existing manufacturing firms, and
(c) government subsidies for the lower- and middle-income Saudis to increase their disposable income.

During the fifth plan period, the overall GDP growth averaged an annual rate of 5.3 percent, exceeding its target rate of 3.2 percent. This occurred because of the higher than expected rate of growth in the oil sector which averaged an annual rate of growth of 8.9 percent, far above the planned rate of 2.7 percent. The average annual rate of growth of 1.9 percent in the non-oil sector was lower than the planned rate of 3.6 percent. The

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36 See Metz (1993, p. 126)
37 See Metz (1993, p. 127)
private sector averaged a 1.5 percent rate of growth which, again, was below the targeted growth rate of 4.6 percent. Agricultural, non-oil manufacturing, and utilities sectors all experienced growth, but at lower rates than projected (for more details, see Table 1.2).

1.2.6 The sixth five-year development plan: 1995/96 - 2000

To satisfy the need for infrastructure development, the first three plans (1970/71 - 1984/85) took a project approach to planning. Accordingly, the individual projects within each sector were first identified, and then government expenditure was allocated to each sector with the aim to complete these projects. The fourth through the sixth development plan, on the other hand, took a program approach, aiming at developing sectoral programs rather than individual projects. In contrast to the project approach, the program approach to planning concentrates on the overall structure of development rather than its component parts. Another important distinguishing feature of the sixth development plan is that this plan, unlike the previous ones, does not face serious capacity constraints, since many of the basic infrastructure needs required for development have already been near completion. Accordingly, the sixth plan places more emphasis on efficiency and cost effectiveness.

More specifically, the fact that the private sector could not initiate large-scale investment projects necessary for basic infrastructural development resulted in heavy involvement of the government under the first five development plans. The sixth development plan, however, seeks to reduce government involvement in the development process by placing a greater reliance on the private sector. This is understandable not only because of the near completion of much of the necessary basic infrastructure but also the downturn in oil revenues.

The sixth development plan, which covers the 1995/96 - 2000 period, calls for further economic diversification through encouraging private sector participation in agriculture, manufacturing, development of mineral resources, completion of

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38 We have relied on Presley (1996b) in our analysis of the sixth development plan.

39 The maintenance of the defence capabilities in light of the political situation in the Gulf region as well as the expansion of infrastructure facilities such as schools and hospitals with the growing Saudi population are still among the priorities under the sixth development plan. See Presley (1996b).
infrastructure projects, and achievement of balanced growth in all regions of the country. The plan also emphasises the development of human resources to meet the economy's needs and to reduce dependence on the foreign labour force. 40

Under the sixth development plan, the average annual rate of growth for overall GDP is projected to be 3.8 percent, with oil and non-oil sectors growing, respectively, at 3.8 percent and 3.9 percent per annum. The non-oil sector growth rate of 3.9 percent combines the non-oil private sector target growth rate of 4.3 percent per annum and the public sector target growth rate of only 2.7 percent per annum. 41 These target rates, of course, reflects the plan's goal for larger non-oil private sector activity and the desire to restrain growth in the public sector (see the last column of Table 1.2 for more detailed projected rates).

With the downturn in oil revenue and emphasis on efficiency and cost effectiveness, the plan has recognised the need for a change in the distribution of government spending between capital and consumption expenditures. That is, in order to achieve the above targets, the plan increases government capital spending while reducing government consumption expenditure. For example, government consumption is expected to grow by 5.5 percent per annum, while government capital formation has an ambitious target growth rate of 19 percent per annum. 42

With respect to sectoral distribution of growth, the average annual rate of growth for the agricultural sector is targeted to be only 3.1 percent. This relatively lower target rate reflects the problems with limited water resources. In addition, the plan also recognises the need to:

(a) replace the crop production with high water-requirement to other crops with low water-requirement, and
(b) explore land areas where renewable water supplies exist.

With respect to the limited water resources, a National Water Plan is in the works to emphasise the water problem as the key factor in forming the future structure of


42 See Presley (1996b, pp. 11, 22 - 23)
agricultural output and in the development of the agricultural sector of the Saudi economy.\textsuperscript{43}

The average annual rate of growth for the mining sector is targeted to be 9.0 percent. This rate, which is the highest among all sectors, is justifiable due to the growing opportunities in this sector. As indicated in Table 1.2, the manufacturing sector is expected to grow by an average annual rate of growth of 4.9 percent. The optimistic growth of the domestic industry reflects opportunities stemming from:

(a) the rapidly growing domestic population and therefore consumer market,
(b) benefits from economies of scale, and
(c) the use of technology from overseas through joint venture activities.

The plan also recognises that industrialisation efforts should be concentrated on oil-related manufacturing industries, since this is the area in which Saudi Arabia has a comparative advantage. For example, the sixth development plan projects a relatively high average annual growth rate of 8.3 percent for the petrochemical manufacturing sector.\textsuperscript{44}

The private sector is expected to contribute significantly to the growth of the service sector. More specifically, the plan's goal is to restrain the growth of the public sector activity in the service sector. As indicated in Table 1.2, the trade, restaurants and hotels sector is expected to be the fastest growing sector, with an average annual growth target rate of 6.2 percent.

In order to reach the above targets, it is essential for both the private and public sectors to finance the necessary investment. Over the duration of the plan, the total investment requirement is estimated to be SR 472 billion. As indicated by Presley (1996b), the sixth development plan expects that SR 212.7 billion of the total investment requirement (nearly 45 percent) will come from the private sector. Most of the public sector investment financing, however, is allocated for petrochemicals, petroleum refining, and electricity and water, with little contribution in construction, trade, restaurants and hotels and financial services. The plan expects the private sector

\textsuperscript{43} See Presley (1996b, pp. 12 and 19)

\textsuperscript{44} See Kingdom of Saudi Arabia Sixth Development Plan 1995-2000 (1995, p. 117). Also see Presley (1996b, pp. 12 - 13)
involvement in financing most of the investment requirement for the latter sectors.\textsuperscript{45}

Beside improving economic efficiency in the public and private sectors, the sixth development plan's private sector policy emphasises privatisation and the encouragement of small-scale enterprises as well as Saudi-ization. Privatisation aims at enhancing the role of the private sector in the Saudi economy, and Saudi-ization aims at encouraging the development and utilisation of Saudi human resources.

More specifically, the privatisation program encourages:
(a) private funds for investment on public sector projects,
(b) privatising public sector management,
(c) the divestment of government shares in joint stock companies, and
(d) deregulation in order to allow a more effective use of market forces.\textsuperscript{46}

The sixth development plan also recognises the need for improving business conditions for small businesses in the Kingdom. For example, as indicated by Presley (1996b), over 90 percent of businesses in Saudi Arabia employ less than 20 people. These businesses have limited access to finance, they do not gain exemption from customs or taxes, and they cannot obtain land and fuel at the nominal prices available to larger companies with industrial licenses. In addition, these small businesses suffer from relatively low managerial and production efficiency.\textsuperscript{47}

In order to enhance business conditions for small businesses, the Saudi Credit Bank is targeted to make SR 1.5 billion loans toward improving small business's access to finance. The government's incentives to industry are also extended to benefit small businesses. To increase managerial and production efficiency, specialised training programs for small businesses are expected to be offered by Chambers of Commerce. The plan also calls for more efforts by the government toward identifying profitable small-scale investment opportunities.

With respect to Saudi-ization, the sixth development plan recognises the major increase in graduate and non-graduate Saudi nationals entering the work force.


\textsuperscript{46} See Presley (1996b, p. 16)

\textsuperscript{47} See Presley (1996b, p. 17)
Accordingly, this plan is more forceful than the previous ones to create Saudi-ization through both incentives as well as mandatory measures. For example, incentives include financial and other supports for the private sector achieving Saudi-ization targets within companies. Mandatory measures, however, include not only ceilings on the employment of non-Saudis but also minimum targets of Saudi employment. Foreign employment will be limited to only skilled and semi-skilled labour. In general, the plan's goal is to create an additional 659,900 employment opportunities for Saudi nationals both through economic growth and by the replacement of non-Saudi workers (target 319,500).48

1.3 The purpose of the study

In light of wide fluctuations in the world demand for oil and oil prices, the main purpose of this study is to examine the degree of effectiveness of fiscal policy in achieving economic stabilisation and steady growth in the Saudi Arabian economy. Such an examination, however, requires a thorough understanding of the degree of responsiveness of the Saudi economy to the conditions in the world market for crude oil. Based on available data for 1971 - 1994, therefore, this study attempts to develop an econometric model that attempts to explain the working of the Saudi economy for the period from 1971 to 1994. This process involves the formulation and estimation of the aggregate demand and aggregate supply sides of the economy.

The general approach in formulating the aggregate demand side of developed economies follows the well-known "IS-LM" analysis by first formulating and then combining the real and monetary sectors of the economy.49 The traditional way of modelling the aggregate demand side of developing economies, however, is the well-known "absorptive capacity" approach,50 which emphasises the real sector of the economy. This study differs by employing the monetary approach instead. In formulating the aggregate demand side of the economy, the monetary approach assumes

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48 See Presley (1996b, pp. 17 - 18)
49 See Pindyck and Rubinfeld (1991, Chapter 12) for some empirical examples of the aggregate demand modelling based on the IS-LM analysis.
50 For example, see El Mallakh and Atta (1981), Vaez-Zadeh (1989), and Haque, Lahiri, and Montiel (1990), among others.
that the interest rate is a predetermined variable (Friedman, 1970, 1971). Based on this assumption, therefore, the LM curve alone can determine the aggregate demand or economic activity through the intersection of the money demand and money supply functions.

According to Islamic law, charging or receiving interest payments are forbidden. However, most commercial banks in Saudi Arabia offer interest on certain savings and time deposits. However, the general consensus is that the majority of the public, in line with Islamic law, do not hold their assets in such deposits. This is supported by the empirical evidence presented in Chapter 2 of this study. For example, it will be shown that the behaviour of money velocity (or the demand for money) is unaffected by changes in the interest rate. Accordingly, we argue that the insignificant role of the interest rate in the Saudi economy justifies the use of the monetary approach to formulate the aggregate demand side of the Saudi economy. That is, we let the aggregate demand or the absorptive capacity be determined by the intersection of the money demand (or money velocity) and money supply functions. Besides including the monetary sector, our aggregate demand model of the Saudi economy also includes the foreign and government sectors. By emphasising the relationship between the foreign, government, and monetary sectors, our aggregate demand model highlights the vulnerability of the Saudi economy to events in the world market for crude oil.

In formulating the aggregate supply side of the economy, this study distinguishes between the oil and non-oil production sectors of the economy. The oil production is taken to be a function of the real exports. On the other hand, in the spirit of the Phillips' (1958) curve approach, the non-oil production and labour sectors are combined to formulate the non-oil supply function. Accordingly, this function relates the non-oil GDP price inflation to the deviations of the non-oil GDP growth from its long-run trend as well as to inflationary expectations.

Combining the behavioural equations and identities forming the aggregate demand and the aggregate supply results in the macroeconometric model of the Saudi

51 This point will be examined in more detail in Chapter 2 of this study.
52 For the application of this theory for developing countries, see Khan (1974) and Otani and Park (1976)
53 See Khan (1986) on the Islamic interest-free banking.
economy. In line with economic theory, the intersection of the aggregate demand and aggregate supply curves defines the equilibrium condition. It is based on this equilibrium condition that such major macroeconomic variables as income, output, and prices are determined within our macroeconometric model of the Saudi economy.

After examining the internal consistency of the model, consistent estimates are utilised to investigate the dynamic stability of the macroeconometric model. This is done by first simulating the model over the estimation period of 1971 – 1994, and then comparing the solution values of the endogenous variables with their corresponding actual values. Reasonably small simulation errors lead to the conclusion that the macroeconometric model is dynamically stable, since it adequately replicates the reality of the economy over the estimation period. This, in turn, allows us to utilise the model for policy (multiplier) analysis and forecasting.

More specifically, based on a within-sample simulation, short- and long-run multipliers of major macroeconomic variables of the oil exports quantity and price and import prices are calculated. Utilising these multiplier analysis results, several forecasting scenarios on the behaviour of oil exports quantity and price will be specified. Then, out-of-sample dynamic simulations for 1995-2005 will be performed to examine the working of the Saudi economy under alternative forms of fiscal policy.

More specifically, our analysis in the previous section of this chapter, especially for the period after 1970, indicates that the rush toward development tied the level of government development expenditures too closely to the government oil revenue, and, therefore, to the unfavourable fluctuations in the world market for crude oil. Tanzi (1990) argues that such expenditures, instead, should have been related to the average or trend level of current or expected revenues over time. That is, "This relationship implies that the country should run a budgetary surplus in good years and a deficit in periods when exports are lagging behind their trend level, or when other negative factors predominate". Accordingly, a fiscal policy that relates government development expenditures to the trend level of expected revenues avoids unfavourable fluctuations outside the control of the policy-makers and is expected to promote economic stability and growth. Tanzi's argument, therefore, calls for the establishment of "emergency reserve funds". In other words, unexpected increases in oil revenue due to higher than

54 See Tanzi (1990, p. 26)
expected oil prices (or oil production) will be set aside in the form of "emergency reserve funds" and used when there is an unexpected decline in oil revenue due to lower than expected oil prices (or oil production). This allows stable and steady growth in government expenditures regardless of the fluctuations in the world oil market.

The sharp decline in Saudi oil production since 1982 and the sharp reduction in oil prices in 1986 and 1998 have created increasing uncertainty about the future course of foreign exchange inflow and revenues. The main concern is how to insulate the economy from the adverse effects of such external shocks by bringing and maintaining economic stability and steady growth. While exploring the feasibility of the "emergency reserve funds" proposal, our scenario analysis for 1999-2005 examines further the effectiveness of other alternative budgetary disciplines which allow for a stable and steady growth in government expenditure regardless of the fluctuations in the world oil market, and consequently, promote economic growth and stability.

1.4 Methodology

As the cornerstone of this study, we need to construct and estimate a macroeconometric model that attempts to describe the working of the Saudi economy. In the pursuit of this goal, it is essential to obtain unbiased, consistent, and efficient estimates of behavioural equations, by dealing appropriately with several statistical problems, including the specification error, autocorrelation, heteroscedasticity, and multicollinearity problems. This section reviews the consequences of such problems for the Ordinary Least Squares (OLS) estimators and the way the problems are detected and then treated.

1.4.1 A specification error problem

A specification error may occur due to the exclusion of an important explanatory variable and/or an incorrect functional form. In such cases, the error term is no longer purely random which leads to biased and inconsistent OLS estimators. The non-
randomness in the error term is usually picked up by a serial correlation in the residuals. Accordingly, we mainly look at the autocorrelation problem as an indication of a specification error due to the exclusion of an important explanatory variable and/or an incorrect functional form. For the treatment, we rely on economic theory as well as potential major events within the estimation period to search for additional explanatory variables or for a correct functional form.

A specification error may also be due to a simultaneity problem. This problem occurs when the behavioural equation contains one (or more) endogenous variable(s) in the right-hand side. The detection follows as we group the behavioural equations of the whole system into non-simultaneous and simultaneous blocks. To be more specific, the behavioural equations in the non-simultaneous block are those containing only exogenous or predetermined variables in the right-hand side. Accordingly, the OLS estimators are still unbiased and consistent. The behavioural equations in the simultaneous block are those containing endogenous variables in the right-hand side. In this case the OLS estimators are both biased and inconsistent. To obtain consistent estimates, we reestimate the behavioural equation with the Two-Stage-Least-Squares (TSLS) using the exogenous and predetermined variables in the system as instrumental variables.

Another source of a specification error is the inclusion of irrelevant variables in the behavioural equations. This problem does not affect the unbiasedness of the OLS estimators but makes such estimates inefficient. We rely on the calculated t-ratios of the coefficient estimates for detection. For example, a low t-ratio indicates that the coefficient is not significantly different from zero, and, therefore, the corresponding explanatory variable is irrelevant and should be deleted. Before dropping the variable, however, one should make sure that the low t-ratio is not due to a high multicollinearity problem. Failure to do so may result in a specification error due to the exclusion of an important explanatory variable.

As shall be discussed in Chapter 5, such a system is said to be block recursive, since the first step in the process of simulation is to find the solution values of the dependent (endogenous) variables of the equations in the non-simultaneous block. The second step follows when these solution values are utilised to find the solution values of the dependent (endogenous) variables of the equations in the simultaneous block. See Chapter 12 of Pindyck and Rubinfeld (1991) on simulation practices.

This issue will be extensively examined in the appendix of Chapter 5.
1.4.2 An autocorrelation problem

The existence of an autocorrelation problem may indicate that the error term is serially correlated. The consequence of this problem, if it is not due to a specification error, makes the OLS estimators inefficient. In case the model is a dynamic or autoregressive one, the existence of this problem may result in non-randomness in the error term and therefore makes the OLS estimators biased and inefficient. The Durbin-Watson test is used to detect a first-order autocorrelation problem for static or non-autoregressive models. In case the model is a first-order autoregressive (e.g., when the lagged dependent variable is included to account for the short-run adjustment process), the Durbin-h test is used to detect a first-order autocorrelation problem.

In order to test the joint null hypothesis of no first- and second-order autocorrelation problem, we utilise the test proposed by Breusch (1978) and Godfrey (1978), which is derived from a general principle called the Lagrangian Multiplier (LM). To explain how this test, referred to as the LM test, works, consider the following simple regression model

\[ Y_t = \alpha + \beta X_t + u_t \quad (1.1) \]

where the error term, \( u_t \), is to be tested for a first- and a second-order autocorrelation problem. That is,

\[ u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + \epsilon_t \]

where \( \rho_1 \) and \( \rho_2 \) are, respectively, the first- and second- order autocorrelation coefficients, and \( \epsilon_t \) is a white noise error term. The LM test equation for testing the joint null hypothesis of no first- and a second- order autocorrelation problem, \( H_0: \rho_1 = \rho_2 = 0 \), can be written as follows:

See Maddala (1992, pp. 250 - 252)

In this study we detect the autocorrelation problem up to the second order, since we have only twenty four observations (1971 - 1994)
\[ \hat{u}_t = a + b x_t + \rho_1 \hat{u}_{t-1} + \rho_2 \hat{u}_{t-2} + \epsilon_t \] (1.2)

where \( \hat{u}_t \) is the residual series obtained by estimating (1.1). The test statistic utilised is calculated as follows:

\[ n R^2 \]

where \( n \) is the number of observations and \( R^2 \) is the coefficient determination from the test equation in (1.2). Breusch (1978) and Godfrey (1978) show that this test statistic has a chi-squared distribution with the degrees of freedom equal to the number of autocorrelation coefficients in the joint null hypothesis which is two in our example. The joint null hypothesis is accepted if the calculated chi-squared statistic is insignificant. In other words, we maintain the absence of a first- and a second-order autocorrelation problem, when the calculated chi-squared statistic has a P-value greater than ten percent.

As mentioned above, an autocorrelation problem usually occurs when the behavioural equation suffers from a specification error due to the exclusion of an important explanatory variable and/or an incorrect functional form. With this in mind, as the first step, we attempt to correct for the problem by referring back to economic theory, making sure all major relevant variables are accounted for and the functional form is theoretically and empirically appropriate. Once such efforts are exhausted and still the problem remains, then we may argue that the problem of autocorrelation is due to the nature of the data and will be corrected based on the rho-transformation technique.

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60 See Gujarati (1995, pp. 462 - 464)

1.4.3 A heteroscedasticity problem

The non-constancy in the error variance or heteroscedasticity problem affects the efficiency of the OLS estimators. For detection, we use the test suggested by White (1980). In order to explain how the White test works, consider the following simple regression model

\[ Y_t = \alpha + \beta X_t + \gamma W_t + u_t \] (1.3)

where \( u_t \) is the error term. Under the null hypothesis of homoscedasticity, the variance of the error term is constant over all the observations; that is, \( H_0: \text{var}(u_t) = \sigma^2 = \text{constant} \) for all \( t = 1, 2, \ldots, n \). The alternative hypothesis is formulated based on the implicit assumption that the variance of the error term is non-constant over the observations, because it is a function of an unknown variable, \( z_t \); that is, \( H_1: \text{var}(u_t) = \sigma_t^2 = \sigma^2 f(z_t) \). This assumption is common among tests for the heteroscedasticity problem. These tests, however, differ from each other, because they use different proxies or surrogates for the unknown function \( f(z_t) \). The test equation for the White test, for example, regresses \( \hat{u}_t^2 \) on all the explanatory variables and their squares and cross products as follows:

\[ \hat{u}_t^2 = a + b X_t + c W_t + d X_t^2 + e W_t^2 + f X_t W_t + e_t \] (1.4)

where \( \hat{u}_t \) is the residual series obtained by estimating (1.3). The null hypothesis of homoscedasticity according to the test equation in (1.4) is \( H_0: b = c = d = e = f = 0 \), and the corresponding test statistic is calculated as follows:

\[ nR^2 \]

where \( n \) is the number of observations and \( R^2 \) is the coefficient determination from the test equation in (1.4). Again, this test statistic has a chi-squared distribution with the

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62 See Maddala (1992, p. 204)

63 When implementing the White test using MicroTSP, the cross product terms are not included in the test equations. Given the low number of observations in our case, this procedure is appropriate, since the inclusion of too many terms in the test equation will reduce the degrees of freedom.
degrees of freedom equal to the number of independent variables in the joint null hypothesis which is five in our example above. The joint null hypothesis is accepted if the calculated chi-squared statistic is insignificant. In other words, we maintain the absence of a heteroscedasticity problem, when the calculated chi-squared statistic has a P-value greater than ten percent.

With respect to treating this problem in this study, as demonstrated by Gujarati (1995), putting the variables in logarithms may help to alleviate this problem. Another approach is to follow White (1980) by utilising the information about heteroscedasticity to calculate the consistent covariance matrix and then standard errors.

1.4.4 Multicollinearity problems

Multicollinearity is the final problem to be investigated here. When the regression model includes more than one explanatory variable, there is a possibility that we encounter the problem of multicollinearity. In what follows, we distinguish between a perfect multicollinearity problem and a high multicollinearity problem. More specifically, in a multiple regression model, the perfect multicollinearity problem arises when there exists a deterministic relationship among two (or more) explanatory variables. On the other hand, a high multicollinearity problem arises when there exists a statistical relationship with high correlation among two (or more) explanatory variables.

1.4.4.1 A perfect multicollinearity problem

In order to better examine this problem, consider the simple multiple regression model in (1.3):

See Gujarati (1995, pp. 382 - 383)
For multicollinearity problems, see Gujarati (1995, Chapter 10, pp. 319 - 354)
\[ Y_t = \alpha + \beta X_t + \gamma W_t + u_t \]

As indicated above, a perfect multicollinearity problem arises if there exists a deterministic relationship between \( X_t \) and \( W_t \). That is,

\[ X_t = \delta_0 + \delta_1 W_t \quad (1.5) \]

where \( \delta_1 \) is a non-zero coefficient. This deterministic relationship indicates that the correlation coefficient among the explanatory variables \( X_t \) and \( W_t \) is unity (in absolute value), and, therefore, \( X_t \) and \( W_t \) contain the same information. The consequence of this problem is that the model cannot be estimated, since the OLS estimators of \( \alpha \), \( \beta \), and \( \gamma \) do not exist.\(^{67}\) To treat this problem, one simply needs to eliminate either one of the explanatory variables \( X_t \) or \( W_t \). It is noted that the elimination of either \( X_t \) or \( W_t \) will not lead to the loss of information or a specification error problem. This is because these explanatory variables contain the same information.

1.4.4.2 A high multicollinearity problem

As indicated above, a high multicollinearity problem is due to the existence of a high (but not perfect) correlation among the explanatory variables. To better understand this problem, consider, again, the simple multiple regression model in (1.3):

\[ Y_t = \alpha + \beta X_t + \gamma W_t + u_t \]

where there is a statistical relationship between \( X_t \) and \( W_t \) as follows:

\[ X_t = \delta_0 + \delta_1 W_t + \varepsilon_t \quad (1.6) \]

\(^{67}\) We will return to this problem in Chapter 5 of this study.
with $\delta_i$ being a non-zero coefficient, and $\varepsilon_i$ being an error term.\footnote{The existence of the error term, $\varepsilon_i$, in (1.6) indicates that the relationship between $X_i$ and $W_i$ is a statistical relationship. Note that the relationship in (1.5) is a deterministic one, since it does not include an error term.}

Now if the relationship in (1.6) has an $R^2$ close to unity, indicating that the correlation coefficient between $X_i$ and $W_i$ is nearly one (in absolute value), then we face a high multicollinearity problem. In this case, $X_i$ and $W_i$ carry similar (but not the same) information. Accordingly, the OLS estimators of $\alpha, \beta$ and $\gamma$ do exist. The consequence of this problem for the OLS estimators, however, is that it makes the standard errors of the coefficient estimates too large and, thus, their $t$-ratios too low to allow us to reject the null hypothesis of the test of significance. That is, one may mistakenly exclude an important explanatory variable on the basis of having a low $t$-ratio, while the low $t$-ratio is due to the existence of a high multicollinearity problem and not because the variable is irrelevant. In the presence of a high multicollinearity problem, the exclusion of the variable with a low $t$-ratio results in a drastic change in the size of the remaining coefficient estimates. For detection, therefore, one may exclude the variable with a low $t$-ratio to see if this exclusion results in a drastic change in the remaining coefficient estimates. If so, we have the multicollinearity problem and it must be dealt with. If the exclusion does not drastically change the size of the coefficient estimates of the remaining variables, then we may argue that the low $t$-ratio is due to the fact that the variable is irrelevant and should be eliminated. Another way to detect this problem is to look at the estimated correlation coefficients among the explanatory variables either in pairs or as a group. The use of a priori information derived from previous empirical work which proves to be compatible with the data, or respecifying the equation in the first-difference form are ways to treat the problem.\footnote{See Gujarati (1995, pp. 339 - 344) on this issue.}

1.4.5 A test of normality

The diagnostic tests examined above are intended to ensure the absence of the statistical problems which affect the unbiasedness and efficiency of the OLS estimates. However, once the absence of these problems is documented, in order to do hypothesis
testing, we also need to see if the normality assumption is met. The normality assumption states that the error term is independently and normally distributed for all observations \( t = 1, 2, 3, \ldots, n \). In this study, we utilise the normality test proposed by Jarque and Bera (1987). To explain how this test works, consider the simple regression model in (1.2):

\[
Y_t = \alpha + \beta X_t + u_t
\]

where the error term, \( u_t \), is to be tested for normality. In doing so, the first step is to obtain the residual series, \( \hat{u}_t \), by estimating the above regression model. The second step is to calculate the residual series' coefficients of skewness and kurtosis. The null hypothesis that the error term, \( u_t \), is independently and normally distributed is accepted if the coefficient of skewness is sufficiently close to zero, and the coefficient of kurtosis is sufficiently close to three. Given these conditions, the Jarque-Bera (JB) test statistic is calculated as follows:

\[
JB = n \cdot \left\{ \left( S^2 / 6 \right) + \left[ (K - 3)^2 / 24 \right] \right\}
\]

where \( S \) is the coefficient of skewness, and \( K \) is the coefficient of kurtosis. Jarque and Bera (1987) show that this test statistic follows a chi-square distribution with two degrees of freedom (note that the degrees of freedom are associated with the two coefficients \( S \) and \( K \), appearing in the JB test statistic above). As seen, with the coefficients of skewness and kurtosis close to, respectively, zero and three, the calculated JB test statistic will be close to zero or falls below the corresponding critical chi-squared value. This allows us to accept the null hypothesis of normality. Conversely, with the coefficients of skewness and kurtosis significantly different from, respectively, zero and three, the calculated JB test statistic will be far above zero or the corresponding critical chi-squared value. This, however, will lead to the rejection of the null hypothesis of normality. In other words, we maintain the normality assumption to be true, when the P-

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70 See Adrian (1994, pp. 278 – 280)

71 The skewness and kurtosis are referred to as the shape coefficients. For a normal distribution, the coefficient of skewness is zero, since the shape of distribution is not skewed either to the right or to the left. For a normal distribution, the coefficient of kurtosis is three, indicating that the distribution peaks at the mean value.
value of the calculated JB test statistic is reasonably high.\(^2\)

1.5 The organisation of the study

The purpose of this study, as already discussed in this introductory chapter, is to develop a structural model which will help us understand the working of the Saudi economy. The aim is to provide policy recommendations for economic stabilisation and growth in light of the foreign sector disturbances. Based on the aggregate demand and aggregate supply approach, the structural macroeconometric model examined here focuses on establishing a clear link between the monetary, foreign, government, and oil and non-oil production sectors of the economy.

With respect to the aggregate demand side, chapters two through three, respectively, concentrate on formulating the monetary, foreign, and government sectors of the Saudi economy. Specifically, Chapter 2 formulates and estimates the demand for money (or velocity) and the money supply functions. This chapter also explains:

(a) the role of the monetary sector in the determination of the absorptive capacity of the economy without any reference to the real sector, and

(b) how the money supply is influenced by developments in both the foreign and government sectors.

Accordingly, the first part of Chapter 3 examines the empirical behaviour of the demand for imports and the balance of payments in order to formulate the working of the foreign sector. The second part of Chapter 3, then, examines the empirical behaviour of the government sector of the economy by focusing on the formulation and estimation of the functions for government oil and non-oil revenues, and expenditure.

With respect to the aggregate supply side of the economy, in Chapter 4, we distinguish between the real oil and non-oil output or GDP. The real oil GDP is directly linked to the volume of exports. Based on the Phillips’ curve methodology, the non-oil GDP is linked to the non-oil GDP price inflation and the inflationary expectations. In this study, the non-oil GDP price deflator represents the price of output or the producers' prices.

\(^2\) See Gujarati (1995, pp. 143 - 144) for more explanation of this test.
prices. The absorptive capacity price deflator, referred to as the general price level, on the other hand, is taken to represent the consumers' prices. In Chapter 4, we further examine the relationship between these prices by accounting for the role of import prices.

Chapter 5 forms a simultaneous-equation system by combining the behavioural equations and identities forming the aggregate demand and aggregate supply sides of the economy. The behavioural equations and identities are then grouped in the recursive blocks of non-simultaneous and simultaneous. The OLS estimates of the behavioural equations in the non-simultaneous block are unbiased and efficient. Those in the simultaneous block do, however, suffer from a simultaneity bias. In order to remove the simultaneity bias, these behavioural equations are first examined for an identification problem. In the absence of the identification problem, they are then reestimated using the TSLS estimation technique to yield consistent estimates. The dynamic stability of the complete macroeconometric model is then examined based on a within sample simulation exercise. Specifically, we establish the stability of the system historically for the 1971–1994 estimation period and thus justify its use for policy analysis both within and out of sample.\(^73\)

More specifically, using the 1990–1994 sample period, Chapter 6 derives and analyses the short- and long-run multiplier effects of:

(a) the price of (oil) exports,
(b) the real (oil) exports, and
(c) the price of imports.

Chapter 7, however, formulates several forecasting scenarios to explore the economic stability and growth of the Saudi Arabian economy under various situations for 1999-2005. Finally, Chapter 8 concludes this study by summarising our overall findings and the policy implications that follow for both economic stability and growth into the next century.

\(^73\) For simultaneous-equation systems and simulation practices, see Pindyck and Rubinfeld (1991), Chapters 11, 12, 13
Chapter 2: On the formulation of the aggregate demand function

Chapter 2.

On the formulation of the aggregate demand model

Macroeconometric modelling involves the formulation and estimation of the aggregate demand and aggregate supply models of the economy. It is through the interaction of these models that such major economic variables as real income, output, and prices are determined. As already discussed, the formulation of the aggregate demand model involves the combination of the monetary, foreign and government sectors of the Saudi economy. This chapter formulates the monetary sector by first providing the theoretical framework which justifies the use of the monetary approach set forth by Friedman (1970, 1971) to determine the aggregate demand.

The outline of this chapter is as follows: Section 2.1 will theoretically discuss two alternative approaches toward formulating the aggregate demand model of the economy. The first approach is the well-known IS-LM analysis which combines the real and monetary sectors of the economy. The second one is the monetary approach which, based on the assumption that the interest rate is predetermined, concentrates on the LM curve alone or the monetary sector to determine the aggregate demand. As will be shown, institutional and Islamic law results in the interest rate's playing an insignificant role in affecting the behaviour of the demand for money in Saudi Arabia. This, therefore, enables us to argue that the aggregate demand model of the Saudi economy can be formulated based on the monetary approach through the intersection of the demand for money (or velocity) function and the money supply function.

Accordingly, in section 2.2, the monetary sector of the Saudi economy will be examined by formulating and estimating the demand for money (or velocity) function and the function for money supply. This examination will include exploring the determinants of the monetary base and discussing the issue of controllability of the money supply in the economy by the Saudi Arabian Monetary Agency (SAMA). In Section 2.3, we will summarise this chapter by first putting together the formulated equations for the money demand (or velocity) function and the money supply function to form a sub-model of the aggregate demand. We will then discuss the need for formulating the foreign and government sectors in order to complete the aggregate demand model of the Saudi economy.
2.1 The aggregate demand model: a general view

As a general view, the IS-LM analysis\(^1\) combines the real and monetary sectors of the economy to formulate the aggregate demand model. To avoid complications, we confine our examination below to a closed economy. The real sector defines the aggregate demand (or real income) as the sum of private and public demand for consumer and investment goods and services:

\[
y = C + I + G
\]

where \(y\) is the real income or total aggregate demand; \(C\) is the real consumption spending or the private demand for consumer goods and services; \(I\) is the real investment spending or the private demand for investment goods and services; \(G\) is the real government spending or the public demand for consumption and investment goods and services; and \(r\) is the rate of interest. In the consumption function, \(a\) defines the autonomous consumption expenditures (or consumption expenditures independent of income), and \(b\) is the marginal propensity to consume. In the investment function, \(\alpha\) is the autonomous investment expenditures (or investment expenditures independent of interest rate), and \(\beta\) is the sensitivity of the investment to the rate of interest. For simplicity, we assume that:

(a) there are no taxes, meaning that the disposable income is the same as the real income, \(y\), and

(b) \(G\) is exogenously determined by the government, and, therefore, represents the fiscal policy variable.

\(^{1}\) The IS-LM analysis in this study is a modified version of the IS-LM analysis presented by Dornbusch and Fischer (1990, Chapter 4, pp. 107 – 147)
Combining the above three equations, we have

\[ y = a + b \cdot y + \alpha - \beta \cdot r + G \]

or

\[ y = \frac{(a+\alpha)}{(1-b)} - \frac{(\beta/(1-b)) \cdot r}{(1/(1-b))} \cdot G \]

which is called the IS curve. The IS curve is the relationship between the aggregate demand (or real income) and the interest rate when the real sector is at equilibrium. As seen, the IS curve shifts upward or downward when the fiscal policy variable represented by government spending, \( G \), increases or decreases (see Figure 2.1). As seen, the IS curve is negatively sloped, \(- \beta/(1-b)<0\), because a decline in the interest rate increases the aggregate demand by increasing the demand for consumer and investment goods and services. The IS curve by itself, however, cannot determine the aggregate demand (or real income), since the interest rate is endogenously determined within the economy. This is the reason why we need to have the monetary sector in order to determine the aggregate demand (or real income) along with the interest rate.

The monetary sector includes the demand for money function, money supply function, and an equilibrium condition:

\[ (M^d/P) = d + e \cdot y - f \cdot r \]

the demand for (real) money function; \( d, e, f > 0 \),

\[ M^s = M \]

the money supply function

\[ M^d = M^s \]

the equilibrium condition in the monetary sector

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\(^2\) This diagram and other diagrams on subsequent pages are general representations of relationships.
where \( M^d \) is the demand for money (in nominal terms), \( M^s \) is the money supply, and \( P \) is the general price level. In the demand for money function, \( d \) is the autonomous demand for money, \( e \) measures the sensitivity of the demand for money to the real income, and \( f \) measures the sensitivity of the demand for money to the rate of interest. Again, for simplicity, we assume that the money supply is exogenously controlled and determined by the central bank, and, therefore, represents the monetary policy variable.

Combining the above three equations, we have

\[
\frac{M}{P} = d + e \cdot y - f \cdot r
\]

or

\[
y = \frac{-d}{e} + \frac{f}{e} \cdot r + \frac{1}{e} \left( \frac{M}{P} \right)
\]

which is called the LM curve. The LM curve is the relationship between the aggregate demand (or real income) and the rate of interest when the monetary sector is at equilibrium. As seen, the LM curve shifts upward or downward when the monetary policy variable represented by the money supply, \( M \), increases or decreases (see Figure 2.2). As seen, the LM curve is positively sloped, \((f/e)>0\), because an increase in the aggregate demand (or real income) increases the money demand which, with the money supply constant, puts an upward pressure on the interest rate.

![Figure 2.2: The LM curve](image-url)
Eliminating the interest rate, $r$, by combining the IS curve from the real sector

$$y = \frac{a + \alpha}{1 - b} - \left(\frac{\beta}{1 - b}\right) r + \left(\frac{1}{1 - b}\right) G$$

and the LM curve from the monetary sector

$$y = -\frac{d}{e} + \left(\frac{f}{e}\right) r + \left(\frac{1}{e}\right) \left(\frac{M}{P}\right)$$

gives the aggregate demand function as follows (the intercept is dropped for simplicity):
\[ y = \left( \frac{\beta}{(1 - b) + \beta e} \right) (M/P) + \left( \frac{\beta}{(1 - b) + \beta e} \right) G \]

As seen, the aggregate demand function is the relationship between the aggregate demand (or real income) and the general price level when the real and monetary sectors of the economy are at equilibrium. As indicated by the positive slopes of both the monetary and fiscal policy variables \( M \) and \( G \), the aggregate demand function shifts upward or downward when any of these policy variables increase or decrease (also see Figure 2.3). As also indicated by the positive parameter on \( 1/P \), \( (\beta/(1 - b) + \beta e)) > 0 \), there is an inverse relationship between \( y \) and \( P \). For example, a decline in prices reduces the real demand for money, which, with the money supply constant, puts a downward pressure on the interest rate and, therefore, increases the aggregate demand by encouraging more demand for consumption and investment goods and services.

### 2.1.1 The aggregate demand model: Friedman's view

By utilising some key ideas from Fisher (1907) and Keynes (1936), Friedman (1970, 1971) argues that the interest rate is predetermined. Accordingly, he proposes a framework within which the aggregate demand function (or, more specifically, the nominal income) is determined based on the monetary sector or the LM curve alone. To describe Friedman's model, we rewrite the equations for the monetary sector of the economy as follows:

\[
\begin{align*}
(M'/P) &= f(y, r) \quad \text{the demand for (real) money function,} \\
M' &= M \quad \text{the money supply function,} \\
M^d &= M' \quad \text{the equilibrium condition in the money sector}
\end{align*}
\]

where the demand for money function is written in a general form rather than a linear form,\(^3\) and again, the money supply is assumed to be exogenous.

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\(^3\) Theoretically, as we shall see later, it is more reasonable to specify the demand for money function in logarithms rather than in linear form.
Friedman's first assumption is that the elasticity of the demand for money with respect to income is unity. This allows rewriting of the demand for money function as follows:

\[
\frac{M_d}{P} = \frac{y}{y} \cdot f'(r)
\]

or

\[
M_d = P \cdot y \cdot f'(r)
\]

or

\[
M_d = Y \cdot f'(r)
\]  

(2.1)

where \(Y (= P \cdot y)\) is the nominal income.

Following Irving Fisher, Friedman partitions the rate of interest, \(r\), into the real rate of interest, \(\rho\), and the rate of inflation, \(\pi\), as follows:

\[
r = \rho + \pi
\]

Given that the above identity also holds when considering the expected or anticipated values, he writes:

\[
r^* = \rho^* + \pi^*
\]  

(2.2)

where \(r^*, \rho^*\) and \(\pi^*\) are the corresponding anticipated values of \(r, \rho,\) and \(\pi\).

Following Keynes, Friedman also argues that the current market interest rate, \(r\), is largely determined by the rate that is expected to prevail over a longer period, \(r^*\). That is,

\[
r = r^*
\]

which, when combined with (2.2), gives

\[
r = \rho^* + \pi^*
\]  

(2.3)
Given that $P^* = Y^* - y^*$, (2.3) can be rewritten as

$$r = \rho^* + y^* - y^*$$

(2.4)

Friedman further argues that, based on empirical observations, the difference between the anticipated real interest rate, $\rho^*$, and the anticipated rate of growth in real income, $y^*$, is approximately constant; that is, $\rho^* - y^* = k_0 = \text{constant}$. Therefore, (2.4) can be rewritten as

$$r = k_0 + y^*$$

(2.5)

Since $k_0$ is assumed to be constant, and $Y^*$ is assumed to be determined adaptively based on the past values of $Y^*$, then Friedman argues that the interest rate, $r$, from (2.5) is a predetermined variable.

Accordingly, because the rate of interest is not endogenously determined, the LM curve derived from the monetary sector of the economy alone can determine the aggregate demand function or the nominal income. That is, combining (2.1) and (2.5), we have a restatement of the quantity theory of money as follows:

$$Y_t = V(r) \cdot M_t$$

(2.6)

where $V(r) = f(r)$ is the velocity function, and it is predetermined, meaning that changes in money supply result in predictable changes in nominal income. This is consistent with the monetarists' view who argue that:

* That is $Y_t^* = \alpha \cdot Y_{t+1}^* + \alpha (1 - \alpha) \cdot Y_{t+2}^* + \alpha (1 - \alpha)^2 \cdot Y_{t+3}^* + ...$, where the coefficient $\alpha$ is assumed to be between zero and one. Accordingly, the anticipated nominal income based on an adaptive expectations model assumes that income in the recent past has a more powerful effect on anticipated income than income in the more distant past. This adaptive process allows Friedman to argue that the anticipated nominal income depends on the previous values of the actual nominal income, and, therefore, it is a predetermined variable.
(a) the money supply is a reliable indicator of nominal income and a powerful tool in stabilising economic activity,
(b) the money supply, as the major determinant of aggregate demand, produces a lasting effect on the aggregate demand, and
(c) the effect of government expenditures on aggregate demand is insignificant and at best temporary.

It is important to note that (2.6) is, in effect, the aggregate demand function, where it is implicitly assumed that the price elasticity of real income is unity.

Friedman's theory of nominal income determination was utilised by Andersen and Jordan (1968) of the Federal Reserve Bank of St. Louis to examine the relative effectiveness of monetary policy vs. fiscal policy based on the following equation, later known as the St. Louis equation:

$$\Delta Y_t = \alpha_0 + \sum_{i=0}^{\delta_1} b_i \Delta M_{t-i} + \sum_{i=0}^{\gamma} c_i \Delta G_{t-i} + \nu_i$$

where $\Delta Y_t$ is the change in nominal income, $\Delta M_t$ is the change in money supply, and $\Delta G_t$ is the change in the government expenditures. The OLS regression estimates of this equation for 1952.1Q - 1968.2Q, using the US quarterly data, indicates the total effect of the monetary policy on the nominal income is $\Sigma b_i = 5.83$ with a highly significant t-ratio of $7.25$, and the total effect of the fiscal policy on the nominal income is $\Sigma c_i = 0.17$ with a highly insignificant t-ratio of $0.54$. This empirical evidence confirmed the monetarists' argument regarding the relative effectiveness of monetary policy vs. fiscal policy in the case of the US, at least, for the above sample period.⁵

#### 2.1.2 The aggregate demand model in Saudi Arabia

As indicated above, within the general framework when the real income and interest rate are simultaneously and endogenously determined, it is necessary to combine

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⁵ Due to the deregulation of the financial sector of the US economy in the early 1980s, the nominal income is no longer closely related to the money supply. On this issue, see Benjamin Friedman (1988)
the IS curve from the real sector and the LM curve from the monetary sector to formulate the aggregate demand model. Friedman's or the Monetary approach assumes that the interest rate is basically predetermined, and, therefore, one can formulate the aggregate demand model based on the LM curve derived from the monetary sector alone. Friedman's approach in formulating the aggregate demand model is readily applicable in the case of the Saudi economy due to, as shown below, the insignificant role of the interest rate in affecting the behaviour of money demand or money velocity. In other words, we follow the monetary approach to formulate the aggregate demand model of the Saudi economy based on the intersection of the demand for money (or velocity) function and the money supply function.

The aggregate demand model in the Saudi economy specifies the relationship between $RDI_t$ and $P_t$, where $RDI_t$ is the real income available to the domestic economy or the real absorptive capacity measured by the sum of private and public demand for consumption and investment goods and services, and $P_t$ is the general price level measured by the implicit price deflator for the absorptive capacity.

### 2.2 Monetary sector of the Saudi economy

In what follows, we concentrate on the monetary sector of the Saudi economy by examining:

(a) the behaviour of economic agents toward demanding for money, and
(b) the process through which money is supplied to the economy.

Such an examination helps to formulate and estimate both the demand for money (or velocity) function and the money supply function.

Before starting our formal examination of the monetary sector, a review of the Saudi banking system may be necessary. Up to the beginning of the 1950s, the Saudi

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4 In formulating the aggregate demand model, the monetary approach has also been utilised for other developing economies. For example, see Otani and Park (1976) in the case of Korea, Otani (1975) in the case of the Philippines, and Khan (1974) in the case of Venezuela.

Arabian banking system, which included a few money changers and some foreign-based banks, was supervised by the Ministry of Finance. Such supervision included some central banking and public finance functions. Due to the rapid increase in transactions, the need for a central banking system was recognised. In 1952, the Saudi Arabian Monetary Agency (SAMA) was established to function as the central bank. The immediate objectives of SAMA were:

(a) to strengthen the value of the local currency, the Saudi riyal, and stabilise its external value, and
(b) to deal with the banking affairs of the government.\(^8\)

With respect to the first objective, three major policy initiatives were undertaken by SAMA:

(One) the management of monetary reserve funds as separate funds earmarked for monetary purposes only;
(Two) the buying and selling of gold, silver coins, and bullion for government account; and
(Three) regulation of commercial banks, exchange dealers, and money changers.

With respect to the second objective, SAMA accommodates the Ministry of Finance by:

(One) acting as a depository for all government funds; and
(Two) acting as an agent for the government in paying out funds for purposes duly approved by the government through the Ministry of Finance.\(^9\)

Accordingly, while the central bank in developed economies functions independently of the government, in the Saudi economy, SAMA, as the central bank, functions primarily as the bank for the government.

Perhaps the most interesting aspect of the financial system of Saudi Arabia is the adoption to Islamic principles. According to these principles, all public organisations,

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\(^8\) See Banaf (1993, p. 34) and Looney (1982, p. 52)

especially the central bank (SAMA), are prohibited from paying or receiving interest.\textsuperscript{10} This restriction has influenced the global performance of the monetary sector, especially in the functions and instruments available to SAMA in controlling the money supply. Later, in this chapter, we will return to this point and discuss how effectively SAMA can control the money supply and liquidity in the economy through the conventional monetary policy tools such as the Open Market Operation, the discount rate, and the requirement reserve ratio.

\textbf{2.2.1 The demand for money function: a theoretical view}

In studying the monetary sector of an economy, it is important to empirically investigate the factors influencing economic agents' behaviour in demanding for money. To start, we need to discuss Baumol's (1952) theory identifying the determinants of the optimal real amount of money, RM\textsuperscript{*}, which economic agents wish to hold. Let's assume that the economic agent makes a steady stream of payments in real terms at the rate of T per period. Let's also assume that the economic agent has the option of holding its assets in the form of money and/or bonds that yield an interest return of r per period. To exchange bonds for money for the purpose of making its payments, the economic agent faces a fixed brokerage fee in real terms, or b. That is, if the economic agent holds all its assets in the form of bonds, the total cost of making its payments is equal to the brokerage fee, b, times the number of times the firm needs to exchange bonds for money, T/RM. This brokerage cost is zero, if the economic agent keeps all its assets in the form of money, but it faces the opportunity cost of holding money, which is equal to the rate of interest on bonds, r, times the average real money holding, RM/2.

To obtain the optimal level of holding money, RM\textsuperscript{*}, the economic agent needs to minimise its total cost, TC, where the total cost is the sum of the total brokerage costs, b(T/RM) plus the total opportunity cost of holding money, r(RM/2), or

\[ TC = b(T/RM) + r(RM/2). \]

\textsuperscript{10} See Abdeen and Shook (1984) on the implications of Islamic laws on the working of the monetary system of Saudi Arabia. Also see Presley and Westaway (1988, pp. 19 - 24) on monetary and institutional framework in Saudi Arabia.
Differentiating the total cost with respect to $RM$ and setting it equal to zero, we have

$$\frac{\partial TC}{\partial RM} = -\frac{b}{RM^2} + \frac{r}{2} = 0,$$

or

$$RM^* = \left(\frac{2b}{T/r}\right)^{0.5},$$

where $RM^*$ is the optimal or desired level of real money holdings.

Taking the logarithm of both sides, we further have

$$\ln RM^* = \ln \left(\frac{2b}{T/r}\right)^{0.5} + 0.5 \ln T - 0.5 \ln r$$

where the income elasticity of the optimal or desired demand for money is $+0.5$ and the interest elasticity of the optimal demand for money is $-0.5$.\(^{11}\)

Baumol's theory of the demand for transaction money is appropriate when a narrow definition of money such as $M1$ is utilised. The demand function for broader measures of money, however, should include the inflationary expectations, $P^*_e$, variable as another measure of opportunity cost of holding money. According to Friedman's (1956) portfolio theory of the demand for money, the expected inflation rate may be an important variable in determining the desired demand for money. For example, if economic agents expect that the inflation rate is going to rise, they may hold less money and instead hold their wealth in the form of physical assets in order to hedge against the expected inflation. The converse is also true.

In general, in developed economies, where financial markets are well developed, alternatives to holding money are both financial and physical assets. Therefore, the opportunity cost of holding money is the expected rate of return on financial assets measured by the market interest rate, and the expected rate of return on physical assets measured by the expected rate of inflation.

In developing economies, on the other hand, a general consensus is that the expected rate of inflation is the only measure of the opportunity cost of holding money. Accordingly, most empirical studies exclude the market interest rate from the demand function.

\(^{11}\) For more detail in the same issue, see Westaway and Weyman-Jones (1977, pp. 110 – 112, p. 126)
function for money. The justification for this usually rests on two arguments:

First, the substitutability between money and other financial assets is very limited due to the fact that the financial markets outside the commercial banks are very rudimentary.

Second, the high rate of inflation experienced by most developed economies makes the real rate of returns on financial assets very low and sometimes negative.\(^\text{12}\)

Based on these arguments, therefore, the only alternative to holding money is physical assets such as durable goods, real estate, gold, etc.\(^\text{13}\)

In the case of Saudi Arabia, as a developing economy, there is an additional element which may make financial assets even less realistic alternatives to holding money. As already discussed, according to Islamic law, interest payments are considered usury and therefore are legally prohibited.\(^\text{14}\) In reality, however, commercial banks pay interest on both savings and time deposits. Nonetheless, as part of our investigation, we utilise the interest rate on savings and time deposits as a proxy for the market rate of interest and then investigate how significantly it affects the behaviour of the demand for money in the Saudi economy.

In the case of developing countries, another explanatory variable in the demand for money function, as argued by Wong (1977), may be the expected degree of credit restraint (CR\(_k\)). Looney (1982) presents some empirical evidence, supporting the relevance of this variable in explaining the behaviour of the demand for money in the case of Saudi Arabia. Following Wong (1977), Looney (1982) argues that "when credit is tightened, individuals conserve on their money balances, whereas in periods of easy credit, they may keep excess balances (because of their low opportunity costs)".\(^\text{15}\) Following a slightly different argument, Presley and Westaway (1988) include a similar measure called instead the "excess liquidity" variable. Their empirical results, in line with Looney (1982), assigns a significant role to this variable in the demand function for money in the Saudi economy.

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\(^{12}\) See, for example, the studies by Aghevli, Khan, Naruekar, and Short (1979), Galbis (1979), and McKinnon (1976)

\(^{13}\) See Adekunle (1968) for contrasting the empirical behaviour of the demand for money in developed and developing economies.

\(^{14}\) See Siddigi (1981) on this and other related issues.

\(^{15}\) See Looney (1982, p. 261)
2.2.1.1 Formulation of the demand function for money in Saudi Arabia

Consistent with the above theoretical examination, we specify the following demand for money function for the Saudi economy:

\[
\ln \left( \frac{M}{P} \right)^*_t = a_t + b_t \ln RDI_t + c_t \ln RDI_{t-1} + d_t \ln CR_t + e_t \left( \frac{P}{P_t} \right) + f_t \ln INT_t + u_{it} \tag{2.7}
\]

where \( u_{it} \) is an error term, \( (M/P)^*_t \) is the optimal or desired demand for real money, with money defined as the sum of currency in circulation, demand deposits, time and savings deposits, and quasi money (M3 definition). The scale variable is measured by the real absorptive capacity or the income available to the domestic economy, \( RDI_t \). This variable, defined as the sum of the private and public demand for consumption and investment goods and services, is theoretically preferable to the real non-oil GDP utilised by some studies as the scale variable.\(^{16} \)\(^{17} \) The price deflator for money is \( P_n \), measured by the implicit price deflator for the absorptive capacity (= 1.0 for 1984).\(^{18} \) This variable is referred to as the general price level throughout this study.

\(^{16} \) For example, see Crockett and Evans (1980) and Presley and Westaway (1988). The real income available to the domestic economy as a scale variable is also preferable to real GDP utilized by Murinde and Presley (1996)

\(^{17} \) It is noted that, following Haque, Lahiri, and Montiel (1990), the desired demand for money in (2.7) is written as a function of both the current year and previous year income available to the domestic economy; that is, \( RDI_t \) and \( RDI_{t-1} \). As also indicated by Haque, Lahiri, and Montiel (1990, pp. 543-544), the inclusion of \( RDI_{t-1} \) allows for a different pattern of response of the demand for money to changes in income as apposed to other explanatory variables such as the expected degree of credit restraint, inflationary expectations, and interest rate.

\(^{18} \) The data on the national accounts, which includes GDP, private consumption and investment expenditures, government expenditure, exports, imports, and changes in stocks for Saudi Arabia are reported on a yearly basis. More formally, these data satisfy the following identities in both nominal and real terms:

- Nominal GDP = Nominal absorptive capacity + Nominal exports - Nominal imports
- Real GDP = Real absorptive capacity (\( RDI \)) + Real exports - Real imports

where the absorptive capacity (or income available to the domestic economy) is defined as the sum of private consumption and investment expenditures and the government expenditure including changes in stocks (the real variables are in 1984 prices). These data for 1969 - 1994, in both nominal and real terms, are obtained from various issues of the Kingdom of Saudi Arabia: Achievements of the Development Plans. The implicit price index for the absorptive capacity (\( P \)) is obtained by dividing the nominal absorptive capacity by the real absorptive capacity (\( P = 1.0 \) for 1984). The data on the money supply (M3 definition), \( M_n \), is obtained from various issues of International Finance Statistics (IFS), line 351, various issues of Saudi Arabia Monetary Agency (SAMA), Annual Report and also Saudi Arabia: Recent Economic Developments (1995)
Our empirical analysis indicates that the expected degree of credit restraint, $CR_t$, defined as the ratio of government oil revenue in period $t$, $GOR_t$, and government expenditure in period $t-1$, $GEX_{t-1}$,

$$CR_t = \frac{GOR_t}{GEX_{t-1}}$$

is highly correlated with the demand for money.\textsuperscript{19} Theoretically, we may argue that, since government expenditure is the largest source of liquidity in the private sector, then the expected degree of credit restraint depends on how this expenditure is expected to be financed. For example, one may expect a lower degree of credit restraint if the government oil revenue is not sufficient enough to keep up with the expenditure to, at least, the level experienced in the previous period. This means that the government is expected to borrow from the banking system to finance its expenditures. With the banking system extending loans to the government, the supply of money or liquidity will expand, and therefore a lower degree of credit restraint will be expected. On the other hand, if the government oil revenue is more than sufficient, economic agents expect no need for the government to borrow from the banking system. In fact, they expect the excess of government revenue to be added to the government deposit in the banking system, which, therefore, lowers the claims of the banking system on the government. This, consequently, contracts the money supply and liquidity, and, therefore, a higher degree of credit restraint will be expected.

As indicated above, there are two opportunity cost variables are included in the demand function for money in (2.7): the first one is the inflationary expectations, $P^*_t$, which measures what economic agents in year $t$ expect the rate of inflation to be in year $t+1$. It is assumed that economic agents set their expected rate of inflation equal to the previous year's actual rate of inflation, $P^*_{t-1}$, which is known at year $t$; that is,

$$P^*_t = P^*_{t-1}$$

\textsuperscript{19} The data on $GOR$ and $GEX$ are obtained from various issues of the Kingdom of Saudi Arabia: \textit{Achievements of the Development Plans}. 
where \( P_{t+1} = \ln \left( \frac{P_{t+1}}{P_t} \right) \).

The second opportunity cost variable is the market interest rate, \( \text{INT}_t \), which, as discussed above, is approximated by the rate offered by commercial banks on time and savings deposits.\(^{20}\) Finally, consistent with Baumol's theoretical formulation, the demand for money function in (2.7) is specified in logarithms. The expected inflation rate, however, is not in logarithms because it may be negative as well as positive.\(^{21}\)

The actual demand for money, which is equal to the money supply, is observable. However, the optimal or desired demand for money is not observable, making it impossible to estimate the demand for money function in (2.7). Following Goldfeld (1973), Laidler (1985), and Haque, Lahiri, and Montiel (1990), we argue that it may take time for the actual demand to adjust to the desired demand. To formulate this adjustment process, in line with these studies, we utilise the following partial adjustment process:

\[
\ln (M/P)_t - \ln (M/P)_{t+1} = \gamma_1 \left[ \ln (M/P)^*_t - \ln (M/P)_{t+1} \right] \tag{2.8}
\]

where \((M/P)_t\) is the actual demand for real money, and \(\gamma_1\) is the speed of the adjustment assumed to be between zero and one. \(\gamma_1\) being between zero and one indicates that the actual demand for money converges to its desired level based on a geometrically declining pattern. This can be seen by rewriting the partial adjustment process in (2.8) in the following form:

\[
\ln (M/P)_t = \gamma_1 \ln (M/P)^*_t + (1 - \gamma_1) \ln (M/P)_{t+1}
= \gamma_1 (1 - \gamma_1)^2 \ln (M/P)^*_{t+2} + \gamma_1 (1 - \gamma_1)^3 \ln (M/P)_{t+3} + ...
\]

\(^{20}\) The data on interest rate are obtained from the following sources: Elhage (1991, p. 229), for 1968-1975; Riyadh Bank for 1975-1985; and Saudi Arabian Monetary Agency (SAMA), Annual Report, various issues, and Monetary and Banking Statistics (SAMA) 2nd Q.tr 1997, Table 20, p. 134) for 1984-1994

\(^{21}\) Accordingly, \(b_t, c_t, d_t, \) and \(f_t\) in (2.7) are elasticities, since \((M/P)^*_t, \text{RDI}_t, \text{RDI}_{t+1}, \text{CR}_t, \) and \(\text{INT}_t\) are all in logarithms. However, since the inflationary expectations variable, \(P^*_t\), is not in a logarithm, \(e_t\) cannot be considered as the elasticity. Instead we refer to \(e_t\) as the effect of inflationary expectations on the desired demand for money.
which implies that the actual demand for money (in logarithms) adjusts to its desired level (in logarithms) by $100 \cdot \gamma_1$ percent in the immediate year, by $100 \cdot \gamma_1(1-\gamma_1)$ percent in the following first period, and by $100 \cdot \gamma_1(1-\gamma_1)^2$ percent in the following second period, $100 \cdot \gamma_1(1-\gamma_1)^3$ percent in the following third period, and so on. Noting that since $\gamma_1$ is between zero and one, the convergence of the actual demand for money to the desired demand for money takes a geometrically declining pattern; that is, the weights on $\ln (M/P)_{t-1}$ declines geometrically as $i$ increases. In general, if $(1-\gamma_1)$ is closer to zero than one, meaning that the speed of adjustment, $\gamma_1$, is closer to one than zero, it takes fewer years for the actual money holding to adjust to the desired level. At the extreme, when $(1-\gamma_1) = 0$, the speed of adjustment, $\gamma_1$, is equal to one, indicating that 100 percent of the adjustment occurs within the immediate year.

Combining the desired demand function in (2.7) and the partial adjustment process in (2.8), we have the following demand for money function:

$$\ln (M/P)_t = a_1 \gamma_1 + b_1 \gamma_1 \ln RDI_t + c_1 \gamma_1 \ln RDI_{t+1} + d_1 \gamma_1 \ln CR_t + c_1 \gamma_1 P^*_{t-1}$$
$$+ f_1 \gamma_1 \ln INT_t + (1-\gamma_1) \ln (M/P)_{t-1} + u_t$$  (2.9)

which eliminates the desired money demand, $(M/P)^*_{t-1}$, and, therefore, allows the demand function for money in (2.9) to be estimable.

2.2.1.2 Estimation of the demand for money (or velocity) function

The OLS estimates of the demand function for money in (2.9) for the 1971 - 1994 sample period are reported in part one of Table 2.1. Because of the existence of the lagged dependent variable in the right-hand side, the Durbin-h, as the appropriate test, is utilised to detect the existence of a first-order autocorrelation problem. Accordingly, the absolute value of the calculated Durbin-h is 0.33 which is less than the ten percent

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22 To calculate the Durbin-h, the following formula (Gujarati, 1995, p. 606) is used:

$$\text{Durbin-h} = (1 - (DW/2)) \cdot \frac{n}{(1-n \cdot \text{var}(\hat{\gamma}_1))^x}$$

where $n$ is the number of observations, and $\text{var}(\hat{\gamma}_1)$ is the variance of the coefficient estimate on the lagged dependent variable, $\hat{\gamma}_1$. It is noted that the Durbin-h follows a standard normal or the $z$-distribution.
critical z-value, 1.282, implying that there exists no first-order autocorrelation problem. The results from the LM test of serial correlation also reveals the absence of a first- as well as a higher-order autocorrelation problem. For example, the calculated $\chi^2$-statistic for this test is 3.70 with a P-value of 15.74 percent which is above the ten percent reasonable level of significance. The null hypothesis of homoscedasticity is tested based on the White test. The calculated $\chi^2$-statistic for this test is 14.4 with an insignificant P-value of 27.86 percent, indicating the absence of a heteroscedasticity problem. Furthermore, using the Jarque-Bera normality test, we cannot reject the null hypothesis that the error term is normally distributed. For example, the calculated JB test statistic is 0.72 with a P-value of 69.9 percent, which, again, is well above the ten percent reasonable level of significance, leading to the conclusion that the error term is normally distributed.23

Based on these regression estimates, the coefficients on $\ln RDI$, $\ln RDI_{t-1}$, $\ln CR$, and $\ln (M/P)_{t-1}$ are all significantly different from zero at reasonable levels of significance.24 On the other hand, the coefficient estimates on the inflationary expectations, $P^*_t$, and the logarithm of the interest rate, $\ln INT$, while having theoretically correct signs, are not significantly different from zero at any reasonable level of significance (for example, the calculated t-ratios on the coefficient estimates of $P^*_t$ and $\ln INT$ are -0.03 and -1.12 with the P-values of 97.71 and 27.84 percent, respectively).

Part two of Table 2.1 reports the regression estimates of the demand function for money in (2.9) with the interest rate variable excluded. These regression estimates indicate the absence of such statistical problems as a first- and higher-order autocorrelation and heteroscedasticity.25 However, the coefficient estimate on the inflationary expectations variable, $P^*_t$, while having the theoretically correct sign, is still

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23 For a description of these diagnostic tests, see the methodology section of this study in Chapter 1

24 In this study, in line with other empirical studies, by the word "reasonable" we mean ten percent or lower levels of significance.

25 For example, the calculated LM test statistic is 1.75 with an insignificant P-value of 41.68 percent. The calculated White test statistic is 11.7 with, again, an insignificant P-value of 30.6 percent. Furthermore, the calculated Jarque - Bera normality test statistic is 0.84 with a P-value of 65.54, well above the ten percent reasonable level of significance, leading to the acceptance of the null hypothesis that the error term is normally distributed.
not significantly different from zero at any reasonable level of significance (for example, the P-value of the corresponding calculated t-ratio, -0.12, is 90.77 percent). It is noted that the insignificant t-ratio on $P^*_i$ is not due to any high multicollinearity problem, since the coefficient estimates on other explanatory variables in the function remain similar in size to their corresponding ones reported in part one.26

Part three of Table 2.1 reports the regression estimates of the demand function for money in (2.9) with the inflationary expectation variable excluded. A closer look at these estimates, again indicates the absence of such statistical problems as a first- and higher-order autocorrelation and heteroscedasticity.27 The coefficient estimate on the logarithm of the interest rate, $\ln INT_p$, while having the theoretically correct sign, again, is not significantly different from zero at any reasonable level of significance (for example, the P-value of the corresponding calculated t-ratio, -1.16, is 26.19 percent). Again, it is noted that the insignificant t-ratio on the coefficient estimate of $\ln INT_p$ is not due to any high multicollinearity problem, since the coefficient estimates on other explanatory variables in the function remain similar in size to their corresponding ones in part one.

26 See the methodology section of this study in Chapter 1 for the description of the high multicollinearity problem.

27 For example, the calculated LM test statistic is 3.61 with an insignificant P-value of 16.45 percent. The calculated White test statistic is 13.3 with, again, an insignificant P-value of 20.86 percent. Furthermore, the calculated Jarque-Bera normality test statistic is 0.70 with a P-value of 70.57, well above the ten percent reasonable level of significance, leading to the acceptance of the null hypothesis that the error term is normally distributed.
Table 2.1.

OLS Regression estimates of the demand for money function in (2.9)
with alternative opportunity cost variables

### Part one:

\[
\ln (M/P)_t = -0.027 + 0.753 \ln RDI_t - 0.541 \ln RDI_{t-1} - 0.126 \ln CR_t - 0.006 P^e_t \\
\quad (\hat{b} = 0.1592) (\hat{b} = 0.2391) (\hat{b} = 0.2393) (\hat{b} = 0.0321) (\hat{b} = 0.2035) \\
\quad [-0.17] [3.15] [-2.26] [-3.94] [-0.03]
\]

\[-0.052 \ln INT_t + 0.774 \ln (M/P)_{t-1} \\
\quad (\hat{b} = 0.0465) (\hat{b} = 0.0458) \\
\quad [-1.12] [16.90]
\]

\[R^2 = 0.998, DW = 2.13, Durbin-h = -0.33, \quad RSS = 0.038627,\]

\[LM \text{ test } = 3.70, \text{ White's test } = 14.4, \text{ Jarque-Bera normality test } = 0.72.\]

### Part two:

\[
\ln (M/P)_t = -0.098 + 0.813 \ln RDI_t - 0.625 \ln RDI_{t-1} - 0.131 \ln CR_t \\
\quad (\hat{b} = 0.1472) (\hat{b} = 0.2347) (\hat{b} = 0.2289) (\hat{b} = 0.0321) \\
\quad [-0.66] [3.46] [-2.73] [-4.08]
\]

\[-0.024 P^e_t + 0.795 \ln (M/P)_{t-1} \\
\quad (\hat{b} = 0.2043) (\hat{b} = 0.0422) \\
\quad [-0.12] [18.83]
\]

\[R^2 = 0.998, DW = 1.94, Durbin-h = 0.15,\]

\[LM \text{ test } = 1.75, \text{ White's test } = 11.7, \text{ Jarque-Bera normality test } = 0.84.\]
Table 2.1. Continued

Part three:

\[
\begin{align*}
\ln (M/P)_t &= -0.026 + 0.747 \ln RD_{i,t} - 0.536 \ln RD_{i,t-1} - 0.126 \ln CR_t \\
& \quad - 0.052 \ln INT_t + 0.775 \ln (M/P)_{t-1} \\
& \quad (.1510) \quad (.1546) \quad (.1747) \quad (.0276) \quad (.0451) \quad (.0400) \\
& \quad [-0.17] \quad [4.84] \quad [-3.07] \quad [-4.56] \quad [-1.16] \quad [19.36]
\end{align*}
\]

\[R^2 = 0.998, \quad DW = 2.13, \quad Durbin-h = -0.33,\]

\[LM \text{ test} = 3.61, \quad \text{White's test} = 13.3, \quad \text{Jarque-Bera normality test} = 0.70.\]

Note: The standard errors are in parentheses and the t-values are in brackets; see the text for the definition of the variables.

The above conclusions also hold when testing the joint null hypothesis that the inflationary expectations and interest rate variables do not jointly explain the behaviour of the demand for money; that is, \( H_0: \gamma_1 = \gamma_2 = 0 \). For example, the calculated F-statistic is found to be equal to \( F(2,17) = 0.63 \), which is far below the ten percent critical F-value, 2.64, leading to the acceptance of the joint null hypothesis.

Based on the regression estimates in Table 2.1, therefore, the demand function for money in (2.9) is respecified by excluding both the inflationary expectations and interest rate variables as follows:

\[\text{Calculated } F(m, (n-k)) = \frac{\left[ (RSS^R - RSS^U) / m \right]}{RSS^U / (n-k)}\]

where \(RSS^R\) and \(RSS^U\) are the residual sum squares, respectively, from the restricted and unrestricted functions; \(m\) is the number of restrictions; \(n\) is the number of observations, and \(k\) is the number of coefficient estimates in the unrestricted function (see Gujarati, 1995, p. 258). The unrestricted function is the one in (2.9) with \(RSS^U = 0.038627\), \(n = 24\), and \(k = 7\) (see the estimates in part one of Table 2.1). The restricted function is the one in (2.10) below which excludes \(P^*\) and \(\ln INT_t\). Based on the estimates of this restricted function, as reported later in the text, \(RSS^R = 0.041508\). Given that the number of restrictions \(m = 2\), then the calculated F-statistic is found to be \(F(2,17) = 0.63\).
\[
\ln (\frac{M}{P})_t = a_1 \gamma_1 + b_1 \gamma_1 \ln RDI_t + c_1 \gamma_1 \ln RDI_{t-1} + d_1 \gamma_1 \ln CR_t \\
+ (1-\gamma_1) \ln (\frac{M}{P})_{t-1} + u_t \\
\] (2.10)

The OLS estimates of the demand for money function in (2.10) are reported below (the standard errors are in parentheses and the t-values are in brackets):

\[
\ln (\frac{M}{P})_t = -0.094 + 0.792 \ln RDI_t - 0.607 \ln RDI_{t-1} - 0.129 \ln CR_t \\
(0.1403) (0.1511) (0.1652) (0.0277) \\
[-0.67] [5.24] [-3.68] [-4.65] \\
+ 0.797 \ln (\frac{M}{P})_{t-1} \\
(0.0352) \\
[22.65]
\]

\[R^2 = 0.998, DW = 1.94, Durbin-h = 0.15, RSS = 0.041508\]

\[LM \text{ test} = 1.76, \text{White's test} = 10.3, \text{Jarque-Bera normality test} = 0.77,\]

where RSS is the residual sum squares.

These estimates, like the ones for (2.9) reported in part one of Table 2.1, indicate the absence of the first- and higher-autocorrelation and heteroscedasticity problems. In addition, the null hypothesis that the error term is normally distributed cannot be rejected at any reasonable level of significance.\(^{29}\)

Based on these regression estimates, we can conclude that:

(a) the coefficient estimate on \(\ln RDI_t\) is not significantly different from unity,\(^{30}\) and

(b) the coefficient estimates on \(\ln RDI_{t-1}\) and \(\ln (M/P)_{t-1}\) are statistically equal in size.\(^{31}\)

\(^{29}\) The P-values for the calculated LM test statistic, 1.76, for the calculated White test statistic, 10.3, and for the calculated Jarque - Bera normality test statistic, 0.77, are, respectively, 41.55 percent, 24.49 percent, and 68.14 percent.

\(^{30}\) The t-ratio for testing the null hypothesis that the coefficient on \(\ln RDI_t\), \(b_{1\gamma_1}\), is equal unity, \(H_0 : b_1 = 1.0\), is 1.38 (= 0.208/0.1511). As seen, this t-ratio is insignificant at any reasonable level of significance, leading to the acceptance of the null hypothesis that \(b_{1\gamma_1}\) is not different from unity.

\(^{31}\) The t-ratio for testing the null hypothesis that the absolute value of the coefficient on \(\ln RDI_{t-1}\), \(|c_{1\gamma_1}|\), is equal to 0.797, \(H_0 : |c_{1\gamma_1}| = 0.797\), is 1.15 (= 0.190/0.1652). As seen, this t-ratio is insignificant at any reasonable level of significance, leading to the acceptance of the null hypothesis that \(|c_{1\gamma_1}|\) is not different from 0.797.
Based on this inspection, we restrict $b_1\gamma_1$ in (2.10) to unity and set $|c_1\gamma_1|$ equal to $(1-\gamma_1)$. Accordingly, the following restricted demand for money function is obtained:

\[
\ln (M/P)_t - \ln RDI_t = a_1\gamma_1 + d_1\gamma_1 \ln CR_t \\
+ (1-\gamma_1) [\ln (M/P)_{t-1} - \ln RDI_{t-1}] + u_t \quad (2.11)
\]

The OLS estimates of the demand function for money in (2.11) are reported below (the standard errors are in parentheses and the t-values are in brackets):

\[
\begin{align*}
\ln (M/P)_t - \ln RDI_t &= -0.201 - 0.140 \ln CR_t + 0.804 [\ln (M/P)_{t-1} - \ln RDI_{t-1}] \\
(0.0418) &\quad (0.0171) &\quad (0.0349) \\
[-4.82] &\quad [-8.17] &\quad [23.01]
\end{align*}
\]

\[R^2 = 0.987, \quad DW = 1.67, \quad \text{Durbin-h} = 0.82, \quad \text{RSS} = 0.047122\]

\[\text{LM test} = 0.90, \quad \text{White's test} = 6.40, \quad \text{Jarque-Bera normality test} = 0.87.\]

Based on the calculated Durbin-h, 0.82, the null hypothesis of no first-order autocorrelation problem is accepted at the ten percent or lower level of significance (the ten percent critical z-value is 1.282). Based on the LM test, the calculated $\chi^2$-statistic is 0.90 with an insignificant P-value of 63.87 percent, leading to the acceptance of the joint null hypothesis of no first- and higher-order autocorrelation problem. The null hypothesis of homoscedasticity cannot be rejected, since, based on the White test, the calculated $\chi^2$-statistic, 6.40, is insignificant with a P-value of 17.1 percent. Furthermore, using the Jarque-Bera normality test, the calculated test statistic is 0.87 with a P-value of 64.79 percent. Again, this P-value is well above the ten percent reasonable level of significance which allows us to accept the null hypothesis that the error term is normally distributed.

As seen, the coefficient estimates of $d_1\gamma_1$ and $(1-\gamma_1)$ in (2.11) remain similar to their corresponding estimates in (2.10). This is an indication that the restrictions imposed are statistically appropriate. More specifically, we refer to the demand for money function in (2.10) and (2.11), respectively, as the unrestricted and restricted functions. The calculated F-statistic in testing the joint null hypothesis $H_0: b_1\gamma_1 = 1.0$
and $|c_i \gamma_i| = (1-\gamma_i)$ is found to be 1.28 which is insignificant.\footnote{The formula given in footnote 27 is used to find the calculated F-statistic. Specifically, given that, as reported in the text, $RSS^a = 0.047122$, $RSS^b = 0.041508$, $m = 2$, $n = 24$, and $k = 5$, the calculated F-statistic is found to be $F(2,19) = 1.28$. This calculated F-statistic is insignificant, since it is well below 2.61 which is the ten percent critical F-value. This indicates that the restrictions in (2.11), $b_i \gamma_i = 1.0$ and $|c_i \gamma_i| = (1-\gamma_i)$, are empirically supported.} This implies that the above joint null hypothesis cannot be rejected at any reasonable level of significance, leading to the conclusion that the restrictions are, in fact, statistically appropriate.

Defining $[\ln RDI_t - \ln (M/P)_t]$ as the logarithm of money velocity, the restricted demand for money function in (2.11) can be written in the form of the money velocity function as follows:\footnote{On the theoretical and empirical behaviour of money velocity in developed economies, see Anderson (1977). On the reasons why the M1 velocity in the US misbehaved after 1980, see Stone and Thornton (1987)}

$$
\ln V_t = -a_i \gamma_i - d_i \gamma_i \ln CR_t + (1-\gamma_i) \ln V_{t-1} + u_{it} \tag{2.12}
$$

where the money velocity, $V_t$, is the real income available to the domestic economy or the real absorptive capacity, $RDI_t$, divided by the real money balances, $(M/P)_t$.

According to this formulation, $-d_i \gamma_i$ is the immediate year (or the short-run) elasticity of the money velocity with respect to the expected degree of credit restraint. Consequently, $-d_i$ is the long-run elasticity of the money velocity with respect to the expected degree of credit restraint.

The OLS regression estimates of (2.12), with a couple of sign changes, are the same as the regression estimates of (2.11) reported above. That is,

$$
\begin{align*}
\ln V_t &= 0.201 + 0.140 \ln CR_t + 0.804 \ln V_{t-1} \\
&= \begin{bmatrix} 0.0418 \\ 4.82 \end{bmatrix} \begin{bmatrix} 0.171 \\ 8.17 \end{bmatrix} \begin{bmatrix} 0.0349 \\ 23.01 \end{bmatrix} \\
R^2 &= 0.987, DW = 1.67, Durbin-h = 0.82, RSS = 0.047122 \\
LM \text{ test} &= 0.90, \text{ White's test} = 6.40, \text{ Jarque-Bera normality test} = 0.87.
\end{align*}
$$

According to the coefficient of determination, $R^2$, 98.7 percent of the total
sample variations in the logarithm of the money velocity are explained by the independent variables. The coefficient estimates on the expected degree of credit restraint and the lagged dependent variables have the theoretically expected signs and are highly significant. In addition, the coefficient estimate on the lagged dependent variable, in line with the assumption underlying the partial adjustment process, is significantly between zero and one. This indicates that the pattern of the effect of the expected degree of credit restraint on the velocity is geometrically declining, and, therefore, the estimated money velocity function is dynamically stable.

Table 2.2 reports the elasticities of the velocity with respect to the expected degree of credit restraint based on the above regression estimates. The immediate year (or the short-run) elasticity is 0.140 and the long-run elasticity is 0.713 (= 0.140/0.196 (= 1 - 0.804)). That is, a one percent increase (or decrease) in the expected degree of credit restraint increases (or decreases) the velocity of money by 0.140 percent in the immediate year (or in the short-run) and by 0.713 percent in the long-run. In addition, the speed of adjustment is estimated to be 0.196 (= 1 - 0.804). Accordingly, 19.6 percent of the effect of a change in the expected degree of credit restraint on the velocity of money is completed within the immediate year and the rest of the effect, 80.4 percent, is completed based on a geometrically declining pattern over the following years (see Table 2.2 for more details).

As already mentioned, the expected degree of credit restraint, CR, is defined as the ratio of the government oil revenue, GOR, and the government expenditure, GEX. It is noted that when we define CR as the ratio of the government total revenue, GTR, and the government expenditure, GEX, the estimated standard error of regression in (2.12) increases from 0.0474 to 0.0500.

The t-ratio for testing the null hypothesis that the coefficient estimate on the lagged dependent variable, (1-γ), is equal or greater than one, \( t \): (1-γ) ≥ 1.0, is 5.62 (= 0.196/0.0349). As seen, this t-ratio is highly significant, leading to the rejection of the null hypothesis in favour of the alternative hypothesis that (1-γ) is less than one.

Based on the velocity function in (2.12) the coefficient, -dγ, on the independent variable, ln CR, represents the immediate year elasticity of velocity with respect to the expected degree of credit restraint. The following first year elasticity is -dγγ * (1-γ); the following second year elasticity is -dγγ * (1-γ)^2; the following third year elasticity is -dγγ * (1-γ)^3; and so on. For example, as seen from the OLS regression estimates of (2.12), -dγγ = 0.140 and (1-γ) = 0.804. The immediate, following first, second, and third elasticities in Table 2.2 are calculated as -dγγ * (1-γ) = (0.140) (0.804) = 0.113, -dγγ * (1-γ)^2 = (0.140) (0.804)^2 = 0.090, and -dγγ * (1-γ)^3 = (0.140) (0.804)^3 = 0.073. The same procedure will be used to calculate the distributed effects for later relationships in this study.
## Table 2.2.
The expected degree of credit restraint elasticities of the money velocity

<table>
<thead>
<tr>
<th>year</th>
<th>impact elasticities</th>
<th>cumulative elasticities</th>
</tr>
</thead>
<tbody>
<tr>
<td>immediate</td>
<td>0.140</td>
<td>0.140</td>
</tr>
<tr>
<td>first</td>
<td>0.113</td>
<td>0.253</td>
</tr>
<tr>
<td>second</td>
<td>0.090</td>
<td>0.343</td>
</tr>
<tr>
<td>third</td>
<td>0.073</td>
<td>0.416</td>
</tr>
<tr>
<td></td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>long-run</td>
<td>.</td>
<td>0.713</td>
</tr>
</tbody>
</table>

Figure 2.4: The pattern of the effect of the expected degree of credit restraint on the velocity of money over time
Before proceeding further, it is important to reemphasise that the inflationary expectations, $0_p$, and the interest rate, $0_{IN}$, do not significantly affect the velocity of money. This can be seen from the regression estimates of the money velocity function reported in the first part of Table 2.3. According to these estimates, the coefficient estimates on both $0_p$ and $0_{IN}$ have the theoretically correct signs, but they are not significantly different from zero.\(^{37}\)

The second part of Table 2.3 reports the regression estimates of the money velocity function with the inflationary expectations, $0_p$, included as the only opportunity cost variable. As seen, while the coefficient estimate on this variable has the theoretically correct sign, it is not significantly different from zero at any reasonable level of significance (the calculated t-ratio on the coefficient estimate of $0_p$ is 1.16 with an insignificant P-value of 25.97 percent).

The third part of Table 2.3 reports the regression estimates of the money velocity function with the interest rate, $0_{IN}$, included as the only opportunity cost variable. As shown, while the coefficient estimate on this variable has the theoretically correct sign, it is not significantly different from zero at any reasonable level of significance (the calculated t-ratio on the coefficient estimate of $0_{IN}$ is 0.83 with an insignificant P-value of 41.71 percent). This, again, implies that the interest rate does not significantly explain the behaviour of money velocity.

The above conclusions also hold when testing the joint null hypothesis that the inflationary expectations and interest rate variables do not explain jointly the behaviour of the money velocity. For example, based on a standard F-test, the corresponding calculated F-statistic is found to be equal to $F(2,19) = 1.17$\(^{38}\) which is far below the ten percent critical F-value, 2.61, leading to the acceptance of the above joint null hypothesis.

\(^{37}\) For example, the calculated t-ratio on the coefficient estimate of $0_p$ is 1.28 with an insignificant P-value of 21.65 percent; the calculated t-ratio on the coefficient estimate of $0_{IN}$ is 1.00 with an insignificant P-value of 33.05 percent.

\(^{38}\) The residual sum squares from the unrestricted function, reported in the part one of Table 2.3, is $RSS^U = 0.041950$ with $n = 24$ and $k = 5$. The residual sum squares from the restricted function in (2.12), which excludes $0_p$ and $0_{IN}$, $RSS^R = 0.047122$ (see the text). Based on this information and the formula given in footnote 27, the calculated F-statistic is found to be $F(2,19) = 1.17$
Table 2.3.

### OLS Regression estimates of the velocity function in (2.12)
with alternative opportunity cost variables

#### Part one:

\[
\ln V_t = 0.145 + 0.140 \ln CR_t + 0.762 \ln V_{t-1} + 0.170 P_t^e + 0.044 \ln INT_{t-1}
\]

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\ln CR_t)</td>
<td>0.140</td>
<td>0.0173</td>
</tr>
<tr>
<td>(\ln V_{t-1})</td>
<td>0.762</td>
<td>0.0441</td>
</tr>
<tr>
<td>(P_t^e)</td>
<td>0.170</td>
<td>0.1330</td>
</tr>
<tr>
<td>(\ln INT_{t-1})</td>
<td>0.044</td>
<td>0.0444</td>
</tr>
</tbody>
</table>

\[ R^2 = 0.989, \text{DW} = 1.92, \text{Durbin-h} = 0.21, \text{RSS} = 0.041950 \]

\(\text{LM test} = 0.927, \text{White's test} = 9.07, \text{Jarque-Bera normality test} = 1.56.\)

#### Part two:

\[
\ln V_t = 0.215 + 0.138 \ln CR_t + 0.782 \ln V_{t-1} + 0.153 P_t^e
\]

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\ln CR_t)</td>
<td>0.138</td>
<td>0.0171</td>
</tr>
<tr>
<td>(\ln V_{t-1})</td>
<td>0.782</td>
<td>0.0394</td>
</tr>
<tr>
<td>(P_t^e)</td>
<td>0.153</td>
<td>0.1319</td>
</tr>
</tbody>
</table>

\[ R^2 = 0.988, \text{DW} = 1.78, \text{Durbin-h} = 0.55, \]

\(\text{LM test} = 0.74, \text{White's test} = 5.29, \text{Jarque-Bera normality test} = 1.29.\)

#### Part three:

\[
\ln V_t = 0.141 + 0.143 \ln CR_t + 0.789 \ln V_{t-1} + 0.037 \ln INT_t
\]

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\ln CR_t)</td>
<td>0.143</td>
<td>0.0175</td>
</tr>
<tr>
<td>(\ln V_{t-1})</td>
<td>0.789</td>
<td>0.0393</td>
</tr>
<tr>
<td>(\ln INT_t)</td>
<td>0.037</td>
<td>0.0448</td>
</tr>
</tbody>
</table>

\[ R^2 = 0.988, \text{DW} = 1.75, \text{Durbin-h} = 0.62, \]

\(\text{LM test} = 0.73, \text{White's test} = 11.01, \text{Jarque-Bera normality test} = 0.96.\)

**Note:** The standard errors are in parentheses and the t-values are in brackets; see the text for the definition of the variables.
2.2.2 The money supply process: a theoretical view

To complete our examination of the monetary sector of the Saudi economy, we now turn to investigate the determinants of the money supply. To start with, we need to discuss the theories put forth by Teigen (1964), Gibson (1972), Mankiw (1997), and Hubbard (1997) which are more applicable to developed economies. It is necessary to cover these theories here in order to have some background to later discuss the availability of the conventional monetary policy tools to the central bank, or the Saudi Arabian Monetary Agency (SAMA).

Following these theories, we express the money supply, $M$, as the product of the money multiplier, $m$, and the monetary base, $MB$, as follows:39

$$M = m \cdot MB$$ \hspace{1cm} (2.13)

Defining the money supply as the sum of the currency in circulation, $CC$, and the total deposits, $D$, and defining the monetary base as the sum of the currency in circulation, $CC$ and the total reserves in the central bank, $R$, we have

$$M = CC + D$$ \hspace{1cm} (2.14)

$$MB = CC + R.$$ \hspace{1cm} (2.15)

Using some simple algebra to combine (2.14) and (2.15),40 we can write the money multiplier in the following form:

$$m = \left[ \frac{1}{CC/M + R/D (1 - CC/M)} \right]$$ \hspace{1cm} (2.16)

where $CC/M$ is defined as the currency ratio, and $R/D$ is defined as the reserve ratio.

Replacing for the money multiplier, $m$, in (2.13) from (2.16), we have

---

39 For simplicity, the time subscript, $t$, for the variables is dropped.

40 For the algebraic manipulation in deriving (2.16) from combining (2.14) and (2.15), see Beare (1978, pp. 224 - 225)
Chapter 2: On the formulation of the aggregate demand function

\[ M = \frac{1}{(CC/M + R/D (1 - CC/M))} \times MB \]  

(2.17)

In order to evaluate the effects of the currency ratio and the reserve ratio on the money supply, we have partially differentiated the money supply, \( M \), in (2.17) with respect to these ratios as follows:

\[
\frac{\partial M}{\partial (CC/M)} = -\frac{MB(1 - R/D)}{(CC/M + R/D (1 - CC/M))^2} \\
\frac{\partial M}{\partial (R/D)} = -\frac{MB(1 - CC/M)}{(CC/M + R/D (1 - CC/M))^2}
\]

Given that the currency ratio and the reserve ratio are between zero and one, the above partial derivatives are both negative. This implies that a decrease (or an increase) in the currency or reserve ratio increases (or decreases) the supply of money. In general, the currency ratio depends on the behaviour of the public toward holding currency. For example, an increase in the interest rate means a higher opportunity cost of holding currency, leading to a decline in the currency ratio as the public attempts to economise on the holding of currency. The decline in the currency ratio, then, increases the money supply. This indicates a positive relationship between the supply of money and interest rate through the behaviour of the public toward holding currency.

The reserve ratio depends on the behaviour of the banking system. For example, if the interest rate relative to the discount rate (the rate that commercial banks borrow from the central bank) increases, then it is more attractive for commercial banks, through an increase in borrowed reserves from the central bank, to expand their volume of loans. Given that an increase in reserves, \( R \), is matched with a multiple increase in deposits, \( D \), then the reserve ratio, \( R/D \), falls, and, therefore, the money supply will increase. This is also true when there is a decline in the discount rate relative to the market interest rate. In general, through the discount rate policy, the central bank can increase (or decrease) the discount rate to contract (or expand) the supply of money to the economy. Accordingly, the money supply is positively related to the interest rate and negatively related to the discount rate through the behaviour of the commercial banks.

Based on the above argument, the money multiplier, therefore, depends on the behaviours of the public and the banking system. Since such behaviours are largely

\[^{41}\text{See Mankiw (1997, pp. 477 - 478)}\]
governed by the movements of the market interest rate, \( r \), relative to the discount rate, \( d \), Teigen (1964) and Gibson (1972) specify the money supply function as follows:

\[
M = f(MB, r, d) \quad (2.18)
\]

where it is theoretically expected that the money supply is positively related to the monetary base and the interest rate and negatively to the discount rate.

2.2.2.1 Conventional monetary policy tools

The central bank's controllability over the money supply and liquidity in the economy is the precondition for the effectiveness of the monetary policy in promoting economic growth and dealing with such problems as inflation and unemployment. Generally, there are three conventional monetary policy tools available to the central bank for controlling the money supply in the economy. These tools are the reserve requirement ratio, the discount rate, and the Open Market Operation (OMO).

The reserve required ratio, as a monetary policy tool, affects the amount of money that commercial banks can create given the monetary base. Specifically, commercial banks are profit maximisers. Therefore, they try to keep their reserves in the central bank very much close to the required reserves in order to avoid the opportunity cost of holding unnecessary excess reserves. Now, if the central bank wants to expand the level of money supply, it can do so by reducing the required reserve ratio. This leaves the commercial banks with more money to expand the volume of their loans to the public, and, therefore, increases the supply of money in the economy. The converse is also true.

Discount rate policy is another important monetary policy tool for the central bank to control the stock of money in the economy. As already mentioned, the discount rate set by the central bank is the rate of interest at which the central bank is willing to lend money to commercial banks. The central bank can increase (or decrease) the stock of money in the economy by reducing (or increasing) the discount rate. That is, a reduction in the discount rate, other things the same, encourages commercial banks to
expand loans which, therefore, increases the supply of money to the economy. The converse is also true. This is consistent with the formulation of the money supply function in (2.18), where, other things equal, the discount rate is expected to negatively influence the supply of money.

For developed economies such as the UK and the US, the Open Market Operation (OMO) is considered the most important tool in controlling the money supply. In such economies there exists a strong market for government securities or bonds. Therefore, the central bank can increase the stock of money in the economy by simply purchasing government bonds for money which, in turn, can be printed. Conversely, it can reduce the stock of money by selling bonds in exchange for money paid by the purchasers of the bonds.

2.2.2.2 Monetary policy in Saudi Arabia

Since, according to Islamic law, SAMA is prohibited from paying or receiving interest, the discount rate, as a monetary policy tool, is not available to SAMA in controlling the supply of money in Saudi Arabia.

In addition, due to the institutional settings, there was no government bond market in the Saudi economy before 1984. Following the Saudi money market reform in February 1984, the issuance of Bankers Security Deposit Accounts (BSDAs) gave SAMA some flexibility in accommodating domestic money market liquidity. This has been done through a limited repurchase facility offered to the banks on BSDAs. The effectiveness of the repurchase facility has been enhanced with its application to Saudi Government Development Bonds (GDBs) since January 1989.\(^{42}\) For a meaningful operation, however, the Saudi economy needs to have an extensive government security market. Given that bond market trading in Saudi Arabia is still in the early stages of development, the Open Market Operation cannot yet be considered as an effective monetary policy tool for SAMA to control liquidity. The Open Market Operation through selling and buying foreign exchange to control the liquidity is also ruled out, since it compromises the stable exchange rate policy pursued by SAMA. In fact,

\(^{42}\) See Banafe (1993, p. 86) and Presley and Westaway (1988, p. 22)
speculation in the riyal is discouraged by SAMA, through, for example, the revaluation of the riyal when a devaluation is expected by the market. With the elimination of both the discount rate and Open Market Operation policies, SAMA is left with the required reserve ratio as the only conventional monetary policy tool in controlling the money supply and liquidity in the Saudi economy. As discussed above, the reserve required ratio, as a monetary policy tool, affects the amount of money that commercial banks can create given the monetary base. Prior to 1987, the actual reserve ratio in Saudi Arabia was determined by commercial banking practices rather than by some minimum required reserve ratio set by SAMA. More specifically, the reserve ratios actually kept by the commercial banks were far above the minimum reserve ratio set by SAMA. This indicates that the reserve requirement ratio as a conventional monetary policy tool available to SAMA was in fact ineffective in controlling the supply of money in Saudi Arabia. Since 1987, as indicated by Presley, there has been a change in the behaviour of the commercial banks toward holding excess reserves. Accordingly, this change in behaviour may affect the effectiveness of this policy tool. However, as argued by Banafe (1993), the reserve requirement policy tool is difficult to fine tune. It is, perhaps, for this reason that SAMA has utilised this tool only a few times in the last twenty-five years, the latest being in 1980. Another reason, as argued by Banafe (1993), may be that the role of the monetary policy, for example, through the required reserve ratios, is restricted because the government expenditure is the major determinant of liquidity. More specifically, since the Saudi government spends a significant portion of its revenue in the domestic economy, the control of the money supply and liquidity in the Saudi economy is achieved through fiscal policy practices which aims to control the government expenditure. This, in turn, implies that monetary and fiscal policies in Saudi Arabia are identical.

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43 See Banafe (1993, pp. 55 - 76) on the exchange rate policy. For a study on the behaviour of the exchange rate in Saudi Arabia, see Milner, Presley, and Westaway (1995)
44 See El Mallakh (1982b pp. 318 - 319)
45 This is based on the comment on an earlier draft of this chapter made by Professor Presley.
46 See Banafe (1993, pp. 77 - 88)
47 See Banafe (1993, p. 77)
2.2.2.3 Sources of endogeneity of the money supply

For developed economies such as the UK and the US, the Open Market Operation gives the central bank a powerful control over the monetary base. Given the control over the monetary base and the discount rate, according to (2.18),

\[ M = f(MB, r, d) \]

leaves the interest rate as the only source of endogeneity of the money supply in the case of developed economies. In small developing and open economies such as the Saudi economy, the monetary base is influenced by the developments in the foreign and government sectors. This, therefore, gives different characteristics as to how money is supplied to the economy.

In order to explore this issue further, we need to examine the determinants of the monetary base in the Saudi economy. This can be done through the examination of the consolidated balance sheet of SAMA which distinguishes between the uses and sources of the monetary base. The uses of the monetary base refer to the allocation of the monetary base between currency in circulation and the commercial bank's reserves in SAMA. In order to see this, we utilise the information in SAMA's consolidated balance sheet in the form summarised by the *International Financial Statistics (IFS)* as presented in Table 2.4. As seen from the liability side, we can obtain the relationship already presented in (2.15),

\[ MB = CC + R. \]
<table>
<thead>
<tr>
<th>Assets:</th>
<th>Liabilities:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign assets</td>
<td>Reserve money or monetary base</td>
</tr>
<tr>
<td>193.08</td>
<td>Commercial banks' reserves</td>
</tr>
<tr>
<td></td>
<td>11.17</td>
</tr>
<tr>
<td></td>
<td>Currency held by public</td>
</tr>
<tr>
<td></td>
<td>42.62</td>
</tr>
<tr>
<td></td>
<td>Government deposits</td>
</tr>
<tr>
<td></td>
<td>42.48</td>
</tr>
<tr>
<td></td>
<td>Other items (net)</td>
</tr>
<tr>
<td></td>
<td>96.81</td>
</tr>
</tbody>
</table>

The sources of the monetary base, on the other hand, refer to the factors determining the base. These determinants can be classified into positive influences and negative influences. The positive influences refer to the factors supplying the base which, as seen from the consolidated balance sheet in Table 2.4, are mostly dominated by the foreign assets in SAMA. The negative influences, on the other hand, are those factors absorbing the base which, as seen from the consolidated balance sheet in Table 2.4, are mostly dominated by government deposits and other net liabilities of SAMA.

Accordingly, the monetary base as a liability of SAMA is determined based on the following identity:

\[ MB = FAS - GDS - NOTH \]  

(2.19)

where \( FAS \) is foreign assets including foreign investments, gold and coins held by SAMA less the loans and credits received from abroad; \( GDS \) is the government deposits less claims on the government with SAMA; and \( NOTH \) is other net liabilities of SAMA.

According to our examination above, therefore, one way to formulate the money supply process in the Saudi economy is by relating the money supply to the monetary base in line with Looney (1982)\(^{48}\)

\[ M = f(MB) \]  

(2.20)

and then examining the determinants of the base according to the balance sheet of SAMA in (2.19). We argue that such a strategy:

(a) leaves the behaviour of the rest of the banking system unexplained, and
(b) eliminates the significant role that the non-oil private sector plays in influencing the supply of money.

A more realistic way to formulate the money supply function in Saudi Arabia is to concentrate on the working of the whole banking system, which, as we shall see allows us to avoid the two problems mentioned above. This approach is also justifiable,

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\(^{48}\) See Looney (1982, p. 263)
Chapter 2: On the formulation of the aggregate demand function

since SAMA has limited monetary policy tools at its disposal to influence monetary aggregates. Concentrating on the whole banking system to formulate the behaviour of the money supply is also consistent with other macroeconometric models of developing economies, as it gives a better understanding of how the money supply is influenced in the Saudi economy.

2.2.3 Formulation and estimation of the money supply function

The balance sheet of the whole banking system in the form summarised by the International Financial Statistics (IFS) is reported in Table 2.5. According to this Table, the following identity can be written:

\[ M_t = NFAB_t + CGOV_t + CLPS_t \]  \hspace{1cm} (2.21)

where \( M_t \) is the money supply (M3 definition), \( NFAB_t \) is the net foreign assets in the banking system, \( CGOV_t \) is the banking system's net claims on the government, and \( CLPS_t \) is the banking system's claims on the private sector including the net of other items.

Based on the above identity, changes in the money supply, \( \Delta M_t \), may be due to three major factors. The first factor is the balance of payments, \( BP_t \), as it affects the changes in the net foreign assets in the banking system. As we shall see, the balance of payments consists of the current account and the capital account. Other things equal, an increase in exports relative to imports, for example, translates itself into higher foreign assets in the banking system, and therefore, a higher supply of money in the economy. The converse is also true. Similarly, other things equal, capital inflows (outflows) increase (decrease) the foreign assets in the banking system, which, result in a higher (lower) level of money supply.

\[ \text{For example, see Otani (1975), Khan and Knight (1981), Vaez-Zadeh (1989), and Haque, Lahiri, and Montiel (1990)}\]

\[ \text{Whether to use a narrow or broader measure of money is an empirical question. In this study, we have used the broad measure of money, M3, since it provides a stronger relationship with income in the demand for money function, and therefore, as we shall see later, a stable macroeconometric model of the Saudi Arabian economy} \]
## Table 2.5.

Banking system's consolidated balance sheet (1993) in billions of current Saudi riyals

<table>
<thead>
<tr>
<th>Assets:</th>
<th>Liabilities:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign assets</td>
<td>Money (M3 definition)</td>
</tr>
<tr>
<td>Domestic credit</td>
<td>Money (M1 definition)</td>
</tr>
<tr>
<td>Claims on government</td>
<td>Quasi-money</td>
</tr>
<tr>
<td>Claims on private sector</td>
<td>Other items (net)</td>
</tr>
</tbody>
</table>

| 267.37                        | 125.52                                           |
| 3.59                          | 101.93                                           |

The second factor is changes in the banking system's claim on the government, which is largely determined by the difference between the government expenditure, $GEX_t$, and the government total revenue, $GTR_t$. For example, when the expenditure dominates the total revenue, $GEX_t > GTR_t$, the government starts financing its deficit by using up its deposits in the banking system or by borrowing from the banking system in case the government deficit is larger than its deposits. In such situations, the banking system's claims on the government will increase, and therefore, the money supply will expand and make the economy more liquid. On the other hand, when the expenditure is dominated by the total revenue, $GEX_t < GTR_t$, the government starts adding the surplus to its deposits in the banking system. In this situation, the banking system's claims on the government will reduce, and therefore, the money supply will contract.

The third factor affecting the change in money supply is the change in the nominal non-oil GDP, $\Delta NGDPN_t$, as it directly affects the change in the banking system's claim on the private sector. For example, higher non-oil GDP encourages higher demand for credit from the banking system. This, in turn, increases the banking system's claims on the private sector and therefore, the supply of money in the economy.

Accordingly, the following regression function is specified to determine changes in the money supply:

$$\Delta M_t = \alpha + \beta_2 BP_t + \gamma (GEX_t - GTR_t) + \delta_2 \Delta NGDPN_t + u_{2t}$$  \hspace{1cm} (2.22)

where $u_{2t}$ is an error term, $BP_t$ is the balance of payments, $GEX_t$ is the government expenditure, $GTR_t$ is the government total revenue, and $\Delta NGDPN_t$ is the change in the nominal non-oil GDP.\(^{51}\) These variables are all in billions of current Saudi riyals. Based on our discussion above, the coefficients $\beta_2$, $\gamma$, and $\delta_2$ are all expected to be positive.

The OLS estimates of the money supply function in (2.22) for the 1971 - 1994 sample period are reported below (the standard errors are in parentheses and the t-values are in brackets):

---

\(^{51}\) The data on nominal non-oil GDP is obtained from various issues of the Kingdom of Saudi Arabia: *Achievements of the Development Plans*. 


\[ \Delta M_t = 5.763 + 0.030 BP_t + 0.064 (GEX_t - GTR_t) + 0.223 \Delta NGDPN_t \]

\[ (1.649) \quad (0.0356) \quad (0.0292) \quad (0.1222) \]

\[ R^2 = 0.373, \quad DW = 1.23. \]

As seen, the calculated Durbin-Watson statistic, 1.23, falls in the indecision zone (for example, the five percent lower and upper bound Durbin-Watson critical values are 1.101 and 1.656). A closer look at the residuals, however, suggests the inclusion of two dummy variables in the money supply function in (2.22):

The first dummy variable, \( D_{717589} \) (equals to one for 1971 -75 and 1989 - 1990 and zero otherwise), is included to capture the downward shifts in the money supply function in 1971 -75 and 1989 - 90. In general the dummy variable, \( D_{717589} \), captures the effect of rapid improvements in the banking system on money supply after 1975, the contraction of money supply in 1989, and the decline in money supply due to customers' withdrawals of deposits from banks in 1990 at the outset of the Gulf crisis.\(^{52}\)

The second dummy variable, \( D_{828392} \) (equals to one for 1982 - 83 and 1992 and zero otherwise), is included to capture the upward shifts in the money supply function in 1982 - 83 and 1992. These upward shifts are due to the expansion of money supply in 1982 - 83 and the sharp rise in bank credits in 1992.\(^{53}\)

Accordingly, the money supply function is respecified as follows:

\[ \Delta M_t = a_{20} + a_{21} D_{717589} + a_{22} D_{828392} + b_2 BP_t \]
\[ + c_2 (GEX_t - GTR_t) + d_2 \Delta NGDPN_t + u_t. \quad (2.23) \]

The OLS estimates of the money supply function in (2.23) for the 1971 - 1994 sample period are reported below (the standard errors are in parentheses and the t-values are in brackets):

---

\(^{52}\) See Banafe (1993, p. 81)

\(^{53}\) See Banafe (1993, p. 80)
\[ \Delta M_t = 7.228 - 5.959 D_{717589} + 9.328 D_{828392} + 0.035 B_{Pt} \]
\[ \text{(.8194)} \quad \text{(9.842)} \quad \text{(1.262)} \quad \text{(0.0135)} \]
\[ [8.82] \quad [-6.05] \quad [7.39] \quad [2.56] \]

+ 0.043 (GEX\text{t} - GTR\text{t}) + 0.171 \Delta \text{NGDPN}_t
\[ \text{(.0113)} \quad \text{(0.0480)} \]
\[ [3.79] \quad [3.55] \]

\[ R^2 = 0.920, \quad DW = 2.26, \quad RSS = 69.44140, \]
\[ \text{LM test} = 1.32, \quad \text{White's test} = 9.56, \quad \text{Jarque-Bera normality test} = 0.53. \]

Based on the calculated Durbin-Watson statistic, 2.26, the null hypothesis of no first-order autocorrelation problem is now accepted at the five percent or lower level of significance. The joint null hypothesis of no first- and higher-order autocorrelation problem is tested based on the LM test. The calculated \( \chi^2 \)-statistic for this test is 1.32 with a highly insignificant P-value of 51.62 percent, leading to the acceptance of the joint null hypothesis and therefore supporting the absence of a first- and higher-order autocorrelation problem. The null hypothesis of homoscedasticity cannot be rejected, since, based on the White test, the calculated \( \chi^2 \)-statistic, 9.56 with a P-value of 30 percent, is, again, insignificant. Furthermore, using the Jarque-Bera normality test, the calculated test statistic is 0.53 with a P-value of 76.88 percent which is well above the ten percent reasonable level of significance. This leads to the acceptance of the null hypothesis that the error term is normally distributed.\(^54\)\(^55\)

\(^54\) The dummy variable \( D_{717589} \) (which is equal to 1.0 for 1971 - 1975 and 1989 - 1990, and zero otherwise) indicates that the 1971 - 1975 shock and the 1989 - 1990 shock are equal in size. This restriction is tested through replacing for \( D_{717589} \) in (2.23) by two dummy variables \( D_{7175} \) (which is equal to 1.0 for 1971 - 1975, and zero otherwise) and \( D_{89} \) (which is equal to 1.0 for 1989 - 1990, and zero otherwise). The residual sum squares from this newly specified (unrestricted) function is \( RSS^u = 69.09600 \). Given that the residual sum squares of (2.23), reported in the text is \( RSS^R = 69.44140 \), the calculated F-statistic is \( F(1,17) = 0.08 \). This calculated F-statistic is highly insignificant, since it is well below 3.03 which is the critical F-value at the ten percent level of significance. This finding indicates that the above restriction in (2.23) that the 1971-75 shock and the 1989-1990 shock are of the same size is empirically supported (see footnote 27 for the calculated F-statistic formula).

\(^55\) The dummy variable \( D_{828392} \) (which is equal to 1.0 for 1982-1983 and 1992, and zero otherwise) indicates that the 1982-1983 shock and the 1992 shock are equal in size. This restriction is tested through replacing for \( D_{828392} \) in (2.23) by two dummy variables \( D_{8283} \) (which is equal to 1.0 for 1982-1983, and zero otherwise) and \( D_{92} \) (which is equal to 1.0 for 1992, and zero otherwise). The residual sum squares from this newly specified (unrestricted) function is \( RSS^u = 69.43182 \). Given that the residual sum squares of (2.23), reported in the text is \( RSS^R = 69.44140 \), the calculated F-statistic is \( F(1,17) = 0.002 \). Again, this calculated F-statistic is highly insignificant, since it is well below 3.03 which is the critical F-value at the ten percent level of significance. This finding indicates that the above restriction in (2.23) that the 1982-83 shock and the 1992 shock are of the same size is empirically supported.
Chapter 2: On the formulation of the aggregate demand function

Based on the coefficient of determination, $R^2$, 92.0 percent of the total sample variations of the change in money supply is explained by the explanatory variables. As seen, all the coefficient estimates are different from zero at reasonable levels of significance. In addition, these coefficient estimates all have the theoretically correct signs. Equally important, however, is the conclusion that the money supply in the Saudi economy is endogenous to both external and internal forces.

External forces include exports, imports, and capital inflows, or in general, the balance of payments. Internal forces include the government total revenue and expenditure as well as the nominal non-oil GDP. Because of its sheer size, the government expenditure becomes the principal source of change in the supply of money. This, in turn, indicates that monetary and fiscal policies in Saudi Arabia are identical. More specifically, the government expenditure becomes the prime policy variable determining the aggregated demand or the real income available to the domestic economy for a given level of prices, through, partly, influencing the supply of money in the Saudi economy. We will return to this and other related issues in the coming chapters.

2.3 Summary

Based on our examination of the monetary sector, we conclude this chapter by forming the aggregate demand model of the Saudi economy as follows:

1. The velocity (demand for money) function:

   $$\ln V_t = -a_1 \gamma_1 - d_1 \gamma_1 \ln CR_t + (1-\gamma_1) V_{t-1} + u_t$$

2. The money supply function:

   $$\Delta M_t = a_{20} + a_{21} D717589 + a_{22} D828392 + b_2 BP_t$$
   $$+ c_2 (GEX_t - GTR_t) + d_2 \Delta NGDP_t + u_{2t}$$
3. The real absorptive capacity identity:

\[ \ln \text{RDI}_t = \ln V_t + \ln (M_t / P_t) \]

where the money velocity function and the money supply function are put together, according to the monetary approach, to form the model for the aggregate demand curve. It is, however, noted that the aggregate demand curve in the Saudi economy is defined as the relationship between the general price level, \( P_t \), and \( \text{RDI}_t \); where \( \text{RDI}_t \) is the sum of the real private and public demand for consumption and investment goods and services or the real absorptive capacity.

Since the balance of payments and the government total revenue and expenditure are endogenously determined, the above model of the aggregate demand curve is not yet complete. In other words, in order to complete the aggregate demand model of the Saudi economy, we still need to determine (1) the balance of payment, \( \text{BP}_t \), from the foreign sector, and (2) the government total revenue, \( \text{GTR}_t \), and the government expenditure, \( \text{GEX}_t \), from the government sector of the economy. The formulation of the foreign and government sectors, however, is the subject of the next chapter, or Chapter 3.
Chapter 3.

Completing the formulation of the aggregate demand model

In Chapter 2 of this study, we justified the use of Friedman's monetary approach to formulate the aggregate demand model of the Saudi Arabian economy. We then proceeded by formulating the monetary sector to relate the sum of the private and public sectors' demand for consumption and investment goods and services (the real absorptive capacity) to the general price level (measured by the price deflator index for the absorptive capacity). As shown, such a relationship is obtained through the intersection of the velocity (or the demand for money) and the money supply functions.

For example, from the demand side of the monetary sector, the velocity of money essentially relates the real absorptive capacity to the real money balances within a partial adjustment process. From the supply side, however, the change in the money supply is shown to be endogenously influenced by such macroeconomic variables as the balance of payments and government total revenue and expenditure. This indicates that, in order to complete the formulation and estimation of the aggregate demand model, we need to further examine the behaviour of the foreign and government sectors of the Saudi economy. This, in fact, is the subject of this chapter.

The outline of the present chapter is as follows: In Section 3.1, after examining the important features of the current and capital accounts of the Saudi economy, the balance of payments is shown to be partly endogenous to the demand behaviour for imports. This, in turn, necessitates the formulation and estimation of the demand function for imported goods and services. In Section 3.2, after examining the factors contributing to the tremendous growth of the government sector, we proceed with the formulation and estimation of the functions for government oil and non-oil revenue, and the function for government expenditure. Section 3.3 concludes this chapter by bringing together the identities and the formulated behavioural equations relating the monetary, foreign, and government sectors to present the complete aggregate demand model for the

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1 The money supply is also endogenously influenced by the nominal non-oil GDP, NGDPN. The determination of this variable through examining the behaviour of the real non-oil GDP, RGDPN, and the non-oil GDP price deflator, PGDPN, is postponed until the next chapter, when we examine the aggregate supply model.
Saudi Arabian economy.

3.1 Foreign sector

The formulation of the foreign sector of the Saudi economy concentrates on the determination of the balance of payments. Before proceeding with this formulation, however, we shall review some important features of:

(1) the foreign trade (exports and imports) and the current account, and
(2) the capital account.²

3.1.1 Foreign trade and the current account

Most of the Saudi economy's exports includes crude oil, refined products and natural gas liquids. Following the 1986 oil-price crash, oil exports fell to their lowest levels since the 1970s and the early 1980s.³ Oil exports have recovered in recent years, however, due to improved oil-prices and increased international market share of world oil supplies. Due mainly to SABIC (Saudi Arabia Basic Industries Corporation) companies, petrochemical and other chemical exports have also improved in recent years.⁴

The Saudi economy's total imports are very much in line with the absorptive capacity as well as the revenue received from oil. The five largest import categories are:

(1) machinery, appliances and electrical equipment,
(2) foodstuffs,
(3) chemical products,
(4) jewellery and metals, and
(5) transport items.

² For the review of foreign trade, the current and capital accounts, we have relied on Presley and Westaway (1989, pp. 106 - 117) and Metz (1993, pp. 183 - 187). Also see Kubursi (1984, pp. 12 - 16)
³ Saudi Arabian Monetary Agency (SAMA), Statistical Summary (1985, p. 70, and 1993, p. 132)
⁴ Saudi Arabian Monetary Agency (SAMA), Annual Report, various issues (see for example 1996, p. 113 and p. 116)
The demand for imports of machinery, appliances, and electrical equipment in terms of the total share fell from 24 percent in 1984 to 16 percent in 1990 due to the slowdown in domestic investment. The share of food imports has also declined from 16 percent in 1984 to only 14 percent in 1990. This decline, however, has been due mainly to the domestic import substitution of vegetable products. The other categories, however, have shown growth in terms of the total share over the recent years. For example, the share of chemical products in 1990 increased to 12 percent of total imports.

The current account consists of the foreign trade surplus (deficit) and the service sector surplus (deficit). Due to the increase in crude oil prices, from the early 1970s through the early 1980s, the Saudi economy enjoyed a considerable trade surplus. For most of the 1980s, especially after the 1986 oil-price crash, such trade surpluses showed signs of substantial reduction. The trade balance, however, recovered after the Iraqi invasion of Kuwait due to higher oil-prices as well as market share.

Unlike the trend in the trade balance, the service sector of the current account has shown large deficits since the mid-1980s. On the revenue side, service receipts such as freight and insurance related to exports and investment income have been declining due to the fall in the volume of oil exports and the depletion of foreign assets. Service payments, which include government purchases of military hardware and public and private transfers related to workers' remittances, however, did not decline enough to offset the decline in service receipts of freight, insurance, and tourism. More specifically, since the mid-1980s, the government policy to keep the deficit in the service sector of the current account manageable was to restrict the purchases of military hardware. This policy was helpful up to 1988. Because of Operation Desert Shield after 1989 and also the outflow of workers' remittances, the deficit increased from US $11.9 billion in 1988 to US $26.9 billion in 1990. With the military situation returning to normal since 1991, the deficit in the service sector of the current account has returned to levels consistent with the structural deficit of the economy. In conclusion, however, the deficit in the service sector due mainly to the service payments has been a principal liability for the current account of the Saudi economy in recent years.

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6 To be more specific, as also indicated by Looney (1994, p. 213) and Banafse (1993, p. 18), the post 1982 revenue from oil exports shows a significant decline relative to that in existence after 1973/74
8 See Metz (1993, p. 184)
Chapter 3: Completing the formulation of the aggregate demand function

3.1.2 The capital account

The Saudi economy enjoyed large current account surpluses in the early 1980s. Such surpluses resulted in large foreign asset holdings, and, therefore, capital account outflows by both official institutions and the private sector for the purpose of overseas investments.

Due to the 1986 oil-price crash and the prolonging of the Gulf War, the process of capital outflow by the private sector was accelerated. This, in addition to the current account deficits, resulted in a reduction of foreign assets. As a result, the capital account showed inflows by the banking sector for the purchase of Saudi development bonds. The capital inflow by the private sector started due to increased confidence in the Saudi economy after the Gulf War. Such inflows by 1991 were significant enough to allow SAMA to stabilise the official assets and stimulate economic activity in the non-oil sector.

Financing the Gulf War by the Saudi government resulted in significant depletion of official assets. Since the official flows have been a major source of the financing of the deficit in the current account in the recent years, as a result, the government was forced to borrow from the international commercial markets.\footnote{In fact, the government has encouraged some of its own enterprise branches such as Saudi Aramco and Sabic to participate in commercial borrowing on the international markets. See Metz (1993, p. 185)} With the current account deficits continuing, such borrowings in addition to private sector asset repatriation seem to have been the dominant factors in the capital accounts in recent years and in the foreseeable future.

3.1.3 On the balance of payments

The determination of the balance of payments is essential to our macroeconometric modelling, since, as already indicated, the money supplied to the Saudi economy is influenced by external factors embedded in the balance of payments. Following the usual approach employed by others,\footnote{For example, see Khan and Knight (1981), Haque, Lahiri, and Montiel (1990), and Murinde and Presley (1996) among others.} we define the balance of payments...
based on the following accounting identity:

\[ BP_t = (REXT_t \times PEXT_t) - (RIMT_t \times PIM_t) + CAPF_t \]

where \( BP_t \) is the balance of payments, \( REXT_t \) is the real exports, \( PEXT_t \) is the price deflator index for exports, \( RIMT_t \) is the real imports, \( PIM_t \) is the price deflator index for imports, and \( CAPF_t \) is the net capital inflow plus the net of all other factors in the balance of payments (including the deficit or surplus in the service sector of the current account). Note that \( BP_t \) and \( CAPF_t \) are in nominal terms, while \( REXT_t \) and \( RIMT_t \) are in real terms. More specifically, \( BP_t \) and \( CAPF_t \) are in billions of current Saudi riyals, and \( REXT_t \) and \( RIMT_t \) are in billions of constant (1984) Saudi riyals. The price deflator indices, \( PEXT_t \) and \( PIM_t \), are, therefore, equal to one for 1984.\(^\text{11}\)

The real exports, \( REXT_t \), which largely include crude oil and oil refinery products, is exogenously determined by the government through negotiations with other OPEC members and the world's demand for crude oil. The price index for exports, \( PEXT_t \), and the price index for imports, \( PIM_t \), are also both determined by the world market forces, and, therefore, are treated as exogenous to the Saudi economy. It is argued that the net capital inflow plus the net of all other factors in the balance of payments (including the deficit or surplus in the service sector of the current account), \( CAPF_t \), are also determined by such factors as the world and regional political situations, and, therefore, are treated as exogenous.

The balance of payments, however, is not totally exogenous to the domestic economy, since the real imports, \( RIMT_t \), as we shall see below, is determined endogenously by such factors as the real income available to the domestic economy (or the absorptive capacity), the real government oil revenue and the relative import prices.

\[ 3.1.4 \text{ The demand function for imports} \]

Based on the theory of demand, the desired demand for imported goods and services is a function of the economic activity and the relative import prices. For

\(^{11}\text{The data on these variables are obtained from various issues of the Kingdom of Saudi Arabia: Achievements of the Development Plans, and International Finance Statistics (IFS).}\)
example, during a boom, higher economic activity encourages not only higher demand for imports of consumer goods and services but also higher imports of investment (capital) goods and raw materials. The converse is also true.

In the case of the Saudi economy, as far as the import of consumers goods and services is concerned, the economic activity may be measured by the real income available to the domestic economy; that is $RDI_t$, in our notation. With respect to the import of investment (capital) goods and raw materials, the real non-oil GDP, $RGDPN_t$, may be the relevant variable to measure economic activity. Accordingly, it is desirable to formulate and estimate two demand functions for imports: one for consumer goods and services and the other for investment (capital) goods and raw materials. However, while the data on the total real imports are available, its division between the real imports of consumer goods and services and the real imports of capital goods and raw materials is not available for the whole sample period under examination. Accordingly, in this study, we are forced to have only one demand function for the real total imports.

A difficulty in having one aggregated demand function for imports, as implied above, is how to measure the economic activity. Our empirical analysis favours the real income available to the domestic economy rather than the real non-oil GDP as the relevant measure of economic activity in the demand function for imports. 12

As another important and relevant variable, the real government oil revenue is shown to significantly explain the behaviour of the demand for real imports. This is not surprising, since the ability of the economy to import either consumer goods or capital goods and raw materials depends largely on the revenue received from oil exports.

The final explanatory variable in the demand function for real imports, as mentioned above, is the relative import prices. For example, higher (lower) import prices relative to domestic prices encourage (discourage) import substitution. In the case of Saudi Arabia, this argument seems appropriate as the government follows the policy of diversification to reduce the country's dependence on imported goods and services.

Based on the above discussion, the following desired demand function for real imports is specified:

---

12 This seems to be logical, since the real non-oil GDP, $RGDPN_t$, is a portion of the real income available to the domestic economy, $RDI_t$. See footnote 19 below, for more discussion on this issue.
In \( RIMT^*_t = a_3 + b_3 \ln RDI_t + c_3 \ln (GOR/PIM)_t \)
\[ + d_3 \ln (PIM/PGDNP)_t + u_{3t} \]  \( (3.1) \)

where \( RIMT^*_t \) is the desired demand for real imports, \( RDI_t \) is the real absorptive capacity or income available to the domestic economy, \( GOR_t \) is the government oil revenue, \( (PIM/PGDPN)_t \) is the relative import prices with \( PIM_t \) and \( PGDNP_t \) defined, respectively, as the price deflator indices for imports and the non-oil GDP (= 1.0 for 1984), and \( u_{3t} \) is an error term.

Unlike the actual demand for real imports, \( RIMT_t \), the desired demand for real imports, \( RIMT^*_t \), is not observable. We consider the possibility that the economic agents are able to adjust their actual demand for imports to their desired demand for imports within the immediate year. That is,

\[ RIMT_t = RIMT^*_t. \]  \( (3.2) \)

Combining (3.1) and (3.2), we have the following demand function for real imports, which can actually be estimated:

\[ \ln RIMT_t = a_3 + b_3 \ln RDI_t + c_3 \ln (GOR/PIM)_t \]
\[ + d_3 \ln (PIM/PGDNP)_t + u_{3t} \]  \( (3.3) \)

where the coefficients \( b_3, c_3, \) and \( d_3 \) are, respectively, the elasticities of the demand for imports with respect to the real absorptive capacity, real government oil revenue, and relative import prices. Furthermore, it is theoretically expected that the coefficients \( b_3 \) and \( c_3 \) be positive, and the coefficient \( d_3 \) be negative.

The OLS regression estimates of (3.3) for the 1971 - 1994 sample period are as follows (the standard errors are in parentheses and the \( t \)-values are in brackets):

\[ \text{It is important to note that the price variable, } PGDNP_n, \text{ obtained from various issues of the Kingdom of Saudi Arabia: Achievements of the Development Plans, is generated through dividing the nominal non-oil GDP (in billions of current Saudi riyals) by the real non-oil GDP (in billions of 1984 Saudi riyals). This is also the case for } PIM, \text{ as noted in Chapter 2, footnote 18. Accordingly, both } PGDNP_t \text{ and } PIM_t \text{ are equal to one for 1984, which, in turn, for the sake of consistency, results in the relative price variable, } (PIM/PGDNP)_t, \text{ to be equal to one for 1984.} \]
\[
\begin{align*}
\ln \text{RIMT}_t &= 0.232 + 0.648 \ln \text{RDI}_t + 0.221 \ln (\text{GOR/PIM})_t \\
&\quad - 1.050 \ln (\text{PIM/PGDPN})_t \\
R^2 &= 0.989, \quad \text{DW} = 1.23.
\end{align*}
\]

As seen, the calculated Durbin-Watson statistic, 1.23, falls in the indecision zone\(^{14}\) (the five percent lower and upper bound Durbin-Watson critical values are 1.101 and 1.656). In an attempt to improve these regression estimates, we may argue that the assumption that the economic agents are able to adjust their actual demand for imports to their desired demand within the immediate period is unrealistic. This implies that the function in (3.3) is not correctly specified due to the exclusion of the short-term adjustment process. In other words, we may argue that the import function in (3.1) represents the long-run demand function for imports, and, therefore, we need to specify a short-run adjustment process through which the actual demand for imports adjusts to the desired demand for imports over time. The short-run adjustment process utilised here is the following partial adjustment process:

\[
\ln \text{RIMT}_t = \gamma_3 \ln \text{RIMT}^*_t + (1 - \gamma_3) \ln \text{RIMT}_{t-1} \quad (3.4)
\]

where \(\gamma_3\) is the speed of adjustment, and it is assumed to be between zero and one. This indicates that the actual demand for imports adjusts to the desired demand with a geometrically declining pattern over time.

Combining (3.1) and (3.4), the demand function for imported goods and services takes the following specification:

\[
\begin{align*}
\ln \text{RIMT}_t &= a_3y_3 + b_3y_3 \ln \text{RDI}_t + c_3y_3 \ln (\text{GOR/PIM})_t \\
&\quad + d_3y_3 \ln (\text{PIM/PGDPN})_t + (1 - \gamma_3) \ln \text{RIMT}_{t-1} + u_{3t} \quad (3.5)
\end{align*}
\]

where \(b_3y_3, c_3y_3,\) and \(d_3y_3\) are, respectively, the short-run elasticities of the demand for imports with respect to the real absorptive capacity, real government oil revenue, and

---

relative import price. On the other hand, \( b_3, c_3, \) and \( d_3 \) are, respectively, the long-run elasticities of the demand for imports with respect to the real absorptive capacity, real government oil revenue, and relative import price.

The OLS regression estimates of (3.5) for the 1971 - 1994 sample period are as follows (the standard errors are in parentheses and the t-values are in brackets):

\[
\ln RIMT_t = 0.328 + 0.351 \ln RDI_t + 0.218 \ln \left( \frac{GOR}{PIM} \right)_t + 0.327 \ln RIMT_{t-1} - 0.682 \ln \left( \frac{PIM}{PGDPN} \right)_t
\]

\[
(0.5576) \quad (0.1548) \quad (0.0272) \quad (0.2292) \quad (0.1355)
\]

\[
[0.59] \quad [2.27] \quad [8.02] \quad [-2.98] \quad [2.42]
\]

\[ R^2 = 0.992, \; DW = 1.17, \; Durbin-h = 2.73. \]

As seen, the inclusion of the short-run adjustment process does not help eliminate the first-order autocorrelation problem. For example, the calculated Durbin-h statistic, 2.73, is significant, since it exceeds the ten percent critical z-value, 1.282. Such results may lead to the conclusion that the actual demand for imports adjusts to the desired demand within the immediate year, and, therefore, there exists no short-run adjustment process.  

Returning back to the regression estimates of (3.3), we take an alternative approach in correcting the first autocorrelation problem by looking at the residual plot in search of significant upward or downward shifts in the relationship. Our inspection suggests a downward shift in the relationship for 1993 - 1994. This downward shift reflect the efforts made in reducing dependence on imported goods and services through "the increased capability of the Saudi economy in meeting the requirements from domestic sources". 16

In order to account for this shift, the dummy variable, \( D_{9394} (= 1.0 \) for 1993 -

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15 The t-ratio on the coefficient estimate of \( \ln RIMT_{t-1} \) appears to be large enough to allow us to reject the null hypothesis that \( (1 - \gamma) \) is different from zero; \( H_0: (1 - \gamma) = 0 \). However, we are not allowed to make this conclusion, since, in the presence of such statistical problems as autocorrelation, hypothesis testing becomes invalid. As will be noted in footnote 17, the inclusion of \( \ln RIMT_{t-1} \) does not improve the regression estimates of the final demand function for imports.

1994 and zero otherwise) is included in (3.3), resulting in the following demand function for imports:

\[
\ln RIMT_t = a_30 + a_31 D9394 + b_3 \ln RDI_t + c_3 \ln (GOR/PIM)_t + d_3 \ln (PIM/PGDPN)_t + u_{3t} \\
\text{(3.6)}
\]

The OLS regression estimates of (3.6) for the 1971 - 1994 sample period are as follows (the standard errors are in parentheses and the t-values are in brackets):

\[
\begin{align*}
\ln RIMT_t &= -0.591 - 0.220 D9394 + 0.811 \ln RDI_t + 0.193 \ln (GOR/PIM)_t \\
&\quad - 0.809 \ln (PIM/PGDPN)_t \\
&\quad (.5209) (.0567) (.0908) (.0244) \quad [-1.131] [-3.871] [8.931] [7.931] \\
R^2 &= 0.994, \quad DW = 1.81, \\
\text{LM test} &= 0.97, \quad \text{White's test} = 8.77, \quad \text{Jarque-Bera normality test} = 0.82.
\end{align*}
\]

Based on the calculated Durbin-Watson statistic, 1.81, the first-order autocorrelation problem now disappears (the five percent lower - and upper -bound Durbin-Watson critical values are 1.101 and 1.656). The results from the LM test of serial correlation also reveals the absence of a first- as well as a higher-order autocorrelation problem. For example, the calculated \(\chi^2\)-statistic for this test is 0.97 with the \(P\)-value of 61.50 percent well above the ten percent reasonable level of significance.\(^{17}\) The null hypothesis of homoscedasticity is tested based on the White test. The calculated \(\chi^2\)-statistic for this test is 8.77 with the \(P\)-value of 27 percent, indicating the absence of a heteroscedasticity problem.\(^{18}\) Furthermore, using the Jarque-Bera normality test, we cannot reject the null hypothesis that the error term is normally distributed. For example, the calculated Jarque-Bera normality test statistic is 0.82 with a \(P\)-value of 66.29 percent, which, again, is well above the ten percent reasonable level of

\(^{17}\) It is important to note that the inclusion of the lagged dependent variable, \(\ln RIMT_{t-1}\), in (3.6) does not improve the regression estimates. In fact, it results in an autocorrelation problem detected by the LM test of serial correlation. For example, the calculated \(\chi^2\)-statistic is 4.73 with a significant \(P\)-value of 9.41 percent.

\(^{18}\) The specification of the function in logarithms helps to alleviate the problem of heteroscedasticity (see Gujarati, 1995, p. 386, on this issue). In other words, when the demand function for imports is estimated in a linear form, heteroscedasticity becomes a serious problem. Based on the White test, for example, the calculated \(\chi^2\)-statistic is 15.58 which is significant at the one percent level of significance.
Based on the above regression estimates, as indicated by the coefficient of determination, $R^2$, 99.4 percent of the sample variations in the logarithm of real imports is explained by the explanatory variables. In addition, all the coefficients have the theoretically correct signs and are significantly different from zero at reasonable levels of significance. The real absorptive capacity, the real government oil revenue, and the relative import price elasticities of the demand for imports are, respectively, 0.811, 0.193 and -0.809. Based on further hypothesis testing, we can conclude that the demand for imports is inelastic with respect to both the real absorptive capacity and the real government oil revenue but unit elastic with respect to the relative price of imports. For example, the coefficient estimates on both the real absorptive capacity and the real government oil revenue, 0.811 and 0.193 respectively, are significantly less than one. Accordingly, other things equal, a one percent increase in either the real absorptive capacity or the real government oil revenue increases the real imports by less than one percent. On the other hand, the coefficient estimate on the relative price of imports, -0.809, is not significantly different from unity in absolute value. Accordingly, other things equal, a one percent increase in the relative price of imports reduces the real imports by one percent.

19 With respect to the argument in footnote 12, when replacing the logarithm of the real absorptive capacity, $\ln RDI$, in (3.6) by the real non-oil GDP, $\ln RGDPN$, the standard error of regression increases significantly from 0.066386 to 0.095591. This is expected since, as indicated in footnote 12, the real non-oil GDP, $RGDPN$, is a portion of the real income available to the domestic economy, $RDI$. When both $\ln RDI$ and $\ln RGDPN$ are included, then the estimated coefficient on $\ln RGDPN$, turns out to be negative which cannot be theoretically justified.

20 One may argue that the total government revenue, $GTR$, may be more relevant in the function for imports than the government oil revenue, $GOR$. However, when replacing $\ln (GOR/PIM)$ in (3.6) by $\ln (GTR/PIM)$, the standard error of regression increases from 0.066386 to 0.072198. In addition, the calculated Durbin-Watson statistic declines from 1.81 to 1.58.

21 The t-ratio for testing the null hypothesis that the coefficient $b_3$ is equal to or greater than one ($H_0: b_3 \geq 1$) is equal to 2.08. This is significant at the five percent level of significance, leading to the rejection of the null hypothesis. The t-ratio for testing the null hypothesis that the coefficient $c_3$ is equal to or greater than one ($H_0: c_3 \geq 1$) is equal to 33.11. This is highly significant, leading to the rejection of the null hypothesis.

22 The t-ratio for testing the null hypothesis that the coefficient $d_3$ is equal to one in absolute value ($H_0: |d_3| = 1$) is equal to 1.20 which is insignificant at any reasonable level of significance. This, therefore, leads to the acceptance of the null hypothesis.
3.2 Government sector

In the case of developed countries, imperfections of market mechanism in the form of income inequality, the existence of public goods, and externalities are often cited to justify the need for government involvement in economic activities. In the case of developing countries, however, the government involvement in economic activities is needed to ensure efficient allocation of economic resources in the process of development and continuous sustainable and decent standards of living for the people.

Since the establishment of the Kingdom of Saudi Arabia, the stated goal of the government has been to improve the economic conditions of the Saudi citizens while preserving the society's Islamic values. The main macroeconomic objective of the Saudi government, however, has been economic diversification through a strong agricultural and industrial structure.

Before 1970, the Saudi government had limited means and operated under financial constraints. The government, therefore, did not have the ability to undertake major economic and social projects. In fact, economic opportunities stemming from government functions were limited to higher employment in the military and the distribution of land. Later, the development of oil resources resulted in some minor benefits such as wage payments to Saudis and local purchases of goods and services by foreign oil companies. In general, however, the income from oil up to the early 1970s increased but only slowly. Accordingly, the Saudi government's economic decisions were confined to determining priorities among alternative uses of limited resources.\(^{23}\)

With the easing of financial constraints in 1970, the first formal development plan was submitted to the Council of Ministers. This was the first organised and important step toward the diversification of the economy. Following the 1973 quadrupled increase in oil prices, government oil revenue increased dramatically.\(^{24}\) Accordingly, in the absence of financial constraints, the Saudi government initiated major structural changes

\(^{23}\) See Metz (1993, pp. 120 - 128) for more detailed information on the Saudi government economic policy before and after 1970

\(^{24}\) Perhaps, the most important economic decision by the government at this point was to determine whether to restrict oil production to the level consistent with world demand for crude oil or to the level that financed domestic economic and social development. By 1974, it was clear that the government decided not to link the oil production and exports with the domestic economic policy but to the world needs for crude oil. Part of the logic was to moderate oil prices and therefore keep oil as the energy source of choice in the world economy.
in the economy.

More specifically, recognising the fact that the private sector could not initiate large-scale investment projects necessary for basic infrastructural development, as the short-term strategy in the process of economic diversification, the government directed a large portion of development expenditures toward the creation of social and economic infrastructure. Massive development efforts concentrated partly on the industrialisation through investing in the processing plants fed by the country's hydrocarbon resources.

The government longer term strategy, on the other hand, has been to limit its economic involvement to regulatory and promotional functions while encouraging the participation of the private sector to invest on a profitable basis in economic diversification projects. Specifically, to increase economic efficiency and to promote sustainable economic growth, the Saudi government is committed to the eventual realisation of indigenous private ownership of all sectors of the economy except oil extraction.

The mid-1970s to the early 1980s can be characterised as the period of rapid development in the Saudi economy. In addition to providing the necessary infrastructure which included revamping and building electricity, water, sewerage, desalinisation, and telecommunication systems, airports, ports and a broad network of roads, the Saudi government saw the need for a subsidy program. This program, implemented through subsidising production, consumption, and investment, aimed at encouraging non-oil economic activity, meeting social goals, and, more importantly, distribution of income.

Following the fall of oil production in 1982 and the crash of oil prices in 1986, the Saudi government, once again, found itself operating under financial constraint. Such unforeseeable events have created many obstacles in the process of economic development. Perhaps the most deeply rooted problem stems from the government's subsidy program. As discussed by Metz (1993), indirect production subsidies, for example, have resulted in a relatively inefficient production process both in the agricultural and industrial sectors.\(^{25}\) In addition, the financial constraint has made it difficult for the Saudi government to continue with this program.

In general, due to the near completion of much of the necessary basic infrastructure and also the downturn in oil revenue in recent years, under the sixth

\(^{25}\) See Metz (1993, pp. 122 - 124)
development plan, the Saudi government is seeking to reduce its involvement in the
development process by placing a greater reliance on the private sector. More
specifically, economic diversification through encouraging private sector participation in
agriculture, manufacturing, development of mineral resources, completion of
infrastructure projects, achievement of balanced growth in all regions of the country, and
the development of human resources to meet the economy's needs and to reduce
dependence on the foreign labour force have become the main current economic
objectives of the Saudi Arabian government.

Given the background provided above, in what follows, we concentrate on
modelling the government sector of the Saudi economy. Our examination includes the
formulation and estimation of the functions for government oil and non-oil revenue as
well as the function for government expenditure.

3.2.1 Government total revenue

Government total revenue, GTR_t, is defined as the sum of government oil
revenue, GOR_t, and government non-oil revenue, GNR_t,

\[ GTR_t = GOR_t + GNR_t. \]

To determine the total government revenue, in what follows, we formulate and
estimate two distinct behavioural functions: the first one is for government oil revenue,
and the second one is for government non-oil revenue. This approach is justified, since,
as we shall see, government oil and non-oil revenue exhibit distinct behaviours, and
therefore, are determined by different macroeconomic variables. 27, 28

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26 See Chapter 1 of this study for more detailed information on the development process of the Saudi
economy as well as the government economic policy under the first through the sixth development plans.

27 This approach is consistent with other macroeconometric models of oil-exporting countries. For
example, see El Mallakh and Atta (1981) in the case of Kuwait, and Vaez-Zadeh (1989) in the case of
Venezuela.

28 The data on GTR_t, GOR_t, GNR_t, and GEX_t are all in billions of current Saudi riyals and are obtained
from various issues of the Kingdom of Saudi Arabia: Achievements of the Development Plans.
3.2.1.1 The function for government oil revenue

Government oil revenue consists of oil royalties from the operating companies, income tax collected from these companies, tapline fees, etc. In formulating the function for government oil revenue, the quantity and price of oil exports are considered as the two major explanatory variables. As already mentioned, the real exports largely include crude oil and oil-related exports. Therefore, for simplicity, the quantity and price of oil exports are approximated, respectively, by the real exports, $\text{REXT}_t$, and the price deflator index for exports, $\text{PEXT}_t$. This, therefore, allows us to specify the function for government oil revenue as follows:

\[
\ln \text{GOR}_t = a_4 + b_4 \ln \text{REXT}_t + c_4 \ln \text{PEXT}_t + u_{4t}
\]  

(3.7)

where $u_{4t}$ is an error term; and the coefficients $b_4$ and $c_4$ are expected to be positive because of the direct relationship between GOR$_t$ and the independent variables REXT$_t$ and PEXT$_t$.

The OLS regression estimates of (3.7) for the 1971 - 1994 sample period are as follows (the standard errors are in parentheses and the t-values are in brackets):

\[
\begin{align*}
\ln \text{GOR}_t & = -1.435 + 1.210 \ln \text{REXT}_t + 1.107 \ln \text{PEXT}_t \\
(0.8180) & \quad (0.1508) \quad (0.0630) \\
[-1.75] & \quad [8.03] \quad [17.56]
\end{align*}
\]

$R^2 = 0.950$, $DW = 1.09$.

The problem with these estimates, as indicated by the calculated Durbin-Watson statistic, 1.09, is a first-order autocorrelation problem (the five percent lower- and upper-bound Durbin-Watson critical values are 1.188 and 1.546). The function for government oil revenue in (3.7) is static, implying that the effects of the quantity and price variables

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29 For example, see Metz (1993, p. 183). Also see Johany, Berne and Mixon (1986, pp. 30 -60) for more details on the history of Saudi Arabia’s oil sector.

30 Our data do not suggest that this relationship is an identity. In addition, it is not appropriate to treat this relationship as an identity, since, as shown in (3.10), (i) the relationship is subject to a shift as captured by $D_{9394}$, and (ii) the effect of real exports on GOR is distributed over time.
Chapter 3: Completing the formulation of the aggregate demand function

on government oil revenue is completed within the immediate period. This assumption may not be correct, reflecting itself in the first-order autocorrelation problem. To investigate this possibility, we specify a dynamic function for government oil revenue. That is, we allow for the effects of the quantity and price variables on government oil revenue to be distributed over time based on a geometrically declining pattern. That is,

$$\ln GOR_t = a_4y_4 + b_4y_4 \ln REXT_t + c_4y_4 \ln PEXT_t + (1 - \gamma_4) \ln GOR_{t-1} + u_{4t}$$  \hspace{1cm} (3.8)$$

where $b_4y_4$ and $b_4$ are, respectively, the short- and long-run elasticities of government oil revenue with respect to real exports; $c_4y_4$ and $c_4$ are, respectively, the short- and long-run elasticities of government oil revenue with respect to the export prices; and $\gamma_4$ is the speed of adjustment which is assumed to be between zero and one.

The OLS regression estimates of (3.8) for 1971 - 1994 are as follows (the standard errors are in parentheses and the t-values are in brackets):

$$\ln GOR_t = -1.424 + 1.215 \ln REXT_t + 1.116 \ln PEXT_t - 0.007 \ln GOR_{t-1}$$

$$\begin{array}{c c c}
\text{(standard errors)} & \text{t-values} \\
(.8622) & (1.767) & (1.909) \\
\end{array}$$

$$R^2 = 0.950, \hspace{0.2cm} DW = 1.06, \hspace{0.2cm} Durbin-h = 2.96.$$  

As seen, the inclusion of the lagged dependent variable does not help eliminate the first-order autocorrelation problem. For example, the calculated Durbin-h statistic, 2.96, is significant, since it exceeds the ten percent critical z-value, 1.282. Such regression results may lead to the conclusion that the autocorrelation problem in (3.7) is not due to the exclusion of the lagged dependent variable, $\ln GOR_{t-1}$.\textsuperscript{31}

Returning back to the regression estimates of (3.7), we take an alternative approach in correcting the first autocorrelation problem by looking at the residual plot in search of significant upward or downward shifts in the relationship. Our inspection

\textsuperscript{31} For example, the coefficient estimate on the lagged dependent variable, - 0.007, is very close to zero. The t -ratio on this coefficient estimate, - 0.05, also appears to be highly insignificant.
suggests a downward shift in the relationship for 1993 - 1994. This, however, indicates a
decline in the government oil revenue independent of the oil export quantity and prices
during this period.

In order to account for this shift, the dummy variable, $D_{9394}$ (= 1.0 for 1993 - 94
and zero otherwise) is included in (3.7), resulting in the following function for
government oil revenue:

$$\ln GOR_t = a_{40} + a_{41} D_{9394} + b_{4} \ln REX_t + c_4 \ln PEXT_t + u_{4t} \quad (3.9)$$

The OLS regression estimates of (3.9) for the 1971 - 1994 sample period are as
follows (the standard errors are in parentheses and the t-values are in brackets):

$$\begin{align*}
\ln GOR_t &= -1.607 - 0.302 D_{9394} + 1.248 \ln REX_t + 1.120 \ln PEXT_t \\
&\quad (0.7485) (0.1310) (0.1383) (0.0577) \\
&[-2.15] [-2.31] [9.03] [19.42]
\end{align*}$$

$$R^2 = 0.961, DW = 1.52.$$

As seen, the inclusion of the dummy variable improves the first-order
autocorrelation problem somewhat. For example, the calculated Durbin-Watson statistic,
1.52, now falls in the indecision zone.\(^{32}\) (the five percent lower- and upper-bound
Durbin-Watson critical values are 1.188 and 1.546). To improve these regression
estimates further, our empirical analysis suggests the inclusion of $\ln REX_{t-1}$ in (3.9).
This yields the following dynamic specification for government oil revenue:

$$\ln GOR_t = a_{40} + a_{41} D_{9394} + b_{40} \ln REX_t + b_{41} \ln REX_{t-1} + c_4 \ln PEXT_t + u_{4t} \quad (3.10)$$

where the effect of the real exports on government oil revenue is distributed over the
immediate period and the following first period.

\(^{32}\) It is noted that the inclusion of the lagged dependent variable, $\ln GOR_{t-1}$, in (3.9) does not help
eliminate the first order autocorrelation problem. More specifically, the resulting Durbin-Watson statistic is 1.55, which is higher than the ten percent critical value, 1.282. In addition, the coefficient estimate of $\ln GOR_{t-1}$ is -0.011 which is very close to zero with a low t-statistic of -0.09
The OLS regression estimates of (3.10) for the 1971 - 1994 sample period are as follows (the standard errors are in parentheses and the t-values are in brackets):

\[
\begin{align*}
\ln GOR_t &= -2.284 - 0.355 \ln D9394 + 0.632 \ln REXT_t + 0.735 \ln REXT_{t_1} \\
&\quad + 1.010 \ln PEXT_t \\
\end{align*}
\]

\[
\begin{align*}
(.6752) & \quad (.1126) & \quad (.2391) & \quad (.2484) \\
[{-3.38}] & \quad [{-3.15}] & \quad [2.64] & \quad [2.96] \\
\end{align*}
\]

\[R^2 = 0.973, \quad DW = 1.67,\]

LM test = 2.08, White's test = 7.46, Jarque-Bera normality test = 1.07.

As indicated by the Durbin-Watson test statistic, 1.67, these estimates no longer suffer from a first-order autocorrelation problem (the five percent lower- and upper-bound Durbin-Watson critical values are 1.101 and 1.656). Furthermore, based on the LM test results, the joint null hypothesis of no first- and higher-order autocorrelation problem cannot be rejected. This is because the calculated \( \chi^2 \)-statistic, 2.08 with a P-value of 35.42 percent, is insignificant. The null hypothesis of homoscedasticity is also accepted, since, based on the White test, the calculated \( \chi^2 \)-statistic, 7.46, has a P-value of 40 percent which is again insignificant.\(^{33}\) Furthermore, using the Jarque-Bera normality test, the null hypothesis that the error term is normally distributed cannot be rejected, since the calculated test statistic is 1.07 with a P-value of 58.55 percent, well above the ten percent reasonable level of significance.\(^{34}\)

Based on the above regression estimates, as indicated by the coefficient of determination, \( R^2 \), 97.3 percent of the sample variations in the logarithm of government oil revenue is explained by the independent variables. In addition, all the coefficients have the theoretically correct signs and are significantly different from zero at reasonable

\(^{33}\) The specification of the function for the government oil revenue in logarithms helps to alleviate the problem of heteroscedasticity (see Gujarati, 1995, p. 386, on this issue). In other words, when the function is estimated in a linear form, heteroscedasticity becomes a serious problem. Based on the White test, for example, the calculated \( \chi^2 \)-statistic is 11.79 which is significant at the 8 percent level of significance.

\(^{34}\) It is important to note that the inclusion of the lagged dependent variable, \( \ln GOR_{t_1} \) in (3.10) does not improve the regression estimates. In fact, the coefficient estimate of this variable is -0.074 with an insignificant t-ratio of - 0.73
levels of significance. Holding the export price constant, a one percent increase (decrease) in the real exports increases (decreases) government oil revenue by 0.632 percent in the immediate period and by 0.735 percent in the following first period. Furthermore, holding the real exports constant, a one percent increase (decrease) in the export price leads to 1.010 percent increase (decrease) in government oil revenue.

3.2.1.2 The function for government non-oil revenue

Government non-oil revenue consists of the compulsory right to be taken from the property in accordance with the Islamic law named "zakat", and fees on services provided by government agencies. In general, government non-oil revenue has a direct relation with the income available to the domestic economy. This variable is, therefore, utilised as the explanatory variable in formulating the function for government non-oil revenue as follows:

\[ GNR_t = a_5 + b_5 NDI_t + u_{5t} \]  

where \( GNR_t \) is government non-oil revenue in billions of current Saudi riyals; \( NDI_t (= RDI_t \times P_t) \) is the income available to the domestic economy or the absorptive capacity in billions of current Saudi riyals, and \( u_{5t} \) is an error term. In addition, the coefficient \( b_5 \) is theoretically expected to be positive.\(^{35}\)

The OLS regression estimates of (3.11) for the 1971 - 1994 sample period are as follows (the standard errors are in parentheses and the t -values are in brackets):

\[ GNR_t = 1.344 + 0.103 NDI_t \]

(2.861) (0.0095) 

[0.47] [10.86] 

\( R^2 = 0.843, DW = 0.91. \)

As seen, these estimates suffer from a first-order autocorrelation problem as

\(^{35}\) This formulation is consistent with Vaez-Zadeh (1989, p. 355) in the case of Venezuela.
indicated by the calculated Durbin-Watson, 0.91 (the five percent lower- and upper-bound Durbin-Watson critical values are 1.273 and 1.446). Again, the function for the non-oil revenue in (3.11) is static, implying that the effect of income on government non-oil revenue is completed within the immediate period. In what follows, we show that this assumption is incorrect, reflecting itself in the first-order autocorrelation problem.

To this end, we specify a dynamic function for non-oil government revenue, where the effect of income on government non-oil revenue is distributed over time based on a geometrically declining pattern. That is,

\[ GN R_t = a\gamma_5 + b\gamma_5 N D I_t + (1 - \gamma_5) G N R_{t-1} + u_t \] (3.12)

where \( b\gamma_5 \) and \( b_5 \) are, respectively, the short- and long-run effects of nominal income available to the domestic economy on government non-oil revenue; \( \gamma_5 \) is the speed of adjustment and is assumed to be between zero and one to ensure that the function for the non-oil government revenue is dynamically stable.

The OLS regression estimates of (3.12) for the 1971 - 1994 sample period are as follows (the standard errors are in parentheses and the t-values are in brackets):

\[ GN R_t = 1.800 + 0.054 N D I_t + 0.456 G N R_{t-1} \]

\[ (2.502) \quad (.0192) \quad (.1621) \]

\[ [0.72] \quad [2.84] \quad [2.81] \]

\[ R^2 = 0.886, \quad DW = 1.81, \quad Durbin-h = 0.75. \]

Based on the calculated Durbin-h statistic, 0.75, the null hypothesis of no first-order autocorrelation problem is accepted at the ten percent or lower level of significance (the ten percent critical z-value is 1.282). However, a closer look at the residual plots suggests the inclusion of two dummy variables in the above function for government non-oil revenue. The first dummy variable, \( D82 \) (equal to one for 1982 and zero otherwise), is included to capture the peak in the government non-oil revenue in 1982. The second dummy variable, \( D9394 \) (equal to one for 1993 - 94 and zero otherwise), is included to capture the downward shift in the function due to the decline in the government non-oil revenue from a number of import related fees and charges. Specifically, as mentioned
before, the Saudi government was successful in bringing down the current account deficit through declining imports during 1993 – 1994. This success, however, has had the side effect of reducing the government non-oil revenue from import-related fees and charges, which is captured by the dummy variable, D9394.

The inclusion of these two dummy variables in (3.12) results in the following function for non-oil government revenue:

\[
GNR_t = a_{50} + a_{51} D82 + a_{52} D9394 + b_5 NDI_t + (1 - \gamma_5) GNR_{t-1} + u_t.
\]  

The OLS regression estimates of (3.13) for the 1971 - 1994 sample period are reported below (the standard errors are in parentheses and the t-values are in brackets):

\[
\begin{align*}
GNR_t &= 1.741 + 18.978 D82 - 7.319 D9394 + 0.057 NDI_t + 0.424 GNR_{t-1} \\
     &= (1.593) (3.862) (2.970) (.0130) (.1048) \\
     &= [1.09] [4.91] [-2.46] [4.40] [4.05] \\
R^2 &= 0.960, \text{ DW} = 1.95, \text{ Durbin-h} = 0.14, \\
\text{LM test} &= 4.19, \text{ White’s test} = 9.28, \text{ Jarque-Bera normality test} = 0.65.
\end{align*}
\]

As seen, the inclusion of the dummy variables significantly increases the coefficient of determination, \(R^2\), from 0.886 in (3.12) to 0.960 in (3.13). These estimates, again, indicate the absence of the first-order autocorrelation problem, as the calculated Durbin-h statistic, 0.14, falls below the ten percent critical z-value, 1.282. In addition, the joint null hypothesis of no first- and higher-order autocorrelation problem cannot be rejected, since the LM test calculated \(\chi^2\)-statistic, 4.19 with a P-value of 12.32 percent, is insignificant. The null hypothesis of homoscedasticity cannot be rejected either, since, based on the White test, the calculated \(\chi^2\)-statistic, 9.28, is insignificant with a P-value of 15 percent. Furthermore, using the Jarque-Bera normality test, the calculated test statistic is 0.65 with a P-value of 72.31 percent which is well above the ten percent reasonable level of significance. Accordingly, the null hypothesis that the error term is normally

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36 See Presley (1996a, p. 3)
Based on the above regression estimates, as indicated by the coefficient of determination, $R^2$, 96 percent of the sample variations in government non-oil revenue is explained by the explanatory variables. In addition, the coefficient estimates on all explanatory variables have the theoretically correct signs and are significantly different from zero at reasonable levels of significance. For example, the estimated coefficient of adjustment, 0.424, while greater than zero, is significantly less than one.\footnote{This indicates that the estimated function for government non-oil revenue is dynamically stable. Accordingly, the speed of adjustment is $\hat{\gamma}_5 = 0.576 (= 1 - 0.424)$, implying that 57.6 percent of the effect of a change in the nominal absorptive capacity on government non-oil revenue occurs in the immediate year and the rest of the effect occurs over the following years with a geometrically declining pattern. To be more specific, the short- and long-run effects are, respectively, 0.057 and 0.099. This indicates that SR 1.0 billion increase (decrease) in the real absorptive capacity increases (decreases) government non-oil revenue by SR 0.057 billion in the immediate period (short-run) and by SR 0.099 billion in the long-run (see Table 3.1 for more details).}

One may argue that the nominal non-oil GDP, NGDPN, may be more relevant in the function for government non-oil revenue than the nominal income available to the domestic economy, NDI. However, when replacing NDI, in (3.13) by NGDPN, the standard error of regression increases from 3.6607 to 4.0813. This is expected since, as indicated in footnote 12, the non-oil GDP is a portion of the income available to the domestic economy.

\footnote{The $t$-ratio for testing the null hypothesis that the parameter estimate on the lagged dependent variable, $(1-\gamma_5)$, is equal or greater than one, $H_0: (1-\gamma_5) \geq 1.0$, is 5.50 (= $0.576/0.1048$). As seen, this $t$-ratio is highly significant, leading to the conclusion that the coefficient on the lagged dependent variable is less than one.}
Table 3.1.

The distributed effects of the absorptive capacity on government non-oil revenue

<table>
<thead>
<tr>
<th>year</th>
<th>impact effects</th>
<th>cumulative effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>immediate</td>
<td>0.057</td>
<td>0.057</td>
</tr>
<tr>
<td>first</td>
<td>0.024</td>
<td>0.081</td>
</tr>
<tr>
<td>second</td>
<td>0.010</td>
<td>0.091</td>
</tr>
<tr>
<td>third</td>
<td>0.004</td>
<td>0.095</td>
</tr>
<tr>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>long-run</td>
<td>.</td>
<td>0.099</td>
</tr>
</tbody>
</table>

Figure 3.1: The pattern of the effect of the absorptive capacity on government non-oil revenue
3.2.2 The function for government expenditure

As indicated in the previous two chapters, government expenditure, as a policy variable, has been playing an important role in the Saudi economy. It is, therefore, important for our study to adequately investigate the behaviour of this variable.

In Chapter 1, we analysed the Saudi economy after 1970. Our analysis revealed that the rush toward development and economic diversification tied the level of government expenditure too closely to government revenue received from oil. This suggests that the function for government expenditure should include government oil revenue as a relevant explanatory variable. Accordingly, the following regression function for government expenditure is specified:

\[
\ln GEX_t = a_6 + b_6 \ln GOR_t + u_{6t}
\]  (3.14)

where \( u_{6t} \) is an error term; and the coefficient \( b_6 \), defined as the elasticity of government expenditure with respect to government oil revenue, is expected to be positive.

The OLS regression estimates of (3.14) for the 1971 - 1994 sample period are as follows (the standard errors are in parentheses and the t-values are in brackets):

\[
\ln GEX_t = 0.070 + 1.045 \ln GOR_t
\]

\[
(0.6443) \quad (1.408)
\]

\[
[0.11] \quad [7.42]
\]

\[ R^2 = 0.715, \text{DW} = 0.33. \]

As indicated by the calculated Durbin-Watson, 0.33, we cannot accept the null hypothesis of no first-order autocorrelation problem (the five percent lower- and upper-bound Durbin-Watson critical values are 1.273 and 1.446). Again, the implicit assumption underlying the static formulation of the above function is that the effect of government oil revenue on government expenditure is completed within the immediate period. This assumption may not be correct, reflecting itself in the first-order

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39 Our data do not suggest that this relationship is an identity. In addition, as shown in (3.16), (i) the relationship is subject to a shift as captured by \( D_{82} \), and (ii) the effect of government oil revenue on government expenditures is distributed over time.
autocorrelation problem.

In an attempt to investigate the validity of this assumption, we specify a dynamic function for government expenditure, where the effect of government oil revenue on government expenditure is distributed over time, based on a geometrically declining pattern. That is,

\[
\ln GEX_t = a_6 \gamma_6 + b_6 \gamma_6 \ln GOR_t + (1 - \gamma_6) \ln GEX_{t-1} + u_{6t} \quad (3.15)
\]

where \( b_6 \gamma_6 \) and \( b_6 \) are, respectively, the short- and long-run elasticities of government expenditure with respect to government oil revenue; \( \gamma_6 \) is the speed of adjustment and is assumed to be between zero and one to ensure that the function for government expenditure is dynamically stable.\(^{40}\)

The OLS regression estimates of (3.15) for the 1971 - 1994 sample period are as follows (the standard errors are in parentheses and the t-values are in brackets):

\[
\ln GEX_t = 0.150 + 0.354 \ln GOR_t + 0.654 \ln GEX_{t-1}
\]

\[
(0.1981) \quad (0.0643) \quad (0.0449)
\]

\[
[0.76] \quad [5.50] \quad [14.56]
\]

\[ R^2 = 0.974, \text{ DW} = 2.12, \text{ Durbin}-h = -0.29. \]

The inclusion of the lagged dependent variable significantly increases the coefficient of determination, \( R^2 \), from 0.715 in (3.14) to 0.974 in (3.15). More importantly, however, based on the calculated absolute value of the Durbin-h statistic, 0.29, the null hypothesis of no first-order autocorrelation problem cannot be rejected at the ten percent or lower level of significance (the ten percent critical z-value is 1.282). In an attempt to further improve these regression results, we look at the residual plot to see if the relationship has been subjected to any significant shift. Our inspection indicates that the relationship in (3.15) has, in fact, undergone a significant downward shift in 1982. This downward shift, however, may reflect the Saudi government extra efforts in reducing the budget deficit in light of declining oil revenue.

In order to account for this shift, the function for government expenditure in (3.15) is respecified by including the dummy variable, \( D_{82} \) (equal to one for 1982 and zero otherwise), as follows:

\[
\ln GEX_t = a_{60} + a_{61} D_{82} + b_{62} \ln GOR_t \\
+ (1 - \gamma_6) \ln GEX_{t-1} + u_{6t}
\]  

(3.16)

The OLS regression estimates of (3.16) for the 1971 - 1994 sample period are reported below (the standard errors are in parentheses and the t-values are in brackets):

\[
\begin{align*}
\ln GEX_t &= 0.080 - 0.430 D_{82} + 0.357 \ln GOR_t + 0.670 \ln GEX_{t-1} \\
&[0.46] [-2.74] [6.35] [16.88]
\end{align*}
\]

\[ R^2 = 0.981, \; DW = 2.03, \; Durbin-h = -0.08, \]

LM test = 0.02, White's test = 3.61, Jarque-Bera normality test = 2.97.

The absence of a first-order autocorrelation problem is confirmed based on the calculated absolute value of the Durbin-h statistic, 0.08, at the ten percent or lower level of significance (the ten percent critical z-value is 1.282). The results from the LM test of serial correlation also reveals the absence of a first- as well as a higher-order autocorrelation problem; the calculated \( \chi^2 \)-statistic for this test is 0.02 with the P-value of 99.19 percent which is highly insignificant. The null hypothesis of homoscedasticity cannot be rejected either, since, based on the White test, the calculated \( \chi^2 \)-statistic, 3.61, is insignificant with a P-value of 60 percent.\(^{41}\) Furthermore, the calculated Jarque-Bera normality test statistic is 2.97 with a P-value of 22.61 percent which, again, is insignificant, leading to the acceptance of the null hypothesis that the error term is normally distributed.

Based on the above regression estimates, as indicated by the coefficient of determination, \( R^2 \), 98.1 percent of the sample variations in the logarithm of government expenditure are explained by the specified function. This suggests that the government expenditure is positively related to the current and lagged values of the government revenue and the lagged government expenditure. Furthermore, the positive and significant coefficient for the lagged government expenditure term indicates a persistence in government expenditure growth.

\(^{41}\) The specification of the function for the government expenditure in logarithms helps to alleviate the problem of heteroscedasticity (see Gujarati, 1995, p. 386, on this issue). In other words, when the function is estimated in a linear form, heteroscedasticity becomes a serious problem. Based on the White test, for example, the calculated \( \chi^2 \)-statistic is 12.80 which is significant at the one percent level of significance.
Chapter 3: Completing the formulation of the aggregate demand function

expenditure is explained by the explanatory variables. In addition, the coefficient estimates on all the explanatory variables have the theoretically correct signs and are significantly different from zero at reasonable levels of significance. The estimated coefficient of adjustment, 0.670, while greater than zero, is significantly less than one.\(^{42}\) This indicates that the estimated function for government expenditure is dynamically stable. Accordingly, the speed of adjustment is \(\hat{\gamma}_6 = 0.330 \approx 1 - 0.670\), implying that 33 percent of the effect of a change in government oil revenue on government expenditure occurs in the immediate year, and the rest of the effect occurs over the following years with a geometrically declining pattern. The short- and long-run elasticities are, respectively, 0.357 and 1.081. This indicates that a one percent increase (decrease) in government oil revenue increases (decreases) government expenditure by 0.357 percent in the immediate period (short-run) and by 1.081 percent in the long-run (see Table 3.2 for more details).

\(^{42}\) The t-ratio for testing the null hypothesis that the coefficient on the lagged dependent variable, \((1-\gamma_6)\), is equal or greater than one, \(H_0 : (1-\gamma_6) \geq 1.0\), is 8.31 \((= 0.330/0.0397)\). As seen this t-ratio is highly significant, leading to the rejection of the above null hypothesis.
## Table 3.2.
The distributed elasticities of government oil revenue on government expenditure

<table>
<thead>
<tr>
<th>year</th>
<th>impact elasticities</th>
<th>cumulative elasticities</th>
</tr>
</thead>
<tbody>
<tr>
<td>immediate</td>
<td>0.357</td>
<td>0.357</td>
</tr>
<tr>
<td>first</td>
<td>0.239</td>
<td>0.596</td>
</tr>
<tr>
<td>second</td>
<td>0.160</td>
<td>0.756</td>
</tr>
<tr>
<td>third</td>
<td>0.107</td>
<td>0.863</td>
</tr>
<tr>
<td>long-run</td>
<td></td>
<td>1.081</td>
</tr>
</tbody>
</table>

Figure 3.2: The pattern of the effect of government oil revenue on government expenditure
3.3 The aggregate demand model revisited: a summary

Our examination of the monetary sector (in Chapter 2) and the foreign and government sectors (in the present chapter) enables us to form the complete model of the aggregate demand for the Saudi economy. This is done by combining the formulated behavioural equations and identities characterising the monetary, foreign, and government sectors as follows:

1. The velocity function:
   \[ \ln V_t = -a_{11} - d_1 V_{t-1} \ln \left( \frac{GOR_t}{GEX_t} \right) + (1-\gamma_1) V_{t-1} + u_{1t} \]

2. The money supply function:
   \[ \Delta M_t = a_{20} + a_{21} D717589 + a_{22} D828392 + b_2 BP_t + c_2 (GEX_t - GTR_t) + d_2 \Delta (RGDPN_t \cdot PGDPN_t) + u_{2t} \]

3. The absorptive capacity identity:
   \[ \ln RDI_t = \ln V_t + \ln \left( \frac{M_t}{P_t} \right) \]

4. The balance of payments identity:
   \[ BP_t = (REXT_t \cdot PEXT_t) - (RIMT_t \cdot PIM_t) + CAPF_t \]

5. The demand function for imports:
   \[ \ln RIMT_t = a_{30} + a_{31} D9394 + b_3 \ln RDI_t + c_3 \ln \left( \frac{GOR}{PIM} \right)_t + d_3 \ln (PIM/PGDPN) + u_{3t} \]

6. The government total revenue identity:
   \[ GTR_t = GOR_t + GNR_t \]
Chapter 3: Completing the formulation of the aggregate demand function

7. The function for government oil revenue:
\[
\ln \text{GOR}_t = a_{40} + a_{41} D9394 + b_{40} \ln \text{REXT}_t + b_{41} \ln \text{REXT}_{t-1}
+ c_4 \ln \text{PEXT}_t + u_{4t}
\]

8. The function for government non-oil revenue:
\[
\text{GNR}_t = a_{50} g_5 + a_{51} g_5 D82 + a_{52} g_5 D9394 + b_{50} (\text{RD}_t^* P_t)
+ (1 - \gamma_5) \text{GNR}_{t-1} + u_{5t}
\]

9. The function for government expenditure:
\[
\ln \text{GEX}_t = a_{60} g_6 + a_{61} g_6 D82 + b_{60} \ln \text{GOR}_t
+ (1 - \gamma_6) \ln \text{GEX}_{t-1} + u_{6t}
\]

10. The total real GDP identity:
\[
\text{RGDP}_t = \text{RDI}_t + (\text{REXT}_t - \text{RIMT}_t)
\]

This model for the aggregate demand specifies a relationship between the real absorptive capacity, \( \text{RDI}_t \), and the general prices, \( P_t \). Accordingly, with \( \text{REXT}_t, \text{PEXT}_t, \text{PIM}_t, \) and \( \text{CAPF}_t \) being determined exogenously, the above aggregate demand model includes more endogenous variables than equations. Specifically, the model includes ten equations with thirteen endogenous variables: \( V_t, M_t, \text{RDI}_t, \text{BP}_t, \text{RIMT}_t, \text{GTR}_t, \text{GOR}_t, \text{GNR}_t, \text{GEX}_t, \text{RGDP}_t, \) \( \text{RGDPN}_t, P_t, \) and \( \text{PGDPN}_t \). The first ten endogenous variables are determined based on the specified equations and identities within the aggregate demand model. The last three endogenous variables, \( \text{RGDPN}_t, P_t \) and \( \text{PGDPN}_t \), however, cannot be endogenously determined in the absence of the aggregate supply model. Accordingly, the subject of the next chapter is to formulate and estimate the aggregate supply model of the Saudi economy.
Chapter 4: On the formulation of the aggregate supply model

Chapter 4.

On the formulation of the aggregate supply model

The aggregate demand model presented in the conclusion section of Chapter 3 cannot by itself describe the working of the Saudi Arabian economy. This is because, as we have seen, the behaviours of such important variables as the non-oil output, RGDPN, the non-oil GDP price level, PGDPN, and the general price level, P, are not yet explained. In order for these variables to be endogenously determined within our macroeconometric model, it is necessary to formulate the dynamics of prices (inflation) and output from the supply side of the economy. Therefore, it is the purpose of this chapter to concentrate on the formulation and estimation of the aggregate supply model of the Saudi economy.

As we have already discussed in Chapter 1 of this study, the aggregate supply of the Saudi economy, defined by the real total GDP, consists of the oil and non-oil production measured, respectively, by the real oil GDP, RGDPO, and the real non-oil GDP, RGDPN. The distinction between oil and non-oil sectors emphasises the sharp difference in the behaviour of oil from non-oil production. For example, the level of oil production in the Saudi economy is mainly determined by the international demand and supply conditions for crude oil. By contrast, however, as we shall see, the level of non-oil production is mainly determined within the domestic economy.

The outline of this chapter is as follows: Section 4.1 combines the non-oil production and non-oil labour sectors of the economy to formulate the non-oil supply function. This supply function, as we shall see, relates the non-oil price inflation to the non-oil production based on the Phillips (1958) curve methodology. The estimation of the derived function reveals a theoretically consistent upward-sloping supply curve for the non-oil sector. Section 4.2 investigates the working of the oil production sector of the Saudi economy. In other words, this section formulates and then estimates the function for the real oil GDP with the real exports utilised as the explanatory variable. The real exports, REXT, is taken to be exogenous, since a large portion of it includes

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1 Utilising British data from 1861 - 1957, Phillips (1958) showed that the unemployment rate tended to be high when the nominal wage inflation rate was low, and vice versa. This relationship is utilised in this chapter as the basis for deriving the non-oil supply function.
the exports of crude oil and oil refinery products which are determined by the government through negotiations with other OPEC countries and the world's demand and supply conditions for crude oil.\footnote{On the history of OPEC, oil policy, oil markets and prices, and the role of Saudi Arabia, see Horsnell Paul and Mabro Robert (1993), Johany, Berne, and Mixon (1986, pp. 48 – 60), Stevens Paul (1982, pp. 214 – 234), and Ortiz Rene G. (1982, pp. 1 – 15)}

Section 4.3 further specifies the equilibrium condition of our macroeconometric model by setting the aggregate demand equal to the aggregate supply. It is from this equilibrium condition that the real non-oil GDP will be endogenously determined as the difference between the aggregate demand and the real oil GDP. This is in line with the argument that it is the intersection of the aggregate demand and the aggregate supply that determines such variables as the absorptive capacity of the economy, the non-oil output or GDP, the non-oil GDP prices, and, ultimately, the general prices as explained in Section 4.4.

More specifically, Section 4.4 completes the specification of our model in this chapter, by further investigating the behaviour of the general price level. This is done by first formulating and then estimating the function for the general price level (or the implicit price deflator for the absorptive capacity) with the non-oil GDP price level and the import price level utilised as the explanatory variables. The regression estimates of this function reveals that the general price level is a weighted average of non-oil GDP prices and import prices. As one may expect, our regression estimates also confirm that the general price level is largely influenced by the non-oil GDP price level with a nearly 75 percent contribution. The contribution of the import price level to the general price level, however, is shown to be nearly 25 percent which is relatively high. This, however, signifies the dependence of the Saudi Arabian economy on imported goods and services in satisfying the private and public sectors' demand for both consumption and investment goods including machineries and raw materials utilised in the process of domestic production.

Section 4.5 finally summarises the chapter by bringing together the identities and the formulated behavioural equations characterising the non-oil and oil production sectors to form the aggregate supply model of the Saudi economy.
Chapter 4: On the formulation of the aggregate supply model

4.1 The non-oil supply function

According to the Kingdom of Saudi Arabia: Achievements of the Development Plans, published annually by the Ministry of Planning, the non-oil output or GDP of the Saudi economy consists of agriculture, forestry and fishing; mining and quarrying; manufacturing; electricity, gas, and water; construction; trade, etc.; transport, storage and communication; finance, insurance, real estate and business services; community, social and personal services; and government services.\(^3\)

As already indicated, the purpose of this study is to develop a macroeconometric model for the purpose of policy analysis and forecasting. In order to keep our model manageable and to the point, we shall concentrate on formulating the supply function for the sum of all productions other than oil through combining the non-oil production and the non-oil labour sectors of the Saudi economy. Avoiding a disaggregated approach, which attempts to formulate each single production sector, also helps us to avoid problems arising from limitations on the data availability.

4.1.1 Formulation of the non-oil supply function

The non-oil supply function of the Saudi economy, in the spirit of the Phillips' curve (Phillips, 1958) approach, relates the non-oil GDP price inflation to the rate of deviations of the actual real non-oil GDP from the normal or long-run level of real non-oil GDP with the economic agents' price inflationary expectations utilised as a shift variable. Following Dornbusch, Fischer and Startz (1998),\(^4\) we take four steps in deriving the supply function for the non-oil sector of the Saudi economy.

As the first step, we specify the non-oil production function which relates the level of output measured by the real non-oil GDP, RGDPN, to the level of employment of labour in the non-oil production sector, N:\n
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\[ \text{RGDPN}_t = \alpha N_t \]  \hspace{1cm} (4.1)

where \( \alpha \) is called the input coefficient, or labour productivity.

As the second step, we relate the price of output, measured by the non-oil GDP prices, \( \text{PGDPN}_t \), to the labour costs, \( W_t \), which is taken to be the main component of the total production costs as follows:

\[ \text{PGDPN}_t = (1 + z) \times (W_t/\alpha) \]  \hspace{1cm} (4.2)

where \( (W_t/\alpha) \) is defined as the unit labour cost, and \( z \) is defined as the price mark-up.

The assumption underlying (4.2) is that firms set prices as a mark-up, \( z \), on labour costs. As argued by Dornbusch Fischer and Startz (1998), "the mark-up over labour costs covers the cost of other factors of production that firms use, such as capital and raw materials, and includes an allowance for the firms' normal profits".\(^5\)

As the third step, we specify the Phillips curve for the non-oil sector. Accordingly, the rate of wage inflation in the non-oil sector, \( (W_t - W_{t-1})/W_{t-1} \), is taken to be negatively related to the deviations of the actual unemployment in the non-oil sector, \( U_t \), from the corresponding natural rate of unemployment, \( U_t^* \). That is,

\[ ((W_t - W_{t-1})/W_{t-1}) = -\varepsilon(U_t - U_t^*) \]

where \( \varepsilon \) measures the responsiveness of wages to the actual unemployment; and \( \varepsilon \) is theoretically expected to be positive, emphasising the trade-off between the wage inflation rate and the actual unemployment rate.

Rewriting this relationship, we have

\[ W_t = W_{t-1} [1 - \varepsilon (U_t - U_t^*)] \]  \hspace{1cm} (4.3)

which indicates that for wages to rise above the previous period's level, the actual unemployment must fall below the natural rate.

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\(^5\) See Dornbusch Fischer and Startz (1998, p. 109)
We then define the deviation of the actual unemployment rate from the natural rate of unemployment, $U_t - U_t^*$, in terms of the level of employment in the non-oil production sector as follows

$$U_t - U_t^* = \left( N_t^* - N_t \right) / N_t^*$$

(4.4)

where $N_t$ measures the actual level of employment in the non-oil sector, and $N_t^*$ is the corresponding full-employment level.

Substituting (4.4) into (4.3), we have

$$W_t = W_{t-1} \left[ 1 + \varepsilon \left( (N_t - N_t^*) / N_t^* \right) \right]$$

(4.5)

which is essentially the Phillips curve defining, instead, a relationship between the wage this period, the wage last period, and the actual level of employment.

As the fourth and last step, (4.5) is combined with (4.1) and (4.2) to obtain the supply function for the non-oil sector, which defines a relationship between the price of non-oil output, $PGDPN_t$, and the level of non-oil output, $RGDPN_t$, as follows:

$$PGDPN_t = PGDPN_{t-1} \left[ 1 + \varepsilon \left( (RGDPN_t - RGDPN_t^*) / RGDPN_t^* \right) \right]$$

(4.6)

where $RGDPN_t^*$ is defined as the normal or long-run level of output in the non-oil production sector of the economy. Given that $\varepsilon$ is a positive coefficient, the non-oil supply curve, as theoretically expected, is upward-sloping. Defining $RGDPN_t^*$ as the full-employment level of the non-oil output, there is no change in prices, $PGDPN_t = PGDPN_{t-1}$, when the non-oil production sector of the economy is operating at full-employment, $RGDPN_t = RGDPN_t^*$. At higher levels of non-oil output, there is overemployment, implying that prices this period will be higher than those last period. The converse is also true. More specifically, if the non-oil output is maintained above the full-employment level, then over time the production costs including wages continue to rise, and the production cost increases are passed on as increased prices.

For the purpose of estimation, the aggregate supply function in (4.6) is rewritten as follows:
\[ PGDPN_t = a_7 + b_7 (\ln RGDPN_t - \ln RGDPN_t^*) + u_{n7} \] (4.7)

where \( PGDPN \), which is generated as \( \Delta \ln PGDPN \), measures the non-oil GDP price inflation rate; \( (\ln RGDPN_t - \ln RGDPN_t^*) \) measures the rate of deviation of actual real non-oil GDP, \( RGDPN_t \), from the normal or long-run real non-oil GDP, \( RGDPN_t^* \); and \( u_{n7} \) is an error term. The coefficient \( b_7 \) measures the responsiveness of the non-oil GDP price inflation rate to the rate of deviation of actual real non-oil GDP from the normal or long run real non-oil GDP. Furthermore, as we have discussed above, this coefficient, \( b_7 \), is theoretically expected to be positive.

The non-oil supply function in (4.7), however, is not yet complete, since it does not include the inflationary expectations as a shift variable. According to Friedman (1968, 1977) and Phelps (1967, 1968), the Phillips curve in (4.3), and, therefore, the non-oil supply function in (4.7) would shift over time as economic agents including workers and firms become used to and begin to expect continuing inflation. On the basis of this argument, therefore, (4.7) should be respecified as follows:

\[ PGDPN_t = a_7 + b_7 (\ln RGDPN_t - \ln RGDPN_t^*) + \beta_7 Pet + u_{n7} \] (4.8)

where \( Pet \) is defined as the inflationary expectations. This variable, therefore, measures what economic agents in year \( t \) expect the rate of inflation to be in year \( t+1 \). Other things equal, the coefficient \( \beta_7 \) measures the responsiveness of the non-oil GDP price inflation to the inflationary expectations. As seen, the formulation in (4.8), following Friedman and Phelps, accounts for the effects of changes in inflationary expectations on the non-oil supply curve. For example, it is theoretically expected that the coefficient \( \beta_7 \)

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\[ Also, see Andersen (1989) for a review of both theory and modern empirical analysis supporting the Friedman and Phelps view.\]

\[ The inclusion of the inflationary expectations variable, following Friedman and Phelps, leads to the distinction of the short-run and long-run supply curves. In the short-run when inflationary expectations are constant or do not change much and differ from the actual inflation, we have the short-run upward sloping supply curve. In the long-run, when the actual rate of inflation adjusts to the corresponding expected rate and the economy produces at full-employment, then we have the long-run supply curve which indicates that the level of output is independent of the actual inflation rate. This argument, consistent with Friedman and Phelps, implies that the supply curve is positively sloped in the short-run, but...\]
be positive. An increase in the expected inflation rate, therefore, will shift the non-oil supply curve upward and to the left, a situation that is called stagflation. A decline in the expected inflation rate, on the other hand, will shift the non-oil supply curve downward and to the right, a situation that is called deflationary growth.4, 9

In order to be able to estimate the non-oil supply function in (4.8), as the first step, we need to measure the inflationary expectations variable, $P^*_t$. It is important to note that the inflationary expectations are not observable, and, therefore, one needs to make an assumption on which to base the generation of this variable. In this study, we assume that economic agents set their expected rate of inflation equal to the previous year's actual rate of inflation, $P_{t-1}$, which is known at year $t$. Accordingly, we can write

$$P^*_t = P_{t-1},$$

Where $$P_{t-1} = \Delta \ln P_t$$

Or $$P_{t-1} = (\ln P_{t-1} - \ln P_{t-2})$$

with $P$, as previously defined, representing the general price level measured by the implicit price deflator for the absorptive capacity.

As the second step, we need to measure the normal or long-run level of real non-oil GDP, $RGDPN^*_t$. Again, it is important to note that the normal or long-run level of real non-oil GDP is not observable, and, therefore, one needs to make an assumption on which to base the generation of this variable. In this study, in line with Friedman (1970,

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4 Within the Phillips curve methodology, stagflation refers to periods in which both inflation and unemployment increase at the same time, resulting in a shift in the Phillips curve to the right. Deflationary growth, on the other hand, refers to periods in which both inflation and unemployment decline at the same time, resulting in a shift in the Phillips curve to the left.

5 For similar specification of the non-oil supply function for Venezuela, see Khan (1976) and Vaez-Zadeh (1989). In the case of the Philippines, see Otani (1975)
1971), we assume that $\text{RGDPN}_t^*$ is determined by the previous years' actual levels of real non-oil GDP based on a geometrically declining pattern. That is,

$$\text{RGDPN}_t^* = \omega \text{RGDPN}_{t-1} + \omega(1 - \omega)\text{RGDPN}_{t-2} + \omega(1 - \omega)^2 \text{RGDPN}_{t-3} \quad (4.9)$$

where the weight for $\text{RGDPN}_{t-1}$, $\omega$, is assumed to be between zero and one, $0 < \omega \leq 1$, implying that the actual real non-oil GDP in the recent past has a more powerful role in the determination of the normal or long-run level of real non-oil GDP than the actual real non-oil GDP in the more distant past.

4.1.2 Estimation of the non-oil supply function

Before proceeding further, it is important to note that a closer look at the data suggests the inclusion of a dummy variable in the non-oil supply function in (4.8) for 1974 - 75. More specifically, the dummy variable, $D_{7475}$ (equal to one for 1974 - 75 and zero otherwise), is included to capture the upward shift in the non-oil supply curve due to, perhaps, higher cost of production after the unexpected fourfold increase in oil prices in 1973/1974.

The inclusion of this dummy variable in (4.8) results in the following modified non-oil supply function:

$$\text{PGDPN}_t = a_7 + a_7 D_{7475}$$

$$+ b_7 (\ln \text{RGDPN}_t - \ln \text{RGDPN}_t^*) + c_7 P_t^* + u_t \quad (4.10)$$

Setting $\omega$ equal to 1.0, 0.9, 0.8, ..., 0.1, (4.9) gives us ten different series for the normal or long-run level of real non-oil GDP, $\text{RGDPN}_t^*$. Utilising these series one at a time, we obtain ten different regression estimates of the non-oil supply function in

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10 More specifically, see Friedman (1971, p. 331, equation (22)). Also, see footnote 3 in Chapter 2 of this study.

11 Our empirical analysis indicates that increasing the number of lags beyond three years does not significantly improve the final regression estimates of the non-oil supply function.
(4.10). The regression estimates with the highest coefficient of determination, \( R^2 \) (or the lowest standard error of regression) in the absence of usual statistical problems are then chosen to be the best fitting estimates of the non-oil supply function of the Saudi economy.

More specifically, the best fitting OLS regression estimates of (4.10) for the 1971 - 1994 sample period are as follows (the standard errors are in parentheses and the t-values are in brackets):\(^{12}\)

\[
\begin{align*}
PGDPN_t &= -0.016 + 0.205 D7475 \\
&\quad + 0.503 (\ln RGDPN_t - \ln RGDPN_t^*) + 0.318 P_t^* \\
&\quad (0.0113) (0.217) (1.301) (1.031) \\
&\quad [-1.39] [9.46] [3.86] [3.09]
\end{align*}
\]

\[ R^2 = 0.949, DW = 2.07, \hat{\omega} = 0.7, \]
LM test = 0.53, White's test = 6.58, Jarque-Bera normality test = 3.36.

As mentioned above, these regression estimates are referred to as the best fitting regression estimates, because, with the normal or long-run level of non-oil output, \( RGDPN_t^* \), generated based on \( \hat{\omega} = 0.7, \)

\[ RGDPN_t^* = 0.7 RGDPN_{t1} + 0.21 RGDPN_{t2} + 0.063 RGDPN_{t3} \]

we obtain the highest R-squared or the lowest standard error of regression in the absence of the usual statistical problems such as autocorrelation and heteroscedasticity.\(^{13}\) For example, based on the above regression estimates, the calculated Durbin-Watson

\(^{12}\) The data are obtained from various issues of the Kingdom of Saudi Arabia: Achievements of the Development Plans.

\(^{13}\) Alternatively, the logarithm of the long-run level of non-oil real GDP, \( \ln RGDPN_t^* \), is generated as the fitted values of an autoregressive integrated moving-average (ARIMA) model of \( \ln RGDPN_t \) [(see Mills, 1990, Chapter 9). I would like to thank Professor Terence C. Mills the Head of the Economics Department at Loughborough University for all his assistance and guidance throughout all this study]. The regression results of (4.10) based on an ARIMA (0,1,1) model of \( \ln RGDPN_t \), however, are inferior to the regression estimates of (4.10) presented above. This is, perhaps, because for the univariate time-series modelling to produce desirable estimates, we need to have a large number of observations.
statistic, 2.07, indicates that there exists no first-order autocorrelation problem (the five percent lower- and upper-bound Durbin-Watson critical values are 1.101 and 1.656). The results from the LM test of serial correlation also reveals the absence of a first- as well as a higher-order autocorrelation problem. The calculated $\chi^2$-statistic for this test is 0.53 with the P-value of 76.73 percent well above the ten percent reasonable level of significance. The null hypothesis of homoscedasticity is tested based on the White test. The calculated $\chi^2$-statistic for this test is 6.58 with the P-value of 25 percent. This test statistic is also insignificant, indicating the absence of a heteroscedasticity problem. Furthermore, using the Jarque-Bera normality test, we cannot reject the null hypothesis that the error term is normally distributed. For example, the corresponding calculated test statistic is 3.36 with a P-value of 18.65 percent, which, again, is above the ten percent reasonable level of significance, indicating that the error term is, in fact, normally distributed.

Based on the above regression estimates, the coefficient of determination, $R^2$, indicates that 94.9 percent of the total sample variations of the non-oil GDP price inflation is explained by the explanatory variables. In addition, the coefficient estimates of the explanatory variables, while significantly different from zero at reasonable levels of significance, have the theoretically correct signs.

The coefficient estimate on $(\ln RGDPN, - \ln RGDPN,')$, for example, is positive, indicating a theoretically consistent upward-sloping supply curve for the non-oil sector. More specifically, other things equal, a one percent point increase (decrease) in the rate of the deviation of the actual real non-oil GDP from the normal or long-run real non-oil GDP leads to a 0.503 percent point increase (decrease) in the non-oil GDP price inflation rate. Furthermore, the coefficient estimate on the inflationary expectations variable, while positive as theoretically expected, is significantly less than one. The implication of this finding is that, other things equal, a one percent point increase (decrease) in the inflationary expectations increases (decreases) the non-oil GDP price inflation rate by less than one percent point, or, more specifically, by 0.318 percent.

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14 The t-ratio for testing the null hypothesis that $c, = 1.0$, is $6.62 (= 0.682/0.1030)$. As seen, this t-ratio is significant at the less than one percent level of significance, leading to the rejection of the null hypothesis in favour of the alternative hypothesis that $c, = 1.0$.
4.2 The oil production sector: the determination of the real oil GDP

The aggregate production for the Saudi economy, as already discussed, consists of non-oil and oil production. In the above analysis, we looked at the behaviour of non-oil production or GDP in relation to non-oil GDP prices (or the supply function for the non-oil sector). In this section, however, we examine the behaviour of oil production, by formulating and then estimating the function for the real oil GDP, $\text{RGDPO}_t$.

Consistent with Looney (1982), it is argued that the level of oil production in the Saudi economy is directly related to the amount of crude oil and refinery products that the country is able to export. Accordingly, the following behavioural function for the real oil GDP is specified:

$$\text{RGDPO}_t = a_8 + b_8 \text{REXT}_t + u_{8t} \quad (4.11)$$

where the coefficient $b_8$ measures the effect on the real oil GDP of the real exports; and $u_{8t}$ is an error term.

The real exports, $\text{REXT}_t$, as the explanatory variable in (4.11) is taken to be exogenously determined. The reason for this treatment, as already noted, is that $\text{REXT}_t$ largely includes the exports of crude oil and refinery products determined by the government through negotiations with other OPEC countries based on the international demand and supply conditions for crude oil. It follows that the real oil GDP, according to (4.11), is essentially exogenously determined in our model.

15 Another implication of $c_r < 1.0$, as we mentioned in footnote 7, is that one should not expect a vertical supply curve in the long-run in our case. This result is also consistent with Otani (1975, p. 758) who finds an estimated value of 0.32 for $c_r$ when estimating the supply curve for the Philippines.

16 Otani (1975, p. 758) also includes the import price inflation variable in the supply function as another shift variable. Our empirical examination, however, suggests that the inclusion of the import price inflation, $\Delta \ln \text{PIM}_t$, in (4.10) does not significantly improve the regression results. For example, the coefficient estimate on this variable is found to be 0.123 with an insignificant t-ratio of 1.30

17 See Looney (1982), p. 255

18 For a discussion of this issue in more detail, see also El Mallakh (1982b, pp. 50-54) and Metz (1993, pp. 151-152)
The OLS regression estimates of (4.11) for the 1971 - 1994 sample period are as follows (the standard errors are in parentheses and the t-values are in brackets):

\[ RGDPO_t = -26.877 + 1.074 \text{REXT}_t \]
\[ (8.658) \quad (.0370) \]
\[ [-3.10] \quad [28.99] \]

\[ R^2 = 0.974, \text{DW} = 0.45. \]

As indicated by the calculated Durbin-Watson statistic, 0.45, these estimates suffer from a first-order autocorrelation problem (the five percent lower- and upper-bound Durbin-Watson critical values are 1.273 and 1.446). A closer look at the residual plot indicates an upward shift in the relationship over the 1993 - 1994 period. Accordingly, the dummy variable, \( D9394 \) (equal to one for 1993 - 1994 and zero otherwise) is included to account for this shift due to increasing domestic use of crude oil as an input in the domestic production of petrochemical and related products.

The inclusion of the dummy variable in (4.11) results in the following function for the real oil GDP:

\[ RGDPO_t = a_{80} + a_{81} D9394 + b_8 \text{REXT}_t + u_{8t}. \] (4.12)

The OLS regression estimates of (4.12) for the 1971 - 1994 sample period are as follows (the standard errors are in parentheses and the t-values are in brackets):

\[ RGDPO_t = -26.031 + 27.333 D9394 + 1.060 \text{REXT}_t \]
\[ (5.4785) \quad (4.6885) \quad (.0236) \]
\[ [-4.75] \quad [5.83] \quad [45.02] \]

\[ R^2 = 0.990, \text{DW} = 0.52, \]

\[ ^{19} \] In an attempt to correct for the first-order autocorrelation, the lagged dependent variable, \( RGDPO_{t-1} \), is included in (4.11). Based on the regression estimates of the resulting function, this inclusion does not help to correct the problem, indicating that the lagged dependent variable is not empirically relevant variable in the function for the real oil GDP. This is also true when the lagged dependent variable is included in the final specifications of the function for the real oil GDP in (4.12)

\[ ^{20} \] See Metz (1993, p. 125)
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LM test = 14.43, White's test = 4.91, Jarque-Bera normality test = 0.35.

The inclusion of the dummy variable does little to eliminate the first-order autocorrelation problem, since the calculated Durbin-Watson statistic, 0.52, still falls in the autocorrelation problem region. Consistent with this result, the LM test statistic, 14.43 with a P-value of 0.07 percent, is highly significant. A closer look at the LM test results indicates the existence of both a first-order and a second-order autocorrelation problem. To correct this problem, we have utilised the rho-transformation technique by including the first- and second-order autoregressive terms in (4.12). Accordingly, the following OLS regression estimates for 1971 - 1994 are obtained (the standard errors are in parentheses and the t-values are in brackets):

$$\text{RGDPO}_t = -27.34 + 20.536 \text{D9394} + 1.069 \text{REXT}_t$$

$$(6.777) \quad (3.859) \quad (.0279)$$

$$[-4.03] \quad [5.32] \quad [38.25]$$

$${\hat{\rho}}_1 = 1.196, \quad {\hat{\rho}}_2 = -0.547, \quad R^2 = 0.997, \quad DW = 1.68, \quad LM \text{ test} = 2.16, \quad \text{White's test} = 3.29, \quad \text{Jarque-Bera normality test} = 0.11.$$  

where $\hat{\rho}_1$ and $\hat{\rho}_2$ are the first- and second-order autoregressive coefficient estimates with the standard errors of 0.1952 and 0.1837, respectively, and highly significant t-ratios of 6.13 and - 2.98.

Based on the calculated Durbin-Watson statistic, 1.68, the null hypothesis of no first-order autocorrelation problem is accepted at the five percent or lower level of significance. The joint null hypothesis of no first- and higher-order autocorrelation problem is tested based on the LM test. The calculated $\chi^2$-statistic for this test is 2.16 with a P-value of 33.89 percent which is insignificant, leading to the acceptance of the joint null hypothesis and, therefore, supporting the absence of a first- and higher-order autocorrelation problem. In addition, the null hypothesis of homoscedasticity cannot be

---

21 For example, the t-ratios on the coefficient estimates of the first and second lagged residual series in the LM test equation, are, respectively, 4.91 and - 2.00. These are highly significant, implying the existence of a first- and second-order autocorrelation problems. See the methodology section in Chapter 1 for the description of the LM test.
rejected, since, based on the White test, the calculated $\chi^2$-statistic, 3.29 with a P-value of 65 percent, is, again, insignificant. Furthermore, using the Jarque-Bera normality test, the calculated test statistic is 0.11 with a P-value of 94.41 percent. This P-value is well above the ten percent reasonable level of significance, allowing us to accept the null hypothesis that the error term is normally distributed.\footnote{As noted above, we have utilised the rho-transformation technique by including the first- and second-order autoregressive terms in (4.12) to correct for the autocorrelation problem. The regression estimates of (4.12) based on the rho-transformation technique (reported above) are superior to the regression estimates of a more general form of the function for oil GDP.}

Based on the coefficient of determination, $R^2$, 99.7 percent of the total sample variations of the real oil GDP is explained by the explanatory variables. In addition, all the coefficient estimates are significantly different from zero at reasonable levels of significance. As indicated by the coefficient estimate on $\text{REXT}_t$, a one percent increase (decrease) in real exports leads to 1.069 percent increase (decrease) in the oil production measured by the real oil GDP.

### 4.3 The equilibrium condition of the macroeconometric model

Consistent with macroeconomic theory, it is the intersection of the aggregate demand curve and the aggregate supply curve that defines the equilibrium condition in our macroeconometric model of the Saudi economy. This intersection determines the levels of the aggregate demand and supply as well as prices.

As shown in Chapter 3, the real total GDP was determined from the aggregate demand side as follows:

$$RGDP, = RDI, + (REXT, - RIMT,)$$

where $RGDP,$ is the real total GDP, $RDI,$ is the sum of the private and public sectors' demand for consumption and investment goods and services (or the real absorptive capacity), $REXT,$ is the real exports, and $RIMT,$ is the real imports.

From the aggregate supply side, however, the real total GDP, $RGDP,$ consists of the real oil GDP, $RGDPO,$ the non-oil GDP, $RGDPN,$ and the real import duties,
RIMD,\(^2\) With the real import duties taken as exogenous, and having already determined the real oil GDP as a function of the real exports, the equilibrium condition below

\[ \text{RGDP}_t = \text{RGDPN}_t + \text{RGDPO}_t + \text{RIMD}_t \]

will, then, help to determine the real non-oil GDP, essentially, as the difference between the real total and the real oil GDP as follows:

\[ \text{RGDPN}_t = \text{RGDP}_t - \text{RGDPO}_t - \text{RIMD}_t. \]

Accordingly, our macroeconometric model not only satisfies the equilibrium condition (aggregate demand = aggregate supply), but also determines the real non-oil GDP, which, in turn, allows the determination of the non-oil GDP price level, \( \text{PGDPN}_t \), in (4.10). As we shall see in the next section, it is the non-oil GDP price level that will further help to determine the general price level.

### 4.4 The function for the general price level: formulation and estimation

The non-oil supply function in (4.10) basically determines the non-oil GDP price level, \( \text{PGDPN}_t \). In the conclusion section of Chapter 3, however, we indicated that, in order to complete our macroeconometric model, we need to also determine the behaviour of the general price level, \( P_t \).

As already discussed, the general price level in this study is measured by the implicit price deflator of the absorptive capacity (or the income available to the domestic economy) as follows:

\[ P_t = \frac{\text{NDI}_t}{\text{RDI}_t}, \]

where \( \text{NDI}_t \) and \( \text{RDI}_t \) are, respectively, the nominal and real absorptive capacity defined as the sum of the private and public sectors' expenditures on the consumption and investment goods and services as follows:

\(^2\) See for example Table 6 in Achievements of the Development Plans (1998, p. 223)
\[
\text{NDI}_t = \text{NGDP}_t - (\text{NEXT}_t - \text{NIMT}_t)
\]

and
\[
\text{RDI}_t = \text{RGDP}_t - (\text{REXT}_t - \text{RIMT}_t)
\]

where \(\text{NGDP}_t\) and \(\text{RGDP}_t\) are, respectively, the nominal and real total GDP; \(\text{NEXT}_t\) and \(\text{REXT}_t\) are, respectively, the nominal and real exports; and \(\text{NIMT}_t\) and \(\text{RIMT}_t\) are, respectively, the nominal and real imports.

Based on the above definitions, and since the consumption and investment goods and services are partly produced domestically and are partly imported, the general price level, \(P_t\), is, therefore, expected to be influenced by the non-oil price level, \(\text{PGDPN}_t\), and the price level for imports, \(\text{PIM}_t\).

Accordingly, the following function for the general price level is specified:

\[
P_t = a_0 + b_9 \text{PGDPN}_t + c_9 \text{PIM}_t + u_{9t}
\]

where \(u_{9t}\) is an error term. The coefficients \(b_9\) and \(c_9\) measure, respectively, the contribution of the non-oil GDP prices and the import prices to the general price level. These contributions or weights are, however, expected to be positive and add up to one.

The OLS regression estimates of (4.13) for the 1971 - 1994 sample period are as follows (the standard errors are in parentheses and the t-values are in brackets): \(^{24}\)

\[
\begin{align*}
P_t &= 0.050 + 0.818 \text{PGDPN}_t + 0.140 \text{PIM}_t \\
(0.0331) &\quad (0.0714) &\quad (0.0832) \\
\end{align*}
\]

\[R^2 = 0.987,\ DW = 0.90.\]

As seen, the problem with these estimates, as indicated by the calculated Durbin-Watson statistic, 0.90, is a first-order autocorrelation problem (the five percent lower- and upper-bound Durbin-Watson critical values are 1.188 and 1.546). A closer look at the residual plot, however, indicates that the relationship in (4.13) has undergone a

---

\(^{24}\) The real absorptive capacity, real non-oil GDP, real imports, and real exports are all measured in million Saudi Riyals at 1984 constant prices. Accordingly, the price indices, \(P_n\), \(\text{PGDPN}_n\), \(\text{PIM}_n\), and \(\text{PEXT}_n\) are all equal to one for 1984.
downward shift for 1993 - 1994. Accordingly, the dummy variable, $D_{9394}$ (equal to 1.0 for 1993 - 1994, and zero otherwise), is included to account for this shift due mainly to declines in sub-indices for food, fabrics and apparel, house furnishings, medical care, entertainment, and education.\textsuperscript{25}

The inclusion of the dummy variable in (4.13) results in the following function for the general price level:

$$P_t = a_{90} + a_{91} D_{9394} + b_g PGDPN_t + c_g PIM_t + u_t$$

(4.14)

The OLS regression estimates of (4.14) for the sample period of 1971 - 1994 are as follows (the standard errors are in parentheses and the t-values are in brackets):

$$P_t = 0.0001 - 0.104 D_{9394} + 0.757 PGDPN_t + 0.252 PIM_t$$

$$(0.0231) (0.0187) (0.0471) (0.0570)$$

$$[0.01] [-5.56] [16.08] [4.41]$$

$R^2 = 0.995, DW = 1.63, RSS = .010083,$

$LM\ test = 0.81, White's\ test = 6.44, Jarque-Bera\ normality\ test = 5.60.$

These regression estimates no longer suffer from a first-order autocorrelation problem. For example, based on the calculated Durbin-Watson statistic, 1.63, the null hypothesis of no first-order autocorrelation problem is accepted at the lower than five percent level of significance. Furthermore, based on the LM test, the joint null hypothesis of no first- and higher-order autocorrelation problem cannot be rejected. For example, the LM test calculated $\chi^2$-statistic is equal to 0.81 with a $P$-value of 66.83 percent which is highly insignificant, indicating the absence of a first- and higher-autocorrelation problem. The null hypothesis of homoscedasticity is also accepted, since, based on the White test, the calculated $\chi^2$-statistic, 6.44, has an insignificant $P$-value of 27 percent. Furthermore, using the Jarque-Bera test of normality, the null hypothesis that the error term is normally distributed cannot be rejected at the five percent or lower

\textsuperscript{25} See Saudi Arabian Monetary Agency (SAMA), 1994, Statistical Summary, p. 25
levels of significance.\textsuperscript{26, 27}

The above regression estimates indicate that 99.5 percent of the total sample variations in the general price level is explained by the explanatory variables. In addition, the coefficient estimates on all the explanatory variables are significantly different from zero at reasonable levels of significance. Based on these estimates, the contribution of the non-oil GDP price level to the general price level is 75.7 percent. The contribution of the import price level to the general price level, however, equals 25.2 percent. Given the openness of the Saudi economy, the relatively large contribution of the import prices seems reasonable. More specifically, this signifies the dependence of the Saudi economy on imported goods and services in satisfying the private and public sectors' demand for both consumption and investment goods including machineries and raw materials utilised in the process of domestic production.

More interestingly, however, is that the weights on the price indices ($\text{PGDPN}_t$ and $\text{PIM}_t$), as expected, add up to nearly one; or $1.009 = (0.757 + 0.252)$. In testing the null hypothesis $H_0 : b_g + c_g = 1.0$, the calculated F-statistic is found to be $F(1, 20) = 0.20$.\textsuperscript{28} This calculated F-statistic is highly insignificant, since it is well below the ten percent critical F-value of 2.97. This, therefore, leads to the conclusion that the null hypothesis $H_0 : b_g + c_g = 1.0$ cannot be rejected at any reasonable level of significance, and that the general price level is, in fact, a weighted average of the non-oil GDP price level and the import price level.

\textsuperscript{26} In the case of the Philippines, Otani (1975) includes also the export price level as an explanatory variable in the function for the general price level. The inclusion of the export price level, $\text{PEXT}_n$ in either (4.13) or (4.14), however, does not significantly improve the regression estimates. For example, the coefficient estimate of $\text{PEXT}_n$ when included in (4.13) is 0.050 with an insignificant t-ratio of 1.42. The coefficient estimate of $\text{PEXT}_n$ when included in (4.14) is 0.024 with an insignificant t-ratio of 1.02

\textsuperscript{27} For a variant specification of the general price level in the case of Venezuela, see Vaez-Zadeh (1989, p. 353)

\textsuperscript{28} In testing the above null hypothesis, the function for the general price level in (4.14) is respecified by imposing the restriction $b_g = 1 - c_g$. This results in the following restricted function for the general price level:

$$
(P_t - \text{PGDPN}_t) = a_m + a_n D9394 + c_n (\text{PIM}_t - \text{PGDPN}_t) + u_n
$$

(4.15)

The residuals sum squares from estimating this restricted function is, $\text{RSS}^R = 0.010183$. The residuals sum squares from the estimated unrestricted function in (4.14) is $\text{RSS}^U = 0.010083$. Given that the number of restriction, $m$, is one, and the degrees of freedom in the unrestricted function in (4.14), $n - k$, is twenty, based on the following formula:

$$
\text{Calculated } F(m, (n-k)) = \frac{(\text{RSS}^R - \text{RSS}^U)/m}{\text{RSS}^U/(n-k)}
$$

the calculated $F(1,20)$ is 0.20. See Gujarati (1995, p. 258)
4.5 The aggregate supply model: a summary

Because of the distinct nature of production in the oil and non-oil sectors of the Saudi economy, in this chapter we have examined the behaviour of oil and non-oil production separately. In order to conclude this chapter, however, in this section, we shall combine the oil and non-oil sectors to present the complete model of the aggregate supply for the Saudi economy. This is done by bringing together the formulated supply function for the non-oil sector, the formulated function for the real oil GDP, the equilibrium condition from which the real non-oil GDP is determined, the formulated function for the general price level, and the related identities as follows:

1. The non-oil supply function:

   \[ \Delta P_{\text{DPN}} = a_0 + a_1 D7475 + b_7 (\ln R\text{GDP}_{\text{N}}, - \ln R\text{GDP}_{\text{N},*}) + c_7 P_{t}^{*} + u_t \]

2. The non-oil GDP price identity:

   \[ \ln P_{\text{GDP}_{\text{N}}} = \Delta P_{\text{DPN}} + \ln P_{\text{GDP}_{\text{N},1}} \]

3. The normal or long-run level of non-oil output identity:

   \[ R\text{GDP}_{\text{N},*} = \omega R\text{GDP}_{\text{N},1} + \omega(1 - \omega) R\text{GDP}_{\text{N},2} + \omega(1 - \omega)^2 R\text{GDP}_{\text{N},3} \]

4. Inflationary expectations identity:

   \[ P_{t}^{*} = P_{t+1} \]

5. General price inflation rate identity:

   \[ P_{t} = \ln \left( \frac{P_t}{P_{t+1}} \right) \]

6. The function for the real oil GDP:

   \[ R\text{GDP}_{O} = a_{90} + a_{81} D9394 + b_8 R\text{EXT}_t + u_{8t} \]
7. The equilibrium condition:
\[ RGDPN_t = RGDP_t - RGDPo_t - RIMD_t \]

8. The function for the general price level:
\[ P_t = a_{90} + a_{91} D9394 + b_9 PGDPN_t + c_9 PIM_t + u_{9t}. \]

As seen, the above model for the aggregate supply side of the Saudi economy specifies a relationship between the real non-oil GDP, \( RGDP_n \), and the non-oil GDP prices, \( PGDP_n \). Accordingly, with \( PIM_t \), \( REXT_t \), and \( RIMD_t \) being exogenously determined, the above aggregate supply model includes more endogenous variables than equations. Specifically, the model includes eight equations with nine endogenous variables. The endogenous variables are \( PGDPN_n, PGDPN_0, RGDPN_0, P_t^*, P_n^*, RGDPo_n, RGDPN_0, P_n \), and \( RGDP_n \). The first eight endogenous variables are determined based on the specified equations within the aggregate supply model. The last endogenous variable, \( RGDP_n \), however, cannot be endogenously determined in the absence of the aggregate demand model. Accordingly, the subject of the next chapter is to combine the aggregate demand model (presented in the conclusion section of Chapter 3) and the aggregate supply model (presented above) to form the complete macroeconometric model of the Saudi economy. As we shall see, the complete macroeconometric model will include the same number of equations as the number of endogenous variables, and, therefore, allows the endogenous variables, including the absorptive capacity, the non-oil output, the non-oil GDP prices, and the general prices to be simultaneously determined.
Chapter 5.

The complete macroeconometric model

Combining the formulated aggregate demand and aggregate supply models presented in the previous three chapters of this study yields the complete macroeconometric model of the Saudi Arabian economy. Before utilising this model for policy (multiplier) analysis and forecasting, however, it is necessary to check whether it reasonably reflects the economic reality of the Saudi economy over the estimation period of 1971 - 1994. Therefore, it is the purpose of the present chapter to examine the validity or dynamic stability of the complete macroeconometric model. In doing so, the usual approach is to solve the estimated model for the endogenous variables over the estimation period. Such a practice, known as the within-sample or historical simulation, yields the solution or simulated values of the endogenous variables over the estimation period. If the solution or simulated series of the endogenous variables closely follow the corresponding actual series throughout the estimation period, then the macroeconometric model is said to be valid or dynamically stable, and, therefore, one can justify its use for both policy (multiplier) analysis and forecasting.

The outline of this chapter is as follows: after presenting the complete macroeconometric model, the theoretical and internal consistency of the model will be once again examined in Section 5.1. This Section will also distinguish between the endogenous and exogenous variables and further present the flow chart of the model to highlight the interrelationship among the variables. Section 5.2 will investigate the block recursiveness of the model by organising the equations into the non-simultaneous and simultaneous blocks. This is necessary to do, since we need to distinguish between the behavioural equations in the non-simultaneous blocks and the behavioural equations in the simultaneous block. More specifically, the ordinary least squares (OLS) estimates of the behavioural equations in the non-simultaneous blocks are unbiased and consistent, and, therefore, will be in the final estimated version of the macroeconometric model. However, the OLS estimates of the behavioural equations in the simultaneous block

\[1\] From this chapter on, we refer to the variables in our macroeconometric model as either endogenous or exogenous. The endogenous variables are those which are determined within the model, and the exogenous variables are those which are determined by international and political situations outside the model.
violate an important Gauss-Markov theorem assumption due to the simultaneity problem, and, therefore, contain the simultaneity bias. To remove the simultaneous bias, we need to see whether or not these behavioural equations are identified. Once they are shown to be identified, we will then proceed by re-estimating them using the two-stage least squares (TSLS) estimation technique to obtain consistent estimates. These TSLS estimates will replace the corresponding OLS estimates of the behavioural equations in the simultaneous block to form the final estimated version of our macroeconometric model presented in Section 5.3.

Section 5.3 will utilise the final estimates of the macroeconometric model to perform the within-sample or the historical dynamic simulation for the 1971 - 1994 estimation period. In order to check the validity of the model, its performance in terms of dynamic stability will be evaluated based on both graphical and numerical measures. The graphical measures will plot the simulated series of the endogenous variables against the corresponding actual series to see how well the macroeconometric model captures the turning points in the series over the estimation period. The numerical measures, which include the mean error, mean absolute error, correlation coefficient, Theil's inequality coefficient, and the bias, regression, and disturbance proportions, will further help us in the evaluation process.

Based on the evidence presented in this chapter, Section 5.4 will conclude by arguing that the macroeconometric model is, in fact, dynamically stable and therefore can be regarded as a valid model. In other words, it will be argued that our macroeconometric model reasonably replicates the reality of the Saudi economy over the estimation period of 1971 - 1994, and, therefore, it can be utilised for the conduct of both policy (multiplier) analysis and forecasting in the following chapters of this study.

5.1 The specification and theoretical consistency of the model

The specification of the macroeconometric model of the Saudi economy is

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1 On the issues of the simultaneous bias, identification, and the TSLS method of estimation, see the appendix at the end of this chapter.

2 For simulation practices and the usual graphical and numerical measures used for model evaluation, see Chapter 12 of Pindyck and Rubinfeld (1991)
presented in Table 5.1. The model includes eighteen equations, nine of which are behavioural equations and the rest are identities. These equations interrelate with each other to determine eighteen endogenous variables. The model also includes five exogenously determined variables. The dynamic nature of the model is very well pronounced, as the model includes thirteen predetermined variables.4

Our macroeconometric model is theoretically consistent, since it follows the usual aggregate demand - aggregate supply methodology. Given the insignificant role of the interest rate in the Saudi economy, following the monetary approach, the absorptive capacity or the sum of the private and public demand for goods and services is determined by the intersection of the velocity (or money demand) and money supply functions (for example, see equations 1 - 3 in Table 5.1). This, of course, is in contrast to the general approach which formulates the aggregate demand through the intersection of the IS - LM curves.4 The supply of money, however, is partly influenced by such factors as the balance of payments, and government total revenue and expenditure. Therefore, in addition to the monetary sector, the aggregate demand model includes the equations characterising both the foreign and government sectors of the economy (see equations 4 - 10 in Table 5.1).

The aggregate supply model, on the other hand, distinguishes between the oil and non-oil production sectors. The non-oil supply function, following the Phillips curve methodology, is derived through combining the non-oil production and non-oil labour sectors. More specifically, the non-oil supply function relates the non-oil GDP price inflation to the deviations of the non-oil GDP growth from its long-run trend as well as to inflationary expectations (see equations 11 - 15 in Table 5.1). The oil production, however, is mainly determined by the real exports which, in turn, is exogenously determined largely by the international market demand conditions for crude oil and related products as well as the supply conditions based on negotiations by other OPEC countries (see equation 16 in Table 5.1). The intersection of the aggregate demand and aggregate supply curves defines the equilibrium condition. It is from this equilibrium condition that the non-oil output measured by the real non-oil GDP is determined (see

---

4 Predetermined variables include both lagged endogenous and exogenous variables. Out of thirteen predetermined variables, twelve are lagged endogenous variables and one is a lagged exogenous variable.

5 See Chapter Two section 2.1 of this study for the difference between the general approach and the monetary approach in formulating the aggregate demand side of the economy.
equation 17 in Table 5.1). Finally, the non-oil GDP price level determined from equation 11 and 12 helps to determine the general price level based on equation 18.

Table 5.1 also distinguishes between the endogenous and exogenous variables. Our macroeconometric model is said to be internally consistent, since, as seen, the number of the endogenous variables (= 18) equals the number of the equations (= 18). The small number of exogenous variables (= 5) gives additional credence to our macroeconometric model.
Chapter 5: The complete macroeconometric model

### Table 5.1
The specification of the macroeconometric model:

1. The velocity function:
   \[
   \ln V_t = -a_1 \gamma_1 - d_1 \gamma_1 \ln (\text{GOR}_t / \text{GEX}_{t-1}) + (1 - \gamma_1) V_{t-1} + u_{1t}
   \]

2. The money supply function:
   \[
   \Delta M_t = a_{20} + a_{21} D717589 + a_{22} D828392 + b_2 B_{t-1} + c_2 (\text{GEX}_t - \text{GTR}_t) + d_2 \Delta (\text{RGDPN}_t * \text{PGDPN}_t) + u_{2t}
   \]

3. The absorptive capacity identity:
   \[
   \ln \text{RDI}_t = \ln V_t + \ln (M_t / P_t)
   \]

4. The balance of payments identity:
   \[
   B_{Pt} = (\text{REXT}_t * \text{PEXT}_t) - (\text{RIMT}_t * \text{PIM}_t) + \text{CAPE}_t
   \]

5. The demand function for imports:
   \[
   \ln \text{RIMT}_t = a_{30} + a_{31} D9394 + b_3 \ln \text{RDI}_t + c_3 \ln (\text{GOR} / \text{PIM})_t + d_3 \ln (\text{PIM} / \text{PGDPN})_t + u_{3t}
   \]

6. The government total revenue identity:
   \[
   \text{GTR}_t = \text{GOR}_t + \text{GNR}_t
   \]

7. The function for government oil revenue:
   \[
   \ln \text{GOR}_t = a_{40} + a_{41} D9394 + b_{40} \ln \text{REXT}_t + b_{41} \ln \text{REXT}_{t-1} + c_4 \ln \text{PEXT}_t + u_{4t}
   \]

8. The function for government non-oil revenue:
   \[
   \ln \text{GNR}_t = a_{50} + a_{51} D82 + a_{52} \gamma_5 + b_{50} D9394 + b_{51} (\text{RDI}_t * P_t) + (1 - \gamma_5) \text{GNR}_{t-1} + u_{5t}
   \]
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>9.</strong> The function for government expenditure:</td>
<td>( \ln GEX_t = a_6 \gamma_6 + a_6 \gamma_6 D82 + b_6 \gamma_6 \ln GOR_t + (1 - \gamma_6) \ln GEX_{t-1} + u_{6t} )</td>
</tr>
<tr>
<td><strong>10.</strong> The total real GDP identity:</td>
<td>( RGDP_t = RDI_t + (REXT_t - RIMT_t) )</td>
</tr>
<tr>
<td><strong>11.</strong> The non-oil supply function:</td>
<td>( \rho PG D PN_t = a_{70} + a_{71} D7475 + b_7 (\ln RGDPN_t - \ln RGDPN_{t-1}) + c_7 P_t^e + u_{7t} )</td>
</tr>
<tr>
<td><strong>12.</strong> The non-oil GDP price identity:</td>
<td>( \ln PGDPN_t = PG D PN_t + \ln PGDPN_{t-1} )</td>
</tr>
<tr>
<td><strong>13.</strong> The normal or long-run level of non-oil output identity:</td>
<td>( RGDPN_t^* = \omega RGDPN_{t-1} + \omega (1 - \omega) RGDPN_{t-2} + \omega (1 - \omega)^2 RGDPN_{t-3} )</td>
</tr>
<tr>
<td><strong>14.</strong> Inflationary expectations identity:</td>
<td>( P_t^e = P_{t-1} )</td>
</tr>
<tr>
<td><strong>15.</strong> General price inflation rate identity:</td>
<td>( P_t = \ln (P_t / P_{t-1}) )</td>
</tr>
<tr>
<td><strong>16.</strong> The function for the real oil GDP:</td>
<td>( RGDPO_t = a_{80} + a_{81} D9394 + b_8 REXT_t + u_{8t} )</td>
</tr>
<tr>
<td><strong>17.</strong> The equilibrium condition:</td>
<td>( RGDPN_t = RGDP - RGDPO_t - RIMD_t )</td>
</tr>
<tr>
<td><strong>18.</strong> The function for the general price level:</td>
<td>( P_t = a_{90} + a_{91} D9394 + b_9 PGDPN_t + c_9 PIM_t + u_{9t} )</td>
</tr>
</tbody>
</table>
The endogenous variables (in the order determined from the above equations) are:

<table>
<thead>
<tr>
<th>Number</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>$V_t$</td>
<td>Velocity of money (ratio)</td>
</tr>
<tr>
<td>2.</td>
<td>$M_t$</td>
<td>Money supply (M3 definition) in billions of current Saudi riyals</td>
</tr>
<tr>
<td>3.</td>
<td>$RDI_t$</td>
<td>Absorptive capacity or the real income available to the domestic economy in billions of constant (1984) Saudi riyals</td>
</tr>
<tr>
<td>4.</td>
<td>$BP_t$</td>
<td>Balance of payments in billions of current Saudi riyals</td>
</tr>
<tr>
<td>5.</td>
<td>$RIMT_t$</td>
<td>Real imports of goods and services in billions of constant (1984) Saudi Riyals</td>
</tr>
<tr>
<td>6.</td>
<td>$GTR_t$</td>
<td>Government total revenue in billions of current Saudi riyals</td>
</tr>
<tr>
<td>7.</td>
<td>$GOR_t$</td>
<td>Government oil revenue in billions of current Saudi riyals</td>
</tr>
<tr>
<td>8.</td>
<td>$GNR_t$</td>
<td>Government non-oil revenue in billions of current Saudi riyals</td>
</tr>
<tr>
<td>9.</td>
<td>$GEX_t$</td>
<td>Government expenditure in billions of current Saudi riyals</td>
</tr>
<tr>
<td>10.</td>
<td>$RGDP_t$</td>
<td>Real total GDP in billions of constant (1984) Saudi riyals</td>
</tr>
<tr>
<td>11.</td>
<td>$PGDPN_t$</td>
<td>Non-oil GDP price inflation rate (*100 = percent)</td>
</tr>
<tr>
<td>12.</td>
<td>$PGDPN_t$</td>
<td>Non-oil price index (1984 = 1.0)</td>
</tr>
<tr>
<td>13.</td>
<td>$RGDPN_t^*$</td>
<td>Normal or long-run level of real non-oil GDP in billions of constant (1984) Saudi riyals</td>
</tr>
<tr>
<td>14.</td>
<td>$P^e_t$</td>
<td>Expected inflation rate (*100 = percent)</td>
</tr>
<tr>
<td>15.</td>
<td>$P_t$</td>
<td>General price Inflation rate (*100 = percent)</td>
</tr>
<tr>
<td>16.</td>
<td>$RGDPO_t$</td>
<td>Real oil GDP in billions of constant (1984) Saudi riyals</td>
</tr>
<tr>
<td>17.</td>
<td>$RGDPN_t$</td>
<td>Real non-oil GDP in billions of constant (1984) Saudi riyals</td>
</tr>
<tr>
<td>18.</td>
<td>$P_t$</td>
<td>General price index (1984 = 1.0)</td>
</tr>
</tbody>
</table>
### Table 5.1. Continued

#### The exogenous variables are:

1. **REXT**<sub>t</sub> = Real exports of goods and services in billions of constant (1984) Saudi riyals

2. **PEXT**<sub>t</sub> = Export price index (1984 = 1.0)

3. **PIM**<sub>t</sub> = Import price index (1984 = 1.0)

4. **CAPF**<sub>t</sub> = Net capital inflow plus the net of all other factors in the balance of payments (including the deficit or surplus in the service sector of the current account) in billions of current Saudi riyals

5. **RIMD**<sub>t</sub> = Real import duties in billions of constant (1984) Saudi riyals

#### The dummy variables are:

| D717589 | = one for 1971 - 1975 and 1989 - 1990, zero for other years |
| D7475 | = one for 1974 - 1975, zero for other years |
| D828392 | = one for 1982 - 1983 and 1992, zero for other years |
| D82 | = one for 1982, zero for other years |
| D9394 | = one for 1993 - 1994, zero for other years |

**Note:** The values for **RDI**, **RIMT**, **RGDP**, **RGDPN**<sup>0</sup>, **RGDPO**, **RGDPN**<sup>0</sup>, **REXT**, and **RIMD**<sub>t</sub> are in billions of constant (1984) Saudi Riyals. The values for **Mi**, **BP**<sub>i</sub>, **GTR**<sub>i</sub>, **GOR**<sub>i</sub>, **GNR**<sub>i</sub>, **GEX**<sub>i</sub> and **CAPF**<sub>i</sub> are in billions of current Saudi Riyals. The values for **V**<sub>i</sub> are in ratios. The values for **PGDP**<sub>i</sub>, **P**<sup>0</sup>, **P**<sup>0</sup>, **P**<sup>0</sup> are percentages. The values for **PGDP**<sub>i</sub>, **P**<sub>i</sub>, **PEXT**<sub>i</sub> and **PIM**<sub>i</sub> are in index points. The **D717589**, **D7475**, **D828392**, **D82** and **D9394** are dummy variables.
The flow chart of the macroeconometric model is presented in Figure 5.1. It depicts the interrelationships among endogenous and exogenous variables. As seen, this flow chart magnifies the vulnerability of the Saudi economy to the developments in the international market for crude oil. For example, as shown, the exogenous variables including the real exports, $\text{REXT}_t$, and the export price level, $\text{PEXT}_t$, affect both the aggregate demand and aggregate supply sides of the economy. The influence of $\text{REXT}_t$ on the aggregate demand is through its effect on government oil revenue, $\text{GOR}_t$, the balance of payments, $\text{BP}_t$, and the real total GDP, $\text{RGDP}_t$. The influence of $\text{REXT}_t$ on the aggregate supply is through its effect on the real oil GDP, $\text{RGDPO}_t$. The influence of $\text{PEXT}_t$, however, is through its effect on the balance of payments, $\text{BP}_t$, and government oil revenue, $\text{GOR}_t$.

Regional and political instability as it affects the net capital inflow, $\text{CAPF}_t$, is another important exogenous factor in influencing the balance of payments, and, therefore, major economic variables in the Saudi economy (see Figure 5.1). Finally, due to the reliance of the Saudi economy on the imported consumption and investment goods and services, the price of imports, $\text{PIM}_t$, as an exogenous variable, plays an important role. The influence of $\text{PIM}_t$ on the aggregate demand is through its effect on the balance of payments, $\text{BP}_t$, and the real imports, $\text{RIMT}_t$. The influence of $\text{PIM}_t$ on the aggregate supply, however, is through its effect on the general price level, $P_t$. 
Figure 5.1 Flow chart of the macroeconometric model in Table 5.1
5.2 Re-estimation of the model

As seen in Table 5.1, our macroeconometric model consists of nine behavioural equations. The OLS estimates of these behavioural equations were presented in Chapters two through four. These OLS estimates are unbiased and consistent only for those behavioural equations which include only exogenous and/or predetermined variables in the right-hand side. The OLS estimates of the remaining behavioural equations which include one or more endogenous variables in the right-hand side are both biased and inconsistent. To obtain consistent estimates, an alternative method of estimation, known as the two-stage least squares (TSLS), is employed. In order for the TSLS method of estimation to be applicable, however, the behavioural equations in the simultaneous block must be identified (see the example provided in the appendix of this chapter for exploring these issues in more details). In what follows, we take the necessary steps toward re-estimating the behavioural equations in our macroeconometric model which suffer from the simultaneity problem.

5.2.1 Block Recursiveness of the model

Based on the specification of the macroeconometric model in Table 5.1, the equations of the model are divided into three blocks. As shown in Table 5.2, the first block contains the equations which include only exogenous and/or predetermined variables in the right-hand side. That is, the function for government oil revenue in equation 7, the normal or long-run level of non-oil output identity in equation 13, the inflationary expectations identity in equation 14, and the function for the real oil GDP in equation 16. Accordingly, the first block determines the values of the endogenous variables $GOR_0$, $RGDPN'\_0$, $P'\_0$, and $RGDPO\_0$ with no reference to any other endogenous variable.

The second block, however, contains the equations which include on the right hand side not only exogenous and/or predetermined variables but also endogenous variables that are determined in the first block - that is, the velocity function in equation
Chapter 5: The complete macroeconometric model

1 and the function for government expenditure in equation 9. As seen in Table 5.2, the second block determines the values of the endogenous variables $V_t$ and $GEX_t$, however, only after the solution values of the endogenous variables in the first block are obtained. We refer to these two blocks as the non-simultaneous blocks, since the first block contains equations which include exogenous and/or predetermined variables and the second block includes also endogenous variables which are entirely determined by exogenous and predetermined variables.

Of the six equations in the first and second blocks, four are behavioural equations. These are the velocity function in equation 1, the function for government oil revenue in equation 7, the function for government expenditure in equation 9, and the function for the real oil-GDP in equation 16. Since these equations do not suffer from a simultaneity problem, their OLS estimates presented, respectively, in Chapters two, three, and four are unbiased and consistent, and, therefore, will be utilised in the final estimated version of the macroeconometric model for simulation practices.

As indicated in Table 5.2, the twelve remaining equations are included in the third block. This block is referred to as the simultaneous block, since it contains the equations which include, on the right-hand side, at least one endogenous variable other than those determined from the first and second block. The third block, however, determines simultaneously the solution values of the remaining twelve endogenous variables only after the solution values of the endogenous variables in the first and second blocks are determined. Accordingly, our macroeconometric model in Table 5.1 is said to be block recursive, since the solution values of the endogenous variables determined in the third block depend on the solution values of the endogenous variable determined in the second block, and the solution values of the endogenous variables determined in the second block depend on the solution values of the endogenous variables determined in the first block.

Five of the twelve equations in the third block are behavioural equations. These are the function for the money supply in equation 2, the demand function for imports in equation 5, the function for government non-oil revenue in equation 8, the non-oil supply function in 11, and the function for the general price level in equation 18. Since these equations include at least one endogenous variable (other than those determined in the first two blocks) in the right-hand side, their OLS estimates, presented in Chapters two through four of this study, contain the simultaneity bias. To remove the bias, as
indicated by the example in the appendix of this chapter, we need to employ the TSLS estimation technique to re-estimate these behavioural equations. For the TSLS estimation technique to be applicable, however, in what follows we first need to show that these behavioural equation are identified.

Table 5.2.

Block recursiveness of the macroeconometric model

<table>
<thead>
<tr>
<th>Block I: non-simultaneous block</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equation (7) determines $GOR_t$</td>
</tr>
<tr>
<td>Equation (14) determines $P_t^*$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Block II: non-simultaneous block</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equation (1) determines $V_t$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Block III: simultaneous block</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equation (2) determines $M_t$</td>
</tr>
<tr>
<td>Equation (4) determines $BP_t$</td>
</tr>
<tr>
<td>Equation (6) determines $GTR_t$</td>
</tr>
<tr>
<td>Equation (10) determines $RGDP_t$</td>
</tr>
<tr>
<td>Equation (12) determines $PGDPN_t$</td>
</tr>
<tr>
<td>Equation (17) determines $RGDPN_t$</td>
</tr>
</tbody>
</table>
5.2.2 Identification of the behavioural equations in the simultaneous block

The TSLS estimates of a behavioural equation in the simultaneous block are said to exist, if the equation is identified. In order to investigate the identifiability of a behavioural equation, as shown in the appendix of this chapter, one should check to see if the rank and order conditions for identification are satisfied. As explained in the appendix to this chapter, the rank condition tells us whether or not the equation is identified. When the rank condition for the equation is satisfied, then we utilise the order condition to see if the equation is exactly identified or overidentified. In case the rank condition is not satisfied, meaning that the equation is not identified, we do not need to proceed with the order condition.

Based on the results of the rank condition for identification (not reported here because of its complexity), our analysis suggests that all five behavioural equations in the simultaneous are in fact identified. The results of the order condition reported in Table 5.3, however, indicates that these behavioural equations are all overidentified. In this case, the use of TSLS estimation technique (rather than other alternatives such as the Indirect least squares, ILS), is advisable. This is because TSLS, unlike ILS, provides us with a unique set of estimates for each behavioural equation that is overidentified.

Table 5.3.

<table>
<thead>
<tr>
<th>Equation no.</th>
<th>G - 1</th>
<th>K</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. $M_t$</td>
<td>17</td>
<td>27</td>
<td>Overidentified</td>
</tr>
<tr>
<td>5. $RIMT_t$</td>
<td>17</td>
<td>31</td>
<td>Overidentified</td>
</tr>
<tr>
<td>8. $GNR_t$</td>
<td>17</td>
<td>32</td>
<td>Overidentified</td>
</tr>
<tr>
<td>11. $PGDPN_t$</td>
<td>17</td>
<td>32</td>
<td>Overidentified</td>
</tr>
<tr>
<td>18. $P_t$</td>
<td>17</td>
<td>33</td>
<td>Overidentified</td>
</tr>
</tbody>
</table>

Notes: $G$ is the number of endogenous variables in the model, and $K$ is the number of missing variables in the equation. The equation is said to be exactly identified if $K = G - 1$; it is said to be overidentified if $K > G - 1$. 
5.2.3 TSLS estimations of the behavioural equations in the simultaneous block

When employing the TSLS method of estimation, as the example presented in the appendix of this chapter indicates, one should utilise all the exogenous and predetermined variables in the model as the instrumental variables or regressors in the first stage of estimation. Given that our macroeconometric model in Table 5.1 includes five exogenous and thirteen predetermined variables, this practice will not leave us with adequate degrees of freedom (note that the number of observations, n, in our study is only twenty-four). Accordingly, in estimating each behavioural equation in the simultaneous block, we have utilised all or a subset of exogenous variables and, if necessary, a predetermined variable that is highly correlated with the endogenous variable(s) in the right-hand side of the behavioural equation in question.

The TSLS estimates of the five behavioural equations in the simultaneous block are reported in Table 5.4 along with the instrumental variables employed. The corresponding OLS estimates (already obtained in the previous chapters) are also reported in Table 5.4 for the sake of comparison.

The calculated Durbin-Watson statistics for the TSLS estimates of the money supply function, the demand function for imports, the non-oil supply function, and the function for the general price level fall in the no-autocorrelation region. This indicates the absence of a first-order autocorrelation problem in all these equations. Also, based on the calculated Durbin-h statistic, 0.33, which is less than the ten percent critical z-value, 1.282, there exists no first-order autocorrelation problem in the function for government non-oil revenue.

The results from the LM test of serial correlation also reveals the absence of a first- as well as a higher-order autocorrelation problem for the TSLS estimates of all five equations reported in Table 5.4. The null hypothesis of homoscedasticity is tested based on the White test. The calculated $\chi^2$-statistics for this test, again, indicate the absence of a heteroscedasticity problem for the TSLS estimates of all five equations in Table 5.4. Furthermore, the Jarque-Bera normality test is used to test the normality assumption.

---

*See the example in the appendix of this chapter for what is involved in the first and second stages of the TSLS estimation technique.*
Table 5.4.

OL and TSLS estimates of the behavioural equations in the simultaneous block

1. The money supply function

<table>
<thead>
<tr>
<th>Equation</th>
<th>OLS Estimates</th>
<th>TSLS Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta M_t = 7.228 - 5.959 D717589 + 9.328 D828392 + 0.035 BP_t$</td>
<td>$\Delta M_t = 6.958 - 5.820 D717589 + 9.367 D828392 + 0.046 BP_t$</td>
<td></td>
</tr>
<tr>
<td>(.8194) (.9842) (1.262) (.0135)</td>
<td>(.0113) (.0480)</td>
<td></td>
</tr>
<tr>
<td>[8.82] [-6.05] [7.39] [2.56]</td>
<td>[3.79] [3.55]</td>
<td></td>
</tr>
<tr>
<td>$+ 0.043 (GEX_t - GTR_t) + 0.171 \Delta NGDPN_t$</td>
<td>$+ 0.052 (GEX_t - GTR_t) + 0.167 \Delta NGDPN_t$</td>
<td></td>
</tr>
<tr>
<td>(.0113) (.0480)</td>
<td>(.0151) (.0753)</td>
<td></td>
</tr>
<tr>
<td>[3.79] [3.55]</td>
<td>[3.45] [2.22]</td>
<td></td>
</tr>
<tr>
<td>$R^2 = 0.920, DW = 2.26.$</td>
<td>$R^2 = 0.915, DW = 2.15.$</td>
<td></td>
</tr>
<tr>
<td>LM test $= 1.32$, White's test $= 9.55$, Jarque-Bera normality test $= 0.53.$</td>
<td>LM test $= 1.74$, White's test $= 8.20$, Jarque-Bera normality test $= 0.45.$</td>
<td></td>
</tr>
</tbody>
</table>

Note: The instrumental variables used are $NGDPN_t$, $CAPF_t$, $PEXT_t$, $PIM_t$, $REXT_t$, and $RIMD_t$. 


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**Table 5.4. Continued**

### 2. The demand function for imports

**OLS estimates:**

\[
\begin{align*}
\ln RIMT_t &= -0.591 - 0.220 D9394 + 0.811 \ln RDI_t + 0.193 \ln (GOR/PIM)_t \\
& \quad (0.5209) \quad (0.0567) \quad (0.0908) \quad (0.0244) \\
& \quad [-1.13] \quad [-3.87] \quad [8.93] \quad [7.93] \\
& \quad - 0.809 \ln (PIM/PGDPN)_t \\
& \quad (0.1590) \\
& \quad [-5.09]
\end{align*}
\]

\[R^2 = 0.994, \quad DW = 1.81,\]

**LM test = 0.97, White’s test = 8.77, Jarque-Bera normality test = 0.82.**

**TSLS estimates:**

\[
\begin{align*}
\ln RIMT_t &= -0.611 - 0.215 D9394 + 0.810 \ln RDI_t + 0.198 \ln (GOR/PIM)_t \\
& \quad (1.134) \quad (0.0685) \quad (0.1907) \quad (0.0248) \\
& \quad [-0.54] \quad [-3.14] \quad [4.25] \quad [7.99] \\
& \quad - 0.789 \ln (PIM/PGDPN)_t \\
& \quad (0.3723) \\
& \quad [-2.12]
\end{align*}
\]

\[R^2 = 0.994, \quad DW = 1.80,\]

**LM test = 1.13, White’s test = 8.69, Jarque-Bera normality test = 0.97.**

**Note:** The instrumental variables used are PEXTt, PIMt, and REXTt.
### Table 5.4. Continued

#### 3. The function for government non-oil revenue

**OLS estimates:**

\[
\text{GNR}_t = 1.741 + 18.978 \text{D82} - 7.319 \text{D9394} + 0.057 \text{NDI}_t + 0.424 \text{GNR}_{t-1}
\]

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>T-statistic</th>
<th>P-value</th>
<th>Durbin-watson</th>
<th>LM Test</th>
<th>White's Test</th>
<th>Jarque-Bera Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1.593)</td>
<td>(3.862)</td>
<td>(.0130)</td>
<td>(.1048)</td>
<td>4.19</td>
<td>9.28</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>[1.09]</td>
<td>[4.91]</td>
<td>[4.40]</td>
<td>[4.05]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ R^2 = 0.960, \text{ DW} = 1.95, \text{ Durbin-h} = 0.14, \]

**TSLS estimates:**

\[
\text{GNR}_t = 1.559 + 18.808 \text{D82} - 7.581 \text{D9394} + 0.060 \text{NDI}_t + 0.401 \text{GNR}_{t-1}
\]

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>T-statistic</th>
<th>P-value</th>
<th>Durbin-watson</th>
<th>LM Test</th>
<th>White's Test</th>
<th>Jarque-Bera Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1.629)</td>
<td>(3.880)</td>
<td>(0.14)</td>
<td>(0.1131)</td>
<td>4.13</td>
<td>9.15</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>[0.96]</td>
<td>[4.85]</td>
<td>[-2.52]</td>
<td>[4.23]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[3.55]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ R^2 = 0.959, \text{ DW} = 1.89, \text{ Durbin-h} = 0.33, \]

**LM test = 4.13, White's test = 9.15, Jarque-Bera normality test = 0.78.**

**Note:** The instrumental variables used are \text{PEXT}_t, \text{PIM}_t, and \text{REXT}_t.
### 4. The non-oil supply function

**OLS estimates:**

\[ PG_{DPN_t} = -0.016 + 0.205 D7475 \]

\[ (0.0113) \quad (0.0217) \]

\[ [-1.39] \quad [9.46] \]

\[ + 0.503 (\ln RGDPN_t - \ln RGDPN_{t-1}) + 0.318 P^e_t \]

\[ (1.301) \quad (1.030) \]

\[ [3.86] \quad [3.09] \]

\[ R^2 = 0.949, \quad DW = 2.07, \]

**LM test** = 0.53, **White's test** = 6.58, **Jarque-Bera normality test** = 3.36.

---

**TSLS estimates:**

\[ PG_{DPN_t} = -0.016 + 0.205 D7475 \]

\[ (0.0142) \quad (0.0223) \]

\[ [-1.13] \quad [9.20] \]

\[ + 0.508 (\ln RGDPN_t - \ln RGDPN_{t-1}) + 0.315 P^e_t \]

\[ (1.787) \quad (1.295) \]

\[ [2.84] \quad [2.43] \]

\[ R^2 = 0.949, \quad DW = 2.06, \]

**LM test** = 0.48, **White's test** = 6.64, **Jarque-Bera normality test** = 3.34.

**Note:** The instrumental variables used are CAPF, and PIM.
Table 5.4. Continued

5. The function for the general price level

**OLS estimates:**

\[ P_t = 0.0001 - 0.104 D_{9394} + 0.757 \ \text{PGDP}_t + 0.252 \ \text{PIM}_t \]

\[
\begin{array}{cccc}
(0.0231) & (0.0187) & (0.0471) & (0.0570) \\
0.01 & -5.56 & 16.08 & 4.41 \\
\end{array}
\]

\[ R^2 = 0.995, \ DW = 1.63, \]

**LM test** = 0.81, **White's test** = 6.44, **Jarque-Bera normality test** = 5.60.

**TSLS estimates:**

\[ P_t = -0.009 - 0.107 D_{9394} + 0.727 \ \text{PGDP}_t + 0.286 \ \text{PIM}_t \]

\[
\begin{array}{cccc}
(0.0269) & (0.0193) & (0.0649) & (0.0766) \\
\end{array}
\]

\[ R^2 = 0.995, \ DW = 1.58, \]

**LM test** = 1.18, **White's test** = 8.35, **Jarque-Bera normality test** = 3.09.

**Note:** The instrumental variables used are \text{CAPF}_t, \text{PEXT}_t, and \text{REXT}_t.
According to the calculated Jarque-Bera normality test statistics reported in Table 5.4, the null hypothesis of normality cannot be rejected for any of the equations. This, therefore, leads to the conclusion that the error terms in all five equations are normally distributed.

In addition, the TSLS coefficient estimates of the independent variables in all five behavioural equations have the theoretically correct signs and are also significantly different from zero at reasonable levels of significance (that is, ten percent or lower). These TSLS estimates are also compared with their corresponding OLS estimates. This comparison leads us to the conclusion that the TSLS coefficient estimates are similar to their corresponding OLS estimates. It is, however, noted that the TSLS coefficient estimates are free of simultaneity bias and, therefore, are preferable to the OLS coefficient estimates. Accordingly, in what follows, we utilise these TSLS coefficient estimates for evaluating the performance of the complete macroeconometric model in replicating the reality of the Saudi economy based on a historical or within-sample simulation practice. In addition, these TSLS coefficient estimates will be utilised to perform both policy (or multiplier) analysis and forecasting, respectively, in Chapters Six and Seven of this study.

5.3 The within sample or historical dynamic simulation of the model: 1971-1994

The macroeconometric model of the Saudi Arabian economy with consistent estimates is reported in Table 5.5. Since the values of the exogenous variables are given, this estimated model is, in fact, a system of eighteen equations with eighteen unknowns or endogenous variables. Utilising the MicroTSP statistical package, this system of equations is dynamically solved for the endogenous variables over the 1971-1994 sample period, a practice known as the within sample or historical simulation.7

To be more specific, using an iteration technique, the system of equations is solved to give the solution or simulation values of the endogenous variables for 1971. In this case, the lagged endogenous (or predetermined) variables take their actual values

7 See the MicroTSP User's Manual by Hall, Johnston, and Lilien (1990, Chapter 18) for more information on simulation practices.
from previous years. When solving the system of equations to obtain the solution values of the endogenous variables for 1972, the one-year lagged endogenous variables take their 1971 solution values instead of their corresponding 1971 actual values. When solving the system of equations to obtain the solution values of the endogenous variables for 1973, the one- and two-year lagged endogenous variables take their 1971 and 1972 solution values instead of their corresponding 1971 and 1972 actual values. This process, called a dynamic simulation, is continued until the solution values of the endogenous variables are obtained for 1994. In other words, the system of equations in Table 5.5 is solved twenty four times, providing us with the solution or simulated series of the endogenous variables for the 1971-1994 estimation period. In what follows, we utilise both graphical and numerical measures to compare these simulated series with their corresponding actual series to judge how well the model replicates the reality of the economy for the estimation period of 1971 – 1994.

Table 5.5.

The macroeconometric model with consistent estimates: 1971-1994

1. \[ \ln V_t = 0.201 + 0.140 \ln \left( \frac{\text{GOR}_t}{\text{GEX}_{t-1}} \right) + 0.804 \ln V_{t-1} \]

2. \[ \Delta M_t = 6.958 - 5.820 \text{D717589} + 9.367 \text{D828392} + 0.046 B_{P_t} \]
   \[ + 0.052 \left( \text{GEX}_t - \text{GTR}_t \right) + 0.167 \Delta \text{NGDPN}_t \]

3. \[ \ln \text{RDI}_t = \ln V_t + \ln \left( \frac{M_t}{P_t} \right) \]

4. \[ B_{P_t} = (\text{REXT}_t \ast \text{PEXT}_t) - (\text{RIMT}_t \ast \text{PIM}_t) + \text{CAPF}_t \]

5. \[ \ln \text{RIMT}_t = -0.611 - 0.215 \text{D9394} + 0.810 \ln \text{RDI}_t + 0.198 \ln \left( \frac{\text{GOR}}{\text{PIM}} \right)_t \]
   \[ -0.789 \ln \left( \frac{\text{PIM}}{\text{PGDPN}} \right)_t \]

6. \[ \text{GTR}_t = \text{GOR}_t + \text{GNR}_t \]
<table>
<thead>
<tr>
<th>Equation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.</td>
<td>$\ln GOR_t = -2.284 - 0.355 D9394 + 0.632 \ln REXT_t + 0.735 \ln REXT_{t-1}$ + 1.010 $\ln PEXT_t$</td>
</tr>
<tr>
<td>8.</td>
<td>$GNR_t = 1.559 + 18.808 D82 - 7.581 D9394 + 0.060 NDI_t + 0.401 GNR_{t-1}$</td>
</tr>
<tr>
<td>9.</td>
<td>$\ln GEX_t = 0.080 - 0.430 D82 + 0.357 \ln GOR_t + 0.670 \ln GEX_{t-1}$</td>
</tr>
<tr>
<td>10.</td>
<td>$RGDP_t = RDI_t + (REXT_t - RIMT_t)$</td>
</tr>
<tr>
<td>11.</td>
<td>$PGDPN_t = -0.016 + 0.205 D7475 + 0.508 (\ln RGDPN_t - \ln RGDPN_{t-1})$ + 0.315 $P_{t-1}^e$</td>
</tr>
<tr>
<td>12.</td>
<td>$\ln PGDPN_t = PGDPN_t + \ln PGDPN_{t-1}$</td>
</tr>
<tr>
<td>13.</td>
<td>$RGDPN_t^* = 0.70 RGDPN_{t-1} + 0.21 RGDPN_{t-2} + 0.063 RGDPN_{t-3}$</td>
</tr>
<tr>
<td>14.</td>
<td>$P_{t-1}^e = P_t^e$</td>
</tr>
<tr>
<td>15.</td>
<td>$P_t = \ln(P_t/P_{t-1})$</td>
</tr>
<tr>
<td>16.</td>
<td>$RGDPO_t = -27.34 + 20.536 D9394 + 1.069 REXT_t$</td>
</tr>
<tr>
<td>17.</td>
<td>$RGDPN_t = RGDP_t - RGDPO_t - RIMD_t$</td>
</tr>
<tr>
<td>18.</td>
<td>$P_t = -0.009 - 0.107 D9394 + 0.727 PGDPN_t + 0.286 PIM_t$</td>
</tr>
</tbody>
</table>

Notes: The behavioural equations in (1), (7), (9), and (16) are estimated using the OLS estimation technique, since they do not suffer from a simultaneity problem. The behavioural equations in (2), (5), (8), (11), and (18), which fall in the simultaneous block, are estimated using TSLS (see Tables 5.2 and 5.4).
5.3.1 Evaluating the performance of the model: a graphical measure

As already discussed, due to the inclusion of the lagged endogenous variables, our macroeconometric model is dynamic in nature. Therefore, the historical simulation over the estimation period 1971 to 1994 is a dynamic one. That is, while the exogenous variables use their historical values, the lagged endogenous variables use their solution values instead of their historical (or actual) values. This practice, therefore, has the ability to distinguish between models that are stable over time and those that are inherently explosive. For example, in the latter models, the dynamic simulation errors accumulate and eventually result in the simulated series permanently departing from the corresponding actual series. This situation, however, is unlikely to happen for models that are dynamically stable over time. Based on this argument, therefore, a graphical evaluation of the performance of our macroeconometric model becomes essential.\(^8\)

The dynamic historical simulation results of the macroeconometric model in Table 5.5 are shown graphically in Figure 5.2 through 5.19. In these figures, the actual and simulated series for each endogenous variable are plotted on the same axes. Looking at these time plots, we observe that, for all the endogenous variables, the simulated series reasonably reproduce the general long-run behaviour of the actual series. This may lead us to conclude that our macroeconometric model is dynamically stable over time, since none of the simulated series have the tendency to permanently depart from their corresponding actual series.

In addition, in many cases, the simulated series tend to capture the short-run fluctuations in the actual series. In other words, the simulated series tend to reproduce the turning points in the actual series in many cases, and, therefore, has the ability to explain the short-run behaviour of the endogenous variables. Such evidence, however, gives more credence to the validity of our macroeconometric model.

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\(^8\) See Pindyck and Rubinfeld (1991, pp. 343 – 346) for the graphical evaluation of a simple macroeconometric model.
Figure 5.2: Money velocity (V₁) ratio 1971-1994: Actual – vs. Simulated ...
Figure 5.6: Real imports (RMIT) in billions of constant (1984) $\bar{S}$. 1971-1994: Actual vs. Simulated...
Figure 5.10: Government expenditure (GEX) in billions of current SR 1971-1994. Actual vs. Simulated.
Figure 5.12: Non-oil price inflation rate (PGDPN_t*100), in percent 1971-1994: Actual – vs. Simulated ...
Figure 5.13: Non-oil price index (PGDPN), 1984 = 1.0 (1971-1994): Actual vs. Simulated...
Figure 5.14: Normal or long-run level of real non-oil GDP ($\text{RGDP}_n^*$) in billions of constant (1984) $\text{SR}$ 1971-1994: Actual – vs. Simulated...
Figure 5.15: Inflationary expectations (P*100), in percent 1971-1994: Actual vs. Simulated...
Figure 5.16: General price inflation rate ($P_t$, 100), in percent 1971-1994: Actual vs. Simulated...
Figure 5.17: Real oil GDP (RGDPO) in billions of constant (1984) SR 1971-1994: Actual – vs. Simulated...
5.3.2 Evaluating the performance of the model: numerical measures

The visual comparison of the simulated and actual series of the endogenous variables, covered in the previous section, should be accompanied with some numerical measures to quantify the simulation error. In what follows, we first explain how the numerical measures employed in this study work and then explain what they have to say about the performance of our macroeconometric model.

1. **Mean simulation error**: This measures the deviation of the simulated series from its actual time path on the average and is computed as follows:

\[
\text{Mean simulation error} = \frac{1}{n} \sum_{i=1}^{n} (S_i - A_i)
\]  

where \( S_i \) and \( A_i \) represent, respectively, the simulated and actual values of the endogenous variable, and \( n \) is the number of periods in the simulation (which, in our case, is twenty four, 1971 - 1994). Positive mean simulation error indicates over-simulation on the average, while negative mean simulation error indicates under-simulation. For a good model, however, the size of this error is expected to be close to zero for all endogenous variables.

2. **Mean absolute simulation error**: One problem with the mean simulation error in (5.1) is that it may be close to zero but with large positive errors cancelling out large negative errors. To investigate the existence of this problem, we utilise the mean absolute simulation error. The formula for this measure is as follows:

\[
\text{Mean absolute simulation error} = \frac{1}{n} \sum_{i=1}^{n} |S_i - A_i|
\]

where, for a good model, the magnitude of this error should be small relative to the average size of the endogenous variable in question. Systematic over- and under-simulation is indicated when the mean simulation error (in absolute value) is of the same or similar size as the mean absolute simulation error.
3. **Correlation coefficient:** Another measure of accuracy is the correlation coefficient between the simulated and actual series of the endogenous variable in question. For a good model, the correlation coefficient is expected to be near to one. One disadvantage with this measure is that it does not account for systematic over- or under-simulation. For example, a model which over- or under-simulates the actual series by, say 50%, throughout the period will receive a perfect score.

4. **Theil's inequality coefficient:** Unlike the correlation coefficient, Theil's inequality coefficient (Theil, 1966) penalises systematic linear bias (that is, systematic over- or under-simulation). The formula for this measure is as follows:

\[
\text{Theil's inequality coefficient} = \left( \sqrt{\frac{\sum_{i=1}^{n} (S_i - A_i)^2}{n}} \right) / \left( \sqrt{\frac{\sum_{i=1}^{n} A_i^2}{n}} \right)
\]

where the numerator is actually the root mean square simulation error. Given the denominator, Theil's inequality coefficient falls between zero and one. For a good model, when the simulated values, \(S_n\), are very close to the actual values, \(A_n\), the root mean square simulation error is close to zero, and therefore, Theil's inequality coefficient is expected to be close to zero. On the other hand, if Theil's inequality coefficient is equal to unity, then the performance of the model in simulating the reality is as bad as it possibly could be.\(^9\)

5. **Bias, regression, and disturbance proportions:**

Consider the regression of actual on simulated values

\[
A_t = \alpha + \beta S_t + \epsilon_t, \quad (5.3)
\]

where \(\epsilon_t\) is the error or disturbance term. In order for the simulated series, \(S_n\), to accurately represent the actual series, \(A_n\), the estimated value of \(\alpha\) is expected to be close to zero and the estimated value of \(\beta\) is expected to be close to one. In addition to reporting these estimates, we will report the mean square error (MSE) decomposition \(U^M\), \(U^R\), and \(U^D\), known as, respectively, the bias, regression, and disturbance

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\(^9\) For more information, also see Maddala (1977, pp. 346 - 347)
Chapter 5: The complete macroeconometric model

proportions.

Theil (1966) shows that the mean square error

$$\text{MSE} = \frac{\sum_{t=1}^{n} (S_t - A_t)^2}{n}$$

can be written as

$$\text{MSE} = (\bar{S} - \bar{A})^2 + (S_s - rS_A)^2 + (1 - r^2)S_A^2$$  \hspace{1cm} (5.4)

where $\bar{S}$ and $\bar{A}$ are, respectively, the mean values of the simulated and actual series; $S_s$ and $S_A$ are, respectively, the standard deviations of the simulated and actual series; and $r$ is the correlation coefficient between the simulated and actual series.

Dividing both sides of (5.4) by MSE, we then have

$$1 = \frac{(\bar{S} - \bar{A})^2}{\text{MSE}} + \frac{(S_s - rS_A)^2}{\text{MSE}} + \frac{(1 - r^2)S_A^2}{\text{MSE}}$$  \hspace{1cm} (5.5)

with the first, second, and third terms on the right hand side of (5.5), representing the bias, $U^M$, regression, $U^R$, and disturbance, $U^D$, proportions. This, further, indicates that these proportions add up to one:

$$U^M + U^R + U^D = 1.$$  \hspace{1cm} (5.6)

The bias proportion indicates the extent to which the magnitude of the MSE is due to a systematic over- or under-simulation. For a good model, this proportion tends to be zero. More specifically, $U^M = 0$ means that the estimated value of $\alpha$ in (5.3) is close to zero. For a good model, the regression proportion should also tend to zero. That is, $U^R = 0$ means that the estimated value of $\beta$ in (5.3) is close to one. In conclusion, for the optimal simulation, both $U^M$ and $U^R$ should tend to zero which implies that the disturbance proportion, $U^D$, should tend to one.\(^\text{10}\)

\(^\text{10}\) For more information, see Maddala (1977, pp. 344-345)
In addition to the mean values of the actual and simulated series of the endogenous variables, Table 5.6 reports the above defined numerical measures for all the endogenous variables. According to these results, for each endogenous variable, the mean error and the mean absolute error relative to the mean value of the endogenous variable are very small. For example, the mean value of the real absorptive capacity, $RDI_t$ is 282.4 billion Saudi riyals for the 1971 – 1994 sample period, while the mean error and the mean absolute error are 0.20 and 14.4 billion Saudi riyals, respectively. As another example, the mean value of the general price level, $P_t$ is 0.826 index points for the 1971 – 1994 sample period, while the mean error and the mean absolute error are 0.007 and 0.031 index points, respectively. The same conclusion follows for all other endogenous variables.

Based on the calculated correlation coefficients between the actual and simulated series, we can conclude that these series for all endogenous variables move together very closely, a conclusion that was also reached based on the time plots of the actual and simulated series in Figures 5.2 – 5.19. For example, the lowest correlation coefficient is 0.904, which belongs to non-oil GDP price inflation, $PG_{DPN_t}$. This conclusion based on the calculated correlation coefficients can be further supported when examining the calculated Theil’s inequality coefficients. For example, as seen in all cases, the calculated Theil’s inequality coefficients are a lot closer to zero than one, indicating, again, that the simulated series closely fluctuate around their corresponding actual series.
### Table 5.6.

**Evaluation of historical simulation: 1971 - 1994**

<table>
<thead>
<tr>
<th></th>
<th>$V_t$</th>
<th>$M_t$</th>
<th>$RDI_t$</th>
<th>$BP_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean of actual series</strong></td>
<td>3.167</td>
<td>110.3</td>
<td>282.4</td>
<td>10.43</td>
</tr>
<tr>
<td><strong>Mean of simulated series</strong></td>
<td>3.136</td>
<td>111.1</td>
<td>282.6</td>
<td>11.15</td>
</tr>
<tr>
<td><strong>Mean error</strong></td>
<td>-0.031</td>
<td>0.736</td>
<td>0.2</td>
<td>0.726</td>
</tr>
<tr>
<td><strong>Mean absolute error</strong></td>
<td>0.157</td>
<td>3.7</td>
<td>14.4</td>
<td>9.70</td>
</tr>
<tr>
<td><strong>Correlation coefficient</strong></td>
<td>0.988</td>
<td>0.998</td>
<td>0.989</td>
<td>0.967</td>
</tr>
<tr>
<td><strong>Theil's inequality coefficient</strong></td>
<td>0.055</td>
<td>0.035</td>
<td>0.057</td>
<td>0.262</td>
</tr>
<tr>
<td><strong>Regression coefficient of actual on simulated series (i.e., $\beta$ in eq. 5.3)</strong></td>
<td>1.015</td>
<td>0.998</td>
<td>1.054</td>
<td>0.918</td>
</tr>
<tr>
<td><strong>Bias proportion, $U^M$</strong></td>
<td>0.028</td>
<td>0.024</td>
<td>0.000</td>
<td>0.003</td>
</tr>
<tr>
<td><strong>Regression proportion, $U^R$</strong></td>
<td>0.009</td>
<td>0.001</td>
<td>0.107</td>
<td>0.104</td>
</tr>
<tr>
<td><strong>Disturbance proportion, $U^P$</strong></td>
<td>0.963</td>
<td>0.975</td>
<td>0.893</td>
<td>0.893</td>
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</table>
### Table 5.6. Continued

<table>
<thead>
<tr>
<th></th>
<th>RIMₜ</th>
<th>GTRₜ</th>
<th>GORₜ</th>
<th>GNRₜ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of actual series</td>
<td>112.5</td>
<td>144.9</td>
<td>116.2</td>
<td>28.62</td>
</tr>
<tr>
<td>Mean of simulated series</td>
<td>111.9</td>
<td>144.5</td>
<td>116.0</td>
<td>28.48</td>
</tr>
<tr>
<td>Mean error</td>
<td>-0.662</td>
<td>-0.39</td>
<td>-0.2</td>
<td>-0.14</td>
</tr>
<tr>
<td>Mean absolute error</td>
<td>9.66</td>
<td>13.49</td>
<td>11.827</td>
<td>3.18</td>
</tr>
<tr>
<td>Correlation coefficient</td>
<td>0.979</td>
<td>0.971</td>
<td>0.967</td>
<td>0.974</td>
</tr>
<tr>
<td>Theil's inequality coeff.</td>
<td>0.099</td>
<td>0.121</td>
<td>0.141</td>
<td>0.113</td>
</tr>
<tr>
<td>Regression coeff. of actual on simulated series (i.e., β in eq. 5.3)</td>
<td>1.117</td>
<td>0.970</td>
<td>0.968</td>
<td>1.040</td>
</tr>
<tr>
<td>Bias proportion, U&lt;sup&gt;M&lt;/sup&gt;</td>
<td>0.003</td>
<td>0.000</td>
<td>0.000</td>
<td>0.001</td>
</tr>
<tr>
<td>Regression proportion, U&lt;sup&gt;R&lt;/sup&gt;</td>
<td>0.203</td>
<td>0.015</td>
<td>0.016</td>
<td>0.027</td>
</tr>
<tr>
<td>Disturbance proportion, U&lt;sup&gt;D&lt;/sup&gt;</td>
<td>0.794</td>
<td>0.985</td>
<td>0.984</td>
<td>0.972</td>
</tr>
<tr>
<td></td>
<td>$GEX_t$</td>
<td>$RGDP_t$</td>
<td>$PGD{PNN}_t$</td>
<td>$PGDPN_t$</td>
</tr>
<tr>
<td>------------------------------</td>
<td>---------</td>
<td>----------</td>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Mean of actual series</td>
<td>160.9</td>
<td>397.0</td>
<td>0.082</td>
<td>0.784</td>
</tr>
<tr>
<td>Mean of simulated series</td>
<td>159.1</td>
<td>397.8</td>
<td>0.084</td>
<td>0.794</td>
</tr>
<tr>
<td>Mean error</td>
<td>-1.8</td>
<td>0.8</td>
<td>0.002</td>
<td>0.010</td>
</tr>
<tr>
<td>Mean absolute error</td>
<td>19.98</td>
<td>9.4</td>
<td>0.034</td>
<td>0.027</td>
</tr>
<tr>
<td>Correlation coefficient</td>
<td>0.953</td>
<td>0.991</td>
<td>0.904</td>
<td>0.995</td>
</tr>
<tr>
<td>Theil's inequality coefficient</td>
<td>0.150</td>
<td>0.027</td>
<td>0.341</td>
<td>0.039</td>
</tr>
<tr>
<td>Regression coefficient of actual on simulated series (i.e., $\beta$ in eq. 5.3)</td>
<td>0.922</td>
<td>1.008</td>
<td>1.029</td>
<td>1.008</td>
</tr>
<tr>
<td>Bias proportion, $U^M$</td>
<td>0.004</td>
<td>0.005</td>
<td>0.002</td>
<td>0.090</td>
</tr>
<tr>
<td>Regression proportion, $U^R$</td>
<td>0.065</td>
<td>0.003</td>
<td>0.003</td>
<td>0.006</td>
</tr>
<tr>
<td>Disturbance proportion, $U^D$</td>
<td>0.931</td>
<td>0.992</td>
<td>0.995</td>
<td>0.904</td>
</tr>
</tbody>
</table>
## Table 5.6. Continued

<table>
<thead>
<tr>
<th></th>
<th>$\text{RGDPN}_t^*$</th>
<th>$\tilde{\text{P}}_t^c$</th>
<th>$\text{P}_t^0$</th>
<th>$\text{RGDPO}_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of actual series</td>
<td>160.7</td>
<td>0.067</td>
<td>0.066</td>
<td>217.1</td>
</tr>
<tr>
<td>Mean of simulated series</td>
<td>160.5</td>
<td>0.069</td>
<td>0.068</td>
<td>217.2</td>
</tr>
<tr>
<td>Mean error</td>
<td>-0.251</td>
<td>0.002</td>
<td>0.002</td>
<td>0.1</td>
</tr>
<tr>
<td>Mean absolute error</td>
<td>9.082</td>
<td>0.026</td>
<td>0.027</td>
<td>5.7</td>
</tr>
<tr>
<td>Correlation coefficient</td>
<td>0.992</td>
<td>0.925</td>
<td>0.927</td>
<td>0.994</td>
</tr>
<tr>
<td>Theil's inequality coefficient</td>
<td>0.061</td>
<td>0.324</td>
<td>0.325</td>
<td>0.030</td>
</tr>
<tr>
<td>Regression coefficient of actual on simulated series (i.e., $\beta$ in eq. 5.3)</td>
<td>1.102</td>
<td>1.139</td>
<td>1.139</td>
<td>1.001</td>
</tr>
<tr>
<td>Bias proportion, $U^M$</td>
<td>0.001</td>
<td>0.002</td>
<td>0.003</td>
<td>0.000</td>
</tr>
<tr>
<td>Regression proportion, $U^R$</td>
<td>0.331</td>
<td>0.081</td>
<td>0.083</td>
<td>0.000</td>
</tr>
<tr>
<td>Disturbance proportion, $U^D$</td>
<td>0.668</td>
<td>0.917</td>
<td>0.914</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>$RGDPN_t$</td>
<td>$P_t$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>----------</td>
<td>-------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean of actual series</td>
<td>176.5</td>
<td>0.826</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean of simulated series</td>
<td>177.2</td>
<td>0.833</td>
<td></td>
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</tr>
<tr>
<td>Mean error</td>
<td>0.7</td>
<td>0.007</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean absolute error</td>
<td>11.9</td>
<td>0.031</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation coefficient</td>
<td>0.980</td>
<td>0.993</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theil's inequality coefficient</td>
<td>0.072</td>
<td>0.040</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression coefficient of actual on</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>simulated series (i.e., $\beta$ in eq. 5.3)</td>
<td>1.069</td>
<td>1.014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bias proportion, $U^M$</td>
<td>0.003</td>
<td>0.042</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression proportion, $U^R$</td>
<td>0.094</td>
<td>0.012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disturbance proportion, $U^D$</td>
<td>0.903</td>
<td>0.946</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The results based on the mean square error decomposition also confirm the high quality performance of the historical simulation of the model. For example, for all endogenous variables, the calculated bias proportion, $U^M$, is very close to zero (the highest value of $U^M$ is 0.090 which belongs to the non-oil GDP price level). According to these results, the fraction of the simulation error due to the difference of the intercept, $\alpha$ in equation (5.3) from zero is very negligible. That is, the simulated series, as also indicated in Figures 5.2 – 5.19 do not systematically over-simulate or under-simulate the actual series.

The calculated regression proportion, $U^R$, is also a lot closer to zero than one for all endogenous variables. This, in turn, indicates that the fraction of the simulation error due to the difference of the slope, $\beta$, in equation (5.3) from one is small. This can also be seen from the estimated values of $\beta$, reported in Table 5.6, which are very close to unity for all endogenous variables. For example, the estimated value of $\beta$ ranges from 0.918 to 1.139. Again, these results point to the high quality performance of the historical simulation of our macroeconometric model.

With the calculated bias and regression proportions, $U^M$ and $U^R$, closer to zero than one, the calculated disturbance proportion, $U^D$, by construction,\textsuperscript{11} happens to be closer to unity than zero for all endogenous variables. This, in turn, indicates that the fraction of the simulation error due to the non-randomness of the error term, $e_n$, in equation (5.3) is small.

In general, the numerical evaluation results reported in Table 5.6 reinforces the conclusion already reached based on the graphical evidence in Figures 5.2 – 5.19. That is, our macroeconometric model is dynamically stable over time and has the ability to reasonably replicate the reality of the Saudi Arabian economy over the estimation period 1971 – 1994. This, as we shall argue, justifies the use of the estimated macroeconometric model reported in Table 5.5 for both the policy (multiplier) analysis and forecasting.

\textsuperscript{11} For example see the identity in (5.6), derived from the mean square error decomposition, indicating that $U^M + U^R + U^D = 1$
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5.4 Summary and conclusion

The purpose of this chapter was first to bring together the equations and identities which were derived in Chapters Two-Four to form the specification of our macroeconometric model of the Saudi Arabian economy. As the second step, the theoretical and internal consistency of the macroeconometric model was examined based on the aggregate demand and aggregate supply methodology. As the third step, after distinguishing between the endogenous and exogenous variables, the equations were organised into the simultaneous and non-simultaneous blocks. The behavioural equation in the simultaneous block were, then, re-estimated using the TSLS method of estimation to correct for the simultaneous bias contained in the corresponding OLS coefficient estimates.

As the fourth step, the TSLS estimates were utilised to perform the within-sample or the historical simulation. That is, the complete macroeconometric model was solved dynamically for the endogenous variables throughout the whole 1971 – 1994 estimation period. As the final step, the validity of the model was examined by evaluating its performance in terms of dynamic stability using both the graphical and numerical measures. The evaluation of the model based on the graphical measures reveals that the simulated series of the endogenous variables closely move together with their respective actual series. Such evidence was used to conclude that the model is stable over the estimation sample period. Furthermore, the results based on the numerical measures utilised in the evaluation process add more credence to the validity of our macroeconometric model. For example, it was shown that, for all endogenous variables, the mean error and mean absolute error were both small relative to the mean value of the actual series. Based on the calculated coefficient correlation and Theil's inequality coefficient, the simulated series were also shown to be highly correlated with the actual series with no tendency of systematic over- or under-simulation. The high quality of the historical simulation was further supported based on the calculated bias and regression proportions which were sufficiently closer to zero than one, and the calculated disturbance proportion which was sufficiently closer to one than zero for each endogenous variable.

Accordingly, we have concluded that our macroeconometric model reasonably
replicates the reality of the Saudi economy over the 1971 – 1994 estimation period. Assuming that the economy remains stable and follows a pattern similar to that in the past, our estimated macroeconometric model in Table 5.5 can be utilised to derive the dynamic multipliers and response of the endogenous variables to changes in the model’s exogenous variables. This will be done in Chapter Six of this study. Under the same assumption, the estimated macroeconometric model will be utilised in Chapter Seven to forecast the future movements of the endogenous variables into the year 2005 based on different scenarios regarding the quantity and price of oil exports as well as the price of imports.
Simultaneity bias, TSLS estimation and identification: an example

Consider the following demand, supply, and price functions for a particular commodity such as wheat:

\[ Q^d_t = \alpha_1 + \alpha_2 P_t + \alpha_3 Y_t + e_{it} \quad \alpha_2 < 0, \quad \alpha_3 > 0 \quad (5.7) \]

\[ Q^s_t = \beta_1 + \beta_2 P_t + e_{2t} \quad \beta_2 > 0 \quad (5.8) \]

\[ P_t = P_{t-1} + (Q^d_t - Q^s_t) \quad (5.9) \]

where \( Q^d_t \) and \( Q^s_t \) are, respectively, the quantities of wheat demanded and supplied, \( P_t \) is the price; \( Y_t \) is the income of potential customers; \( e_{it} \) and \( e_{2t} \) are two independent white noise error terms. All variables are in index points.

The endogenous variables are \( Q^d_t \), \( Q^s_t \), and \( P_t \); \( Y_t \) is the exogenous variable; and \( P_{t-1} \) is a predetermined or lagged endogenous variable which is essentially exogenous, since its value in period \( t-1 \) is given. The demand and supply functions are behavioural equations, while the equation for the price is written, for simplicity, in the form of an identity. Consistent with the economic theory, the demand function is negatively sloped and the supply function is positively sloped. According to the price equation, the price in this period will be above the price in the previous period, if there exists an excess demand; that is \( Q^d_t > Q^s_t \). In case of an excess supply, \( Q^s_t > Q^d_t \), the price in this period will be below the price in the previous period. There will be no change in the price, if the quantity demanded is equal to the quantity supplied; that is, \( Q^d_t = Q^s_t \).

Both the demand and supply functions include an endogenous variable, \( P_t \), in the right-hand side. This means that the OLS estimates of \( \alpha_1 \), \( \alpha_2 \) and \( \alpha_3 \) in the demand function are biased and inconsistent, since the Gauss-Markov theorem assumption that the independent variable(s) must be uncorrelated with the error term is violated; that is, \( \text{cov} (P_t, e_{it}) \neq 0 \). The same is true for the supply function, since it includes an endogenous variable, \( P_t \), in the right-hand side. This, again, means that the OLS estimates of \( \beta_1 \) and \( \beta_2 \) in the supply function are biased and inconsistent, since the Gauss-
Markov theorem assumption that the independent variable(s) must be uncorrelated with the error term is violated; that is, \( \text{cov} (P_t, e_t) \neq 0 \).

To obtain consistent estimates, an alternative method of estimation, known as the two-stage least squares (TSLS) estimation technique, is employed. As the name indicates, this estimation technique involves two stages. The first stage regresses the endogenous variable(s) on the right hand side on all exogenous and predetermined variables in the model using OLS. In this example, \( P_t \) is the endogenous variable on the right-hand side of the demand and supply equations in (5.7) and (5.8). Therefore, in the first stage, we need to regress the endogenous variable \( P_t \) on the exogenous and predetermined variables \( Y_t \) and \( P_{t-1} \)

\[
P_t = \gamma_0 + \gamma_1 Y_t + \gamma_3 P_{t-1} + e_t
\]

to obtain the fitted values of \( P_t \), denoted \( \hat{P}_t \), as follows

\[
\hat{P}_t = \hat{\gamma}_0 + \hat{\gamma}_1 Y_t + \hat{\gamma}_2 P_{t-1}.
\]

The second stage for the demand function involves replacing for \( P_t \) on the right-hand side of (5.7) by \( \hat{P}_t \)

\[
Q_t = \alpha_1 + \alpha_2 \hat{P}_t + \alpha_3 Y_t + e_{1t}
\]

and estimating (5.10) using OLS to obtain the TSLS estimates of \( \alpha_1, \alpha_2 \) and \( \alpha_3 \). These TSLS estimates are consistent, since \( \hat{P}_t \), unlike \( P_t \), is a deterministic function of the exogenous and predetermined variables \( Y_t \) and \( P_{t-1} \), and, therefore, it is no longer correlated with the error term in the demand function; that is, \( \text{cov} (\hat{P}_t, e_t) = 0 \).

The second stage for the supply function involves replacing for \( P_t \) on the right-hand side of (5.8) by \( \hat{P}_t \)

\[
Q_t = \beta_1 + \beta_2 \hat{P}_t + e_{2t}
\]
and estimating (5.11) using OLS to obtain the TSLS estimates of $\beta_1$ and $\beta_2$. These TSLS estimates are consistent, since, again, $\hat{P}_t$, unlike $P_t$, is a deterministic function of the exogenous and predetermined variables $Y_t$ and $P_{t-1}$, and, therefore, it is no longer correlated with the error term in the supply function; that is, $\text{cov}(\hat{P}_t, \epsilon_t) = 0$.

The identification problem arises if the demand function in (5.10) and/or the supply function in (5.11) cannot be estimated due to a perfect multicollinearity problem. This problem does not happen with either the demand and supply function in the above example, and, therefore, the TSLS estimates of $\alpha$'s and $\beta$'s exists. For instance, $\hat{P}_t$ is not perfectly correlated with $Y_t$ which allows (5.10) to be estimatable. Similarly, $\hat{P}_t$ is the only independent variable in (5.11), eliminating the possibility of a perfect multicollinearity problem, and therefore allows (5.11) to be estimatable. In this case, we say that both the demand and supply function are identified, since we can obtain the TSLS estimates of $\alpha$'s and $\beta$'s.

The demand function would have failed to be identified, if it also included $P_{t-1}$ as an explanatory variable. In this case, (5.7) would have been

$$Q_t = \alpha_0 + \alpha_1 P_t + \alpha_2 Y_t + \alpha_3 \epsilon_t$$

and therefore, (5.10) would have been

$$Q_t = \alpha_0 + \alpha_1 \hat{P}_t + \alpha_2 Y_t + \alpha_3 \epsilon_t$$

or

$$Q_t = \alpha_0 + \alpha_1 (\hat{\gamma}_0 + \hat{\gamma}_1 Y_t + \hat{\gamma}_2 P_{t-1}) + \alpha_2 Y_t + \alpha_3 \epsilon_t$$

As seen from (5.13), the demand function in (5.12) suffers from a perfect multicollinearity problem, and the TSLS estimates of $\alpha$'s cannot be obtained.

In practice, when the model includes many equations, it becomes difficult to visually examine the identifiability of the behavioural equations. In this situation, one

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12 For a description of a perfect multicollinearity problem, see the methodology section in Chapter 1 of this study.
should make use of the rank and order conditions. For example, for an equation to be identified the rank condition must be satisfied. To explain what the rank condition is, we follow Maddala\textsuperscript{13} to create the following table for the original model in (5.7) through (5.9):

\[
\begin{array}{c|ccccc}
\text{Equation} & Q'_t & Q'_t & P_t & Y_t & P_{t+1} \\
\hline
\text{Demand eq.} & x & 0 & x & x & 0 \\
\text{Supply eq.} & 0 & x & x & 0 & 0 \\
\text{Price eq.} & x & x & x & 0 & x \\
\end{array}
\]

In this table, "x" indicates that the equation includes the corresponding variable, and "0" indicates that the equation does not include the corresponding variable.

In order to do the rank condition, we delete the row corresponding to the equation in question and pick up the columns corresponding to the elements that have zeros in that row. The equation is said to be identified, if and only if we can form from these columns a matrix of rank \((G - 1)\); where \(G\) is the number of endogenous variables.

Accordingly for the demand function, we delete the first row and pick up the columns corresponding to missing variables \(Q'_t\) and \(P_{t+1}\). The columns are

\[
\begin{bmatrix}
 x \\
 x \\
\end{bmatrix}
\]

The rank of this matrix is 2. Therefore, the demand function is identified, since \((G - 1)\) is also equal to 2.

For the supply function, we delete the second row and pick up the columns corresponding to missing variables \(Q'_t\), \(Y_t\), and \(P_{t+1}\). The columns are

\[
\begin{bmatrix}
 x & x \\
 x & 0 \\
\end{bmatrix}
\]

The rank of this matrix is, again, 2. This means that the supply function is also

\textsuperscript{13} See Maddala (1977, pp. 223 – 225)
identified, since \((G - 1)\) is also equal to 2.

Once the rank condition confirms that the equations are identified, then the order condition can be utilised to tell us whether they are exactly identified or over-identified. Based on the order condition, the equation in question is said to be exactly identified if \(K = (G - 1)\); where \(K\) is the number of the missing variables in the equation. The equation is said to be over-identified, if \(K > (G - 1)\).

Based on the order condition, the demand equation is exactly identified (that is, \(K = 2\) and \(G - 1 = 2\)), while the supply function is over-identified (for example, \(K = 3\) and, again, \(G - 1 = 2\)). Over-identification of the supply function means that if we use such a method of estimation as indirect least squares (ILS)\(^{14}\) instead of TSLS to obtain consistent estimates, then we will have two different sets of estimates for the coefficients \(\beta_1\) and \(\beta_2\) in the supply function. In such situations, therefore, it is advantageous to utilise TSLS which yields a unique set of estimates for the coefficients rather than ILS which yields multiple sets of estimates.

\(^{14}\) The indirect least squares (ILS) estimation technique is an alternative method of estimation which, like TSLS, yields consistent estimates. The use of ILS is justifiable only if the equation is exactly identified. See Gujarati (1995, pp. 682 - 686)
In the previous chapter, we showed that our macroeconometric model satisfactorily replicates the reality of the Saudi Arabian economy for the estimation period of 1971-1994. As already discussed, this justifies the use of our macroeconometric model in the derivation of the dynamic multiplier effects of the exogenous variables. Consequently, in this chapter, we shall concentrate on deriving and analysing the dynamic multiplier effects on major endogenous macroeconomic variables of a change in three “key” exogenous variables. These are the price of (oil) exports, $\text{PEXT}_t$, the real (oil) exports, $\text{REXT}_t$, and the price of imports, $\text{PIM}_t$.

Since we are concerned with the most recent part of the estimation period, the 1990-1994 sample period is chosen for the multiplier analysis under consideration. For each exogenous variable, we calculate and analyse both the short-run multiplier effects and the long-run (or cumulative) multiplier effects.

The outline of this chapter is as follows: Section 6.1 reports and analyses the short-run and long-run (or cumulative) dynamic multiplier effects of a ten percent increase in the price of (oil) exports in the major endogenous variables. The short-run and long-run (or cumulative) dynamic multiplier effects of a ten percent increase in the real (oil) exports in the major endogenous variables are reported and analysed in Section 6.2. Section 6.3 reports and analyses the short-run and long-run (or cumulative) dynamic multiplier effects of a ten percent decrease in the price of imports on the major endogenous variables. Section 6.4 concludes by summarising the findings of this chapter.

6.1 Price of (oil) exports multiplier effects

In this section we shall analyse the short-run and long-run (or cumulative) effects of a ten percent increase in the price of exports, $\text{PEXT}_t$, on the endogenous variables. As previously discussed, the real exports largely include crude oil and oil
refinery products. Therefore, we may utilise the price deflator index for exports, $PEXT_t$, as a proxy for the price of oil exports.

6.1.1 Short-run multiplier effects

In order to calculate the short-run dynamic multiplier effects of the price of (oil) exports, we take the following three steps:

The first step is to simulate the estimated macroeconometric model in Table 5.5 for 1990-1994 and retain the solution values of the endogenous variables. These values are referred to as the solution values of the endogenous variables in the absence of the change in the price of (oil) exports.

The second step is to find the solution values of the endogenous variables after the change in the price of (oil) exports. That is, we increase the price of exports, $PEXT_t$, by ten percent above its actual value in 1990, and then simulate the estimated macroeconometric model in Table 5.5 for 1990-1994 to find and then retain the solution values of the endogenous variables. These values are referred to as the solution values of the endogenous variables in the presence of the ten percent increase in the price of (oil) exports.

The third step is to calculate for each endogenous variable the dynamic multiplier effects of the ten percent increase in the price of (oil) exports. This is done by subtracting the solution values of the endogenous variable in the absence of the change in the price of exports from their corresponding solution values in the presence of the ten percent increase in the price of exports. These dynamic multipliers are referred to as the short-run dynamic multiplier effects of a ten percent increase in the price of (oil) exports on the endogenous variables which are calculated and reported in Table 6.1.
Table 6.1.

Short-run dynamic multiplier effects of the price of exports

<table>
<thead>
<tr>
<th>Period</th>
<th>RDIt</th>
<th>RGDPNt</th>
<th>RGDOt</th>
<th>RGDPN*It</th>
<th>RIMTt</th>
<th>BPt</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.790</td>
<td>0.979</td>
<td>0.000</td>
<td>0.000</td>
<td>3.838</td>
<td>13.48</td>
</tr>
<tr>
<td>1</td>
<td>2.583</td>
<td>1.434</td>
<td>0.000</td>
<td>0.686</td>
<td>1.149</td>
<td>-1.512</td>
</tr>
<tr>
<td>2</td>
<td>1.270</td>
<td>0.546</td>
<td>0.000</td>
<td>1.209</td>
<td>0.726</td>
<td>-0.959</td>
</tr>
<tr>
<td>3</td>
<td>0.542</td>
<td>0.258</td>
<td>0.000</td>
<td>0.745</td>
<td>0.284</td>
<td>-0.376</td>
</tr>
<tr>
<td>4</td>
<td>0.192</td>
<td>0.074</td>
<td>0.000</td>
<td>0.386</td>
<td>0.118</td>
<td>-0.156</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period</th>
<th>Mt</th>
<th>DEFt</th>
<th>GExt</th>
<th>GTrt</th>
<th>GOrt</th>
<th>GNRt</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.543</td>
<td>-6.144</td>
<td>5.910</td>
<td>12.05</td>
<td>11.72</td>
<td>0.338</td>
</tr>
<tr>
<td>1</td>
<td>0.836</td>
<td>4.149</td>
<td>4.516</td>
<td>0.367</td>
<td>0.00</td>
<td>0.367</td>
</tr>
<tr>
<td>2</td>
<td>0.791</td>
<td>3.253</td>
<td>3.539</td>
<td>0.286</td>
<td>0.00</td>
<td>0.286</td>
</tr>
<tr>
<td>3</td>
<td>0.796</td>
<td>2.064</td>
<td>2.248</td>
<td>0.184</td>
<td>0.00</td>
<td>0.184</td>
</tr>
<tr>
<td>4</td>
<td>0.778</td>
<td>1.309</td>
<td>1.412</td>
<td>0.103</td>
<td>0.00</td>
<td>0.102</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period</th>
<th>Vt</th>
<th>PG DPNt</th>
<th>PGDPNt</th>
<th>P</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.025</td>
<td>0.207</td>
<td>0.002</td>
<td>0.001</td>
<td>0.138</td>
</tr>
<tr>
<td>1</td>
<td>0.012</td>
<td>0.220</td>
<td>0.004</td>
<td>0.003</td>
<td>0.143</td>
</tr>
<tr>
<td>2</td>
<td>0.003</td>
<td>-0.121</td>
<td>0.003</td>
<td>0.002</td>
<td>-0.077</td>
</tr>
<tr>
<td>3</td>
<td>-0.002</td>
<td>-0.141</td>
<td>0.002</td>
<td>0.001</td>
<td>-0.080</td>
</tr>
<tr>
<td>4</td>
<td>-0.004</td>
<td>-0.087</td>
<td>0.001</td>
<td>0.001</td>
<td>-0.065</td>
</tr>
</tbody>
</table>

Note: The numbers 0, 1, 2, 3, and 4 refer to the immediate, following first, following second, following third, and following fourth period, respectively. The values for the first five endogenous variables reported above, RDIt, RGDPNt, RGDOt, RGDPN*It, and RIMTt, are in billions of constant (1984) Saudi Riyals. The values for the next seven endogenous variables reported above, BPt, Mt, (GExt - GTrt), GExt, GTrt, GOrt, and GNRt, are in billions of current Saudi Riyals. The values for Vt, are in ratios. The values for PG DPNt, P, and P, are percentages. The values for PGDPNt, and P, are in index points. See Table 5.1 for the definition of the variables.
More specifically, the first row of Table 6.1 reports the difference between the 1990 solution values of the endogenous variable after and before the ten percent increase in the price of (oil) exports, these values are referred to as the immediate period effects. The second row reports the difference between the 1991 solution values after and before the ten percent increase in the price of (oil) exports. These values are referred to as the following first period effects. Finally, the last row reports the difference between the 1994 solution values after and before the ten percent increase in the price of (oil) exports. These values are referred to as the following fourth period effects.

According to the calculations in Table 6.1, a ten percent increase in the price of (oil) exports, while increasing the nominal exports, boosts the government oil revenue by SR 11.72 billion in the immediate period. This, in turn, partially encourages the demand for real imports. With the price of imports unchanged, the increase in the exports dominates the increase in imports, resulting in an increase surplus in the balance of payments by SR 13.48 billion.

The increase in the government oil revenue by SR 11.72 billion also encourages the government expenditure by SR 5.910 billion in the immediate period. The increase in the government total revenue, however, dominates the increase in the government expenditure, resulting in a reduction in the government deficit by SR 6.144 billion.

The effect of the increase in the balance of payments on the money supply, however, dominates the effect of the reduction in the government deficit. This, in addition to the growth in the nominal non-oil GDP, increases the money supply by SR 0.543 billion in the immediate period. The effect of the increase in the money supply in encouraging the real absorptive capacity is reinforced by the increase in the velocity of the money. As a result, the real absorptive capacity increases by SR 4.790 billion in the immediate period. This increase in the absorptive capacity or the aggregate demand for consumption and investment goods and services is satisfied by both the

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1 As also indicated in the footnote of Table 6.1, the first five variables in Table 6.1, RDIₙ, RGDPNₙ, RGDPOn, RGDPNₙ*, and RIMT, are in real terms, and, therefore, are in billions of constant (1984) Saudi Riyals. The second seven variables in Table 6.1, BPₙ, Mₙ(GEXₙ - GTRₙ), GEXₙ, GTRₙ, GORₙ, and GNRₙ, are in nominal terms, and, therefore are in billions of current Saudi Riyals. In order to distinguish between these two quantities, in the text, we use SR to indicate “billions of constant (1984) Saudi Riyals”, and SR to indicate “billions of current Saudi Riyals.”
increase in the real imports by SR 3.838 billion and the increase in the real non-oil GDP by SR 0.979 billion in the immediate period. As seen, the increase in the real non-oil GDP is far less than the increase in the real imports, indicating that the increase in the aggregate demand is largely met by importing consumption and investment goods and services rather than necessary demand for the domestic non-oil production.

The increase in the real non-oil GDP relative to the normal or long-run level of non-oil GDP, however, increases the non-oil GDP price level by 0.002 index points. This, in turn, increases the general price level by 0.001 index points in the immediate period. This increase in the general price level means an increase in the rate of inflation by 0.138 percent which, in turn, reflects itself in an increase of 0.138 percent in the inflationary expectations in the following first period.

More specially, in the following first period, when the ten percent increase in the price of oil exports is no longer in effect, there is no increase in the government oil revenue. As a result, the increase in the total government revenue is mainly due to the increase in the government non-oil revenue by only SR 0.367 billion following the increase in the non-oil GDP. On the other hand, however, the increase in the government expenditure by SR 4.516 billion continue to be substantial, resulting in an increase in the government deficit by SR 4.149 billions.

Furthermore, because of the absence of the ten percent increase in the price of oil exports in the following first period, the balance of payments declines by SR 1.512 billion. This is because the nominal exports remain unchanged, while the real imports continue to increase by SR 1.149 billion. The effect of this reduction in the balance of payments on the money supply, however, is dominated by the effect of the increase in the government deficit. This, in addition to the increase in the non-oil GDP, increases the money supply by SR 0.836 billion. The effect of the increase in the money supply in encouraging the real absorptive capacity is, again, reinforced by the increase in the velocity of money. The increase in the velocity, however, is not as large as that in the immediate period, as the increase in government expenditure relative to the revenue eases public expectations about the liquidity constraint. As a result, the real absorptive capacity increases but by only SR 2.583 billion in the following first period which is far less than the increase of SR 4.790 billion in the immediate period.
This increase in the absorptive capacity or the aggregate demand for consumption and investment goods and services is met by the increase in real imports by SR 1.149 billion and the increase in real non-oil GDP by SR 1.434 billion. It is noted that, unlike for the immediate period, the share of the non-oil domestic production relative to imports in satisfying the increase in the aggregate demand is larger in the following first period. This is because of the absence of the ten percent increase in the price of (oil) exports which leaves the government oil revenue unchanged, and, therefore, adversely affects the ability of the economy to import.

The increase in the real non-oil GDP by SR 1.434 billion, however, dominates the increase in the normal or long-run level of non-oil GDP by SR 0.686 billion. This, in addition to the increase in the inflationary expectations by 0.138 percent, increases the non-oil GDP price level by 0.004 index points and the general price level by 0.003 index points in the following first period. The increase in the general price level, again, means an increase in the rate of inflation by 0.143 percent which, in turn, reflects itself in an increase of 0.143 percent in the inflationary expectations in the following second period.

In the absence of the ten percent increase in the price of (oil) exports in the following second period, again, the government oil revenue is unchanged. Accordingly, the increase in the total government revenue is mainly due to the increase in the government non-oil revenue by only SR 0.286 billion, which is far less than the increase in the government expenditure by SR 3.539 billion. This leads to an increase in the government deficit by SR 3.253 billion.

On the other hand, in the absence of the ten percent increase in the price of (oil) exports, the nominal exports is unchanged, and, therefore, with the increase in the real imports by SR 0.726, the balance of payments continues to decline by SR 0.959 billion in the following second period. The effect of this reduction in the balance of payments on the money supply, however, is dominated by the effect of the increase in the government deficit. This, in addition to the increase in the non-oil GDP, leads to an increase in the money supply by SR 0.791 billion. The effect of the increase in the money supply in encouraging the real absorptive capacity is, again, reinforced by the increase in the velocity of the money. The increase in the velocity, however, is not as large as that in the immediate or the following first period. As a result, the increase in the real absorptive capacity by SR 1.270 billion is lower than that in the following first
period. This increase in the absorptive capacity or the aggregate demand for consumption and investment goods and services is met by both the increase in the real imports by SR 0.726 billion and the increase in the real non-oil GDP by SR 0.546 billion.

This increase in the real non-oil GDP, however, is lower than the increase in the normal or long-run level of non-oil GDP by SR 1.209 billion. This puts a downward pressure on the non-oil GDP price level. This downward pressure, however, is dominated by the effect of the increase in the inflationary expectations by 0.143 percent, leading to an increase in the non-oil GDP price level by 0.003 index points and the general price level by 0.002 index points in the following second period. This increase in the general price level is below the corresponding increase in the following first period, resulting in a decline in the rate of inflation by 0.077 percent. This decline, then, reflects itself in a decline in the inflationary expectations by 0.077 percent in the following third period.

In the absence of the ten percent increase in the price of (oil) exports in the following third and fourth periods, again, the government oil revenue stays unchanged. The increase in the total government revenue, due to the increase in the government non-oil revenue, continues to be dominated by the increase in the government expenditure, leading to further increase in the government deficit.

The effect of these increases in the government deficit on the money supply dominate the effects of the continuing declines in the balance of payments. These, in addition to the increase in the non-oil GDP, increase the money supply in the following third and fourth periods. The effects of money supply increases in encouraging the real absorptive capacity are partially frustrated by the declines in the velocity of the money (the declines in the velocity follow the increases in government expenditure which ease the public expectations about the liquidity constraint). As a result, the increase in the real absorptive capacity in the following third and fourth periods (by SR 0.542 billion and SR 0.192 billion, respectively) continue to be much smaller than those in the previous periods. These increases in the absorptive capacity or the aggregate demand for consumption and investment goods, however, are almost equally met by both the increases in the real imports and by the domestic non-oil production.
The increases in the real non-oil GDP in the following third and fourth periods, again, are less than the corresponding increases in the normal or long-run level of non-oil GDP, putting downward pressures on the non-oil GDP price levels. These downward pressures, however, are reinforced by the declines in the inflationary expectations, leading the non-oil GDP price level to decline in the following third and fourth periods. As a result, the general price level, and, therefore, the rate of inflation continue to decline in these periods.

6.1.2 Long-run multipliers (or cumulative) effects

In order to calculate the long-run (or cumulative) dynamic multiplier effect, we take the following three steps:

The first step is to simulate the estimated macroeconometric model in Table 5.5 for 1990-1994 and retain the solution values of the endogenous variables. These values are referred to as the solution values of the endogenous variables in the absence of the ten percent increase in the price of (oil) exports.

The second step is to find the solution values of the endogenous variables after the change in the price of (oil) exports. Accordingly, we first increase the price of exports, PEXTr, by ten percent above its actual value in 1990, and unlike for the short-run multipliers, we keep this increase in effect for 1991-1994. Then we simulate the estimated macroeconometric model in Table 5.5 for 1990-1994 to find and then retain the solution values of the endogenous variables. These values are referred to as the solution values of the endogenous variables in the presence of the ten percent increase in the price of (oil) exports.

The third step is to calculate for each endogenous variable the dynamic multiplier effects of the ten percent increase in the price of (oil) exports. This is done by subtracting the solution values of the endogenous variable in the absence of the change in the price of exports from their corresponding solution values in the presence of the change in the price of exports. These dynamic multipliers are referred to as the long-run (or cumulative) dynamic multiplier effects of a ten percent increase in the
price of (oil) exports on the endogenous variable which are calculated and reported in Table 6.2.²

### Table 6.2.

**Long-run dynamic multiplier effects of the price of exports**

<table>
<thead>
<tr>
<th>Period</th>
<th>RDI&lt;sub&gt;t&lt;/sub&gt;</th>
<th>RGDPN&lt;sub&gt;t&lt;/sub&gt;</th>
<th>RGDPO&lt;sub&gt;t&lt;/sub&gt;</th>
<th>RGDPN*&lt;sub&gt;t&lt;/sub&gt;</th>
<th>RIMT&lt;sub&gt;t&lt;/sub&gt;</th>
<th>BP&lt;sub&gt;t&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.790</td>
<td>0.979</td>
<td>0.000</td>
<td>0.000</td>
<td>3.838</td>
<td>13.48</td>
</tr>
<tr>
<td>1</td>
<td>8.354</td>
<td>2.607</td>
<td>0.000</td>
<td>0.686</td>
<td>5.747</td>
<td>14.83</td>
</tr>
<tr>
<td>2</td>
<td>10.73</td>
<td>3.260</td>
<td>0.000</td>
<td>2.030</td>
<td>7.450</td>
<td>13.05</td>
</tr>
<tr>
<td>3</td>
<td>12.40</td>
<td>5.405</td>
<td>0.000</td>
<td>2.891</td>
<td>6.982</td>
<td>11.17</td>
</tr>
<tr>
<td>4</td>
<td>12.34</td>
<td>5.280</td>
<td>0.000</td>
<td>4.632</td>
<td>7.060</td>
<td>11.14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period</th>
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<th>GTR&lt;sub&gt;t&lt;/sub&gt;</th>
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**Note:** See the notes in Table 6.1

² Simple cumulative sums using the values in Table 6.1 should give the correct cumulative multiplier effects if the model is linear in terms of variables. However, since our model is non-linear (for example, it includes logarithmic equations), simple linear cumulative sums will not give the correct multiplier effects (see Pindyck and Rubinfeld, 1991, p.378). Therefore, in order to find the correct cumulative multiplier effects, we follow the procedure outlined in the text.
As it should be, the immediate period multiplier effects reported in Table 6.2 are the same as those in Table 6.1, and, therefore, have the same interpretation as that given above.

In the following first period, however, with the ten percent increase in the price of (oil) exports in effect, the nominal exports continues to increase and boosts the government oil revenue by SR 15.49 billion in the following first period. This, in turn, partially encourages the demand for real imports, with the price of imports unchanged, the increase in the exports dominates the increase in imports, resulting in an increase in the balance of payments by SR 14.83 billion.

The increase in the government oil revenue by SR 15.49 billion in addition to the increase in the government expenditure in the immediate period encourages the government expenditure in the following first period by SR 12.36 billion. This increase in the government expenditure, however, is dominated by the increase of SR 16.27 billion in the government total revenue. This results in a reduction in the government deficit by SR 3.908 billion.

The effect of the increase in the balance of payments on the money supply, however, dominates the effect of the reduction in the government deficit. This, in addition to the growth in the nominal non-oil GDP, increases the money supply by SR 1.459 billion in the following first period. The effect of the increase in the money supply in encouraging the real absorptive capacity is reinforced by the increase in the velocity of the money. As a result, the real absorptive capacity increases by SR 8.354 billion in the following first period. This increase in the absorptive capacity is satisfied by both the increase in real imports by SR 5.747 billion and the increase in the real non-oil GDP by SR 2.607 billion.

The increase in the real non-oil GDP dominates the increase in the normal or long-run level of non-oil GDP, and, therefore, increases the non-oil GDP price level by 0.007 index points. This, in turn, increases the general price level by 0.005 index points in the following first period. This increase in the general price level means an increase in the rate of inflation by 0.320 percent which, in turn, reflects itself in an increase of 0.320 percent in the inflationary expectations in the following second period.
The above analysis for the following first period can be repeated to analyse the following second period multiplier effects. Unlike the immediate, first, and second period, however, in the following third and fourth periods, the government expenditure dominates the government total revenue, resulting in an increase in the government deficit. This reinforces the effect of the increase in the balance of payments on the money supply, resulting in faster increases in the money supply in the following third and fourth periods. The effect of money supply increases on the real absorptive capacity, however, is partly frustrated by the slower increases in the velocity of money. In any event, the real absorptive capacity increases by SR 12.40 billion in the following third period which is satisfied by a SR 5.405 billion increase in the real non-oil GDP and by a SR 6.982 billion increase in the real imports. The real absorptive capacity increase by SR 12.34 billion in the following forth period which, again, is satisfied by a SR 5.28 billion increase in the real non-oil GDP and by a SR 7.060 billion increase in the real imports. As seen, the increases in the real absorptive capacity are more equally satisfied by the increases in the real non-oil GDP and real imports in the following third and fourth periods than in previous periods. For example, as reported in Table 6.2 the increases in the real absorptive capacity in the immediate, following first and second periods are largely satisfied by the increases in the real imports than the increases in the real non-oil GDP.

6.2 Real (oil) exports multiplier effects

In this section, we shall analyse the short-run and long-run (or cumulative) effects on the endogenous variables of a ten percent increase in the real exports, \( \text{REXT}_t \). As previously mentioned, the real exports largely include crude oil and oil refinery products. Therefore, we may utilise the real exports as a proxy for the quantity of oil exports.
Chapter 6: Derivation and analysis of dynamic multipliers

6.2.1 Short-run multiplier effects

In order to calculate the short-run dynamic multiplier effects of a ten percent increase in the real exports on the endogenous variables, the estimated macroeconometric model in Table 5.5 is simulated for 1990-1994 both before and after an increase in the real exports by ten percent above its historical value in 1990. The difference between the solution values of the endogenous variables after and before the ten percent increase in the real exports are calculated and reported in Table 6.3. We refer to these values as the short-run dynamic multiplier effects of a ten percent increase in the real exports on the endogenous variables.

Based on these calculated short-run multipliers in Table 6.3, a ten percent increase in the real exports encourages oil production and, therefore, increases the real oil GDP by SR 22.03 billion in the immediate period. This increase, on the aggregate supply side, matches the increase in the aggregate demand as the real net exports increases by SR 19.472 billion and the real absorptive capacity increases by SR 3.507 billion.

More specifically, the ten percent increase in the real exports increases the government oil revenue by SR 7.197 billion in the immediate period. This partially increases the real imports by SR 2.562 billion. This increase in imports, however, is dominated by the increase in exports, leading to an increase of SR 15.09 billion in the balance of payments.

The increase in the real exports though increasing the government oil revenue encourages the government expenditure by SR 3.673 billion. This increase in the government expenditure, however, is below the SR 7.448 billion increase in the government total revenue, leading to a reduction in the government deficit by SR 3.775 billion in the immediate period.

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3 It should be noted that, in calculating the short-run and long-run dynamic multipliers for the real exports, the macroeconometric model in Table 5.5 is slightly altered. That is, the equation for the real oil GDP (equation 16) is replaced by an identity which makes the real oil GDP equal to the real exports. This is necessary to do in order to avoid complications in interpretations, due to the slight difference between the two variables when the behavioural equation for the real oil GDP is utilised.
Table 6.3.

Short-run dynamic multiplier effects of real exports

<table>
<thead>
<tr>
<th>Period</th>
<th>RDI_t</th>
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<th>RGDPN*_t</th>
<th>RIMT_t</th>
<th>BP_t</th>
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<td>0.000</td>
<td>2.562</td>
<td>15.09</td>
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<th>DEF_t</th>
<th>GEX_t</th>
<th>GTR_t</th>
<th>GOR_t</th>
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</table>

Note: See the notes in Table 6.1
The effect of the increase in the balance of payments on the money supply, however, dominates the effect of the reduction in the government deficit. This, in addition to the growth in the nominal non-oil GDP, increases the money supply by SR 0.727 billion in the immediate period. The effect of the increase in the money supply in encouraging the real absorptive capacity is reinforced by the increase in the velocity of money. As a result, the real absorptive capacity increases by SR 3.507 billion in the immediate period. This increase in the absorptive capacity or the aggregate demand for consumption and investment goods and services is satisfied by the increase in the real imports by SR 2.562 billion and the real non-oil GDP by SR 0.947 billion in the immediate period.

The increase in the real non-oil GDP relative to the normal or long-run level of non-oil GDP, however, increases the non-oil GDP price level by 0.002 index points. This, in turn, increases the general price level by 0.001 index points in the immediate period. The increase in the general price level means an increase in the rate of inflation by 0.140 percent which reflects itself in an increase of 0.140 percent in the inflationary expectations in the following first period.

More specially, in the following first period, the ten percent increase in the real exports is no longer in effect. However, due to the distributed effects of the real exports on the government oil revenue, the ten percent increase in the real exports in the immediate period increases the government oil revenue in the following first period by SR 9.792 billion. This, again, partially increases the real imports. In the absence of the increase in the real exports in the following first period, this increase in imports leads to a decline in the balance of payments by SR 4.470 billion. On the other hand, the increase in the government oil revenue in the following first period encourages the government expenditures by SR 7.795 billion which is below the increase of SR 10.255 billion in the government total revenue. This therefore, leads to a decline in the government deficit by SR 2.460 billion.

The effect of the declines in the balance of payments and the government deficit on the money supply are dominated by the growth in the nominal non-oil GDP, leading to an increase in the money supply by SR 0.516 billion in the following first period. The effect on the increase in the money supply in encouraging the real absorptive capacity is reinforced by the increase in the velocity of money. As a result, the real absorptive capacity increases by SR 4.706 billion in the following first period.
Again, the increase in the absorptive capacity or the aggregate demand for consumption and investment goods and services is satisfied by both the increase in the real imports by \( \text{SR} \ 3.397 \) billion and the increase in the real non-oil GDP by \( \text{SR} \ 1.309 \) billion.

The increase in the real non-oil GDP relative to the normal or long-run level of non-oil GDP, in addition to the increase in the inflationary expectations, increases the non-oil GDP price level by 0.004 index points. This, in turn, increases the general price level by 0.003 index points in the following first period. This increase in the general price level, means an increase in the rate of inflation by 0.127 percent which reflects itself in an increase of 0.127 percent in the inflationary expectations in the following second period.

In the absence of the ten percent increase in the real exports in the following second period, the government oil revenue is unchanged. Accordingly, the increase in the government total revenue is mainly due to the increase in the government non-oil revenue by only \( \text{SR} \ 0.419 \) billion, which is far less than the increase in the government expenditure by \( \text{SR} \ 6.092 \) billion. This leads to an increase in the government deficit by \( \text{SR} \ 5.673 \) billion.

On the other hand, in the absence of the ten percent increase in the real exports, the nominal exports is unchanged, and, therefore, with the increase in the real imports by \( \text{SR} \ 1.187 \) billion, the balance of payments continues to decline by \( \text{SR} \ 1.568 \) billion in the following second period. The effect of this reduction in the balance of payments on the money supply, however, is dominated by the effect of the increase in the government deficit. This, in addition to the increase in the non-oil GDP, leads to an increase in the money supply by \( \text{SR} \ 0.759 \) billion. The effect of the increase in the money supply in encouraging the real absorptive capacity is, again, reinforced by the increase in the velocity of money. The increase in the velocity, however, is not as large as that in the immediate or the following first period. As a result, the increase in the real absorptive capacity by \( \text{SR} \ 2.382 \) billion is lower than that in the previous periods. This increase in the absorptive capacity or the aggregate demand for consumption and investment goods and services is met by both the increase in the real imports by \( \text{SR} \ 1.187 \) billion and the increase in the real non-oil GDP by \( \text{SR} \ 1.179 \) billion.
This increase in the real non-oil GDP, however, is higher than the increase in the normal or long-run level of non-oil GDP which is SR 1.115 billion. This puts an upward pressure on the non-oil GDP price level. This upward pressure is reinforced by the increase in the inflationary expectations by 0.127 percent, leading to an increase in the non-oil GDP price level by 0.004 index points and the general price level by 0.003 index points in the following second period. This increase in the general price level, however, leads to an increase in the rate of inflation by 0.020 percent. This increase, then, reflects itself in an increase in the inflationary expectations by 0.020 percent in the following third period.

In the absence of the ten percent increase in the real exports in the following third and fourth periods, again, the government oil revenue stays unchanged. The increase in the government total revenue, due to the increase in the government non-oil revenue, continues to be dominated by the increase in the government expenditure, leading to further increases in the government deficit.

The effect of these increases in the government deficit on the money supply dominates the effects of the continuing declines in the balance of payments. These, in addition to the increase in the non-oil GDP, increase the money supply in the following third and fourth periods. The effect of the money supply increase in encouraging the real absorptive capacity is reinforced by the increase in the velocity in the following third period. Accordingly, the real absorptive capacity increases by SR 0.824 billion. This increase, however, is met by both the increase in the real imports and by the increase in the domestic non-oil production. In the following fourth period, however, the effect of the money supply increase in encouraging the real absorptive capacity is partially frustrate by the decline in the velocity. This is why the increase in the real absorptive capacity by SR 0.072 billion is much smaller than that in the following third period. This slight increase in the aggregate demand for goods and services, however, is entirely satisfied by the increase in real imports which also compensates for the slight decline in the real non-oil GDP.
6.2.2 Long-run multiplier (or cumulative) effects

In order to calculate the long-run dynamic multiplier effects of a ten percent increase in the real exports on the endogenous variables, we first simulated the estimated macroeconometric model in Table 5.5 for 1990-1994 in the absence of any change in the real exports and retain the solution values of the endogenous variables. We then increase the real exports $\text{REXT}_t$, by ten percent above its historical value in 1990 and keep this increase in effect for 1991-1994. Then, simulating the estimated macroeconometric model in Table 5.5 for 1990-1994 gives the solution values of the endogenous variables in the presence of the ten percent increase in the real exports. The difference between the solution values of the endogenous variables after and before the ten percent increase in the real exports are calculated and reported in Table 6.4. We refer to these values as the long-run dynamic multiplier effects of a ten percent increase in the real exports on the endogenous variables.

As seen, the immediate period multiplier effects reported in Table 6.4 are the same as those in Table 6.3, and, therefore, have the same interpretation as that given above. In the following first period, however, with the ten percent increase in the real exports in effect, oil production measured by the real oil GDP increases by SR 22.03 billion in the following first period. This increase, on the aggregate supply side, matches the increase in the aggregate demand as the real net exports increases by SR 16.354 billion and the real absorptive capacity increases by SR 7.795 billion.

To be more specific, the ten percent increase in the real exports increases the government oil revenue by SR 17.17 billion in the following first period. This partially increases the real imports. The increase in imports, however, is dominated by the increase in exports, leading to an increase of SR 8.668 billion in the balance of payments. On the other hand, the ten percent increase in the real exports increases the government oil revenue and then the government expenditure by SR 11.41 billion. This increase in the government expenditure, however, is below the SR 17.86 billion increase in the government total revenue, leading to a reduction in the government deficit by SR 6.450 billion in the following first period.
### Table 6.4.

**Long-run dynamic multiplier effects of real exports**

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<th>( RGDPN_t )</th>
<th>( RGDPN_t )</th>
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<td>0.000</td>
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</table>

**Note:** See the notes in Table 6.1.
The effect of the increase in the balance of payments on the money supply, however, dominates the effect of the reduction in the government deficit. This, in addition to the growth in the nominal non-oil GDP, increases the money supply by SR 1.107 billion in the following first period. The effect of the increase in the money supply in encouraging the real absorptive capacity is reinforced by the increase in the velocity of money. As a result, the real absorptive capacity increases by SR 7.795 billion. This increase in the absorptive capacity or the aggregate demand for consumption and investment goods and services is satisfied by the increase in real imports by SR 5.681 billion and the real non-oil GDP by SR 2.117 billion in the following first period.

The increase in the real non-oil GDP is higher than the increase in the normal or long-run level of non-oil GDP. This, however, puts an upward pressure on the non-oil GDP price level. More specifically, the non-oil GDP price level increases by 0.006 index points. This, in turn, increases the general price level by 0.004 index points in the following first period. The increase in the general price level means an increase in the rate of inflation by 0.249 percent which reflects itself in an increase of 0.249 percent in the inflation expectations in the following second period.

The analysis for the following second period is the same as that for the following first period described above. For the following third and fourth periods, however, the government expenditure dominates the government total revenue, resulting in an increase in the government deficit. This reinforces the effect of the increase in the balance of payments on the money supply, resulting in faster increases in the money supply in the following third and fourth periods. The effect of these money supply increases on the real absorptive capacity is reinforced by the continuing increases in the velocity. As a result, the real absorptive capacity increases by SR 11.70 billion in the following third period which is satisfied by a SR 4.913 billion increase in the real non-oil GDP and by a SR 6.800 billion increase in the real imports. The real absorptive capacity increase by SR 11.81 billion in the following forth period which, again, is satisfied by a SR 4.736 billion increase in the real non-oil GDP and by a SR 7.069 billion increase in the real imports. In the following third and fourth periods, as seen, the increase in the real non-oil GDP are more substantial relative to the previous period. Accordingly, the real non-oil GDP plays a more important role in
satisfying the increases in the real absorptive capacity in the following third and fourth periods.

6.3 Price of imports multiplier effects

As indicated before, the price of imports $P_{IM}$, is another important exogenous variable in our macroeconometric model. Given the reliance of the Saudi economy on imported consumption and investment goods and services, this section analyses the short-run and long-run (or cumulative) effects on the endogenous variables of a ten percent decline in the price of imports, $P_{IM}$.

6.3.1 Short-run multiplier effects

In order to calculate the short-run dynamic multiplier effects of a ten percent decline in the price of imports on the endogenous variables, the estimated macroeconometric model in Table 5.5 is simulated for 1990-1994 both before and after the ten percent decline in the price of imports below its historical value in 1990. The difference between the solution values of the endogenous variables after and before the ten percent decline in the price of imports are calculated and reported in Table 6.5. We refer to these values as the short-run dynamic multiplier effects of a ten percent decline in the price of imports on the endogenous variables.

A ten percent decline in the price of imports means that the imported goods and services are cheaper relative to the domestically produced non-oil goods and services. This encourages the demand for imports but discourages the demand for the non-oil products despite the slight decline in the price of non-oil GDP. The increase in the demand for imports (with the exports unchanged) results in a deficit of SR 2,867 billion in the balance of payments in the immediate period. The reduction in the real non-oil GDP, however, reduces the government non-oil revenue by SR 0.127 billion. With the government oil revenue and expenditure unchanged, the decline in the government non-oil revenue decreases the government total revenue, and, therefore,
increases the government deficit by SR 0.127 billion. The effect of the decline in the balance of payments on the money supply dominates by the effect of the increase in the government deficit. This, in addition to the reduction in the non-oil GDP, reduces the money supply by SR 1.156 billion in the immediate period. With the velocity unchanged, the effect of the decline in the money supply is reflected in a reduction in the general price level. This reduction in the general price level is reinforced by the ten percent decline in the price of imports.

More specifically, in the immediate period, the general price level declines by 0.043 index points. This, in turn, encourages the real absorptive capacity or the aggregate demand for goods and services by SR 11.10 billion, which, in turn, further encourages the real imports. As seen, the increase in the real imports in the immediate period is SR 15.28 billion. This increase in the real imports not only satisfies the increase in the real absorptive capacity or the aggregate demand but also makes up for the decline in the real non-oil GDP by SR 4.176 billion. As already mentioned, the decline in the non-oil GDP follows the cheaper imported goods and services relative to the domestically produced goods and services.

The decline in the real non-oil GDP, with the normal or long-run level of non-oil GDP unchanged, puts a downward pressure on the non-oil GDP price level. This downward pressure causes the non-oil GDP price level to decline by 0.009 index points. This decline in the non-oil GDP price level reinforces the effect of the ten percent decline in the price of imports on the general price level. Specifically, the general price level declines by 0.043 index points in the immediate period, which, in turn, results in the inflation rate declining by 4.069 percent. This decline, then, reflects itself in a decline in the inflationary expectations by 4.069 percent in the following first period.
### Table 6.5.

Short-run dynamic multiplier effects of the price of imports

<table>
<thead>
<tr>
<th>Period</th>
<th>RDI(t)</th>
<th>RGDPN(t)</th>
<th>RGDP(t)</th>
<th>RGDPN(t^*)</th>
<th>RIMT(t)</th>
<th>BP(t)</th>
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<tbody>
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<td>11.10</td>
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<td>0.000</td>
<td>15.28</td>
<td>-2.867</td>
</tr>
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<th>GEX(t)</th>
<th>GTR(t)</th>
<th>GOR(t)</th>
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<table>
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<th>P(t)</th>
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<th>(\frac{\partial^2 P}{\partial t^2})</th>
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<td>-4.069</td>
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<td>0.594</td>
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<tr>
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</table>

**Note:** See the notes in Table 6.1
The decline in the inflationary expectations is partially responsible for the decline in the non-oil GDP price level by 0.009 index points in the following first period. Consequently, in the absence of the ten percent decline in the price of imports in the following first period, the domestically produced non-oil goods and services become cheaper relative to the imported goods and services. This encourages the demand for domestically produced non-oil products but discourages the demand for imported products. For example, the real imports is declined by $\text{SR} \ 0.330$ billion, which, with the exports unchanged, leads to an increase in the balance of payments by $\text{SR} \ 0.435$ billion in the following first period. On the other hand, with the government oil revenue and expenditure unchanged, the decline in the government non-oil revenue by $\text{SR} \ 0.058$ billion decreases the government total revenue, and, therefore, increase the government deficit by $\text{SR} \ 0.058$ billion. The effect of the increase in the balance of payments on the money supply, however, is reinforced by the effect of the increase in the government deficit and the growth in non-oil GDP. Accordingly, the change in money supply, $\Delta M_t$, is positive, and, as a result, the decline in the money supply by $\text{SR} \ 0.061$ billion in the following first period is far less than that in the immediate period. With the velocity of money unchanged, the effect of the decline in the money supply is reflected in a reduction in the general price level by 0.007 index points. This, in turn, increases the real absorptive capacity or the aggregate demand for goods and services by $\text{SR} \ 2.069$ billion. This increase in the real absorptive capacity in the following first period is satisfied by the increase in the real non-oil GDP. In fact the increase in the real non-oil GDP by $\text{SR} \ 2.402$ billion not only satisfies the increase in the real absorptive capacity or the aggregate demand for goods and services but also makes up for the decline in the real imports by $\text{SR} \ 0.330$ billion.

The increase in the real non-oil GDP is dominated by the decline in the normal or long-run level of non-oil GDP. This, therefore, puts a downward pressure on the non-oil GDP price level. This downward pressure, which is also reinforced by the decline in the inflationary expectations, results in a decline in both the non-oil GDP price level and the general price level. The decline in the general price level in the following first period is 0.007 index points which is far below the decline of 0.043 index points in the immediate period. This means an increase in the rate of inflation in the following first period by 3.431 percent. Accordingly, the inflationary expectations increases by 3.431 percent in the following second period.
The effect of the increase in the inflationary expectations on the non-oil GDP price inflation dominates the effect of the decline in the real non-oil GDP gap, resulting in an increase in the non-oil GDP price inflation of 0.903 percent. Consequently, the decline in the non-oil GDP price level by 0.001 index points in the following second period is substantially lower than that in the following first period. In the absence of the ten percent decline in the price of imports in the following second period, domestically produced non-oil goods and services remain cheaper relative to imported goods and services. This continues to discourage the demand for imported products by SR 0.085 billion but encourages the demand for domestically produced non-oil products by SR 0.047 billion in the following second period. The decline in the real imports (with the exports unchanged) results in the balance of payments increasing by SR 0.112 billion in the following second period. On the other hand, with the government oil revenue and expenditure unchanged, the decline in the government non-oil revenue by SR 0.037 billion decreases the government total revenue, and, therefore, increases the government deficit by SR 0.037 billion. The effects of the increases in the balance of payments and the government deficit on the money supply, however, is dominated by the decline in the growth of non-oil GDP. Accordingly, the change in money supply, $\Delta M_t$, is negative. As a result, the decline in the money supply by SR 0.114 billion in the following second period is larger than that in the following first period. With the velocity of money unchanged, the effect of the decline in money supply is reflected in a reduction in the real absorptive capacity or the aggregate demand for goods and services by SR 0.038 billion. Part of the decline in the real imports by SR 0.085 billion matches this reduction in the real absorptive capacity. The remaining reduction in the real imports matches the increase in the non-oil GDP, as the domestically produced goods and services remain cheaper than the imported goods and services.

The increase in the real non-oil GDP, again, is dominated by the increase in the normal or long-run level of non-oil GDP. This, therefore, puts a downward pressure on the non-oil GDP price level. This downward pressure, however, dominates the increase in the inflationary expectations, causing the non-oil GDP price level and the general price level to decrease. The decline in the general price level in the following second period is far below the decline of 0.007 index points in the following first period. This means an increase in the rate of inflation in the following second period
by 0.594 percent reflects itself in an increase in the inflationary expectations by 0.594 percent in the following third period.

In the absence of the ten percent decline in the price of imports in the following third and fourth periods, the real imports continue to decline, and, therefore the balance of payments continues to increase. On the other hand, the government non-oil revenue continues to decline, and, with the government oil revenue and expenditure unchanged, the government deficit continues to increase. The effects of these increases in the balance of payments and government deficit on the money supply are dominated by the declines in the non-oil GDP. Accordingly, the money supply continues to decline in the following third and fourth periods. With the velocity of money unchanged, the effects of the declines in the money supply are reflected in reductions in the real absorptive capacity or the aggregate demand for goods and services by SR 0.284 billion in the following third period and by SR 0.218 billion in the following fourth period. These declines in the real absorptive capacity are matched by the declines in both the real non-oil GDP and the real imports. The declines in the real non-oil GDP, however, are larger than those in the real imports, as the changes in the non-oil GDP price level become very negligible.

6.3.2 Long-run multiplier (or cumulative) effects

In order to calculate the long-run dynamic multiplier effects of a ten percent decline in the price of imports on the endogenous variables, we first simulated the estimated macroeconometric model in Table 5.5 for 1990-1994 in the absence of any change in the price of imports and retain the solution values of the endogenous variables. We then reduce the price of imports, $P_{IM_t}$, by ten percent below its historical value in 1990 and keep this reduction in effect for 1991-1994. Then, simulating the estimated macroeconometric model in Table 5.5 for 1990-1994 gives the solution values of the endogenous variables in the presence of the ten percent decline in the price of imports. The difference between the solution values of the endogenous variables after and before the ten percent decline in the price of imports is calculated and reported in Table 6.6. We refer to these values as the long-run dynamic
multiplier effects of a ten percent decline in the price of imports on the endogenous variables.

As seen, the immediate period multiplier effects reported in Table 6.6 are the same as those in Table 6.5, and, therefore, have the same interpretation as that given above. In the presence of the ten percent decline in the price of imports in the following first period, the imported goods and services remain cheaper relative to the domestically produced non-oil goods and services. This continues to encourage the demand for imported products but discourages the demand for domestically produced non-oil products. For example, the real non-oil GDP decreases by SR 1.067 billion, while the real imports increases by SR 15.22 billion. This increase in the real imports (with the exports unchanged) results in a decline in the balance of payments by SR 2.832 billion in the following first period. On the other hand, with the government oil revenue and expenditure unchanged, the decline in the government non-oil revenue by SR 0.173 billion decreases the government total revenue, and, therefore, increases the government deficit by SR 0.173 billion. The decline in the balance of payments, the increase in the government deficit, and the decline in the non-oil GDP jointly results in a decline in the money supply by SR 1.049 billion in the following first period. With the velocity of money unchanged, the effect of the decline in the money supply is reflected in a reduction in the general price level by 0.049 index points. This, in turn, encourages the real absorptive capacity or the aggregate demand for goods and services by SR 14.16 billion. This increase in the real absorptive capacity in the following first period is satisfied by the increase in the real imports which also compensates for the decline in the real non-oil GDP.
Table 6.6.

Long-run dynamic multiplier effects of the price of imports

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<thead>
<tr>
<th>Period</th>
<th>$RDI_t$</th>
<th>$RGDPN_t$</th>
<th>$RGDPO_t$</th>
<th>$RGDPN^*_t$</th>
<th>$RIMT_t$</th>
<th>$BP_t$</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>11.10</td>
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<td>0.000</td>
<td>0.000</td>
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<td>-2.867</td>
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<th>$GTR_t$</th>
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Note: See the notes in Table 6.1
The decline in the real non-oil GDP is dominated by the decline in the normal or long-run level of non-oil GDP. This, therefore, puts an upward pressure on the non-oil GDP price level. However, the decline in the inflationary expectations by 4.069 percent not only frustrates the effect of this upward pressure on the non-oil GDP price level but also reduced the non-oil GDP price level by 0.017 index points in the following first period. The effect of this decline in the non-oil GDP price level on the general price level is reinforced by the ten percent decline in the price of imports. As a result, the general price level declines by 0.049 index points in the following first period, this means a decline in the rate of inflation by 0.556 percent which is directly reflected in a decline in the inflationary expectations by 0.556 percent in the following second period.

The analysis for the following second period is the same as that for the following first period described above. With the ten percent decline in the price of imports in effect, the general price level continues to decline by 0.046 and 0.045 index points, respectively, in the following third and fourth periods. This encourages the real absorptive capacity or the aggregate demand for goods and services. However, unlike the previous periods, the increase in the real absorptive capacity in the following third and fourth periods is satisfied also by the growth in the real non-oil GDP. For example, the increase in the real absorptive capacity by SR 17.50 billion in the following third period is satisfied by a SR 1.752 billion increase in the real non-oil GDP and by a SR 15.77 billion increase in the real imports. The real absorptive capacity increases by SR 16.55 billion in the following fourth period which, again, is satisfied by a SR 1.104 billion increase in the real non-oil GDP and by a SR 15.45 billion increase in the real imports.

6.4 Summary and conclusions

In this chapter, we have utilised our estimated macroeconometric model to derive and analyse the short-run and long-run (or cumulative) multiplier effects on the endogenous variables of:
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(i) a ten percent increase in the price of (oil) exports,

(ii) a ten percent increase in the real (oil) exports, and

(iii) a ten percent decline in the price of imports.

The results of our multiplier analysis for a ten percent increase in the price of (oil) exports and a ten percent increase in the real (oil) exports are similar, and, therefore, lead to similar conclusions. As seen, based on the short-run multiplier results in Tables 6.1 and 6.3, the effects of a one-time increase in either the price of (oil) exports or the real (oil) exports on the real absorptive capacity, non-oil GDP, and imports die off quickly over the periods. For example, such effects are relatively large in the immediate, the following first and second periods, but became substantially small in the following third and fourth periods. In comparison, the effect of a one-time increase in either the price of (oil) exports or the real (oil) exports in the government expenditure does not die off as quickly. This is perhaps due to the long-term nature of the development projects that the government commits to, following a one-time increase in either the price of (oil) exports or the real (oil) exports. Initially, the increase in the government expenditure is dominated by the government oil revenue improving the government’s position in terms of deficit. However, as soon as the increase in the government oil revenue disappears, then the persistent increase in the government expenditure contributes to higher government deficit. This, in turn, is partially responsible for the increase in the money supply dying off rather slowly over the periods. An important conclusion that may follow from these observations is that such fiscal and monetary variables as the government expenditure and the money supply have, at best, temporary (but not lasting) effects on the real absorptive capacity and non-oil production.

A similar conclusion can be derived based on the long-run multiplier analysis of an increase in either the price of (oil) exports or the real (oil) exports. For example, as shown in Tables 6.2 and 6.4, the cumulative effects on the real absorptive capacity, non-oil GDP, and imports, tend to level off by the following third period despite the continuing increase in the government expenditure and the money supply. Another important conclusion, based on both the short-run and long-run multiplier results, is that the general price and the non-oil GDP price levels do not seem to be very
sensitive to an increase in either the price of (oil) exports or the real (oil) exports (see Tables 6.1 - 6.4).

Based on the multiplier analysis of the price of imports, however, these price levels seem to be much more sensitive to a ten percent decline in the price of imports. In addition to this conclusion, a one-time decline in the price of imports, as shown in Table 6.5, reduces the relative price of imports, and, therefore, results in substantial increase in the real imports and the real absorptive capacity, but a decline in the non-oil GDP in the immediate period. The decline in the real non-oil GDP is as a result of the cheaper price of imports relative to the price of non-oil GDP which discourages the demand for domestically produced goods and services. For example, as seen, the increase in the real imports is large enough not only to meet the increase in the real absorptive capacity but also compensate for the decline in the real non-oil GDP. In the absence of the decline in the price of imports in the following first period, the increase in the real imports disappears, and, therefore, the continuing increase in the real absorptive capacity is entirely met by the increase in the real non-oil GDP. Also, as indicated in Table 6.5, the effects of a one-time decline in the price of imports on almost all endogenous variables die off rather quickly from the following second period on.

The corresponding long-run multiplier analysis, reported in Table 6.6, provides us with the cumulative effects of a decline in the price of imports on the endogenous variables. An important observation that follows is that the real absorptive capacity increases at a faster rate than the real imports. This not only helps the decline in the real non-oil GDP be substantially lower in the following first and second period relative to that in the immediate period, but also leads to an increase in the real non-oil GDP in the following third and fourth periods.

Given the results of the multiplier analysis presented in this chapter, we shall continue our study by predicting the behaviour of the endogenous variables of our Saudi Arabian macroeconometric model into the year 2005. Needless to say, these predictions are based on several alternative scenarios on the key exogenous variables such as the price of (oil) exports, the real (oil) exports, and the price of imports.
In Chapter Five of this study, we showed that our estimated macroeconometric model in Table 5.5 satisfactorily replicates the reality of the Saudi Arabian economy for the estimation period of 1971-1994. Accordingly, in Chapter Six, we utilised the estimated macroeconometric model to derive the dynamic multiplier effects of such exogenous variables as the price of (oil) exports, the real (oil) exports, and the price of imports. The purpose of the present chapter is to utilise the estimated macroeconometric model in Table 5.5 once again, but for forecasting and scenario analysis.

Our forecasting of the endogenous variables of the model covers two distinct periods. The first period is 1995-1998. As will be discussed in Section 7.1, the predicted values of the endogenous variables for this period are obtained based on the 1995-1998 actual values of the exogenous variables (when available) and generated based on the historical values (when unavailable). The second period is 1999-2005. Utilising the predicted values of the endogenous variables for 1995-1998, the forecast values of the endogenous variables for 1999-2005 are obtained based on several alternative scenarios which assume different behaviour for such exogenous variables as the price of (oil) exports, the real (oil) exports, and the price of imports. Sections 7.2-7.4 compare the forecasting results of nine such scenarios for 1999-2005. Under all these scenarios, the government expenditure, according to the estimated macroeconometric model in Table 5.5, is endogenously determined.

Given the crucial rule of government expenditure in the Saudi economy, however, it is important for us to re-examine the behaviour of the endogenous variables under the above nine scenarios when the behaviour of government expenditure is controlled based on some budgetary considerations. This re-examination produces nine additional forecasting scenarios. Sections 7.5-7.7 compare the forecasting results of these nine additional scenarios for 1999-2005. These comparisons will lead us to conclude this chapter in Section 7.8 by advocating a sound budgetary discipline that promotes economic growth and stability.
Chapter 7: Forecasting and scenario analysis

7.1 Prediction results for 1995-1998

As mentioned earlier in this study, the availability of data on the endogenous and exogenous variables restricts our estimation period up to 1994. In order to forecast the values of the endogenous variables into the year 2005, however, we first need to predict the values of the endogenous variables up to 1998.

This is done in this section by first assigning values to the five exogenous variables in the model for 1995-1998. These five exogenous variables are the price of (oil) exports, \( PE_{Xt} \), the real (oil) exports, \( REX_{Xt} \), the price of imports, \( PIM_{I} \), the net capital inflow including the net of all other factors in the balance of payments, \( CAPF_{I} \), and the real import duties, \( RIMD_{t} \).

The price of (oil) exports (\( PE_{Xt} \)) takes its actual value presently known for 1995. For 1996-1998, the values of this variable are generated based on the available data on exports f.o.b. (as an approximation for nominal exports) and the available data on the export volume (as an approximation for real exports). Based on these generated values, the price of (oil) exports in 1998 is lower than the corresponding 1997 level by over 24 percent. This is consistent with the observed drop in oil prices in 1998.

The real (oil) exports (\( REX_{Xt} \)) takes its actual value presently known for 1995. For 1996-1998, the values of this variable are approximated based on the available data on the export volume. The value assigned to the price of imports (\( PIM_{I} \)) for 1995-1998 is the average value of this variable over 1991-1994. Similarly, the value assigned to the net capital inflow (\( CAPF_{I} \)) for 1995-1998 is the average value of this variable over 1991-1994. Finally, the value assigned to the real import duties (\( RIMD_{t} \)) for 1995-1998 is the average value of this variable over 1991-1994.

After assigning the values of the exogenous variables, the estimated macroeconometric model in Table 5.5 is then simulated dynamically for 1995-1998 to

1 See Saudi Arabia: Staff Report for the 1998 Article IV Consultation (1998), prepared for the International Monetary Fund, Table 1, p. 7. Note that the data for 1998 are preliminary estimates.
2 See Saudi Arabia: Staff Report for the 1998 Article IV Consultation (1998), prepared for the International Monetary Fund, Table 1, p. 7.
3 Our macroeconometric model also includes five dummy variables. These are \( D717589, D7475, D828392, D82 \) and \( D9394 \). As indicated in Table 5.1, the values of the first four dummy variables are zero in 1994, and, therefore, their values for 1995-1998 are set equal to zero. The 1994 value of the last dummy variable, \( D9394 \), is one, and, therefore, we set it equal to one for 1995-1998. It is important to note that when forecasting the values of the endogenous variables for 1999-2005 in the following
obtain the predicted values of the endogenous variables reported in Table 7.1. According to these results, the real absorptive capacity is predicted to grow at an average annual rate of 6.48 percent up to 1997 but decline by 0.33 percent in 1998. The same pattern is observed in the real imports, as it is predicted to increase by 14.22 percent up to 1997 but declined by 3.05 percent in 1998. The domestic production measured by the real non-oil GDP, on the other hand, is projected to grow throughout the period but at different rates; that is, the real non-oil GDP is projected to grow at an average annual rate of 4.56 percent for 1995-1997 but at a lower rate of 1.24 percent in 1998. The growth in the non-oil GDP in 1998, although at a slower rate, highlights the larger share of the domestic production than imports in satisfying the aggregate demand or the real absorptive capacity. This as seen, is because the decline in the real absorptive capacity in 1998 is smaller than the decline in the real imports which, in effect, is more sensitive to the large reduction in the oil revenue. In fact, the decline in the price of oil in 1998 is predicted to produce a decline in the government oil revenue by SR 26.5 billion and a decline in government total revenue by SR 24.7 billion. The government expenditure in 1998 is predicted to decline as well but by only SR 6.9 billion. As a result, the government deficit continues to increase at a larger amount (SR 17.78 billion) in 1998. The balance of payments shows a deficit of SR 35.71 billion due to the decline in the price of (oil) exports, as the decline in nominal exports dominates the decline in nominal imports. The decline in the balance of payments and the increase in the government deficit, despite the increase in the non-oil GDP, is predicted to slow down the growth in money supply in 1998. For example, the money supply shows an average annual rate of growth of 5.76 percent for 1995-1997 but a lower growth of 3.81 percent in 1998. This slower rate of growth in the money supply in addition to the decline in the money velocity not only reduces the real absorptive capacity but also lowers the rate of inflation in 1998. That is, the general price inflation rate reduces from 2.959 and 2.838, respectively, in 1996 and 1997 to 1.594 percent in 1998. The same result holds for the non-oil GDP price inflation rate, as it reduces from 3.880 and 3.686, respectively, in 1996 and 1997 to 2.059 percent in 1998. The results in Table 7.1, generally, highlight the adverse impact of the 1998 fall in the price of (oil) exports on the behaviour of major macroeconomic variables in the Saudi economy during 1998.

sections of this chapter, the first four dummy variables continue to be equal to zero and the last dummy variable, D9394, continues to be equal to one for the 1999-2005 forecasting period.
Table 7.1.

The 1995-1998 forecasting results

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<th>GOR&lt;sub&gt;t&lt;/sub&gt;</th>
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<th>P&lt;sub&gt;t&lt;/sub&gt;</th>
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<td>1.884</td>
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Notes: The values for the first five endogenous variables reported above RDI<sub>t</sub>, RGDPN<sub>t</sub>, RGDPO<sub>t</sub>, RGDP<sub>t</sub>, and RIMT<sub>t</sub>, are in billions of constant (1984) Saudi Riyals. The values for the next seven endogenous variables reported above BP<sub>t</sub>, M<sub>t</sub>, (DEF<sub>t</sub>=GEX<sub>t</sub>-GTR<sub>t</sub>), GEX<sub>t</sub>, GTR<sub>t</sub>, GOR<sub>t</sub>, and GNR<sub>t</sub> are in billions of current Saudi Riyals. The values for V<sub>t</sub> are in ratios. The values for PG<sup>0</sup>DN<sub>t</sub>, P<sub>t</sub>, and P<sub>t</sub> are in percentages. The values for PGDPN<sub>t</sub> and P<sub>t</sub> are in index points. See Table 5.1 for the definition of the variables.
7.2 Forecasting scenarios A1, B1, and C1: 1999-2005

Having obtained the predicted values of the endogenous variables for 1995-1998 (reported in Table 7.1), we are now ready to forecast the values of the endogenous variables into the year 2005. In this section, we concentrate on three forecasting scenarios A1, B1 and C1. All these scenarios assume that:

(i) the real (oil) exports (REXTt) for 1999-2005 will remain the same at the 1998 level,

(ii) the price of imports (PIMt) for 1999-2005 will remain the same at its 1998 level,

(iii) the net capital inflow including the net of all other factors in the balance of payments (CAPFt) for 1999-2005 will remain the same at its 1998 level, and

(iv) the real import duties (RIMDt) for 1999-2005 will also remain the same at its 1998 level.

The difference between these scenarios, however, relates to the different set of prices for (oil) exports. For example, under scenario A1, the price of (oil) exports (PEXTt) for 1999-2005 will continue to remain the same at its 1998 level. This scenario is referred to as the pessimistic scenario. Under scenario B1, the price of (oil) exports for 1999-2005 will remain the same but at its 1997 level which is over 24 percent higher than the corresponding level under scenario A1. This scenario is referred to as the moderate scenario. Under scenario C1, the price of (oil) exports for 1999 is at its 1997 level but will increase for 2000-2005 at 2 percent per year. This scenario is referred to as the optimistic scenario.

Utilising the assigned values of the exogenous variables under each scenario, the estimated macroeconometric model in Table 5.5 is then simulated dynamically for 1999-2005 to obtain the forecast values of the endogenous variables. For example, Table 7.2 reports the forecasting results under scenario A1; Table 7.3 reports the forecasting results under scenario B1; and Table 7.4 reports the forecasting results under scenario C1.
Under scenario A1, the low 1998 price of (oil) exports results in the government oil revenue staying at the 1998 level of SR 105.9 billion (see Table 7.2). Accordingly, the increase in the government total revenue is entirely due to the increase in the government non-oil revenue resulted from the growth in the non-oil GDP. At the same time, in response to the zero growth in the government oil revenue, the government expenditure declines at an average rate of 0.754 percent per year from SR 208.9 billion to SR 197.9 billion. With the government total revenue increasing sluggishly, the decline in the government expenditure lowers the government deficit from SR 61.83 billion to SR 40.70 billion. On the other hand, with the real imports increasing and the exports remaining constant, the balance of payments deficit grows from SR 35.71 billion in 1998 to SR 63.20 billion in 2005 (see Table 7.2).

The effect of the higher balance of payments deficit on the money supply, however, is dominated by the effects of the lower government deficit and the growth in the non-oil GDP. As a result, the money supply grows at an average rate of 2.99 percent per year from SR 286.1 billion in 1998 to SR 346.0 billion in 2005 (see Table 7.2). This growth in the money supply, despite the decline in the velocity of money, results in a growth in the aggregate demand or real absorptive capacity by 1.58 percent per year from SR 450.0 billion in 1998 to SR 499.6 billion in 2005. This, further, results in an average inflation rate of 0.734 percent and 0.938 percent, respectively, in the general prices and non-oil GDP prices.

The increase in the real absorptive capacity combined with the lower relative import prices, despite the zero growth in the government oil revenue, encourages a growth in the real imports by an average rate of 2.12 percent per year from SR 140.5 billion in 1998 to SR 161.4 billion in 2005. However, this growth in the real imports is not large enough to satisfy the increase in the aggregate demand for goods and services or the real absorptive capacity. As a result, the domestic production or the non-oil GDP increases at an average rate of 1.34 percent per year from SR 290.3 billion in 1998 to SR 317.7 billion in 2005 (see Table 7.2).

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As also indicated in the footnote of Table 7.1, the first five variables in Table 7.1, \( \text{RDI}_n \), \( \text{RGDPN}_n \), \( \text{RGDPO}_n \), \( \text{RGDP}_n \), and \( \text{RIMT}_n \), are in real terms, and, therefore, are in billions of constant (1984) Saudi Riyals. The second seven variables in Table 7.1, \( \text{BP}_n \), \( \text{M}_n \) (\( \text{GEX}_n - \text{GTR}_n \)), \( \text{GEX}_n \), \( \text{GTR}_n \), \( \text{GOR}_n \), and \( \text{GNR}_n \), are in nominal terms, and, therefore, are in billions of current Saudi Riyals. In order to distinguish between these two quantities, in the text, we use \( \text{SR} \) to indicate "billions of constant (1984) Saudi Riyals", and SR to indicate "billions of current Saudi Riyals".
Table 7.2.

Forecasting results for (pessimistic) scenario A1

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Note: See the notes in Table 7.1
As opposed to scenario A1, scenario B1 assumes that the price of (oil) exports for 1999-2005 is constant but at the 1997 level. That is, under scenario B1, we are assuming that the price of (oil) exports for 1999-2005 is over 24 percent higher than that under scenario A1. As a result, the government oil revenue is SR 34.15 billion higher than that under scenario A1 (see Tables 7.2 and 7.3). This higher level of government oil revenue, in turn, results in the government expenditure increasing at an average rate of 3.69 percent per year from SR 208.9 billion in 1998 to SR 262.9 billion in 2005 (see Table 7.3). Accordingly, unlike under scenario A1, the government deficit gets worse under scenario B1 by the year 2005 at SR 65.66 billion. On the other hand, the higher price of (oil) exports under scenario B1 helps improve the balance of payments deficit. For example, the balance of payments deficit averages SR 18.25 billion under scenario B1 compared to SR 50.73 billion under scenario A1. This, in addition to higher increase in the non-oil GDP, results in the money supply growing at a faster rate under scenario B1. That is, under scenario B1, the money supply increases at an average rate of 3.95 percent (compared to 2.99 percent under scenario A1) per year from SR 286.1 billion in 1998 to SR 365.2 billion in 2005 (see Table 7.3).

This faster growth in the money supply encourages a faster growth in the aggregate demand or real absorptive capacity by 2.66 percent (compared to 1.58 percent under scenario A1) per year from SR 450.0 billion in 1998 to SR 533.6 billion in 2005. This, however, results in a slightly higher average inflation rate of 1.090 percent (compared to 0.734 percent under scenario A1) and 1.388 percent (compared to 0.938 percent under scenario A1), respectively, in the general prices and the non-oil GDP prices (see Table 7.3).

The increase in the real absorptive capacity combined with lower relative import prices and higher government oil revenue encourages a higher growth in the real imports by an average rate of 4.46 percent (compared to 2.12 percent under scenario A1) per year from SR 140.5 billion in 1998 to SR 184.4 billion in 2005. Again, this growth in the real imports is not large enough to satisfy the increase in the aggregate demand for goods and services or the real absorptive capacity. As a result, the domestic production or the non-oil GDP increases at an average rate of 1.88 percent (compared to 1.34 percent under scenario A1) per year from SR 290.3 billion in 1998 to SR 328.6 billion in 2005 (see Table 7.3).
Table 7.3.

Forecasting results for (moderate) scenario B1

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Note: See the notes in Table 7.1
As opposed to scenarios A1 and B1, scenario C1 assumes that the price of (oil) exports for 1999 is at the 1997 level and then continues to increase at 2 percent per year for 2000-2005. That is, under scenario C1, we are assuming that the price of (oil) exports for 2000-2005 will be even higher than that under scenario B1. Accordingly, the government oil revenue is higher than that under scenario B1 by SR 2.8 billion in 2000 and by SR 17.8 billion in 2005 (see Tables 7.3 and 7.4). As a result, the government expenditure grows at a higher average rate of 5.38 percent (compared to 3.69 percent under scenario B1) per year from SR 208.9 billion in 1998 to SR 287.5 billion in 2005 (see Table 7.4). Therefore, the government deficit gets even worse by the year 2005 under scenario C1, as it reaches SR 70.34 billion by the year 2005. On the other hand, the higher price of (oil) exports under scenario C1 helps improve the balance of payments deficit as it averages SR 9.15 billion (compared to SR 18.25 billion under scenario B1). This, in addition to a higher increase in the non-oil GDP, results in the money supply growing at an even faster rate under scenario C1. That is, under scenario C1, the money supply increases at an average rate of 4.20 percent (compared to 3.95 percent under scenario B1) per year from SR 286.1 billion in 1998 to SR 370.2 billion in 2005 (see Table 7.4).

This faster growth in the money supply encourages a faster growth in the aggregate demand or real absorptive capacity by 3.13 percent (compared to 2.66 percent under scenario B1) per year from SR 450.0 billion in 1998 to SR 548.5 billion in 2005. Again, this results in a slightly higher average inflation rate of 1.214 percent (compared to 1.090 percent under scenario B1) and 1.544 percent (compared to 1.388 percent under scenario B1), respectively, in the general prices and the non-oil GDP prices (see Table 7.4).

The increase in the real absorptive capacity combined with lower relative import prices and higher government oil revenue encourages a higher growth in the real imports by an average rate of 5.51 percent (compared to 4.46 percent under scenario B1) per year from SR 140.5 billion in 1998 to SR 194.8 billion in 2005. Again, this growth in the real imports is not large enough to satisfy the increase in the aggregate demand for goods and services or the real absorptive capacity. As a result, the domestic production or the non-oil GDP increases at an average rate of 2.11 percent (compared to 1.88 percent under scenario B1) per year from SR 290.3 billion in 1998 to SR 333.2 billion in 2005 (see Table 7.4).
Table 7.4.

Forecasting results for (optimistic) scenario C1

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Note: See the notes in Table 7.1
In short, in comparing scenarios A1, B1, and C1, the increase in the price of (oil) exports:

(i) worsens the government deficit but improves the balance of payments,
(ii) increases the rate of growth of the money supply,
(iii) increases slightly the rate of inflation, and
(iv) encourages the absorptive capacity, the real imports, and the domestic production or the real non-oil GDP.

7.3 Forecasting scenarios A2, B2, and C2: 1999-2005

In this section, we will concentrate on three forecasting scenarios, A2, B2 and C2. Scenario A2, like scenario A1, represents the pessimistic scenario, since the price of (oil) exports ($P_{\text{EXT}_t}$) for 1999-2005 is assumed to remain the same at its 1998 level. Scenario B2, like scenario B1, represents the moderate scenario, since the price of (oil) exports ($P_{\text{EXT}_t}$) for 1999-2005 is assumed to remain the same but at its 1997 level which is over 24 percent higher than the corresponding level under scenario A2. Scenario C2, like scenario C1, represents the optimistic scenario, since the price of (oil) exports ($P_{\text{EXT}_t}$) for 2000-2005 is assumed to increase at 2 percent per year.

Moreover, like the previously analysed scenarios A1, B1, and C1, scenarios A2, B2, and C2 also assume that:

(i) the price of imports ($P_{\text{IM}_t}$) for 1999-2005 will remain the same at its 1998 level,
(ii) the net capital inflow including the net of all other factors in the balance of payments ($C_{\text{APF}_t}$) for 1999-2005 will remain the same at its 1998 level, and
(iii) the real import duties ($R_{\text{IMD}_t}$) for 1999-2005 will also remain the same at its 1998 level.

The only difference, however, is that under scenarios A1, B1 and C1, the real (oil) exports ($R_{\text{EXT}_t}$) for 1999-2005 will remain the same at the 1998 level, while under scenario A2, B2 and C2, the real (oil) exports ($R_{\text{EXT}_t}$) for 1999-2005 will increase by 2 percent per year.
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Utilising the predicted values of the endogenous variables for 1995-1998 (reported in Table 7.1) and the assigned values of the exogenous variables under each scenario A2, B2, and C2, the estimated macroeconometric model in Table 5.5 is then simulated dynamically for 1999-2005 to obtain the forecast values of the endogenous variables. For example, Table 7.5 reports the forecasting results under scenario A2; Table 7.6 reports the forecasting results under scenario B2; and Table 7.7 reports the forecasting results under scenario C2.

Because of the assumed increase in the real (oil) exports under scenarios A2, B2, and C2, the real oil GDP increases by an average rate of 2.26 percent per year from SR 292.3 billion in 1998 to SR 338.5 billion in 2005 (see Tables, 7.5, 7.6, and 7.7). This, of course, is in contrast to the forecasting results under scenario A1, B1, and C1, where the real (oil) exports for 1999-2005 was assumed to be constant at its 1998 level.

The growth in the real (oil) exports under scenarios A2, B2, and C2 increases the level of government oil revenue for 1999-2005 well above the corresponding level under scenarios A1, B1, and C1. This higher level of government oil revenue, in turn, results in the government expenditure increasing at a faster rate than the government total revenue, thus worsening the government deficit by the year 2005. On the other hand, the growth in the real (oil) exports under scenarios A2, B2, and C2 helps improve the balance of payments deficit, compared, respectively to that under scenarios A1, B1, and C1. Despite the higher government deficit, the improvement in the balance of payments, in addition to a higher increase in the non-oil GDP, results in the money supply growing at a faster rate under scenarios A2, B2, and C2 than that, respectively, under scenarios A1, B1, and C1 (see Tables 7.2, and 7.5 for scenarios A1 and A2; Tables 7.3 and 7.6 for scenarios B1 and B2; Tables 7.4 and 7.7 for scenarios C1 and C2).

This faster growth in the money supply encourages a faster growth in the aggregate demand or real absorptive capacity for 1999-2005 by an average rate of:

(i) 2.18 percent under scenario A2 (compared to 1.58 percent under scenario A1) per year from SR 450.0 billion in 1998 to SR 518.5 billion in 2005.

(ii) 3.34 percent under scenario B2 (compared to 2.66 percent under scenario B1) per year from SR 450.0 billion in 1998 to SR 555.3 billion in 2005,
(iii) 3.85 percent under scenario C2 (compared to 3.13 percent under scenario C1) per year from SR 450.0 billion in 1998 to SR 571.2 billion in 2005.

The increase in the real absorptive capacity combined with lower relative import prices and higher government oil revenue increases the real imports for 1999-2005 by an average rate of:

(i) 3.35 percent under scenario A2 (compared to 2.12 percent under scenario A1) per year from SR 140.5 billion in 1998 to SR 173.5 billion in 2005.

(ii) 5.92 percent under scenario B2 (compared to 4.46 percent under scenario B1) per year from SR 140.5 billion in 1998 to SR 198.8 billion in 2005.

(iii) 7.07 percent under scenario C2 (compared to 5.51 percent under scenario C1) per year from SR 140.5 billion in 1998 to SR 210.1 billion in 2005.

Again, this growth in the real imports is not large enough to satisfy the increase in the aggregate demand for goods and services or the real absorptive capacity. As a result, the domestic production or the non-oil GDP increases for 1999-2005 by an average rate of:

(i) 1.53 percent under scenario A2 (compared to 1.34 percent under scenario A1) per year from SR 290.3 billion in 1998 to SR 321.5 billion in 2005.

(ii) 2.10 percent under scenario B2 (compared to 1.88 percent under scenario B1) per year from SR 290.3 billion in 1998 to SR 333.0 billion in 2005.

(iii) 2.33 percent under scenario C2 (compared to 2.11 percent under scenario C1) per year from SR 290.3 billion in 1998 to SR 337.6 billion in 2005 (see Tables 7.2-7.7).
### Table 7.5.

Forecasting results for (pessimistic) scenario A2

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Forecasting results for (moderate) scenario B2

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Note: See the notes in Table 7.1
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Forecasting results for (optimistic) scenario C2

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Note: See the notes in Table 7.1
In short, in comparison with scenarios A1, B1, and C1, the growth in the real (oil) exports under the corresponding scenarios A2, B2, and C2:

(i) worsens the government deficit but improves the balance of payments,
(ii) increases the rate of growth of the money supply,
(iii) increases slightly the rate of inflation, and
(iv) encourages the absorptive capacity, real imports, domestic production or real non-oil GDP and real oil GDP.

7.4 Forecasting scenarios A3, B3, and C3: 1999-2005

In this section, we will concentrate on three other forecasting scenarios A3, B3, and C3. Scenario A3, like scenarios A2, represents the pessimistic scenario, since the price of (oil) exports (PEXT) for 1999-2005 is assumed to remain the same at its 1998 level. Scenario B3, like scenario B2, represents the moderate scenario, since the price of (oil) exports (PEXT) for 1999-2005 is assumed to remain the same but at its 1997 level which is over 24 percent higher than the corresponding level under scenario A3. Scenario C3, like scenario C2, represents the optimistic scenario, since the price of (oil) exports (PEXT) for 2000-2005 is assumed to increase at 2 percent per year.

Like the previously analysed scenarios, scenarios A3, B3, and C3 also assume that:

(i) the net capital inflow including the net of all other factors in the balance of payments (CAPF) for 1999-2005 will remain the same at its 1998 level, and
(ii) the real import duties (RIMD) for 1999-2005 will also remain the same at its 1998 level.

Moreover, like scenarios A2, B2 and C2, the real (oil) exports (REXT) for 1999-2005 will increase by 2 percent per year. The only difference, however, is that, under scenarios A2, B2, and C2, the price of imports (PIM) for 1999-2005 will remain the same at its 1998 level, while under scenarios A3, B3, and C3, the price of imports for 1999-2005 will increase by 2 percent per year.
Utilising the predicted values of the endogenous variables for 1995-1998 (reported in Table 7.1) and the assigned values of the exogenous variables under each scenario A3, B3, and C3, the estimated macroeconometric model in Table 5.5 is then simulated dynamically for 1999-2005 to obtain the forecast values of the endogenous variables. For example, Table 7.8 reports the forecasting results under scenario A3; Table 7.9 reports the forecasting results under scenario B3; and Table 7.10 reports the forecasting results under scenario C3.

Consistent with the forecasting results of scenarios A2, B2, and C2, because of the assumed increase in the real (oil) exports also under scenarios A3, B3, and C3, the real oil GDP increases by an average rate of 2.26 percent per year from SR 292.3 billion in 1998 to SR 338.5 billion in 2005 (see Tables, 7.8, 7.9, and 7.10). This, of course, is in contrast to the forecasting results under scenario A1, B1, and C1, where the real (oil) exports for 1999-2005 was assumed to be constant at its 1998 level.

The increase in the price of imports (PIMt) under scenarios A3, B3, and C3 does not change the government oil revenues and expenditure but slightly increases government non-oil revenues. The net result is a slight and rather insignificant improvement in the government deficit.

Higher import prices under scenarios A3, B3, and C3, however, increases the general prices more significantly than it increases the price of domestically produced goods and services measured by the non-oil GDP prices. For example, the average general price inflation rate for 1999-2005 is:

(i) 1.660 percent under scenario A3 (compared to 0.846 percent under scenario A2),

(ii) 2.049 percent under scenario B3 (compared to 1.211 percent under scenario B1), and

(iii) 2.186 percent under scenario C3 (compared to 1.336 percent under scenario C2).

On the other hand, the average non-oil GDP price inflation rate for 1999-2005 is:
(i) 1.324 percent under scenario A3 (compared to 1.080 percent under scenario A2),

(ii) 1.833 percent under scenario B3 (compared to 1.541 percent under scenario B2), and

(iii) 2.011 percent under scenario C3 (compared to 1.699 percent under scenario C2); see Tables 7.5-7.10.

The increase in the price of imports relative to the price of domestically produced goods and services measured by the non-oil GDP prices coupled with the slower growth in the real absorptive capacity under scenarios A3, B3, and C3 significantly reduces the rate of growth in the real imports. That is, the real imports for 1999-2005 grows by an average rate of:

(i) 0.68 percent under scenario A3 (compared to 3.35 percent under scenario A2) per year from SR 140.5 billion in 1998 to SR 147.3 billion in 2005.

(ii) 2.91 percent under scenario B3 (compared to 5.92 percent under scenario B2) per year from SR 140.5 billion in 1998 to SR 169.2 billion in 2005,

(iii) 3.91 percent under scenario C3 (compared to 7.07 percent under scenario C2) per year from SR 140.5 billion in 1998 to SR 179.0 billion in 2005.

Despite the increase in the price of imports, this slower growth in the real imports (with the level of exports unchanged) results in an improvement in the balance of payments under scenarios A3, B3, and C3, as compared respectively with, scenarios A2, B2, and C2. For example, the balance of payments for 1999-2005 averages:

(i) SR -39.87 billion under scenario A3 compared to SR -43.10 billion under scenario A2,

(ii) SR -3.73 billion under scenario B3 compared to SR -7.05 billion under scenario B2, and

(iii) SR 6.68 billion under scenario C3 compared to SR 3.35 billion under scenario C2.
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The improvement in the balance of payments, however, leads to a slightly higher growth in the money supply for 1999-2005 by an average rate of:

(i) 3.33 percent under scenario A3 (compared to 3.21 percent under scenario A2)
per year from SR 286.1 billion in 1998 to SR 352.9 billion in 2005.

(ii) 4.40 percent under scenario B3 (compared to 4.25 percent under scenario B2)
per year from SR 286.1 billion in 1998 to SR 374.3 billion in 2005, and

(iii) 4.69 percent under scenario C3 (compared to 4.52 percent under scenario C2)
per year from SR 286.1 billion in 1998 to SR 380.1 billion in 2005.

This increase in the rate of growth in the money supply under scenarios A3, B3, and C3, however, is not significant enough to dominate the adverse effect of the higher general prices on the demand for goods and services or the real absorptive capacity. For example, the aggregate demand or the real absorptive capacity grows, but at a lower rate of:

(i) 1.37 percent under scenario A3 (compared to 2.18 percent under scenario A2)
per year from SR 450.0 billion in 1998 to SR 493.1 billion in 2005,

(ii) 2.48 percent under scenario B3 (compared to 3.34 percent under scenario B2)
per year from SR 450.0 billion in 1998 to SR 528.1 billion in 2005, and

(iii) 2.96 percent under scenario C3 (compared to 3.85 percent under scenario C2)
per year from SR 450.0 billion in 1998 to SR 543.2 billion in 2005.

When comparing scenarios A3, B3, and C3, respectively with scenarios A2, B2, and C2, we see that the decline in the real absorptive capacity is slightly below the decline in the real imports. As a result, the domestic production or the non-oil GDP shows a slightly higher growth for 1999-2005 by an average rate of:

(i) 1.58 percent under scenario A3 (compared to 1.53 percent under scenario A2)
per year from SR 290.3 billion in 1998 to SR 322.4 billion in 2005.

(ii) 2.22 percent under scenario B3 (compared to 2.10 percent under scenario B2)
per year from SR 290.3 billion in 1998 to SR 335.4 billion in 2005, and
### Table 7.8

Forecasting results for (pessimistic) scenario A3

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Note: See the notes in Table 7.1
### Table 7.9.

Forecasting results for (moderate) scenario B3

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Note: See the notes in Table 7.1.
(iii) 2.48 percent under scenario C3 (compared to 2.33 percent under scenario C2) per year from SR 290.3 billion in 1998 to SR 340.7 billion in 2005 (see Tables 7.5-7.10).

In short, in comparison with scenarios A2, B2, and C2, the increase in the import prices under the corresponding scenarios A3, B3, and C3:

(i) has a slight, rather insignificant effect on the government deficit, the balance of payments, and the real non-oil GDP,

(ii) produces a larger increase in the general price inflation than the non-oil price inflation, and

(iii) slows down the rate of growth in the real imports and the real absorptive capacity.

7.5 Forecasting scenarios A1g, B1g, and C1g: 1999-2005

In all scenarios A1, 2, 3, B1, 2, 3, and C1, 2, 3 examined above, the government expenditure is a function of the government oil revenue based on a partial adjustment process (see Table 5.5, equation 9). Given the crucial rule of the government expenditure in the Saudi economy, it is important for us to re-examine the forecasting results of the above scenarios when the government expenditure is instead exogenously controlled. This examination will be done in this and the next two sections of this chapter.

In this section, we will concentrate in analysing the forecasting results of three forecasting scenarios A1g, B1g, and C1g. The forecasting results of these scenarios will be compared with the forecasting results of scenarios A1, B1, and C1 already analysed in Section 7.2. Like scenarios A1, B1, and C1, scenarios A1g, B1g, and C1g also assume that the 1999-2005 values of the exogenous variables, the real (oil) exports (REXTt), the price of imports (PIMt), the real import duties (RIMD) and the net capital inflow including the net of all other factors in the balance of payments (CAPFt) will remain the same at their respective 1998 value. Scenario A1g like scenario A1, represents the pessimistic scenario, since the price of (oil) exports
(PEXTt) for 1999-2005 will continue to remain the same at its 1998 level; scenario B1g, like scenario B1, represents the moderate scenario, since the price of (oil) exports for 1999-2005 will remain the same but at its 1997 level, which is over 24 percent higher than the corresponding level under scenario A1 or A1g; and scenario C1g, like scenario C1, represents the optimistic scenario, since the price of (oil) exports for 1999 is at its 1997 level but will increase for 2000-2005 at 2 percent per year. The difference between these two sets of scenarios is that under scenarios A1, B1, and C1, the government expenditure (GEXt) is a function of the government oil revenue, while under scenarios A1g, B1g, and C1g, the government expenditure for 1999-2005 is restricted to grow at 2 percent per year.

In order to obtain the forecasting results for scenarios A1g, B1g, and C1g, therefore, we first need to modify the estimated macroeconometric model in Table 5.5 to reflect the assumption on the behaviour of the government expenditure. That is, the modified macroeconometric model, utilised from now on, replaces the function for the government expenditure in equation 9 by the following identity:

\[ \text{GEX}_t = 1.02 \text{GEX}_{t-1} \]  

(7.1)

which restricts the government expenditure to grow at 2 percent per year.

Utilising the predicted values of the endogenous variables for 1995-1998 (reported in Table 7.1) and the assigned values of the exogenous variables under each scenario A1g, B1g, and C1g, the estimated macroeconometric model in Table 5.5 (modified by replacing equation 9 by equation 7.1) is then simulated dynamically for 1999-2005 to obtain the forecast values of the endogenous variables. Table 7.11 reports the forecasting results under scenario A1g, Table 7.12 reports the forecasting results under scenario B1g, and Table 7.13 reports the forecasting results under scenario C1g.

As seen, under scenarios A1g, B1g, and C1g, the government expenditure for 1999-2000 grows at 2 percent per year from SR 208.9 billion in 1998 to SR 240.0 billion in 2005 (see Tables 7.11-7.13). This is in contrast to the forecasting results under scenarios A1, B1, and C1. For example, under the pessimistic scenario A1, the government expenditure actually declines for 1999-2005 by an average rate of 0.75
percent per year from SR 208.9 billion in 1998 to SR 197.9 billion in 2005 (see Table 7.2). Under the moderate scenario B1, the government expenditure increases for 1999-2005 by an average rate of 3.69 percent per year from SR 208.9 billion in 1998 to SR 262.9 billion in 2005 (see Table 7.3). Finally, under the optimistic scenario C1, the government expenditure increases for 1999-2005 by an average rate of 5.38 percent per year from SR 208.9 billion in 1998 to SR 287.5 billion in 2005 (see Table 7.4).

Accordingly, restricting the rate of growth of the government expenditure to 2 percent per year under the pessimistic scenario A1g worsens the government deficit; for example, the government deficit declines from SR 61.83 billion in 1998 to SR 40.70 billion in 2005 under scenario A1, while it increases from SR 61.83 billion in 1998 to SR 85.05 billion in 2005 under scenario A1g (see Tables 7.2 and 7.11). In light of the low level of government oil revenue, the increase in the government expenditure under scenario A1g, eases public expectations about the liquidity constraint (see equation 1 in Table 5.5). Accordingly, the velocity of money falls at a faster average rate of 1.35 percent under scenario A1g (compared to 0.48 percent under scenario A1) per year from 1.846 in 1998 to 1.671 in the year 2005. This faster rate of fall in the velocity of money further frustrates the effect of the increase in the money supply on the absorptive capacity. As a result, under scenario A1g:

(i) the real absorptive capacity grows for 1999-2005 but at a slower average rate of 1.14 percent (compared to 1.58 percent under scenario A1) per year from SR 450.0 billion in 1998 to SR 486.0 billion in 2005, and

(ii) the average general price inflation rate for 1999-2005 falls to 0.515 percent (compared to 0.734 percent under scenario A1).

The slower growth in the real absorptive capacity combined with higher relative import prices, in turn, results in the real imports growing under scenario A1g at a slower average rate of 1.51 percent (compared to 2.12 percent under scenario A1) per year from SR 140.5 billion in 1998 to SR 155.4 billion in 2005. Similarly, due to the slower growth in the aggregate demand for goods and services or the real absorptive capacity under scenario A1g, the domestic production or the non-oil GDP for 1999-2005 grows at a slower average rate of 0.97 percent (compared to 1.34
percent under scenario A1) per year from SR 290.3 billion in 1998 to SR 310.0 billion in 2005 (see Tables 7.11 and 7.2).

With respect to the moderate and optimistic scenarios, as implied above, restricting the rate of growth of the government expenditure to 2 percent per year improves the government deficit under scenarios B1g and C1g. For example, the government deficit declines from SR 61.83 billion in 1998 to SR 40.63 billion in 2005 under scenario B1g, while it increases from SR 61.83 billion in 1998 to SR 65.66 billion in 2005 under scenario B1 (see Tables 7.12 and 7.3); similarly, the government deficit declines from SR 61.83 billion in 1998 to SR 19.86 billion in 2005 under scenario C1g, while it increases from SR 61.83 billion in 1998 to SR 70.34 billion in 2005 under scenario C1 (see Tables 7.13 and 7.4).

Improvement in the government deficit by committing to a slower rate of increase in the government expenditure under scenarios B1g and C1g worsens public expectations about the liquidity constraint. Accordingly, the velocity of money for 1999-2005 increases:

(i) at an average rate of 0.84 percent under scenario B1g (compared to 0.04 percent under B1) per year from 1.846 in 1998 to 1.954 in the year 2005, and

(ii) at an average rate of 1.50 percent under scenario C1g (compared to 0.36 percent under C1) per year from 1.846 in 1998 to 2.040 in the year 2005.

The faster rate of increase in the velocity of money, however, reinforces the effect of the increase in the money supply on the absorptive capacity under both scenarios B1g and C1g. For example, under scenario B1g, the real absorptive capacity grows for 1999-2005 at a faster average rate of 3.01 percent (compared to 2.66 percent under scenario B1) per year from SR 450.0 billion in 1998 to SR 544.8 billion in 2005, and the average general price inflation rate for 1999-2005 increases, but slightly, to 1.265 percent (compared to 1.090 percent under scenario B1) (see Tables 7.12 and 7.3). Similarly, under scenario C1g, the real absorptive capacity grows for 1999-2005 at a faster average rate of 3.64 percent (compared to 3.13 percent under scenario C1) per year from SR 450.0 billion in 1998 to SR 564.5 billion in 2005, and the average general price inflation rate for 1999-2005 increases, but slightly, to 1.447 percent (compared to 1.214 percent under scenario C1) (see Tables 7.13 and 7.4).
Chapter 7: Forecasting and scenario analysis

The faster growth in the real absorptive capacity combined with slightly lower relative import prices, in turn, results in a faster rate of growth in the real imports under both scenarios B1g and C1g. For example, the real imports grows under scenario B1g at a higher average rate of 5.01 percent (compared to 4.46 percent under scenario B1) per year from SR 140.5 billion in 1998 to SR 189.8 billion in 2005 (see Tables 7.12 and 7.3), under scenario C1g, the real imports grows at a higher average rate of 6.31 percent (compared to 5.51 percent under scenario C1) per year from SR 140.5 billion in 1998 to SR 202.6 billion in 2005 (see Tables 7.13 and 7.4).

Due to the higher rate of growth in the aggregate demand for goods and services or the real absorptive capacity, the domestic production or the non-oil GDP for 1999-2005 also grows at a faster rate under both scenarios B1g and C1g. For example, under scenario B1g, the real non-oil GDP grows at a higher average rate of 2.17 percent (compared to 1.88 percent under scenario B1) per year from SR 290.3 billion in 1998 to SR 334.4 billion in 2005 (see Tables 7.12 and 7.3); under scenario C1g, the non-oil GDP for 1999-2005 grows at a higher average rate of 2.51 percent (compared to 2.11 percent under scenario C1) per year from SR 290.3 billion in 1998 to SR 341.4 billion in 2005 (see Tables 7.13 and 7.4).

In short, under the pessimistic scenario A1 when the government oil revenue is far below its historical level for 1999-2005, the government expenditure shows a declining pattern. Therefore, restricting the government expenditure to grow at 2 percent per year worsens the government deficit under scenario A1g. Given that the government expenditure is a major source of liquidity in the Saudi economy, the growth in the government expenditure eases public expectations about the liquidity constraints. As a result, the velocity of money exhibits a declining pattern for 1999-2005. Accordingly, this expansionary fiscal policy under the pessimistic scenario for 1999-2005:

(i) slows down the growth in the real absorptive capacity,
(ii) slows down the growth in the real imports, which, in turn, improves the balance of payments,
(iii) slows down the growth in the non-oil GDP, and
(iv) slightly reduced the rate of inflation.
Table 7.11.
Forecasting results for (pessimistic) scenario Alg

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Note: See the notes in Table 7.1
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Note: See the notes in Table 7.1
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Note: See the notes in Table 7.1
Based on our analysis, therefore, the expansionary fiscal policy under the pessimistic scenario results in a partial crowding-out as it affects the behaviour of the public toward demanding for money.

Under the moderate and optimistic scenarios (B1 and C1, respectively) when the government oil revenue is in line with its historical level for 1999-2005, the government expenditure grows at substantially higher than 2 percent per year. Therefore, restricting the government expenditure to grow at 2 percent per year improves the government deficit under scenarios B1g and C1g. This slower growth in the government expenditure worsens public expectations about the liquidity constraint. As a result, the velocity of money exhibits an increasing pattern for 1999-2005. Accordingly, under the moderate and optimistic scenarios, the slower growth in the government expenditure as it affects the behaviour of the public toward demanding for money for 1999-2005:

(i) increases the growth in the real absorptive capacity,
(ii) increases the growth in the real imports which, in turn, worsens the balance of payments,
(iii) increases the growth in the non-oil GDP, and
(iv) slightly increases the rate of inflation.

7.6 Forecasting scenarios A2g, B2g, and C2g: 1999-2005

In this section, we will concentrate on analysing the forecasting results of three forecasting scenarios A2g, B2g, and C2g. The forecasting results of these scenarios will be compared with the forecasting results of scenarios A2, B2, and C2 already analysed in Section 7.3. Like scenarios A2, B2, and C2, scenarios A2g, B2g, and C2g also assume that:

(i) the 1999-2005 values of the exogenous variables, the price of imports (PIMt), the real import duties (RIMDt), and the net capital inflow including the net of all other factors in the balance of payments (CAPFi) will remain the same at their respective 1998 value, and
(ii) the real (oil) exports ($\text{REXT}_t$) for 1999-2005 will increase by 2 percent per year.

Scenario A2g, like scenario A2, represents the pessimistic scenario, since the price of (oil) exports ($\text{PEXT}_t$) for 1999-2005 will continue to remain the same at its 1998 level; scenario B2g, like scenario B2, represents the moderate scenario, since the price of (oil) exports for 1999-2005 will remain the same but at its 1997 level which is over 24 percent higher than the corresponding level under scenario A2 or A2g; and scenario C2g, like scenario C2, represents the optimistic scenario, since the price of (oil) exports for 1999 is at its 1997 level but will increase for 2000-2005 at 2 percent per year. The difference between these two sets of scenarios is that under scenarios A2, B2, and C2, the government expenditure ($\text{GEX}_t$) is a function of the government oil revenue, while under scenario A2g, B2g, and C2g, the government expenditure for 1999-2005 is restricted to grow at 2 percent per year.

Utilising the predicted values of the endogenous variables for 1995-1998 (reported in Table 7.1) and the assigned values of the exogenous variables under each scenario A2g, B2g, and C2g, the estimated macroeconometric model in Table 5.5 (modified by replacing equation 9 by equation 7.1) is then simulated dynamically for 1999-2005 to obtain the forecast values of the endogenous variables. Table 7.14 reports the forecasting results under scenario A2g; Table 7.15 reports the forecasting results under scenario B2g; and Table 7.16 reports the forecasting results under scenario C2g.

Following our assumption, under scenarios A2g, B2g, and C2g, the government expenditure for 1999-2005 grows at 2 percent per year from SR 208.9 billion in 1998 to SR 240.0 billion in 2005 (see Tables 7.14-7.16). This is in contrast to the forecasting results under scenarios A2, B2, and C2. For example, under the pessimistic scenario A2, the government expenditure increases for 1999-2005 but by an average rate of only 1.19 percent per year from SR 208.9 billion in 1998 to SR 226.3 billion in 2005 (see Table 7.5). Under the moderate scenario B2, the government expenditure increases for 1999-2005 by an average rate of 6.27 percent per year from SR 208.9 billion in 1998 to SR 300.6 billion in 2005 (see Table 7.6). Finally, under the optimistic scenario C2, the government expenditure increases for
1999-2005 by an average rate of 8.20 percent per year from SR 208.9 billion in 1998 to SR 328.9 billion in 2005 (see Table 7.7).

Accordingly, restricting the rate of growth of the government expenditure to 2 percent per year under the pessimistic scenario A2g worsens the government deficit; for example, the government deficit declines from SR 61.83 billion in 1998 to SR 46.37 billion in 2005 under scenario A2. While it slightly declines from SR 61.83 billion in 1998 to only SR 61.24 billion in 2005 under scenario A2g (see Tables 7.5 and 7.14). With the government oil revenue remains the same under both scenarios A2 and A2g, the increase in the government expenditure under scenario A2g eases public expectations about the liquidity constraint (see equation 1 in Table 5.5). Accordingly, the velocity of money falls at a faster average rate of 0.48 percent under scenario A2g (compared to 0.03 percent under scenario A2) per year from 1.846 in 1998 to 1.784 in the year 2005. This faster rate of fall in the velocity of money further frustrates the effect of the increase in the money supply on the absorptive capacity. As a result, under scenario A2g:

(i) the real absorptive capacity grows for 1999-2005 but at a slower average rate of 1.96 percent (compared to 2.18 percent under scenario A2) per year from SR 450.0 billion in 1998 to SR 511.8 billion in 2005, and

(ii) the average general price inflation rate for 1999-2005 falls to 0.737 percent (compared to 0.846 percent under scenario A2).

The slower growth in the real absorptive capacity combined with higher relative import prices, in turn, results in the real imports growing under scenario A2g at a slower average rate of 3.03 percent (compared to 3.35 percent under scenario A2) per year from SR 140.5 billion in 1998 to SR 170.4 billion in 2005. Similarly, due to the slower growth in the aggregate demand for goods and services or the real absorptive capacity under scenario A2g, the domestic production or the non-oil GDP for 1999-2005 grows at a slower average rate of 1.36 percent (compared to 1.53 percent under scenario A2) per year from SR 290.3 billion in 1998 to SR 318.0 billion in 2005 (see Tables 7.14 and 7.5).
Table 7.14.

Forecasting results for (pessimistic) scenario A2g

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Note: See the notes in Table 7.1
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Note: See the notes in Table 7.1
### Table 7.16.

Forecasting results for (optimistic) scenario C2g

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**Note:** See the notes in Table 7.1
With respect to the moderate and optimistic scenarios, as implied above, restricting the rate of growth of the government expenditure to 2 percent per year improves the government deficit under scenarios B2g and C2g. For example, the government deficit declines from SR 61.83 billion in 1998 to SR 9.66 billion in 2005 under scenario B2g, while it increases from SR 61.83 billion in 1998 to SR 73.69 billion in 2005 under scenario B2 (see Tables 7.15 and 7.6). Similarly, the government deficit declines from SR 61.83 billion in 1998 to a surplus of SR 14.70 billion in 2005 under scenario C2g, while it increases from SR 61.83 billion in 1998 to SR 78.36 billion in 2005 under scenario C2 (see Tables 7.16 and 7.7).

Improvement in the government deficit by committing to a slower rate of increase in the government expenditure under scenario B2g and C2g worsens public expectations about the liquidity constraint. Accordingly, the velocity of money for 1999-2005 increases:

(i) at an average rate of 1.86 percent under scenario B2g (compared to 0.51 percent under B2) per year from 1.846 in 1998 to 2.085 in the year 2005, and

(ii) at an average rate of 2.56 percent under scenario C2g (compared to 0.84 percent under C2) per year from 1.846 in 1998 to 2.177 in the year 2005.

The faster rate of increase in the velocity of money, however, reinforces the effect of the increase in the money supply in the absorptive capacity under both scenarios B2g and C2g. For example, under scenario B2g, the real absorptive capacity grows for 1999-2005 at a faster average rate of 3.94 percent (compared to 3.34 percent under scenario B2) per year from SR 450.0 billion in 1998 to SR 574.1 billion in 2005, and the average general price inflation rate for 1999-2005 increases, but slightly, to 1.478 percent (compared to 1.211 percent under scenario B2) (see Tables 7.15 and 7.6). Similarly, under scenario C2g, the real absorptive capacity grows for 1999-2005 at a faster average rate of 4.60 percent (compared to 3.85 percent under scenario C2) per year from SR 450.0 billion in 1998 to SR 595.0 billion in 2005, and the average general price inflation rate for 1999-2005 increases to 1.656 percent (compared to 1.336 percent under scenario C2) (see Tables 7.16 and 7.7).

The faster growth in the real absorptive capacity combined with slightly lower relative import prices, in turn, results in a faster rate of growth in the real imports
under both scenarios B2g and C2g. For example, the real imports grows under scenario B2g at a higher average rate of 6.86 percent (compared to 5.92 percent under scenario B2) per year from SR 140.5 billion in 1998 to SR 208.1 billion in 2005) (see Tables 7.15 and 7.6); under scenario C2g, the real imports grows at a higher average rate of 8.28 percent (compared to 7.07 percent under scenario B2) per year from SR 140.5 billion in 1998 to SR 222.0 billion in 2005 (see Tables 7.16 and 7.7).

Due to the higher rate of growth in the aggregate demand for goods and services or the real absorptive capacity, the domestic production or the real non-oil GDP for 1999-2005 also grows at a faster rate under both scenarios B2g and C2g. For example, under scenario B2g, the real non-oil GDP grows at a higher average rate of 2.57 percent (compared to 2.10 percent under scenario B2) per year from SR 290.3 billion in 1998 to SR 342.5 billion in 2005 (see Tables 7.15 and 7.6); under scenario C2g, the non-oil GDP for 1999-2005 grows at a higher average rate of 2.91 percent (compared to 2.33 percent under scenario C2) per year from SR 290.3 billion in 1998 to SR 349.5 billion in 2005 (see Tables 7.16 and 7.7).

In short, under the pessimistic scenario A2, the growth rate of the government expenditure for 1999-2005 is below 2 percent per year. Therefore, restricting the government expenditure to grow at 2 percent per year worsens the government deficit under scenario A2g. This higher rate of growth in the government expenditure, however, eases public expectations about the liquidity constraint, and, therefore, lowers the velocity of money for 1999-2005. Accordingly, under the pessimistic scenario, the higher government expenditure for 1999-2005:

(i) slows down the growth in the real absorptive capacity,
(ii) slows down the growth in the real imports which, in turn, improves the balance of payments,
(iii) slows down the growth in the non-oil GDP, and
(iv) slightly reduces the rate of inflation.

Again, based on our analysis, the higher government expenditure under the pessimistic scenario A2g results in a partial crowding-out as it affects the behaviour of the public toward demanding for money.
Under the moderate and optimistic scenarios (B2 and C2, respectively), the government expenditure grows at substantially higher than 2 percent per year. Therefore, restricting the government expenditure to grow at 2 percent per year improves the government deficit under scenarios B2g and C2g. This slower growth in the government expenditure worsens public expectations about the liquidity constraint, and, therefore, increases the velocity of money for 1999-2005. Accordingly, under the moderate and optimistic scenarios, the slower growth in the government expenditures as it affects the behaviour of the public towards demanding for money for 1999-2005:

(i) increases the growth in the real absorptive capacity,
(ii) increases the growth in the real imports which, in turn, worsens the balance of payments,
(iii) increases the growth in the non-oil GDP, and
(iv) slightly increases the rate of inflation.

7.7 Forecasting scenarios A3g, B3g, and C3g: 1999-2005

In this section, we will concentrate on analysing the forecasting results of three forecasting scenarios A3g, B3g, and C3g. The forecasting results of these scenarios will be compared with the forecasting results of scenarios A3, B3, and C3 already analysed in Section 7.4. Like scenarios A3, B3, and C3, scenarios A3g, B3g, and C3g also assume that:

(i) the 1999-2005 values of the exogenous variables, the real import duties (RIMDi), and the net capital inflow including the net of all other factors in the balance of payments (CAPFi) will remain the same at their respective 1998 value,
(ii) the real (oil) exports (REXTi) for 1999-2005 will increase by 2 percent per year, and
(iii) the price of import (PIMi) for 1999-2005 will increase by 2 percent per year.
Scenario A3g, like scenario A3, represents the pessimistic scenario, since the price of (oil) exports \( \text{PEXT}_t \) for 1999-2005 will continue remain the same at its 1998 level. Scenario B3g, like scenario B3, represents the moderate scenario, since the price of (oil) exports for 1999-2005 will remain the same but at its 1997 level which is over 24 percent higher than the corresponding level under scenarios A3 or A3g; and scenario C3g, like scenario C3, represents the optimistic scenario, since the price of (oil) exports for 1999 is at its 1997 level but will increase for 2000-2005 at 2 percent per year. The difference between these two sets of scenarios is that under scenarios A3, B3, and C3, the government expenditure \( \text{GEX}_t \) is a function of the government oil revenue, while under scenarios A3g, B3g, and C3g, the government expenditure for 1999-2005 is restricted to grow at 2 percent per year.

Utilising the predicted values of the endogenous variables for 1995-1998 (reported in Table 7.1) and the assigned values of the exogenous variables under each scenario A3g, B3g, and C3g, the estimated macroeconometric model in Table 5.5 (modified by replacing equation 9 by equation 7.1) is then simulated dynamically for 1999-2005 to obtain the forecast values of the endogenous variables. Table 7.17 reports the forecasting results under scenario A3g; Table 7.18 reports the forecasting results under scenario B3g; and Table 7.19 reports the forecasting results under scenario C3g.

Following our assumption, under scenarios A3g, B3g, and C3g, the government expenditure for 1999-2005 grows at 2 percent per year from SR 208.9 billion in 1998 to SR 240.0 billion in 2005 (see Tables 7.17-7.19). This is in contrast to the forecasting results under scenarios A3, B3, and C3. For example, under the pessimistic scenario A3, the government expenditure increases for 1999-2005 but by an average rate of only 1.19 percent per year from SR 208.9 billion in 1998 to SR 226.3 billion in 2005 (see Table 7.8). Under the moderate scenario B3, the government expenditure increases for 1999-2005 by an average rate of 6.27 percent per year from SR 208.9 billion in 1998 to SR 300.6 billion in 2005 (see Table 7.9). Finally, under the optimistic scenario C3, the government expenditure increases for 1999-2005 by an average rate of 8.20 percent per year from SR 208.9 billion in 1998 to SR 328.9 billion in 2005 (see Table 7.10).
## Table 7.17.

**Forecasting results for (pessimistic) scenario A3g**

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Note: See the notes in Table 7.1
## Table 7.18.

Forecasting results for (moderate) scenario B3g

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Note: See the notes in Table 7.1
## Table 7.19.

### Forecasting results for (optimistic) scenario C3g

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Note: See the notes in Table 7.1
Accordingly, restricting the rate of growth of the government expenditure to 2 percent per year under the pessimistic scenario A3g worsens the government deficit; for example, the government deficit declines from SR 61.83 billion in 1998 to SR 45.98 billion in 2005 under scenario A3, while it slightly declines from SR 61.83 billion in 1998 to only SR 60.88 billion in 2005 under scenario A3g (see Tables 7.8 and 7.17). With the government oil revenue remaining the same under both scenarios A3 and A3g, the increase in the government expenditure under scenario A3g eases public expectations about the liquidity constraint (see equation 1 in Table 5.5). Accordingly, the velocity of money falls at a faster average rate of 0.48 percent under scenario A3g (compared to 0.03 percent under scenario A3) per year from 1.846 in 1998 to 1.784 in the year 2005. This faster rate of fall in the velocity of money further frustrates the effects of the increase in the money supply on the absorptive capacity. As a result, under scenario A3g:

(i) the real absorptive capacity grows for 1999-2005 but at a slower average rate of 1.16 percent (compared to 1.37 percent under scenario A3) per year from SR 450.0 billion in 1998 to SR 486.6 billion in 2005, and

(ii) the average general price inflation rate for 1999-2005 falls to 1.551 percent (compared to 1.660 percent under scenario A3).

The slower growth in the real absorptive capacity combined with higher relative import prices, in turn, results in the real imports growing under scenario A3g at a slower average rate of 0.41 percent (compared to 0.68 percent under scenario A3) per year from SR 140.5 billion in 1998 to SR 144.5 billion in 2005.

Similarly, due to the slower growth in the aggregate demand for goods and services or the real absorptive capacity under scenario A3g, the domestic production or the non-oil GDP for 1999-2005 grows at a slower average rate of 1.39 percent (compared to 1.58 percent under scenario A3) per year from SR 290.3 billion in 1998 to SR 318.6 billion in 2005 (see Tables 7.17 and 7.8).

With respect to the moderate and optimistic scenarios, as implied above, restricting the rate of growth of the government expenditure to 2 percent per year improves the government deficit under scenario B3g and C3g. For example, the government deficit declines from SR 61.83 billion in 1998 to SR 9.03 billion in 2005.
under scenario B3g, while it increases from SR 61.83 billion in 1998 to SR 73.16 billion in 2005 under scenario B3 (see Tables 7.18 and 7.9); similarly, the government deficit declines from SR 61.83 billion in 1998 to a surplus of SR 15.44 billion in 2005 under scenario C3g, while it increases from SR 61.83 billion in 1998 to SR 77.76 billion in 2005 under scenario C3 (see Tables 7.19 and 7.10).

Improvement in the government deficit by committing to a slower rate of increase in the government expenditure under scenarios B3g and C3g worsens public expectations about the liquidity constraint. Accordingly, the velocity of money for 1999-2005 increases:

(i) at an average rate of 1.86 percent under scenario B3g (compared to 0.51 percent under scenario B3) per year from 1.846 in 1998 to 2.085 in the year 2005, and

(ii) at an average rate of 2.56 percent under scenario C3g (compared to 0.84 percent under scenario C3) per year from 1.846 in 1998 to 2.177 in the year 2005.

The faster rate of increase in the velocity of money, however, reinforces the effect of the increase in the money supply on the absorptive capacity under both scenarios B3g and C3g. For example, under scenario B3g, the real absorptive capacity grows for 1999-2005 at a faster average rate of 3.07 (compared to 2.48 percent under scenario B3) per year from SR 450.0 billion in 1998 to SR 546.5 billion in 2005, and the average general price inflation rate for 1999-2005 increases to 2.319 percent (compared to 2.049 percent under scenario B3) (see Tables 7.18 and 7.9). Similarly, under scenario C3g, the real absorptive capacity grows for 1999-2005 at a faster average rate of 3.70 percent (compared to 2.96 percent under scenario C3) per year from SR 450.0 billion in 1998 to SR 566.6 billion in 2005, and the average general price inflation rate for 1999-2005 increases to 2.510 percent (compared to 2.186 percent under scenario C3) (see Tables 7.19 and 7.10).

The faster growth in the real absorptive capacity combined with slightly lower relative import prices, in turn, results in a faster rate of growth in the real imports under both scenarios B3g and C3g. For example, the real imports grows under scenario B3g at a higher average rate of 3.74 percent (compared to 2.91 percent under
scenario B3) per year from **SR 140.5 billion** in 1998 to **SR 177.4 billion** in 2005 (see Tables 7.18 and 7.9); under scenario C3g, the real imports grows at a higher average rate of 4.99 percent (compared to 3.91 percent under scenario C3) per year from **SR 140.5 billion** in 1998 to **SR 189.6 billion** in 2005 (see Tables 7.19 and 7.10).

Due to the higher rate of growth in the aggregate demand for goods and services or the real absorptive capacity, the domestic production or the non-oil GDP for 1999-2005 also grows at a faster rate under both scenario B3g and C3g. For example, under scenario B3g, the real non-oil GDP grows at a higher average rate of 2.72 percent (compared to 2.22 percent under scenario B3) per year from **SR 290.3 billion** in 1998 to **SR 345.7 billion** in 2005 (see Tables 7.18 and 7.9); under scenario C3g, the non-oil GDP for 1999-2005 grows at a higher average rate of 3.11 percent (compared to 2.48 percent under scenario C3) per year from **SR 290.3 billion** in 1998 to **SR 353.5 billion** in 2005 (see Tables 7.19 and 7.10).

In short, under the pessimistic scenario A3, the growth rate of the government expenditure for 1999-2005 is below 2 percent per year. Therefore restricting the government expenditure to grow at 2 percent per year worsens the government deficit under scenario A3g. This higher rate of growth in the government expenditure, however, eases public expectations about the liquidity constraint, and, therefore, lowers the velocity of money for 1999-2005. Accordingly, under the pessimistic scenario, the higher government expenditure for 1999-2005:

(i) slows down the growth in the real absorptive capacity,

(ii) slows down the growth in real imports which, in turn, improves the balance of payments,

(iii) slows down the growth in the non-oil GDP, and

(iv) slightly reduces the rate of inflation.

Again, based on our analysis, the higher government expenditure under the pessimistic scenario A3g results in a partial crowding-out as it affects the behaviour of the public toward demanding for money.

Under the moderate and optimistic scenarios (B3 and C3, respectively), the government expenditure grows at substantially higher than 2 percent per year.
Therefore, restricting the government expenditure to grow at 2 percent per year improves the government deficit under scenarios B3g and C3g. This slower growth in the government expenditure worsens public expectations about the liquidity constraint, and, therefore, increases the velocity of money for 1999-2005. Accordingly, under the moderate and optimistic scenarios, the slower growth in the government expenditures as it affects the behaviour of the public toward demanding for money for 1999-2005:

(i) increases the growth in the real absorptive capacity,
(ii) increases the growth in the real imports which, in turn, worsens the balance of payments,
(iii) increases the growth in the non-oil GDP, and
(iv) slightly increases the rate of inflation.

7.8 Policy recommendations based on the scenario analysis

Our examination of the Saudi economy in Chapter One of this study, especially for the period after 1970, indicated that the rush toward development tied the level of government development expenditures too closely to the government oil revenue, and, therefore, to the unfavourable fluctuations in the world market for crude oil. Tanzi (1990) argues that such expenditures, instead, should have been related to the average or trend level of current or expected revenues over time. That is, “this relationship implies that the country should run a budgetary surplus in good years and a deficit in periods when exports are lagging behind their trend level, or when other negative factors predominate”. Accordingly, a fiscal policy that relates government development expenditures to the trend level of expected revenues avoids unfavourable fluctuations outside the control of the policy-makers and are expected to promote economic stability and growth. Tanzi’s argument, therefore, calls for the establishment of “emergency reserve funds”. In other words, unexpected increases in oil revenue due to higher than expected oil prices (or oil production) will be set aside in the form of “emergency reserve funds” and used when there is an unexpected decline in oil revenue due to lower than expected oil prices (or oil production). This

allows stable and steady growth in government expenditure regardless of the fluctuations in the world oil market.

Following the sharp decline in Saudi oil production in 1982 and later the sharp drop in oil prices in 1986, the Saudi Arabian economy has been experiencing a persistent budgetary deficit. Based on the results of the forecasting scenarios A1, A2, A3, B1, B2, B3 and C1, C2, C3 examined in Sections 7.2-7.4 of this chapter, with the government expenditure being tied too closely to the government oil revenue, this trend is likely to continue well into the year 2005. The absence of a budgetary surplus, anytime soon therefore, rules out the establishment of “emergency reserve funds”, in the sense advanced by Tanzi (1990). It is for this reason that we have introduced the forecasting scenarios A1g, A2g, A3g, B1g, B2g, B3g and C1g, C2g, C3g in Sections 7.5-7.7 of this chapter. In response to the close tie between the government expenditure and oil revenue, all these scenarios (whether pessimistic, moderate, or optimistic), restrict the growth of the government expenditure to 2 percent per year.

Under the pessimistic scenarios when the price of oil is low restricting the growth of government expenditure to 2 percent per year results in the following disadvantages and advantages.

Disadvantages:

(1) higher government deficit,
(2) slower growth in real absorptive capacity or aggregate demand for goods and services,
(3) slower growth in non-oil production or real non-oil GDP.

Advantages:

(1) slightly lower inflation, and
(2) slower growth in real imports, and, therefore, improved balance of payments.

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Under the moderate and optimistic scenarios, when the price of oil is relatively higher, restricting the growth of government expenditure to 2 percent per year results in the following advantages and disadvantages.

Advantages:
(1) lower government deficit,
(2) higher growth in real absorptive capacity or aggregate demand for goods and services,
(3) higher growth in non-oil production or real non-oil GDP.

Disadvantages:
(1) slightly higher inflation, and
(2) higher growth in real imports, and, therefore, higher balance of payments deficit.

As seen, under the pessimistic scenarios, the disadvantages of restricting the government expenditure to 2 percent per year for 1999-2005 dominate the advantages. Accordingly, we may then recommend intervention by allowing zero growth in the government expenditure for 1999-2005 under scenario A1, and only 1 percent rate of growth per year under scenarios A2 and A3. Note that in the absence of intervention, the government expenditure for 1999-2005 actually declines by an average rate of 0.75 percent per year under the pessimistic scenario A1 (see Table 7.2) but increases by an average rate of 1.19 percent per year under the pessimistic scenarios A2 and A3 (see Tables 7.5 and 7.8).

Under the moderate and optimistic scenarios, the advantages of restricting the government expenditure to 2 percent per year for 1999-2005 dominate the disadvantages. Accordingly, we may then recommend intervention by restricting the government expenditure growth by 2 percent per year for 1999-2005. Note that in the absence of intervention, the government expenditure for 1999-2005 would increase:

(i) by an average rate of 3.69 percent per year under the moderate scenario B1 (see Table 7.3), and
(ii) by an average rate of 6.27 percent per year under the moderate scenarios B2 and B3 (see Tables 7.6 and 7.9).

Furthermore, in the absence of intervention, the government expenditure for 1999-2005 would increase:

(i) by an average rate of 5.38 percent per year under the optimistic scenario C1 (see Table 7.4), and

(ii) by an average rate of 8.20 percent per year under the optimistic scenarios C2 and C3 (see Tables 7.7 and 7.10).

Therefore, our policy recommendations under the pessimistic, moderate, or optimistic scenarios call for a smaller government and seek to reduce government involvement in the development process by placing a greater reliance on the private sector. This necessitates a comprehensive privatisation program which, in part, encourages private funds for investment in public sector development plans. Accordingly, our policy recommendations are well in line with the sixth development plan which calls for both the private and public sectors to finance the necessary investment. Over the duration of the plan, the total investment requirement is estimated to be SR 472 billion. As indicated by Presley (1996b), the sixth development plan expects that SR 213 billion of the total investment requirement (nearly 45 percent) will come from the private sector. Most of the public sector investment financing, however, is allocated for petrochemicals, petroleum refining, and electricity and water, with little contribution in construction, trade, restaurants and hotels, and financial services. The plan expects private sector involvement in financing most of the investment requirement for the latter sectors.

Furthermore, in an effort to successfully restrain the growth of the government sector, our policy recommendations emphasise:

(i) such factors as efficiency and cost effectiveness in government spending, and

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(ii) the need for a redistribution of government spending by increasing government capital expenditure while significantly reducing government consumption expenditure.

Moreover, based on the findings of our scenario analysis in this chapter, the real imports is almost as equally responsive as the real non-oil GDP to an increase in the real absorptive capacity. As an example, in comparing the moderate scenario B2g with B2, the increase in the real aggregate demand for consumption and investment goods and services (or the real absorptive capacity) by SR 61.1 billion for 1999-2005 is met by SR 28.8 billion increase in the real imports and by SR 32.3 billion increase in the real non-oil production or GDP (see Tables 7.15 and 7.6). With the level of exports unchanged, this substantial increase in the real imports, consequently, worsens the balance of payments.

Improving this situation requires a strong non-oil production sector, being able to respond more strongly to satisfy higher demand for, at least, consumption goods and services. This, in line with the sixth development plan, suggests economic policies aimed at improving business conditions in the private sector.

More specifically, the sixth development plan's private sector policy emphasises privatisation and the encouragement of small-scale enterprises as well as Saudi-isation. Privatisation aims at enhancing the role of the private sector in the Saudi economy, and Saudi-isation aims at encouraging the development and utilisation of Saudi human resources. As indicated by Presley (1996b), over 90 percent of businesses in Saudi Arabia employ less than 20 people. These businesses have limited access to finance, they do not gain exemption from customs or taxes, and they cannot obtain land and fuel at the nominal prices available to larger companies with industrial licenses. In addition, these businesses suffer from relatively low managerial and production efficiency. In order to enhance business conditions for small businesses, the Saudi Credit Bank is targeted to make SR 1.5 billion loans towards improving small business's access to finance. The government’s incentives to industry are also extended to benefit small businesses. To increase managerial and production efficiency, specialised training programs for small businesses are expected to be offered by Chambers of Commerce. The plan also calls for more efforts by the government toward identifying profitable small-scale investment opportunities.
In addition, foreign employment is to be limited to only skilled and semi-skilled labour. Accordingly, Saudi-isation is emphasised by both incentives as well as mandatory measures. For example, incentives include financial and other supports for the private sector achieving Saudi-isation targets within companies. Mandatory measures, however, include not only ceilings on the employment of non-Saudis but also minimum targets of Saudi employment.⁸

Finally, in the pursuit of a strong non-oil production sector, economic policies should aim at discouraging the imports of consumption goods and services and instead encourage the imports of technology and up-to-date means of production and know-how. Such a redistribution of real imports between consumer and capital goods and service with the aim of reducing the total real imports will ultimately lead to improving the balance of payments.

Chapter 8. Summary and conclusions

A great deal of discussion in the introductory chapter of this study concentrates on a general economic background of Saudi Arabia before and after 1970. As discussed, following the introduction of formal development plans in 1970 and the unexpected fourfold increase in oil prices in 1973, Saudi Arabia started massive investment in industrial infrastructure, and at the same time, directed a substantial portion of her huge development outlays toward the creation of heavy industry. Despite the fact that the decline in the oil revenue in the 1980s has undermined this strategy, our analysis still points to a structural change in the working of the Saudi economy before and after 1970. As a result, the purpose of this study has been to develop a structural model which will help us understand the working of the Saudi economy after 1970. The aim is to provide policy recommendations for economic stabilisation and growth in light of the foreign sector disturbances.

Based on the aggregate demand and aggregate supply approach, we have worked in this study toward building a structural macroeconometric model which provides us with a clear link between the monetary, foreign, government, and oil and non-oil production sectors of the Saudi economy. Accordingly, Chapters 2 and 3 concentrates on the formulation of the aggregate demand model, and Chapter 4 concentrates on the formulation of the aggregate supply model.

More specifically, the aggregate demand model in the Saudi economy specifies the relationship between the sum of private and public demand for consumption and investment goods and services or the real absorptive capacity (RD\textsubscript{1}) and the general price level (P\textsubscript{1}) measured by the implicit price deflator for the absorptive capacity. The macroeconomic textbook approach in formulating the aggregate demand model is to combine the IS curve from the real sector and the LM curve from the monetary sector. This approach is appropriate when the interest rate is simultaneously determined with the aggregate demand (or real income). Friedman's or the monetary approach assume that the interest rate is basically predetermined, and, therefore, formulates the aggregate demand model based on the LM curve derived from the monetary sector alone. Having shown that the interest rate plays an insignificant role in affecting the behaviour of money demand or money velocity, this study makes use
of Friedman's approach to formulate the aggregate demand model of the Saudi economy based on the intersection of the demand for money (or velocity) function and the money supply function.

Economic theory suggests that the behaviour of the demand for real money balances is affected by the level of transactions, interest rate, and inflationary expectations, as well as the expected degree of credit restraint in the case of developing economies (Wong, 1977). Our empirical examination of the Saudi demand for money function assigns an important role for the level of transactions measured by the real absorptive capacity or the income available to the domestic economy. Another important variable explaining the behaviour of the Saudi demand for money is the expected degree of credit restraint. More specifically, in line with Wong (1977), Looney (1982, p. 261), in the case of the Saudi economy, argues that "when credit is tightened, individual's conserve on their money balances, whereas in periods of easy credit, they may keep excess balances (because of their low opportunity costs)". Following a slightly different argument, Presley and Westaway (1988) include a similar measure called instead the "excess liquidity" variable. Their empirical results, in line with Looney (1982), assign a significant role to this variable in the demand function for money in the Saudi economy. Our empirical analysis indicates that the expected degree of credit restraint defined as the ratio of government oil revenue in period $t$ and government expenditure in period $t-1$ is highly correlated with the demand for money. Theoretically, we may argue that, since government expenditure is the largest source of liquidity in the private sector, then the expected degree of credit restraint depends on how this expenditure is expected to be financed. For example, one may expect a lower degree of credit restraint if the government oil revenue is not sufficient enough to keep up with the expenditure to, at least, the level experienced in the previous period. This means that the government is expected to borrow from the banking system to finance its expenditures. With the banking system extending loans to the government, the supply of money or liquidity will expand, and therefore, a lower degree of credit restraint will be expected. On the other hand, if the government oil revenue is more than sufficient, economic agents expect no need for the government to borrow from the banking system. In fact, they expect the excess of government revenue to be added to the government deposit in the banking system, which, therefore, lowers the claims of the banking system on the government. This,
consequently, contracts the money supply and liquidity, and, therefore, a higher degree of credit restraint will be expected.

The opportunity cost variables in the demand function for money examined are the market interest rate (approximated by the rate offered by commercial banks on time and saving deposits) and inflationary expectations (measured by the previous year's rate of general price inflation). Our empirical analysis indicates that neither the interest rate nor inflationary expectations explain the behaviour of the Saudi demand for money. Our examination also suggests that the actual demand for money does not adjust to the desired demand for money in the immediate period. Accordingly, we have formulated the demand for money function within a partial adjustment process to allow the actual demand for money to adjust to the desired demand for money over time. Further examination reveals that the demand for money function can be respecified in the form of the velocity function within a partial adjustment process.

Our examination of the balance sheet of the Saudi banking system indicates that the changes in the money supply, \( \Delta M_t \), may be explained by three major factors. The first factor is the balance of payments \( BP_t \), as it affects the changes in the net foreign assets in the banking system. Given that the balance of payments consists of the current account and the capital account, other things equal, an increase in exports relative to imports, for example, translates itself into higher foreign assets in the banking system, and, therefore, a higher supply of money in the economy. Similarly, other things equal, capital inflows (outflows) increase (decrease) the foreign assets in the banking system, which results in a higher (lower) level of money supply.

The second factor is changes in the banking system's claim on the government, which is largely determined by the difference between the government expenditure, \( GEX_t \), and the government total revenue, \( GTR_t \). For example, when the expenditure dominates the total revenue, \( GEX_t > GTR_t \), the government starts financing its deficit by using up its deposits in the banking system or by borrowing from the banking system in case the government deficit is larger than its deposits. In such situations, the banking system's claim on the government will increase, and, therefore, the money supply will expand and make the economy more liquid. On the other hand, when the expenditure is dominated by the total revenue, \( GEX_t < GTR_t \), the government starts adding the surplus to its deposits in the banking system. In this situation, the banking
system’s claims on the government will reduce, and, therefore, the money supply will contract.

The third factor affecting the change in money supply is the change in nominal non-oil GDP, $\Delta \text{NGDPN}_t$, as it directly affects the change in the banking system’s claim on the private sector. For example, higher non-oil GDP encourages higher demand for credit from the banking system. This, in turn, increases the banking system’s claims on the private sector and, therefore, the supply of money in the economy.

Our empirical examination of the money supply function reveals that 92.0 percent of the total sample variations of the change in money supply is explained by the balance of payments ($\Delta \text{BP}_t$), the difference between the government expenditure and total revenue ($\Delta \text{GEX}_t - \Delta \text{GTR}_t$), the change in the nominal non-oil GDP ($\Delta \text{NGDPN}_t$). In addition, all these explanatory variables have the theoretically correct coefficient estimates. The conclusion that follows is that the money supply in the Saudi economy is endogenous to both external and internal forces. External forces include exports, imports, and capital inflows, or, in general, the balance of payments. Internal forces include the government total revenue and expenditure as well as the nominal non-oil GDP. Because of its sheer size, the government expenditure becomes the principal source of change in the supply of money. This, in turn, indicates that monetary and fiscal policies in Saudi Arabia are identical.

In general, formal studies of the money supply process examine the role of three conventional monetary policy tools in controlling the level of liquidity in the economy. These tools include the discount rate, Open Market Operation, and the required reserve ratio. Since, according to Islamic law, SAMA is prohibited from paying or receiving interest, the discount rate, as a monetary policy tool, is not available to SAMA in controlling the supply of money in Saudi Arabia. Given that bond market trading in Saudi Arabia is still in the early stages of development, the Open Market Operation cannot yet be considered as an effective monetary policy tool for SAMA to control liquidity. The Open Market Operation through selling and buying foreign exchange to control the liquidity is also ruled out, since it compromises the stable exchange rate policy pursued by SAMA. In fact, speculation in the Riyal is discouraged by SAMA, through, for example, the revaluation of the Riyal when a devaluation is expected by the market. With the elimination of both the discount rate
and Open Market Operation policies, SAMA is left with the required reserve ratio as the only conventional monetary policy tool in controlling the money supply and liquidity in the Saudi economy. As discussed above, the reserve required ratio, as a monetary policy tool, affects the amount of money that commercial banks can create given the monetary base. Prior to 1987, the actual reserve ratio in Saudi Arabia was determined by commercial banking practices rather than by some minimum required reserve ratio set by SAMA. More specifically, the reserve ratio actually kept by the commercial banks were far above the minimum reserve ratio set by SAMA. This indicates that the reserve requirement ratio as a conventional monetary policy tool available to SAMA was in fact ineffective in controlling the supply of money in Saudi Arabia. Since 1987, as indicated by Professor Presley, there has been a change in the behaviour of the commercial banks towards holding excess reserves. Accordingly, this change in behaviour may affect the effectiveness of this policy tool. However, as argued by Banafe (1993), the reserve requirement policy tool is difficult to fine tune. It is, perhaps, for this reason that SAMA has utilised this tool only a few times in the last twenty-five years, the latest being in 1980. Another reason, as argued by Banafe (1993), may be that the role of the monetary policy, for example, through the required reserve ratio, is restricted because the government expenditure is the major determinant of liquidity. More specifically, since the Saudi government spends a significant portion of its revenue in the domestic economy, the control of the money supply and liquidity in the Saudi economy may be achieved through fiscal policy practices which aim to control the government expenditure. This, again, implies that monetary and fiscal policies in Saudi Arabia are identical.

The model of the Saudi Arabian monetary sector, developed in Chapter 2, cannot by itself determine the aggregate demand curve. This is because the supply of money is endogenously influenced by such macroeconomic variables as the balance of payments and government total revenue and expenditure. To complete the formulation and estimation of the aggregate demand model, we further examine the behaviour of the foreign and government sectors of the Saudi economy in Chapter 3.

The formulation of the foreign sector concentrates on the determination of the balance of payments, BP, which is defined as the sum of the trade balance, \((REXT_t \times PEXT_t) - (RIMT_t \times PIM_t)\), and the net capital inflow plus the net of all other factors in the balance of payments, CAPF. The real exports, REXT, which largely include
crude oil and oil refinery products, is exogenously determined by the government through negotiations with other OPEC members and the world's demand for crude oil. The price index for exports, $\text{PEXT}_t$, and the price index for imports, $\text{PIM}_t$, are also both determined by the world market forces, and, therefore, are treated as exogenous to the Saudi economy. It is further argued that $\text{CAPF}_t$ is determined by such factors as the world and regional political situations, and, therefore, is treated as exogenous.

The balance of payments, however, is not totally exogenous to the domestic economy, since the real imports, $\text{RIMT}_t$, is endogenously determined. More specifically, based on the theory of demand, the level of economic activity is a major determinant of the desired demand for imported goods and services. For example, during a boom, higher economic activity encourages not only higher demand for imports of consumer goods and services but also higher imports of investment (capital) goods and raw materials. The converse is also true.

In the case of the Saudi economy, as far as the import of consumer goods and services are concerned, the economic activity may be measured by the real absorptive capacity or the real income available to the domestic economy; that is $\text{RDI}_t$. With respect to the import of investment (capital) goods and raw materials, the real non-oil GDP, $\text{RGDPN}_t$, may be the relevant variable to measure economic activity. Accordingly, it is desirable to formulate and estimate two demand functions for imports: one for consumer goods and services and the other for investment (capital) goods and raw materials. However, while the data on the total real imports are available, its division between the real imports of consumer goods and services and the real imports of capital goods and raw materials is not available for the whole sample period under examination. Accordingly, we are forced to have only one demand function for the real total imports.

A difficulty in having one aggregate demand function for imports, as implied above, is how to measure the economic activity. Our empirical analysis favours the real income available to the domestic economy rather than the real non-oil GDP as the relevant measure of economic activity in the demand function for imports. Another important determinant of the real imports is shown to be the real government oil revenue. This is not surprising, since the ability of the economy to import either consumer goods or capital goods and raw materials depends largely on the revenue received from oil exports. Our empirical analysis also suggests the importance of the
relative import prices in explaining the behaviour of the demand for real imports. For example, higher (lower) import prices relative to domestic prices encourage (discourage) import substitution. In the case of Saudi Arabia, this argument seems appropriate as the government follows the policy of diversification to reduce the country’s dependence on imported goods and services.

In modelling the government sector of the Saudi economy, our examination in Chapter 3 includes the formulation and estimation of the function for government oil and non-oil revenue as well as the function for government expenditure. Government oil revenue consists of oil royalties from the operating companies, income tax collected from these companies, tapline fees, etc. in formulating the function for government oil revenue, the quantity and price of oil exports are considered as the two major explanatory variables. Given that the real exports largely include crude oil and oil-related exports, for simplicity the quantity and price of oil exports are approximated, respectively, by the real exports, $REXT_t$, and the price deflator index for exports, $PEXT_t$. Our empirical analysis, however, suggests a dynamic specification for the government oil revenue function, where the effect of the real exports on government oil revenue is distributed over the immediate period and the following first period.

Government non-oil revenue consists of the compulsory right to be taken from the property in accordance with the Islamic law named “Zakat”, and fees on services provided by government agencies. In general, government non-oil revenue has a direct relation with the income available to the domestic economy (or the absorptive capacity). Our empirical analysis, however, suggests a dynamic specification for the government non-oil revenue function, where the effect of income on government non-oil revenue is distributed over time based on a geometrically declining pattern. Accordingly, the short-run and long-run effects are found to be, respectively, 0.057 and 0.099. This indicates that a SR 1.0 billion increase (decrease) in the real absorptive capacity increases (decreases) government non-oil revenue by SR 0.057 billion in the immediate period (short-run) and by SR 0.099 billion in the long-run.

In formulating the function for the government expenditure, we have utilised the government oil revenue as a relevant explanatory variable. This follows the conclusion reached based on our analysis of the Saudi economy after 1970 that the rush toward development and economic diversification tied the level of government
expenditure too closely to government revenue received from oil. Our empirical examination of this function further reveals a dynamic specification where the effect of government oil revenue on government expenditure is distributed over time based on a geometrically declining pattern. Accordingly, the short-run and long-run elasticities are found to be, respectively, 0.357 and 1.081. This indicates that a one percent increase (decrease) in government oil revenue increases (decreases) government expenditure by 0.357 percent in the immediate period (short-run) and by 1.081 percent in the long-run.

Combining the equations and identities forming the monetary foreign, and government sectors, the concluding section of Chapter 3 presents the aggregate demand model of the Saudi economy, as it specifies a relationship between the real absorptive capacity, $RDI_t$, and the general prices, $P_t$. Accordingly, with $REXT_t$, $PEXT_t$, $PIM_t$, and $CAPF_t$ being determined exogenously, the above aggregate demand model includes more endogenous variables than equations. Specifically, the model includes ten equations with thirteen endogenous variables: the velocity of money ($V_t$), money supply ($M_t$), real absorptive capacity ($RDI_t$), balance of payments ($BP_t$), real imports ($RIMT_t$), government total revenue ($GTR_t$), government oil revenue ($GOR_t$), government non-oil revenue ($GNR_t$), government expenditure ($GEX_t$), real total GDP ($RGDP_t$), real non-oil GDP ($RGDPN_t$), general price level ($P_t$), and non-oil GDP price level ($PGDPN_t$). The first ten endogenous variables are determined based on the specified equations and identities within the aggregate demand model. The last three endogenous variables, $RGDPN_t$, $P_t$, and $PGDPN_t$, however, cannot be endogenously determined in the absence of the aggregate supply model. This, therefore, necessitates the formulation and estimation of the aggregate supply model in Chapter 4 of this study.

The aggregate supply of the Saudi economy, defined by the real total GDP, consists of the oil and non-oil production measured, respectively, by the real oil GDP, $RGDPO_t$, and the real non-oil GDP, $RGDPN_t$. The distinction between oil and non-oil sectors is necessary because of the sharp difference in the behaviour of oil from non-oil production. For example, the level of oil production in the Saudi economy is mainly determined by the international demand and supply conditions for crude oil. By contrast, however, the level of non-oil production is mainly determined within the domestic economy.
Following Looney (1982), it is argued that the level of oil production in the Saudi economy is directly related to the amount of crude oil and refinery products that the country is able to export. Accordingly, the function for real oil GDP, $\text{RGDPO}_t$, includes the real exports, $\text{REXT}_t$, as the only explanatory variable. As already discussed, the real exports largely include the exports of crude oil and refinery products exogenously determined by the government through negotiations with other OPEC countries based on the international demand and supply conditions for crude oil. It follows that the real oil GDP is essentially exogenously determined in our model.

The non-oil supply function of the Saudi economy, in the spirit of the Phillip's curve (Phillips, 1958) approach, relates the non-oil GDP price inflation, $\text{PGD PN}_t$, to the rate of deviations of the actual real non-oil GDP, $\text{RGDPN}_t$, from the normal or long-run level of real non-oil GDP, $\text{RGDPN}_t^*$, with the economic agents' price inflationary expectations, $\text{Pt}^*$, utilised as a shift variable. It is important to note that both the normal or long-run level of real non-oil GDP and the inflationary expectations variables are endogenously determined within the model. That is, the normal or long-run level of real non-oil GDP is determined by the previous years' actual levels of real non-oil GDP based on a geometrically declining pattern, and the economic agents' inflationary expectations in year $t$ is set equal to the previous year's actual rate of inflation $\text{Pt}^*$, which is known at year $t$. Our empirical analysis indicates a theoretically consistent upward-sloping supply curve for the non-oil production sector. It also provides us with a significant and positive coefficient estimate on the inflationary expectations variable as theoretically expected.

In addition to studying the behaviour of the oil and non-oil production sectors in Chapter 4, we have also specified the equilibrium condition of our macroeconometric model. Consistent with macroeconomic theory, it is the intersection of the aggregate demand curve and the aggregate supply curve that defines the equilibrium condition in our macroeconometric model of the Saudi economy. This intersection determines the levels of the aggregate demand and supply as well as prices. However, as indicated above, the aggregate demand specifies the relationship between the real absorptive capacity, $\text{RDI}_t$, and the general prices, $\text{Pt}$, while the
aggregate supply curve specifies basically the relationship between the real non-oil GDP and the non-oil GDP prices. The equilibrium condition, \[ (RGDPN_t + RGDPO_t - RIMD_t) = RGDP_t = RDI_t + (REXT_t - RIMT_t) \], specifies a relationship between the real absorptive capacity and the real non-oil GDP. However, in order to complete our macroeconometric model, we still need to specify a relationship between the general price level and the non-oil GDP price level. This is done based on the formulation of the function for the general price level. More specifically, the demand for consumption and investment goods and services (or the real absorptive capacity) is satisfied by domestically produced goods and services (measured by the real non-oil GDP) and imported goods and services (measured by the real imports). This indicates that the general price level (measured by the price deflator of the absorptive capacity) is influenced by both the price of non-oil GDP and the import prices. In fact, our empirical analysis indicates that the general price level is a weighted average of the non-oil GDP price level and the import prices. For example, based on the estimation of function for the general price level, the contribution of the non-oil GDP price level to the general price level is 75.7 percent. On the other hand, however, the contribution of the import price level to the general price level, however, equals 25.2 percent. It is argued that, given the openness and the dependence of the Saudi economy on imported goods and services in satisfying the private and public sectors' demand for both consumption and investment goods, this relatively large contribution of the import prices seems reasonable.

The concluding section of Chapter 4 presents the aggregate supply model of the Saudi economy, which specifies a relationship between the real non-oil GDP, \( RGDPN_t \), and the non-oil GDP prices, \( PGDPN_t \). Accordingly, with the real exports \( REXT_t \), import prices \( PIM_t \), and real import duties \( RIMD_t \) being exogenously determined our aggregate supply model includes more endogenous variables than equations. Specifically, the model includes eight equations with nine endogenous variables. The endogenous variables are the non-oil GDP price inflation \( PGDPN_t \), non-oil GDP price level \( PGDPN_t \), the normal or long-run level of real non-oil GDP \( RGDPN_t \), expected rate of inflation \( P^*_t \), actual rate of inflation \( P_t \), real oil GDP \( RGDPO_t \), real non-oil GDP \( RGDPN_t \), general price level \( P_t \) and real total GDP \( RGDP_t \). The first eight endogenous variables are determined based on the specified
equations within the aggregate supply model. The last endogenous variable, $\text{RGDP}_t$, however, cannot be endogenously determined in the absence of the aggregate demand model. Therefore, the aggregate demand and supply models are combined in Chapter 5 to give us the complete macroeconometric model of the Saudi economy.

Based on the aggregate demand and aggregate supply methodology, the theoretical and internal consistency of the complete macroeconometric model is once again examined in Chapter 5. The complete model includes eighteen equations and eighteen endogenous variables with five exogenous variables. Nine of the eighteen equations are behavioural and the other nine are identities. Our analysis indicates that six of these eighteen equations fall in two non-simultaneous blocks and the other twelve equations fall in a simultaneous block. More importantly, however, four of the nine behavioural equations fall in the non-simultaneous block. Accordingly, it is argued that the OLS coefficient estimates of the equations are unbiased and consistent. The other five behavioural equations fall in the simultaneous block. Given that the OLS coefficient estimates of these behavioural equations contain a simultaneity bias, we have re-estimated them using the TSLS estimation technique to obtain consistent estimates.

Our macroeconometric model with consistent coefficient estimates for the 1971-1994 estimation period is reported in Table 5.5. The validity of this estimated model has been checked based on graphical and numerical measures applied to the dynamic historical simulation results. It is noted that the historical dynamic simulation of the model in Table 5.5 gives a simulated series for each endogenous variable for 1971-94. The evaluation of the model is then based on comparing the simulated series with the actual series for each endogenous variable. According to the graphical measures, the simulated series of the endogenous variables closely move together with their corresponding actual series, leading to the conclusion that the model is dynamically stable over the estimation sample period. Based on the numerical measures, it is shown that, for all endogenous variables, the mean error and mean absolute error are both small relative to the mean value of the actual series. The calculated coefficient correlation and Theil’s inequality coefficient also reveal that the simulated series are higher correlated with the actual series with no tendency of systematic over-simulation or under-simulation. The high quality of the historical
simulation is further supported based on the calculated bias, regression, and disturbance proportions for each endogenous variable.

Accordingly, we have concluded that our macroeconometric model reasonably replicates the reality of the Saudi economy over the 1971-1994 estimation period. Assuming that the economy remains stable and follows a pattern similar to that in the past, our estimated macroeconometric model in Table 5.5 is utilised in Chapter 6 to derive and analyse the short-run and long-run (or cumulative) multiplier effects on the endogenous variables of:

(i) a ten percent increase in the price of (oil) exports,
(ii) a ten percent increase in the real (oil) exports, and
(iii) a ten percent decline in the price of imports.

The results of our multiplier analysis for a ten percent increase in the price of (oil) exports and a ten percent increase in the real (oil) exports are similar, and, therefore, lead to similar conclusions. That is, the effects of a one-time increase in either the price of (oil) exports or the real (oil) exports on the real absorptive capacity, non-oil GDP, and imports die off quickly over the periods. In contrast, however, the effect on the government expenditure does not die off as quickly. This is perhaps due to the long-term nature of the development projects that the government commits to, following a one-time increase in either the price of (oil) exports or the real (oil) exports. Initially, the increase in the government expenditure is dominated by the government oil revenue, improving the government’s position in terms of deficit. However, as soon as the increase in the government oil revenue disappears, then the persistent increase in the government expenditure contributes to higher government deficit. This, in turn, is partially responsible for the increase in the money supply dying off rather slowly over the periods. An important conclusion that may follow from these observations is that such fiscal and monetary variables as the government expenditure and the money supply have, at best, temporary (but not lasting) effects on the real absorptive capacity and non-oil production.

A similar conclusion can be derived based on the long-run multiplier analysis of an increase in either the price of (oil) exports or the real (oil) exports, as the cumulative effects on the real absorptive capacity, non-oil GDP, and imports, tend to
level off by the following third period despite the continuing increases in the government expenditure and the money supply. Another important conclusion, based on both the short-run and long-run multiplier results, is that the general price and the non-oil GDP price levels do not seem to be very sensitive to an increase in either the price of (oil) exports or the real (oil) exports.

Based on the multiplier analysis of the price of imports, however, these price levels seem to be much more sensitive to a ten percent decline in the price of imports. In addition to this conclusion, a one-time decline in the price of imports reduces the relative price of imports, and, therefore, results in substantial increases in the real imports and the real absorptive capacity, but a decline in the non-oil GDP in the immediate period. In the absence of the decline in the price of imports in the following first period, the increase in the real imports disappears, and, therefore, the continuing increase in the real absorptive capacity is entirely met by the increase in the real non-oil GDP. Based on the cumulative effects of a decline in the price of imports, the real absorptive capacity increases at a faster rate than the real imports. This:

(i) helps the decline in the real non-oil GDP be substantially lower in the following first and second period relative to that in the immediate period, and

(ii) leads to an increase in the real non-oil GDP in the following third and fourth periods.

As part of the scenario analysis in Chapter 7, after predicting the values of the endogenous variables for 1995-1998, the forecast values of the endogenous variables for 1999-2005 are obtained based on nine alternative scenarios which assume different behaviours for such exogenous variables as the price of (oil) exports, the real (oil) exports and the price of imports.

The first three forecasting scenarios examined are A1, B1, C1. All these scenarios assume that the real (oil) exports, the price of imports, the net capital inflow including the net of all other factors in the balance of payments, and the real import duties for 1999-2005 will remain the same at their respective 1998 level.

The difference between these scenarios, however, relates to the different set of prices for (oil) exports. For example, under scenario A1, the price of (oil) exports for 1999-2005 will continue to remain the same at its 1998 level. This scenario is referred
to as the pessimistic scenario. Under scenario B1, the price of (oil) exports for 1999-2005 will remain the same but at its 1997 level which is over 24 percent higher than the corresponding level under scenario A1. This scenario is referred to as the moderate scenario. Under scenario C1, the price of (oil) exports for 1999 is at its 1997 level but will increase for 2000-2005 at 2 percent per year. This scenario is referred to as the optimistic scenario. In comparing the forecasting results of scenarios A1, B1, and C1, our analysis indicates that the increase in the price of (oil) exports:

(i) worsens the government deficit but improves the balance of payments,
(ii) increases the rate of growth in the money supply,
(iii) increases slightly the rate of inflation, and
(iv) encourages the absorptive capacity, the real imports, and the domestic production or the real non-oil GDP.

The second three forecasting scenarios examined are A2, B2 and C2. Scenario A2, like scenario A1, represents the pessimistic scenario. Scenario B2, like scenario B1, represents the moderate scenario. Scenario C2, like scenario C1, represents the optimistic scenario. The only difference, however, is that under scenarios A1, B1 and C1, the real (oil) exports for 1999-2005 will remain the same at the 1998 level, while under scenario A2, B2 and C2, the real (oil) exports for 1999-2005 will increase by 2 percent per year. In comparison with scenarios A1, B1, and C1, our analysis indicates that the growth in the real (oil) exports under the corresponding scenarios A2, B2, and C2:

(i) worsens the government deficit but improves the balance of payments,
(ii) increases the rate of growth of the money supply,
(iii) increases slightly the rate of inflation, and
(iv) encourages the absorptive capacity, real imports, domestic production or real non-oil GDP and real oil GDP.

The third three forecasting scenarios examined are A3, B3, and C3. Scenario A3, like scenarios A2, represents the pessimistic scenario. Scenario B3, like scenario
B2, represents the moderate scenario. Scenario C3, like scenario C2, represents the optimistic scenario. Like scenarios A2, B2, and C2 the real (oil) exports for 1999-2005 will increase by 2 percent per year. The only difference, however, is that, under scenarios A2, B2, and C2, the price of imports for 1999-2005 will remain the same at its 1998 level, while under scenarios A3, B3, and C3, the price of imports for 1999-2005 will increase by 2 percent per year. In comparison with scenarios A2, B2, and C2, our analysis indicates that the increase in the import prices under the corresponding scenarios A3, B3, and C3:

(i) has a slight positive effect on the government deficit, the balance of payments, and the real non-oil GDP,
(ii) produces a larger increase in the general price inflation than the non-oil price inflation, and
(iii) slows down the rate of growth in the real imports and the real absorptive capacity.

In all scenarios A1, 2, 3, B1, 2, 3, and C1, 2, 3 examined above, the government expenditure is a function of the government oil revenue based on a partial adjustment process. Given the crucial role of the government expenditure in the Saudi economy, it is important for us to re-examine the forecasting results of the above scenarios when the government expenditure is instead exogenously controlled. This re-examination results in nine additional forecasting scenarios A1g, 2g, 3g, B1g, 2g, 3g, and C1g, 2g, 3g.

The first three forecasting scenarios examined are A1g, B1g, and C1g. The forecasting results of these scenarios are compared, respectively, with those of A1, B1, and C1. The only difference between these two scenarios is that under scenarios A1, B1, and C1, the government expenditure is a function of the government oil revenue, while under scenarios A1g, B1g, and C1g, the government expenditure for 1999-2005 is restricted to grow at 2 percent per year. Our analysis indicates that under the pessimistic scenario A1 when the government oil revenue is far below its historical level for 1999-2005, the government expenditure shows a declining pattern. Therefore restricting the government expenditure to grow at 2 percent per year worsens the government deficit under scenario A1g. Given that the government expenditure is a
major source of liquidity in the Saudi economy, the growth in the government expenditure eases public expectations about the liquidity constraints, resulting in the velocity of money exhibiting a declining pattern for 1999-2005. Accordingly, the increase in the government expenditure under the pessimistic scenario for 1999-2005:

(i) slows down the growth in the real absorptive capacity,

(ii) slows down the growth in the real imports, which, in turn, improves the balance of payments,

(iii) slows down the growth in the non-oil GDP, and

(iv) slightly reduced the rate of inflation.

Based on our analysis, therefore, the expansionary fiscal policy under the pessimistic scenario results in a partial crowding-out as it affects the behaviour of the public toward demanding for money. Under the moderate and optimistic scenarios (B1 and C1, respectively) when the government oil revenue is in line with its historical level for 1999-2005, the government expenditure grows at substantially higher than 2 percent per year. Therefore, restricting the government expenditure to grow at 2 percent per year improves the government deficit under scenarios B1g and C1g. Accordingly, under the moderate and optimistic scenarios, the slower growth in the government expenditure as it affects the behaviour of the public toward the demand for money for 1999-2005:

(i) increases the growth in the real absorptive capacity,

(ii) increases the growth in the real imports which, in turn, worsens the balance of payments,

(iii) increases the growth in the non-oil GDP, and

(iv) slightly increases the rate of inflation.

The second three forecasting scenarios examined are A2g, B2g, and C2g. The forecasting results of these scenarios are compared, respectively, with those of A2, B2, and C2. The only difference between these two sets of scenarios is that under scenarios A2, B2, and C2, the government expenditure is a function of the government
oil revenue, while under scenario A2g, B2g, and C2g, the government expenditure for 1999-2005 is restricted to grow at 2 percent per year. Our analysis indicates that under the pessimistic scenario A2 the growth rate of the government expenditure for 1999-2005 is below 2 percent per year. Therefore, restricting the government expenditure to grow at 2 percent per year worsens the government deficit under scenario A2g. Under the pessimistic scenario, the higher government expenditure through its effect on the velocity of money for 1999-2005:

(i) slows down the growth in the real absorptive capacity,
(ii) slows down the growth in the real imports which, in turn, improves the balance of payments,
(iii) slows down the growth in the non-oil GDP, and
(iv) slightly reduces the rate of inflation.

Again, based on our analysis, the higher government expenditure under the pessimistic scenario A2g results in a partial crowding-out as it affects the behaviour of the public toward the demand for money. Under the moderate and optimistic scenarios (B2 and C2, respectively), the government expenditure grows at substantially higher than 2 percent per year. Therefore, restricting the government expenditure to grow at 2 percent per year improves the government deficit under scenarios B2g and C2g. Under the moderate and optimistic scenarios, the slower growth in the government expenditure as it affects the behaviour of the public toward demand for money for 1999-2005:

(i) increases the growth in the real absorptive capacity,
(ii) increases the growth in the real imports which, in turn, worsens the balance of payments,
(iii) increases the growth in the non-oil GDP, and
(iv) slightly increases the rate of inflation.

The third three forecasting scenarios examined are A3g, B3g, and C3g. The forecasting results of these scenarios are compared, respectively, with those of A3, B3,
and C3. The only difference between these two sets of scenarios is that under scenarios A3, B3, and C3, the government expenditure is a function of the government oil revenue, while under scenarios A3g, B3g, and C3g, the government expenditure for 1999-2005 is restricted to grow at 2 per cent per year. Our analysis indicates that under the pessimistic scenario A3, the growth rate of the government expenditure for 1999-2005 is below 2 percent per year. Therefore, restricting the government expenditure to grow at 2 percent per year worsens the government deficit under scenario A3g. Under the pessimistic scenario, the higher government expenditure through its effects on the velocity of money for 1999-2005:

(i) slows down the growth in the real absorptive capacity,
(ii) slows down the growth in the real imports which, in turn, improves the balance of payments,
(iii) slows down the growth in the non-oil GDP, and
(iv) slightly reduces the rate of inflation.

Again, based on our analysis, the higher government expenditure under the pessimistic scenario A3g results in a partial crowding-out as it affects the behaviour of the public toward demanding for money. Under the moderate and optimistic scenarios (B3 and C3, respectively), the government expenditure grows at substantially higher than 2 percent per year. Therefore, restricting the government expenditure to grow at 2 percent per year improves the government deficit under scenarios B3g and C3g. Under the moderate and optimistic scenarios, the slower growth in the government expenditures as it affects the behaviour of the public toward demanding for money for 1999-2005:

(i) increases the growth in the real absorptive capacity,
(ii) increases the growth in the real imports which, in turn, worsens the balance of payments,
(iii) increases the growth in the non-oil GDP, and
(iv) slightly increases the rate of inflation.
A general comparison of the forecasting results indicates that under the pessimistic scenarios, the disadvantages of restricting the government expenditure to 2 percent per year for 1999-2005 are:

(i) higher government deficit,
(ii) slower growth in real absorptive capacity or aggregate demand for goods and services,
(iii) slower growth in non-oil production or real non-oil GDP.

The advantages are:

(i) slightly lower inflation, and
(ii) slower growth in real imports, and, therefore, improved balance of payments.

Accordingly, the disadvantages dominate the advantages. We may then recommend intervention by allowing zero growth in the government expenditure for 1999-2005 under scenario A1 and only 1 percent rate of growth per year under scenarios A2 and A3. Note that in the absence of intervention, the government expenditure for 1999-2005 actually declines by an average rate of 0.75 percent per year under the pessimistic scenario A1, but increases by an average rate of 1.19 percent per year under the pessimistic scenarios A2 and A3. Under the moderate and optimistic scenarios, the advantages of restricting the government expenditure to 2 percent per year for 1999-2005 are:

(i) lower government deficit,
(ii) higher growth in real absorptive capacity or aggregate demand for goods and services,
(iii) higher growth in non-oil production or real non-oil GDP.

The disadvantages are:

(i) slightly higher inflation, and
(ii) higher growth in real imports, and, therefore, higher balance of payments deficit.

Accordingly, the advantages dominate the disadvantages. We may then recommend intervention by restricting the government expenditure growth by 2 percent per year for 1999-2005. Note that in the absence of intervention, the government expenditure for 1999-2005 would increase:

(i) by an average rate of 3.69 percent per year under the moderate scenario B1, and
(ii) by an average rate of 6.27 percent per year under the moderate scenarios B2 and B3.

Furthermore, in the absence of intervention, the government expenditure for 1999-2005 would increase:

(i) by an average rate of 5.38 percent per year under the optimistic scenario C1, and
(ii) by an average rate of 8.20 percent per year under the optimistic scenarios C2 and C3.

Therefore, our policy recommendations under the pessimistic, moderate, or optimistic scenarios call for a smaller government and seek to reduce government involvement in the development process by placing a greater reliance on the private sector. This necessitates a comprehensive privatisation program which, in part, encourages private funds for investment in public sector development plans. This, of course, is in line with the goals of the sixth development plan which calls for both the private and public sectors to finance the necessary investment. In addition, in an effort to successfully restrain the growth of the government sector, our policy recommendations emphasise:

(i) such factors as efficiency and cost effectiveness in government spending, and
(ii) the need for a redistribution of government spending by increasing government capital expenditure while significantly reducing government consumption expenditure.

Our scenario analysis further indicates that the real imports is almost as equally responsive as the real non-oil GDP to an increase in the real absorptive capacity. Improving this situation requires a strong non-oil production sector, being able to respond more strongly to satisfy higher demand for, at least, consumption goods and services. This, in line with the sixth development plan, suggests economic policies aimed at improving business conditions in the private sector. More specifically, the sixth development plan’s private sector policy emphasises privatisation and the encouragement of small-scale enterprises as well as Saudi-isation. Privatisation aims at enhancing the role of the private sector in the Saudi economy, and Saudi-isation aims at encouraging the development and utilisation of Saudi human resources. Foreign employment is to be limited to only skilled and semi-skilled labour, and Saudi-isation is emphasised by both incentives as well as mandatory measures.

Our policy recommendation, in line with the goals of the sixth development plan, further calls for enhancing business conditions for small businesses by providing exemption from customs or taxes, more access to finance through, for example, the Saudi Credit Bank, offering specialised training programs for increasing managerial and production efficiency, and obtaining land and fuel at the same nominal prices available to larger companies with industrial licenses.

Moreover, in the pursuit of a strong non-oil production sector, economic policies should aim at discouraging the imports of consumption goods and services, and, instead, encourage the imports of technology and up-to-date means of production and know-how. Such a redistribution of real imports between consumer and capital goods and services, with the aim of reducing the total real imports, will ultimately lead to improving the balance of payments.
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