Macroeconometric Model of an Oil Based Economy: Case Study of Libya

By

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DEDICATION

This thesis is dedicated to my parents; Hamed and Kalthoom, and my wife and children

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ABSTRACT

Macroecometric models are extremely important for developing countries as well as for developed countries. They can help and guide planners, policy makers and government leaders to establish priorities in their activities and to chose those policies which permit the most the rapid advance of economic development.

The aim of this thesis is to construct a macroeconometric model for the Libyan economy and to use the model to forecast future economic activities under different scenarios.

The Background of the Libyan economy is outlined first. Brief reviews of the theory of the background to the model components are given in the first part of the thesis. The specification of the model equations, depending on the economic theory and estimation procedures are carried out in the second part of the thesis. The calculations are carried out with a TSP package. Model validation is carried out in the third part of the thesis. This includes model evaluation (tracking performance and dynamic properties) and multiplier analysis. Model implications, such as forecasting (Ex-Post and Ex-Ante) are described in the last part of the thesis. Two different scenarios are considered. These scenarios explore the effects of different sets of oil prices and production on the Libyan economy, for the period 1996-2005. Several policy implications are derived from the results of the scenarios. The conclusion reached is that the Libyan economy is heavily dependent on Oil Revenues and any shock in this variable will have great effects on the Libyan economy. Also, excessive government spending is the main reason for the high inflation rate, which also leads to the crowding out of private investment.

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CHAPTER ONE

INTRODUCTION

1.1 Econometric Models of Less Developing Countries

Pioneering work in the development of macroeconometric models of industrialised economies began in the late forties and early fifties (Klein, 1950). However, the construction and estimation of such models for developing economies started only in the 1960s, (Lykourgou, 1967).

The first step in constructing a macroeconometric model, after collecting the data, is the specification of the model equations. The second step is the estimation procedure, in which the model equations are estimated by applying suitable techniques (OLS, 2SLS, etc.). The next stage is the validation of the model. This includes evaluation procedures (tracking performance, dynamic properties) and multiplier analysis (linear or non-linear). The last stage is the application of the model. This includes forecasting (ex-post and ex-ante forecasting) and policy evaluation.

At the present time, awareness of the importance of model building for developing economies is growing fast, as such models can help planners, government leaders and managers to establish priorities in their activities and to choose those policies which permit the most rapid rate of economic development. Macroeconometric models have usually been built for the following purposes :

1. Policy simulation and multiplier analysis. This enables us to learn how previous policies which resulted in unfavourable outcomes (high inflation rate, high levels of unemployment, etc.) could have been avoided and what policies should have been used at what time and at what level.

2. Forecasting the future level of economic activity. Here we distinguish between short-run, medium-run and long-run forecasting. The forecasting process might suggest possible methods of altering the economic variables being forecast, in terms of monetary, fiscal and other policies.

The success or failure of an econometric model, regardless of the questions it is designed to answer, depends primarily on the availability (or lack) of good statistical information on the various economic variables involved. If the econometricians were provided with all the data they wanted, even if it was of excellent quality, then econometric modelling would be, more or less, a simple application of economic theory. Unfortunately, this is almost never the case. If the availability of excellent quality data is considered as the best situation, the availability of reliable, but not excellent, information (which is the case in most industrialised countries), would be considered the second best. The case in less developed countries in general, and Libya in particular, is one of a short supply of statistical information and that of unimpressive quality. When facing all these limitations, one may get discouraged and abandon any thought of econometric modelling under these conditions. However, this study suggests that even if the data underlying an econometric model is of doubtful quality, it is still a useful tool to have to hand, as long as one is aware of the model limitations .

1.2 Study Objectives

Bearing the above difficulties in mind, the objective of this study is to construct a macroeconometric model of the Libyan economy. This involves the estimation of the numerical values for various important parameters relating to the behaviour of several economic phenomena during the period 1962-1991. For this period some reliable data are available. Once such parameters are known, multiplier analysis can be used as a guide to enlighten the policy maker as to the likely behaviour of the economy if various shocks are made to important variables. This might suggest possible actions to guide the course of the economy. Furthermore, the model may be used to forecast future economic activity under different scenarios, particularly regarding the impact of different oil prices and production levels. This is because Libya is an oil economy.

The questions that need to be asked in this study are:

(1) How is a Macroeconometric model constructed so that it reflects the real structure of Libyan economy that can be used for development planning as well as for stabilisation purposes?

(2) What does a model of the Libyan economy reveal? Or, in other words, what can be said about current Libyan economic problems and their proposed policy solutions by extrapolation from the resulting model?

1.3 Data

In most developing countries, including Libya, data and information needed for research are limited and sometimes unavailable. The problems in these countries include short time series of data, lack of monthly and quarterly data, missing observations and variables and the imposition of secrecy on some data and information. Compared with developed countries, data in developing countries also has less reliability. This is due to technical inexperience. In addition to the above problems, some unpublished data can usually only be obtained through a personal contact.

In the Libyan economy, the process of compiling national accounts takes some time and final estimates are not usually ready for publishing until about two or three years after the end of the year under consideration. This is due to the lack of quarterly statistical data.

This study is based on the annual time series data over the period 1962-1991. To take account of the rate of inflation, all data used in this study is expressed in real terms taking 1970 as the base year. In addition, all monetary data used to estimate the model are valued in the Libyan currency (i.e. Libyan dinar).

1.4 Historical Background to the Libyan Economy

Libya achieved independence in 1969. The area of Libya is 1,754,000 square kilometres and it is situated between the Mediterranean sea in the north and Chad and Niger in the south, and between Egypt and northern Sudan in the east, and Tunisia and southern Algeria in the west. It has a population of over 4.9 million (Statistical Bureau, 1996). The next sections will attempt to throw some light on the historical development of the Libyan economy.

The national economy in general suffered from dire underdevelopment in the early fifties. This was exhibited by the low per capita income and the population's living at subsistence level, if not below that level. The spread of disease and low standard of education were the direct causes of that poverty. Industry was non-existent except for some light industries of insignificant value and mineral resources were not known. Despite the fact that agriculture constituted the major source of living for the majority of the population, it lacked the application of sound scientific methods and the use of modern machinery as traditional methods of ploughing and harvesting prevailed. Therefore, and in spite of its importance as a sector on which the majority of the population depended, agriculture was retarded and greatly affected by several other factors, chiefly by lack of necessary capital investment and of agricultural credit banks that could extend loans to farmers to improve their lot (Ministry of Petroleum 1954-1971).

A new era for the Libyan economy began during the 1960s, through the agreement between the government and the international oil companies. This agreement increased the Libyan share of oil profit to 50%. This introduced profound changes in the whole economy, not only because of the new and relatively abundant financial resources received by the country, but also because of the changes brought about in the country's economic structure.

The development of the industrial sector was accelerated by the establishment of the Agricultural and Industrial Bank, which led to the extension of credit facilities and also by the active participation of the government in establishing some factories. The oil sector became the most important source of finance for industrial development.

The first Five-Year Economic and Social Development Plan 1963-1968 was constructed in 1963 and represented the beginning of Libya's formal development planning attempt. The objectives of the First Five-Year Plan 1963-1968 were:

1. To ensure the early improvement of the standard of living of the people, particularly those of limited income who did not benefit from the economic prosperity.
2. To give special consideration to the agricultural sector, this being the source of supply of most of the essential consumer goods, besides being the source of income and employment for the majority of the people.
3. To permit the public sector to continue its investments in such services as education, health, communications and housing, together with other sectors as required to consolidate the basic elements for rapid economic growth.
4. To develop rural areas by establishing productive and public projects.
5. To take such monetary, financial and commercial measures - all in a co-ordinated effort - as may be necessary to ensure increased revenue and to enforce tight control on expenditures.
6. To take steps to overcome the lack of information and statistical data which are necessary for planning by strengthening the existing statistical organs and by carrying out studies and research work.

Table 1.1 shows the planned and actual development spending of the various economic sectors for the first Five-Year Plan. The plan actually spent only 12.9% of the total expenditure on directly productive sectors (Agriculture, Industry and Trade). The relatively small allocation to these productive activities reflected the limited capacity of the economy to utilise capital (Badi, 1983).

The main results of the plan were apparent in expanded infrastructure, road construction, schools and hospital construction and increased electric power. The performance of agriculture and industry was very poor. Between 1962 and 1967, the average annual growth rate of the agricultural and industrial sectors was only 4.5% and 9.6% respectively. The gross national product of Libya (GNP) had more than trebled between 1963 and 1968. Per capita income at current prices increased over twenty times, from $40 in 1952, to $881 in 1967 and to $1125 in 1968.

Table 1.1
Comparison Between Planned and Actual Expenditure for The First Five-Year Plan (1963-1968)

($ millions)

Category	Planned Amount	Planned Percentage	Actual Amount	Actual Percentage
Agriculture	081.8	17.3	139.7	10.4
Industry	018.8	04.0	032.5	02.4
Economy and Trade	008.0	01.7	001.1	00.1
Tourism	-	-	011.5	00.9
Education	062.9	13.3	123.8	09.2
Civil Service	017.9	03.8	008.7	00.7
Information and Culture	007.1	01.5	021.3	01.6
Health	035.1	07.4	048.8	03.6
Youth and Sports	-	-	036.7	02.7
Communications	077.1	16.3	258.4	19.2
Municipalities	-	-	168.6	12.5
Housing	-	-	221.8	16.5
Public Works	108.4	22.9	220.4	16.4
Interior	-	-	021.0	01.6
Planning and Development	031.7	06.7	010.6	00.8
Labour and Social Affairs	024.1	05.1	014.0	01.0
Reserve	-	-	005.9	00.4
Totals	**473.2**	**100.0**	**1344.8**	**100.0**

Sources:

- *Ministry of Planning (1964), Five-Year Economic and Social Development Plan 1963-1968, Tripoli-Libya.*
- *Ministry of Planning (1972), National Accounts of the Libyan Arab Republic: 1962- 1971, Tripoli-Libya.*

The second Five-Year Plan 1969-1974 was prepared by the overthrown government. However, this second Five-Year Plan was rejected before it began, following the revolution in September 1969. The total development expenditure allocation intended in this plan was 3.2 million dollars. The highest priority was to be given to public work which was assigned 16% of the total allocation of the plan. The third Three-Year Economic and Social Development Plan 1973-1975 had a development budget which totalled L.D2.6 billion. However, the actual spending amounted to L.D2.2 billion. Table 1.2 shows the allocation of the plan and actual expenditures during the plan period.

Table 1.2
Allocation of the Three-Year Development Plan 1973 -1975 and the Actual Expenditures of the Plan

(L.D million)

Sector	Allocation	%	Actual Expenditure	%
Agriculture and Agrarian Reform	244.400	09.4	237.300	10.8
Integrated Agricultural Developments	326.145	12.7	317.700	14.4
Nutrition and sea wealth	003.870	00.2	005.800	00.3
Industry and Mineral Resources	329.306	12.8	269.500	12.2
Oil and Gas Utilisation	185.738	07.2	138.200	06.3
Electricity	261.258	10.2	212.200	09.6
Information and Culture	025.012	00.8	014.100	00.6
Labour		00.9	015.700	00.7
Public Health	064.883	02.5	046.600	02.1
Social Affairs and Social Security	022.900	00.8	016.300	00.7
Housing	366.800	14.1	366.100	15.3
Municipalities	193.500	07.5	177.200	08.1
Transport and Communication	221.092	08.6	138.600	06.3
Administrative Development	001.322	00.1	-	-
Maritime Transport	063.370	02.5	087.600	04.0
Economy and Tourism	009.640	00.3	007.500	00.3
Planning and Scientific Research	012.269	00.5	007.800	00.4
Project Reserve	009.300	00.3	-	-
Totals	**2585.900**	**100.0**	**2203.000**	**100.0**

Source:
- *Ministry of Planning, The Economic and Social Achievement of the First of September Revolution 1971-1979, Tripoli-Libya.*

The main targets of the Three Year Plan 1973-1975 were:

1. Achieve a maximum rate of growth of the national economy as a whole.

2. Diversify the economy by accelerating the rate of growth of crude oil production.

3. To increase per capita income from L.D638.6 in 1973, to L.D749.9 by the end of 1975.

4. Raise gross national income at an annual compound rate of 10.4%.

5. Raise total employment in the economy from 557,000 in 1972, to 682.900 by the end of 1975.

6. Increase the output of the agricultural sector at an annual rate of 14.5%, while the output of the industrial sector would increase at an annual rate of 24.5%.

The best achievements of the Three Year Plan 1973-1975 were made in the sectors of agriculture, manufacturing and construction. The Gross Domestic Product (GDP) increased from L.D2182.7 million in 1973 to L.D3674.3 million in 1975, at an annual average rate of 31.7%, while the Agricultural Sector grew from L.D60.0 million in 1973 to L.D82.9 million in 1975, at an annual average of 24.5%. The Manufacturing Sector also increased from L.D43.8 million in 1973, to L.D65.5 million in 1975, at an annual average rate of 27.2%. The Construction Sector grew by 34.2% for the period 1973-1975. Non-oil activities rose from L.D1038.9 million in 1973 to L.D1692.5 million in 1975, at an annual average rate of 27.3% for the period 1973-1975. Also, the Oil and Gas sector grew from L.D1143.8 million in 1973, to L.D1981.8 million in 1975 with an annual average rate of 38.6% for the same period. During the plan period 1973-1975, the per capita income from GDP increased from L.D929 in 1973 to L.D1369 in 1975.

The fourth Five-Year Development Plan 1976-1980 attempted to carry out radical changes in various aspects of the Libyan economy. It was provided with a total planned expenditure of L.D7.6 billion and Table 1.3 shows the breakdown of major allocation by sector and the actual expenditure during the period.

The main objectives of this plan may be summarised as follows:

1. To raise the total production in all sectors to realise an annual compound rate of 10.7%.

Table 1.3
The Planned Expenditures for 1976-1980 Plan and the Actual Expenditures During the Plan

(L.D million)

Sector	Allocation	%	Actual	%
Agriculture	1817.9	20.6	1604.3	21.1
Food and Sea Wealth	0038.6	00.4	0029.8	00.4
Industry	1485.2	16.9	1304.8	17.2
Oil and Gas	0350.2	04.0	0278.4	03.7
Electricity	0858.4	09.7	0859.7	11.3
Education	0588.6	06.7	0432.8	05.7
Information and Culture	0124.5	01.4	0102.0	01.3
Labour	0057.1	00.6	00 41.6	00.5
Health	0310.1	03.5	0264.1	03.5
Social Affairs and Security	0023.0	00.3	0011.7	00.2
Sports	0075.6	00.9	0051.3	00.7
Housing	0954.5	10.8	0815.0	10.7
Justice	0052.5	00.6	0031.7	00.4
Municipalities	0748.1	08.5	0718.2	09.4
Transportation and Communication	1051.0	11.9	0960.0	01.0
Economy	0087.5	01.0	0074.6	01.0
Planning	0026.0	00.3	0021.4	00.3
Project Reserve	0164.5	01.9	-	-
Total	**8813.3**	**100.0**	**7601.4**	**100.0**

Source:
- *Socialist People's Libyan Arab Jamahiriya (1980), Secretariat of Planning, the Economic and Social Achievement 1970-1980, Tripoli-Libya.*

2. To increase the private final consumption at planned annual compound rate of 9.4%, while the public final consumption was planned to grow at an annual compound rate of 9.6%.

3. The per capita income was planned to increase from L.D1678.9 in 1976 to L.D1939.7 in 1980.

The fifth Five Year Plan 1981-1985 established the overall target of growth for the non-oil activities at an annual compound rate of 10.3%. Other overall objectives of the plan were stated as follows:

1. Continuation of investments in the economic infrastructure.

2. Placement of emphasis on industrialisation following an extension of advanced production techniques in other fields of economic activity.

3. Decreasing the dependence on foreign countries in meeting basic requirements by increasing the rate of agricultural growth and achieving sufficient supply of foodstuffs for the population of Libya

4. Creating more equitable income distribution by providing employment, extending social and welfare services and expanding local development programmes, especially in rural areas.

5. Diversifying the exportation of goods, expanding the existing foreign markets and penetrating into new foreign markets.

6. Improving the administrative services by introducing basic changes in the administrative system and extending advanced managerial techniques to all ministries, and to public and private organisations.

To achieve these goals, a total investment of L.D16894 million would be required; this investment would increase the ratio of investment to gross domestic product from 23.3% for the period 1976-1980 to 40.4 % for the period 1981-1985. Due to the rapid growth of the oil sector, the relative contribution of the other sectors to the gross domestic product declined. However, the increase in financial resources from the oil sector would affect the growth of the other sectors.

The plans for 1973-1985 paid special attention to the industrial sectors, which aimed to build up large scale advanced national industries that would contribute to the promotion of the socialist construction of the country, and lead towards the realisation of economic independence. The most significant indicators for the development of the industrial sector were:

1. The increase in investment allocation amounted to L.D2170 million during the period 1973-1975, L.D7840 million for the period 1976-1980 and increased to L.D16894 million for the period 1981-1985.

2. The introduction of new industries, such as iron, the engineering and electrical industries, and extraction industries, as well as expansion of the already existing industries.

3. The publicly owned industrial sector was expanded and occupied a leading role in the country's industrial activity.

The large scale involvement of the government in the economy resulted in the rapid expansion of government expenditure, which stimulated other sectors of the economy. This expansion of government expenditure caused inflationary pressure, but this pressure was eased by increasing imports, through the availability of foreign exchange from oil revenues.

1.4.1 National Income and Gross Domestic Product

All variables used in the model are at constant price (1970), unless stated otherwise. It can seen from Table 1.4 that a remarkable increase in National Income, Gross Domestic Product and Gross Fixed Capital Formation was achieved during the period 1962-1991. This increase can be attributed to the policy of the government in nationalising the formerly foreign-owned oil industry in 1970 and to the simultaneous increase in oil price on the world markets. Also, it can be seen that income increased more rapidly than the increase in population. This in turn led to a higher standard of living and to more investment and hence to further development.

Table 1.4
National Income and Gross Domestic Product 1962-1991
(In millions of constant 1970 Libyan Dinars)

Year	1962	1964	1972	1982	1991
National Income (NATY)	247.4	417.1	1314.7	3336.6	1542.7
Per Capita Domestic Product	158.8	311.3	0635.0	0550.6	0500.0
Gross Fixed Capital Formation (GFCF)	047.3	091.4	0343.5	1089.1	0538.0
Gross Domestic Product (RGDP)	230.5	485.7	1368.3	1832.0	2110.0
GFCE / NATY%	019.1	022.0	0026.1	0032.6	0035.0
GFCF / GDP%	020.5	019.0	0025.1	0059.5	0025.5

Sources:
- *Ministry of Planning, Department National Accounts, National Accounts, Libya, (various issues).*
- *Central Bank of Libya, Economic Bulletin, (various issues).*

Table 1.5 shows the annual rate of growth for National Income, Population, Per Capita Income, Gross Domestic Product, and Per Capita Domestic Product. Also, it shows the increase in the rate of growth during the period 1973-1991. Looking at the GDP structure in Table 1.6, we find that, after the Oil Sector, the Services Sector is highest and Construction takes the third place. However, these sectors still generated only a small part of the National Income.

Table 1.5
Annual Compound Rate of Growth (% p.a.)

Year	1973	1976	1980	1985	1991
National Income	11.2	30.0	26.0	-1.2	-10.8
Population	04.3	04.4	04.6	4.3	04.0
Per Capita Income	06.7	24.7	20.0	-5.2	-13.8
Real Gross Domestic Product	03.6	22.7	0.4	8.1	18.9
Per Capita Domestic Product	-0.6	17.5	-3.9	3.6	12.9

Sources:
- *Ministry of Planning, Department National Accounts, National Accounts, Libya, (various issues).*
- *Central Bank of Libya, Annual Report, (various issues).*
- *IMF, International Financial Statistics, (various issues).*

Table 1.6
Gross Domestic Product
(In million of constant 1970 Libyan Dinars)

Sector	1973	1976	1980	1985	1991
Agriculture	0040.0	0038.4	0039.7	0064.0	0113.9
Oil & Mining	0743.2	1069.5	1436.6	0756.3	0658.3
Manufacturing	0028.5	0034.9	0041.7	0082.5	0158.3
Construction	0169.7	0198.6	0203.1	0208.1	0266.6
Services	0437.4	0496.7	0509.2	0708.8	0912.9
Total	**1418.8**	**1838.1**	**2230.3**	**1819.7**	**2110.0**

Sources:
- *Ministry of Planning, Department of National Accounts, National Accounts, Libya, (various issues).*
- *Central Bank of Libya, Economic Bulletin, (various issues).*

During the period 1964-1985, the economy was dominated by the oil sector, which was always far more important than all other sectors put together. This picture changed after 1985. Table 1.7 presents the annual compound rates of growth of Real Gross Domestic Product by sector. The growth rate of the Services Sector for the year 1976, 1985 and 1991 is high. This is because of the huge investment into this sector by the government, in order to supply and improve services, especially health and education. The growth rate of the Construction Sector is, as Table 1.7 shows. This is because of the scale infrastructure projects implemented by the government and the facilities made available by the government to the private sector.

Table 1.7
Sectoral Annual Rate of Growth (% p.a.)

Sector	1973	1976	1980	1985	1991
Agriculture	14.0	13.7	03.1	12.8	14.4
Oil & Mining	02.5	32.3	07.2	10.0	31.4
Manufacturing	13.9	30.7	-23.1	26.2	13.0
Construction	18.9	12.0	-04.3	11.5	11.1
Services	-0.7	09.8	-11.2	03.4	10.8
GDP	03.6	22.7	00.4	08.1	16.9

Source:
-Commuted from Table 1.6.

The share of the Agriculture Sector in the GDP declined, as Table 1.8 indicates. This decline, in spite of the increase in the agricultural output for the same period, as Table 1.6 shows, is attributed to the large increase in output in the other sectors, as is indicated in Table 1.8. In other words, it is attributed to the declining rate of growth of the Agricultural sector (Table 1.7) and to the increasing growth rate of the other sectors. The share of the Services Sector in the GDP increased considerably. This is because of the high increase in its output, as Table 1.6 shows and the high rate of growth, as Table 1.7 shows.

The share of the Manufacturing sector in GDP increased over the years, as is shown in Table 1.8. The increase in this sector's share was due to the large scale of investment in refineries and in the petrochemical industry.

Table 1.8

The Sectoral Share of GDP (%)

Sector	1973	1976	1980	1985	1991
Agriculture	02.7	02.1	01.8	03.5	05.4
Oil & Mining	52.4	58.2	64.4	42.0	31.2
Manufacturing	02.0	01.9	02.1	04.5	07.5
Construction	12.0	10.8	09.1	11.4	13.0
Services	30.9	27.0	22.8	38.9	43.3

Source:
- *Computed from Table 1.6.*

During the period 1973-1991, substantial changes were achieved in the other economic sectors in Libya, due to the high rates of growth, particularly in Construction and Services, indicated in Table 1.7. Despite the high growth in all sectors of the economy during the period 1963-1991. The Oil Sector still played the dominant role in the Libyan economy. Table 1.6 and 1.8 show that more than half of the GDP came from the Oil Sector during the same period. Because of the importance of the Oil Sector in the Libyan economy, we will present an historical review of this sector in the next section.

1.4.2 The Oil Sector

Libya has abundant natural resources, especially oil. Proven reserves of oil are estimated at 22.8 billion barrels (The Economist Intelligence Unit, 1996). As noted above, the oil industry is the major source of foreign exchange, which finances government spending, development programmes and imports. We could say that the Libyan economy is totally dependent on oil revenues.

The early oil industry in Libya was under the control of foreign companies, especially the Libyan Petroleum Company (LPC). In 1955, the government reached an agreement with the oil companies on equal profit sharing. The negotiations between the Libyan government and the oil companies continued during the 1960s, with the aim of increasing the Libyan share of the profits. The situation changed completely after the revolution of 1969. The leaders of the revolution demanded more control over the resources of the country and over the oil companies. The oil companies resisted the pressure from the Libyan government and the negotiations between the government and oil companies reached an impasse. Therefore, the Libyan government nationalised the oil companies in June 1971.

Oil Production expanded rapidly to bring Libya into fourth place among Middle East and North African producers by 1973. Production reached a peak in 1970 at 3.3 million barrels per day, declining to 1.48 mn b/d in 1975 in accordance with the government's declared conservation policies, as Table 1.9 shows. By 1980 it had risen to 1.83 mn b/d. In March 1983, Libya accepted an OPEC quota limit of 1.1 mn b/d at agreed OPEC price levels, a limit that was generally observed. In November 1984, the quota level was reduced to 957,000 b/d as part of an OPEC attempt to maintain prices. Though OPEC abandoned its quota system in December 1985, Libya's production remained below 1 mn b/d in 1986 at an average of 948,000b/d. When OPEC decided to restore production quotas in December 1986, the Libyan quota was fixed at 948,000 barrels per day. This gradually went up to 1.4 mn b/d in 1990. After the beginning of the Gulf crisis in August 1990, OPEC's quotas were abandoned and Libya increased its production to 1.5 mn b/d. However, at the OPEC meeting of June 1991, an overall cut in oil production and restoration of the quota system was advocated.

Oil revenues are the most significant source of income for the country. The Libyan government relies heavily on oil revenues for financing its economic development programmes because government revenues come in large amounts from the value added in oil. Libyan production and oil revenues increased considerably after 1970, Table 1.9 shows. The biggest increases in oil revenues came after the nationalisation of oil in 1971, the jump in oil prices after 1974, and the increase in production, as shown in Table 1.9.

Table 1.9
Oil Revenues, Oil Prices, and Oil Production of Libya
1962-1991

Year	Oil Revenues (L.D.M)	Oil Price (L.D)	Oil Production (Mbd)
1964	0075.300	00.689	0.865
1967	0224.100	00.663	1.733
1972	0624.575	01.193	2.300
1977	2625.846	04.339	2.063
1982	4129.200	11.401	1.017
1987	1029.700	07.400	0.973
1991	1411.200	06.440	1.515

Sources:
-Ministry of Planning, Department of National Accounts, National Accounts, Libya, (various issues).
- Central Bank of Libya, Economic Bulletin, (various issues).
- Organisation of Arab Petroleum Exporting Countries (OAPEC), Annual Report Kuwait, (various issues).

The contribution of oil production to the total gross domestic product was around 58.7% during the 1960's. Then due to the oil price shocks that existed in the 1970's, the share of value added in oil to GDP increased to an average of 64%. After that, it declined to about 47% throughout the 1980's as indicated in Table 1.10. Thus the contribution of oil products to gross domestic product fluctuated due to the fluctuation in oil prices.

Table 1.10
Value Added in Oil and Its Share in GDP for Libyan Economy
(1962-1991)

(L.D. million)

Year	Oil Output	Percentage Share in GDP
1964	0196.5	53.9
1967	0403.8	54.0
1972	0930.0	53.1
1977	3304.4	58.9
1982	4532.6	51.6
1987	2139.3	31.1
1991	2776.5	31.2

Sources:
-Ministry of Planning, Department of National Accounts, National Accounts, Libya, (various issues).
- Central Bank of Libya, Economic Bulletin, (various issues).

1.4.3 Aggregate Demand

In this section, a review of the behaviour of the basic aggregate demand components will be presented.

1.4.4 Private Consumption Expenditure

The data permits us to split Consumption Expenditure into Private Consumption Expenditure and Government Consumption Expenditure. Private consumption can be classified into the following six categories: (1) food, drink and tobacco (2) clothing and footwear (3) rent, fuel and water (4) house furnishings (5) entertainment and (6) miscellaneous services. Private Consumption Expenditure increased at a rate of 16.6% p.a. for the period 1962-1972, 24% p.a. for the period 1972-1982 and 9.4% p.a. for the period 1982-1991, as Table 1.11 shows. This could be explained by the rapid rate of population growth and the increase in the internal migration from rural to urban areas. Private Consumption Expenditure decreased in the years 1982, 1983 and 1984.

This was because of the Political Instability which led to Private Consumption Expenditure decreasing because of the uncertainty about the future, import restrictions and disruption of production.

1.4.5 Government Consumption Expenditure

The government of Libya plays an important role in economic development. In addition to its conventional job of providing defence and security, the Libya government provide free medical care and education.

Government Consumption Expenditure generally increased over the period of the study, as Table 1.11 indicates. It declined in the years in 1984, 1987 and 1989, due to the political instability in those years, which reflected the continuity of government consumption expenditure. However, it increased rapidly after 1973, because of the increase in oil prices and the consequent increase in government revenues

1.4.6 Government Investment Expenditure

Data is limited concerning the components of Investment Expenditure. Government Investment grew at a rate of 38% p.a. for the period 1962-1972, 26.4% p.a. for the period 1972-1982 and -6% p.a. for the period 1982-1991, as Table 1.11 shows. It fell during the period 1982-1986. This was because of the political instability in those years, which affected the continuity of government programmes. Government Investment Expenditure increased after 1973, due to the huge increase in oil revenues, which are the main source of government revenue.

This high increase in government revenue made it possible for the government to implement highly ambitious development investment programmes in order to establish and strengthen the industrial base.

Table 1.11
Private and Government Consumption and Government Investment Expenditure in Libya (1962-1991)

(L.D. million)

Year	Private Consumption Expenditure	Government Consumption Expenditure	Government Investment Expenditure
1962	0137.3	0026.0	0027.7
1967	0280.0	0101.4	0140.0
1972	0543.3	0359.1	0405.3
1977	1482.6	1400.3	1320.6
1982	3617.9	3005.0	2306.8
1987	4026.1	2285.0	1196.1
1991	6787.3	2435.0	1387.6

Sources :
- *Ministry of Planning, Department of National Accounts, National Accounts, Libya, (various issues).*
- *United Nations, Yearbook of National Accounts Statistics, New York, (various issues).*

1.4.7 Foreign Trade

There has been great progress in foreign trade, both in the volume and type of goods exported and imported, as Tables 1.12 and 1.13 show.

1.4.8 Exports

Total Exports can be split into Oil and Non-Oil Exports. Oil Exports increased at a rate of 45% p.a. for the period 1962-1972, 21.4% p.a. for the period 1972-1982 and -1.8% p.a. for the period 1982-1991, as indicated in Table 1.12. Oil Exports increased rapidly after the nationalisation of the oil industry and the rise in oil prices. Oil Exports formed 95% of Total Exports in 1962, 99% in 1972, 99% in 1982 and 96% in 1991, as shown in Table 1.12. This is a very clear indicator of the high dependency of the Libyan economy on Oil Exports.

Non-Oil Exports as a proportion of Total Exports were only 4.8% in 1962, 0.4% in 1972, 0.1% 1982 and 4.3% in 1991, as Table 1.12 shows. Most of the Non-Oil Exports were raw materials and agricultural products.

Table 1.12
Total, Oil, and Non-Oil Exports in Libya in 1962-1991
(L.D million)

Year	Total Exports	Oil Exports	Non-Oil Exports
1962	0050.0	0047.5	002.4
1967	0419.0	0417.4	002.6
1972	0968.1	0964.2	003.9
1977	3081.0	3077.0	003.6
1982	4056.2	4054.1	002.1
1987	2373.0	1663.6	001.2
1991	3063.0	2794.2	125.5

Sources:
- *Ministry of Planning, Department of National Accounts, National Accounts, Libya, (various Issues).*
- *Central Bank of Libya, Economic Bulletin, (various issues).*
- *Organisation of Arab Petroleum Exporting Countries, Annual Report, OAPEC, Kuwait, (various issues).*

1.4.9 Imports

Total Imports increased from L.D73.4 million in 1962 to L.D343.2 million in 1972, L.D2124.3 million 1982 and L.D1505.0 million in 1991, as Table 1.13 shows. Total Imports grew at a rate of 19.8% p.a. for the period 1962-1972, 26% p.a. for the period 1972-1982 and -3.5% p.a. for the period 1982-1991, as indicated in Table 1.13. Total Imports have been especially directed to meet domestic needs for foodstuffs and beverages, consumer goods, capital goods, and for raw materials and intermediate goods

Imports of Consumer Goods increased from L.D8.4 million in 1962, to L.D67 million in 1972, L.D339 million in 1982 and L.D354.4 million in 1991, as shown in Table 1.13. It fell in the years, 1976, 1982, 1983, 1984, 1985 and 1987 which can be attributed to the political instability in those years. The high rate of population growth, the high rate of urbanisation, improvements in the standard of living, the expansion of electricity networks to the rural areas and the failure of the local production industry to meet the increasing demand for such goods were the main factors which caused Imports of Consumer Goods to rise.

Imports of Raw Materials and Intermediate Goods increased steadily and reached a peak in 1983. The decline of Raw Materials Imports can be attributed to the policies adopted by the government, which encouraged the establishment of industries using local raw materials and intermediate goods.

The Import of Raw Materials formed 13% of Total Imports in 1962, 10% in 1972, 7% in 1982 and 10.4% in 1991. The decline is related to the increase of the Capital Imports share in Total Imports, in order to satisfy the needs of developments under construction.

Imports of Capital Goods increased from L.D56 million in 1962 to L.D242 million in 1972, L.D1640 million 1982 and L.D995 million in 1991. Import of Capital Goods increased rapidly after 1973 and the rate of growth for the period 1970-1991 was 30% p.a. This high rate of increase in Capital Goods Imports can be attributed to the highly ambitious development programme implemented by the government during this period and to the lack of a capital goods industry in Libya.

Table 1.13
Total Imports and Its Components for Libya 1962-1991
(L.D. million)

Year	Imports of Consumption Goods	Imports of Raw Materials Goods	Imports of Capital Goods Goods	Total Imports
1962	008.4	009.3	0055.7	0073.4
1963	011.9	010.2	0063.2	0085.3
1964	016.1	013.5	0074.8	0104.4
1965	015.8	013.4	0085.2	0114.4
1966	022.7	016.4	0105.6	0144.7
1967	031.0	017.4	0121.6	0170.0
1968	031.7	024.2	0174.4	0230.3
1969	034.2	024.8	0182.3	0241.3
1970	044.6	021.3	0132.1	0198.0
1971	055.6	029.2	0165.6	0250.4
1972	067.1	034.0	0242.1	0343.2
1973	096.4	056.3	0387.2	0539.9
1974	141.8	075.0	0605.5	0822.3
1975	179.6	087.6	0781.5	1048.7
1976	140.4	083.1	0727.2	0950.7
1977	209.0	075.8	0832.3	1117.1
1978	246.4	079.9	1036.3	1362.6
1979	263.1	103.9	1205.4	1572.4
1980	387.7	157.7	1461.5	2006.9
1981	449.8	175.3	1856.3	2481.4
1982	339.0	145.7	1639.6	2124.3
1983	316.4	180.8	1287.6	1657.7
1984	295.4	137.6	1408.7	2505.7
1985	206.8	096.0	0911.6	1706.0
1986	239.2	109.0	1151.8	1396.8
1987	227.1	136.1	0914.9	1556.2
1988	263.2	157.0	1265.2	1685.4
1989	297.9	145.7	1031.3	1475.0
1990	342.6	138.7	1029.6	1510.9
1991	354.4	156.1	0994.9	1505.5

Sources:

- *Ministry of Planning, Department of National Accounts, National Accounts, Libya, (various issues).*
- *Ministry of Planning, Annual Foreign Trade Statistics, Libya, (various issues).*
- *Central Bank of Libya, Economic Bulletin, (various issues).*

1.4.10 Price Indices

Four price indices will be used to deflate the variables of the model. These indices are the Consumer Price Index ($PSDX$), the Capital Formation Price Index ($INVDX$), the Import Price Index (PIM) and the Gross Domestic Product Deflator ($PGDPIDX$). Each is based on 1970 = 100.

The Consumer Price Index increased from 59.7 in 1962, to 104.4 in 1972, 242.7 in 1982 and 387.5 in 1991, as indicated in Table 1.14. The high rate of increase started after the nationalisation of the oil industry, the rise in oil prices and the government's highly ambitious development programmes after 1973. This large increase in total government spending was accompanied by increases in nominal wages, in order to improve the living standard of the citizens. These were the main factors leading to the inflation shown in Table 1.14.

Table 1.14
Price Indices (1970 = 100)

Year	*PSDX*	*INVDX*	*PIM*	*PGDPIDX*
1962	059.712	058.500	098.900	063.134
1967	094.303	075.500	104.500	089.900
1972	104.393	118.000	123.900	128.111
1977	127.797	150.600	228.600	279.700
1982	242.691	211.800	323.900	479.300
1987	355.182	232.900	379.100	435.600
1991	387.509	258.100	464.600	421.800

$PSDX$ = Consumer Price Index 1970 = 100.
$INVDX$ = Capital Formation Price Index 1970 = 100 .
PIM = Imports Price Index 1970 = 100 .
$PGDPIDX$ = GDP deflator 1970 = 100 .

Sources :

- *Ministry of Planning, Department of National Accounts, National Accounts, Libya, (various issues).*
- *International Monetary Fund, International Financial Statistics Yearbook, (various issues).*
- *World Bank, World Tables, (various issues).*

The Capital Formation Price Index increased steadily for the period 1962-1973 and then increased sharply after 1973, due to the high demand for capital goods and the limited supply of such goods because Libyan industry was incapable of supplying such goods to a high technical quality.

The Imports Price Index increased from 99.0 in 1962, to 123.9 in 1972, 323.9 in 1982 and to 464.6 in 1991. The Gross Domestic Product Deflator also increased over the study period, as Table 1.14 indicates

1.4.11 Employment

Manpower in Libya was neglected by the policy makers and planners before 1969. In Libya the economically active population represents only 53% of the population, as shown in Table 1.15. This low rate of active population can be attributed to the fact that Libya is considered to be one of the youngest nations, whose population in the (0-14) age bracket comprises a high percentage of the total population.

Table 1.15
Total, Economically Active, and Employed Population

(Thousands)

Year	Male 15-19	Female 15-59	Economically Active	Employed Population	Total Population
1964	401.2	368.3	0769.5	0365.3	1451.0
1970	450.2	413.6	0863.8	0433.5	2006.0
1975	502.7	469.7	0972.4	0677.4	2683.0
1980	624.3	588.3	1212.6	0812.8	3246.0
1985	789.8	750.7	1540.5	0894.2	3668.0
1990	976.5	932.7	1909.2	1018.6	4848.0

Sources:

- *Ministry of Planning, Department of National Accounts, National Accounts, Libya, (various issues).*
- *International Labour Office, Yearbook of Labour Statistics , ILO, Geneva, (various issues)*
- *Secretariat of Planning (1979), Final Results of 1973 Population Census, Tripoli- Libya.*

The labour force in Libya represents less than 25% of the total population and 46% of the economically active population. This low rate can be attributed mainly to the low participation rate of females in the labour force which is attributed to the conservative characteristics of traditional society, especially in rural areas. The other reason for the low level of the labour force is the increasing number of students and pupils above the age of 16 years pursuing their secondary and university studies.

The employed population in the Agricultural Sector increased steadily during the period 1969-1991, as Table 1.16 shows. From 1962, the employed population in agriculture decreased, from 0.145 million in 1962, to 0.133 million in 1975. The population employed in the agricultural sector grew at a rate 0.3% p.a. for the period 1962-1972, 2.8% p.a. for the period 1972-1982 and 2% p.a. for the period 1982-1991. The drop in the number of agricultural workers is attributed to the huge government investment expenditure in various economic sectors. This led to the creation of wider opportunities elsewhere in the economy.

The manufacturing employed population increased from 0.024 million in 1962, to 0.074 million in 1982 and to 0.101 million in 1991. The population employed in the manufacturing sector grew at a rate of -0.3% p.a. for the period 1962-1972, 13% p.a. for the period 1972-1982, 5% p.a. for the period 1982-1991, as shown in Table 1.16. The high rate of growth of manufacturing employment during the 1970's may be attributed to the special attention the government gave to the manufacturing Sector in its development programmes

The population employed in the services sector increased from 0.139 million in 1962, to 0.254 million in 1972, to 0.501 million in 1982 and to 0.543 million in 1991, as Table 1.16 shows. The annual rate of growth was 6.8% p.a. for the period 1962-1972, 8% p.a. for the period 1972-1982 and 2.2% p.a. for the period 1982-1991. Most of these rates of increase can be related to the decline in the agricultural sector. This is because many former agricultural workers emigrated to the cities, searching for better conditions of life. Most of these immigrants were unskilled and therefore a large proportion of them ended up in the Services sector.

The population employed in the construction sector increased from 0.032 million in 1962, to 0.070 million in 1972, to 0.317 million in 1982 and 0.156 million in 1991, as Table 1.16 shows. The high rate of increase was during the 70's, which can be attributed to the huge development programmes implemented in this sector.

Table 1.16
Employed Population at Sector in the Libyan Economy
(19962-1991)

(Thousands)

Year	*AGRNK*	*MANNK*	*SERNK*	*COTNK*	*OILNK*
1962	145.7	023.8	139.5	032.4	14.6
1967	135.3	022.0	181.8	035.9	14.3
1972	127.7	022.9	253.5	069.5	14.4
1977	144.9	041.5	387.8	171.4	19.2
1982	167.5	073.7	500.7	317.4	24.4
1987	180.0	079.0	487.3	149.2	20.7
1991	188.0	101.1	543.4	155.7	25.2

AGRNK = Agricultural Employees.
MANNK = Manufacturing Employees.
SERNK = Services Employees.
COTNK = Construction Employees.
OILNK = Oil Employees.

Sources

- *Ministry of Planning, Department of National Accounts, National Accounts, Libya, (various issues).*
- *Ministry of Economy and Planning (1990), Economic and Social Growth in Libya: 1970-1990, Libya.*
- *Central Bank of Libya, Annual Report, (various issues).*

1.5 Organisation of the Study

Any work on macroeconometric must consist of the following components:

1. Model specification, based on economic theory.

2. Model estimation, using published and/or other available data.

3. Model testing, to establish the robustness and forecasting capabilities of the model.

4. Forecasting and policy analysis.

Consequently chapter tow to five deal with the economic theory necessary for model specification. Chapter six concerns the estimation of the model. chapter seven and eight are on model testing. Chapter nine deals with forecasting and policy analysis. In more detail, the thesis is structured as follows:

Chapter one deal with the Libyan economy. It identifies the main features of the Libyan economy. This help in understanding the following chapters. In chapter two consumption theories will be presented. Chapter three will discuss theories of investment expenditure. Chapter four deal with production functions. Chapter five will present theories of inflation. Chapter six will concern the estimation of the model equation. Chapter seven will present the model simulation. Chapter eight will present multiplier analysis. Chapter nine will present the model forecasts. Chapter ten will contain the conclusions derived from the thesis.

CHAPTER TWO

THE CONSUMPTION FUNCTION

2 1 Introduction

The main consumption theories will be discussed briefly in this chapter. Section two will deal with the Absolute Income Hypothesis. Section three explains the Relative Income Hypothesis. Sections four and five introduce the Permanent Income Hypothesis and the Life Cycle Hypothesis. Sections six, seven and eight will deal with the Davidson and Hendry equation, the Treasury Consumption Function, and the Hendry and Sternberg Consumption Function. Section nine will explain the Consumption Function in Libya. Section ten will summarise the main points of the chapter.

The early theories of consumption, [(Keynes, 1936); (Duesenberry, 1949); (Brown, 1952); (Friedman, 1957); (Spiro, 1962); (Ando and Modigliani, 1963)] fitted expenditure patterns in the developed countries reasonably well until the early seventies, when they failed to predict the increasing rate of saving, especially in the UK. However, even before that time, the predictions from these theories showed an expenditure overestimation and saving underestimation.

Most recent work [(Townend, 1976); (Davidson and Hendry, 1978); (Bean, 1978); (Davis, 1984)] has concentrated on improving the early theories' explanatory power, by adding new variables. The majority of these developments came through establishing macroeconometric models for various economies.

In developing countries the availability of data plays an essential restricting role in the most advanced consumption theories. Therefore, the research for developing countries relates consumption to income. This is partly because of the limitations of the data and partly because income really represents the most important factor for low income societies, where markets are not developed or sometimes do not exist.

This chapter deals with the different theories which try to explain the consumption function, starting from Keynes's theory and progressing to the more recent theories. The importance attached to the consumption function is partly due to the high share of consumption expenditure in total domestic expenditure, especially in developing countries, where it represents about four-fifths of total expenditure. This places a constraint on the amount of resources left for investment.

2.2 Absolute Income Hypothesis

The fundamental psychological law of Keynes was the base from which most consumption functions have stemmed. (Keynes, 1936) stated that :

"Men are disposed, as a rule and on average, to increase their consumption as their income increases, but not by as much as the increase in their income."

From this it is clear that Keynes considered current personal disposable income to be the most important determinant of consumption, with a marginal propensity to consume less than unity but more than zero. The simple form of Keynes's Absolute Income Hypothesis is :

$$C_t = B_0 + B_1 Y_d \tag{2.1}$$

Where,

C_t = Consumption expenditure.

Y_d = Disposable income.

B_0 = Intercept.

B_1 = Marginal Propensity to Consume.

Equation (2.1) is the consumption function specifying that consumption at period t is a linear function of income and the error term in the same period. This equation is referred to literature as the structural equation. It is the theoretical base of the model which derives its specification from economic theory as well as from the investigator's judgement. Note that economic theory does not in this case specify the functional form of the equation. The most it offers is that $C_t = F(Y_t)$ and the functional form is left to be determined empirically. Furthermore, the theory determines which equation (2.1) is stochastic (i.e. probabilistic) due to the presence of the error term (ε_t). In equation (2.1), C_t is called the current endogenous or dependent variable, where Y_t is described as the independent or explanatory variable. B_0 and B_1 are the parameters or coefficients of the consumption function which we aspire to estimate.

The marginal propensity to consume (MPC) is B_1 in the short as well as in the long run.

The predictive power of this equation is very poor. However, research in consumption theory has been widened, in order to resolve the apparent inconsistencies between predictions based on the absolute income hypothesis and observation in the real world.

2.3 Relative Income Hypothesis

One of the earliest attempts in this direction was the Relative Income Hypothesis by Duesenberry (1949). It was based on the idea that household consumption is not a function of its absolute income, but of its relative position in the distribution of income among households and of its previous peak income. Therefore, a rise in income will not lead to a corresponding rise in consumption, since the household is still influenced by its old standard. On the other hand, a decline in income will lead to dissaving, because the consumer will resist any drop in his standard of living, as set by the previous income peak. Therefore current saving will fall in an effort to maintain his previous standard of living. The consumption function based on the Relative Income Hypothesis of Duesenberry is formulated as follows :

$$\frac{S_t}{Y_t} = B_0 + B_1[\frac{Y_t}{Y_0}] \qquad (2.2)$$

Where,

C_t = Current consumption in period t.

S_t = Current saving in period t.

Y_t = Current income in period t.

$\frac{Y_t}{Y_0}$ = The ratio of current income to previous peak income.

But,

$$\frac{C_t}{Y_t} = 1 - \frac{S_t}{Y_t} \qquad (2.3)$$

So,

$$\frac{C_t}{Y_t} = 1 - B_0 - B_1\frac{Y_t}{Y_o}$$

Or:

$$C_t = [1 - B_0]Y_t - Y_t(B_1\frac{Y_t}{Y_0}) \qquad (2.4)$$

The Marginal Propensity to Consume (MPC) is the first derivative of equation (2.4) :

$$\frac{dC_t}{dY_t} = 1 - B_0 - 0.5B_1 \frac{Y_t}{Y_0} \tag{2.5}$$

Brown (1952) argued that the effect of habits slowly diminishes over time. Therefore, he substituted consumption in the previous period for the previous peak income. The addition of the lagged dependent variable gives the consumption function the following form:

$$C_t = B_0 + B_1 Y_t + B_2 C_{t-1} \tag{2.6}$$

Where,

$B_1 > 0$ $\qquad$ $B_2 < 1$

The short run (MPC) is B_1, which is less than the long run value, $\frac{B_1}{1-B_2}$. This equation could be considered as a dynamic Keynesian equation.

2.4 Permanent Income Hypothesis

Friedman (1957) made a clear distinction between actual income, which he called Measured Income and the income on which the consumer actually based his consumption, which he called Permanent Income. He defined this as the amount the consumer could consume (or believed that he could consume) while maintaining wealth intact. Similarly, Permanent Consumption is the value of the services planned to be consumed during the period in question. The difference between Measured and Permanent Income is Transitory Income. The mathematical form for these relations is as follows:

$$C_t = KY_p \qquad \text{Where} K = F(r, w, u) \qquad (2.7)$$

His consumption function is stated as:

$$Y = Y_p + Y_{tr} \; E(\overline{Y}_{tr}) = 0, \qquad COV(Y_p, Y_{tr}) = 0 \qquad (2.8)$$

$$C = C_p + C_{tr} \; E(\overline{C}_{tr}) = 0, \qquad COV(C_p, C_{tr}) = 0 \qquad (2.9)$$

Where,

r = Interest rate.

w = Ratio of non-human wealth to permanent income.

u = Other economic and demographic factors.

Y_p, C_P = Permanent income and permanent consumption respectively.

Y_{tr}, C_{tr} = Transitory income and transitory consumption respectively.

Y, C = Disposable income and consumption respectively.

To test the theory empirically, it is necessary to derive a practical approximation to C_p, and Y_p. C_p and C are very close and so Friedman argued that:

$$\overline{C}_p = \overline{C}$$

Y_p is approximated by an exponential declining weight average of present and past measured income. Friedman used an equation with seventeen annual lags in estimating his model:

$$Y_{pt} = B\sum_{i=0}^{17} \lambda^i Y_{t-i}$$

Now:

$$C = KY_{pt}$$

i.e.

$$C_t = KB\sum_{i=0}^{17} \lambda^i Y_{t-i}$$

So;

$$C_t = KB[Y_t + \lambda Y_{t-1} + \lambda^2 Y_{t-2} + \ldots + \lambda^{17} Y_{t-17}] \qquad (2.10)$$

By lagging equation (2.10) one period and multiplying by λ, we get:

$$\lambda C_{t-1} = KB[\lambda Y_{t-1} + \lambda^2 Y_{t-2} + \ldots + \lambda^{18} Y_{t-18}] \qquad (2.11)$$

Subtracting equation (2.11) from (2.10) gives:

$$C_t - \lambda C_{t-1} = KBY_t$$

i.e.

$$C_t = KBY_t - \lambda C_{t-1} \qquad (2.12)$$

From equation (2.12),

$$MPC_S = K.B \qquad MPC_L = KB / (1 - \lambda)$$

2.5 Life Cycle Hypothesis

Ando and Modigliani (1963), in their Life Cycle Hypothesis, argued that the consumer aims to maximise his utility by maintaining a stable pattern of consumption throughout his lifetime. They also said that individuals plan their consumption and savings over a long period, with the intention of allocating resources in such a way as to maximise utility over the lifetime of the consuming unit. The consumer will tend to save in the early years of employment in order to build up a stock of wealth to finance consumption in retirement. This means that consumption expenditure at any given period is constrained not only by current income, but also by the present value of expected future income and by present net worth, and so :

$$C_t = \Omega V_t \tag{2.13}$$

$$V_t = W_{t-1} + Y_t + \sum_{t=1}^{n} \frac{Y_{t+T}^e}{[1 + r_t]^T} \tag{2.14}$$

Where,

C_t = Current consumption.

Ω = A proportionality factor, depending on several variables, such as the rate of return on assets and the present age of the person.

W_{t-1} = Accumulated wealth from previous period.

Y_t = Current income.

$\sum_{t=1}^{n} \frac{Y_{t+T}^e}{[1 + r_t]^T}$ = The discounted expected future income stream from employment over the remainder of the individual's life, N.

By substituting V_t of equation (2.14) in equation (2.13), we get :

$$C_t = \Omega W_{t-1} + \Omega Y_t + \Omega \sum_{t=1}^{n} \frac{Y_{t+T}^e}{[1+r_t]^T} \qquad (2.15)$$

But Ando and Modigliani chose to analyse and estimate the ratio from:

$$\left(\frac{C}{Y_L}\right)_t = \alpha_1 + \alpha_2 \left(\frac{Y_L^e}{Y_L}\right) + \alpha_3 \left(\frac{W_{t-1}}{(Y_L)_{t-1}}\right) \qquad (2.16)$$

Where,

Y_L = Current labour income of individual.

Y_L^e = Expected future labour income of individual.

W_{t-1} = Net wealth of individual.

Several forms of the model to hypothesise the wealth-income relationship have been developed.

Ando and Modigliani tested the form:

$$C_t = \alpha Y_{Lt} + BW_{t-1}$$

Where,

Y_{Lt} = Labour income.

W_{t-1} = Accumulated wealth at period t.

Spiro (1962) assumed that the function takes the following form:

$$C_t = f(W_t, Y_t, Y_{t-1}, \ldots, Y_{t-8})$$

$$C_t = \sum_{i=0}^{\infty} B^i Y_{t-i}$$

$$C_t = K\sum_{i=0}^{\infty}(1 - K)^i Y_{t-i}$$

Where

K is a constant to be statistically determined.

Ball and Drake (1964) tested the function :

$$C_t = BY_t + \delta C_{t-1}$$

The functions of Spiro, Ball and Drake can be combined and rearranged in order to exclude wealth, to give:

$$C_t = \frac{K}{(K + 1)} Y_t + \frac{1}{(K + 1)} C_{t-1} \qquad (2.17)$$

In equation (2.17), the sum of the coefficients of Y_t and C_{t-1} is equal to unity, which is an important requirement in testing the hypotheses that $C_t = KW_t$ and that the Long-run Marginal Propensity to Consume (MPC_L) equals unity. Furthermore, Ball and Drake mentioned that the function of Brown and Friedman did not take consumption growth into consideration when they calculated the Long-run Marginal Propensity to Consume (MPC_L) in the stationary condition. To argue this, let consumption growth be (q) per period, then in the equilibrium we have:

$$C_t = (1 + q)C_{t-1} \qquad (2.18)$$

Replacing that in Brown's function (2.6) we get :

$$C_t = \frac{B_0(1 + q)}{1 + q - B_2} + \frac{B_1(1 + q)}{1 + q - B_2} Y_t \quad (2.19)$$

and replacing it in Friedman's function (2.12) we have:

$$C_t = \frac{K(1+q)}{1-q-\lambda} Y_t \quad (2.20)$$

It is clear from equation (2.19) and (2.20) that the long-run propensities are $\frac{B_1(1 + q)}{1 + q + B_2}$ and $\frac{K(1+q)}{1-q+\lambda}$, which are different from Brown's and Friedman's functions respectively.

Houthakker and Taylor (1966) presented the form:

$$C_t = B_0 + B_1 \Delta Y_t + B_2 Y_{t-1} + B_3 C_{t-1} \quad (2.21)$$

Where Δ is the first difference, such that $\Delta Y_t = Y_t - Y_{t-1}$. The short-run Marginal Propensity to Consume (MPC_S) is B_1 and the long-run (MPC_L) is $B_2 / (1 - B_3)$.

Having reviewed the main early theories of consumption function, we turn now to recent developments in the specification of consumption function.

Hendry (1974) made real consumer expenditure on non-durable goods and services (C_t) as a function of real personal disposable income (Y_t), where both are shown in logarithmic form, in addition to lagged consumption. He also introduced seasonal dummies (Q) for each quarter. His function takes the following form:

$$C_t = a_0 + a_1 Y_t + a_2 C_{t-1} + \sum_{i=1}^{3} a_{i+3} Q_{It} + \sum_{i=1}^{4} a_{i+6} Q_2 + U_{1t} \qquad (2.22)$$

Ball et al (1975) stated their function of real consumer expenditure on non-durable goods and services (C_t) as a function of real personal disposable income (Y_t), where both were adjusted for current grants to persons by the government. They also showed lagged consumption and a dummy for the expected and actual tax changes in 1968 (D_1). They specified the function as:

$$C_t = B_0 + B_1 Y_t + B_2 C_{t-1} + B_3 D_1 + U_{2t} \qquad (2.23)$$

Townend (1976) formulated an equation used by the Bank of England. This related real consumption of non-durable goods (C_t) to lagged real consumption (C_{t-1}), current real income (Y_t) and the stock of net liquid assets, lagged for half an annual period $(L_{t-1/2})$ and an annual and a half period $(L_{t-\frac{3}{2}})$. The consumption and income have been adjusted by government grants to persons (CG), with declining weights $(0.6CG + 0.3CG + 0.1CG)$. So:

$$C^* = \alpha(1-d) + B(1-d)Y_t^* + \theta L_{t-\frac{1}{2}} + \Psi L_{t-\frac{3}{2}} + \Omega C_{t-1}^* + V_t \qquad (2.24)$$

Where,

$C^* = C - 0.6CG_t + 0.3CG_{t-1} - 0.1CG_{t-2}$

$Y^* = Y - CG$

$V_t = U_t - dU_{t-1}$

V_t = Autoregressive error.

L_t = Gross holding of liquid assets minus personal bank borrowing deflated by the price deflator for consumption of non-durable goods.

The Treasury Model (1976) assumed consumer expenditure in constant prices (C_t) as a function of real income from wages and salaries net of tax (YW_t), government grants to persons in real terms (YG_t) and other personal income in real terms (all income being seasonally adjusted). Other variables include imputed rent from owner-occupied dwellings (R_t) assumed in constant prices, and a dummy for changes in HP regulations (D_t):

$$C_t = B_0 + B_1 YW_t + B_2 YG_t + B_3 YO_t + B_4 R_t + B_5 D_{2t} + U_{3t} \qquad (2.25)$$

2.6 Davidson and Hendry (1978) Equation

This equation was of the following general form:

$$\ln C_t = B_1 \ln Y_t + B_2 \ln Y_{t-4} + B_3 \ln C_{t-4} + V_t \qquad (2.26)$$

It used the restriction on the parameters of equation (2.26):

$B_1 + B_2 + B_3 = 1$

One can rationalise Equation (2.26) by applying feed-back theory. This postulates that consumers plan to spend in each quarter of the year the same as they spent in the same quarter of the previous year ($\ln C_t = \ln C_{t-4}$), modified by a proportion of the annual change in income ($\Delta_4 \ln Y_t$) and the feed-back from the previous year's consumption/income ratio ($\ln(\frac{C}{Y})_{t-4}$). Equation (2.26) can be written as follows:

$$\Delta_4 \ln C_t = \alpha \Delta_4 \ln Y_t + B \ln(\frac{C}{Y})_{t-4} + V_t \qquad (2.27)$$

Equation (2.27) is in log form. This was determined by the goodness of fit of the equation rather than by theoretical considerations. Davidson (1978) added the log of the consumer price index ($\ln P_t$) to equation (2.27) to account for the correlation of the savings ratio with inflation. Equation (2.28) related the fourth difference in current income ($\Delta_4 \ln Y$), the product of the first and the fourth difference of current income ($\Delta_1 \ln Y \Delta_4 \ln Y$), the fourth difference of the consumer price index ($\Delta_4 \ln P$), the product of the first and the fourth difference of the consumer price index ($\Delta_1 \ln Y \Delta_4 \ln P$), the consumer/income ratio lagged four periods $(C/Y)_{t-4}$ and D_t as a dummy variable, to the fourth difference of consumption ($\Delta_4 \ln C_t$). This gives:

$$\Delta_4 \ln C_t = \alpha \Delta_4 \ln Y_t + B_1 \Delta_1 \Delta_4 \ln Y_t + B_2 \Delta_4 \ln P_t + B_3 \Delta_1 \Delta_4 \ln P_4 + B_4 \ln(\frac{C}{Y})_{t-4} + D_t + V_t \quad (2.28)$$

2.7 The Treasury Consumption Function (1978)

Bean (1978) tried to add real wealth (W) to the Davidson and Hendry equation instead of $(C/Y)_{t-4}$ and $\Delta_4 \ln P$, but when tested it was found insignificant. He then added the acceleration of the unemployment rate ($\Delta_4 \ln U$). The importance of this variable might come from the greater uncertainty when unemployment accelerates, leading to increased precautionary saving. The above factors led Bean to formulate equation (2.29), which describes the data adequately.

$$\Delta_4 \ln C_t = \sum_{i=0}^{3} a_i \ln Y_{t-i} + b \ln(\tfrac{Y_t}{C_t})_{t-4} + c \Delta_4 \ln P_t + d \Delta_t U_t + e_i D_t + V_t \quad (2.29)$$

2.8 Hendry and Sternberg (1980) Consumption Function

Hendry and Sternberg (1980) believe that inflation affects consumption through the ratio of wealth/income. Inflation erodes real wealth, because if the agents have a target ratio of wealth to income, a part of nominal income needs to be devoted to restoring the real value of wealth. A new measure of income was shown (Y^*). This was defined as the accrual which would leave wealth intact. This income will be less than the cash flow when there is inflation, as inflation (P) causes a fall in the real value of all assets, with the exception of some kinds of assets such as housing, gilts and equities. So the erosion by inflation of liquid assets was adjusted by a (λ), which was found by grid search to minimise the residual sum of squares. Using this method, Hendry and Sternberg found (λ) to be 0.5 :

$$Y^* = Y - \lambda PL$$

This means that price is no longer needed in the consumption function. They also added the real liquid assets lagged one period (L_{t-1}) and seasonal dummies (Q_i), for each quarter. A linear accumulated Almon lag with declining weight $[\sum_{i=0}^{3}(3-i)]$ was imposed on income. This gives the equation (2.30):

$$\Delta_4 \ln C_t = B_0 + \sum_{i=0}^{3}(3-i)\alpha \ln Y_t + B\Delta_1 \ln L_{t-1} + \delta \ln(\frac{L}{Y^*})_{t-4} + \gamma \ln(C/_{Y^*})_{t-4} + Q_{it} + V_t \qquad (2.30)$$

Cuthbertson (1980) formulated his function for durable expenditures and tested three models for hire purchase credit, bank advances, liquid assets and interest rates. He showed that the model of liquid assets and interest rates (as a proxy for the cost of credit) performed better than the others. He assumed his function as:

$$\Delta \ln C_t = B_0 + B_1 \ln Y_{t-4} + B_2 \ln\left(C/Y\right)_{t-1} + B_3 \Delta \ln\left(C/Y\right)_{t-2} + B_4 \sum_{j=0}^{3} \Delta \ln Y_{t-j} + B_5 \Delta_2 HP + B_6 \Delta_2 \ln L_{t-1} + B_7 RR_t^a \qquad (2.31)$$

Where Y is real personal disposable income, HP is hire purchase credit, L is the gross liquid assets of the private sector and RR^a is the real rate of interest.

The London Business School function (1981) is also based on the error correction formulation of aggregate consumer behaviour, with the additional dependence of consumption on prices, though with the omission of the fourth lag of consumption. It is formulated as:

$$\Delta_1 \ln C_t = B_1 \Delta_1 \ln C_{t-1} + B_2 \Delta_2 \ln C_{t-2} + B_3 \Delta_1 \ln Y_t + B_4 \Delta_2 \ln Y_{t-2} + B_5 \ln\left(C_{t-3}/Y_{t-4}\right) + B_6 \Delta_1 \ln P_t + B_7 \Delta_1 \Delta_1 \ln P_{t-3} + B_8 \Delta \ln P + B_9 Dti \qquad (2.32)$$

Davis (1984) developed the equation (2.30) by omitting the accumulated Almon term $\sum_{i=0}^{3}(3-i)$ and added $(\ln Y^*)$ and the real interest rate $(\ln r_t - \ln P_{t-1})$. The developed equation is:

$$\ln C_t = A + \alpha \Delta_4 \ln Y^* + B \Delta_1 \Delta_4 \ln Y^* + \delta \ln(\frac{L}{Y^*}) + \mu \ln \Delta_1 L_{t-1} + \Pi \ln(\frac{C}{Y^*})_{t-4} + \lambda(\ln r_t - \Delta_4 \ln P_{t-1}) + D_t + \zeta Q_{it} + V_t$$

In the consumption function of the National Institute for Economic and Social Research (NIESR), Davis (1984), the loss of liquid assets was adjusted because of inflation:

$$IL = 0.5 \Delta_4 \ln P_{t-3} \frac{L_{t-4}}{Y_{t-3}} + 0.25 \Delta_4 \ln P_{t-4} \frac{L_{4-5}}{Y_{t-4}}$$

Where,

IL= Loss of liquid assets by inflation.

They substituted the above form instead of the losses in the liquid assets in the Hendry and Sternberg equation. The NIESR equation is:

$$\Delta_4 \ln C_t = \alpha \ln(\frac{C}{Y})_{t-4} + B\Delta_4 \ln Y_t + \delta\Delta_1 \ln L + \gamma IL + D_t + \varsigma Q_{it} + V_t$$

Patterson (1991) developed the form:

$$\Delta c_t = \theta_0 + \theta_1 \Delta y_t + \theta_2 (c_t - y_t)_{-1} + \theta_3 (w_t - y_t)_{-1} + u_t$$

Where c_t, w_t and y_t are consumption, wealth and income respectively and lower case letters denote natural logarithms.

Muellbauer and Murphy (1993) assumed the aggregate consumer expenditure (C_t) for the US through the period 1956-1988 as a function of real personal disposable non-property income (Y_t), real interest rate (r_t), income uncertainty which is proxied by (ΔU_t), the change in the unemployment rate (UN_t), liquid assets (LA), illiquid assets (IA) and the fitted value of expected income growth (EY). They showed the equation as:

$$\Delta \ln C_t = B_0 + B_1(\ln Y_t - \ln C_{t-1}) + B_2 \Delta \ln Y_t - B_3 r_t - B_4 \Delta U_t - B_5 UN_t$$
$$+ B_6 (LA_{t-1} / Y_t) + B_7 (IA_{t-1} / Y_t) + B_8 EY_t$$

Lattimore (1994) formulated his function of consumption in Australia. The consumption function was estimated using the annual data of the period 1951-1990. He assumed the real per capita aggregate consumption (C_t) as a function of real non-property income per capita (Y_t), the weighted combination of net liquid and illiquid assets to income (W_t), the aggregate credit ($CREDIT_t$), the proportion of those aged 20-34 in the non-dependent population ($YOUNG_t$), the proportion of those aged 45-64 in the non-dependent population ($PMID_t$), the number of hours lost through industrial disputes per hour worked ($STRIKE_t$) and the unemployment rate (UNR_t). He specified his equation as:

$$\ln C_t = a_0 + a_1 \Delta \ln Y_t + a_2(\ln Y_t - \ln C_{t-1}) + a_3 W_t + a_4 \ln CREDIT_t$$
$$+ a_5 YOUNG_t - a_6 PMID_t - a_7 STRIKE_{t-1} - a_8 UNR_t$$

We conclude from the previous theories of consumption that income wealth, inflation, and lagged consumption expenditure (to capture the effect of last period explanatory variables) are important in explaining current consumption.

2.9 The Consumption Function for the Libyan Economy

The constraint of the availability of data for Libya is very serious and we will restrict our formulation to suit the data available. The available data allows us to split the Total Consumption into Private and Government Consumption.

The main factors expected to have an effect on Private Consumption are: Disposable Income or Permanent Income; the Inflation Rate; Wealth or Liquid assets, represented by the broad definition of Money Supply plus Capital Stock; and Real Private Consumption lagged one period.

The current rate of inflation will be represented by the index number of consumer prices.

The demonstration effect in Libya may have affected the consumption pattern, especially through the wide diffusion of the mass media, large migration to the big cities and through people travelling abroad for study or tourism. All of these factors, as well as the increasing level of education, may have affected the level of consumption.

Wealth holdings are often considered a variable that should be included in the consumption function. Modiglian-Ando's life cycle hypothesis is a typical one, which explicitly takes into consideration the assets effects on consumption.

Liquid assets will represent the wealth effect on consumption; its effect is expected to be positive. The capital stock plus money supply will be used as an approximation of liquid assets, because of the underdevelopment of the assets market in Libya.

The general form of the consumption function will include most of the variables as assumed by previous consumption theories:

$$CONS_t = F[DISY,(\frac{C}{Y})_{t-1}, MONEY_t, PSDX_t, CONS_{t-1}, TIME_t]$$

Where,

$CONS_t$ = Private Consumption.

$DISY_t$ = Disposable Income.

$(\frac{C}{Y})_{t-1}$ = Consumption/Income Ratio lagged one period.

$MONEY_t$ = Money Supply.

$PSDX_t$ = Consumer Price Index

$TIME_t$ = Time trend.

Government Expenditure is usually considered to be exogenous in most of the macroeconomic models of developed countries. However, government plays a vital role in the economic life of developing countries, so Government

Expenditure (consumption and investment) will be endogenized in our model. Government Consumption ($GCONS_t$) in Libya is financed mostly from Oil Revenues, so it is very logical to formulate Government Consumption ($GCONS_t$) as a Function of Oil Revenues ($OILREV_t$) and Government Consumption lagged one period ($GCONS_{t-1}$), i.e.

$$GCONS_t = F(OILREV_t, GCONS_{t-1})$$

2.10 Conclusions

This chapter has explained various theories of consumption. It was found that all the theories agreed that Disposable Income is the most important determinant of Private Consumption. Wealth and prices are represented in these theories to improve the explanatory power of the equations. Lagged income and prices are also used for the same goal.

The Private Consumption function proposed for Libya utilises the same explanatory variables in formulating the consumption function.

Oil Revenues and lagged Government Consumption Expenditure are believed to be the variables affecting Government Consumption Expenditure. The final forms of these functions will be determined by the estimation process, using economic and statistical criteria and will be discussed in the next chapters. The other part of total expenditure is investment expenditure. This will be discussed in chapter Three.

CHAPTER THREE

THE INVESTMENT FUNCTION

3.1 Introduction

Although most economists agree that investment expenditure plays a dominant role determining the pace of economic activity, there is little agreement on the determinants of investment spending. Therefore, unlike the consumption function, investment expenditure does not seem to be a stable function of a few factors. Different theories assume different explanatory variables. Some of these emphasise the role of interest rates and the change in output; others stress the importance of sales and profits in determining investment, and availability of internal or external finance.

Section two discusses the Keynesian marginal efficiency of capital approach. Sections three and four explain the flexible accelerator principle and the neoclassical theory of investment. Section five will examine the importance of profits and retained earning in the investment function. Sections six and seven will review briefly some empirical studies on the investment function for developed and developing countries. Section eight will focus on the government investment function for Libya. The summary and the conclusion will be provided in the final section.

3.2 The Marginal Efficiency of Capital

Keynes (1936) argued that the actual rate of current investment will be pushed to the point where there is no longer any class of capital asset of which the marginal efficiency exceeds the current rate of interest.

The marginal efficiency of capital (r) is that of discount which equates the anticipated net income stream to be derived from the asset, to the supply price of the asset (Greenaway and Shaw, 1984) .i.e.:

$$X = \frac{Y_1}{(1+r)} + \frac{Y_2}{(1+r)^2} + \frac{Y_3}{(1+r)^3} + \ldots + \frac{Y_n}{(1+r)^n} + \frac{J_n}{(1+r)^n}$$

Where,

X = Supply price of the asset.

r = Marginal efficiency of capital.

Y_n = Income stream.

J_n = Scrap value.

So, whatever the value of the income stream and whatever the cost of the asset there is some rate of discount (r) which equates the two. Keynes called this rate the Marginal Efficiency of Capital (MEC) which can be considered as the rate of return upon the asset. It is, of course, the Internal Rate of Return (IRR) of any investment project, using cost-benefit terminology.

The Marginal Efficiency of Capital (MEC) changes if expectation, technology, or output change. A decrease in the rate of interest will cause a positive expansion of investment through reducing the supply of the assets. This movement is reinforced by an upward shift in the MEC for two reasons: first, as capital production occurs and some investment opportunities are used up, the prospective yield on further projects will begin to fall; second, because of the rising cost of reproducing capital, there is a rise in the supply price.

The marginal efficiency of capital is a framework for analysing the firm's determination of its optimal capital stock. This will assist in deriving an investment theory, given the actual current level of the capital stock, by establishing the desired level of the capital stock. The difference between the actual and desired capital stock will generate the need for a net investment.

The schedule shows the level of net investment which would accompany alternative interest rates, given the original stock of capital, called the Marginal Efficiency of Investment (MEI) schedule (Venieris, 1977). This schedule is downward sloping. Thereby, at a given level of existing capital stock, net investment is inversely related to the rate of interest, so any change in the existing capital stock will shift the Marginal Efficiency of Investment (MEI) schedule. Consequently, the level of net investment is related both to the rate of interest and the size of the existing capital stock.

$$I_t = I(r, K)$$

Where,

$$\frac{\partial I_t}{\partial K} < 0$$

$$\frac{\partial I_t}{\partial r} < 0$$

When,

I_t = Net investment level.

r = Rate of interest.

K = Existing capital stock.

3.3 The Accelerator Theory

The accelerator theory was introduced by Clark (1917) as a technological relationship between the final output and capital stock. According to this principle it is assumed that the desired capital stock is proportional to the current level of output (Arestis and Hadjimathecou, 1982), i.e.

$$K_t^* = BY_t \tag{3.1}$$

Where,

K_t^* = Desired capital stock.

Y_t = Output.

This theory depends on several vital assumptions, such as a constant capital-output ratio, the impossibility of substituting between production function inputs, and the adjustment process of the capital stock to its desired level being completed within one period. If the currently desired capital stock is proportional to current output, then the previous period's desired capital stock is also proportional to the previous level of output. Given the net current investment as the difference between the current and previous desired capital stock:

$$I_t = K_t^* - K_{t-1}^* \tag{3.2}$$

Substituting K_t^* from equation (3.1):

$$I_t = \beta(Y_t - Y_{t-1})$$

Where,

β = Constant accelerator coefficient.

So, the level of net investment depends on the change of output.

The main problem with the accelerator theory is that it ignores the financial factors which are not linked closely to the expected volume of sales or output, such as the interest rate, profitability, and the level of retained profit.

In practice there are lags between decisions to invest and investment expenditure. It takes time for managers to make decisions, to get planning permission if required, to obtain information about machinery and tenders, to place contracts, and take delivery of capital equipment. So a more realistic relationship would be (Pratten, 1990):

$$I_t = \beta(Y_{t-1} - Y_{t-2})$$

Plainly, the level of output in relation to past levels of output or capacity affects the impact of an expected change in output on investment. If output is far below capacity, firms will not need to invest to produce increased output. This means that additions to the capital stock are related negatively to the size of the existing stock of capital equipment, as well as positively to the level of output (Pratten, 1990):

$$I_t = aY_{t-1} - bK_{t-1}$$

Where,

a and b = Constant coefficients.

K_{t-1} = Capital stock at the end of the preceding period.

In general, taking the time structure of investment into consideration, capital will be adjusted toward its desired level by a constant proportion of the difference between the actual and desired level of capital stock [(Arestis and Hadjimatheou, 1982; Precious, 1987)]:

$$I_t = (1 - \lambda)(K_t^* - K_{t-1}) \tag{3.3}$$

Where,

$0 \langle \lambda \langle 1$

Given:

$$I_t = K_t - K_{t-1}$$

Equation (3.3) could be written as :

$$K_t = (1 - \lambda)K_t^* + \lambda K_{t-1}$$

Which after repeated substitutions for (K) can be expressed as :

$$K_t = (1 - \lambda)K_t^* + \lambda(1 - \lambda)K_{t-1}^* + \lambda^2(1 - \lambda)K_{t-2}^* + \ldots + \lambda^n(1 - \lambda)K_{t-n}^*$$

Or,

$$K_t = (1 - \lambda)\sum_{r=0}^{\infty}\lambda^n K_{t-n}^* \tag{3.4}$$

But, from equation (3.1) :

$$K_t^* = BY_t$$

Then,

$$I_t = (1-\lambda)B_n \sum_{n=o}^{\infty} \lambda^n (Y_{t-n} - Y_{t-n-1}) \qquad (3.5)$$

This is the standard distributed-lag model with geometrically declining weights. By assuming that replacement investment is proportional to the actual stock, and substituting into equation (3.5), I_t will be gross investment instead of net investment:

$$I_t = (1-\lambda)B_n \sum_{n=0}^{\infty} [Y_{t-n} - Y_{t-n-1}] + \delta K_{t-1} \qquad (3.6)$$

A more general formulation of equation (3.6) which does not constrain the coefficient, is:

$$I_t = \alpha \sum_{n=0}^{\infty} B_n [Y_{t-n} - Y_{t-n-1} - 1] + \delta K_{t-1}$$

The above formula is called The Flexible Accelerator and has remained a favourite empirical formulation of aggregate investment behaviour.

3.4 The Neoclassical Model of Investment

The neoclassical model of investment is one of the most highly developed areas of model economic analysis. The investment theories based on the neoclassical theory of optimal capital accumulation find their antecedents in the early writing of Fisher (1930). It was extensively redeveloped and very successfully revitalised by Dale Jorgenson (1967) and his colleagues at the University of California and Harvard University. The neoclassical model of investment incorporates output, the interest rate, the price of capital, and the existing stock of capital, into a coherent framework.

The central theoretical feature of neoclassical capital theory is the user cost of capital concept (Jorgenson, 1967), which represents the price of the services provided by capital. This model links the maximisation of the present value of the firm with the concept of the accelerator theory to give the flexible accelerator. It then substitutes the desired stock of capital formula, which is derived from the production function, into the flexible accelerator formula. Doing this, the neoclassical investment function will be derived as follows:

$$Z = PQ - WL - CK$$

Where,

Z = Profit (the difference between revenues and the costs).

PQ = Revenue (the product of price P times the quantity produced Q).

The costs are split into two main categories:

WL = Labour cost (the wage rate W times the quantity of Labour units L).

CK = Capital cost (the product of the cost of capital service C, and the quantity of capital units K).

The firm, in order to maximise its profits, will choose quantities of labour and capital up to a point at which the value of the marginal product of each factor equals its price. The value of the marginal product is the marginal physical product times the product price. The necessary conditions for profit maximisation will be:

$$P^{*} MPPL = W$$

$$P^{*} MPPK = C$$

Or,

$$MPPL = W / P$$

$$MPPK = C / P \tag{3.7}$$

Where,

$MPPL$ = Marginal Physical Product of Labour.

$MPPK$ = Marginal Physical Product of Capital.

We will concentrate on equation (3.7). C is the user cost of capital, and equals the opportunity cost of using capital plus depreciation of the capital over the period of use, minus the capital gains received by the owner over the period.

Let,

r = Interest rate (the opportunity cost).

δ = Rate of depreciation of capital.

$q =$ Acquisition price of the capital assets.

$q^0 =$ Proportional rate of capital gain (loss).

The user cost (C) will be :

$$C = [r + \delta - q^0]q$$

So:

$$MPPK = [r + \delta - q^0]q / p \qquad (3.8)$$

Assuming the production function is Cobb-Douglas:

$$Q = AL^{\alpha} K^{B} \qquad (3.9)$$

Where,

$A, \alpha,$ and B are constant.

By differentiating equation (3.9) with respect to (K), we get the marginal physical product of capital is as follows:

$$MPPK = B\frac{Q}{K} \qquad (3.10)$$

Where,

$\frac{Q}{K}$ = the average product per unit of capital (APK).

So:

$B = MPPK / APK$

This means that (B) is the elasticity of output with respect to capital. Combining the profit maximisation condition in equation (3.8) with the specific expression of *MPPK* in equation (3.10), we get:

$$B\frac{Q}{K}=(r+\delta-q^{0})q/p$$

$$K = BPQ / (r + \delta - q^{0})q$$

Or:

$$K = B\frac{PQ}{C} \tag{3.11}$$

This gives the optimal level of capital. The equilibrium value demanded by maximising producers is equal to the output elasticity of capital, times the value of output, divided by the user cost of capital. Therefore, the optimal level of capital will be determined by the production function, output level, product price and the user cost. The change in any variables on the right hand side of the equation (3.11) will cause an instant and complete response to capital accumulation.

To explain the investment delay response to changes in the optimal level of capital, let us assume that:

K_{t-1} represents the actual stock of capital at the beginning of period t.

K_t^* represents the stock desired at the end of the time period derived from the maximisation process discussed above.

The adjustment process toward K_t^* from K_{t-1} is the real rate of capital accumulation:

$$K_t - K_{t-1} = (1-\lambda)(K_t^* - K_{t-1}) \tag{3.12}$$

The net investment and the gap between the desired and actual capital are proportionally related by a geometrically declining distributed lag $(1-\lambda)$. To introduce gross investment into equation (3.12), replacement capital will be added which is proportional to the capital stock, with the rate of depreciation (δ) serving as a proportionality factor:

$$R_t = \delta K_{t-1}$$

Where,

R_t = Replacement investment.

Since gross investment is the sum of net and replacement investment:

$$I_t = (1-\lambda)(K_t^* - K_{t-1}) + \delta K_{t-1}$$

The equation above represents the flexible accelerator, which adapts gradually to the deviation between actual and desired capital. It explicitly considers replacement requirements and allows them to be filled faster than new demand. Also, it can be combined with any possible specification of K^*. In our framework, K^* has been derived from the Cobb-Douglas production function:

$$K^* = B\frac{P_t Q_t}{C_t}$$

Substituting this formula into the flexible accelerator, we have:

$$I_t = (1-\lambda)(B\frac{P_t Q_t}{C_t K_{t-1}} + \delta K_{t-1}) \qquad (3.13)$$

Where,

$$C_t = (r_t + \delta - q_t^0) q_t$$

Equation (3.13) shows the neoclassical theory of investment spending.

Another development was introduced by Tobin (1969), who added the variable q:

$$q = p / c$$

Where,

q = Tobin ratio.

p = Market price for exchanging existing assets.

c = Cost of newly produced assets of this type.

Under perfectly competitive equilibrium conditions, the market valuation for exchanging existing assets and the replacement cost of producing new assets would be equal, so the value of (q) should be equal to unity. Tobin's (q) theory is one of disequilibrium investment behaviour. In disequilibrium, (q) could be greater than unity, and hence will lead to more investment. Alternatively, it could be less than unity, so investment will be depressed. According to Tobin, investment is greatly influenced by financial market conditions, by the interest rates, the availability of loans, the nature of bonds, and the risk involved in these markets. All of these factors are summarised in the value of a firm's stock.

3.5 The Importance of Profits and Retained Earnings

Without any doubt, profit, or its expectation, is an essential element in the investment decision. Some writers concentrate upon one element of profit, retained earnings, as being a crucial determinant in the volume of investment spending. The reason for this is that firms may have a strong preference to finance their investment spending out of retained earnings rather than out of debt finance. This is because the computed cost will be less using retained earnings than the cost of borrowing from the capital market. Retained earnings can be defined as follows:

Retained Earnings Profit - Tax Payment + Subsidies Payment

Therefore any factor increasing retained earnings, such as a tax cut or generous depreciation allowances, may have a sizeable impact on investment analysis. While this could be true for small firms, large organisations, which collectively dominate business investment behaviour, will not consider financing as a constraint. The size of retained earnings may, however, be an important determinant of the optimal capital stock. The optimal capital stock is a function of expected profits, which in its turn depends on actual profits in the past.

Thus:

$$K_t^* = f(R_{t-1}) \qquad (3.14)$$

Empirically, this is indistinguishable from accelerator theories, since profits are expected to be a function of the level of output or sales. This can be shown with a Cobb-Douglas function, as follows (Junankar, 1972):

$$Q = AK^{\alpha} L^{B}$$

$$\frac{\partial Q}{\partial K} = \alpha \frac{Q}{K}$$

Total profit:

$$R = \alpha[Q / K]K$$

$$R = \alpha Q$$

So:

$$R_t = g(Q_t) \tag{3.15}$$

If we substitute equation (3.14) into (3.12) and then into the adjustment equation, we get:

$$K_t - K_{t-1} = [1 - \lambda][K_t^* - K_{t-1}]$$

$$I_t = (1 - \lambda)[f(R_{t-1}) - K_{t-1}]$$

Where,

$f(R_{t-1})$ = A positive function of profit.

If profits depend on output, then we return to the accelerator equation, and so there is no real empirical difference between a profit theory and an accelerator theory of investment.

3.6 Econometric Studies of Investment Behaviour

The review of the studies will contain analysis of developed and developing economics. We shall concentrate on the last category for two reasons. Firstly, because this study is of a developing country, Libya, studies of investment behaviour in other developing countries may help us to understand the way in which investment behaves in Libya. Secondly, in developing economies, there is a lack of developed capital markets of the western type, or an unavailability of data about important variables, such as capital formation, price indices for capital, profits, sales, and so on. Also, there is a large role for the government in the economic life of Libya. All these factors will affect the formulation of our investment function. We will start by surveying some studies of developed economics and then we will turn to developing countries.

Ueno (1963) in his model of the Japanese economy, split gross investment into two parts; Gross investment in the textile industry and gross investment in heavy industry. He assumed the profits of the textile industry deflated by the price index of material and machinery, and average yield of corporate bond, to be the main determinants of gross investment in the textile industry at constant prices. He also relied on the profits of heavy industry deflated by the price index of metals and machinery, and index of domestic demand for the metals and machinery as the main determinants of gross investment in the heavy industry at constant prices.

Bourneuf (1964) showed production capacity and output as the only determinants of investment expenditure in his model of the United States. The model's results showed that the difference between capacity and output was highly significant. He demonstrated also that capacity at the beginning of the period, the representing replacement requirement generated by existing capital stock, was a significant determinant of investment expenditure as well. In addition, the model found that the change in output was barely significant as a determinant of investment.

Eisner (1965) considered the change in sales, change in profits, and the level of the capital stock as a proxy for replacement investment, to be the main determinants of investment in his model of the United States.

Resek (1966) used output, change in output, rate of interest, measure of debt capacity and an index of stock prices, as the main determinants of investment in his model. His results showed that the interest rate and the stock price index were clearly significant determinants of investment expenditure, while the change in output was less significant.

Anderson (1967) considered the pressure on capacity, interest rate, profits, stock of government securities held at the beginning of the period, accrued tax liability at the end of the period and the long term debt capacity, as the main determinants of fixed investment. The model's results showed that only capacity utilisation and the interest rate were clearly significant determinants of investment.

In the models of Resek and Anderson, each incorporating the rate of interest and the price of corporate securities associated with the cost of external funds, the changes in output were the significant determinants of the level of investment. Korliras and Thorn (1979) considered the main determinants of investment expenditure to be the change in output lagged several periods, the stock of capital at the beginning of the period, and the price of capital services.

In the Arestis and Hadjimatheou (1982) macroeconomic model of the United Kingdom, the main determinants of gross investment expenditure were: the change in real GDP lagged one and two periods, the level of capacity utilisation (CU), the internal funds of the corporate sector (IF), the real rate of interest, and gross investment lagged one period. The model's results showed that the capacity utilisation and the cash flow were significant determinants. This indicated that the degree to which investment responded to an expected change in demand depends on the extent to which the existing productive capacity was utilised and on the availability of internal funds.

3.7 Empirical Studies of Investment in Developing Countries

Lykourgou (1967) in his model of the Greek economy, split private gross fixed investment into three parts: private investment in plant and equipment, residential construction, and changes in inventory stocks. He relied on total expenditure as a proxy variable for sales, gross capital stock in plant and equipment lagged one year, and government investment in plant and equipment, as the main determinants of private investment in plant and equipment. He also considered the bank interest rate and the number of marriages as explanatory variables of private investment in the residential construction function. Gross domestic product and stocks lagged one period were the main variables determining private investment in inventory stocks in his model of the Greek economy.

In his model of the Colombian economy, Marwah (1969) used the accelerator theory in building an investment function. His results showed the real gross national product lagged one period, imports of capital goods deflated by the import price index, and aggregate fixed gross capital formation deflated by the implicit deflator for total gross investment lagged one period, to be the main determinants of the aggregate fixed gross capital formation in his macromodel of Colombian economy.

SU (1969) considered the gross domestic product and take-home profits of outside investors as the main determinants of private investment expenditure in his model of the Puerto Rico economy.

Evans (1970) in his model of Israel, divided the gross fixed investment expenditure into five categories. The first category represented the fixed business investment in agriculture, forestry and water projects, which was determined by the national income originating in agriculture and the government development budget spent on investment in agriculture. The second category was the fixed business investment in manufacturing, mining and construction, which was determined by the national income originating in manufacturing and mining, the government budget spent on investment in this group, the income velocity lagged one period, and the capital stock in this group, lagged one period. The third category represented the fixed business investment in transportation and communication. The fixed business investment in this group was explained by the national income originating in this category, the government development budget spent on investment in this group and income velocity lagged one period. The fourth category was the fixed business investment in trade and services determined in the model by the national income, the government development budget spent on investment in this group and the income velocity lagged one period. The last category represented residential construction determined by personal disposable income, net immigration and the capital stock in this sector lagged one period.

Lope (1975) in his model of Malaysia considered gross domestic product, government investment lagged one period and the supply of bank credit, as the main determining variables of private fixed investment.

In his model of Saudi Arabia, Al-bashir (1976) divided gross fixed investment into three parts; The first part being gross fixed investment in the transportation and communications sector. This was determined by government annual appropriation for investment in this sector and the *GDP* of the transportation and communications sector lagged one year. The second part of the model was gross fixed investment in the construction sector, explained by government annual appropriation for investment in this sector and the total private personal income. The third part was gross fixed investment in the manufacturing sector, determined by government annual appropriation for investment in this sector and the *GDP* of the manufacturing sector lagged one year.

Chang (1977) considered real gross domestic product, the real interest rate and real private investment lagged one year, to be the main variables determining the private investment in his macromodel of the Taiwanese economy.

In their macroeconomic model, Leff and Sato (1980) examined the aggregate investment function for six developing countries (Argentina, Brazil, Chile, Costa Rica, Israel, and Taiwan). They found that the change of real GNP, rate of inflation and the change in the real volume of bank credit were the main determinants of the investment function.

Sundarajan and Thaker (1980) in their models of India and Korea, found that the main factors determining gross fixed investment by the private sector were the ratio of capital cost to wage rate, the private sector *GDP*, the public sector capital stock, the difference between nominal aggregate savings and public sector investment at current prices, and private capital stock lagged one period.

Wai and Wong (1982) relied on the accelerator theory in building an investment equation for five countries (Greece, Malaysia, Korea, Mexico, and Thailand). The model's results showed that government investment (fixed capital formation), the change in domestic credit to the private sector, and the net capital inflow to the private sector, were the main variables determining private investment in their macromodel.

In his model of the Malaysian economy, Semudrem (1982) considered real total loans and advances by commercial banks, real gross domestic product lagged one period, net foreign assets of the central bank divided by the import price index lagged one period, and real private investment lagged one period, as the main determining factors of private investment expenditure.

Ibrahim (1983) considered the remittances from Jordanians working abroad, government investment lagged one to three periods and the total commodity exports proceeds, as the main determinants of private investment in his macromodel of the Jordanian economy.

Rashid (1984), in his study of the Philippines economy assumed the following factors to be the main variables determining net fixed investment; gross domestic product, national market rate of interest, bank credit to the private sector, retained earnings plus depreciation allowance of the corporate sector, imports of raw materials, intermediate goods, capital goods, government expenditure and the cumulative net fixed investment lagged one period.

In their model of the Kenyan economy, Elliott, Kwack and Tavlas (1986) split up gross fixed investment into four categories. The first category was real fixed investment in agriculture. This was determined by the real gross domestic product in the agriculture sector, real agricultural capital stock lagged one period and the development project expenditures of the central government, divided by the deflator of fixed income in agriculture. The second category was real fixed investment in government services, which was determined by the real gross domestic product in government services, real capital stock of government sector lagged one period and the development project expenditures of the central government, divided by the deflator of fixed income in government services. The third category represented real fixed investment in industry, which relied on the real gross domestic product in industry, loans by deposit money banks divided by the deflator of fixed investment in industry and the real capital stock of the industrial sector. The fourth category represented real fixed investment in service industries. This was determined by loans by deposit money banks divided by the deflator of fixed investment in service industries, real capital stock of the service industry and the development project expenditures by central government, divided by the deflator of fixed investment in service industries.

Ghartey and Rao (1990) used the reciprocal of the real interest rate, real capital stock and the real fixed investment lagged one period, as the main determinants of the aggregate real fixed investment in their models of Ghana.

Abdulghani (1991) in his macroeconometric model of Kuwait, considered the price of crude oil and the level of income lagged one period as the main variables determining private investment in Kuwait.

Park (1993) relied on the accelerator theory in explaining the gross investment expenditure for the Korean economy. The model's results showed that the real gross domestic products, money supply and the gross investment lagged one period were the main variables determining the gross investment in the Korean economy.

Sakellarlou and Howland (1993) in their macroeconometric model of Greece, split private investment into four sectors. The first sector was private investment in manufacturing, which was determined by the capital stock in this category, gross domestic product in manufacturing, total profits in manufacturing and the private investment in manufacturing lagged one period. The second sector was private investment in agriculture. This was explained by the wholesale price index of agricultural products and bank credit for agriculture. The third sector represented private investment in housing, which was determined by bank credit for housing, real interest rate for housing, three-year moving average of marriages and the private investment in housing lagged one period. The fourth represented private investment in services, explained by bank credit to trade, and the gross domestic product in agriculture.

Al-Jerayed (1993), in his macroeconometric model of Saudi Arabia, divided government investment expenditure into five sectors; Transportation and communication, construction, manufacturing, agriculture, and the oil sector. Investment in all of these sectors, except oil, was explained by current output originating in the relevant sector, and government annual appropriation for investment in each sector. Finally, the oil sector investment was explained by output originating in this sector, and oil investment lagged one year.

Rankaduwa and Tomson (1995) in their forecasting model of the Sri-Lankan economy split up gross fixed investment into two parts. The first part was real fixed investment by central government, which was determined by the first difference of real gross domestic product, first difference of real fixed investment of private sector, first difference of broad money supply, change in central government external debt, and real fixed investment of central government lagged one year. The second part was fixed investment of private sector, which was determined by the first difference of real gross domestic product, first difference of real investment of central government, real value of capital goods imports, and real fixed investment of the private sector lagged one year.

We could conclude that for developing countries there is evidence that investment expenditure, whether it has been split into sector levels or into plant and machinery, construction and change in inventory stock, seems to be determined by gross national product lagged one period, government expenditure, credit facilities available to the private sector, imports of capital goods, retained earnings, remittances from abroad and private investment expenditure lagged one period.

3.8 The Investment Function for the Libyan Economy

In Libya as in most developing countries, investment expenditure is subject to certain constraints. There is a lack of an organised western-type capital market, so the official rate of interest does not reflect the real scarcity of loanable funds because it is not determined according to market forces. Thus, the rate of interest has been constant for many years and there is a need for large, government supported investment.

Also, interest rates, which play a major role in the theories of investment which have been applied to western developed countries, are prohibited by the Islamic religion which regulates the economy under study. Therefore, interest rates can not be a big factor (in fact, they may not be a factor at all) in stimulating government investment in Libya. Thus, interest rates are not a determinant of investment in the country.

The desegregation of total investment expenditure depends on the characteristics of the economy under consideration and availability of data.

Empirical studies of developed countries and economic theory are suggested by investment theories, such as the accelerator theory, the neoclassical model of investment, profit maximisation theory, theories which emphasise the importance of profits and retained earnings. Since in Libya, government is the dominant investor and oil revenue is the main source of invisible funds, it is believed that factors such as the interest rate, sales, change in sales, profit and retained profit, which affect the direction of investment behaviour in industrial countries, will not affect the direction of government investment. Given the abundance of the oil revenue, the direction and amount of investment appropriated to different sectors will depend, to a large extent, on the government's desire to satisfy the social needs of its people and to implement its long-term goal of creating an alternative productive source of foreign exchange.

Government is the main investor in almost all sectors of the Libyan economy. In 1979, government share in total investment was equivalent to 92 percent, its share in the total investment in agriculture was equivalent to 90 percent and in manufacturing it formed more than 90 percent for the same year. Thus, it was with regard to the government's dominant role that investment was grouped, according to its industrial origin, into the following four sectors: Manufacturing, Agriculture, Services, and Construction. An attempt will be made to formulate an investment function for each of these, starting with the Manufacturing sector:

3.8.1 The Manufacturing Sector

The increasing role of government and the declining share of private investment is a basic feature of this model. Another feature is the excess of investment over value added, particularly in the last few years. The following reasons may partly explain the latter feature:

(a) The last few years witnessed a huge increase in government investment in the manufacturing sector, whereby investment decisions were more affected by maximisation of social welfare than by profit maximisation.

(b) Some of these investment projects have long gestation periods. In addition, some projects need a long time for completion. Government industrialisation policy in the 1973-1975 plan was directed toward building more industries supplying basic necessities, while in the 1976-1980 plan more emphasis was put on building heavy industries. Furthermore, the 1981-1985 plan emphasises building new industries and completes some industries which had not been completed from the plan 1976-1980.

In order to describe how the desired level of investment is determined in the manufacturing sector, some factors which might affect the investment function of the sector will be explained:

$$MANI_t = F(OILREV_t, MANVAL_t, MANDE_t, MANVAL_{t-1}, MANDE_{t-1}, MANI_{t-1})$$

Where,

$MANI_t$ = Investment Expenditure in the Manufacturing Sector.

$OILREV_t$ = Oil Revenues.

$MANVAL_t$ = Value-Added Generated in the Manufacturing Sector.

$MANDE_t$ = Government's Annual Appropriation for Investment in the Manufacturing Sector.

$MANVAL_{t-1}$ = Value-Added Generated in the Manufacturing Sector lagged one period.

$MANDE_{t-1}$ = Government's Annual Appropriation for Investment in the Manufacturing Sector lagged one period.

$MANI_{t-1}$ = Investment Expenditure in the Manufacturing Sector lagged one period.

3.8.2 The Agriculture Sector

Although Libya suffers from a harsh climate and scarcity of water resources, agriculture plays a major role in the diversification of its economy. It contributes a low percentage to total *GDP*. Most investment in agriculture took place after the huge wealth that came to Libya from oil revenues due to higher oil prices. Investment in agriculture is mainly made by the government. Huge amounts of money were directed toward investment in agriculture for constructing new facilities for farmers, building dams, irrigation, rural development, and capital intensive farming projects.

To construct the behavioural equation for investment in agriculture, the independent variables that influence investment in this sector must first be determined; these will be specified as:

$$AGRI_t = F(OILREV_t, AGRVAL_t, AGRDE_t, AGRVAL_{t-1}, AGRDE_{t-1}, AGRI_{t-1})$$

Where,

$AGRI_t$ = Investment Expenditure in the Agriculture Sector.

$OILREV_t$ = Oil Revenues.

$AGRVAL_t$ = Value-Added Generated in the Agriculture Sector

$AGRDE_t$ = Government's Annual Appropriation for Investment in the Agriculture Sector.

$AGRVAL_{t-1}$ = Value-Added Generated in the Agriculture Sector lagged one period.

$AGRDE_{t-1}$ = Government's Annual Appropriation for Investment in the Agriculture Sector lagged one period.

$AGRI_{t-1}$ = Investment Expenditure in the Agriculture Sector lagged one period.

3.8.3 The Services Sector

A large share of government investment was directed toward building and improving the country's transportation and communication systems. In common with most developing countries, the components of this sector include: electricity, transportation and communication, wholesale trade, banking and insurance, education, health and other services, airlines and postal services. Some of these components may not have a tangible return and mainly serve the purpose of improving the social welfare of people; others such, as human capital, take time to yield return. So, it is assumed that function investment in services sector will be specified as:

$$SERI_t = F(OILREV_t, SERVAL_t, SERDE_t, SERVAL_{t-1}, SERDE_{t-1} SERI_{t-1})$$

Where,

$SERI_t$ = Investment Expenditure in the Services Sector.

$OILREV_t$ = Oil Revenues.

$SERVAL_t$ = Value-Added Generated in the Services Sector.

$SERDE_t$ = Government's Annual Appropriation for Investment in the Services Sector.

$SERVAL_{t-1}$ = Value-Added Generated in the Services Sector lagged one period

$SERDE_{t-1}$ = Government's Annual Appropriation for Investment in the Services Sector lagged one period.

$SERI_{t-1}$ = Investment Expenditure in the Services Sector lagged one period..

3.8.4 The Construction Sector

Construction in Libya contains various components, such as constructing government buildings, schools, hospital, dams, industrial and other infrastructure which helps the pace of development in the country and improves the social welfare of the people. Investment in construction is heavily dependent on the government's appropriation for investment in construction. Also, other factors that might affect investment in construction are value added in the construction sector, the government total revenues are likely to play an important role in determining the sector's investment function. So, the investment function of the Construction Sector will be:

$$COTI_t = F(TREVN_t, COTVAL_t, COTDE_t, COTVAL_{t-1}, COTDE_{t-1}, COTI_{t-1})$$

Where,

$COTI_t$ = Investment Expenditure in the Construction Sector.

$TREVN_t$ = Government Total Revenues.

$COTVAL_t$ = Value-Added Generated in the Construction Sector.

$COTDE_t$ = Government's Annual Appropriation for Investment in the Construction Sector.

$COTVAL_{t-1}$ = Value-Added Generated in the Construction Sector lagged one period.

$COTDE_{t-1}$ = Government's Annual Appropriation for investment in the Construction Sector lagged one period.

$COTI_{t-1}$ = Investment Expenditure in the Construction Sector lagged one period.

3.9 Conclusions

Having discussed different theories of investment (Keynesian Marginal Efficiency of Capital, Simple and Flexible Accelerator Principle, the Neo-classical Theory and Tobin's theory), it is clear that the investment expenditure function depends on a wide range of variables. These variables differ between developed countries and developing countries.

The most important variables affecting investment expenditure are: the interest rate, change in output, production capacity, credit to the private sector, capital stock, real *GDP*, price of corporate securities with cost of external funds, level of capacity utilisation, and imports of capital goods. Also, some of the independent variables may be introduced with a lag structure.

Gross investment expenditure in Libya is split into four sectors: Manufacturing, Agriculture, Services, and the Construction.

Having discussed the demand side of the economy, the next chapter will discuss the supply side of the economy, represented by the production function.

CHAPTER FOUR

THE PRODUCTION FUNCTION

4.1 Introduction

Having discussed the demand side in the last two chapters, this chapter discusses the supply side of the economy. This will be done through the production function.

This chapter will be divided into eight sections. Section two will discuss the production function from the supply point of view. The third, fourth, fifth and six sections will deal with the Cobb-Douglas Production Function (CD), the Constant Elasticity of Substitution Production Function (CES), the Variable Elasticity of Substitution Production Function (VES) and the Transcendental Logarithmic Production Function (TLS), respectively. Section seven will explain the production function for the Libyan economy. Section eight will summarise the main ideas examined in this chapter.

4.2 The Production Function for the Supply Side

This second approach is to reflect the supply side, in which the production function is considered as a mathematical function which relates the quantities of inputs and the quantities of outputs within a production unit, which may be variously defined as an activity or process, a firm, an industry or a national economy (Wynn and Holden 1974). This is usually assumed to be a technical relationship between the quantities of inputs and the maximum amount of output which can be produced with a given set of inputs. It is common, when dealing with the production function, to set aside the material input and concentrate on the two major economic factors of production, Labour(L) and Capital (K). The general form of the production function is then as follows:

$$Q = f(K, L)$$

Where,

Q = The rate of output.

K = The rate of capital input.

L = The rate of labour input.

According to the neoclassical theory of production, the marginal products of capital and labour are positive but diminishing. This means that the first partial derivatives of the production function with respect to each of its arguments is positive, while the second derivatives are negative.

$$Q_k = \frac{\partial Q}{\partial K} > 0 \qquad Q_{kk} = \frac{\partial^2 Q}{\partial K^2} < 0$$

$$Q_L = \frac{\partial Q}{\partial L} > 0 \qquad Q_{LL} = \frac{\partial^2 Q}{\partial L^2} < 0$$

Production function will exhibit a certain degree of returns to scale. This means that if the inputs increase by a certain amount, say λ, the production function shows the pattern below:

$$\begin{bmatrix} CONSTANT \\ INCREASING \\ DECREASING \end{bmatrix} \text{Returns To Scale if } f(\lambda K, \lambda L) \begin{bmatrix} = \\ > \\ < \end{bmatrix} \lambda f(K, L) \text{ for all } \lambda > 1$$

Constant returns to scale means that, at any level of inputs, scaling both inputs by the same multiplicative factor scales output by the same multiplicative factor. Generally the production function is said to be positive homogeneous of degree (h) if:

$$f(\lambda K, \lambda L) = \lambda^h f(K, L) \qquad \text{for all } \lambda > 0$$

So if,

$h = 1$ The function exhibits constant returns to scale.

$h > 1$ The function exhibits increasing returns to scale.

$h < 1$ The function exhibits decreasing returns to scale.

Another important property of production function is the substitutability of inputs for one another. This is measured by the elasticity of substitution (η), which is defined as the ratio of the proportionate change in the ratio of input factors to the changes in the ratio of marginal products. This can be written as:

$$\eta = \frac{\partial \ln(\frac{K}{L})}{\partial \ln(\frac{MP_L}{MP_K})} \qquad (4.1)$$

i.e.

$$\eta = \frac{\partial(\frac{K}{L}) / (\frac{K}{L})}{\partial(\frac{MP_L}{MP_K}) / (\frac{MP_L}{MP_K})}$$

$$\eta = \frac{\partial(\frac{K}{L}).(\frac{\partial K}{\partial L})}{\partial(\frac{\partial K}{\partial L}).(\frac{K}{L})}$$

Now, assuming perfect competition and profit maximisation:

$$\Pi = P_q Q - wL + rK$$

$$\frac{\partial Q}{\partial K} = \frac{r}{p_q}$$

and,

$$\frac{\partial Q}{\partial L} = \frac{w}{p_q}$$

So,

$$\frac{\partial K}{\partial L} = \frac{w}{r} \qquad (4.2)$$

Where,

Π = Excess profit.

P_q = Price of output.

Q = Output.

w = Wage rate of labour.

r = Price of capital.

Equation (4.2) means that the ratio of the marginal products is equal to the factor prices. Substituting this in equation (4.1), it is fund that:

$$\eta = \frac{\partial \ln(\frac{K}{L})}{\partial \ln(\frac{w}{r})}$$

$$\eta = \frac{\partial (\frac{K}{L}) / (\frac{K}{L})}{\partial (\frac{w}{r}) / (\frac{w}{r})}$$

$$\eta = \frac{(\frac{w}{r}).\partial (\frac{K}{L})}{\partial (\frac{w}{r}).(\frac{K}{L})}$$

Thus, the elasticity of substitution is a measure of how rapidly factor proportions change with changes in relative factor prices.

Next, the most widely used forms of the production functions will be presented. The Cobb-Douglas Production Function (CD); The Constant Elasticity of Substitution Production Function (CES); The Variable Elasticity of Substitution Production Function (VES); and finally The Transcendental Logarithmic Production Function (TRANSLOG), which will be discussed in turn. At the end of this chapter a production function for the Libyan economy will be explained.

4.3 The Cobb-Douglas (CD) Production Function

The general statistical version of the Cobb-Douglas (CD) production function is assumed by equation (4.3), where L and K identify labour and capital, respectively, t is time subscript and u is an error term:

$$Q_t = AK_t^B L_t^\alpha e_t^u \tag{4.3}$$

In order to estimate equation (4.3) by the Ordinary Least Squares Method (OLS), we have to transform it into a linear form by taking logarithms. This gives:

$$\ln Q_t = \ln A + B \ln K_t + \alpha \ln L_t + U_t$$

This is linear in the transformed variables, $\ln Q$, $\ln K$, $\ln L$ and homogeneous of degree $(\alpha + B)$. If it is assumed that $(\alpha + B) = 1$, then it will be linear homogeneous. Cobb and Douglas (1928) used the following equation (4.4) in their estimation. This enables them to circumvent the problem of collinearity between K and L, which was inherent in their time series data:

$$\ln(\frac{Q_t}{K_t}) = \ln A + (1 - \alpha) \ln(\frac{L_t}{K_t}) + U_t \tag{4.4}$$

Equation (4.4) is derived from equation (4.3), as follows:

$$Q_t = AK_t^\alpha L_t^B e_t^u$$

Where,

$$\alpha + B = 1$$

i.e.

$$B = 1 - \alpha$$

So,

$$Q_t = AK_t^{\alpha} L_t^{1-\alpha} e_t^{u}$$

$$\frac{Q_t}{K_t} = AK_t^{\alpha-1} L_t^{1-\alpha} e_t^{u}$$

i.e.

$$\frac{Q_t}{K_t} = A(\frac{L_t}{K_t})^{1-\alpha} e_t^{u}$$

So,

$$\ln(\frac{Q_t}{K_t}) = \ln A + (1-\alpha)\ln(\frac{L_t}{K_t}) + U$$

Where,

$\frac{Q_t}{K_t}$ = Capital efficiency of the technology.

$\frac{L_t}{K_t}$ = Labour intensity, i.e. labour per unit of capital.

In equation (4.4), if $\alpha \rangle 0$, output per unit of capital will be higher if the amount of labour per unit of capital also rises. This is because the marginal product of labour $(\alpha \frac{Q_t}{L_t})$ is always positive in this function for $\alpha \rangle 0$. The (CD) model has constant returns to scale if $\alpha + B = 1$, increasing returns to scale and decreasing returns to scale if $\alpha + B \rangle 1$ and $\alpha + B \langle 1$, respectively.

Technical change in a CD production function could be presented in several form, such as the parameter (A) in the previous form of the CD production function. The elasticity of substitution in the CD production function equals unity, as shown below.

$$\eta = \frac{\partial(\frac{K}{L})}{\frac{K}{L}} \cdot \frac{\frac{\partial K}{\partial L}}{\partial(\frac{\partial K}{\partial L})}$$

$$\frac{\partial L}{\partial K} = -\frac{\beta}{\alpha} \cdot \frac{L}{K}$$

So,

$$\frac{\frac{\partial K}{\partial L}}{\frac{K}{L}} = -\frac{\alpha}{\beta}$$

Differentiating the right-hand side of the above equation with respect to $\frac{K}{L}$, we get:

$$\frac{\partial(\frac{\partial K}{\partial L})}{\partial(\frac{K}{L})} = -\frac{\alpha}{\beta}$$

then,

$$\eta = -\frac{\alpha}{\beta} \cdot \frac{\beta}{-\alpha}$$

i.e.

$$\eta = 1$$

The share going to reach factor is constant and equal to the output elasticities of Labour (α) and capital (β), as follows:

A two factors distribution relationship is given by:

$$1 = \frac{rK}{Q} + \frac{wL}{Q}$$

i.e.

$$1 = S_K + S_L$$

Where,

Q = Nominal income.

S_K, S_L = Proportional shares of capital and labour, respectively.

From the (CD) production function we know that:

$$\frac{\partial Q}{\partial L} = \alpha \frac{Q}{L}$$

and,

$$Y = P_q Q$$

So,

$$\frac{wL}{Q} = \frac{w(P_q \alpha \frac{Q}{w})}{P_q Q}$$

i.e.

$$\frac{wL}{Q} = \alpha$$

This means that the output elasticity of labour is equal to its income share, and similarly for the output elasticity of capital. The (CD) production function, with its strong assumptions, faced several criticisms about why its elasticity of substitutions should equal unity and about the constancy of the shares going to each factor. Therefore, a new function was suggested in order to overcome these criticisms.

4.4 The Constant Elasticity of Substitution (CES) Production Function

The first step in the development of the production function had been taken by Cobb and Douglas in the 1920s. The second step was to come some forty years later by the economists Arrow, Chenery, Minhas and Solow, (1961). They assumed a Constant Elasticity of Substitution (CES) production function, which has a constant, but not necessarily unitary, elasticity of substitution and a non-constant distribution of income among the factors of production. Generally, this function can be written as follows (Heathfield and Soren, 1987):

$$Q = A[BL^{-\theta} + (1 - B)K^{-\theta}]^{-\nu/\theta} \qquad (4.5)$$

Where,

A = Total efficiency of production.

$B, (1 - B)$ = Distribution or intensity, in the sense of attributing to each factor its contribution to the output.

Ω = Degree of homogeneity reflecting returns to scale.

θ = Substitution parameter.

To explain the economies of scale of the function, let both factors change by (λ) in equation (4.5) so that:

$$Q^* = A[B\lambda^{-\theta}L^{-\theta} + (1-B)\lambda^{-\theta}K^{-\theta}]^{-\Omega/\theta}$$

Factoring out (λ) we get:

$$Q^* = \lambda^{\Omega}A(BL^{-\theta} + (1-B)K^{-\theta})^{-\Omega/\theta} = \lambda^{\Omega}Q$$

The above equation shows that the (CES) production function is homogeneous of degree (Ω). Our next step is to deduce the elasticity of substitution for the (CES) function.

Recalling equation (4.1), we have to find the marginal product of labour (MP_L), and of capital (MP_K) by definition:

$$MP_L = \frac{\partial Q}{\partial L}$$

$$= (-\frac{\Omega}{\theta})AB(-\theta L^{-\theta-1})(BL^{-\theta} + [1-B]K^{-\theta})^{-(\Omega/\theta)-1}$$

$$= \frac{\Omega AB}{L^{1+\theta}}(\frac{Q}{A})^{1+\Omega/\theta} \qquad (4.6)$$

and,

$$MP_K = \frac{\partial Q}{\partial K}$$

$$= -(\frac{\Omega}{\theta})A(1-B)(-\theta K)^{-\theta-1}[BL^{-\theta}+(1-B)K^{-\theta}]^{-(\Omega/\theta)-1}$$

$$= \Omega\frac{(1-B)}{K^{1+\theta}}[\frac{Q}{A}]^{1+\Omega/\theta} \tag{4.7}$$

The above two marginal products equations (4.6 & 4.7) will be positive if B, $(1-B)$ and A are positive, and the second derivative with respect to inputs will be negative. That means the marginal productivity is diminishing (Wynn and Holen, 1974). Now the definition of the elasticity from equation (4.1) is:

$$\eta = \frac{\partial \ln(\frac{K}{L})}{\partial \ln \frac{MP_L}{MP_K}}$$

But,

$$\frac{MP_L}{MP_K} = \frac{B}{1-B}(\frac{K}{L})^{1+\theta}$$

i.e.

$$\eta = \frac{\partial \ln(\frac{K}{L})}{\partial[\ln(\frac{B}{1-B}) + \ln(\frac{K}{L})^{1+\theta}]}$$

$$= \frac{\partial \ln(\frac{K}{L})}{(1+\theta)\partial \ln(\frac{K}{L})}$$

$$= \frac{1}{(1+\theta)}$$

If $\theta = 0$, then $\eta = 1$, and the (CES) production function reduces to the (CD) production function.

The distribution of income between the input factors of the (CES) function is as follows. The distribution formula under competitive conditions is:

$$S_L = MP_L \frac{L}{Q}$$

$$S_K = MP_K \frac{K}{Q}$$

Where,

S_L, S_K = Percentage shares of labour and capital respectively.

MP_L, MP_K = Marginal product of labour and capital respectively.

Hence,

$$\frac{S_L}{S_K} = \frac{MP_L}{MP_K} \frac{K}{L} \tag{4.8}$$

By substituting the MP_L, MP_K of equations (4.6), (4.7) into equation (4.8), it is found that:

$$\frac{S_L}{S_K} = \frac{B}{I - B} (\frac{K}{L})^{\theta} \tag{4.9}$$

The above equation (4.9) shows that the relative shares function is a non-linear function of the capital-labour ratio. The relative distribution is again constant, as in the (CD) production function, so if $\theta \rangle 0$, then $\eta \langle 1$. This will imply an increase in relative shares of labour, on account of a relatively rapid fall of the marginal productivity of capital.

Although the elasticity of substitution is not supposed to be unity in this function, it should be constant. Researchers have argued that the elasticity might change over time and according to the industry, and hence a new formula for the production function was suggested.

4.5 The Variable Elasticity of Substitution (VES) Production Function

The function permits the elasticity of substitution to vary over the data space. This is useful, especially in view of the evidence with regard to the (CES) production function, that its parameter may vary from industry to industry and possibly over time. The (VES) production function could be presented as a generalisation of the (CES) production function as suggested by Bruno (1968), or as an extended (CD) production function (Revankar, 1971). The (VES) production function is formulated as follows:

$$Q = AK^{\gamma(1-\zeta\psi)}[L + (\psi - 1)K]^{\gamma\zeta\psi} \tag{4.10}$$

Where Q is output, K is capital, and L is labour; γ, ζ, ψ, and A are parameters.

If $\psi = 1$, the following equation is obtained:

$$Q = AK^{\gamma(1-Xi)}L^{\gamma\zeta}$$

This is a (CD) production function, and it will have constant returns to scale if $\gamma = 1$.

The marginal product of labour in the (VES) production function is equal to:

$$MP_L = \frac{\partial Q}{\partial L} = \gamma\zeta\psi\frac{Q}{L} + (\psi - 1)K \qquad (4.11)$$

Similarly, the marginal product of capital is equal to:

$$MP_K = \gamma(1 - \zeta\psi)\frac{Q}{K} + \gamma\zeta\psi(\psi - 1)\frac{Q}{L} + (\psi - 1)K \qquad (4.12)$$

The variable elasticity of substitution can be calculated as the marginal rate of substitution of capital for labour which is equal to:

$$MP_{K/L} = \frac{\psi - 1}{1 - \zeta\psi} + \frac{1 - \zeta\psi}{\zeta\psi}(\frac{L}{K})$$

then,

$$\eta = \frac{\frac{K}{L}\partial(L / K)}{\frac{1}{MRS_{K/L}}\partial MRS_{K/L}}$$

$$= 1 + \frac{\psi - 1}{1 - \psi\zeta}(\frac{K}{L})$$

If $\psi = 1$ then, $\eta = 1$. This means that (η) is a linear function of $(\frac{K}{L})$ and has an intercept of unity. The relative distribution of income in the Revankar (VES) model could be obtained by putting (ζ) in equations (4.11) and (4.12) equal to unity. In other words, we assume constant returns to scale. Assuming competitive conditions in factor and product markets, we may now equate each factor's marginal product to the ratio of the factor prices to the product price, as in equation (4.13). So:

$$\zeta\psi\frac{Q}{L} + (\psi - 1)K = \frac{P_L}{P_Q} \tag{4.13}$$

$$(1-\zeta\psi)\frac{Q}{K}+\frac{\zeta\psi(\psi-1)Q}{L+(\psi-1)K}=\frac{P_K}{P_Q} \tag{4.14}$$

Dividing (4.13) by (4.14) it is found that:

$$\frac{L}{K} = 1 - \frac{\psi}{1-\zeta\psi} + \psi\frac{\zeta}{1-\zeta\psi}.\frac{r}{w}$$

Where,

$$r = \frac{P_K}{P_Q}$$

$$w = \frac{P_L}{P_Q}$$

By definition:

$$\frac{S_L}{S_K} = \frac{MP_L}{MP_K}.\frac{L}{K}$$

$$= w\frac{L}{r}K$$

$$= \frac{1-\psi}{1-\zeta\psi}\frac{w}{r} + \zeta\frac{\psi}{1-\zeta\psi}$$

This is the linear function of the $(\frac{w}{r})$ ratio, where it is a log linear function of the (CES) production function, as shown above.

$$\ln(\frac{S_L}{S_K}) = \alpha + \beta \ln(\frac{w}{r})$$

There are several forms of the (VES) production function and some of them will be explained, starting with that of Hillenbrand and Liu (1965) and Bruno (1968). This is:

$$Q = A[(1-B)K^{\theta\alpha} L^{(1-\alpha)\theta}]^{(\frac{1}{\theta})} \tag{4.15}$$

If $\alpha = 0$, this function is reduced to the (CES) function. Equation (4.15) has a variable elasticity of substitution given by:

$$\eta = \frac{1}{1-\theta} + \frac{\alpha\theta}{S_K}$$

This formula has two properties. The first is that S_K (and hence S_L) appears explicitly in the formula of the elasticity of substitution. Secondly, an implication of the model is that:

$$\ln\frac{Q}{L} = B_0 + B_1 \ln W + B_2 \ln\frac{K}{L}$$

Where,

B_0, B_1, and B_2 are parameters in the original function (4.15). This is easily estimated econometrically (Arrow and Intriligator, 1984).

Hatley and Carter (1957) presented another version of the (VES) production function as:

$$Q = Ae^{B_1K + B_2L} K^{1-\alpha} L^{\alpha}$$

Its elasticity of substitution is:

$$\eta = \frac{(1 - \alpha + B_1K)(\alpha + B_2L)}{(1 - \alpha)(\alpha + B_2L)^2 + \alpha(1 - \alpha + B_1K)^2}$$

If $B_1 = B_2 = 0$, this reduces to the (CD) production function.

4.6 The Transcendental Logarithmic (TLS) Production Function

This generalisation of the (CD) production function was developed by Christensen and Jorgenson (1973). They presented a formula, which in fact is a generalised form of the (CD) production function into the Translog, or Transcendental Logarithmic, production function. It is formulated as follows:

$$\ln Q = \beta_0 + \beta_1 \ln L + \beta_2 \ln K + \beta_3 \ln L \ln K + \beta_4(\ln L)^2 + \beta_5(\ln K)^2$$

This is quadratic in the logarithms of the variables, and it will reduce to the (CD) production function if the parameters $\beta_3, \beta_4, \beta_5$, all disappear. The general form of the (TLS) production function presented by Humphrey and Moroney (1975), is:

$$\ln Q = \ln \alpha + \sum_{i=1}^{n} \alpha_i \ln V_i + \frac{1}{2}\sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln V_{ij} \ln V_j$$

Where,

Q= Output.

V_i = Input.

γ_{ij}= Substitution parameters.

If $\gamma_{ij} = 0$, the (TLS) production function will be reduced to the (CD) production function and be linear homogeneous for $\sum \gamma_{ij} = 1$.

If we assume that the inputs (V_i) contain three inputs factors (L, K, M), then the marginal products of the inputs to the (TLS) function are:

$$\frac{\partial Q}{\partial L} = \frac{Q}{L}(\alpha_l + \sum_{j=1}^{3} \gamma_{lj} \ln V_j)$$

$$\frac{\partial Q}{\partial K} = \frac{Q}{K}(\alpha_k + \sum_{j=1}^{3} \gamma_{kj} \ln V_j)$$

$$\frac{\partial Q}{\partial M} = \frac{Q}{M}(\alpha_m + \sum_{j=1}^{3} \gamma_{mj} \ln V_j)$$

Where,

M= Any third input factor.

L, K= Labour and Capital respectively.

The distributive shares of the (TLS) model are found by the three equations above in elasticities from (transposing $\frac{Q}{V_j}$) (Douglas, 1983). We obtain:

$$\frac{\partial Q}{\partial V_i}\frac{V_i}{Q} = \frac{\partial \ln Q}{\partial \ln V_i}$$

$$= \alpha_i + \sum_{j=1}^{3} \gamma_{ij} \ln V_i \qquad j = 1,\ldots,3$$

If we is assumed that all markets are competitive, we is found that:

$$\frac{\partial Q}{\partial V_i} = \frac{P_i}{P_Q}$$

So:

$$S_i = \frac{P_i V_i}{P_Q}$$

$$= \alpha_i + \sum_{j=1}^{3} \gamma \log V_j \rangle 0$$

This shows the expression for shares in terms of the substitution form, and each share should be positive to be consistent with the neoclassical restriction of positive marginal product.

Revankar (1971) presented another (TLS) form, by generalising the (CD) production function as:

$$Q = \gamma \; e^{a_1 K + a_2 L} K^{1-b} L^b$$

Where,

γ, a_1, a_2, b = Parameters.

The above function will collapse to the (CD) production function if $a_1, a_2 = 0$ and its elasticity of substitution can be written as:

$$\eta = (1-b+a_1K)(b+a_2L)(1-b)(b+a_2L)+b(1-b+a_1K)^2$$

4.7 The Production Function for the Libyan Economy

The Total Capital Stock, the Total Number of Workers Employed in the economy, and technical change, are assumed to be the determinants of the Total Value-Added in the Libyan economy. The production function for Libya will be written in a general form. The final form of this function will be determined in the estimation producer, which will be carried out in the next chapters. The production function for the whole Libyan economy will be specified as:

$$RTVAL_t = f(RCST_t, TNW_t, TIME_t)$$

Where,

$RTVAL_t$ = Real Total Value-Added.

$RCST_t$ = Real Total Capital Stock.

TNW_t = Total Number of Workers Employed in the Economy.

$TIME_t$ = Time, proxying Technical Change.

Because of data availability, the Libyan economy will be split into two sectors: Non-Oil Sector and the Oil Sector. A production function for each of these will be formulated, starting with the Non-Oil Sector.

4.7.1 The Non-Oil Sector

A Cobb-Douglas production function is used to estimate the output in the non-oil sector. The data on capital stock, as in most less Developing Countries is not available in any form in Libyan statistics. Therefore, we intended to estimated capital stock form the available data on annual investment and annual fixed capital consumption. Following Goldsmith's (1962) " inventory method ", capital stock in any year can be estimated as follows:

$$K_t = I_t + (1 - d)K_{t-1}$$

Where,

K_t = The level of capital stock in year t.

I_t = The undertaken investment level at year t.

d = The rate of capital deprecation (9%).

K_{t-1} = The level of capital stock in the previous year.

The production function of the Non-Oil Sector will be specified as:

$$NOQT_t = f(NOKT_t, NONK_t, TIME_t)$$

Where,

$NOQT_t$ = Value-Added in the Non-Oil Sector.

$NOKT_t$ = Capital Stock in the Non-Oil Sector.

$NONK_t$ = Population Employed in the Non-Oil Sector.

$TIME_t$ = Time, proxying technical change.

4.7.2 The Oil Sector

The Value-Added in this sector will be a function of the total physical product of oil. Its production function will be specified as follows:

$$OILVAL_t = f(BARREL_t, OEXP_t, OILVAL_{t-1})$$

Where,

$OILVAL_t$ = Value-Added in the Oil Sector.

$BARREL_t$ = Production of Oil.

$OEXP_t$ = Oil Exports.

$OILVAL_{t-1}$ = Lagged of $OILVAL_t$.

4.8 Conclusions

In this chapter, different theories of production functions have been discussed. The availability of data ruled out the supply side approach from being used in the empirical estimation of the production function. The supply side was examined in the rest of the chapter. The CD, CES, VES, TLS production functions have been explored.

Separate production functions were suggested for the various sectors of the Libyan economy in terms of a number of different inputs. Having presented the supply side of the Libyan economy in this chapter and the demand side in the previous two chapters, the price function will be examined in the next chapter.

CHAPTER FIVE

THE PRICE FUNCTION

5.1 Introduction

Having discussed in the previous chapters the demand and the supply side of the economy, the price function will be examined in this chapter, which will be divided into six sections. The second section will discuss the Monetary Theory of Inflation; the Structuralism Theory of Inflation will be considered in the third section. Section four will explore some econometric studies of inflation in developing countries. Section five will examine the price function in Libya. Section six will provide some conclusions.

Various theories have been used in the attempts to analyse and explain the phenomenon of inflation, such as the Demand-Pull theory, Cost-Push theory, Monetary theory, Structural Rigidity, and Expectations theory (Johnson, 1972). In recent years, two schools of thought have come to dominate empirical studies explaining inflation in the developing countries. These are the Monetarist and Structuralist (Cost-Push) schools.

5.2 Monetary Theory of Inflation

According to the monetary theory of inflation, changes in price levels are related to the growth rate of the money supply (Friedman, 1956). The simplest equation of the quantity theory of money is as follows:

$$P_t Y_t = V_t M_t \qquad (5.1)$$

Where,

P_t = Price level.

Y_t = Real income.

V_t = Velocity of circulation

M_t = Money supply.

We may assume a simple money demand function (Vogel, 1974):

$$V^{-1} = Y^a C^b \tag{5.2}$$

Here,

C = The expected cost of holding real balances.

By substituting (5.2) into (5.1), it is found:

$$M = PY^{1+a}C^b \tag{5.3}$$

By taking the logarithms of equation (5.3) and arranging, we get:

$$\ln P_t = \ln M_t - (1 + a) \ln Y_t - b \ln C_t \tag{5.4}$$

But the increase in the money supply does not affect prices instantaneously, so the money supply with different lags must be introduced in order to capture this effect. By assuming that the velocity of money tends to be constant and the cost of holding money can be measured by the past rate of inflation, equation (5.4) can be reformulated as:

$$\ln P_t = b_0 + b_1 \ln M_t + b_2 \ln Y_t + b_3 \ln P_{t-1} + b_4 \ln M_{t-1} \tag{5.5}$$

If the velocity is constant over the sample period, b_0 will equal zero. It is expected in the long run (i.e. the stability condition) to have b_1 plus b_4 to equal unity, and b_2 to equal minus unity, while b_3, which measures the speed of adjustment, is expected to be greater than zero.

This monetary theory has been examined by many researchers for different countries, such as Behraman, (1973) for Chile; Vogel, (1974) for Latin America; Saini, (1982) for Asian countries; Alogoskoufis, (1986) for the Greek economy; Abdulghani, (1991) for Kuwait; Park, (1993) for Korea; and Rankaduwa, (1995) for Sri-Lankan economy.

Vogel assumed the rate of inflation as the dependent variable. The current and lagged rates of money supply were introduced to capture the lagged adjustment of price to changes in the money supply. Past changes in the rate of inflation were considered as the main variable affecting the expected costs of holding real balances. The current and lagged rates of real income were also used as independent variables, as a proxy for permanent income.

Despite the extreme diversity of inflation rates among the sixteen Latin American countries in Vogel's study, current money supply and money supply lagged one year are highly significant. This indicates that an increase in the rate of growth of the money supply causes a proportionate increase in the rate of inflation within two years and the greater part of this adjustment takes place within the first year. The sign of the current income coefficient has the expected negative, but an increase in the rate of growth of real income results in a significantly less than proportionate decrease in the rate of inflation. The lagged income variable, used as a possible proxy for permanent income, does not improve the equation's explanatory power. Also, its coefficient is significantly positive rather than negative.

5.3 Structuralist Theory of Inflation

The name of this theory comes from relating inflation to changes in the economic structure of developing countries. This school relates the rate of inflation to cost-push factors rather than the money balances [Bear and Kertenetzky, (1964); Davis, (1966); Argy, (1970); Kirkpatrick and Nixson, (1976); Frisch, (1983); McCafferty, (1990); and Griffith and Stuat, (1991)]. According to this theory, there are several factors thought to be playing a vital role in pushing the level of prices up. These are:

1- Demand-shift hypothesis.

2- Export instability hypothesis.

3- Foreign exchange scarcity hypothesis.

4- Agricultural bottleneck hypothesis.

5.3.1 Demand-Shift Hypothesis

The demand-shift hypothesis argues that shifts in the composition of demand, as distinct from generalised excess demand, will create an upward bias in the price level. This could be due to the process of industrialisation, which most of the developing countries are experiencing. This process will change the output-mix, the distribution of income and also tastes. Beside these factors, the resources are less mobile in developing countries than in developed countries. Therefore, any new excess demand will not meet with an increase in supply, due to the rigidity of resources mobility. From the above analysis we might expect that shifts in the demand structure will create pressure on the price level.

5.3.2 Export Instability Hypothesis

The export instability hypothesis argues that, other things being equal, fluctuations in export receipts tend to create a long-term upward movement in the price level. This implies that the rate of inflation is a positive function of degree of export variability. The mechanism of this hypothesis is that, when exports receipts rise, a demand-pull type inflation might occur, but when it falls, prices need not fall. This is partly because demand is supported by the government, and partly due to wages tend to be rigid in the downward direction. Also, when export receipts rise, wages in the export sector rise. This may spread to other sectors in the economy. When receipts fall, there is no offsetting effect. The government might increase its expenditure when its revenues rise, as a result of exports receipts, but government expenditure might be inflexible in the downward direction. In such a situation, government will often restrict imports. This will push up prices, due to the higher demand and scarcity of goods.

5.3.3 Foreign Exchange Scarcity Hypothesis

This hypothesis argues that many developing countries experience difficulties in their long-term balance of payments. This is due to the rather low income elasticity of demand for their primary exports and high income elasticity of demand for imports (mainly as a result of industrialisation). The resulting decline foreign reserve holdings will tend to push the government down one of two paths. The first is to constrain imports by direct controls, either by the introduction or increase of import duties, or by devaluation. The second path is to encourage an import substitution policy. These two paths will both result in higher price levels.

5.3.4 Agricultural Bottleneck Hypothesis

According to this hypothesis, population growth, the improvement in living standards, and urbanisation, combine to give an excess demand for food. For a number of reasons in some countries, the agriculture sector will not respond adequately to those demands. Hence an excess demand develops for domestic food production. This will cause the price of food-stuffs to rise, unless the government intervenes by cutting the exports of food, or allowing imports of food. Alternatively, subsidies and/or price controls may be introduced. All these policies will result in higher price levels in general. The structuralist hypothesis could be summarised as:

$$P_t = b_0 + b_1 PR_t + b_2 PIM_t + b_3 GD_t + b_4 WAGRW_t + b_5 FA_t + b_6 Y_t + b_7 P_{t-1} \qquad (5.6)$$

Where,

P_t = Price level.

PR_t = Relative price of food to the consumer price index.

PIM_t = Import prices.

GD_t = Budget deficit.

$WAGRW_t$ = Wage rate.

FA_t = Foreign assets.

Y_t = Real income.

P_{t-1} = Price level lagged one period.

Among these theories, there is a middle view which says that inflation is caused by combining the monetarist with the structuralist hypothesis. Thus by combining the monetary factors with the cost-push factors, we can write:

$$P_t = b_0 + b_1 Y_t + b_2 M_t + b_3 M_{t-1} + b_4 RP_t + b_5 PIM_t + b_6 GD_t + b_7 WAGRW_t + b_8 FA_t + b_9 P_{t-1} \qquad (5.7)$$

This kind of composite model has been tested by Diz (1970) for Argentina, Kirkpatrick and Nixson, (1976) for less developed countries, Lowinger, (1978) for four developing countries, and by Leventakis, (1980) for Greece, and Ibrahim, (1982) for Jordanian economy.

A review of some empirical studies of inflation in developing countries will be the subject of the next section.

5.4 Empirical Studies of Inflation in Developing Countries

Marwall (1969) in his economic model of Colombia, divided prices into three parts The first was implicit deflator of private consumption, which was determined by index of general price level and implicit deflator of private consumption lagged one year. The second was price index of capital goods, which was explained by price index of manufactured goods and import price index of capital goods. The third was index of general price level, which was explained by price index of capital goods and index of general price level lagged one year.

Carrillo (1976) in his macroeconometric model of Venezuela showed the general wholesale price index, oil price index and the ratio of wage rate to average productivity, as the main determinants of the inflation rate.

Chang (1977) in his model of Taiwan, stated that the change in the money supply, changes in imports prices and the change in the money wage rate lagged one period, were the important variables to which the higher level of prices could be attributed.

Ghosh, Karia and Zaria (1978) suggested that the general price index, measured by gross domestic product deflator of the Nigerian economy for the period 1958-1974, was a function of the money supply lagged one period.

Ahmed (1979) tried to explain the inflation rate in the Sudan. He found that the percentage change in the money supply and the excess demand in food indicator, were the main variables determining the inflation rate.

Al-bashir (1979) considered that the price index of imports and the money supply, were the main factors determining the inflation rate in the Saudi Arabian economy.

Semudram (1982) in his macro model of the Malaysian economy found that the real gross domestic product, the imports price index and the inflation lagged one period, to be the main determinants of the rate of inflation in his model.

Ibrahim (1983) relied on the monetarist and structural factors in explaining the inflation rate in the Jordanian economy. The model showed that the real gross national product, the price index for imported goods, the consumer price index, the total government expenditure and the money supply were the main variables determining the inflation rate in his model.

Alogoskoufis (1986) suggested that the consumer price index of the Greek economy for the period 1963-1984 was a function of the world inflation rate, exchange rate depreciation, excess monetary growth, slowdown in gross domestic product growth, changes in the interest rate and the changes in indirect taxes are the main variables affecting the consumer price index.

Kwack (1986) in his model of Korea divided prices into three parts. The first part was the consumer price index. This was determined by the wholesale price index lagged one period, and the price deflator for gross domestic product. The second represented the fixed investment deflator in the non-agriculture sector. This was explained by the price deflator for the non-agriculture sector and imports of capital goods. The third was the wholesale price index. This was determined by the price deflator of GDP and imports of capital goods.

Tavlas, Elliott and Kwack (1986) in their econometric model of the Kenyan economy split prices into three categories. The first category was the consumer price index which was determined by the average wage in formal sectors lagged one period, and productivity. The second category was the deflator for fixed investment in service industries which was explained by the deflator for aggregate GDP at factor costs lagged one period. The third was the deflator for GDP in industry. This was determined by the average annual wage in industry lagged one period.

Togan (1987) assumed that real income, money supply and the interest rate were the determinants of the inflation rate in the Turkish economy.

Ghartey and Rao (1990) estimated the consumer price index of Ghana as a function of the money supply, the time trend and the consumer price index lagged one period.

Abdulghani (1991) in his macroeconometric model of Kuwait, suggested that the import level index, the stock of money and the foreign exchange index were the determinants of the domestic price level index.

Park (1993) in his macroeconometric model of the Korean economy, considered the money supply, the real gross domestic product, the nominal value of stock transactions, the nominal interest rate in the regulated market and the import price in domestic currency, as the main determinants of the inflation rate in his model.

Rankaduwa and Tomson (1995) in their model of the Sri-Lankan economy, found that the consumer price index of domestic goods and services, the consumer price index of imports and the consumer price index of exports were the main variables determining the consumer price index.

From the above studies, it is clear that both monetary and structuralist factors combine to cause the inflation phenomenon. This view will be taken into consideration in examining the inflation rate for the Libyan economy which will be the subject of the next section.

5.5 The Price Function of the Libyan Economy

Three types of factors seem to affect price behaviour in developing countries in general and in Libya specifically, real factors, monetary factors and external factors. Among the first group, wages and general production factor costs are important detriments of prices. Consumption is also considered in this group. Money supply variation represents the monetarist view. Import prices, representing the external variables, seem also to play an important role in Libyan price determination.

In Libya the large quantity of oil exports has supplied the government with a considerable flow of foreign currency. This has enabled Libyan planners to import as many goods as required, without affecting the trade balance seriously. Also, large scale subsidies are implemented in order to support the limited incomes of the poor groups within the population and to avoid price increases of domestic and imported goods. Furthermore, Libyan planners have adopted an import substitution strategy in the industrial sector. This strategy has aimed at producing goods domestically instead of importing them. This policy will save a considerable amount of foreign exchange and will ease the pressure on the balance of payments, which will occur as oil and gas reserves are depleted. Thus, the budget deficit and the problem of the balance of payments, which most developing countries suffer from, are not the main factors to which inflation may be attributed.

The successive increases in the nominal wages of government employees, intended to improve their standard of living, creates a huge pressure on the supply of goods in the market, which results in either price increase or long queues.

Furthermore, these wages increase in the public sector have spread rapidly throughout the whole economy. This causes most of the private products and services to increase in price.

The other factor contributing to increasing prices is the large scale of infrastructure projects the government started to implement in the basic sectors (health, transport, irrigation, services sectors). These high cost projects result in a considerable amount of spending by the government. These large projects also have offered a large number of work opportunities to everybody who wished to work and have resulted in severe shortage of labour, especially of skilled labour. This strong demand for labour has pushed up the wage rate, especially in the construction and services sectors. This new wave of purchasing power, and the limited response of imports to this demand, has forced up the price level, in spite of government subsidies and price control policies on the basic consumer goods. The first wave of wage increases was mostly allocated to food and other necessary goods. The next successive wage increase was allocated partly to basic goods and partly to durable goods. The inflexibility of the internal production systems (industrial and agricultural) and the required time delay for imports to adjust, has caused the prices to rise responding to the excess demand.

Three behavioural equations will be used to explain the three indices used in our model (Consumer Price Index, Capital Formation Price Index and the *GDP* Deflator).

The first function will be for the Consumer Price Index ($PSDX_t$). The Consumer Price Index is expected to be a function of the Gross Domestic Product Deflator ($PGDPIDX_t$), Import Price Index (PIM_t), the Monetary Balances, and the Consumer Price Index lagged one year ($PSDX_{t-1}$), to give the equation some dynamics.

$$PSDX_t = f(PGDPIDX_t, MONEY_t, PIM_t, INTAX_t, PSDX_{t-1})$$

Where,

$PSDX_t$ = Consumer Price Index.

$PGDPIDX_t$ = Gross Domestic Product Deflator.

$MONEY_t$ = Money Supply.

PIM_t = Import Price Index.

$INTAX_t$ = Indirect Tax.

$PSDX_{t-1}$ = Consumer Price Index lagged one year.

The second function will be for the Capital Formation Price Index ($INVDX_t$). The explanatory variables included in this function are *GDP* deflator ($PGDPIDX_t$) and the Capital Formation Price Index lagged one year ($INVDX_{t-1}$). The ($INVDX_{t-1}$) variable is introduced to capture the effects of the explanatory variables of the previous period.

$$INVDX_t = f(PGDPIDX_t, INVDX_{t-1})$$

Where,

$INVDE_t$ = Capital Formation Price Index.

$PGDPIDX_t$ = Gross Domestic Product Deflator.

$INVDX_{t-1}$ = Capital Formation Price Index lagged one year.

The third function is to explain the *GDP* deflator ($PGDPIDX_t$). Three main components can be used to explain the *GDP* deflator. These are the Consumer Price Index ($PSDX_t$), the Capital Formation Price Index ($INVDX_t$), and the Import Price Index (PIM_t).

$$PGDPIDX_t = f(PSDX_t, INVDX_t, PIM_t, PGDPIDX_{t-1})$$

Where,

$PGDPIDX_{t-1} = PGDPIDX_t$ lagged one year.

5.6 Conclusions

Having discussed inflation theories (monetary and structuralist), it appears that in developing countries three categories of variables seem to affect price behaviour. These are monetary, real factors and external variables. In the first category lies current and lagged money supply and the past level of the inflation rate. In the second category lies gross domestic demand, the budget deficit, the nominal wage rate, population growth and the relative price of food to the consumer price index. The third category includes the cost of imports, represented by the Imports Price Index and foreign assets.

The Libyan case is a special one compared to most developing countries. This is because of the availability of foreign currency due to oil exports. This means that the budget deficit does not seriously affect price levels in Libya. It is felt that excessive government spending, import prices, the inflexibility of the production system, nominal money balances, and subsidies by the government to the private sector are the main determinants of prices levels in Libya.

CHAPTER SIX

THE ESTIMATION OF THE MODEL EQUATIONS

6.1 Introduction

Chapters Two to Five have discussed the theoretical foundations of the specification of the model equations for the Libyan economy. We now move to the estimation of these equations. The estimation procedure follows the usual methods to explain the behaviour of the economic variables endogenised in the model. Since Libya is a developing country, the factors controlling its economy fall into two main categories. The first category contains the general features of developing economies. The second category reflects the specific characteristics of the Libyan economy. Both of these sets of factors have been taken into account in the model formulation.

A sample period of 30 years (1962-1991) was used in the model estimations. This data range was dictated by the limitation of the data (up to 1991 only). The full set of data and its sources used for estimation is shown in Appendix 1, Table 1.2., and Appendix 3.

Aggregate demand includes consumption, investment and foreign trade. Aggregate demand is determined based on the following identity:

$$GDP_t = (CONS_t + GCONS_t) + TINVS_t + OEXP_t - TIMP_t + NFI_t$$

Where,

GDP_t = Gross Domestic Product at market prices.

$CONS_t$ = Private Consumption Expenditure.

$GCONS_t$ = Government Consumption Expenditure.

$TINVS_t$ = Total Government Investment Expenditure.

$OEXP_t$ = Oil Exports.

$TIMP_t$ = Nominal Imports.

NFI_t = Net Factor Income.

While aggregate supply components can be disaggregated based on the following identity:

$$GDP_t = MANVAL_t + AGRVAL_t + SERVAL_t + COTVAL_t + OILVAL_t$$

Where,

GDP_t = Gross Domestic Product.

$MANVAL_t$ = Value-Added Generated in the Manufacturing Sector.

$AGRVAL_t$ = Value-Added Generated in the Agriculture Sector.

$SERVAL_t$ = Value-Added Generated in the Services Sector.

$COTVAL_t$ = Value-Added Generated in the Construction Sector.

$OILVAL_t$ = Value-Added Generated in the Oil Sector.

Following the discussion of the range of theories in earlier chapters, various equations will be estimated. The following statistical criteria are used in the selection procedure amongst the different forms of each equation:

$\bar{R}^2$ = The explanatory power of the equation.

F = Statistic- shows the significant of the equation as a whole.

t = Test- test the significance of a particular coefficient.

Durbin-Watson- statistic ($D.W$) Demonstrate the presence or the absence of serial correlation.

χ^2_{SC} - Lagrange multiplier test of residual serial correlation.

χ^2_{FF} - Ramsey's RESET test of functional form using the square of fitted values.

χ^2_{HS} - test of heteroscedasticity based on the regression of squared residuals on squared fitted values.

As well as the above statistical criteria, economic theory may provide us with criteria, which suggest the sign and size of the explanatory variables coefficients. Both of these criteria should be considered in choosing the best equation and the best function form.

This chapter has ten sections. The estimation of the Consumption Function is discussed in the second section; in particular, Private Consumption Expenditure and Government Consumption Expenditure will be estimated and discussed in the two sub-sections respectively. Section three will be allocated to the estimation and discussion of the Total Government Investment Expenditure functions (Investment Expenditure in the Manufacturing sector, Investment Expenditure in the Agriculture Sector, Investment Expenditure in the Services Sector, and Investment Expenditure in the Construction Sector). Total Imports, Imports of Consumption Goods, Imports of Raw Materials and Intermediate Goods, and Imports of Capital Goods equations are estimated and discussed in Section four. Section five will be allocated to the estimation and discussion of the three price functions (Consumer Price Index, Capital Formation Price Index and Gross Domestic Product Deflator). Sections six, seven and eight will examine the estimation of Employment function, Real Oil Revenues and the Indirect Taxes function, respectively. Section nine will be allocated to the estimation and discussion of the production functions. Section ten will be allocated to the conclusions.

6.2 The Estimation of the Consumption Function

Two behavioural equations were applied for the estimation of the consumption function of the model. These equations explain the behaviour of the Private Consumption Function and Government Consumption Function. It was not possible to disaggregate the private consumption expenditure into its main components, due to the lack of data on such components (e.g. consumption goods, durable consumption goods, food and beverages).

6.2.1 Private Consumption Expenditure

In order to specify the behavioural equation for the Private Consumption Expenditure, it is possible to test for unit roots or stationary of the variables using the Dickey-Fuller methodology. The objective is to find whether or not the variables under investigation are I(1), i.e. if they become stationary after differencing them once. This test is applied to a univariate time series of two variables given by the modified Private Consumption Function:

$$RCONS_t = f(RADY_t) \qquad (6.1)$$

Where,

$RCONS_t$ = Real Private Consumption Expenditure.

$RADY_t$ = Real Adjusted Disposable Income.

We will test for stationary using the Dickey-Fuller (DF) and the Augmented Dickey-Fuller (ADF) tests without and with a time trend

[Fuller(1976) and Dickey-Fuller(1979)]. The essence of these tests is the null hypothesis of non-stationary whose rejection requires a negative and significant test statistic. The DF statistics are calculated as the t-ratios of the coefficient on X_{t-1} (i.e. a_t) in the regression equations (6.2) and (6.3).

$$\Delta X_t = a_0 + a_1 X_{t-1} + U_t \tag{6.2}$$

$$\Delta X_t = a_0 + a_1 X_{t-1} + a_2 T + U_t \tag{6.3}$$

where T is time. In testing for stationarity without time trend the test statistic t_μ [tabulated in Fuller (1976) and discussed in Dickey and Fuller (1979)] is used, while in testing for stationarity of a deterministic time trend the statistic t_τ is used [tabulated in Fuller (1976)]. Similarly, the ADF statistics are calculated as the t -ratios of the coefficient on X_{t-1} (i.e. a_1) in the regression equation (6.4) and (6.5).

$$\Delta X_t = a_0 + a_1 X_{t-1} + b_1 \Delta X_{t-1} + b_2 \Delta X_{t-2} + \ldots + b_k \Delta X_{t-k} + U_t \tag{6.4}$$

$$\Delta X_t = a_0 + a_1 X_{t-1} + a_2 T + b_1 \Delta X_{t-1} + b_2 \Delta X_{t-2} + \ldots + b_k \Delta X_{t-k} + U_t \tag{6.5}$$

It is important to note that although these test statistics are calculated as t -ratios, they do not have the standard t -distribution because under the null hypothesis of non-stationarity, the variance is unlimited.

The order of the ADF test, i.e. k, was chosen by starting from a maximum lag of 2 and working downwards, ensuring residual whiteness by comparing the values of these statistics with the 5% critical values as tabulated in Mackinnon (1990).

Table 6.1 represents the results of these tests. The DF and ADF test statistics are calculated without and with time trend for (log of) level data and first differences. The results broadly indicate that none of the variables is stationary in its level, but are stationary in the first differences. This means that the variables are integrated of order 1, i.e. I(1). Consequently, it is possible to move on to the next step, attempting to detect whether or not some of these variables cointegrate.

Table 6.1
Testing for Stationarity
(Private Consumption Function)

	DF				ADF			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
$\ln RCONS_t$	-1.059	-3.138*	-1.039	-2.550*	-1.490	-3.332*	-1.974	-5.180*
$\ln RADY_t$	-1.320	-3.426*	-1.128	-3.500*	-1.382	-5.072*	-1.702	-3.792*

* Significant at 5% level. Critical values are tabulated in Mackinnon (1990).

The second step, as mentioned above, is testing for cointegration using the Engle-Granger (1987) two-step method. The first step is to estimate a cointegration regression and the second is to test for the stationarity of the residuals derived from the regression. If the residuals are non-stationary, the variables are not cointegrated. Indeed, the cointegration regression Durbin-Watson statistic ($CRDW$) can be used to test the null hypothesis that the variables are not cointegrated, because if the residuals are non-stationary, the $CRDW$ will be close to zero.

Table 6.2 displays the results of cointegration testing bivariate cointegration regression. The DF and ADF statistics indicate the existence of cointegration between the Real Private Consumption Expenditure ($RCONS_t$) and

Real Adjusted Disposable Income ($RADY_t$). This means that the variables are cointegrated.

Table 6.2
Testing for Cointegration: The Engle-Granger Method
(Private Consumption Function)

Dep. Variable	constant	$\ln RADY_t$	$\bar{R}^2$	*DF*	*ADF*	*CRDW*
$\ln RCONS_t$	0.278 (1.85)	0.936 (42.25)	0.98	-3.000*	-4.159*	0.731

all variables are expressed in logarithmic terms.
* significant at 5% level.

Different hypotheses were tested in order to estimate the private consumption expenditure function. The first one tested was the simplest Keynesian hypothesis, according to which Private Consumption Expenditure in real terms is a simple function of Real Disposable Income.

Equation (1) in Table 6.3 shows the Marginal Propensity to Consume (MPC) to be equal to β, i.e.:

$$RCONS_t = \alpha + \beta \; RDISY_t$$

i.e.

$$\frac{\partial (RCONS_t)}{\partial (RDISY_t)} = \beta$$

Where,

$RCONS_t$ = Real Private Consumption Expenditure.

$RDISY_t$ = Real Disposable Income.

α = Constant term.

β = Marginal Propensity to Consume.

From Table 6.3, the coefficient of equation (1) is significant according to the F- statistic. The t -test value in respect of the coefficient is to reject the null hypothesis (the value of the particular coefficient is not different from zero). The statistical problem is the low value of the Durbin-Watson statistic ($D.W.$) which lies below the lower limit of the $D.W.$ schedule. This indicates the presence of serial correlation.

There is another problem from the economic point of view concerning the value of the Marginal Propensity to Consume (MPC) in equation (1). This value is not acceptable for a developing country such as Libya. In such countries the consumption expenditure is expected to utilise more than three quarters of the disposable income. The reason behind the low MPC value could be related to the data and especially to the disposable income statistics. The second reason for the low MPC is the huge investment spending by the government, especially after the nationalisation of oil in Libya in 1971. This investment spending will undermine the MPC value. In order to clear up this confusion the recalculation of Real Disposable Income is suggested.

The suggestion proposed for the estimation of the real MPC for the private sector is to recalculate Disposable Income. We will use the following identity which indicates how private disposable income has been calculated:

$$RADY_t = (RGDP_t - RINTAX_t)$$

Where,

$RADY_t$ = Real Adjusted Disposable Income.

$RGDP_t$ = Real Gross Domestic Product.

$RINTAX_t$ = Real Indirect Tax Revenues

Equations (2) and (3) in Table 6.3, which represent the Friedman and Brown consumption functions, try to capture the effects of the last period's income by applying the Koyck transformation. In these equations Adjusted Disposable Income was used instead of Simple Disposable Income. The short-run *MPC* is 0.59 and 0.60 for the Friedman and Brown equations, respectively.

Equation (4) in Table 6.3 shows the error correction model of the private consumption expenditure function. According to the results, all the estimated coefficients have the correct signs and are significantly different from zero. The coefficient of error correction term ($RADY_{t-1} - RCONS_{t-1}$) implies a gradual adjustment of the dependent variable towards its long term value. The short-run Marginal Propensity to Consume (MPC_S) is 0.613. This is acceptable for a developing country. On other words , Libya is considered to be an oil-exporting country and in most of these countries the capital/income ratio is very high. The government participates on a large scale in most of the economy and especially in the basic sectors, such as health, education, housing, trade and transport. Hence, most of the benefit charges for the services of these sectors are symbolic. The government carries the real burden of these benefits in order to support people with a limited income, who constitute a high percentage of the total population. Thus, although the short-run *MPC* for equation (4) is still much smaller than the short-run *MPC* average for all developing countries, it is quite reasonable compared with the MPC_S of oil-producing countries, such as Saudi Arabia, Algeria and Kuwait. These countries have a MPC_S of 0.420, 0.312 and 0.730, respectively [Al-Bashir, 1977; Laabas, 1989; Abdulghani, 1991]. The long-run MPC_L (reflecting the effects of the last period's income as well as that of the current period) of equation (4) is 0.654. This is acceptable, in developing countries and it shows clearly the effect of the last period's income on current consumption.

Table 6.3
The Empirical Results for the Private Consumption Function

No.	Method of Estimation	Estimation Results
1.	OLS	$RCONS_t = 319.619 + 0.292 RDISY_t$ (6.46) $\bar{R}^2 = 0.59$ $D.W = 0.300$ $S.E = 325.533$ $F = 41.7$ $\chi^2_{SC}(1) = 71.438$ $\chi^2_{FF}(1) = 9.967$ $\chi^2_{HS}(1) = 1.449$
2.	OLS	$\ln RCONS_t = 0.133 + 0.586 \ln RADY_t + 0.383 \ln RCONS_{t-1}$ (10.82) (6.90) $\bar{R}^2 = 0.99$ $D.W = 1.700$ $S.E = 0.053$ $F = 2305.1$ $\chi^2_{SC}(1) = 1.479$ $\chi^2_{FF}(2) = 3.299$ $\chi^2_{HS}(1) = 1.000$
3.	OLS	$\ln RCONS_t = 0.598 \ln RADY_t + 0.391 \ln RCONS_{t-1}$ (11.00) (6.96) $\bar{R}^2 = 0.99$ $D.W = 1.600$ $S.E = 0.054$ $F = 4453.0$ $\chi^2_{SC}(1) = 1.437$ $\chi^2_{FF}(1) = 1.543$ $\chi^2_{HS}(1) = 0.713$
4.	OLS	$\Delta \ln RCONS_t = -0.082 + 0.613 \Delta \ln RADY_t + 0.654(\ln RADY_{t-1} - \ln RCONS_{t-1})$ (6.89) (5.03) $\bar{R}^2 = 0.82$ $DW = 1.700$ $S.E = 0.068$ $F = 56.9$ $\chi^2_{SC}(2) = 1.018$ $\chi^2_{FF}(2) = 1.748$ $\chi^2_{HS}(1) = 1.717$

$RCONS_t$ = Real Private Consumption Expenditure.
$RCONS_{t-1}$ = Real Private Consumption Expenditure lagged one year.
$RDISY_t$ = Real Disposable Income.
$RADY_t$ = Real Adjusted Disposable Income.
$RADY_{t-1}$ = Real Adjusted Disposable Income lagged one year.
$\Delta RCONS_t$ = First Difference of Real Private Consumption Expenditure.
$\Delta RADY_t$ = First Difference of Real Adjusted Disposable Income.

The other part of the Total Consumption Expenditure is Government Consumption Expenditure, which will be dealt with in the next section.

6.2.2 Government Consumption Expenditure

The government of Libya plays an important role in economic development. In addition to its conventional job of providing defence and security, the Libyan government provides free medical care and education. It is also the major producer and investor in the services sector. The government may direct its revenue either to development or to consumption expenditures. The government's current expenditures consist of purchases of goods and services for operational and administrative purposes.

Before moving on to estimation of the Government Consumption Expenditure ($GCONS_t$), testing for stationarity or testing for unit root is carried out prior to testing for cointegration. This test is applied to univariate time series of three variables given by the modified Government Consumption Function:

$$GCONS_t = f(OILREV_t, TREVN_t)$$

Where,

$GCONS_t$ = Government Consumption Expenditure at current price.

$OILREV_t$ = Oil Revenues at current price.

$TREVN_t$ = Total Government Revenues at current price.

In testing for stationarity, the Dickey-Fuller methodology [Fuller (1976), Dickey and Fuller (1979)] is applied in the same way as for the Private Consumption Function. The results of these tests are shown in Table 6.4. When the calculated statistics are compared with the 5% critical value as tabulated in Mackinnon (1990), the results indicate that none of the variables is stationary in its level but some of the variables are stationary in the first differences. Therefore, the next step in attempting to detect which, if any, of these variables cointegrate.

The second step, as mentioned above, is testing for cointegration between Government Consumption Expenditure, Oil Revenues and Total Government Revenues using the Engle-Granger (1987) two-step method.

Table 6.4
Testing for Stationarity
(Government Consumption Function)

	DF				**ADF**			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
$\ln GCONS_t$	-2.202	-3.432*	-0.337	-4.675*	-2.538	-5.933*	-0.584	-3.065
$\ln OILREV_t$	-1.402	-4.241*	-2.382	-5.155*	-2.909	-3.000*	-1.675	-3.407
$\ln TREVN_t$	-1.493	-3.984*	-1.276	-4.934*	-2.588	-2.255	-1.255	-3.074

* Significant at 5% level.

Table 6.5 indicates the results of the cointegration test. The DF and ADF statistics accept the null hypothesis of no cointegration between Government Consumption Expenditure and Oil Revenues, and also between Government Consumption Expenditure and Total Revenues.

Table 6.5
Testing for Cointegration: The Engle-Granger Method
(Government Consumption Function)

Dep. Variable	constant	$\ln OILREV_t$	$\ln TREVN_t$	$\bar{R}^2$	*DF*	*ADF*	*CRDW*
$\ln GCONS_t$	-0.226	0.981 (19.31)		0.93	-2.887	-1.886	0.499
$\ln GCONS_t$	-1.526		1.135 (22.08)	0.94	-1.983	-1.641	0.499

all variables are expressed in logarithmic terms.
* Significant at 5% level.

Government Consumption Expenditure in Libya is mostly financed from Oil Revenues. Oil Revenues form 72% of Total Government Revenues for the whole period. This percentage increased to 89% after 1972. Current Oil Revenues, and Current Total Government Revenues, are the suggested independent variables in the Government Consumption Function.

Equation (1) in Table 6.6 displays the Government Consumption Expenditure ($GCONS_t$). The Oil Revenues ($OILREV_t$) and the Government Consumption Expenditure lagged one year ($GCONS_{t-1}$) are the main independent variables in the Government Consumption Function. These explanatory variables are significantly different from zero since this equation has high student t-values. In addition, $\bar{R}^2$ (0.99), the measure of goodness of fit, indicates that 99% of the variation in the dependent variable is explained by the explanatory variables. The short-run Marginal Propensity of Government Consumption of Oil Revenues ($GMPC_S$) is (0.15), but the long-run propensity ($GMPC_L$) is (0.83). The high value of the long-run $GMPC$ indicates the slight effect of current Oil Revenues on Government Consumption and the high effect of the last period Oil Revenues.

Table 6.6

The Empirical Results for the Government Consumption Function

No.	Method of Estimation	Estimation Results
1.	OLS	$\ln GCONS_t = 0.273 + 0.148 \ln OILREV_t + 0.826 \ln GCONS_{t-1}$ (4.78) (33.9) $\bar{R}^2 = 0.99$ $D.W = 1.900$ $S.E = 0.090$ $F = 3719.6$ $\chi^2_{SC}(2) = 1.300$ $\chi^2_{FF}(1) = 1.204$ $\chi^2_{HS}(1) = 1.200$
2.	OLS	$\ln GCONS_t = 0.169 + 0.153 \ln TREVN_t + 0.832 \ln GCONS_{t-1}$ (4.64) (34.80) $\bar{R}^2 = 0.99$ $D.W = 1.910$ $S.E = 0.090$ $F = 3614.0$ $\chi^2_{SC}(2) = 1.112$ $\chi^2_{FF}(1) = 2.144$ $\chi^2_{HS}(1) = 1.200$

$GCONS_t$ = Government Consumption Expenditure at current price.

$GCONS_{t-1}$ = Government Consumption Expenditure at current price lagged one year.

$OILREV_t$ = Oil Revenues at current price.

$TREVN_t$ = Total Government Revenues at current price

In equation (2) in Table 6.6 Total Government Revenues is introduced instead of Oil Revenues. The results, as shown in equation (2), seem to satisfy the statistical and economic criteria. The long-run Marginal Propensity of

Government Consumption of Total Government Revenues ($GMPC_L$) is 0.832 which is higher that the short-run of ($GMPC_S$) (0.153). This shows that the effect of the last period of Total Government Revenues on Government Consumption was higher than the current Total Government Revenues. In addition the short-run of $GMPC_S$ in equation (2) seems to be similar to that in equation (1). Therefore, the presence of the Total Government Revenues, instead of the Oil Revenues, does not make any difference to the value of the *GMPC* in the short-run. The reason behind the similarity of the Total and Oil Revenues coefficients in equation (1) and equation (2), respectively, is the high percentage which the Oil Revenues represents as a share of Total Revenues.

6.3 The Estimation of the Investment Function

The Libyan government tries to do its best to stimulate the development of the economy through investment in development projects. The government has been in a position to muster the available resources and channel them for construction and development. It undertakes some projects which are either non-profitable or beyond the means of the private sector, such as specialised banks, a national airline and all the main manufacturing industries. It has also invested enormous sums of money in both social overheads such as infrastructure, schools and so on and directly productive capital, for example in the petrochemical industry.

Investment in the Libyan economy is characterised by two features: (1) At least 80% of the gross fixed investment has originated from the government. As expected, almost all government investment has been in social overhead projects, such as roads, hospitals and schools. (2) Most investment in the country has gone into construction activities, such as houses, roads and so on. Only an insignificant amount has gone into the small manufacturing on the private sector.

Because of these two features of investment in the country under study, it makes the construction of an investment function almost impossible if we follow traditional economic theory. As we mention in Chapter Three, the theory and especially the empirical studies of industrial countries specify that interest rates, profits, total sales, income of a sector or country, mortgage rates and so on should be used, selectively or in combination, as independent variables. Even if statistics were available, they would not be considered the main factors in explaining investment in Libya, because most are irrelevant to government investment.

Investment in the Libyan economy may be disaggregated into: (1) Investment Expenditure in the Manufacturing Sector; (2) Investment Expenditure in the Agriculture Sector; (3) Investment Expenditure in the Services Sector; (4) Investment Expenditure in the Construction Sector.

Thus, the following identities will be formed:

$$TINVS_t = MANI_t + AGRI_t + SERI_t + COTI_t$$

Where,

$TINVS_t$ = Total Government Investment Expenditure.

$MANI_t$ = Investment Expenditure in the Manufacturing Sector.

$AGRI_t$ = Investment Expenditure in the Agriculture Sector.

$SERI_t$ = Investment Expenditure in the Services Sector.

$COTI_t$ = Investment Expenditure in the Construction Sector.

6.3.1 Investment in the Manufacturing Sector

As mentioned in chapter one, the increasing role of government and the declining share of private investment is a basic feature of this model. A high percentage of manufacturing is owned by the government, while only a small percentage is owned by the private sector. The government has tried to reduce its heavy dependency on oil revenues through programmes of industrial diversification.

Before moving to an estimation of the behaviour equation for Investment in the Manufacturing Sector, testing for the unit root is applied as a preliminary step to testing for cointegration. This test is applied to a univariate time series of three variables given by the modified Investment Function in the Manufacturing Sector:

$$RMANI_t = f(RMANDE_t, RMANVAL_t)$$

Where,

$RMANI_t$ = Real Investment Expenditure in the Manufacturing Sector.

$RMANDE_t$ = Real Government's Annual Appropriation for Investment in the Manufacturing Sector.

$RMANVAL_t$ = Real Value-Added in the Manufacturing Sector.

Table 6.7 shows the results of the DF and ADF test statistics . The results broadly indicate that none of the variables is stationary at its level, but they are stationary in the first differences. This means that the variables are integrated of order 1, i.e. I(1). Therefore, it is possible to move on to the next step, attempting to detect which, if any, of these variables cointegrate.

This step, as mentioned above, is testing for cointegration using the Engle-Granger (1987) two-step method. Table 6.8 exhibits the results of the cointegration test using bivariate and multivariate cointegration regression. The results are mixed. The DF test indicates the existence of cointegration in 2 out of 3 regressions, the only exception being the bivariate regression of Real

Investment Expenditure in the Manufacturing Sector on Real Value-Added in the Manufacturing Sector. Finally, the ADF test accepts the null hypothesis of no cointegration in three regressions.

Table 6.7
Testing for Stationarity
(Investment Function in the Manufacturing Sector)

	DF				ADF			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
$\ln RMANI_t$	-2.521	-3.329*	-0.360	-4.117*	-2.006	-3.000*	-0.695	-5.235*
$\ln RMANDE_t$	-2.250	-4.261*	-0.386	-5.727*	-2.514	-2.691*	-0.607	-3.821*
$\ln RMANVAL_t$	-0.582	-4.844*	-0.459	-4.864*	-0.848	-4.404*	-1.526	-4.528*

* significant at 5% level.

Table 6.8
Testing for Cointegration: The Engle-Granger Method
(Investment Function in the Manufacturing Sector)

Dep. Variable	constant	$\ln RMANDE_t$	$\ln MANVAL_t$	$\bar{R}^2$	DF	ADF	$CRDW$
$\ln RMANI_t$	0.710	0.846 (32.17)		0.97	-4.103*	-2.332	1.516
$\ln RMANI_t$	-1.228		1.238 (7.65)	0.67	-1.080	-1.141	0.192
$\ln RMANI_t$	0.371	0.781 (18.73)	0.142 (1.95)	0.97	-4.408*	-2.443	1.627

all variables are expressed in logarithmic terms.
* significant at 5% level.

Equation (1) in Table 6.15 states Real Investment Expenditure in the Manufacturing Sector ($RMANI_t$). As equation (1) estimates, the Real Value-Added in the Manufacturing Sector ($RMANVAL_t$) and Real Government's Annual Appropriation for Investment in the Manufacturing Sector ($RMANDE_t$)

are the main independent variables in the Investment Function in the Manufacturing Sector. Equation (1) emphasises on the role of the government's annual appropriation for investment in manufacturing and the products of manufacturing for its major influence on the desired level of investment in the manufacturing sector. All explanatory variables are highly significantly different from zero at the 1% level of significance due to the high t-test. In addition, the explanatory power of the independent variables ($\bar{R}^2=0.98$) is 98% which indicates that the size of the residuals is small.

In equation (2), Table 6.15 represents the Real Investment in the Manufacturing Sector. Real Government's Annual Appropriation for Investment in the Manufacturing Sector ($RMANDE_t$) and the Real Investment Expenditure in the Manufacturing Sector lagged one year ($RMANI_{t-1}$) are explanatory variables in the equation. Equation (2) is highly significant according to the $\bar{R}^2$ and F- test. The coefficients of the explanatory variables are significant at the 1% level of significance. The signs of the explanatory coefficients are as expected. The higher value of the lagged dependent variable reflects the importance of the explanatory variables for the previous period.

6.3.2 Investment in the Agriculture Sector

Before constructing the behavioural equation for investment in agriculture, the stationarity of the variables using the Dickey-Fuller methodology is tested. The DF and ADF test statistics are calculated without and with time trend for (log of) level data and first differences. This test is applied to a univariate time series of three variables given by the modified Investment Function in the Agriculture Sector:

$$RAGRI_t = f(RAGRDE_t, RAGRVAL_t)$$

Where,

$RAGRI_t$ = Real Investment Expenditure in the Agriculture Sector.

$RAGRDE_t$ = Real Government's Annual Appropriation for Investment in the Agriculture Sector.

$RAGRVAL_t$ = Real Value-Added in the Agriculture Sector.

Table 6.9 shows the results of these tests. The results indicate that none of the variables is stationary at its level, but they are stationary in the first differences. This means that the variables are integrated of order 1, i.e. I(1). Therefore, the next step is to attempt to detect whether any of these variables cointegrate.

Table 6.9
Testing for Stationarity
(Investment Function in the Agriculture Sector)

	DF				**ADF**			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
ln $RAGRI_t$	-1.867	-3.878*	-0.249	-5.104*	-2.125	-3.000*	-0.605	-4.094*
ln $RAGRDE_t$	-2.264	-3.207*	-0.586	-5.020*	-2.255	-2.343*	-1.074	-4.349*
ln $RAGRVAL_t$	-0.865	-6.358*	-1.900	-6.367*	-1.236	-4.299*	-1.579	-4.454*

* significant at 5% level.

The second step is testing for cointegration between the Real Investment Expenditure in the Agriculture Sector ($RAGRI_t$), Real Government's Annual Appropriation for Investment in the Agriculture Sector ($RAGRDE_t$) and Real Value-Added in the Agriculture Sector ($RAGRVAL_t$) applying the Engle-Granger (1987) two-step method. Table 6.10 represents the results of the cointegration test using bivariate and multivariate cointegrations regression. The results are mixed. The DF and ADF statistics reject the null hypothesis of no cointegration between the Real Investment Expenditure in the Agriculture Sector ($RAGRI_t$) and Real Government's Annual Appropriation for Investment in the Agriculture Sector ($RAGRDE_t$). Also, the DF and ADF statistics accept the null hypothesis of no cointegration between the Real Investment Expenditure in the Agriculture Sector ($RAGRI_t$) and Real Value-Added in the Agriculture Sector ($RAGRVAL_t$). Finally, the DF test indicates the existence of cointegration between $RAGRI_t$, $RAGRDE_t$ and $RAGRVAL_t$.

Tale 6.10
Testing for Cointegration: Engle-Granger Method
(Investment Function in the Agriculture Sector)

Dep. Variable	constant	$\ln RAGRDE_t$	$\ln RAGRVAL_t$	$\bar{R}^2$	DF	ADF	$CRDW$
$\ln RAGRI_t$	0.538	0.825 (19.73)		0.93	-4.170*	-4.165*	0.514
$\ln RAGRI_t$	-3.485		1.732 (6.00)	0.54	-0.563	-0.317	0.165
$\ln RAGRI_t$	-1.375	0.691 (20.57)	0.589 (6.48)	0.97	-4.240*	-3.271	1.257

all variables are expressed in logarithmic terms.
* significant at 5% level.

Equation (3) in Table 6.15 represents the error correction model for the Real Investment Expenditure in the Agriculture Sector. The First Difference of Real Government's Annual Appropriation for Investment in the Agriculture Sector ($\Delta RAGRDE_t$) and the error correction term ($RAGRDE_{t-1} - RAGRI_{t-1}$) are the main explanatory variables in the Real Investment Expenditure in the Agriculture Sector ($RAGRI_t$). Several forms of this function were tried and the double error correction model seemed to be the best, from both the statistical and economic points of view. The coefficient of the error correction term implies a gradual adjustment of the dependent variable toward its long term value. The short-run of the marginal propensity of investment in the agriculture sector is 0.62 while the long-run propensity is equal 0.27.

6.3.3 Investment in the Services Sector

An enormous portion of government fixed investment was directed toward establishing the development of the country's services. The Libyan government, as is the case with most governments of developing countries, owns the components of these sectors, such as roads, bridges, airlines, main stations and so on. Therefore, in order to specify the behavioural equation for investment in the services sector, it is possible to test for unit roots or for stationarity of the variables using the Dickey-Fuller methodology. This test is applied to the univiariate time series of three variables given by the modified Investment Function in the Services Sector:

$$RSERI_t = f(RSERDE_t, RSERVAL_t)$$

Where,

$RSERI_t$ = Real Investment Expenditure in the Services Sector.

$RSERDE_t$ = Real Government's Annual Appropriation for Investment in the Services Sector.

$RSERVAL_t$ = Real Value-Added in the Services Sector.

The results of these tests are presented in Table 6.11 and generally indicate that none of the variables is stationary at it level, but stationary in the first differences. This means that the variables are integrated of order 1, i.e. I(1). Consequently, it is possible to proceed to the next step, attempting to detect whether or not some of these variables cointegrate.

This step tests for cointegration between Real Investment Expenditure in the Services Sector, Real Government's Annual Appropriation for Investment in the Services Sector and Real Value-Added in the Services Sector using the Engel-

Granger (1987) two step method. Table 6.12 indicates the results of the cointegration test. The DF and ADF statistics accept the null hypothesis of no cointegration between Real Investment Expenditure in the Services Sector ($RSERI_t$) and Real Government's Annual Appropriation for Investment in the Services Sector ($RSERDE_t$) and Real Value-Added in the Services Sector ($RSERVAL_t$) for both the bivariate and multivariate cointegration regressions.

Table 6.11
Testing for Stationarity
(Investment Function in the Services Sector)

	DF				ADF			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
ln $RSERI_t$	-2.677	-2.405*	-0.075	-3.730*	-2.483	-2.339*	-0.920	-3.172*
ln $RSERDE_t$	-2.437	-3.425*	-0.763	-4.680*	-2.535	-3.000*	-1.295	-3.987*
ln $RSERVAL_t$	-2.718	-5.147*	-2.841	-5.485*	-2.436	-3.834*	-2.727	-4.333*

* significant at 5% level.

Table 6.12
Testing for Cointegration: Engle-Granger Method
(Investment Function in the Services Sector)

Dep. Variable	constant	ln $RSERDE_t$	ln $RSERVAL_t$	$\bar{R}^2$	DF	ADF	$CRWD$
ln $RSERI_t$	1.488	0.812 (22.77)		0.94	-2.277	-1.555	0.686
ln $RSERI_t$	-2.088		1.165 (14.63)	0.88	-0.687	-1.990	0.308
ln $RSERI_t$	-0.159	0.540 (11.54)	0.461 (6.62)	0.97	-3.556	-3.144	1.300

all variables are expressed in logarithmic terms.
* significant at 5% level.

Equation (4) in Table 6.15 examines the Real Investment Expenditure in the Services Sector. The Real Value-Added in the Services Sector ($RSERVAL_t$), Real Government's Annual Appropriation for Investment in the Services Sector ($RSERDE_t$) and the Real Investment Expenditure in the Services Sector lagged one year ($RSERI_{t-1}$) are the explanatory variables in this function. According to the results, all the explanatory variables are significantly different from zero and they have the expected signs. Furthermore, the explanatory power of the regression is ($\bar{R}^2 = 0.97$), which shows that the constant term, $RSERVAL_t$, $RSERDE_t$ and $RSERI_{t-1}$ explain 97% of the variation in the investment expenditure in services.

6.3.4 Investment in the Construction Sector

As a mentioned in the chapter three, construction in Libya contains various components, such as constructing government buildings, schools, hospitals, dams, industrial cities and other infrastructure which helps the pace of development in the country and improves the social welfare of the people. Therefore, in order to specify the behavioural equation for investment in this sector, it is essential to test for stationarity of the variables using the Dickey-Fuller methodology. This test is applied to a univariate time series of three variables given by the modified Investment Function in the Construction Sector:

$$RCOTI_t = f(RCOTDE_t, RCOTVAL_t)$$

Where,

$RCOTI_t$ = Real Investment Expenditure in the Construction Sector.

$RCOTDE_t$ = Real Government's Annual Appropriation for Investment in the Construction Sector.

$RCOTVAL_t$ = Real Value-Added in the Construction Sector.

Table 6.13 shows the results of DF and ADF tests. In general these indicate that none of the variables is stationary in its level, but they are some stationary in the first differences. This means that the variables are integrated of order 1, i.e. I(1). Therefore, the next step is to try to detect whether or not any of these variables cointegrate.

Table 6.13
Testing for Stationarity
(Investment Function in the Construction Sector)

	DF				ADF			
	Without Trend		With trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
$\ln RCOTI_t$	-0.748	-3.454*	-1.340	-4.342*	-2.179	-4.292*	-1.278	-4.197*
$\ln RCOTDE_t$	-2.515	-4.593*	-1.310	-7.177*	-2.726	-2.263	-1.811	-4.000*
$\ln RCOTVAL_t$	-2.489	-3.520*	-1.657	-4.440*	-1.280	-3.307*	-2.000	-3.864*

* significant at 5% level.

This step, as mentioned above, is testing for cointegration between Real Investment Expenditure in the Construction Sector, Real Government's Annual Appropriation for Investment in the Construction Sector and Real Value-Added in the Construction Sector by applying the Engle-Granger (1987) two-step method. Table 6.14 shows the results of the cointegration test using bivariate and multivariate cointegration regressions.

Table 6.14
Testing for Cointegration: Engle-Granger Method
(Investment in the Construction Sector)

Dep. Variable	constant	$\ln RCOTDE_t$	$\ln RCOTVAL_t$	$\bar{R}^2$	DF	ADF	$CRDW$
$\ln RCOTI_t$	0.850	0.916 (17.87)		0.91	-3.854*	-4.362*	0.969
$\ln RCOTI_t$	0.329		0.772 (13.34)	0.86	-2.258	-1.735	0.451
$\ln RCOTI_t$	0.394	0.588 (7.79)	0.328 (5.00)	0.96	-3.804*	-3.334*	1.416

all variables are expressed in logarithmic terms.
* significant at 5% level.

The DF and ADF statistics reject the null hypothesis of no cointegration between Real Investment Expenditure in the Construction Sector and Real Government's Annual Appropriation for Investment in the Construction Sector. Conversely, bivariate cointegration of $RCOTI_t$ on $RCOTVAL_t$ do not reject the null hypothesis. However, multivariate regression of $RCOTI_t$ on $RCOTDE_t$ and $RCOTVAL_t$ indicate that the three variables are cointegrated.

Equation (5) in Table 6.15 represents the error correction model of Real Investment Expenditure in the Construction Sector. The results show that all the estimated coefficients have the correct signs and are significantly different from zero. The coefficient of the error correction term ($RCOTDE_{t-1} - RCOTI_{t-1}$) implies a gradual adjustment of the dependent variable towards its long term value. The short-run of the marginal propensity of government investment in the construction sector is 0.57 while the long-run propensity is 0.42.

Table 6.15
The Empirical Results for the Investment Function

No.	Method of Estimation	Estimation Results
1.	OLS	$\ln RMANI_t = 0.371 + 0.143 \ln RMANVAL_t + 0.782 \ln RMANDE_t$ (2.00) (18.70) $\bar{R}^2 = 0.98$ $D.W = 1.630$ $S.E = 0.206$ $F = 571.1$ $\chi^2_{SC}(2) = 1.040$ $\chi^2_{FF}(2) = 1.213$ $\chi^2_{HS}(1) = 1.031$
2.	OLS	$\ln RMANI_t = 0.605 + 0.570 \ln RMANDE_t + 0.301 \ln RMANI_{t-1}$ (6.50) (3.17) $\bar{R}^2 = 0.98$ $D.W = 1.740$ $S.E = 0.188$ $F = 580.9$ $\chi^2_{SC}(2) = 1.022$ $\chi^2_{FF}(2) = 2.702$ $\chi^2_{HS}(1) = 2.612$
3.	OLS	$\Delta \ln RAGRI_t = -0.015 + 0.620 \Delta \ln RAGRDE_t$ (6.84) $+0.269(\ln RAGRDE_{t-1} - \ln RAGRI_{t-1})$ (2.84) $\bar{R}^2 = 0.65$ $D.W = 2.629$ $S.E = 0.197$ $F = 27.5$ $\chi^2_{SC}(2) = 4.149$ $\chi^2_{FF}(1) = 2.054$ $\chi^2_{HS}(1) = 1.741$
4.	OLS	$\ln RSERI_t = 0.226 + 0.182 \ln RSERVAL_t + 0.413 \ln RSERDE_t$ (2.00) (8.11) $+0.375 \ln RSERI_{t-1}$ (4.50) $\bar{R}^2 = 0.97$ $D.W = 2.00$ $S.E = 0.100$ $F = 266.6$ $\chi^2_{SC}(2) = 1.707$ $\chi^2_{FF}(1) = 2.222$ $\chi^2_{HS}(1) = 1.100$
5.	OLS	$\Delta \ln RCOTI_t = 0.239 + 0.566 \Delta \ln RCOTDE_t$ (4.81) $+0.416(\ln RCOTDE_{t-1} - \ln RCOTI_{t-1})$ (2.92) $\bar{R}^2 = 0.52$ $D.W = 1.730$ $S.E = 0.171$ $F = 15.2$ $\chi^2_{SC}(1) = 1.249$ $\chi^2_{FF}(1) = 2.655$ $\chi^2_{HS}(1) = 2.025$

$RMANI_t$ = Real Investment Expenditure in the Manufacturing Sector.

$RMANI_{t-1}$ = Real Investment Expenditure in the Manufacturing Sector lagged one year.

$RMANDE_t$ = Real Government's Annual Appropriation for Investment in the Manufacturing Sector.

$RMANVAL_t$ = Real Value-Added in the Manufacturing Sector.

$\Delta RAGRI_t$ = First Difference of Real Investment Expenditure in the Agriculture Sector.

$\Delta RAGRDE_t$ = Firs Difference of Real Government's Annual Appropriation for Investment in the Agriculture Sector.

$RAGRDE_{t-1}$ = Real Government's Annual Appropriation for Investment in the Agriculture Sector lagged one year.

$RAGRI_{t-1}$ = Real Investment Expenditure in the Agriculture Sector lagged one year.

$RSERI_t$ = Real Investment Expenditure in the Services Sector.

$RSERVAL_t$ = Real Value-Added in the Services Sector.

$RSERI_{t-1}$ = Real Investment Expenditure in the Services Sector lagged one year.

$RSERDE_t$ = Real Government's Annual Appropriation for Investment in the Services Sector.

$\Delta RCOTI_t$ = First Difference of Real Investment Expenditure in the Construction Sector.

$\Delta RCOTDE_t$ = First Difference of Real Government's Annual Appropriation for Investment in the Construction Sector.

$RCOTDE_{t-1}$ = Real Government's Annual Appropriation for Investment in the Construction Sector. lagged one year.

$RCOTI_{t-1}$ = Real Investment Expenditure in the Construction Sector lagged one year.

6.4 The Estimation of the Imports Function

Total Imports were disaggregated into three main groups, Consumption Goods ($IMPCONS_t$), Raw Materials and Intermediate Goods ($IMPINT_t$), and Capital Goods ($IMPCAP_t$).

To estimate the behaviour equation for Total Imports, the stationarity or testing for unit root is a preliminary step to testing for cointegration. The objective is to find whether or not the variables under investigation are I(1), i.e. if they become stationary after differencing them once. This test is applied to the univariate time series of three variables given by the modified Total Imports Function:

$$RTIMP_t = f(RGNP_t, ROILREV_t)$$

Where,

$RTIMP_t$ = Real Total Imports.

$RGNP_t$ = Real Gross National Product.

$ROILREV_t$ = Real Oil Revenues.

The results of these tests are presented in Table 6.16. The DF and ADF indicate that none of the variables are stationary at its level, but are some stationary in the first differences. This means that the variables are integrated of order 1, i.e. I(1). Therefore, it is possible to move on to the next step, attempting to detect whether or not some of these variables cointegrate.

This step, as mentioned above, is testing for cointegration between Real Total Imports, Real Gross National Product and Real Oil Revenues using the Engle-Granger (1987) two-step method.

Table 6.16
Testing for Stationarity
(Total Imports Function)

	DF				ADF			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
$\ln RTIMP_t$	-1.793	-4.312*	-0.610	-4.875*	-1.755	-5.135*	-0.737	-5.025*
$\ln RGNP_t$	-1.482	-4.035*	-0.770	-5.722*	-2.326	-2.171	-0.564	-3.914*
$\ln ROILREV_t$	-1.629	-4.818*	-1.334	-5.438*	-1.467	-3.483*	-1.108	-3.500*

* significant at 5% level.

Table 6.17 represents the results of the cointegration test using bivariate cointegration regression. The results are mixed. The DF statistic rejects the null hypothesis of no cointegration between the Real Total Imports ($RTIMP_t$) and Real Gross National Product ($RGNP_t$). However, a bivariate cointegration regression of Real Total Imports ($RTIMP_t$) on Real Oil Revenues ($ROILREV_t$) does not reject the null hypothesis, according to DF and ADF test statistics. This means that the variables are not cointegrated.

Table 6.17
Testing for Cointegration: The Engle-Granger Method
(Total Imports Function)

Dep. Variable	constant	$\ln RGNP_t$	$\ln ROILREV_t$	$\bar{R}^2$	DF	ADF	$CRDW$
$\ln RTIMP_t$	-0.289	0.847 (19.30)		0.93	-4.179*	-2.758	1.317
$\ln RTIMP_t$	2.580		0.847 (10.23)	0.78	-2.583	-1.732	0.609

all variables are expressed in logarithmic terms.
* significant at 5% level.

Equation (1) in Table 6.24 shows Real Total Imports ($RTIMP_t$). As the estimated results of equation (1), Real Gross National Product ($RGNP_t$) and Real

Total Imports lagged one period ($RTIMP_{t-1}$) are the main explanatory variables in the equation. Also, the explanatory variables are very significant in influencing the total amount of imports since both of these explanatory variables have high t- statistics, and also all of them have the expected signs. Furthermore, this equation has a high $\bar{R}^2$ (= 0.95) which suggests that 95% of the variation in the total imports over the estimation period is interpreted by right-hand side explanatory variables. The elasticity of imports with respect to the last period of Gross National Product is higher than for the current period, as equation (1) in Table 6.24 shows. In equation (2) in Table 6.24, Real Oil Revenues was used instead of Real Gross National Product. Oil Revenues are the main source of foreign exchange for Libya. The availability of foreign exchange is the important factor on which imports depend. So, equation (2) shows that Real Oil Revenues and Real Total Imports lagged one year, these are significant in influencing the amount of Total Imports since both these explanatory variables have high t-statistics and also, all of them have the expected signs. The long-run elasticity of Total Imports to Oil Revenues is 0.74 which is higher then the short-run elasticity (0.12). This shows that the higher effect of the last period Oil Revenues on Total Imports was higher than the current Oil Revenues.

The first group to explore is the Imports of Consumption Goods ($IMPCONS_t$). Before moving to an estimation of the behaviour equation for Imports of Consumption Goods, testing for stationarity is applied as a preliminary step to testing for cointegration.

Table 6.18 represents the testing for stationarity of the Imports of Consumption Goods ($IMPCONS_t$). This test is applied to the univariate time series of two variables given by the modified Imports of Consumption Goods Function:

$$RIMPCONS_t = f(RMANVAL_t, RADY_t)$$

Where

$RIMPCONS_t$ = Real Imports of Consumption Goods.

$RMANVAL_t$ = Real Value-Added in the Manufacturing Sector.

$RADY_t$ = Real Adjusted Disposable Income.

The results in Table 6.18 indicate that none of the variables is stationary in its level, but all are stationary in the first differences. This means that the variables are integrated of order 1, i.e. I(1). It is possible, therefore to move on to the next step, attempting to detect if any of these variables cointegrate.

Table 6.18
Testing for Stationarity
(Imports of Consumption Goods Function)

	DF				ADF			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
ln $RIMPCONS_t$	-2.337	-4.457*	-1.204	-4.848*	-1.929	-3.179*	-1.132	-3.510*
ln $RMANVAL_t$	-0.582	-4.844*	-0.959	-4.864*	-0.848	-4.404*	-1.563	-4.528*
ln $RADY_t$	-1.321	-3.426*	-1.128	-3.463*	-1.382	-3.000*	-1.702	-4.855*

* significant at 5% level.

The next step, as mentioned above, is testing for cointegration between Real Imports of Consumption Goods, Real Value-Added in the Manufacturing Sector and Real Adjusted Disposable Income applying the Engle-Granger (1987) two-step method. Table 6.19 shows the results of the cointegration test. The DF and ADF statistics accept the null hypothesis of no cointegration between the

Real Total Imports of Consumption Goods, Real Value-Added in the Manufacturing Sector and Real Adjusted Disposable Income.

Table 6.19
Testing for Cointegration: The Engle-Granger Method
(Imports of Consumption Goods Function)

Dep. Variable	constant	$\ln RMANVAL_t$	$\ln RADY_t$	$\bar{R}^2$	DF	ADF	$CRDW$
$\ln RIMPCONS_t$	1.484	0.687 (6.90)		0.62	-1.514	-1.232	0.210
$\ln RADY_t$	-1.850		0.907 (10.81)	0.80	-1.070	-0.558	0.273

all variables are expressed in logarithmic terms.
* Significant at 5% level

Equation (3) in Table 6.24 displays the Imports of Consumption Goods ($IMPCONS_t$). The explanatory variables used in this function are: Real Adjusted Disposable Income ($RADY_t$), Real Value-Added in the Manufacturing Sector ($RMANVAL_t$) and Real Imports of Consumption Goods lagged one year ($RIMPCONS_{t-1}$). Real Adjusted Disposable Income reflects purchasing power. Import substitution policies, which are often implemented in developing countries, consist of quantity restrictions, or high import duties on the goods, are starting to be produced in the country. Libyan planners have followed this policy since the 1960's but it was intensified after the 1969 revolution. The main aim of this planning is to establish an industrial base, starting with consumption goods, which can be manufactured internally in order to cut the import of such goods. Therefore, Real Value-Added of the Manufacturing Sector is expected to be negatively related to the Imports of Consumption Goods, due to the substitution effects. This reflects import substitution, a policy pursued by Libyan planners. The results in equation (3), Table 6.24 support the substitution effect of manufactured outputs on Imports of Consumption Goods. Also, the explanatory variables are highly significant different from zero due to the high ratio of student t - test at 1% level of significance. Furthermore, the equation (3) has a high $\bar{R}^2$ (0.96) which points out that 96% proportion of variation in imports of consumption goods is explained by independent variables.

The second group to be examined is the Imports of Intermediate Goods and Raw Materials ($IMPINT_t$). In order to specify the behavioural equation for Imports of Intermediate Goods and Raw Materials, it is possible to test for stationarity or unit roots of the variables using the Dickey-Fuller methodology.

Table 6.20 concerns the testing for Stationarity of the Imports of Intermediate Goods and Raw Materials. The DF and ADF test statistics are calculated without and with time trend for (log of) level data and first differences. This test shows the univariate time series of two variables given by the modified Imports of Intermediate Goods and Raw Materials Function:

$$RIMPINT_t = f(ROILREV_t)$$

Where,

$RIMPINT_t$ = Real Imports of Intermediate Goods and Raw Materials.

$ROILREV_t$ = Real Oil Revenues.

Table 6.20 displays the results of the testing for stationarity. The DF and ADF indicate that none of the variables is stationary at its level, but they are stationary in the first differences. This means that the variables are integrated of order 1, i.e. I(1). Consequently, the next step is to attempt to detect which of these variables cointegrate.

Table 6.20
Testing for Stationarity
(Imports of Raw Materials and Intermediate Goods Function)

	DF				ADF			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
ln $RIMPINT_t$	-1.753	-4.250*	-1.159	-4.425*	-1.921	-3.537*	-1.474	-3.665*
ln $ROILREV_t$	-1.629	-4.818*	-1.334	-5.438*	-1.467	-3.483*	-1.710	-3.483*

* significant at 5% level.

Table 6.21 represents the testing for cointegration between Real Imports of Intermediate Goods and Raw Materials and Real Oil Revenues using the Engle-Granger (1987) two-step method. The DF and ADF statistics accept the null hypothesis of no cointegration between ($RIMPINT_t$) and ($ROILREV_t$).

Table 6.21
Testing for Cointegration: The Engle-Granger Method
(Imports of Intermediate Goods and Raw Materials Function)

Dep. Variable	constant	ln $ROILREV_t$	$\bar{R}^2$	DF	ADF	$CRDW$
ln $RIMPINT_t$	1.110	0.402 (9.02)	0.73	-2.617	-2.145	0.694

all variables are expressed in logarithmic terms.
* significant at 5% level.

Equation (4) in Table 6.24 demonstrates the Real Imports of Raw Materials and Intermediate ($RIMPINT_t$). Real Oil Revenues ($ROILREV_t$) affect Imports of Intermediate Goods and Raw Materials positively, because Oil Revenues are the main source of finance, not just for Imports of Intermediate Goods, but for all imports. Real Imports of Intermediate Goods and Raw Materials lagged one year ($RIMPINT_{t-1}$) is introduced into the equation to capture the effects of the last period explanatory variables. The signs of the coefficients are as expected, as shown in equation (4) in Table 6.24. Also, the long-run elasticity of Real Imports of Raw Materials to Real Oil Revenues is 0.64 which is higher than the short-run elasticity (0.172). This shows the higher effect of last period Oil Revenues on Imports of Raw Materials than the current Oil Revenues.

The third group to be investigated is the Imports of Capital Goods ($IMPCAP_t$). In order to construct the behavioural equation for Imports of Capital Goods, it is necessary to test for unit roots of the variables using the Dickey-Fuller methodology in the same way as for the Imports of Intermediate Goods and Raw Materials. The results of testing for stationarity of the Imports of Capital Goods is shown in Table 6.22. This test is applied to the univariate time series of three variables given by the modified Imports of Capital Goods Function:

$$RIMPCAP_t = f(ROILREV_t, RMANVAL_t)$$

Where,

$RIMPCAP_t$ = Real Imports of Capital Goods.

$ROILREV_t$ = Real Oil Revenues.

$RMANVAL_t$ = Real Value-Added in the Manufacturing Sectors.

The results of the DF and ADF tests are represented in Table 6.22 and when the calculated statistics are compared with the 5% critical values as tabulated in Mackinnon (1990), the results lend support to the hypothesis that none of the variables is stationary in its level, but all are stationary in the first differences. This means that the variables are integrated of order 1, i.e. I(1).

Therefore, the next step is the attempt to detect which of these variables cointegrate.

Table 6.22
Testing for Stationarity
(Imports of Capital Goods Function)

	DF				ADF			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
$\ln RIMPCAP_t$	-1.673	-4.685*	-0.576	-5.285*	-1.682	-5.034*	-0.595	-5.144*
$\ln ROILREV_t$	-1.629	-4.818*	-1.334	-5.438*	-1.467	-3.483*	-1.108	-3.500*
$\ln RMANVAL_t$	-0.582	-4.844*	-0.959	-4.864*	-0.848	-4.404*	-1.563	-4.528*

* significant at 5% level.

This step, as mentioned above, is testing for cointegration between Real Imports of Capital Goods, Real Oil Revenues and Real Value-Added in the Manufacturing Sector using the Engle-Granger (1987) two-step method. The results of this test are demonstrated in Table 6.23. The DF and ADF statistics accept the null hypothesis of no cointegration between $RIMPCAP_t$, $ROILREV_t$ and $RMANVAL_t$.

Table 6.23
Testing for Cointegration: The Engle-Granger Method
(Imports of Capital Goods Function)

Dep. Variable	constant	$\ln ROILREV_t$	$\ln RMANVAL_t$	$\bar{R}^2$	*DF*	*ADF*	*CRDW*
$\ln RIMPCAP_t$	2.243	0.551 (9.68)		0.76	-2.720	-1.890	0.655
$\ln RIMPCAP_t$	3.264		0.604 (6.05)	0.55	-0.738	-0.596	0.217

all variables are expressed in logarithmic terms.
* significant at 5% level.

Equation (5) in Table 6.24 illustrates Imports of Capital Goods ($IMPCAP_t$). Real Oil Revenues ($ROILREV_t$) plays an important part in determining the size of capital imports, due to the high cost of capital. Equation (5) shows that Real Oil Revenues lagged one year and Real Capital Imports lagged one year are significant in influencing the total amount of Real Capital Imports since both of these explanatory variables have high t - statistics and also all of them have the expected signs. Furthermore, the explanatory power of the regression $\bar{R}^2$ (= 0.90) indicates that 90% of variation in the Real Capital Imports is explained by these predetermined variables.

Table 6.24
The Empirical Results for the Imports Function

No.	Method of Estimation	Estimation Results
1.	OLS	$\ln RTIMP_t = -0.172 + 0.362 \ln RGNP_t + 0.506 \ln RTIMP_{t-1}$ (3.33) (4.27) $\bar{R}^2 = 0.95$ $D.W = 2.541$ $S.E = 0.134$ $F = 262.0$ $\chi^2_{SC}(1) = 2.666$ $\chi^2_{FF}(1) = 1.285$ $\chi^2_{HS}(1) = 1.100$
2.	OLS	$\ln RTIMP_t = 0.810 + 0.117 \ln ROILREV_t + 0.737 \ln RTIMP_{t-1}$ (2.43) (10.26) $\bar{R}^2 = 0.92$ $D.W = 2.537$ $S.E = 0.147$ $F = 138.6$ $\chi^2_{SC}(1) = 2.336$ $\chi^2_{FF}(1) = 1.285$ $\chi^2_{HS}(1) = 1.619$
3.	OLS	$\ln RIMPCONS_t = 0.743 + 0.488 \ln RADY_t - 0.214 \ln RMANVAL_t$ (3.56) (-3.06) $+0.570 \ln RIMPCONS_{t-1}$ (5.47) $\bar{R}^2 = 0.96$ $D.W = 2.525$ $S.E = 0.138$ $F = 194.6$ $\chi^2_{SC}(1) = 2.827$ $\chi^2_{FF}(1) = 1.534$ $\chi^2_{HS}(1) = 1.130$
4.	OLS	$\ln RIMPINT_t = 0.234 + 0.172 \ln ROILREV_t + 0.639 \ln RIMPINT_{t-1}$ (2.22) (4.98) $\bar{R}^2 = 0.85$ $D.W = 1.600$ $S.E = 0.187$ $F = 69.4$ $\chi^2_{SC}(2) = 1.220$ $\chi^2_{FF}(1) = 1.969$ $\chi^2_{HS}(1) = 1.224$
5.	OLS	$\ln RIMPCAP_t = 0.736 + 0.133 \ln ROILREV_{t-1} + 0.716 \ln RIMPCAP_{t-1}$ (2.35) (8.76) $\bar{R}^2 = 0.90$ $D.W = 2.560$ $S.E = 0.170$ $F = 140.0$ $\chi^2_{SC}(1) = 2.400$ $\chi^2_{FF}(1) = 1.00$ $\chi^2_{HS}(1) = 1.712$

$RTIMP_t$ = Real Total Imports
$RTIMP_{t-1}$ = Real Total Imports lagged one year.
$RGNP_t$ = Real Gross National Product.
$ROILREV_t$ = Real Oil Revenues.
$RIMPCONS_t$ = Real Imports of Consumption Goods.
$RIMPCONS_{t-1}$ = Real Imports of Consumption Goods lagged one year.
$RADY_t$ = Real Adjusted Disposable Income.
$RMANVAL_t$ = Real Value-Added in the Manufacturing Sector.
$RIMPINT_t$ = Real Imports of Intermediate Goods and Raw Materials.
$RIMPINT_{t-1}$ = Real Imports of Intermediate Goods and Raw Materials lagged one year.
$RIMPCAP_t$ = Real Imports of Capital Goods.
$RIMPCAP_{t-1}$ = Real Imports of Capital Goods lagged one year.

6.5 The Estimation of Price Function

Four prices indices have been used to deflate the variables in the model. Three of these indices [Consumer Price Index ($PSDX_t$), Capital Formation Price Index ($INVDX_t$) and the Gross Domestic Product Deflator ($PGDPIDX_t$)] are considered to be endogenous to the model. The fourth index is the Import Price Index (PIM_t), which is considered as exogenous to the model, because it is determined outside the country.

The first price index to be examined is the Consumer Price Index. Before moving on to estimation of the Consumer Price Index, testing for stationarity is carried out prior to testing for cointegration. This test is applied to univariate time series of two variables given by the modified Consumer Price Index Function:

$$PSDX_t = f(MONEY_t)$$

Where,

$PSDX_t$ = Consumer Price Index.

$MONEY_t$ = Money Supply.

Table 6.25 displays the results of DF and ADF testes. The results broadly indicate that none of the variables are stationary in their level, but the variables are stationary in the first differences. This means that the variables are integrated of order 1, i.e. I(1). Therefore, the next step is attempting to detect whether or not some of these variables cointegrate.

Table 6.25
Testing for Stationarity
(Consumer Price Index Function)

	DF				**ADF**			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
ln $PSDX_t$	-0.644	-4.110*	-1.385	-4.049*	-0.646	-3.000*	-1.802	-5.378*
ln $MONEY_t$	-2.950	-3.543*	-0.581	-4.771*	-2.874	-3.001*	-1.002	-3.819*

* significant at 5% level.

The next step, as mentioned above, is testing for cointegration between Consumer Price Index and Money Supply using the Engle-Granger (1987) two-step method. Table 6.26 shows the results of the cointegration test. The DF and ADF statistics accept the null hypothesis of no cointegration between the Consumer Price Index and Money Supply.

Table 6.26
Testing for Cointegration: The Engle-Granger Method
(Consumer Price Index Function)

Dep. Variable	constant	ln $MONEY_t$	$\bar{R}^2$	DF	ADF	$CRDW$
ln $PSDX_t$	2.814	0.340 (12.22)	0.84	-0.601	-1.069	0.120

all variables are expressed in logarithmic terms.
* significant at 5% level.

Equation (1), Table 6.31 concerns the Consumer Price Index Function ($PSDX_t$). The Money Supply ($MONEY_t$) and Consumer Price Index lagged one period ($PSDX_{t-1}$) are explanatory variables in the Consumer Price Index Function. The results of equation (1) indicates that all the explanatory variables are significantly from zero at the 1% level of significance. Also, these variables have the expected signs. The explanatory power of the equation $\bar{R}^2$ (0.99) implies that 99% of the variation in $PSDX_t$ is explained by these explanatory variables.

The second price index to explore is the Capital Formation Price Index ($INVDX_t$). Before moving to an estimation of the behaviour equation for Capital Formation Price Index, testing for stationarity is applied as a preliminary step to testing for cointegration.

Table 6.27 indicates the testing for stationarity of the Capital Formation Price Index. The DF and ADF test statistics are calculated without and with time trend for (log of) level data and first differences. This test shows the univariate time series of two variables given by the modified Capital Formation Price Index Function:

$$INVDX_t = f(PGDPIDX_t)$$

Where,

$INVDX_t$ = Capital Formation Price Index.

$PGDPIDX_t$ = Gross Domestic Product Deflator.

Table 6.27 displays the results of the testing for stationarity. The DF and ADF indicate that none of the variables are stationary in their level, but are stationary in the first differences. This means that the variables are integrated of order 1, i.e. I(1). Therefore, it is possible to move on to the next step, attempting to detect if any of these variables cointegrate.

Table 6.27
Testing for Stationarity
(Capital Formation Price Index)

	DF				**ADF**			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
ln $INVDX_t$	-2.239	-4.848*	-0.193	-5.758*	-2.322	-3.000*	-0.012	-4.112*
ln $PGDPIDX_t$	-1.869	-4.450*	-0.434	-4.829*	-1.666	-3.246*	-0.548	-3.721*

* significant at 5% level.

This step is testing for cointegration between Capital Formation Price Index and Gross Domestic Product Deflator applying the Engle-Granger (1987) two-step method. Table 7.28 exhibits the results of the cointegration test. The DF and ADF statistics accept the null hypothesis of no cointegration between the Capital Formation Price Index and Gross Domestic Product Deflator.

Table 6.28
Testing for Cointegration: The Engle-Granger Method
(Capital Formation Price Index Function)

Dep. Variable	constant	ln $PGDPIDX_t$	$\bar{R}^2$	DF	ADF	$CRDW$
ln $INVDX_t$	1.477	0.641 (22.90)	0.95	-1.700	-1.800	0.440

all variables are expressed in logarithmic term.
* significant at 5% level.

Equation (2) in Table 6.31 represents the Capital Formation Price Index ($INVDX_t$). As we see from this equation, the Gross Domestic Product Deflator ($PGDPIDX_t$) and the Capital Formation Price Index lagged one year ($INVDX_{t-1}$) are the explanatory variables in this function. Thus, these two major explanatory variables can be considered very significant. All the statistical tests are significant since all the independent variables have high student t - tests which indicate that all the estimated coefficients are significantly different from zero at the 1% level of significance. Also, it has a high $\bar{R}^2$ (0.99) which implies that 99% of the variation in $INVDX_t$ is expected by the explanatory variables on the right-hand side.

The third price index to be explained is the Gross Domestic Product Deflator ($PGDPIDX_t$).

To estimate the behaviour of the equation for Gross Domestic Product Deflator, the unit root test is a preliminary step to testing for cointegration. The objective is to find whether or not the variables under investigation are I(1), i.e. if they become stationary after differencing them once. This test is applied to the univariate time series of three variables given by the modified Gross Domestic Product Deflator Function:

$$PGDPIDX_t = f(MONEY_t, PIM_t)$$

Where,

$PGDPIDX_t$ = Gross Domestic Product Deflator.

$MONEY_t$ = Money Supply.

PIM_t = Imports Price Index.

In testing for stationarity, the Dickey-Fuller methodology is used, in the same way as for the Capital Formation Price Index Function. Table 6.29 shows the results of DF and ADF testes. The results indicate that none of the variables are stationary in their level, but are stationary in the first differences. This means that the variables are integrated of order 1, i.e. I(1). Consequently, it is possible to move on to the next step, attempting to detect whether or not some of these variables cointegrate.

Table 6.29
Testing for Stationarity
(Gross Domestic Product Deflator Function)

	DF				**ADF**			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
ln $PGDPIDX_t$	-1.869	-4.450*	-0.434	-4.829*	-1.666	-3.246*	-0.548	-3.721*
ln $MONEY_t$	-2.950	-3.543*	-0.581	-4.771*	-2.874	-3.001*	-1.002	-3.819*
ln PIM_t	-0.136	-3.469*	-1.625	-5.641*	-0.478	-3.259*	-2.331	-5.334*

all variables are expressed in logarithmic terms.
* significant at 5% level.

The next step, as mentioned above, is testing for cointegration between Gross Domestic Product Deflator, Money Supply and Imports Price Index applying the Engle-Granger (1987) two-step method. Table 6.30 exhibits the results of the cointegration test using bivariate and multiviate cointegration regressions. The DF and ADF statistics accept the null hypothesis of no cointegration between the Gross Domestic Product Deflator, Money Supply and the Imports Price Index.

Table 6.30
Testing for Cointegration: The Engle-Granger Method
(Gross Domestic Product Deflator Function)

Dep. Variable	constant	$\ln MONEY_t$	$\ln PIM_t$	$\bar{R}^2$	DF	ADF	$CRDW$
$\ln PGDPIDX_t$	0.778	0.483 (19.66)		0.93	-1.995	-2.562	0.323
$\ln PGDPIDX_t$	-0.490		1.297 (19.79)	0.93	-1.663	-1.738	0.325
$\ln PGDPIDX_t$	0.068	0.251 (7.21)	0.682 (7.28)	0.98	-1.889	-1.940	0.670

all variables are expressed in logarithmic terms.
* significant at 5% level.

Equation (3) in Table 6.31 illustrates the Gross Domestic Product Deflator ($PGDPIDX$). The Money Supply lagged one year ($MONEY_{t-1}$), the Imports Price Index (PIM_t) and the Gross Domestic Product Deflator lagged one year ($PGDPIDX_{t-1}$) are the explanatory variables. Equation (3) is highly significant according to the $\bar{R}^2$ and F - test. The coefficients of the explanatory variables are significant at the 5% level, except for the coefficient of the Imports Price Index, which is significant at the 1% level. The signs of the explanatory coefficients are expected.

Table 6.31
The Empirical Results for the Price Function

No.	Method of Estimation	Estimation Results
1.	OLS	$\ln PSDX_t = 0.100 + 0.110 \ln MONEY_t + 0.840 \ln PSDX_{t-1}$ (4.25) (19.13) $\bar{R}^2 = 0.989$ $D.W = 1.700$ $S.E = 0.052$ $F = 998.8$ $X^2_{SC}(1) = 1.100$ $X^2_{FF}(2) = 2.449$ $X^2_{HS}(1) = 1.000$
2.	OLS	$\ln INVDX_t = 0.322 + 0.072 \ln PGDPIDX_t + 0.864 \ln INVDX_{t-1}$ (2.10) (16.00) $\bar{R}^2 = 0.995$ $D.W = 2.00$ $S.E = 0.030$ $F = 2734.0$ $X^2_{SC}(2) = 1.00$ $X^2_{FF}(1) = 1.490$ $X^2_{HS}(1) = 2.430$
3.	OLS	$\ln PGDPIDX_t = 0.647 + 0.135 \ln MONEY_{t-1} + 0.246 \ln PIM_t$ (2.14) (1.8) $+0.383 \ln PGDPIDX_{t-1}$ (2.94) $\bar{R}^2 = 0.98$ $D.W = 1.600$ $S.E = 0.112$ $F = 370.4$ $X^2_{SC}(1) = 1.620$ $X^2_{FF}(2) = 2.720$ $X^2_{HC}(1) = 1.900$

$PSDX_t$ = Consumer Price Index (1970 = 100).
$PSDX_{t-1}$ = Consumer Price Index lagged one year.
$MONEY_t$ = Money Supply.
$MONEY_{t-1}$ = Money Supply lagged one year.
$INVDX_t$ = Capital Formation Price Index (1970 = 100).
$INVDX_{t-1}$ = Capital Formation Price Index lagged one year.
PIM_t = Imports Price Index.
$PGDPIDX_t$ = Gross Domestic Product Deflator (1970)=100)
$PGDPIDX_{t-1}$ = Gross Domestic Product Deflator lagged one year.

6.6 The Estimation of the Employment Function

In order to specify the behavioural equation for the Employment Function, it is possible to test for unit roots or stationarity of the variables using the Dickey-Fuller methodology. This test is applied to the univiariate time series of two variables given by the modified Employment Function.

$$TNW_t = f(RGDP_t)$$

Where,

TNW_t = Total Number of Workers Employed in the Libyan Economy.

$RGDP_t$ = Real Gross Domestic Product.

Table 6.32 shows the results of the testing for stationarity. The DF and ADF broadly indicate that none of the variables is stationary in its level, but they are stationary in the first differences. This means that the variables are integrated of order 1, i.e. I(1). So, it is possible to move on to the next step, attempting to detect whether or not some of these variables cointegrate.

Table 6.32
Testing for Stationarity
(Employment Function)

	DF				ADF			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
$\ln TNW_t$	-0.986	-4.147*	-0.998	-4.071*	-1.171	-3.441*	-1.697	-3.815*
$\ln RGDP_t$	-1.790	-4.031*	-1.887	-4.966*	-2.651	-3.000*	-1.543	-3.370*

* significant at 5% level.

The next step, as mentioned above, is testing for cointegration between Total Number of Workers Employed and Real Gross Domestic Product applying the Engle-Granger (1987) two-step method. Table 6.33 shows the results of the cointegration test. The DF and ADF statistics accept the null hypothesis of no cointegration between Total Number of Workers Employed and Real Gross Domestic Product.

Table 6.33
Testing for Cointegration: The Engle-Granger Method
(Employment Function)

Dep. Variable	constant	$\ln RGDP_t$	$\bar{R}^2$	DF	ADF	$CRDW$
$\ln TNW_t$	3.371	0.414 (6.61)	0.60	-3.252	-2.842	0.140

all variables expressed in logarithmic terms.
* significant at 5% level.

Equation (1), Table 6.38 concerns the Employment Function. The empirical results indicate that the level of employment increases along with increases in the Real Gross Domestic Product ($RGDP_t$). This effect could be explained in two ways. First, this increase could be explained through the high profit margin for most economic activity, especially in services, and construction. This is intensified, especially in the private industrial sector, by the protective trade policy implemented by the government, to protect newly developed industries, and by the allowance on taxes. Secondly, through the demand for labour to implement the ambitious government development plans. Also, the results in equation (1), seem to satisfy the statistical and economic criteria. The Real Gross Domestic Product ($RGDP_t$) and the level of Employment lagged one year (TNW_{t-1}) play a chief role in affecting the employment function. Both of these two explanatory variables are significant from zero since this equation has high student t - values. $\bar{R}^2$ (0.98), the measure of goodness of fit, indicates that 98% of the variation in the dependent variable (TNW_t) is explanatory variables.

6.7 The Estimation of the Oil Revenues Function

The government is the owner of all the valuable natural resources in Libya. Oil, which is the single most valuable resource, is owned by the Libyan government and all its revenues accrue to the government. As such, the government can provide consumption goods and services to its citizens, and go far in dictating the pace of the country's development. The discovery of enormous quantities of oil in Libya played a significant role in forming the structure of government revenue sources. Government oil revenues composes almost all government revenues. With this huge wealth which comes from oil revenues, it gives power to the government to play a substantial role in the economic development process. The fundamental objective of the government is to use the earnings from oil to effect the domestic economic development to achieve some degree of diversification and raise the standard of living.

In order to construct the behavioural equation for government oil revenues, it is necessary to test for unit roots of the variables using the Dickey-Fuller methodology. This test is applied to the univariate time series of two variables given by the modified Oil Revenues Function:

$$ROILREV_t = f(ROEXP_t)$$

Where,

$ROILREV_t$ = Real Oil Revenues

$ROEXP_t$ = Real Oil Exports.

Table 6.34 exhibits the results of DF and ADF tests by comparing the values of these statistics with 5% critical values tabulated in Mackinnon (1990). It is apparent that none of the variables are stationary in its level, but they are stationary in the first differences. Hence, the next step is to try to detect whether or not any of these variables cointegrate.

This step tests for cointegration between Real Oil Revenues and Real Oil Exports using the Engle-Granger (1987) two-step method. Table 6.35 represents the results of the cointegration test applying bivariate cointegration regression. The DF and ADF tests indicate that there is no existing cointegration between Real Oil Revenues and Real Oil Exports. This means that the variables are not cointegrated.

Table 6.34
Testing for Stationarity
(Oil Revenues Function)

	DF				ADF			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
$\ln ROILREV_t$	-1.629	-4.818*	-1.334	-5.438*	-1.467	-3.483*	-1.108	-3.500*
$\ln ROEXP_t$	-0.887	-4.337*	-2.543	-4.751*	-2.201	-3.724*	-1.710	-4.211*

* significant at 5% level.

Table 6.35
Testing for Cointegration: The Engle-Granger Method
(Oil Revenues Function)

Dep. Variable	constant	$\ln ROEXP_t$	$\bar{R}^2$	DF	ADF	$CRDW$
$\ln ROILREV_t$	-1.177	1.103 (15.22)	0.89	-2.071	-1.970	0.618

all variables are expressed in logarithmic terms.
* significant at 5% level.

Equation (2) in Table 6.38 shows the Real Oil Revenues Function ($ROILREV_t$). Real Oil Exports ($ROEXP_t$) and the Real Oil Revenues lagged one year ($ROILREV_{t-1}$) are the main explanatory variables in the Real Oil Revenues equation. Both of these explanatory variables are significantly different from zero and, also, they have the expected signs. Furthermore, the explanatory power of the regression is ($\bar{R}^2 = 0.94$), which shows that 94% of the variation in Oil Revenues over the estimation period is interpreted by right-hand side explanatory variables. The long-run elasticity of Real Oil Revenues to Real Oil Exports is 0.59 which is higher than the short-run elasticity (0.40). This shows the higher effect of the last period Oil Exports on Oil Revenues than the current Oil Exports.

6.8 The Estimation of the Indirect Tax Function

During the same period of study, the value of indirect taxes has always exceeded that of direct taxes. This could be attributed to the fact that indirect taxes are easier to collect and harder to evade. In addition, this could also be related to the tremendous increase in the country's imports, since indirect taxes are mostly imposed on imports.

Before moving to an estimation of the behaviour equation for Indirect Tax Function, testing for stationarity is applied as a preliminary step to testing for cointegration. This test is applied to univariate time series of two variables given by the modified Indirect Tax Function:

$$RINTAX_t = f(RTIMP_t)$$

Where,

$RINTAX_t$ = Real Indirect Tax Revenues.

$RTIMP_t$ = Real Total Imports.

Table 6.36 exhibits the results of this test. The DF and ADF test statistics are calculated without and with time trend for (log of) level data and first differences. The results broadly indicate that none of the variables is stationary in its level, but are stationary in the first differences. This means that the Real Indirect Tax Revenues and Real Total Imports are integrated of order 1, i.e. I(1).

Therefore, the next step is to attempt to detect which if any of these variables cointegrate.

Table 6.36
Testing for Stationarity
(Indirect Tax Function)

	DF				ADF			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
$\ln RINTAX_t$	-1.314	-4.077*	-1.038	-4.119*	-1.330	-4.438*	-1.362	-4.338*
$\ln RTIMP_t$	-2.211	-7.298*	-1.734	-8.006*	-2.467	-3.659*	-1.284	-4.255*

* significant at 5% level.

The next step, as mentioned above, is testing for cointegration between Real Indirect Tax and Real Total Imports using the Engle-Granger (1987) two step method. Table 6.37 shows the results of the cointegration test. The DF and ADF statistics accept the null hypothesis of no cointegration between the Real Indirect Tax and Real Total Imports due to the small sample of study.

Table 6.37
Testing for Cointegration: The Engle-Granger Method
(Real Indirect Tax Revenues Function)

Dep. Variable	constant	$\ln RTIMP_t$	$\bar{R}^2$	DF	ADF	$CRDW$
$\ln RINTAX_t$	-4.838	1.677 (12.97)	0.85	-2.326	-1.438	0.740

all variables are expressed in logarithmic terms.
* significant at 5% level.

Equation (3) in Table 6.38 exhibits Real Indirect Tax Revenues. Real Total Imports ($RTIMP_t$) and the Real Indirect Tax lagged one year ($RINTAX_{t-1}$) are the main explanatory variables in the Indirect Tax function.

The empirical results of the equation (3) shows that the explanatory variables are very significant in influencing the total amount of indirect tax revenues since both of these explanatory variables have high t - statistics and also all of them have the expected signs. Furthermore, this equation has a high $\bar{R}^2$ (0.97) which suggests that 97% of the variation in the indirect tax revenues over the estimation period is interpreted by right-hand side explanatory variables.

Table 6.38
The Empirical Results for the Employment, Oil Revenues and Indirect Tax Functions

No.	Method of Estimation	Estimation Results
1.	OLS	$\ln TNW_t = -1.019 + 0.497 \ln RGDP_t + 0.884 \ln TNW_{t-1}$ (2.74) (21.02) $\bar{R}^2 = 0.98$ $D.W = 2.000$ $S.E = 0.061$ $F = 572.5$ $\chi^2_{SC}(1) = 1.217$ $\chi^2_{FF}(1) = 2.800$ $\chi^2_{HS}(1) = 1.937$
2.	OLS	$\ln ROILREV_t = 0.119 + 0.402 \ln ROEXP_t + 0.590 \ln ROILREV_{t-1}$ (2.83) (7.02) $\bar{R}^2 = 0.94$ $D.W = 1.700$ $S.E = 0.200$ $F = 404.1$ $\chi^2_{SC}(1) = 1.310$ $\chi^2_{FF}(1) = 1.407$ $\chi^2_{HS}(1) = 2.637$
3.	OLS	$\ln RINTAX_t = -0.561 + 0.557 \ln RTIMP_t + 0.743 \ln RINTAX_{t-1}$ (2.83) (9.65) $\bar{R}^2 = 0.97$ $D.W = 1.600$ $S.E = 0.029$ $F = 386.5$ $\chi^2_{SC}(1) = 1.014$ $\chi^2_{FF}(1) = 1.474$ $\chi^2_{HS}(1) = 1.000$

TNW_t = Total Number of Workers Employed in the Libyan Economy.
TNW_{t-1} = Total Number of Workers Employed in the Libyan Economy lagged one year.
$RGDP_t$ = Real Gross Domestic Product.
$ROILREV_t$ = Real Oil Revenues.
$ROILREV_{t-1}$ = Real Oil Revenues lagged one year.
$ROEXP_t$ = Real Oil Exports.
$RINTAX_t$ = Real Indirect Tax Revenues.
$RINTAX_{t-1}$ = Real Indirect Tax Revenues lagged one year.
$RTIMP_t$ = Real Total Imports.

6.9 The Estimation of the Production Function

In previous sections of this chapter, explanations of aggregate demand and its factors have been explored, but an explanation of the aggregate supply and its determinants is still needed. The supply side approach is based on the production function, explaining output as a function of inputs, such as existing capital stock and the number of workers. The production function for the whole economy, except the oil sector, will be explored first.

The first production function to be investigated is the Production Function for the Non-Oil Sector ($NOQT_t$). In order to specify the production function for the Non-Oil Sector, it is possible to test for stationarity of the variables using the Dickey-Fuller methodology. This test is applied to the univiariate time series of the three variables given by the modified Production Function in the Non-Oil Sector:

$$RNOQT_t = f(RNOKT_t, NONK_t)$$

Where,

$RNOQT_t$ = Real Value-Added in the Non-Oil Sector.

$RNOKT_t$ = Real Capital Stock in the Non-Oil Sector.

$NONK_t$ = Population Employed in the Non-Oil Sector.

Table 6.39 represents the results of DF and ADF tests. They broadly indicate that none of the variables is stationary in its level, but some are stationary in the first differences. This means that some of the variables are integrated of order 1, i.e. I(1). Therefore, the next step to attempt is to detect whether or not some of these variables cointegrate.

Table 6.39
Testing for Stationarity
(The Production Function for the Non-Oil Sector)

	DF				ADF			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
ln $RNOQT_t$	-2.542	-5.001*	-2.657	-5.383*	-2.533	-3.917*	-2.901	-4.464*
ln $RNOKT_t$	-2.857	-3.220*	-2.033	-3.261	-1.687	-3.000*	-1.589	-2.602
ln $NONK_t$	-0.994	-3.675*	-1.093	-3.689*	-1.175	-4.181*	-1.800	-4.265*

* significant at 5% level.

The next step, as mentioned above, is testing for cointegration between the Real Value-Added in the Non-Oil Sector, Real Capital Stock in the Non-Oil Sector and Population Employed in the Non-Oil Sector applying the Engle-Granger (1987) two-step method. Table 6.40 displays the results of the cointegration test. The DF and ADF statistics indicate the existence of cointegration between the Real Value-Added in the Non-Oil Sector, Real Capital Stock in the Non-Oil Sector and the Total Population Employed in Non-Oil Sector.

Table 6.40
Testing for Cointegration: The Engle-Granger Method
(The Production Function for the Non-Oil Sector)

Dep. Variable	constant	ln $RNOKT_t$	ln $NONK_t$	$\bar{R}^2$	DF	ADF	$CRDW$
ln $RNOQT_t$	-4.549	0.325 (13.33)	1.445 (28.30)	0.98	-4.127*	-4.703*	1.629

all variables are expressed in logarithmic term.
* significant at 5% level.

Equation (1) in Table 6.43 shows the production function for the Non-Oil Sector. The explanatory variables are: Non-Oil Value-Added is the dependent variable ($RNOQT_t$). Non-Oil Capital Stock in the Non-Oil Sector ($RNOKT_t$), Population Employed in the Non-Oil Sector ($NONK_t$) and the time trend ($TIME_t$). Since the data for the capital stock series and the rate at which it depreciates in the non-oil sector were not available, the net accumulated in real investment was used as a proxy for real capital stock in that sector. A 9% rate of depreciation was employed in calculating this series.

Different functional forms were tried such as linear Cobb-Douglas and according to the statistical and economic criteria, the best function was chosen. The coefficient signs are as expected and significant at 1% level, except for the time trend, which represents technological progress, this is significant at the 10% level. In addition, the equation (1), Table 6.43 shows the explanatory power of the independent variables ($\bar{R}^2 = 0.97$) is 0.97 which indicates that the size of the residuals is small. It indicates that the production system of the Libyan economy is highly labour intensive, as the labour elasticity value indicates. The Services, Construction, and the Agriculture Sectors are highly labour intensive. The low value of the capital elasticity of the aggregate production function, along with the high value of the labour elasticity, means that labour productivity will improve when new capital is introduced in those highly labour intensive sectors. This is due to the higher marginal productivity of capital in these sectors.

The second production function to be explored is the Production Function for the Oil Sector ($OILVAL_t$). Before moving to an estimation of the production function for the oil sector, testing for stationarity is applied as a preliminary step to testing for cointegration.

Table 6.41 exhibits the results of the testing for stationarity. The DF and ADF test statistics are calculated without and with time trend for (log of) level data and first differences. This test displays the univariate time series of three variables given by the modified function of the Value-Added in the Oil Sector:

$$ROILVAL_t = f(ROEXP_t)$$

Where,

$ROILVAL_t$ = Real Value-Added in the Oil Sector.

$ROEXP_t$ = Real Oil Exports.

Table 6.41 shows the results of the testing for stationarity. The DF and ADF indicate that none of the variables is stationary in its level, but are stationary in the first differences. This means that the Real Value-Added in the Oil Sector ($ROILVAL_t$) and Real Oil Exports ($ROEXP_t$) are integrated of order 1, i.e. I(1).

Table 6.41
Testing for Stationarity
(The Production Function For The Oil Sector)

	DF				ADF			
	Without Trend		With Trend		Without Trend		With Trend	
	X	ΔX	X	ΔX	X	ΔX	X	ΔX
ln $ROILVAL_t$	-1.629	-4.818*	-1.334	-5.438*	-1.467	-3.483*	-1.108	-3.500*
ln $ROEXP_t$	-0.887	-4.337*	-2.542	-4.751*	-2.101	-3.725*	-1.710	-4.213*

* significant at 5% level.

Therefore, it is possible to move on to the next step, attempting to detect if any of these variables cointegrate. This step, as mentioned above, is testing for cointegration between the Real Value-Added in the Oil Sector and Real Oil Exports applying the Engle-Granger (1987) two-step method. Table 6.42 shows the results of the cointegration test. The DF and ADF statistics accept the null hypothesis of no cointegration between the Real Value-Added in the Oil Sector and Real Oil Exports.

Table 6.42
Testing for Cointegration: The Engle-Granger Method
(The Production Function for the Oil Sector)

Dep. Variable	constant	$\ln ROEXP_t$	$\bar{R}^2$	DF	ADF	$CRDW$
$\ln ROILVAL_t$	-0.111	1.055 (17.85)	0.92	-2.07	-2.379	0.509

all variables are expressed in logarithmic term.
* significant at 5% level.

Equation (2), Table 6.43 examines Real Value-Added in the Oil Sector ($ROILVAL_t$). The Real Oil Exports ($\ln ROEXP_t$) is thought to affect the Real Value-Added in the Oil Sector ($ROILVAL_t$) positively and equation (2) supports this. The results in this equation are satisfactory, as the right signs for each individual coefficient were acquired and the t- values suggest that the explanatory variables are significant. Also, the calculated $\bar{R}^2$ suggests that 97% of the variation in the Real Value-Added in the Oil Sector over the estimation period, 1962-1991, can be explained by determining variables.

Table 6.43
The Empirical Results For The Production Function

No.	Method of Estimation	Estimation Results
1.	OLS	$\ln RNOQT_t = -3.304 + 0.356 \ln RNOKT_t + 1.190 \ln NONK_t + 0.013 TIME_t$ (10.40) (6.65) (1.54) $\bar{R}^2 = 0.97$ $D.W = 1.630$ $S.E = 0.101$ $F = 303.4$ $\chi^2_{SC}(2) = 2.287$ $\chi^2_{FF}(1) = 2.474$ $\chi^2_{HS}(1) = 1.142$
2.	OLS	$\ln ROILVAL_t = -0.166 + 0.899 \ln ROEXP_t + 0.124 \ln ROILVAL_{t-1}$ (10.50) (1.84) $\bar{R}^2 = 0.97$ $D.W = 2.060$ $S.E = 0.123$ $F = 514.3$ $\chi^2_{SC}(2) = 2.490$ $\chi^2_{FF}(1) = 1.200$ $\chi^2_{HS}(1) = 1.020$

$RNOQT_t$ = Real Value-Added in the Non-Oil Sector.
$RNOKT_t$ = Real Capital Stock in the Non-Oil Sector.
$NONK_t$ = Population Employed in the Non-Oil Sector.

$TIME_t$ = Time Trend.
$ROILVAL_t$ = Real Value-Added in the Oil Sector.
$ROILVAL_{t-1}$ = Real Value-Added in the Oil Sector lagged one year.
$ROEXP_t$ = Real Oil Exports.

6.10 Conclusions

Different equations, with different functions, have been estimated to chose the best equations and functional forms to represent the endogenous variables of the model. First difference of Real Adjusted Disposable Income ($\Delta RADY_t$) and the error correction term ($RADY_{t-1} - RCONS_{t-1}$) are the most important variables believed to determine Private Consumption Expenditure. The error correction model with OLS seems to be the best form to fit Real Private Consumption Expenditure, as Equation (1), Table 6.3 shows.

Oil Revenues ($OILREV_t$) and Government Consumption Expenditure lagged one year ($GCONS_{t-1}$) are the explanatory variables in the Government Consumption Expenditure Equation. The logarithmic form with OLS was the most sutable form to fit the Government Consumption Expenditure historical data, as Equation (1), Table 6.6 shows.

Real Investment Expenditure in the Manufacturing Sector is a function of Real Government's Annual Appropriation for Investment in the Manufacturing Sector ($RMANDE_t$) and Real Investment Expenditure in the Manufacturing Sector lagged one year ($RMANI_{t-1}$). The logarithmic form with OLS is the most appropriate form, as Equation (2), Table 6.15, shows.

The first difference of Real Government's Annual Appropriation for Investment in the Agriculture Sector ($\Delta RAGRDE_t$) and the error correction term ($RAGRDE_{t-1} - RAGRI_{t-1}$) are the main explanatory variables in the Real Investment Expenditure in the Agriculture Sector. The error correction model with OLS seems to be the most suitable form to fit Real Investment in the Agriculture, as Equation (3), Table 6.15 shows.

Real Value-Added in the Services Sector ($RSERVAL_t$), Real Government's Annual Appropriation for Investment in the Services Sector ($RSERDE_t$) and the Real Investment Expenditure in the Services Sector lagged one year ($RSERI_{t-1}$) are the explanatory variables in this function as Equation (4), Table 6.15 shows.

Real Investment Expenditure in the Construction Sector is determined by the first difference of Real Government's Annual Appropriation for Investment in the Construction Sector ($\Delta RCOTDE_t$) and the error correction term ($RCOTDE_{t-1} - RCOTI_{t-1}$). The error correction model with OLS seems to be the best form to fit Real Investment Expenditure in the Construction Sector, as Equation (5), Table 6.15 shows.

Real Oil Revenues ($ROILREV_t$) and Real Total Imports lagged one year ($RTIMP_{t-1}$) are the most important variables believed to determine Real Total Imports ($RTIMP_t$). The logarithmic form with OLS is the most appropriate form, which fits the data very well, as Equation (1), Table 6.24 shows.

Real Imports of Consumption Goods ($RIMPCONS_t$) is determined by the Real Adjusted Disposable Income ($RADY_t$), the Real Value-Added in the Manufacturing Sector ($RMANVAL_t$) and Real Imports of Consumption Goods lagged one year ($RIMPCONS_{t-1}$), as Equation (3) Table 6.24 shows.

Real Oil Revenues ($ROILREV_t$) and Real Imports of Intermediate and Raw Materials lagged one year ($RIMPINT_{t-1}$) are the most important variables believed to determine Real Imports of Intermediate and Raw Materials ($RIMPINT_t$), as Equation (4) Table 6.24 indicates.

Real Oil Revenues lagged one period ($ROILREV_{t-1}$) and Real Imports of Capital Goods lagged one year ($RIMPCAP_{t-1}$) are the main determinants of the Real Imports of Capital Goods ($RIMPCAP_t$), as Equation (5) Table 6.24 shows.

Money Supply ($MONEY_t$) and Consumer Price Index lagged one year ($PSDX_{t-1}$) are the main determinants of the Consumer Price Index , as Equation (1), Table 6.31 shows.

Capital Formation Price Index ($INVDX_t$) is determined by the Gross Domestic Product Deflator ($PGDPIDX_t$) and Capital Formation Price Index ($INVDX_{t-1}$), as Equation (2) Table 6.31 indicates.

The Gross Domestic Product Deflator is a function of Money Supply lagged one year ($MONEY_{t-1}$), Imports Price Index (PIM_t) and Gross Domestic Product Deflator lagged one year ($PGDPIDX_{t-1}$). The log form with OLS is the most suitable form to fit the historical data, as Equation (3), Table 6.31 shows.

Real Gross Domestic Product (GDP_t) and Total Number of Workers Employed in the Economy lagged one year (TNW_{t-1}) are the explanatory variables of the Employment function, as Equation (1), Table 6.38 shows.

Real Oil Exports ($ROEXP_t$) and the Real Oil Revenues lagged one year ($OILREV_{t-1}$) are the most important variables believed to determine Real Oil Revenues Function. The log form with OLS seems to be the best form to fit the historical data of the Oil Revenues, as Equation (2), Table 6.38 shows.

Real Total Imports ($RTIMP_t$), Real Indirect Tax Revenues lagged one year ($RINTAX_{t-1}$) are the explanatory variables of the Indirect Tax Revenues Function, as Equation (3), Table 6.38 shows.

Real Capital Stock in the Non-Oil Sector ($RNOKT_t$), Population Employed in the Non-Oil Sector ($NONK_t$) and the Time Trend ($TIME_t$) are the most important variables believed to determine production function in the Non-

Oil Sector. The Cobb-Douglas form seems to fit the historical data of the Non-Oil Value-Added Equation (1), as Table 6.43 shows.

Real Oil Exports ($ROEXP_t$) and Real Value-Added in the Non-Oil Sector lagged one year ($ROILVAL_{t-1}$) are the main determinants of the Real Value-Added in the Oil Sector. The log form with OLS seems to be the most suitable form, which fits the data very well, as Equation (2) Table 6.43 shows.

Having estimated the model equations, the next step is to use the estimated equations together, to attempt to simulate the functioning and interactions of the entire Libyan economy. This simulation is discussed in the next chapter.

CHAPTER SEVEN

The Model Simulation

7.1 Introduction

Having discussed the estimation of individual equations in chapter Six, the next stage is to combine those individual equations together to form a model of the Libyan Economy. This chapter will be divided into ten sections. The next section will introduce the Multi-equation simulation model. Sections three and four will investigate the aggregate version of the model, applying the Ordinary Least Square (OLS) method of estimation, its evaluation depending on its Root Mean Square Percent Error (RMSPE) values and its capability of tracking the historical data. Section five will discuss the improvement of the aggregate model simulation and its capability of tracking the historical data by applying the Two Stage Least Square (2SLS) method. Sections six, seven, eight and nine, will present the disaggregate version of the model, the evaluation of its performance in tracking the historical data and the capturing of the turning points. The OLS and 2SLS methods have been applied to the disaggregated version. Section ten will summarise the main findings of this chapter.

7.2 Introduction to Multi-Equation Simulation Models

A simulation is simply a mathematical solution of a simultaneous set of difference equations (Pindyck and Rubinfeld 1991). This statement should not give us the impression that the simulation process is just putting together several equations that have already been estimated individually. It is very possible that, in spite of the individual equations fitting the historical data very well, the simulation of the system of these equations may track the historical data poorly. This could be due to the dynamic structure of the system.

In a simulation process we have several behavioural equations and identities. The behavioural disaggregate equations have already been estimated individually and their parameters are all known through the estimation procedure, or numerical values for some of these parameters can be supplied. Given initial values for the endogenous variables and given time series for the exogenous variables, the model will be solved over a certain range of time to yield solutions for each endogenous variable. This could be written as a mathematical form for a linear model as follows:

$$\underline{AY_t} = \underline{\alpha X_t} + \underline{\beta Y_{t-1}} + \underline{E_t}$$

Where,

$\underline{Y_t}$ = [N *1] vector of endogenous variables.

$\underline{Y_{t-1}}$ = [N_{-1} *1] vector of endogenous variables lagged one period.

$\underline{X_t}$ = [K *1] vector of exogenous variables.

$\underline{E_t}$ = [N *1] vector of residuals.

$\underline{A}$, $\underline{\alpha}$, $\underline{\beta}$ = Numerical matrices of order [N * N], [N * K] and [N * N] receptively.

$\underline{N}$, $\underline{K}$ = Number of endogenous and exogenous variables respectively.

The solution of this model is:

$$\underline{Y_t} = \underline{\chi_{10} X_t} + \underline{\chi_{21} Y_{t-1}} + \underline{E_t^{/}}$$

Where,

$$\underline{\chi_{10}} = \underline{A^{-1}\alpha}$$

$$\underline{\chi_{21}} = \underline{A^{-1}B}$$

$$\underline{E_t'} = \underline{A^{-1}E_t}$$

Simulation exercises are very important for purposes such as model testing and evaluation, historical policy analysis and forecasting. The time horizon over which the simulation is performed will depend on the objective of the simulation. Therefore, if the simulation of the model is performed over the historical data for all the variables, this type of simulation is called ex-post simulation. Ex-post simulation is used to judge the validity of the model, by comparing the original data series with the simulated series for each endogenous variable.

Policy analysis is another important area of ex-post simulation. This is performed by changing parameter values, or letting exogenous policy variables follow different time paths, so that one can examine and compare what might have happened as a result of alternative policies. Backcast simulation is another type of simulation, which is used to generate values of the endogenous variables before the estimation period of the model. Therefore, backcast simulation generates data prior to the starting year of estimation (1964), while ex-post simulation generates data after the last year of estimation (1991).

Ex-ante simulation is also known as forecasting, where the model simulates forward in time beyond the estimation period. This requires the availability of the time series of the exogenous variables covering the period for which the forecast is intended.

There are two kinds of forecast. The first is called the ex-post forecast, in which the forecasting process yields values of the endogenous variables starting at the end of the estimation period to the present. It is necessary that post-estimation values of the endogenous variables are available, to make it possible to compare the forecast values with the real data for the endogenous variables. This procedure is often applied as a test of the accuracy of the model forecasting power. The second kind of forecast is called the ex-ante forecast, in which the simulation begins in the current year and extends into the future. The forecast exercisers are usually used for predictive purposes, sensitivity analysis and policy analysis.

After the simulation process is completed, the evaluation procedure then follows. Evaluation is a process which enables us to form some judgement as to how well the model performs as an interdependent unit in tracking the movements of certain strategies economic variables. There are several criteria that have been used in the evaluation process, such as:

7.2.1 Mean Simulation Error (MSE)

The MSE simulation error for the variable Y_t is defined as:

$$MSE = \frac{1}{T}\sum_{t=1}^{T}(Y_t^s - Y_t^a)$$

Where,

Y_t^s = Simulated value of the variable.

Y_t^a = Actual value of the variable.

T = Number of periods in the simulation.

The MSE error is a measure of the deviation of the simulated variable from its actual time path. The MSE can be written in proportional form [MSEP] as below:

$$MSEP = \frac{1}{T}\sum_{t=1}^{T}\frac{Y_t^s - Y_t^a}{Y_t^a}$$

The MSE and the MSEP might give a false picture of the accuracy of the model in tracking its historical data. This is large positive errors might cancel out large negative errors. So in order to overcome this drawback, the absolute value of the errors, or the square of the errors, will be taken instead of its value. The new criterion is called the Root Mean Square Error (RMSE) and its mathematical form is:

$$RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2}$$

Sometimes the RMSE is presented in proportional form and called the Root Mean Square Percentage Error RMSPE, as:

$$RMSPE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(\frac{Y_t^s - Y_t^a}{Y_t^a})^2}$$

In models of less developed countries a variable is considered to have done well in simulation if the Root Mean Squared Percentage Error (RMSPE) is 15 or less with the exception of the foreign trade sector when an RMSPE of 25 or less is acceptable (Klein and Evans, 1968).

The capability of the model to track the turning points in the real data could also be an important criterion in evaluation, especially when the model is intended to be used in detailed forecasting.

7.3 Simulation and Evaluation of the Model Performance

The first version of the model is highly aggregate. The model consists of twenty-five equations, thirteen of which are behavioural while the other twelve are identities. There are twenty-five endogenous variables and thirteen exogenous variables, as Table 7.1 shows. The OLS estimator is used in the estimation procedure.

The results of this model simulation are presented in Table 1.2 Appendix 1. From that table, graphs may be derived of the actual and the simulated values of each endogenous variable in the model. From the graphs, which are presented in Appendix 2, the model seems to track historical data quite well, except for Total Imports and Indirect Tax Revenues. This could be related to a mis-specification problem.

The Oil Revenues is the main explanatory variable in the Government Consumption Expenditure ($GCONS_t$), Total Government Investment ($RTINVS_t$) and also in the Total Imports equation ($RTIMP_t$). This will make these equations very sensitive to the Oil Revenues equation, in which the value of the Oil Revenues is generated. Oil Revenues is also used in the other equations. Because of this, Oil Revenues was considered to be exogenous in the second version of the model.

The results of the simulation of the second version of the model are shown in Appendix 1 Table 1.3 and the graphs of the simulated and actual endogenous variables are presented in Appendix 2, Graph 2.9 to 2.14. From these graphs, it is clearly seen that the capability of the second version of the model in tracking data is improved over the first version.

Table 7.1
The Aggregate Version of the Model Using OLS Method

No	Method of Estimation	Equation
1.	OLS	$\Delta \ln RCONS_t = -0.082 + 0.613\Delta \ln RADY_t + 0.654(\ln RADY_{t-1} - \ln RCONS_{t-1})$
2.	OLS	$\ln GCONS_t = 0.273 + 0.148 \ln OILREV_t + 0.826 \ln GCONS_{t-1}$
3.	OLS	$\ln RTNVS_t = 0.103 \ln ROILREV_t + 0.169 \ln RGDP_t + 0.689 \ln RTINVS_{t-1}$
4.	OLS	$\ln RTGSP_t = 0.520 + 0.183 \ln ROILREV_t + 0.760 \ln RTGSP_{t-1}$
5.	OLS	$\ln PSDX_t = 0.274 + 0.027 \ln MONEY_t + 0.921 \ln PSDX_{t-1}$
6.	OLS	$\ln INVDX_t = 0.322 + 0.073 \ln PGDPIDX_t + 0.864 \ln INVDX_{t-1}$
7.	OLS	$\ln PGDPIDX_t = 0.647 + 0.135 \ln MONEY_{t-1} + 0.246 \ln PIM_t + 0.480 \ln PGDPIDX_{t-1}$
8.	OLS	$\ln RTIMP_t = 0.638 + 0.121 \ln ROILREV_t + 0.766 \ln RTIMP_{t-1}$
9.	OLS	$\ln RNOQT_t = -3.304 + 0.356 \ln RNOKT_t + 1.188 \ln NONK_t + 0.013 TIME_t$
10.	OLS	$\ln TNW_t = 0.262 + 0.033 \ln ROILREV_t + 0.933 \ln TNW_{t-1}$
11.	OLS	$\ln RINTAX_t = -1.043 + 0.210 \ln RTIMP_t + 0.403 \ln RTCONS_t + 0.352 \ln RINTAX_{t-1}$
12.	OLS	$\ln ROILVAL_t = -0.166 + 0.899 \ln ROEXP_t + 0.124 \ln ROILVAL_{t-1}$
13.	OLS	$\ln ROILREV_t = 0.119 + 0.402 \ln ROEXP_t + 0.590 \ln ROILREV_{t-1}$
14.	IDENT	$RCST_t = RTINVS_t + 0.9(RCST_{t-1})$
15.	IDENT	$NOKT_t = RCST_t - OILCST_t$
16.	IDENT	$TCONS_t = CONS_t + GCONS_t$
17.	IDENT	$TINVS_t = MANI_t + AGRI_t + SERI_t + COTI_t$
18.	IDENT	$RTINVS_t = (TINVS_t \;/\; INVDX_t) * 100$
19.	IDENT	$NOQT_t = GDP_t - OILVAL_t$
20.	IDENT	$TNW_t = MANNK_t + AGRNK_t + SERNK_t + COTNK_t + OILNK_t$
21.	IDENT	$NONK_t = TNW_t - OILNK_t$
22	IDENT	$RNATY = CONS / PSDX * 100 + GCONS / PSDX * 100 + TINVS / INVDX * 100 + TEXPORT / PSDX * 100 - TIMP / PIM * 100 - INTAX / PSDX * 100 - CST / INVDX * 100)$
23	IDENT	$RGDP = CONS / PSDX * 100 + GCONS / PSDX * 100 + TINVS / INVDX * 100 + TEXPORT / PSDX * 100 + ERRTEM - TIMP / PIM * 100$
24	IDENT	$RADY = (GDP / PGDPIDX * 100) - (INTAX / PSDX * 100)$
25	IDENT	$TGSP = GCONS + TINVS$

The Root Mean Square Percent Error (RMSPE) and the capability of the model to capture the turning points on the historical data will be considered as main criteria to evaluate the model performance. From the detailed simulation results for the model within the sample estimation period, which are given in Appendix 1 Table 1.2 and 1.3, the RMSPE for the first and the second version of the model were calculated and are summarised in Table 7.2.

From Table 7.2, it can be seen that the RMSPE of the second version of the model is lower for most of the variables than the RMSPE for the corresponding variables of the first version.

The highest values of the RMSPE in the first and the second versions are 0.900 and 0.724, which are related to the Real Indirect Tax Revenues ($RINTAX_t$) in both versions.

Table 7.2
The Accuracy of the Ex-Post Simulation of the Aggregate Version of the Model

No.	Endogenous Variable	Version 1 RMSPE %	Version 2 RMSPE %
1.	$\ln RCONS_t$	0.365	0.365
2.	$\ln GCONS_t$	0.340	0.240
3.	$\ln RTINVS_t$	0.631	0.500
4.	$\ln PSDX_t$	0.449	0.440
5.	$\ln INVDX_t$	0.174	0.174
6.	$\ln PGDPIDX_t$	0.425	0.425
7.	$\ln RTIMP_t$	0.550	0.340
8.	$\ln RNOQT_t$	0.166	0.166
9.	$\ln TNW_t$	0.266	0.206
10.	$\ln RINTAX_t$	0.900	0.724
11.	$\ln GDP_t$	0.372	0.310
12.	$\ln ROILREV_t$	0.793	-
	Average RMSPE	0.500	0.353

Note:
Version 1 = Real Oil Revenues is Endogenous.
Version 2 = Real Oil Revenues is Exogenous.

The lowest value of RMSPE in Table 7.2 is related to the Real Non-Oil Value Added ($RNOQT_t$) in both versions. On average, the RMSPE value is 0.500 and 0.353 for the first and the second versions of the model, respectively. From the above discussion it could be said that the model performance in tracking its data is fairly good.

7.4 Tracking the Turning Points

The second criterion to evaluate the model performance is the capability of the model in tracking the turning points of its historical data.

Table 7.3 shows the real turning points and the ones captured by the model for each endogenous variable. Most of the turning points have been missed by one year. This might be related to the lag structure in the model specification and to the dynamic features of the solution technique used. Accordingly, turning points with a one year margin of error will be considered to have been captured. in this criterion, the model captured 64% of total turning points, as Table 7.3 shows.

Table 7.3
Model's Capability of Capturing the Turning Points

No.	Endogenous Variable	No. of Real Turning Points	No. of Turning Points Captured
1.	$\ln RCONS_t$	7	5
2.	$\ln RTINVS_t$	7	4
3.	$\ln RTIMP_t$	9	5
4.	$\ln RNOQT_t$	10	7

7.5 Applying the Two Stage Least Square (2SLS) Method

The Two Stage Least Square (2SLS) was applied to the model equations to see whether the model performance, in tracking its historical data and in capturing the turning points of the historical data, would be improved or not.

The estimated equations are presented at Table 7.4 and the results of the simulation are presented in Appendix 1 Table 1.4, and the graphs of the simulated and actual endogenous variables are presented in Appendix 2, Graph 2.15 to 2.21. From that graphs, the simulation results generated by applying 2SLS did not differ greatly from those generated by applying OLS.

List of Variables

(a) Endogenous Variables:

$RCONS_t$ = Real Private Consumption Expenditure (Million L.D.).

$GCONS_t$ = Government Consumption Expenditure (Million L.D.).

$RTINVS_t$ = Real Total Investment Expenditure (Million L.D.).

$RMANI_t$ = Real Gross Investment in the Manufacturing Sector (Million L.D.).

$RAGRI_t$ = Real Gross Investment in the Agricultural Sector (Million L.D.).

$RSERI_t$ = Real Gross Investment in the Services Sector (Million L.D.).

$RCOTI_t$ = Real Gross Investment in the Construction Sector (Million L.D.).

$RTGSP_t$ = Real Total Government Expenditure (Million L.D.).

$PSDX_t$ = Consumer Price Index.

$INVDX_t$ = Capital Formation Price Index (Million L.D.).

$PGDPIDX_t$ = Gross Domestic Product Deflator.

$RTIMP_t$ = Real Total Imports (Million L.D.).

$RIMPCAPT_t$ = Real Imports of Capital Goods (Million L.D.).

$RIMPCONS_t$ = Real Imports of Consumption Goods (Million L.D.).

$RIMPINT_t$ = Real Imports of Raw Materials and Intermediate Goods (Million L.D.).

$RNOQT_t$ = Real Non-Oil Value-Added (Million L.D.).

TNW_t = Total Population Employed in the Libyan Economy (Thousands).

$RINTAX_t$ = Real Indirect Tax Revenue (Million L.D.).

$ROILVAL_t$ = Real Value-Added Generated in the Oil Sector (Million L.D.).

$ROILREV_t$ = Real Oil Revenues (Million L.D.).

$RADY_t$ = Real Adjusted Disposable Income (Million L.D.).

$RGDP_t$ = Real Gross Domestic Product (Million L.D.).

$RAGRVAL_t$ = Real Value-Added Generated in the Agricultural Sector (Million L.D.).

$RMANVAL_t$ = Real Value-Added Generated in the Manufacturing Sector (Million L.D.).

$RSERVAL_t$ = Real Value-Added Generated in the Services Sector (Million L.D.).

$RCOTVAL_t$ = Real Value-Added Generated in the Construction Sector (Million L.D.).

$RNOKT_t$ = Real Non-Oil Capital Stock (Million L.D.).

$RTCONS_t$ = Real Total Consumption Expenditure (Million L.D.).

(b) Predetermined Variables:

$MANNK_t$ = Population Employed in the Manufacturing Sector lagged one year (Thousand).

$AGRNK_t$ = Population Employed in the Agricultural Sector lagged one year (Thousand).

$SERNK_t$ = Population Employed in the Services Sector lagged one year (Thousand).

$COTNK_t$ = Population Employed in the Construction Sector lagged one year (Thousand).

$OILNK_t$ = Population Employed in the Oil Sector lagged one year (Thousand).

$NONK_t$ = Non-Oil Total Population Employed lagged one year (Thousand).

$RAGRDE_t$ = Real Government's Annual Appropriation for Investment in the Agriculture Sector (Million L.D.).

$BARREL_t$ = Oil Production (Mbd).

$RCOTDE_t$ = Real Government's Annual Appropriation for Investment in the Construction Sector (Million L.D.).

$RCST_t$ = Real Total Capital Stock (Million L.D.).

$RMANCST_t$ = Real Capital Stock in the Manufacturing Sector (Million L.D.).

$RAGRCST_t$ = Real Capital Stock in the Agricultural Sector (Million L.D.).

$RSERCST_t$ = Real Capital Stock in the Services Sector (Million L.D.).

$RCOTCST_t$ = Real Capital Stock in the Construction Sector (Million L.D.).

$ROILCST_t$ = Real Capital Stock in the Oil Sector (Million L.D.).

$DISY_t$ = Personal Disposable Income (Million L.D.).

$DTAX_t$ = Direct Tax Revenue (Million L.D.).

$ECHRATE_t$ = Official Exchange Rate.

$RMANDE_t$ = Real Government's Annual Appropriation for Investment in the Manufacturing Sector (Million L.D.).

$MONEY_t$ = Money Supply (Million L.D.).

$NATY_t$ = National Income (Million L.D.).

$NOEXP_t$ = Non-Oil Exports (Million L.D.).

$OEXP_t$ = Oil Exports (Million L.D.).

$OILPRI_t$ = Oil Price (L.D.).

PIM_t = Import Price Index.

POP_t = Total Population.

$RSERDE_t$ = Real Government's Annual Appropriation for Investment in the Services Sector (Million L.D.).

$RTDE_t$ = Real Total Government's Annual Appropriation for Investment (Million L.D.).

$TIME_t$ = Time

$RTINVS_{t-1}$ = Real Total Investment Expenditure lagged one year.
$TREVN_t$ = Government Total Revenue (Million L.D.).

$RCONS_{t-1}$ = Real Private Consumption Expenditure lagged one year.

$GCONS_{t-1}$ = Government Consumption Expenditure lagged one year.

$RTINVS_{t-1}$ = Real Total Investment Expenditure lagged one year.

$RMANI_{t-1}$ = Real Gross Investment in the Manufacturing Sector lagged one year.

$RAGRI_{t-1}$= Real Gross Investment in the Agricultural Sector lagged one year.

$RSERI_{t-1}$ = Real Gross Investment in the Services Sector lagged one year.

$RCOTI_{t-1}$ = Real Gross Investment in the Construction Sector lagged one year.

$RTGSP_{t-1}$ = Real Total Government Expenditure lagged one year.

$PSDX_{t-1}$ = Consumer Price Index lagged one year.

$INVDX_{t-1}$ = Capital Formation Price Index lagged one year.

$PGDPIDX_{t-1}$ = Gross Domestic Product Deflator lagged one year.

$RTIMP_{t-1}$ = Real Total Imports lagged one year.

$RIMPCAPT_{t-1}$ = Real Imports of Capital Goods lagged one year.

$RIMPCONS_{t-1}$ = Real Imports of Consumption Goods lagged one year.

$RIMPINT_{t-1}$ = Real Imports of Raw Materials and Intermediate Goods lagged one year

$RNOQT_{t-1}$ = Real Non-Oil Value-Added lagged one year.

TNW_{t-1} = Total Population Employed in the Libyan Economy lagged one year Thousand).

$RINTAX_{t-1}$ = Real Indirect Tax Revenue lagged one year.

$ROILVAL_{t-1}$ = Real Value-Added Generated in the Oil Sector lagged one year.

$ROILREV_{t-1}$ = Real Oil Revenues lagged one year.

$RADY_{t-1}$ = Real Adjusted Disposable Income lagged one year.

$RCOTDE_{t-1}$ = Real Government's Annual Appropriation for Investment in the Construction Sector lagged one year.

$RMANDE_{t-1}$ = Real Government's Annual Appropriation for Investment in the Manufacturing Sector lagged one year.

$RMANVAL_{t-1}$ = Real Value-Added Generated in the Manufacturing Sector lagged one year.

$ROILREV_{t-1}$ = Real Oil Revenues lagged one year.

$ROILVAL_{t-1}$ = Real Value-Added Generated in the Oil Sector lagged one year.

$RSERDE_{t-1}$ = Real Government's Annual Appropriation for Investment in the Services Sector lagged one year.

$RSERI_{t-1}$ = Real Gross Investment in the Services Sector lagged one year.

$TEXPORT_t$ = Total Exports (Million L.D.).

$RTCONS_{t-1}$ = Real Total Consumption Expenditure lagged one year.

Table 7.4
The Aggregate Version of the Model Using 2SLS Method

No	Method of Estimation	Equation
1.	2SLS	$\ln \Delta RCONS_t = -0.059 + 0.631 \ln \Delta RADY_t + 0.545(\ln RADY_{t-1} - \ln RCONS_{t-1})$
2.	2SLS	$\ln GCONS_t = 0.282 + 0.146 \ln OILREV_t + 0.827 \ln GCONS_{t-1}$
3.	2SLS	$\ln RTNVS_t = 0.591 + 0.184 \ln ROILREV_t + 0.749 \ln RGDP_t + 0.672 \ln RTINVS_{t-1}$
4.	2SLS	$\ln RTGSP_t = 0.592 + 0.184 \ln ROILREV_t + 0.750 \ln RTGSP_{t-1}$
5.	2SLS	$\ln PSDX_t = 0.271 + 0.029 \ln MONEY_t + 0.9191 \ln PSDX_{t-1}$
6.	2SLS	$\ln INVDX_t = 0.333 + 0.069 PGDPIDX_t + 0.866 \ln INVDX_{t-1}$
7.	2SLS	$\ln PGDPIDX_t = 0.555 + 0.153 \ln MONEY_{t-1} + 0.338 \ln PIM_t + 0.383 \ln PGDPIDX_{t-1}$
8.	2SLS	$\ln RTIMP_t = 0.667 + 0.118 \ln ROILREV_t + 0.763 \ln RTIMP_{t-1}$
9.	2SLS	$\ln RNOQT_t = -3.345 + 0.350 \ln RNOKT_t + 1.206 \ln NONK_t + 0.011 TIME_t$
10.	2SLS	$\ln TNW_t = 0.263 + 0.034 \ln ROILREV_t + 0.931 \ln TNW_{t-1}$
11.	2SLS	$\ln RINTAX_t = -1.055 + 0.203 \ln RTIMP_t + 0.412 \ln RTCONS_t + 0.346 \ln RINTAX_{t-1}$
12.	2SLS	$\ln ROILVAL_t = -0.170 + 0.899 \ln ROEXP_t + 0.124 \ln ROILVAL_{t-1}$
13.	2SLS	$\ln ROILREV_t = -1.989 + 1.021 \ln ROEXP_t + 0.220 \ln ROILREV_{t-1}$
14.	IDENT	$RCST_t = RTINVS_t + 0.9(RCST_{t-1})$
15.	IDENT	$NOKT_t = RCST_t - OILCST_t$
16.	IDENT	$TCONS_t = CONS_t + GCONS_t$
17.	IDENT	$TINVS_t = MANI_t + AGRI_t + SERI_t + COTI_t$
18.	IDENT	$RTINVS_t = (TINVS_t \,/\, INVDX_t) * 100$
19.	IDENT	$NOQT_t = GDP_t - OILVAL_t$
20.	IDENT	$TNW_t = MANNK_t + AGRNK_t + SERNK_t + COTNK_t + OILNK_t$
21.	IDENT	$NONK_t = TNW_t - OILNK_t$
22.	IDENT	$RNATY = CONS / PSDX * 100 + GCONS / PSDX * 100 + TINVS / INVDX * 100 + TEXPORT' / PSDX * 100 - TIMP / PIM * 100 - INTAX / PSDX * 100 - CST / INVDX * 100)$
23.	IDENT	$RGDP = CONS / PSDX * 100 + GCONS / PSDX * 100 + TINVS / INVDX * 100 + TEXPORT / PSDX * 100 + ERRTEM - TIMP / PIM * 100$
24.	IDENT	$RADY = (GDP / PGDPIDX * 100) - (INTAX / PSDX * 100)$
25.	IDENT	$TGSP = GCONS + TINVS$

The estimated equations are presented at Table 7.4 and the results of the simulation are presented in Appendix 1 Table 1.4. As this Table shows, the simulation results generated by applying 2SLS did not differ greatly from those generated by applying OLS.

The RMSPE is calculated from Table 1.4 Appendix 1 and summarised in Table 7.5. The RMSPE of variables is lower for 2SLS than OLS ($RCONS_t$, $GCONS_t$, $PSDX_t$, etc.), while for $RGDP_t$ it decreased from 0.372 to 0.340. The RMSPE on average improved from 0.500 for the model estimated applying OLS to 0.345 when 2SLS method was applied. Comparing the 2SLS results with the OLS results, the bias error, which we tried to reduce by applying the 2SLS seems to be significant.

Table 7.5
The Accuracy of Ex-Post Simulation of the Aggregate Version of the Model Using 2SLS

No.	Endogenous Variable	RMSPE %
1.	ln $RCONS_t$	0.275
2.	ln $GCONS_t$	0.222
3.	ln $RTINVS_t$	0.530
4.	ln $PSDX_t$	0.400
5.	ln $INVDX_t$	0.160
6.	ln $PGDPIDX_t$	0.400
7.	ln $RTIMP_t$	0.400
8.	ln $RNOQT_t$	0.166
9.	ln TNW_t	0.230
10	ln $RINTAX_t$	0.680
11	ln $RGDP_t$	0.340
	Average RMSPE	0.345

The model performance in capturing the turning points of the historical data, by applying 2SLS, has been improved compared to the model performance using OLS, as Table 7.6 shows. The 2SLS version of the model captured 73% of the turning points.

Table 7.6
2SLS Version Capability of Capturing the Turning Points

No.	Endogenous Variable	No. of Real Turning Points	No. of Turning Points Captured
1.	$\ln RCONS_t$	7	5
2.	$\ln RTINVS_t$	7	5
3.	$\ln RTIMP_t$	9	7
4.	$\ln RNOQT_t$	10	7

7.6 Disaggregation of the Model

In this stage the model will be disaggregated to the level the data allows. The variables which will be disaggregated are:

1. Total Consumption Expenditure ($TCONS_t$), split into:
   a. Private Consumption Expenditure ($CONS_t$).
   b. Government Consumption Expenditure ($GCONS_t$).
2. Total Government Investment Expenditure ($TINVS_t$) is disaggregated into:
   a. Investment in the Manufacturing Sector ($MANI_t$).
   b. Investment in the Agriculture Sector ($AGRI_t$).
   c. Investment in the Services Sector ($SERI_t$).
   d. Investment in the Construction Sector ($COTI_t$).
3. Total Imports ($TIMP_t$), split into:
   a. Imports of Consumption Goods ($IMPCONS_t$).
   b. Imports of Raw Materials and Intermediate Goods ($IMPINT_t$).
   c. Imports of Capital Goods ($IMPCAPT_t$).
4. Gross Domestic Product (GDP_t) is disaggregated into:
   a. Value-Added Generated in the Non-Oil Sector ($NOQT_t$).
   b. Value-Added Generated in the Oil Sector ($OILVAL_t$).

Table 7.7
The Disaggregate Version of the Model Using OLS Method

No	Method of Estimation	Equation
1.	OLS	$\ln \Delta RCONS_t = -0.082 + 0.613 \ln \Delta RADY_t + 0.654(\ln RADY_{t-1} - \ln RCONS_{t-1})$
2.	OLS	$\ln GCONS_t = 0.207 + 0.102 \ln OILREV_t + 0.892 \ln GCONS_{t-1}$
3.	OLS	$\ln RTGSP_t = 0.520 + 0.183 \ln ROILREV_t + 0.760 \ln RTGSP_{t-1}$
4.	OLS	$\ln RTNVS_t = 0.104 \ln ROILREV_t + 0.170 \ln RGDP_t + 0.690 \ln RTINVS_{t-1}$
5.	OLS	$\ln RMANI_t = 0.605 + 0.570 \ln RMANDE_t + 0.301 \ln RMANI_{t-1}$
6.	OLS	$\ln \Delta RAGRI_t = -0.015 + 0.620 \ln \Delta RAGRDE_t + 0.269(\ln RAGRDE_{t-1} - \ln RAGRI_{t-1})$
7.	OLS	$\ln RSERI_t = 1.740 + 0.774 \ln RSERDE_t$
8.	OLS	$\ln \Delta RCOTI_t = 0.239 + 0.566 \ln \Delta RCOTDE_t + 0.416(\ln RCOTDE_{t-1} - \ln RCOTI_{t-1})$
9.	OLS	$\ln PSDX_t = 0.274 + 0.028 \ln MONEY_t + 0.922 \ln PSDX_{t-1}$
10.	OLS	$\ln INVDX_t = 0.322 + 0.073 \ln PGDPIDX_{t-1} + 0.864 \ln INVDX_{t-1}$
11.	OLS	$\ln PGDPIDX_t = 0.647 + 0.135 \ln MONEY_{t-1} + 0.246 \ln PIM_t + 0.480 \ln PGDPIDX_{t-1}$
12.	OLS	$\ln RTIMP_t = 0.638 + 0.121 \ln ROILREV_t + 0.766 \ln RTIMP_{t-1}$
13.	OLS	$\ln RIMPCONS_t = -0.730 + 0.485 \ln RADY_t - 0.218 \ln RMANVAL_t + 0.576 \ln RIMPCONS_{t-1}$
14.	OLS	$\ln RIMPINT_t = 0.234 + 0.172 \ln ROILREV_t + 0.639 \ln RIMPINT_{t-1}$
15.	OLS	$\ln RIMPCAP_t = 0.736 + 0.133 \ln ROILREV_t + 0.716 \ln RIMPCAP_{t-1}$
16.	OLS	$\ln RNOQT_t = -3.304 + 0.356 \ln RNOKT_t + 1.188 \ln NONK_t + 0.013 TIME_t$
17.	OLS	$\ln TNW_t = 0.262 + 0.032 \ln ROILREV_t + 0.932 \ln TNW_{t-1}$
18.	OLS	$\ln RINTAX_t = -1.042 + 0.402 \ln RTCONS_t + 0.208 \ln RTIMP_t + 0.352 \ln RINTAX_{t-1}$
19.	OLS	$\ln ROILVAL_t = -0.166 + 0.899 \ln ROEXP_t + 0.124 \ln ROILVAL_{t-1}$
20.	OLS	$\ln ROILREV_t = -2.032 + 1.041 \ln ROEXP_t + 0.201 \ln ROILREV_{t-1}$
21.	IDENT	$RCST_t = RTINVS_t + 0.9(RCST_{t-1})$
22.	IDENT	$NOKT_t = RCST_t - OILCST_t$
23.	IDENT	$TCONS_t = CONS_t + GCONS_t$
24.	IDENT	$TINVS_t = MANI_t + AGRI_t + SERI_t + COTI_t$
25.	IDENT	$RTINVS_t = (TINVS_t / INVDX_t) * 100$

26.	IDENT	$NOQT_t = GDP_t - OILVAL_t$
27.	IDENT	$TNW_t = MANNK_t + AGRNK_t + SERNK_t + COTNK_t + OILNK_t$
28.	IDENT	$NONK_t = TNW_t - OILNK_t$
29	IDENT	$RNATY = CONS / PSDX * 100 + GCONS / PSDX * 100 + TINVS / INVDX * 100 + TEXPORT / PSDX * 100 - TIMP / PIM * 100 - INTAX / PSDX * 100 - CST / INVDX * 100)$
30.	IDENT	$RGDP = CONS / PSDX * 100 + GCONS / PSDX * 100 + TINVS / INVDX * 100 + TEXPORT / PSDX * 100 + ERRTEM - TIMP / PIM * 100$
31.	IDENT	$TDE_t = MANDE_t + AGRDE_t + SERDE_t + COTDE_t$
32.	IDENT	$RADY = (GDP / PGDPIDX * 100) - (INTAX / PSDX * 100)$
33.	IDENT	$TGSP = GCONS + TINVS$

7.7 Simulation Procedures

As was the case with the aggregate version of the model, OLS was applied first to estimate the model equations. The 2SLS method was applied later and its simulation results were compared with OLS simulation results. Real Oil Revenues was considered first as an endogenous variable in the model and then as an exogenous variable.

The dynamic simulation exercise was implemented. The results on applying the OLS method are detailed in Table 1.5 Appendix 1.

The RMSPE was calculated from Table 1.5 in Appendix 1 and is summarised in Table 7.8. Comparing Table 7.8 with Table 7.2, the RMSPE for the remaining aggregate variables are very similar. This indicates that the new equations introduced have little interdependence with the equations which have not been disaggregated. That might be related to our inability to disaggregate the entire set of endogenous variables of the model. The disaggregated variables are therefore related to each other rather than related to the remaining aggregate variables.

The RMSPE values are clearly lower for several variables when the Real Oil Revenues is considered as exogenous as Table 7.8 shows. For other variables, their RMSPE values did not alter at all, such as the investment expenditure at sector level, as Table 7.8 shows. The highest value of RMSPE is related to the Real Investment Expenditure in the Construction Sector ($RCOTI_t$) in both versions.

Table 7.8
The Accuracy of Ex-Post Simulation of the Disaggregate Version of the Model Using OLS Method

No.	Endogenous Variable	RMSPE % 1	RMSPE % 2
1.	$\ln RCONS_t$	0.330	0.330
2.	$\ln GCONS_t$	0.260	0.340
3.	$\ln RMANI_t$	1.660	1.660
4.	$\ln RAGRI_t$	1.330	1.330
5.	$\ln RSERI_t$	0.424	0.424
6.	$\ln RCOTI_t$	1.700	1.700
7.	$\ln PSDX_t$	0.460	0.440
8.	$\ln INVDX_t$	0.168	0.170
9.	$\ln PGDPIDX_t$	0.353	0.353
10	$\ln RTIMP_t$	0.360	0.460
11.	$\ln RIMPCONS_t$	1.400	1.370
12.	$\ln RIMPINT_t$	1.370	1.500
13.	$\ln RIMPCAP_t$	0.510	0.600
14.	$\ln RNOQT_t$	0.165	0.165
15.	$\ln TNW_t$	0.240	0.280
16.	$\ln RINTAX_t$	0.680	0.860
17.	$\ln ROILVAL_t$	1.066	1.066
18.	$\ln RGDP_t$	0.300	0.375
19.	$\ln ROILREV_t$	-	0.750
	Average RMSPE	0.709	0.800

Note:

(1) = Real Oil Revenues is exogenous.
(2) = Real Oil Revenues is endogenous.

The lowest value of RMSPE in Table 7.8 is related to the Value-Added in the Non-Oil Sector ($RNOQT_t$), which is very close to its value in the aggregate version, as Table 7.8 and 7.2 show. On average, the RMSPE values are 0.709 and 0.800, for the Real Oil Revenues exogenous and endogenous respectively.

7.8 Tracking the Turning Points

The capability of the model's performance in tracking the turning points of the historical data is presented in Table 7.9.

From Table 7.9, the model captured six turning points from seven relating to the Real Private Consumption Expenditure ($RCONS_t$), five turning points from seven relating to the Real Total Government Investment ($RTINVS_t$), six turning points from nine relating to Real Total Imports ($RTIMP_t$), and five turning points from six relating to Capital Formation Price Index ($INVDX_t$). On average, the desegregated version of the model captured 80.3% of the total turning points.

Table 7.9
Model Capability of Capturing the Turning Points

No.	Endogenous Variable	No. of Real Turning Points	No. of Turning Points Captured
1.	$\ln RCONS_t$	7	6
2.	$\ln RTINVS_t$	7	5
3.	$\ln RMANI_t$	11	9
4.	$\ln RSERI_t$	9	7
5.	$\ln RTIMP_t$	9	6
6.	$\ln PSDX_t$	7	5
7.	$\ln INVDX_t$	6	5
8.	$\ln RNOQT_t$	10	10

7.9 Applying the Two Stage Least Square (2SLS) Method

The 2SLS method was applied to estimate the disaggregated model equations simultaneously and the results of the simulation are presented in Table 1.6 Appendix 1, and the graphs of the simulated and actual endogenous variables are presented in Appendix 2, Graph 2.22 to 2.32.

The RMSPE is calculated from Table 1.6 in Appendix 1 and summarised in Table 7.11. Some of the variable ($RCONS_t$, $GCONS_t$, $RMANI_t$, $RAGRI_t$ $RSERI_t$, $PSDX_t$, $INVDX_t$, $PGDPIDX_t$, $RTIMP_t$, $RIMPCONS_t$, $RIMPINT_t$, $RINTAX_t$, TNW_t, $ROILVAL_t$) have their RMSPE values reduced as compared with those generated by the OLS method. Only two endogenous variables ($RCOTI_t$, $RIMPCAP_t$) had their RMSPE values increase slightly as compared with those generated by applying the OLS method, as Table 7.8 shows. For the rest, their RMSPE values stayed constant, because the absence of any interdependency between these variables and the rest of the model. On average, the RMSPE value is 0.615.

In general, the capability of the model in capturing the turning points was not improved when the 2SLS method was applied, as Table 1.5 and Table 1.6 in Appendix 1 show.

Table 7.10
The Disaggregate Version of the Model Using 2SLS Method

No	Method of Estimation	Equation
1.	2SLS	$\ln \Delta RCONS_t = -0.059 + 0.631 \ln \Delta RADY_t + 0.544(\ln RADY_{t-1} - \ln RCONS_{t-1})$
2.	2SLS	$\ln GCONS_t = 0.281 + 0.146 \ln OILREV_t + 0.827 \ln GCONS_{t-1}$
3.	2SLS	$\ln RTINVS_t = 0.119 \ln ROILREV_t + 0.147 \ln RGDP_t + 0.702 \ln RTINVS_{t-1}$
4.	2SLS	$\ln RTGSP_t = 0.592 + 0.184 \ln ROILREV_t + 0.750 \ln RTGSP_{t-1}$
5.	2SLS	$\ln RMANI_t = 0.604 + 0.570 \ln RMANDE_t + 0.301 \ln RMANI_t$
6.	2SLS	$\ln \Delta RAGRI_t = -0.018 + 0.6201 \ln \Delta RAGRDE_t + 0.283(\ln RAGRDE_{t-1} - \ln RAGRI_{t-1})$
7.	2SLS	$\ln RSERI_t = 1.740 + 0.774 \ln RSERDE_t$
8.	2SLS	$\ln \Delta RCOTI_t = 0.253 + 0.562 \ln \Delta RCOTDE_t + 0.423(\ln RCOTDE_{t-1} - \ln RCOTI_{t-1})$
9.	2SLS	$\ln PSDX_t = 0.025 \ln TGSP + 0.053 \ln MONEY_t + 0.922 \ln PSDX_{t-1}$
10.	2SLS	$\ln INVDX_t = 0.333 + 0.069 \ln PGDPIDX_{t-1} + 0.866 \ln INVDX_{t-1}$
11.	2SLS	$\ln PGDPIDX_t = 0.079 \ln MONEY_{t-1} + 0.355 \ln INVDX_t + 0.554 \ln PSDX_t + 0.577 \ln PGDPIDX_{t-1}$
12.	2SLS	$\ln RTIMP_t = 0.639 + 0.162 \ln ROILREV_t + 0.720 \ln RTIMP_{t-1}$
13.	2SLS	$\ln RIMPCONS_t = -0.411 + 0.102 \ln ROILREV_t + 0.751 \ln RIMPCONS_{t-1}$
14.	2SLS	$\ln RIMPINT_t = 0.167 + 0.102 \ln ROILREV_t + 0.519 \ln RIMPINT_{t-1}$
15.	2SLS	$\ln RIMPCAP_t = 0.572 + 0.215 \ln ROILREV_t + 0.665 \ln RIMPCAP_{t-1}$
16.	2SLS	$\ln RNOQT_t = -3.345 + 0.351 \ln RNOKT_t + 1.206 \ln NONK_t + 0.011 TIME_t$
17.	2SLS	$\ln TNW_t = 0.032 \ln ROILREV_t + 0.974 \ln TNW_{t-1}$
18.	2SLS	$\ln RINTAX_t = -1.055 + 0.413 \ln RTCONS_t + 0.203 \ln RTIMP_t + 0.346 \ln RINTAX_{t-1}$
19.	2SLS	$\ln ROILVAL_t = -0.164 + 0.866 \ln ROEXP_t + 0.157 \ln ROILVAL_{t-1}$
20.	IDENT	$RCST_t = RTINVS_t + 0.9(RCST_{t-1})$
21.	IDENT	$NOKT_t = RCST_t - OILCST_t$
22.	IDENT	$TCONS_t = CONS_t + GCONS_t$
23.	IDENT	$TINVS_t = MANI_t + AGRI_t + SERI_t + COTI_t$
24.	IDENT	$RTINVS_t = (TINVS_t / INVDX_t) * 100$
25.	IDENT	$NOQT_t = GDP_t - OILVAL_t$

26.	IDENT	$TNW_t = MANNK_t + AGRNK_t + SERNK_t + COTNK_t + OILNK_t$
27.	IDENT	$NONK_t = TNW_t - OILNK_t$
28.	IDENT	$RNATY = CONS / PSDX * 100 + GCONS / PSDX * 100 + TINVS / INVDX * 100 + TEXPORT / PSDX * 100 - TIMP / PIM * 100 - INTAX / PSDX * 100 - CST / INVDX * 100)$
29.	IDENT	$RGDP = CONS / PSDX * 100 + GCONS / PSDX * 100 + TINVS / INVDX * 100 + TEXPORT / PSDX * 100 + ERRTEM - TIMP / PIM * 100$
30.	IDENT	$TDE_t = MANDE_t + AGRDE_t + SERDE_t + COTDE_t$
31.	IDENT	$RADY = (GDP / PGDPIDX * 100) - (INTAX / PSDX * 100)$
32.	IDENT	$TGSP = GCONS + TINVS$

Table 7.11
The Accuracy of Ex-Post Simulation of the Disaggregate Version of the Model Using 2SLS Method

No.	Endogenous Variable	RMSPE %
1.	$\ln RCONS_t$	0.240
2.	$\ln GCONS_t$	0.250
3.	$\ln RMANI_t$	1.300
4.	$\ln RAGRI_t$	1.030
5.	$\ln RSERI_t$	0.368
6.	$\ln RCOTI_t$	2.000
7.	$\ln PSDX_t$	0.340
8.	$\ln INVDX_t$	0.137
9.	$\ln PGDPIDX_t$	0.340
10.	$\ln RTIMP_t$	0.350
11.	$\ln RIMPCONS_t$	0.670
12.	$\ln RIMPINT_t$	0.960
13.	$\ln RIMPCAP_t$	0.660
14.	$\ln RNOQT_t$	0.165
15.	$\ln TNW_t$	0.230
16.	$\ln RINTAX_t$	0.680
17.	$\ln ROILVAL_t$	1.030
18.	$\ln GDP_t$	0.330
	Average RMSPE	0.615

7.10 Conclusion

Different versions of the model and different estimators have been used in order to establish the best version and most efficient method of estimation. We may conclude that the disaggregate version of the model using 2SLS estimators gives the best results in tracking the historical data, as measured by the RMSPE. Therefore, this version of the model will be adopted in the multiplier analysis, which is discussed in the next chapter.

CHAPTER EIGHT

MULTIPLIER ANALYSIS OF THE MODEL

8.1 Introduction

Having completed the estimation and evaluation stages, the next step is to validate the model. Multiplier analysis is a technique which is often used in the validation of a forecasting system. The multipliers are concerned with finding out the effects on the endogenous variables of specified changes in the exogenous variables (Chalien and Hagger, 1983). This chapter will be divided into seven sections. The second section will discuss linear multiplier analysis. The third section is allocated to a discussion of the non-linear multipliers. The fourth section will present the working mechanism of the system. The fifth section will discuss the elasticities of some of the endogenous variables. Section six will test the stability of the model. Section seven will summarise the main points discussed in the chapter.

8.2 Linear Multiplier Analysis

There are four kinds of multipliers. The first is called the impact multiplier. This measures the change in the period t value of the ith endogenous variable per unit increase in the period t value of the jth exogenous variable, with all other determinants of the endogenous variable held fixed. This can be defined as:

$$\frac{\partial y_t^i}{\partial x_t^j}$$

Where

y_t^i = ith element of endogenous variable y_t.

x_t^j = jth element of exogenous variable x_t

The second multiplier is the delay multiplier. This measures the change in the period t+r value of ith endogenous variable per unit increase in the period t value of the jth exogenous variable, with all other determinants of y_{t+r}^i held fixed. This multiplier can be defined as:

$$\frac{\partial y_{t+r}^i}{\partial x_t^j}$$

The third kind of multiplier is the intermediate-run multiplier. This measures the cumulated change in the value of the ith endogenous variable over the run of s period, t to t+s, per unit maintained increase in the period t value of exogenous variable, with all other determinants of y_t^i, ..., y_{t+s-1}^i held fixed. In mathematical form this can be written as:

$$\frac{\partial y_t^i}{\partial x_t^j} + \frac{\partial y_{t+1}^i}{\partial x_t^j} + \ldots + \frac{\partial y_{t+s-1}^i}{\partial x_t^j}$$

The fourth multiplier is the long-run multiplier. This measures the total change in the value of the ith endogenous variable per unit maintained increase in the period t value of the exogenous variable. The long-run multiplier can be defined as the limit as s tends to infinity of the corresponding intermediate-run multiplier, provided that a limit exists. The multiplier can be written as:

$$\lim_{s\to\infty}\left[\frac{\partial y_t^i}{\partial x_t^j}+\frac{\partial y_{t+1}^i}{\partial x_t^j}+\ldots+\frac{\partial y_{t+s-1}^i}{\partial x_t^j}\right]$$

8.3 Non-linear Multiplier Analysis

All the above kinds of multiplier could be easily extracted from the reduced form for the linear system. For the non-linear system, where the reduced from does not exist, the story will be different. The alternative is to make use of an appropriately designed simulation experiment.

It is important to note that the system of simulation comprises two runs of solution over the same time period. The first is called the control-run, the second the shocked-run. The shocked-run is generated where a shock is introduced into the system. The shock often takes the form of a change in the path of one or more of the exogenous variables. Alternatively, a change may occur in one or more of the parameters of the system, or sometimes a change may even involve replacing one of the equations of the system by another.

Comparing the solution values of the endogenous variable, which are generated in the shocked-run, with those which are generated in the control-run, one can obtain information on the response of the system to the postulated shock.

A comparison of the difference between the shock-run and the control-run solution for any particular endogenous variable in which the shock was introduced, provides us with a measure of the impact multiplier of a given endogenous variable, with respect to the shocked exogenous variable. The corresponding one period intermediate-run multiplier is measured by the given endogenous variable in the shocked-run, for a given endogenous variable in the period after the shock was introduced (period 4) and so on.

The size of the shock is optional, but is typically an increase of the order of 10 percent of the simulation period mean historical value of the exogenous variable in equation. Multipliers are calculated by dividing the difference between the appropriate shocked-run and control-run solution values by the shock size.

An impulse change in the exogenous variables could be adopted instead of the maintained changes. This method is often applied to avoid the problem of a sequence of a varying proportion of the shock throughout the control-run variables of the exogenous variable in different periods of the simulation. Alternatively, the shock can be presented as a constant percentage of the control-run value of the exogenous variable. The percentage deviation of the shock-run solution values in each period is the elasticity of the response of the endogenous variable to the exogenous shock.

8.4 Working Mechanism of the Multipliers

Three variables were chosen to generate the model shock over the historical path. Those variables are Oil Revenues ($OILREV_t$), Total Government Spending ($TGSP_t$) and the Money Supply ($MONEY_t$). Oil Price and hence Oil Revenues, was chosen to be shocked, because of the high dependency of the Libyan economy on Oil Revenues. Total Government Spending was chosen to be shocked, because of its large effect on the level of economic activity in Libya. The Money Supply was chosen to examine the monetary theory of inflation. The interest rate and the tax rate were not chosen because they are limited as a policy in the Libyan economy.

8.4.1 Oil Price Shock

Oil Price is the first exogenous variable to be shocked, by 10% for the period 1964-1991. This shock will affect most of the endogenous variables of the model.

The 10% increase in Oil Price will generate a 10% increase in the Oil Revenues by the Oil Revenues identity. The 10% increase in the Oil Revenues will affect all the equations which have Oil Revenues as an endogenous variable. This is called the direct effect. Some of the endogenous variables which are affected at the first round (the direct effect) are independent variables in the other equations. These variables will in turn be affected by the shock introduced in Oil Price, even though the effect is indirect. Therefore, the second round of effects is called an indirect effect.

Total Government Spending ($TGSP_t$) will be affected directly by the increase in the Oil Price through the Real Oil Revenues as equation (4) Table 7.10, shows.

$$\ln RTGSP_t = 0.592 + 0.184 \ln ROILREV_t + 0.750 \ln RTGSP_{t-1} \qquad (4)$$

The Consumer Price Index ($PSDX$) will be affected by the shock because the Total Government Spending ($TGSP$) is an independent variable in the Consumer Price Index, as equation (9), Table 7.10, shows.

$$\ln PSDX_t = 0.025 \ln TGSP_t + 0.053 \ln MONEY_t + 0.922 \ln PSDX_{t-1} \qquad (9)$$

The Consumer Price Index ($PSDX$) will affect the Gross Domestic Deflator ($PGDPIDX$), as equation (11), Table 7.10, indicates. This will affect the determination of the Capital Formation Index ($INVDX$), as equation (10), Table 7.10, indicates.

$$\ln PGDPIDX_t = 0.079 \ln MONEY_t + 0.355 \ln INVDX_t + 0.554 \ln PSDX_t + 0.577 \ln PGDPIDX_{t-1} \quad (11)$$

$$\ln INVDX_t = 0.333 + 0.069 \ln PGDPIDX_{t-1} + 0.866 \ln INVDX_{t-1} \quad (10)$$

The Real Oil Revenues ($ROILREV_t$) is an independent variable in the Real Total Imports ($RTIMP_t$) and its components. Real Imports of Consumption Goods ($RIMPCONS_t$), Real Imports of Raw Materials and Intermediate Goods ($RIMPINT_t$), and Real Imports of Capital Goods ($RIMPCAPT_t$), will be affected directly, because they are functions of the Real Oil Revenues, as equations (12, 13, 14, 15), Table 7.10, indicate.

$$\ln RTIMP_t = 0.639 + 0.162 \ln ROILREV_t + 0.720 \ln RTIMP_{t-1} \quad (12)$$

$$\ln RIMPCONS_t = -0.411 + 0.102 \ln ROILREV_t + 0.751 \ln RIMPCONS_{t-1} \quad (13)$$

$$\ln RIMPINT_t = 0.167 + 0.102 \ln ROILREV_t + 0.519 \ln RIMPINT_{t-1} \quad (14)$$

$$\ln RIMPCAP_t = 0.572 + 0.215 \ln ROILREV_t + 0.665 \ln RIMPCAP_{t-1} \quad (15)$$

This change in the Real Total Imports ($RTIMP_t$) will be passed on to the Real Indirect Tax Revenues ($RINTAX_t$), as equation (18) Table 7.10, indicates.

$$\ln RINTAX_t = -1.055 + 0.413 \ln RTCONS_t + 0.203 \ln RTIMP_t + 0.346 \ln RINTAX_{t-1} \quad (18)$$

The Total Number of Workers Employed (TNW_t) will be affected directly by the increase in the Real Oil Revenues ($ROILREV_t$), as equation (17) Table 7.10, shows.

$$\ln TNW_t = 0.032 \ln ROILREV_t + 0.974 \ln TNW_{t-1} \qquad (17)$$

The change in Real Oil Revenues ($ROILREV_t$) will change the Total Export identity in the same direction. The change in $PGDPIDX_t$, $PSDX_t$, $TGSP_t$, $TIMP_t$, $TINVS_t$ and $TEXPORT_t$ will affect the determination of the Real National Income ($RNATY_t$) and Real Gross Domestic Product ($RGDP_t$), as identities (28) and (29) Table 7.10, show.

$$RNATY = (CONS / PSDX * 100) + (TGSP / PSDX * 100) + (TEXPORT / PSDX * 100) - (TIMP / PIM * 100) - (INTAX / PSDX * 100) - (CST / INDX * 100) \qquad (28)$$

$$RGDP = (CONS / PSDX * 100) + (GCONS / PSDX * 100) + (TINVS / INVDX * 100) + (TEXPORT / PSDX * 100) + ERRTEM + (TIMP / PIM * 100) \qquad (29)$$

Changes in the Real Gross Domestic Product ($RGDP_t$) will affect the determination of the Total Government Investment Expenditure ($RTINVS_t$), as equation (3) Table 7.10 shows.

$$\ln RTINVS_t = 0.119 \ln ROILREV_t + 0.147 \ln RGDP_t + 0.702 \ln RTINVS_{t-1} \qquad (3)$$

8.4.2 Total Government Spending Shock

The second variable on which a shock was imposed is the Total Government Spending ($TGSP_t$). Total Government Spending is a vital policy instrument, which affects the whole economic activity of the country. The Total Government Spending ($TGSP_t$) is endogenous to the model as equation (4) Table 7.10, indicates. This will force us to re-estimate the model with Total Government Spending ($TGSP_t$) as exogenous. A shock of 10% will be imposed on $TGSP$ for the period 1964-1991. In this case the direct effects is only on the Consumer Price Index ($PSDX_t$), as equation (9), Table 7.10, indicates.

$$\ln PSDX_t = 0.025 \ln TGSP + 0.053 \ln MONEY_t + 0.971 \ln PSDX_{t-1} \quad (9)$$

The indirect effect of the Consumer Price Index ($PSDX_t$) will follow the same path as analysis in the previous section.

8.4.3 Money Supply Shock

The third exogenous variable on which a shock was imposed is the Money Supply ($MONEY_t$). The Money Supply was increased by 10%, for the period 1964-1991. The direct effect of this shock will be on the Consumer Price Index ($PSDX_t$) and the Gross Domestic Deflator ($PGDPIDX_t$), as equations (9) and (11), Table 7.10, show.

8.5 The Empirical Results

The slight effect of the taxation system in Libya, especially direct taxes, can be attributed to the high level of tax avoidance and the low level of personal income in general. The interest rate in Libya has been almost constant for approximately the last thirty years and therefore, has no effect on changes in private consumption or investment. It has never been used as a policy instrument by the control planners.

These reasons lead us to use the three available exogenous variables and impose a maintained shock on their historical path.

Three different starting years were chosen for introducing the shocks. The first year chosen is 1964. The second year is 1973 and the third 1982. The impact, delay or intermediate, and the long-run elasticities, will be calculated.

8.5.1 Gross Domestic Product Elasticities

Real Gross Domestic Product is calculated in the model as an identity (identity (29), Table 7.10). The Real Gross Domestic Product ($RGDP$) identity contains positive and negative terms. The size and the sign of the $RGDP$ elasticity will depend on the effects of the shock on those two elements.

The impact, the intermediate and the long-run multiplier elasticities of the $RGDP$, resulting from a 10% maintained increase in Oil Price, are higher than those resulting from a 10% increase in Money Supply ($MONEY_t$) and Total Government Spending ($TGSP_t$), as Table 8.1, shows.

The negative sign of the Real GDP multiplier elasticity of a 10% maintained increase in Money Supply for the period 1982-1991, as Table 8.1 shows, could be attributed to the higher value of the Consumer Price Index ($PSDX_t$) and the GDP Deflator elasticities. The Consumer Price Index increased by a rate higher than the Money Supply rate of increase, especially after 1982, as Table 8.4 shows. This increase will affect Real Private Consumption Expenditure ($RCONS$) determination negatively, as equation (1), Table 7.10 indicates. The increase in the Consumer Price Index ($PSDX$) will affect GDP Deflator ($PGDPIDX$) determination positively, as equation (11), Table 7.10, shows. This means that a higher $PGDPIDX$ rate will lead to lower real GDP.

Table 8.1 The Impact, Intermediate and The Long-Run Elasticities of Gross Domestic Product

Elasticity %	Period	Exogenous Variable		
		Oil Revenues	Government Spending	Money Supply
Impact		0.300	0.200	-0.030
Intermediate	1964-73	3.020	1.300	-0.160
Long-Run		3.220	1.942	-0.251
Impact		0.382	0.230	-0.150
Intermediate	1973-82	3.900	1.700	-0.120
Long-Run		4.400	2.100	-0.258
Impact		0.590	0.260	-0.300
Intermediate	1982-91	3.300	1.900	-0.300
Long-Run		3.400	2.593	-0.386

The conclusion that we can draw from the above discussion and from Table 8.1, is that the Real Gross Domestic Product (*GDP*) elasticity of the shock in Oil Revenues is higher than the elasticity of the shock of the Total Government Spending and Money Supply. The increase in Money Supply will result in a high but negative impact, an intermediate and a long run Real Gross Domestic Product elasticity. Furthermore, these will result in a higher level of prices and a lower level of Real Gross Domestic Product, when the level of prices increases substantially.

From the above, it may be concluded that the Libyan planners' target was a higher level of Real Gross Domestic Product in the long-run, an increase in Oil Revenues, either by increasing Oil Prices or by putting up Oil Production, seems a suitable policy instrument to achieve this target. According to Table 8.1, a 1% maintained increase in Oil Price, or Oil Revenues, results in an impact on *GDP* multiplier elasticity of 0.3%, 0.382% and 0.590% for the periods 1964-73, 1973-82 and 1982-91, respectively. This means a 3%, 4% and 5.9% increase in the real Gross Domestic Product in the first year of the shock for the three periods respectively, resulting from a 1% increase in Oil Revenues. The increases in real

GDP will be of 30.2%, 39% and 33% after four years, for the three periods, respectively, as the intermediate-run (four years) of Real Gross Domestic Product elasticities of Table 8.1 shows. The increase in *GDP* in the long-run (nine years) will be higher, at 32.2%, 44% and 34% for the three periods, respectively.

8.5.2 Private Consumption Elasticities

The elasticity of Real Private Consumption Expenditure will depend on the rate of change in Disposable Income, as equation (1) Table 7.10, shows.

The impact multiplier elasticity of Real Private Consumption is higher for the three periods when Money Supply is the shocked variable, than from Oil Revenues or Total Government Spending, as Table 8.2 indicates. This could be attributed to the direct increase effect of Money Supply on Consumer Price Index. This increase will affect Real Private Consumption Expenditure negatively.

The intermediate-run multiplier elasticity of Real Private Consumption Expenditure responds more to the shock introduced in Oil Revenues than to the shock on Government Spending or Money Supply, as Table 8.2 shows. This could be attributed to the increasing effect of Disposable Income, due to its higher rate of increase in the intermediate-run, compared with the increasing rate of growth of the Consumer Price Index. This means that a maintained increase (decrease) in Oil Revenues will affect Real Private Consumption Expenditure by affecting Disposable Income. In other words, a 10% increase in Oil Revenues will result in a increase in Real Private Consumption of 0.53%, 0.68% and 0.71%, compared to 0.2%, 0.5% and 0.27% for Total Government Spending, and 0.43%, 0.67% and 0.9% for the Money Supply, for the three periods respectively, as shown in Table 8.2.

The long-run multiplier elasticities, in Table 8.2, shows that the suitable policy instrument to affect Private Consumption by affecting Disposable Income is an increase in Oil Revenues, especially after 1982.

Table 8.2 The Impact, Intermediate and The Long-Run Elasticities of Private Consumption Expenditure

Elasticity %	Period	Exogenous Variable		
		Oil Revenues	Government Spending	Money Supply
Impact Intermediate Long-Run	1964-73	0.030 0.533 1.400	-0.020 -0.200 -0.600	-0.130 -0.430 -0.763
Impact Intermediate Long-Run	1973-82	0.055 0.680 2.000	-0.170 -0.500 -1.020	-0.400 -0.670 -0.830
Impact Intermediate Long-Run	1982-91	0.055 0.710 2.290	-0.020 -0.270 -0.910	-0.500 -0.900 -1.480

As Table 8.2 shows, an increase of 10% in Oil Revenues in the periods (1964-1973), (1973-1982) and (1982-1991) would have resulted in 14%, 20% and 23% increase in Private Consumption Expenditure, respectively. On the other hand an increase (decrease) of 10% in Money Supply or Government Spending for the three periods would result in a 7.6%, 8.3%, 14.8% and 6%, 10.2%, 9.1% increase (decrease) in Real Private Consumption Expenditure for three periods, respectively.

8.5.3 Total Government Investment Elasticities

The Real Total Government Investment ($RTINVS_t$) multiplier elasticity depends on the elasticity of *GDP* and also directly on Oil Revenues. This means that Total Government Investment Expenditure will be submitted to direct and indirect effects when the Oil Price is shocked. Total Government Investment is affected indirectly only by the change in Gross Domestic Product, when the Money Supply is shocked.

Total Government Investment multiplier elasticity of Total Government Spending is ignored, because the Total Government Spending contains part of Total Government Investment, which is the Government Investment Spending.

The impact multiplier elasticity of Total Government Investment of a 10% maintained increase in Oil Price (Oil Revenues) is very high for three periods, compared to the Total Government Investment elasticity of Money Supply for the same periods. As Table 8.3 shows, the Total Investment impact elasticity of Oil Price was 0.3%, 0.31% and 0.42% for three periods. This means that an increase in Oil Revenues (Oil Price) of 10% would have increased the Total Government Investment Expenditure by 3%, 3.1% and 4.2% for the same years in which the Oil Price increased.

Table 8.3 The Impact, Intermediate and The Long-Run Elasticities of Real Total Investment Expenditure

Elasticity %	Period	Exogenous Variable	
		Oil Revenues	Money Supply
Impact Intermediate Long-Run	1964-73	0.300 2.610 4.000	-0.020 -0.140 -0.200
Impact Intermediate Long-Run	1973-82	0.310 3.500 3.640	-0.080 -0.270 -0.434
Impact Intermediate Long-Run	1982-91	0.420 3.580 4.600	-0.200 -0.300 -0.510

The Total Government Investment Impact multiplier elasticities of Money Supply for the starting years of the periods are shown in Table 8.3. With a 10% shock, the impact elasticities of Total Government Investment, as Table 8.3

indicates, will mean a decrease of 0.02%, 0.08% and 0.2% in the Total Government Investment for the three years, respectively. This could be attributed to the indirect effect of Money Supply on Real Gross Domestic Product and Capital Formation Price Index.

The intermediate and long-run elasticities of the Total Government Investment due to a change of Oil Revenues are substantially higher than those resulting from a change in Money Supply, as Table 8.3 indicates clearly. This could be attributed to the direct effect of Oil Revenues on Total Government Investment as equation (3), Table 7.10, shows.

The long-run Total Government Investment multiplier elasticity of Oil Price for the period 1982-1991 (4.6%) is higher elasticity among all the long-run elasticities of Total Government Investment as Table 8.3 indicates. This means that a 10% maintained increase in the Oil Revenues will push the Total Government Investment up by 46% after nine years.

The decreasing of Total Government Investment long-run elasticity of Money Supply is attributed to the negative value of *GDP* elasticity for the same period.

The above analysis shows very clearly that Total Government Investment Expenditure is very sensitive to a slight shock to the Oil Price, to Oil Revenues in general. Furthermore, Total Government Investment sensitivity towards a shock in Oil Price, or Oil Revenues, is far higher than its sensitivity towards any shock in Money Supply. The shock in Money Supply results in a negative impact, intermediate, and long-run elasticities of Total Government Investment for the three periods, as Table 8.3 shows. This means that a higher inflation rate will lead to a lower Real Gross Domestic Product and this will lead to a lower Real Total Government Investment.

8.5.4 Price Elasticities

Three price indices are used in the model, the Consumer Price Index ($PSDX_t$), the Capital Formation Price Index ($INVDX_t$) and the Gross Domestic Product Deflator ($PGDPIDX_t$), as equations (9), (10) and (11) Table 7.10, show.

8.5.4.1 Consumer Price Index Elasticities

The Consumer Price Index will be affected directly by the shocks imposed on the Money Supply ($MONEY_t$) and Total Government Spending ($TGSP_t$), as equation (9) Table 7.10, shows. Money Supply affects the Consumer Price Index heavily, as Table 8.4, shows.

The Consumer Price Index impact, intermediate, and long-run multiplier elasticities of the Money Supply are substantially higher than the Total Government Spending. This finding reinforces the monetary theory of inflation as an explanation of the inflationary tendencies in the Libyan economy.

A 10% increase in Money Supply in 1973 would have had an impact increase on the Consumer Price Index of 3.3%, while the same size of shock imposed on the Total Government Spending in the same year gives a 0.013% increase in the Consumer Price Index, as Table 8.4, indicates.

The intermediate-run multiplier elasticity of $PSDX_t$ of Money Supply is 13 times higher than the intermediate-run $PSDX_t$ of $TGSP_t$ for the period (1982-1991), as Table 8.4 shows.

While the long-run Consumer Price Index multiplier elasticity of Money Supply is 2.914 for the period 1982-1991. This means that a 10% maintained increase in the Money Supply will push the Consumer Price Index up to 29.1% after nine years. This could be attributed to the direct increase effect of Money Supply on the Consumer Price Index.

Table 8.4 The Impact, Intermediate and The Long-Run Elasticities of Consumer Price Index

Elasticity %	Period	Exogenous Variable	
		Government Spending	Money Supply
Impact Intermediate Long-Run	1964-73	0.020 0.300 0.727	0.233 0.350 0.720
Impact Intermediate Long-Run	1973-82	0.013 0.220 0.981	0.330 1.650 3.000
Impact Intermediate Long-Run	1982-91	0.020 0.200 1.000	0.450 2.500 2.914

The above analysis indicates very clearly that the Consumer Price Index is highly sensitive to any increase in Money Supply. This gives a good indicator to the planner on how to curb inflationary tendencies.

8.5.4.2 Gross Domestic Product Deflator Elasticities

The *GDP* deflator ($PGDPIDX_t$) is a function of Money Supply ($MONEY_t$), Capital Formation Price Index ($INVDX_t$), Consumer Price Index ($PSDX_t$) and the *GDP* Deflator lagged one year ($PGDPIDX_{t-1}$), as equation (11) Table 7.10, shows.

The response of the $PGDPIDX_t$ towards any shock in the selected exogenous variable depends on the response of the $PSDX_t$, $MONEY_t$ and $INVDX_t$ toward the shock.

The impact *GDP* deflator multiplier elasticity of Money Supply is higher for the periods (1964-1973), (1973-1982) and (1982-1991) than the impact *GDP* deflator elasticities of the Total Government Spending, as Table 8.5, shows.

The intermediate-run *GDP* deflator elasticity of Money Supply is 1.2% for the period (1982-1991), which is 4 times higher than the intermediate-run

GDP deflator elasticity of Total Government Spending for the same periods, as Table 8.5 shows. This means that an increase in the Money Supply of 10% in the period 1982-1991 will result in a 12% increase in *GDP* deflator, while the same size of shock for the same period imposed on Total Government Spending ($TGSP_t$) results in 2.8% increase in the *GDP* deflator, as Table 8.5, indicates.

Table 8.5 The Impact, Intermediate and The Long-Run Elasticities of GDP Deflator Price Index

Elasticity %	Period	Exogenous Variable	
		Government Spending	Money Supply
Impact Intermediate Long-Run	1964-73	0.013 0.150 0.330	0.070 0.680 1.600
Impact Intermediate Long-Run	1973-82	0.020 0.159 0.400	0.200 0.775 2.140
Impact Intermediate Long-Run	1982-91	0.010 0.278 0.700	0.198 1.200 2.000

The long-run Gross Domestic Product Deflator elasticity of Money Supply is even higher and reaches 2% for the period 1982-1991. It is 3 times higher than the long-run $PGDPIDX_t$ elasticities of $TGSP_t$, as Table 8.5 indicates. This means that a shock of 10% in the Money Supply and the Total Government Spending will generate an increase of 20% and 7% by the end of the period in the *GDP* deflator.

8.5.4.3 Capital Formation Price Index Elasticities

The Capital Formation Price Index ($INVDX_t$) is a function of the Gross Domestic Product Price Index ($PGDPIDX_t$) and The Capital Formation Price Index lagged one year ($INVDX_{t-1}$), as equation (10), Table 7.10, shows. This means that a change in $PGDPIDX_t$ is the only source which could disturb the Capital Formation Price Index ($INVDX_t$) in our shock exercise.

Table 8.6 The Impact, Intermediate and The Long-Run Elasticities of Capital Formation Price Index

Elasticity %	Period	Exogenous Variable	
		Government Spending	Money Supply
Impact Intermediate Long-Run	1964-73	0.018 0.155 0.310	0.020 0.627 1.600
Impact Intermediate Long-Run	1973-82	0.012 0.200 0.565	0.150 0.750 1.722
Impact Intermediate Long-Run	1982-91	0.040 0.260 0.642	0.190 0.882 1.839

The impact, the intermediate and the long-run multiplier elasticities of the Capital Formation Price Index ($INVDX_t$) of the shock in Money Supply are significantly higher than the elasticities of Total Government Spending, as Table 8.6 indicates. This is attributed to the direct and indirect effects of the Money Supply on *GDP* deflator, as equation (11) Table 7.10, shows.

The long-run Capital Formation Price Index multiplier elasticity of Money Supply is 3 times higher than the Capital Formation Price Index ($INVDX_t$) elasticity of Total Government Spending for the period (1982-1991).

The positive signs of the long-run Capital Formation Price Index elasticities of Money Supply, for the three periods, are attributed to the positive signs of the *GDP* deflator elasticities, as Table 8.5, indicates.

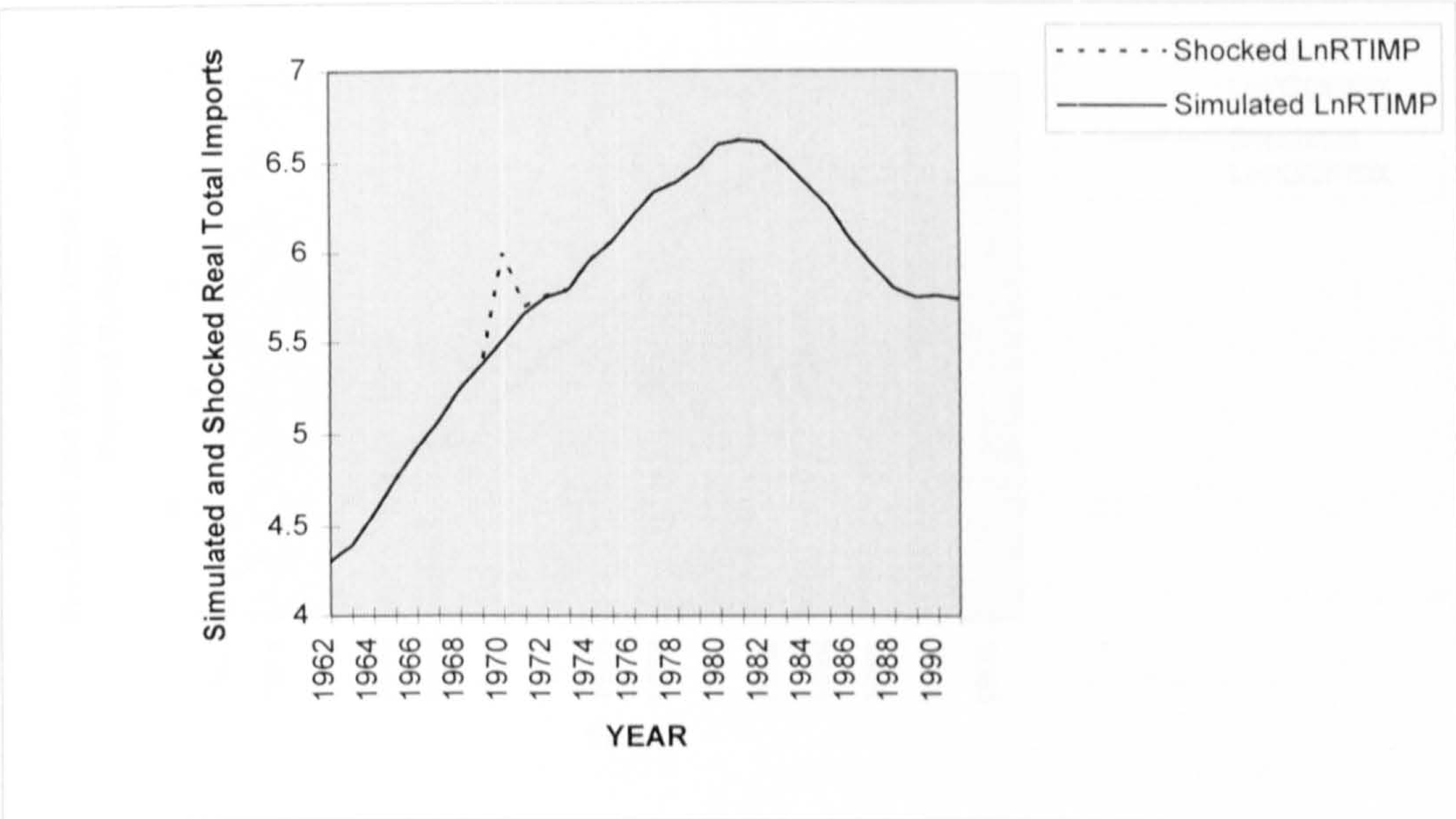
8.6 Model Stability

This section will examine the stability of the model. This test will be carried out by introducing an impulse shock in one of the exogenous variables. The control-run will be compared to the historical-run. The model is considered to be stable if the impulse shock dies out gradually, year after year and the control-run becomes co-incident with the historical-run. The model is considered unstable if the impulse shock generates a large divergence of the control-run from the historical-run throughout the simulation years. An impulse shock of 10% in the Oil Revenues in 1970 is introduced. The model is solved and the control-run of the model endogenous variable obtained. Comparing the two runs, as Figure 8.1 shows, the shock caused the control-run to divert from the historical-run. This divergence is diminishing and the control-run reverts back to the historical-run after several years, as Figure 8.1 shows. The same exercise was carried out on Money Supply and Total Government Spending. The results, as Figures 8.2, 8.3 and 8.4 show, indicate the stability of the model.

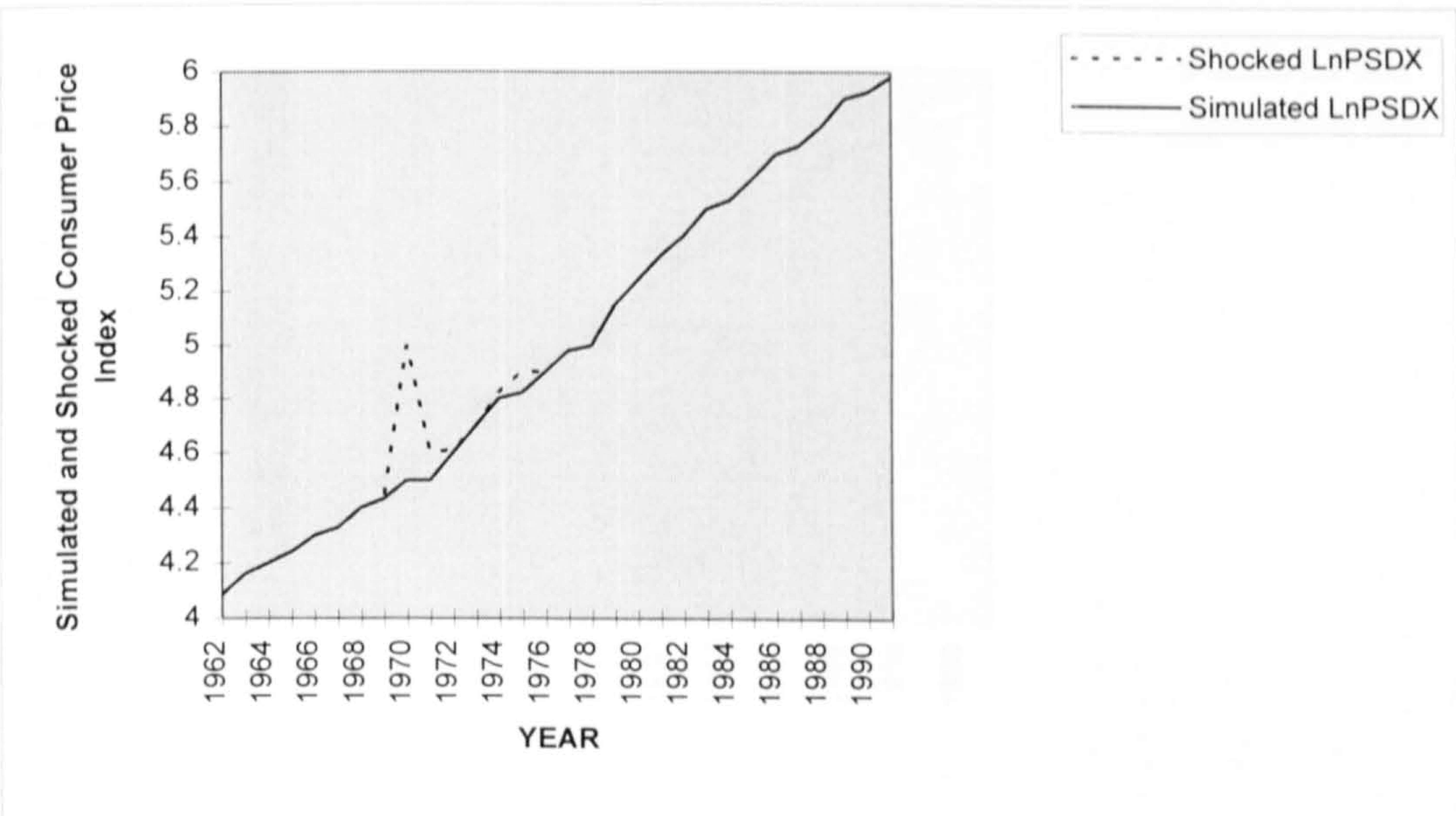
8.7 Conclusions

The high responses the model shows to Oil Revenues comes from the fact that Libyan economic activity depends almost totally on this source of foreign currency. The implementation of any short, intermediate and long-run national plans depends heavily on Oil Revenues as a source of finance. So any shock to this source will have significant effects on the whole of the Libyan economy. This has been the case, as we have seen from the analysis of the elasticities, for most endogenous variables in the model. In the next chapter we will take a further step in model exploration, with forecasting.

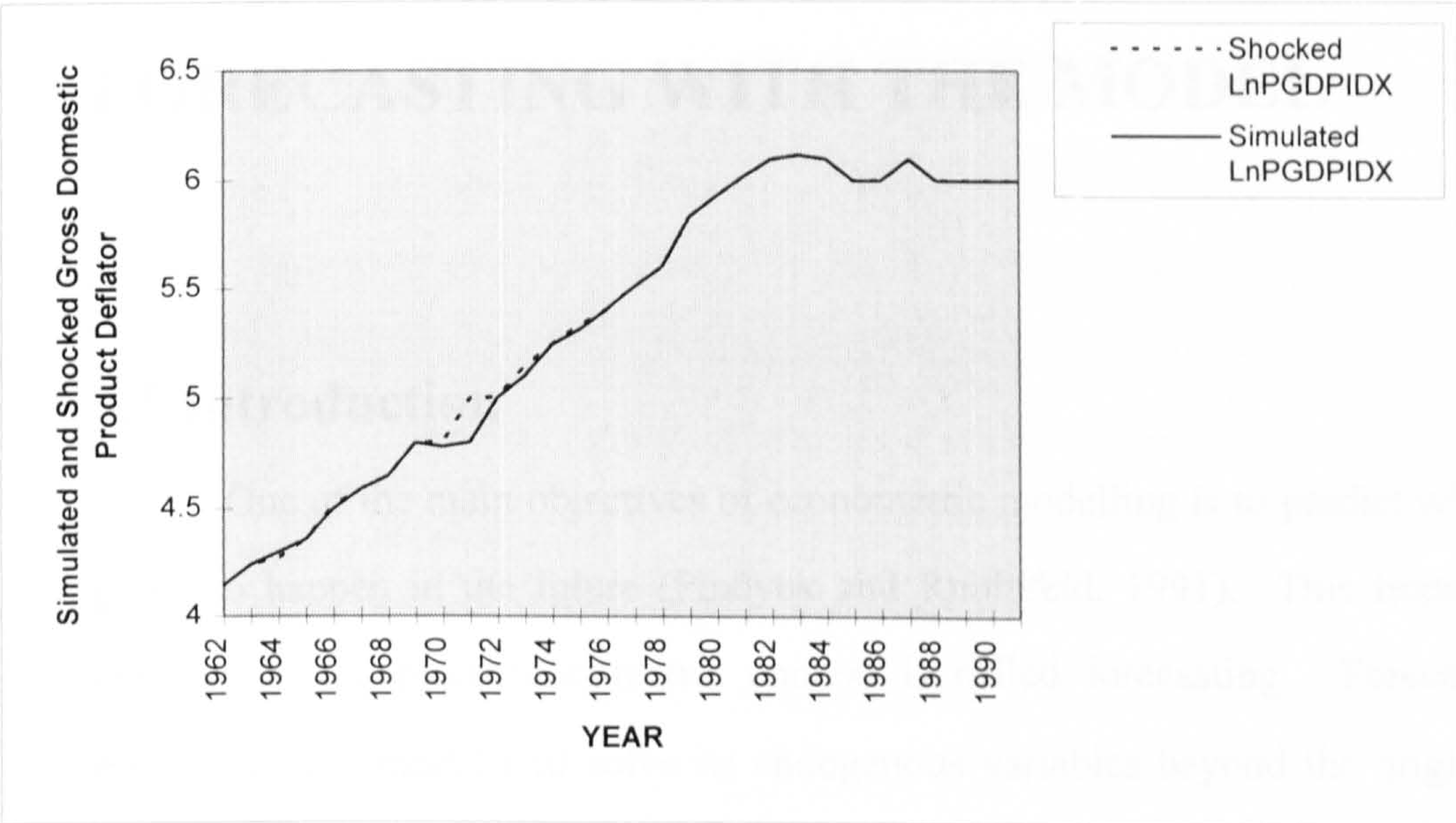
Graph 8.1 Simulated and Shocked Real Total Imports Resulting from an Impulse Shock in Oil Price in 1970



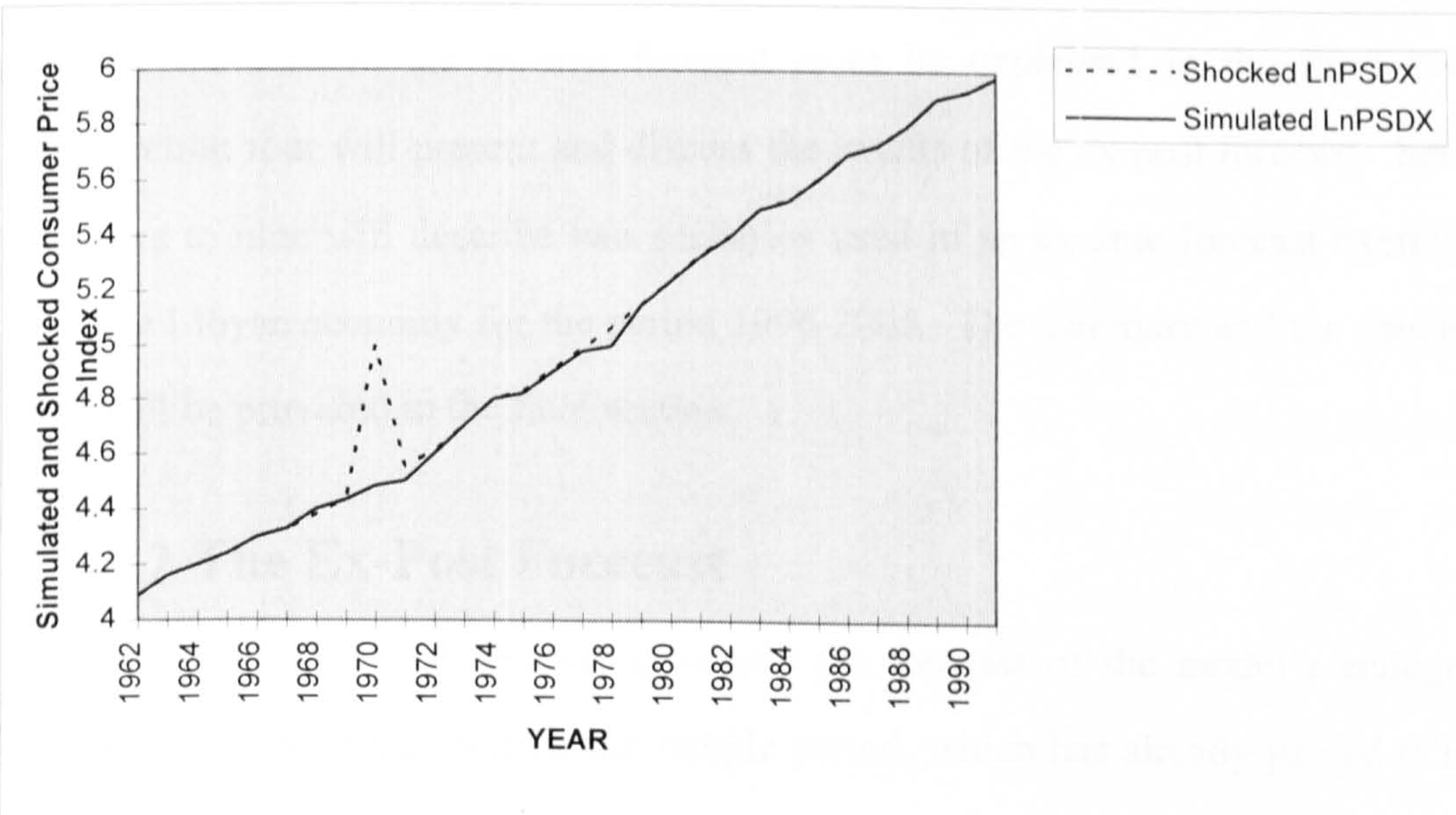
Graph 8.2 Simulated and Shocked Consumer Price Index Resulting from an Impulse Shock in Money Supply in 1970



Graph 8.3 Simulated and Shocked Gross Domestic Product Deflator Resulting from an Impulse Shock in Money Supply in 1970



Graph 8.4 Simulated and Shocked Consumer Price Index Resulting from an Impulse Shock in Total Government Spending in 1970



CHAPTER NINE

FORECASTING WITH THE MODEL

9.1 Introduction

One of the main objectives of econometric modelling is to predict what is going to happen in the future (Pindyck and Rubinfeld, 1991). This important exercise in the macroeconometric context is called forecasting. Forecasting means that the model will solve its endogenous variables beyond the originally utilised set of data. This forecast exercise needs the predetermined variables of the model for the forecast period.

There are two main types of forecast. The first is the ex-post forecast and the second is the ex-ante forecast. The ex-post forecast will be discussed in the second section; the ex-ante forecast is to be explained in the third section. Section four will present and discuss the results of the ex-post forecast. Sections five to nine will describe two scenarios used in an ex-ante forecast exercise for the Libyan economy for the period 1996-2005. The summary and the conclusion will be provided in the final section.

9.2 The Ex-Post Forecast

The ex-post forecast is simply the forecast of the model's endogenous variables for years outside the sample period, which has already passed (Challen and Hagger, 1983). This means that the predetermined variables of the model for the period of forecast are available. This kind of forecast is often carried out to test the capability of the model in predicting the values of the endogenous variables for the period beyond the model's historical data.

This can be carried out by comparing the forecast endogenous variables to the recorded ones for the same period of forecast. The Root Mean Square Percent Error (RMSPE) will be utilised as an indicator to judge the accuracy of the model in the ex-post forecast exercise. If the RMSPE values for some of the endogenous variables are high, then two alternative routes can be followed.

The first is to try to adjust the equation which determines the specific variable. The adjustment can be carried out in two ways by adjusting the constant term of its equation or by rejecting the null hypothesis for the equation.

The second route which might be followed is to revise the specification of the equation and try to introduce other explanatory variables where their absence could be the cause of very high error in the forecasting value of the endogenous variable, as indicated by the RMSPE. Then the ex-post forecast exercise would be repeated, and the RMSPE re-calculated. The researcher will judge the model's performance depending on the RMSPE values and if he is satisfied with the result, an ex-ante forecast exercise will follow.

9.3 The Ex-Ante Forecast

The ex-ante forecast aims to forecast the model's endogenous variables for a period in the future (Challen and Hagger, 1983). This means that there will be no information about the exogenous variables at these future times. Let us suppose that we want to forecast one year ahead in the future, where no data is available for most of the predetermined variables. The predetermined variables in the macroeconometric model, as we have seen, are divided into three categories:

1. Lagged endogenous variables.
2. Lagged exogenous variables.

3. Exogenous variables.

The first group present no problem. Let us suppose that we are at the end of period t, and we wish to forecast the value of the endogenous variable Y_t for period $t + 1$ (Y_{t+1}). In this case, the lag of the variable Y_{t+1} is Y_t , and it already exists. The same analysis can be applied to the lagged exogenous variables (category 2).

The difficulties arise with the third group of predetermined variables (the exogenous variables). For this group there is no data available at all. The exogenous variables can be divided into three groups:

1. Dummy variables.

2. Policy variables.

3. Other miscellaneous unlagged variables.

The first group can be disposed of without much difficulty if they are measured in years from some arbitrary origin, or seasonal dummies. The second group is the policy variables, such as fiscal policy instruments (government expenditure, tax variables, and transfer payment variables), or monetary variables, such as the money supply and the interest rate.

The fiscal policy variables forecast relies heavily on announcements, which the government and other policy-making authorities make from time to time, as to their plans and intentions in the economic field. The monetary policy variables forecast will depend on whether the government has announced its intention to change the trend of these variables. Otherwise, we will postulate that no sudden change will occur, and the time trend can be utilised to generate future values of these variables.

Once all of the predetermined variables for the years to be forecast are known, the model can be solved to give the forecast future values of its endogenous variables. There is another step which could be taken in our forecast exercise, which is to modify our forecasting process (Granger and Newbold, 1977). This step aims to provide a means of keeping the macroeconometric model on track and to accommodate future shocks, which are not readily captured by the system as currently specified. This kind of exercise is called Judgmental Forecasting.

Judgmental Forecasting differs from the previous forecasting approach, by adding a constant term adjustment to the equations which are to be modified. In the previous forecasting approach, it was assumed that the residual terms in the model's equations are equal to zero. In Judgmental Forecasting, some or all of these residual terms are allowed to have non-zero values for some or all of the sequence of forecast years.

The value of the residual term will depend on the reason for introducing this term into the equation. The first reason involves fitting the value that will serve to keep the relationship in the equation on track in the forecast year, in the absence of significant shocks of a kind that can not be accommodated by the model as specified. The second reason involves modifying this value, if necessary, to take into account any shock which seems likely to occur.

The value of the residual term will be determined depending on the patterns of the residuals for several years for the specific equation. On examining the patterns of the residuals, if the residuals are behaving in a roughly random fashion around the zero mean, then the residual term will be set to zero. However, if the residual patterns are behaving randomly around a non-zero mean, this mean will be used as the value of the residual term in the equation. Furthermore, if the residual term behaviour is subject to an upward trend, or controlled by a first-order autoregressive process, the residual term value would rise or fall from one year to the next by the trend increment.

The next stage is to check for the existence of serious inconsistency between the forecast of the endogenous variables and the forecast of the predetermined variables. This check is necessary to ensure that the endogenous variables have not become distorted in the sequence of forecast years by the process of the constant term adjustment. Should any inconsistencies or distortions of this type be recorded, the forecast of the predetermined variables, and/or the figures used for the residual term, will be revised, and a fresh set of forecasts of the endogenous variables be produced. The check exercise will be applied once again, until no serious inconsistency or distortion is apparent.

9.4 The Ex-Post Forecast: Empirical Results

The ex-post forecast was carried out for the period 1991-1996, using available data for the exogenous variables.

The results of the ex-post exercise, as Table 9.1 shows, are very close to the historical data, as the Root Mean Square Percent Error (RMSPE) values indicate. The forecast values of Real Investment Expenditure in the Manufacturing Sector ($RMANI_t$) are less than the recorded ones. This can be attributed mainly to a high jump in the Government's Annual Appropriation for Investment in the Manufacturing Sector in the forecast years, which the Investment Expenditure in Manufacturing equation for the period 1991-1996 failed to anticipate. Hence, it was necessary to adjust the weight of the Government's Annual Appropriation for Investment in the Manufacturing variable in the Investment Expenditure in Manufacturing equation, by adjusting its parameters to the extent which achieved a reasonable forecast of Investment Expenditure in Manufacturing Sector.

Table 9.1 shows that the RMSPE of the Real Investment Expenditure in Manufacturing ($RMANI_t$) declined from 13% to 2.2%, following the adjustment of the Government's Annual Appropriation for Investment in Manufacturing parameter in the Investment Expenditure in Manufacturing equation from 0.570 to 0.750, as shown in equation (5), Table 7.10. This adjustment pulls down the RMSPE for the model as a whole from 3% to 2.06%. The RMSPE in Table 9.1 is a good indicator of the model's forecasting capability and it is acceptable, taking into consideration the abnormalities within the forecasting period.

Table 9.1
The Root Mean Square Percentage Error (RMSPE) of the Ex-Post and Ex-Post Adjusted Forecast Results for the Model 1991-1996

No.	Endogenous Variable	Original Version RMSPE (%)	Adjusted Version RMSPE (%)
1.	$\ln RCONS$	1.100	1.100
2.	$\ln GCONS$	2.400	2.400
3.	$\ln RTINVS$	1.660	1.660
4.	$\ln TGSP$	0.940	0.940
5.	$\ln RMANI$	13.000	2.200
6.	$\ln RSERI$	2.600	2.600
7.	$\ln RCOTI$	4.800	4.800
8.	$\ln PSDX$	1.500	1.500
9.	$\ln INVDX$	0.320	0.320
10	$\ln PGDPIDX$	4.000	4.000
11.	$\ln RTIMP$	1.200	1.200
12.	$\ln RIMPCONS$	4.000	4.000
13.	$\ln RIMPINT$	3.200	3.200
14.	$\ln RNOQT$	0.600	0.600
15.	$\ln TNW$	0.640	0.640
16.	$\ln RINTAX$	1.980	1.980
17.	$\ln ROILVAL$	3.500	3.500
18.	$\ln RGDP$	0.560	0.560
	RMSPE	3.000	2.060

9.5 The Ex-Ante Forecast: Empirical Results

In this section the ex-ante forecast will be discussed. Data until 1991 are available for Libya, in one way or another. Beyond this year a great deal of difficulty was found in obtaining the necessary data to perform the ex-ante exercise. Oil Price, Oil Production and some other aggregate indicators were obtained from different sources, as follows:

- Organisation of Arab Petroleum Exporting Countries (OAPEC), Annual Reports, Kuwait, various issues.
- Economist Intelligence Unit Reports (1996), Report on Libya 1996-97, London.
- Central Bank of Libya, Annual Report, various issues.
- Central Bank of Libya, Economic Bulletin, various issues.
- Ministry of Planning (1989), General Development Program 1991-2000, The First General Framework of the Social and Economic Transformation, Libya.

The rest of the exogenous variables had to be estimated by formulating equations for them depending on their historical values. The values of the endogenous variables from 1992-1996, resulting from solving the model, were considered as historical data when the ex-ante forecast for the period 1996-2005 was performed.

9.6 Ex-Ante Forecast Scenarios

Two scenarios were employed in the forecast. The first scenario postulated nothing unusual happening in the oil market during the forecasting period, 1996-2005. The huge amount of Libyan oil reserves will enable Libyan oil production to increase steadily, whenever the world market permits. It is assumed that the Libyan representative in OPEC will keep pushing for a higher quota and higher prices, to meet the re-building of the economy. According to this scenario, oil prices will continue to rise steadily at 8% p.a. for the period 1996-2005. Libyan oil production is assumed to increase by 4% p.a., starting from 1.5m b/d in 1996 (Economist Intelligence Unit Reports, 1996).

The second scenario is extremely pessimistic. It postulates that the Oil Revenues fall considerably. Therefore, this scenario will result in a low price of oil and Libya will be affected badly.

The next sections will investigate these two scenarios. The graphs presenting the scenarios outcomes are grouped at the end of this chapter, for ease of reference and comparison.

9.7 The Forecast Results for the First Scenario

Most of the exogenous variables were generated by using an annual rate of growth of 5%, except for the number of workers in each sector, which is assumed to be 3%. The other exogenous variables are derived by relating them to the Oil Revenues. These variables are Money Supply and Investment Expenditure at sector levels. A dynamic forecasting procedure was applied. This means that the values of the endogenous variables of the current year, generated by the forecast simulation, are used for the year's forecast as predetermined variables. Having obtained the exogenous variables, the ex-ante forecast procedure is straightforward. The results of this scenario show a steady upward trend, similar to the trend of the Oil Revenues.

Gross Domestic Product grows steadily at a rate of 8% p.a., as Graph 9.11 shows. It will increase from L.D13389.9 million in 1996 to L.D30768.7 million in 2005 (Table 1.8, Appendix 1). This increasing rate of growth is attributed to the increase of Oil Revenues in general.

Total Government Spending rises steadily throughout the forecast period, as Graph 9.3 indicates. It will increase from L.D3837.8 million in 1996 to L.D7077.8 million in 2005 (Table 1.8, Appendix 1). Its rate of growth is 6.3% p.a., which is very reasonable, due to the low rate of growth of Oil Revenues on which Total Government Spending depends totally. The small rate of growth of

Oil Revenues will put restrictions on the planners in the implementation of prospective development programs. Therefore, restricted Government Spending is a natural consequence, which is what the model forecast results indicate. The limited development programs created by the government mean few work opportunities will be created. This means there will be no excessive demand pressure on the labour market. This result suggests that any rate of increase in Oil Revenues will result in approximately the same rate of increase in Government Spending.

The price level, represented by the Consumer Price Index, will increase from 434.2 in 1996 to 765.9 in 2005 (Table 1.8, Appendix 1), at a moderate rate of 8% p.a., as Graph 9.4 shows. This rate of inflation is small compared with inflation during the eighties (13%). This moderate rate of inflation is attributed to the small increase in Government Spending. The other variable affecting the inflation rate is the Money Supply. The Money Supply is an exogenous variable in the model, but its value is generated for the simulation by relating it to the Oil Revenues. Therefore, a small and steady increase in Oil Revenues results in a small, steady increase in the Money Supply. Thus, inflation is kept under control in this scenario.

Total Government Investment Expenditure grows steadily throughout the forecast period, as Graph 9.2 indicates. It will increase from L.D1928 million in 1996 to L.D2144.2 million in 2005 (Table 1.8, Appendix 1), at an annual average rate of 3% p.a., which is reasonable, due to the low rate of growth of Oil Revenues on which Total Government Investment Expenditure depends totally.

Real Private Consumption Expenditure will increase from L.D9062.7 million in 1996 to L.D16246 million in 2005 (Table 1.8, Appendix 1), at an annual average rate of 6% p.a., as Graph 9.1 shows. This increase in Real Private

Consumption is attributed to the increase in Disposable Income (5%), as Graph 9.12 indicates.

Total Imports will increase from L.D1717.4 million in 1996 to L.D2671 million in 2005 (Table 1.8, Appendix 1), at an annual average rate of 5% p.a., as shown by Graph 9.5. This increase is attributed to the increase in the foreign exchange reserves because of the increase in Oil Revenues and the expansion of Government Spending, particularly on development programs. These programs depend heavily on imported materials for their implementation and for their subsequent running.

Imports of Consumption Goods will decline from L.D533.3 million in 1996 to L.D453.9 million in 2000, at an annual average rate of 3.8% p.a. for the period 1996-2000. It will then increase from L.D459.6 million in 2001 to L.D527 million in 2005 (Table 1.8, Appendix 1), at an annual average rate of 3% p.a., for the period 2001-2005, as shown by Graph 9.6. The decline in Consumption Goods Imports could be attributed to the increase in Manufacturing Value-Added (5%). This means that it is attributed to substitution by the local manufacturing production sector. The increase in Consumption Goods Imports for the period 2001-2005 is attributed to the increase in Oil Revenues.

The Imports of Raw Materials and Intermediate Goods will increase from L.D202.6 million in 1996 to L.D359.1 million in 2005 (Table 1.8, Appendix 1), at an annual average rate of 5.9% p.a., as Graph 9.7 shows. This increase is attributed to the continuous increase in Oil Revenues and the increase in Non-Oil Value-Added, as Graph 9.9 indicates.

The imports of Capital Goods will fall from L.D494.5 million in 1996 to L.D 271.6 million in 2005 (Table 1.8, Appendix 1), at an annual average rate of 5.3% p.a., as Graph 9.8 indicates. This decrease is attributed to the increase in

Manufacturing Value-Added, which seems to be able to substitute for some capital needs and for the restricted foreign exchange.

The Number of Employed will increase from 1222.7 thousand in 1996 to 1327.9 thousand in 2005 (Table 1.8, Appendix 1), at a rate of 2% p.a., as Graph 9.10 shows. This increase is attributed to the increase in the Non-Oil Value-Added (Graph 9.9) and the return of a considerable number of workers from military service.

9.8 The Forecast Results for the Second Scenario

This Scenario is extremely pessimistic. The Oil Revenues fall considerably. Therefore, we should expect a sharp decline in all aspects of the economy.

Gross Domestic Product will fall from L.D12017.9 million in 1996 to L.D9816.2 million in 2005 (Table 1.8, Appendix 1), at an annual average rate of 2% p.a., as Graph 9.11 indicates. This decline in the Gross Domestic Product is attributed to the decline of Oil Revenues in general.

Total Government Spending declines steadily throughout the forecast period, as Graph 9.3 shows. It will decline from L.D4300.5 million in 1996 to L.D4099.9 million in 2005 (Table 1.8, Appendix 1), at an annual average rate of 1% p.a., due to the decline of Oil Revenues on which Total Government Spending depends totally.

The price level, represented by the Consumer Price Index, will increase from 429.4 in 1996 to 618.7 in 2005 (Table 1.8, Appendix 1), at an annual average rate of only 3% p.a., as shown by Graph 9.4. This is the lowest rate of inflation in Libya since the seventies. This is strong evidence that excessive Total Government Spending is the reason for high rates of inflation in the Libyan economy.

Total Government Investment Expenditure will fall from L.D1807.8 million in 1996 to L.D1063.7 million in 2005 (Table 1.8, Appendix 1), at an annual average rate of 5.1% p.a., as shown by Graph 9.2. This decline is attributed to the decline in Oil Revenues on which Total Government Investment Expenditure depends totally.

Real Private Consumption Expenditure will decrease from L.D8403.8 million in 1996 to L.D5442.3 million in 2005 (Table 1.8, Appendix 1), at an annual average rate of 4% p.a., as Graph 9.1 indicates. This decline in Private Consumption is attributed to the decline in Disposable Income (4.5%), as graph 9.12 shows.

Total Goods Imports will fall from L.D1675.9 million in 1996 to L.D743 million in 2005 (Table 1.8, Appendix 1), at an annual average rate of 6% p.a. for the period 1996-2005, as Graph 9.5 indicates. This is attributed to the limited availability of foreign exchange, due to the sharp decline in Oil Revenues.

Imports of Consumption Goods will fall from L.D479.2 million in 1996 to L.D160.1 million in 2005 (Table 1.8, Appendix 1), at an annual average rate of 5.9% p.a., as Graph 9.6 shows. This decline in Consumption Goods Imports could be attributed to the decline in purchasing power and the decline in foreign exchange, due to the decline in Oil Revenues.

Imports of Raw Material and Intermediate Goods will decline from L.D120.6 million in 1996 to L.D764.0 million in 2005 (Table 1.8, Appendix 1), at an annual average rate of 4.1% p.a., as Graph 9.7 indicates. This decline is similarly attributed to the decline in Oil Revenues.

The Imports of Capital Goods will fall considerably from L.D416.5 million in 1996 to L.D117.2 million in 2005 (Table 1.8, Appendix 1), at an annual average rate of 11% p.a., as Graph 9.6 indicates. This decline in Capital Goods Imports is attributed to the sharp decline in Oil Revenues. The decline in

Capital Imports will affect the progress of current projects which are still being implemented, and will present an obstacle to new investment programs. This will affect the growth of Gross Domestic Product, as Graph 9.11 indicates, due to the decline in Total Government Investment Expenditure (Graph 9.2).

The Total Number of Workers Employed will decrease from 1220.2 thousand in 1996 to 1194 thousand in 2005 at an annual average rate of 0.2% p.a., as Graph 9.10 shows. This decline is attributed to the decline in private sector activities and other sectors of the economy except oil, as Graph 9.9 indicates.

9.9 Policy Implications of the Scenarios

Inflation appears to be the most serious problem for the Libyan planners to deal with. The inflation problem can be tackled by restraining government spending and money supply. Restraining government spending implies cuts in the variety of subsidies by the government and a reduction in expenditure on the central bureaucracy and armed forces. From the scenarios, high government spending leads to decreased government investment. However, cuts in subsidies will badly harm those on limited incomes. These form a considerable proportion of the total population of Libya.

The other alternative is to give more space to the private sector in economic life. For such a policy to succeed in Libya, there needs to be political stability and the assurance of the government against nationalisation in the future. In order to succeed, this policy has to be widened and also requires the assurance of the government on the seriousness of its intention to continue implementing such a policy.

Government intervention should be achieved by the setting up of a framework of incentives to encourage import substituting industries, and particularly those which utilise local raw materials and local intermediate goods.

The establishment of such industries will save foreign exchange by reducing the imports of such consumption goods and will strengthen inter-dependency between industries.

It is vitally important that Libyan planners reallocate resources to create a new source of income other than oil revenues, in order to reduce the Libyan economy's dependency on oil revenues and to reduce the effect of shocks to the oil market on the Libyan economy.

9.10 Conclusions

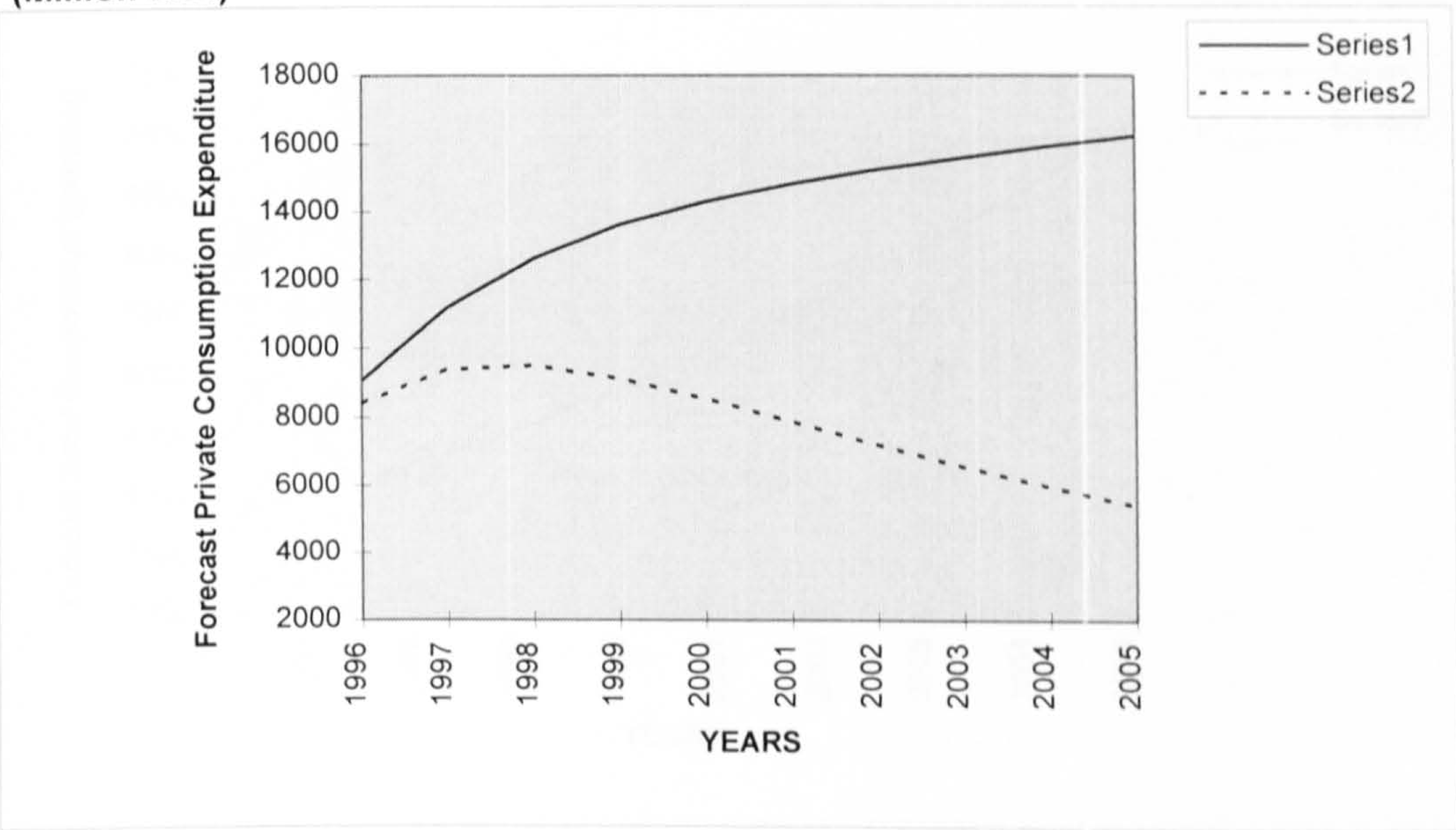
Ex-post and ex-ante forecasts have been examined. The ex-post results indicate the reasonable capacity of the model for predicting data beyond its historical data.

Two scenarios have been used in the ex-ante forecast exercise. The results of the two scenarios indicate the Libyan economy's high dependency on and sensitivity of variations in the oil revenues. It also shows that inflation often accompanies higher oil revenues. A high inflation rate erodes the increase in the nominal wage rate and the purchasing power of the people declines. Therefore, it is important to control inflation in order to sustain and improve the purchasing power of the people. The root of the inflation problem is excessive Government Spending. Therefore, in order to get inflation under control, Government Spending has to be cut considerably and freedom has to be given to the private sector.

The implementation of import substitution policies in the industrial sector seems to be working. In general, the capability of the economy to substitute imported goods by locally produced ones is increased. The decline of Imported Consumption Goods and Capital Goods (Scenarios 1 and 2, Graphs 9.6 and 9.8) is a clear suggestion of the capability of the Libyan economy to substitute for imported goods.

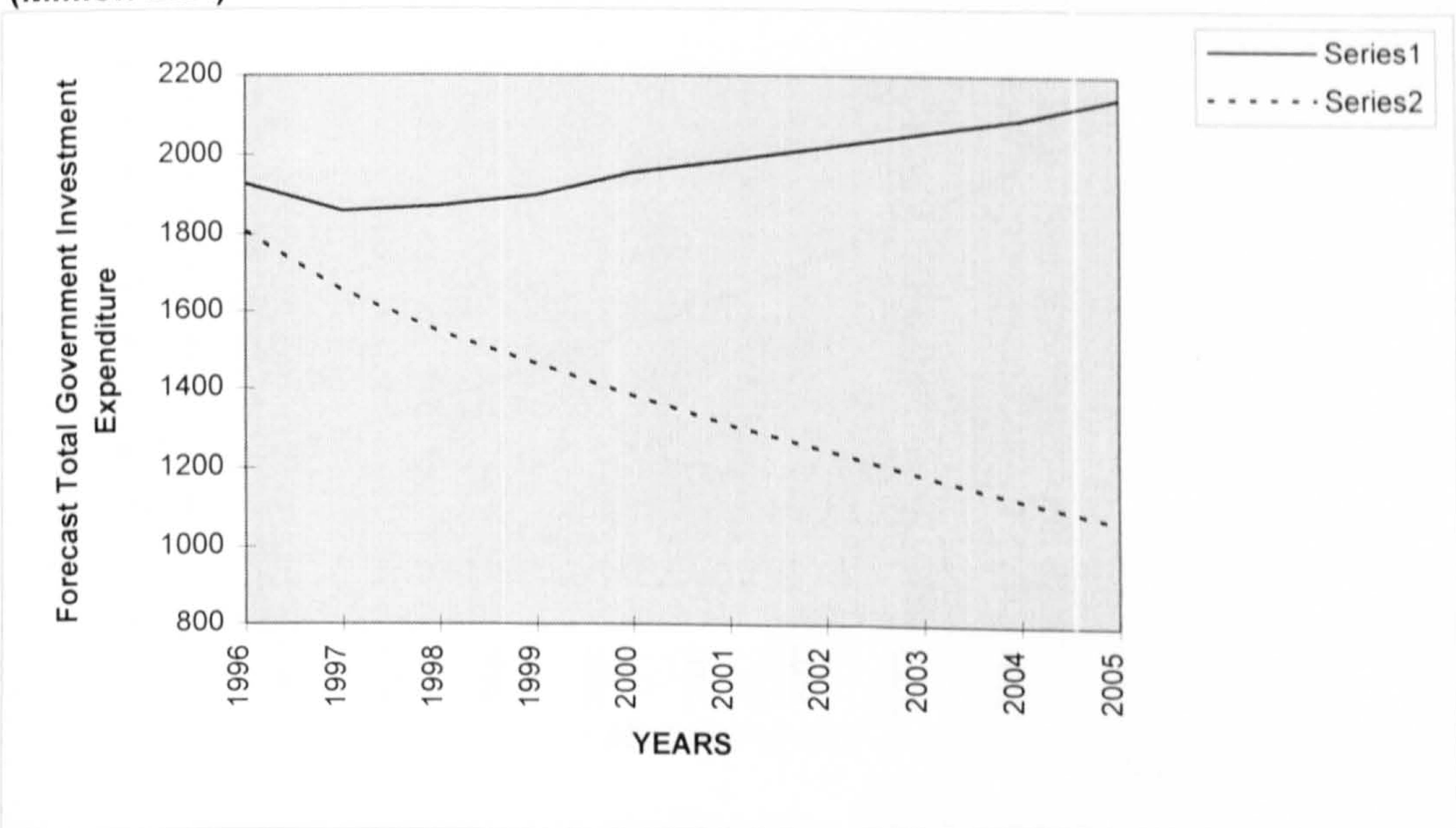
Graph 9.1
Private Consumption Expenditure Forecast
(1996-2005)

(Million L.D.)



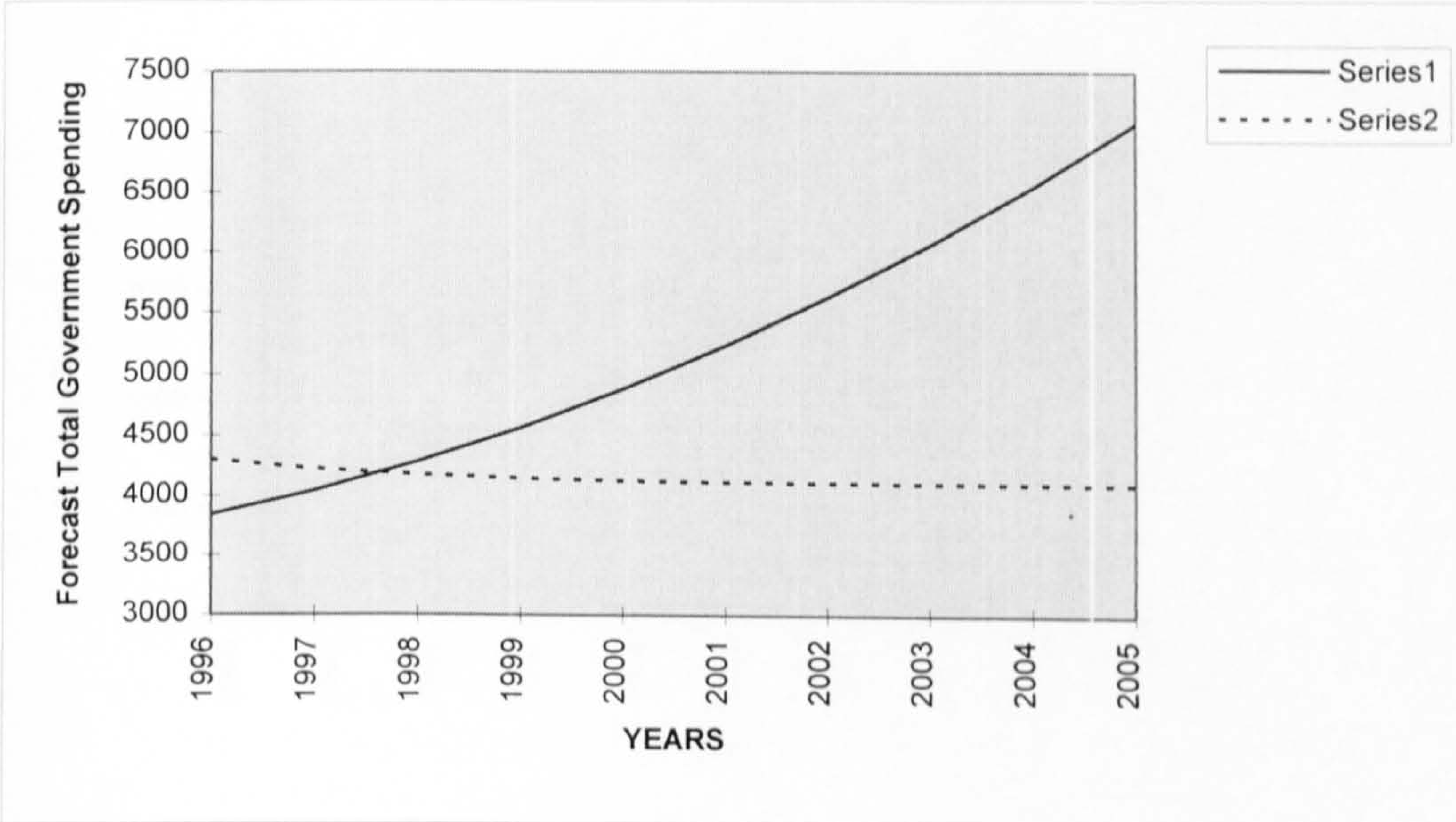
Graph 9.2
Total Government Investment Expenditure Forecast
(1996-2005)

(Million L.D.)

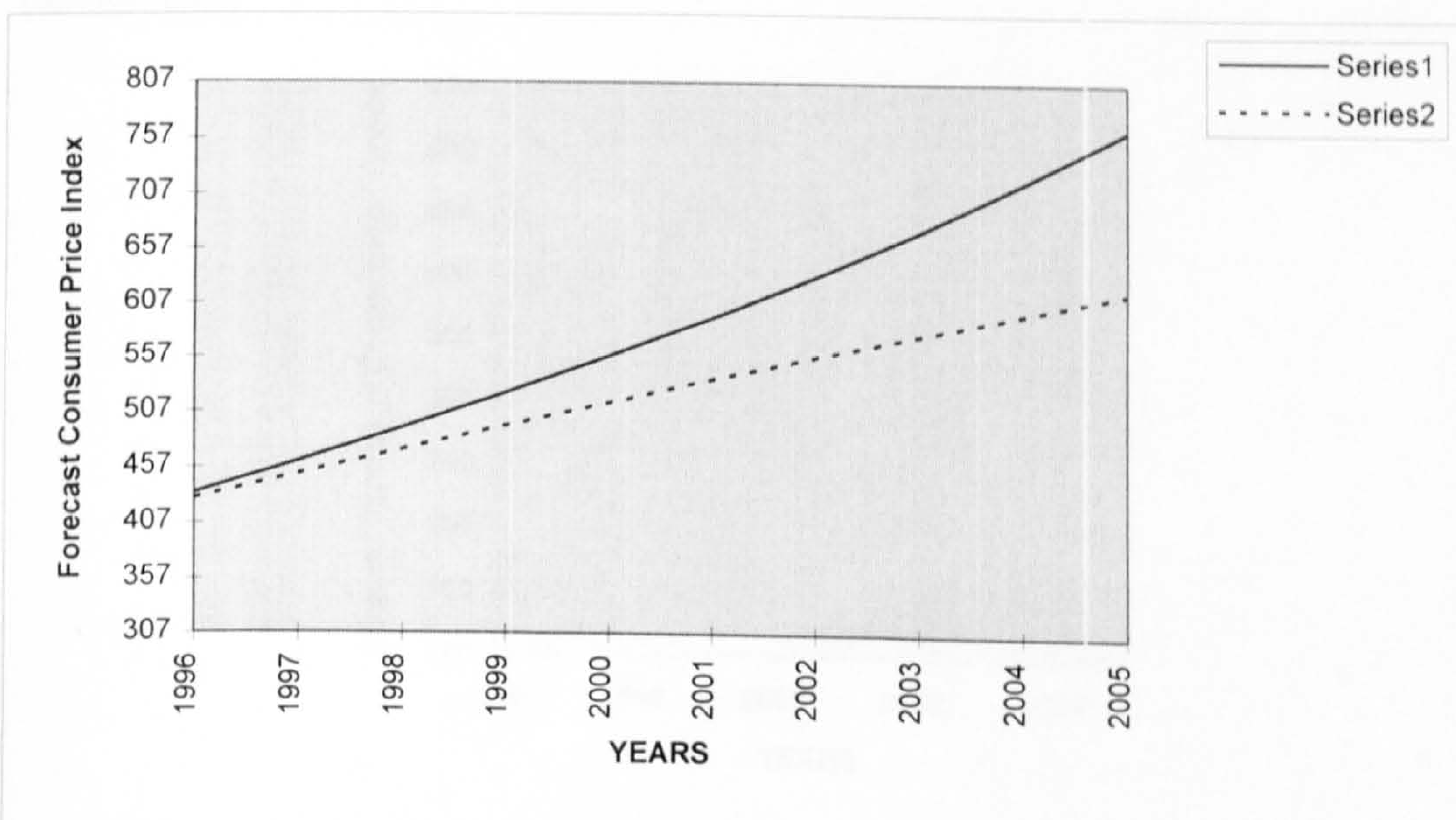


Graph 9.3
Total Government Spending Forecast
(1996-2005)

(Million L.D.)

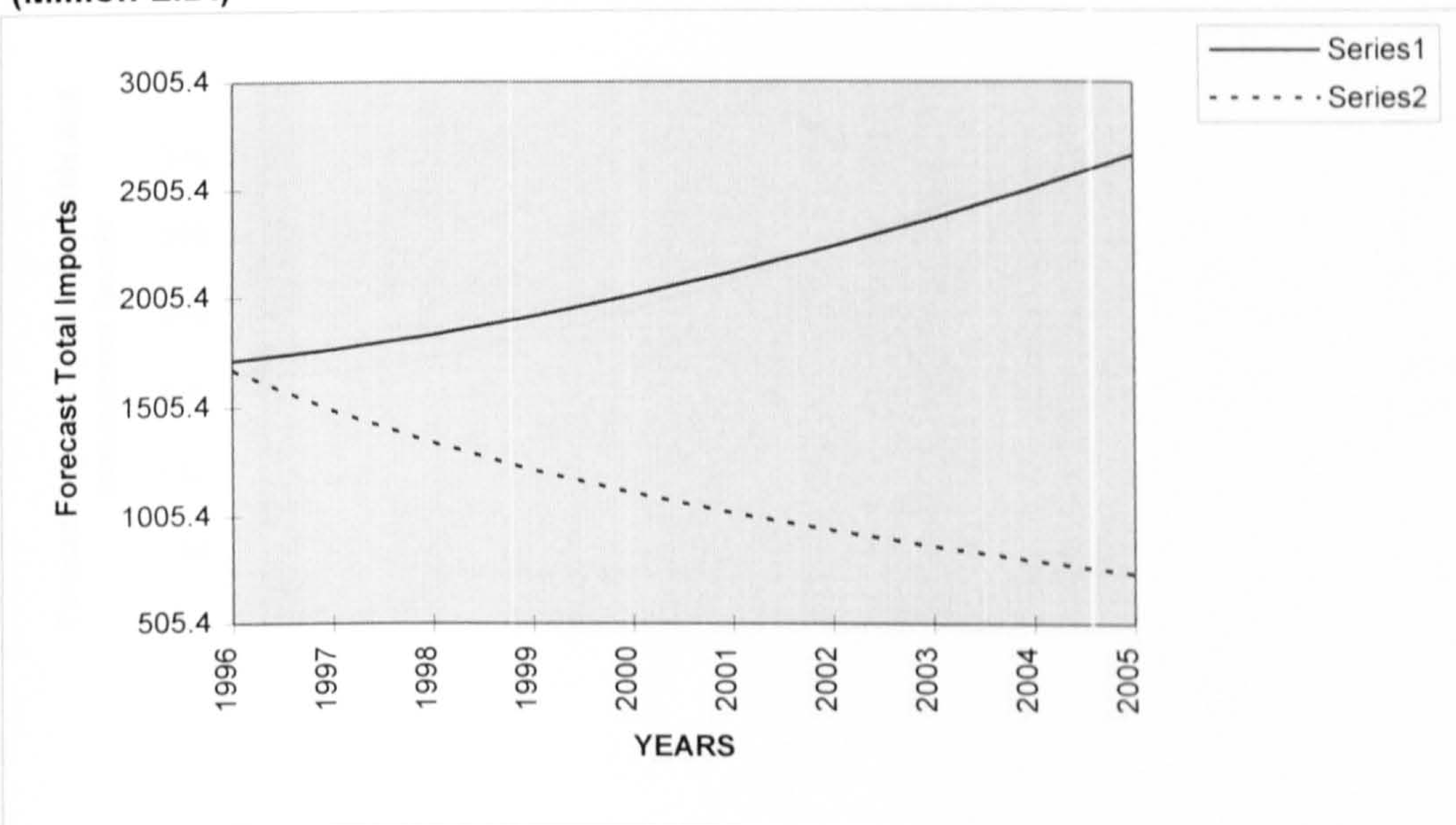


Graph 9.4
Consumer Price Index Forecast
(1996-2005)



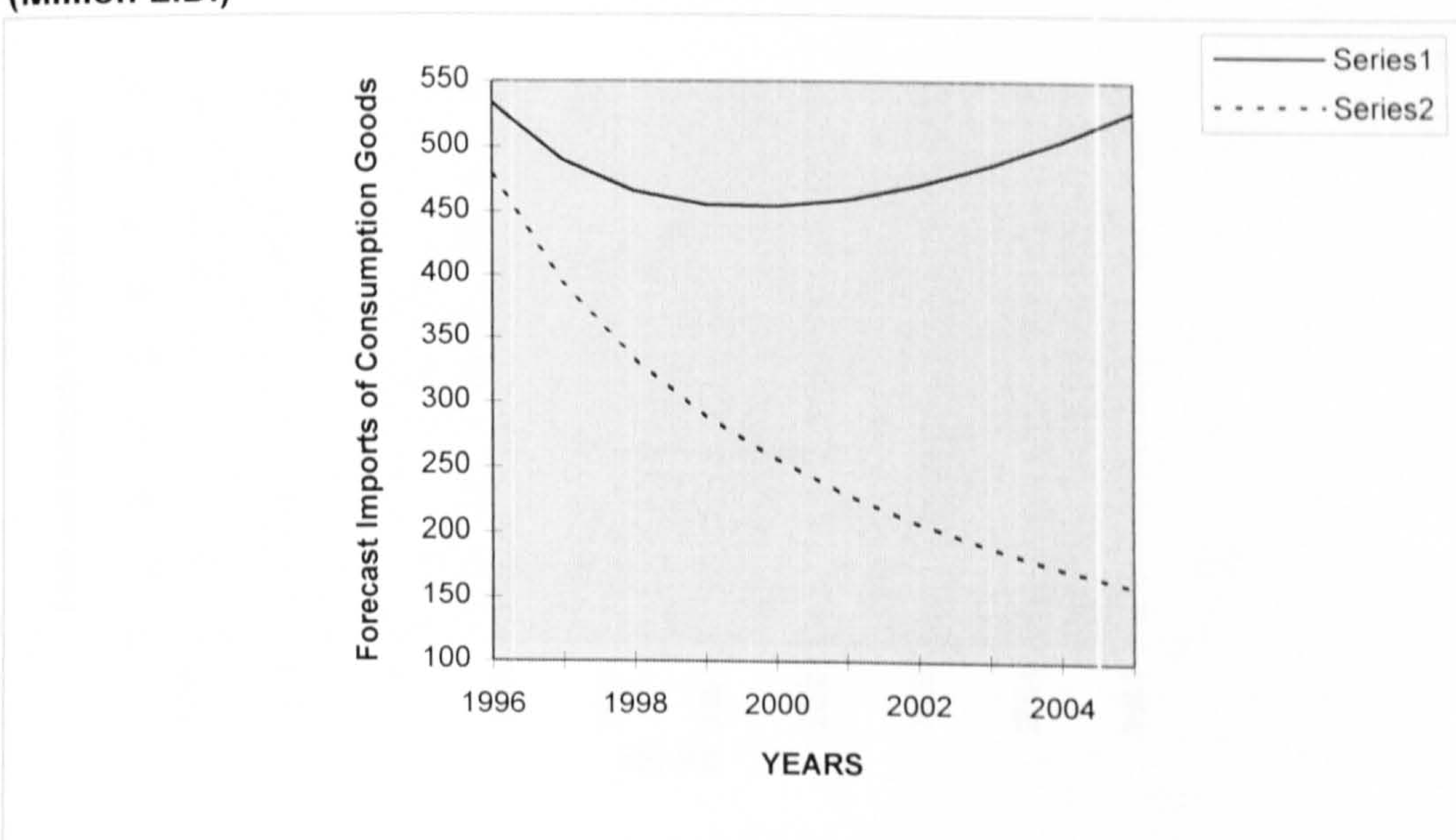
Graph 9.5
Total Imports Forecast
(1996-2005)

(Million L.D.)



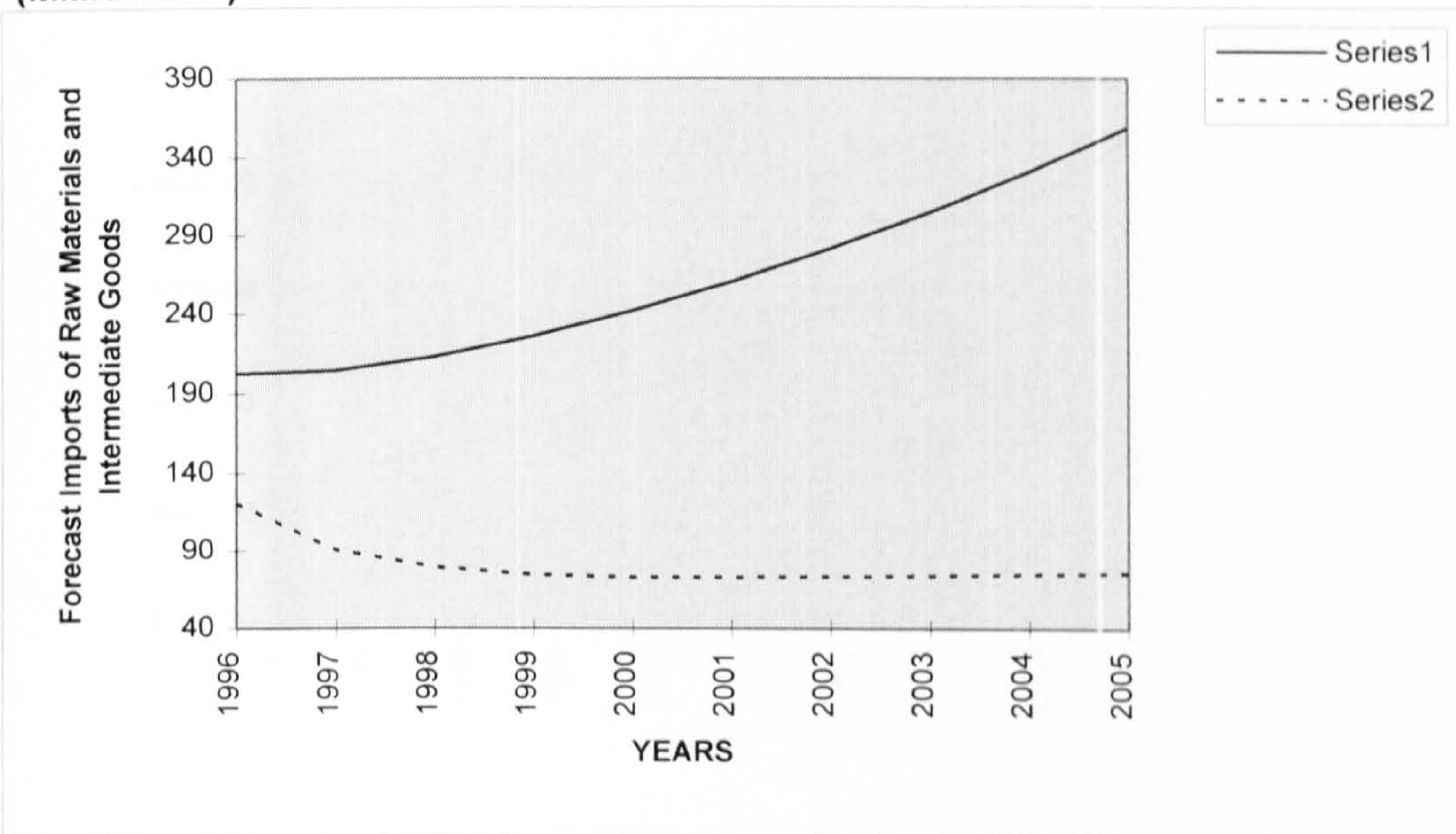
Graph 9.6
Imports of Consumption Goods Forecast
(1996-2005)

(Million L.D.)



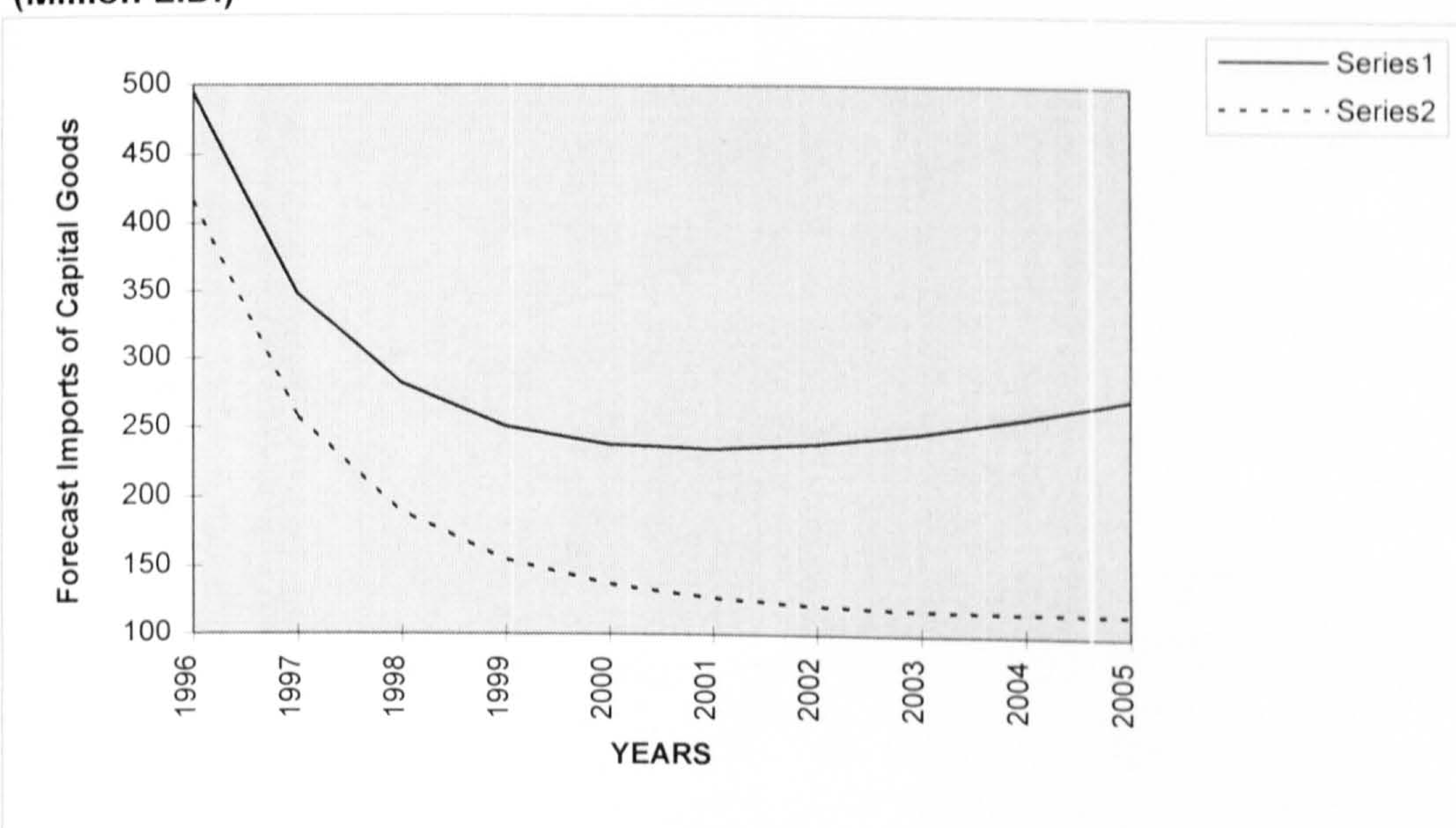
Graph 9.7
Imports of Raw Materials and Intermediate Goods
(1996-2005)

(Million L.D.)



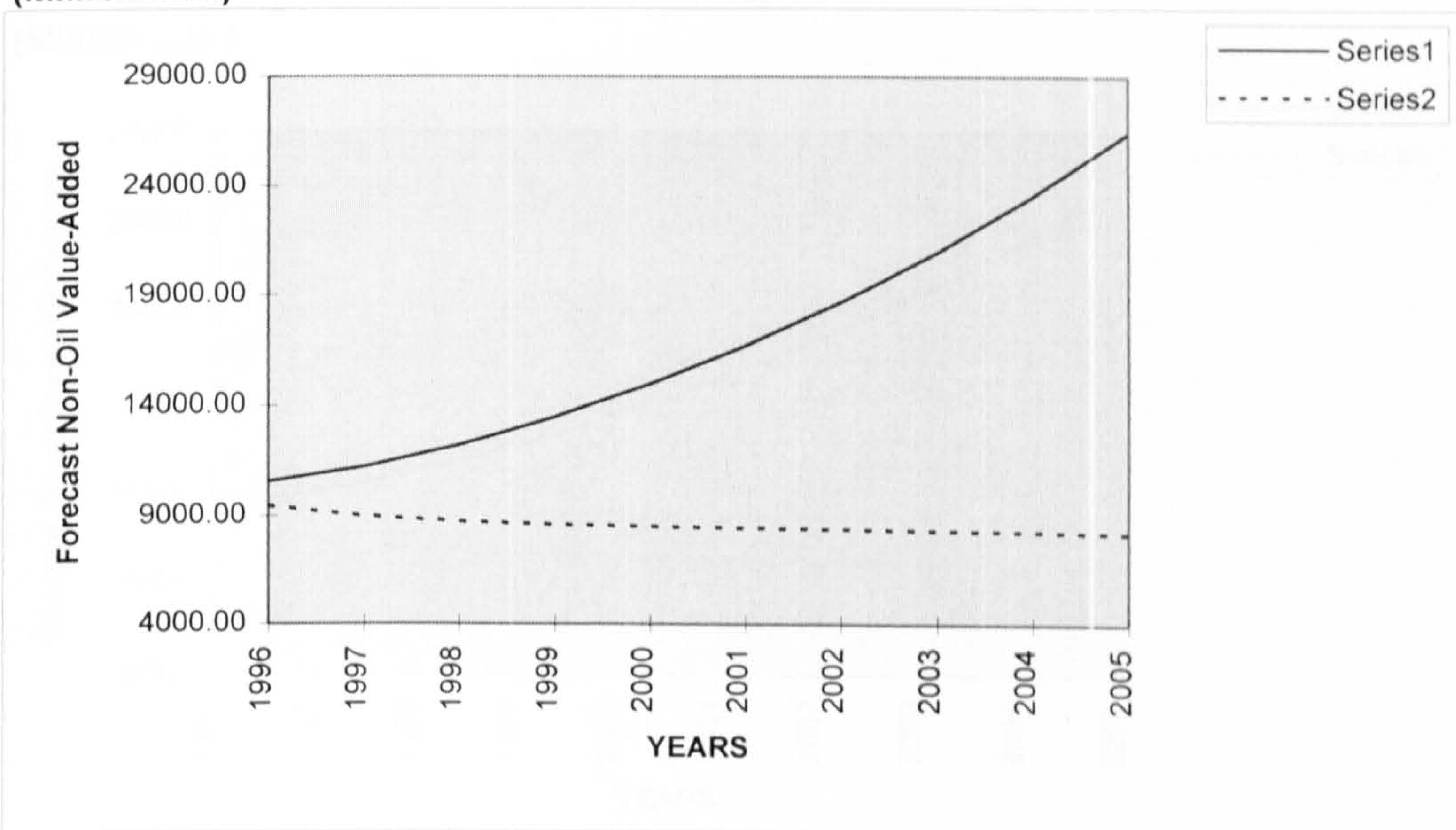
Graph 9.8
Imports of Capital Goods Forecast
(1996-2005)

(Million L.D.)



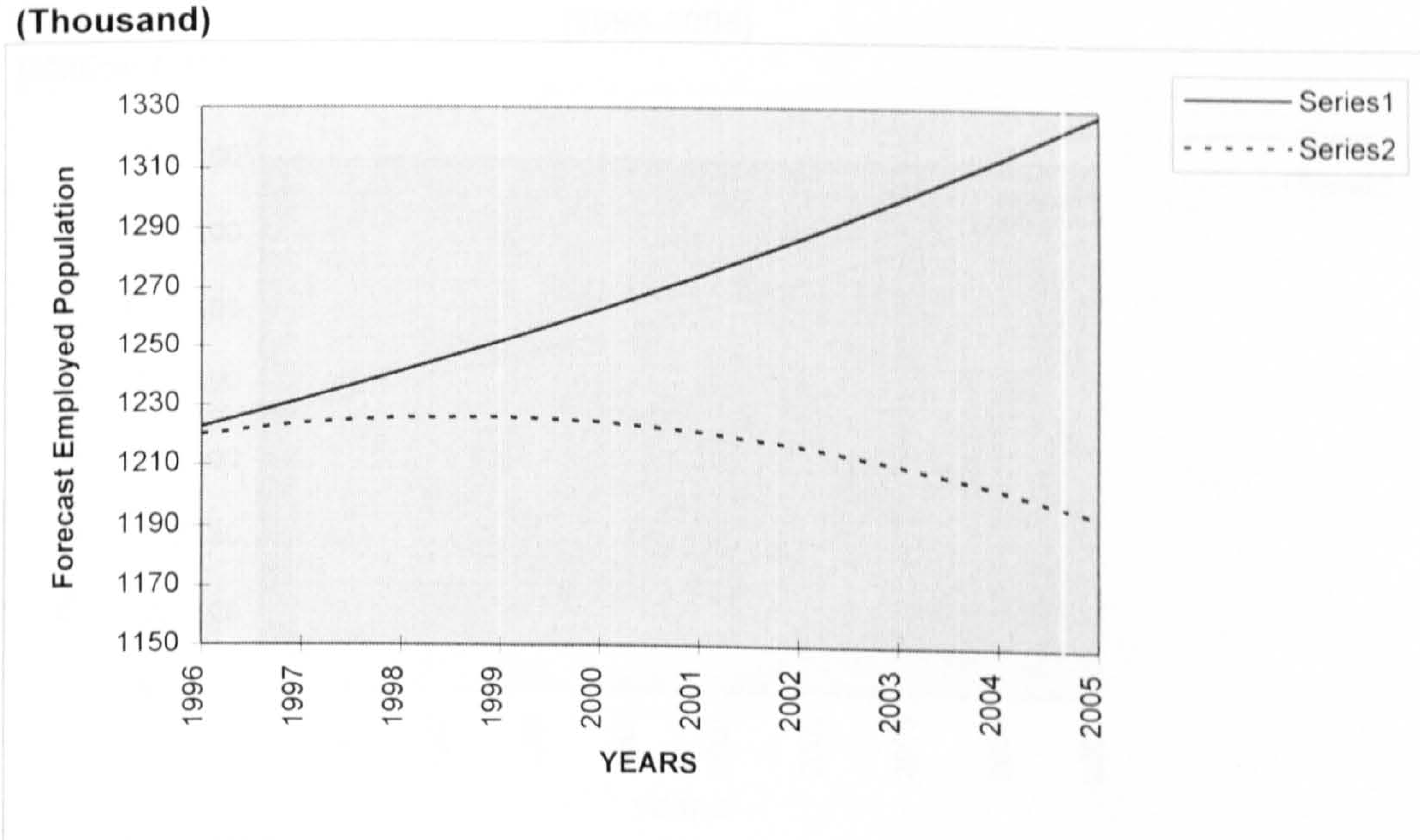
Graph 9.9
Non-Oil Value-Added Forecast
(1996-2005)

(Million L.D.)



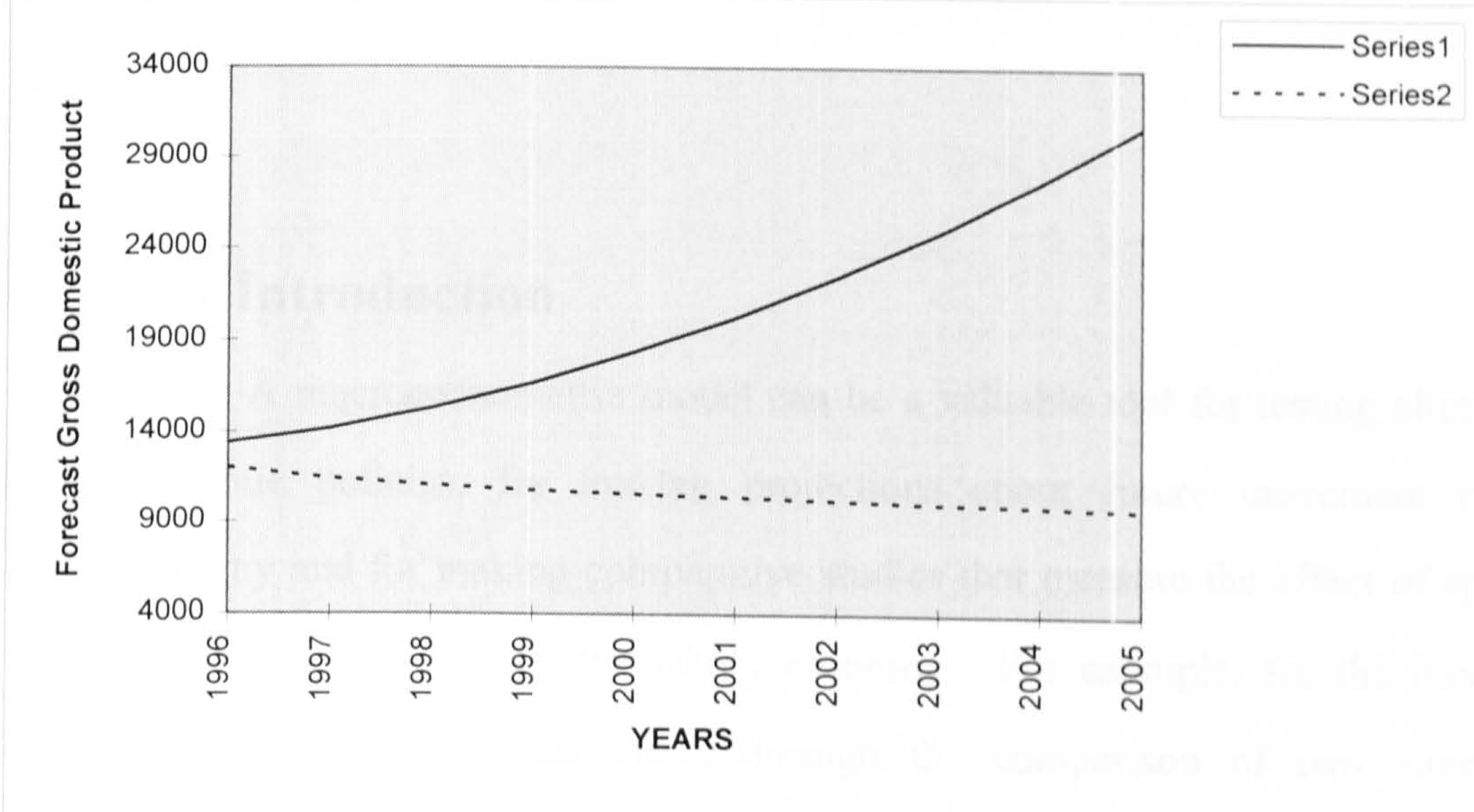
Graph 9.10
Total Employed Population Forecast
(1996-2005)

(Thousand)



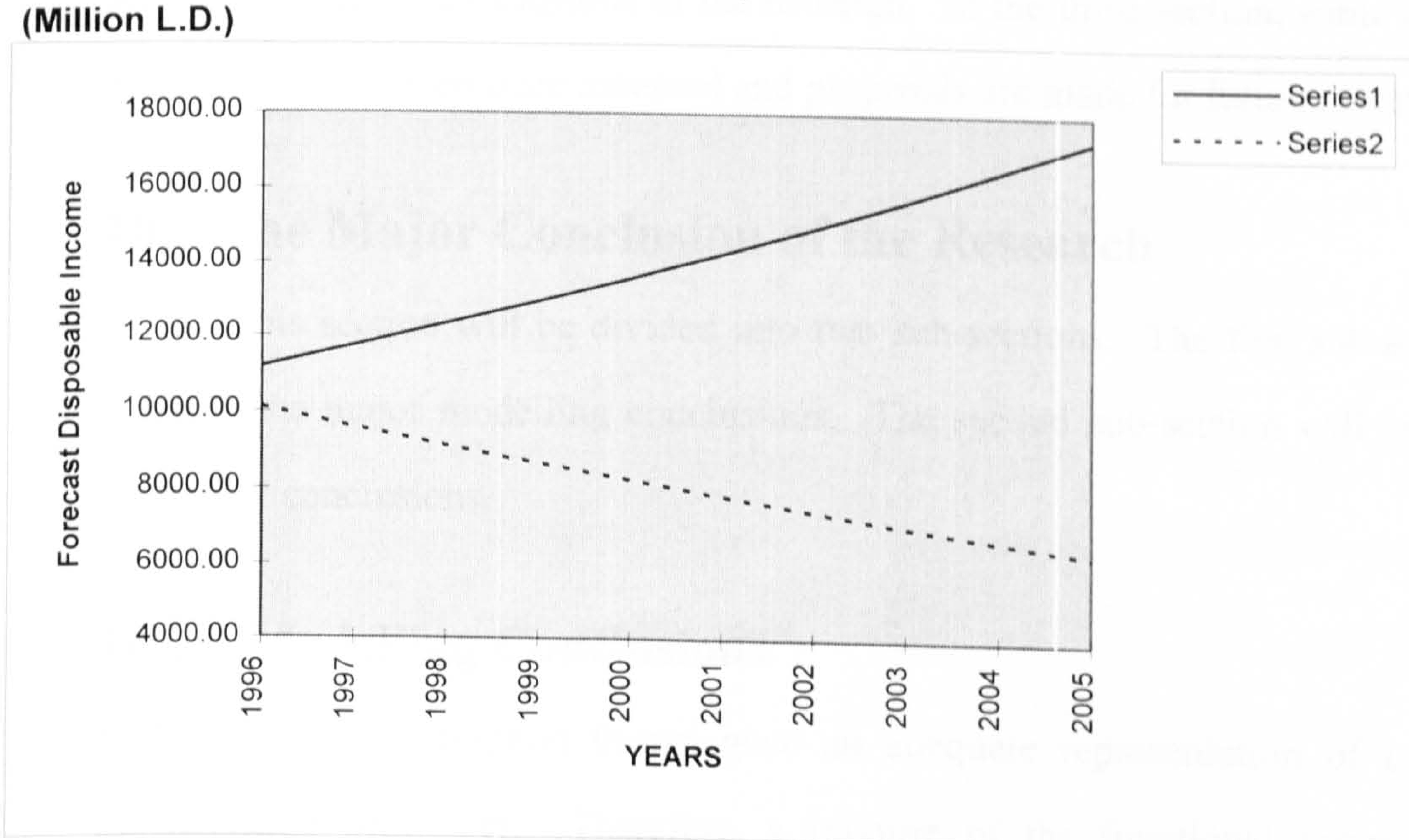
Graph 9.11
Gross Domestic Product Forecast
(1996-2005)

(Million L.D.)



Graph 9.12
Disposable Income Forecast
(1996-2005)

(Million L.D.)



CHAPTER TEN

Conclusion

10.1 Introduction

A macroeconometric model can be a valuable tool for testing alternative economic policies, for making projections about future movement of the economy and for making comparative studies that measure the effect of specific economic conditions on the whole economy. For example, for the model of Libya developed in this thesis through the comparison of two alternative scenarios, it has been possible to establish and quantify the likely impacts of changing oil prices and oil quotas on the Libyan economy.

This chapter will be divided into three sections. The second section presents the major conclusions of the research. In the third section, some of the difficulties encountered are assessed and proposals are made for future research.

10.2 The Major Conclusion of the Research

This section will be divided into two sub-sections. The first sub-section presents the major modelling conclusions. The second sub-section will present the policy conclusions.

10.2.1 Modelling Conclusions

1. No single consumption theory gave an adequate representation of Libyan consumption behaviour. Therefore, a mixture of the functional forms from different consumption theories was used to represent the Private Consumption

Expenditure Function. The first difference of Real Adjusted Disposable Income ($\Delta RADY_t$) and the error correction term ($RADY_{t-1} - RCONS_{t-1}$) are the most important variables believed to determine Private Consumption Expenditure in Libya (Chapter 6, Table 6.3, Eqn. (4), p.123).

2. Government Consumption Expenditure is largely determined by Oil Revenues and Government Consumption Expenditure lagged one year (Chapter 6, Table 6.6, Eqn. (1), p.126).

3. Real Government Annual Appropriation for Investment in the Manufacturing Sector and Real Investment Expenditure in the Manufacturing Sector lagged one year are the most significant variables affecting Real Investment Expenditure in the Manufacturing Sector (Chapter 6, Table 6.15, Eqn. (2), p.139)

4. The first difference of Real Government Annual Appropriation for Investment in the Agriculture Sector ($\Delta RAGRDE_t$) and the error correction term ($RAGRDE_{t-1} - RAGRI_{t-1}$) are the main explanatory variables in Real Investment Expenditure in the Agriculture Sector. The error correction model seems to be the best form to fit Real Investment in the Agriculture Sector (Chapter 6, Table 6.15, Eqn. (3), p.139)

5. Real Investment in the Services Sector is determined by Real Value-Added in the Services Sector, Real Government's Annual Appropriation for Investment in the Services Sector and Real Investment Expenditure in the Services Sector lagged one year (Chapter 6, Table 6.15, Eqn. (4), p.139).

6. The error correction model represents Real Investment Expenditure in the Construction Sector. The determining variables of this function are the first difference of Real Government Annual Appropriation for Investment in the Construction Sector ($\Delta RCOTDE_t$) and the error correction term ($RCOTDE_{t-1} - RCOTI_{t-1}$) (Chapter 6, Table 6.15, Eqn. (5), p.139).

7. Real Oil Revenues and Real Total Imports lagged one year are the most significant variables affecting imports by Libya. The logarithmic form seemed to be the most suitable form for the Real Total Imports function (Chapter 6, Table 6.24, Eqn. (2), p.150). Real Oil Revenues was used in the Imports function instead of the traditional Gross National Product (GNP_t), because Oil Revenues are almost the only source of foreign exchange for Libya. Therefore, imports are determined to a large extent by the availability of foreign exchange.

8. Real Imports of Consumption Goods is largely determined by Real Disposable Income, Real Manufacturing Value-Added and Real Imports of Consumption Goods lagged one year (Chapter 6, Table 6.24, Eqn. (3), p.150).

9. The determining variables of The Real Imports of Intermediate Goods and Raw Materials function are Real Oil Revenues and the Real Imports of Intermediate Goods and Raw Materials Goods lagged one year (Chapter 6, Table 6.24, Eqn. (4), p.150).

10. Real Oil Revenues and Real Imports of Capital Goods lagged one year are the most significant variables affecting Imports of Capital Goods (Chapter 6, Table 6.24, Eqn. (5), p.150).

11. The availability of foreign currency due to the export of Oil and the non-availability of data mean that budget deficit and foreign assets could not be judged to greatly affect the formation of price levels during the model historical period. The log form is the best form to represent the Consumer Price Index (Chapter 6, Table 6.31, Eqn. (1), p.157). The Money Supply and the Consumer Price Index lagged one year are the factors mainly affecting inflation in the Libyan economy.

12. Gross Domestic Product Deflator and Capital Formation Price Index lagged one year are the explanatory variables in the Capital Formation Price Index (Chapter 6, Table 6.31, Eqn. (2), p.157).

13. Gross Domestic Product Deflator is determined by Money Supply, Imports Price Index and Gross Domestic Product Deflator lagged one year (Chapter 6, Table 6.31, Eqn. (3), p.157).

14. Real Gross Domestic Product and Total Number of Workers Employed in the economy lagged one year are the explanatory variables of the Employment function (Chapter 6, Table 6.38, Eqn. (1), p.164).

15. Oil Revenues is largely determined by Real Oil Exports and Real Oil Revenues lagged one year (Chapter 6, Table 6.38, Eqn. (2), p.164).

16. Real Total Imports and Real Indirect Tax lagged one year are the explanatory variables of the Real Indirect Tax Revenues function (Chapter 6, Table 6.38, Eqn. (3), p.164).

17. The Cobb-Douglas function was found to be the most robust form to represent the Libyan production function. Labour elasticity is very high (Chapter 6, Table 6.43, Eqn. (1), p.169). This indicates that the production system of the Libyan economy is highly labour intensive. This means that labour productivity will improve when new capital is introduced in the highly labour-intensive sectors (Agriculture, Services, and Construction).

18. Real Value-Added in the Oil Sector is largely determined by Real Oil Exports and Real Value-Added in the Oil Sector lagged one year (Chapter 6, Table 6.43, Eqn. (2), p.169).

19. The capability of the aggregate and the disaggregate versions of the model in tracking the historical data improved considerably when Real Oil Revenues were considered to be exogenous rather than endogenous (Chapter 7, Tables 7.2 and 7.8, p.180 and p.188).

20. The Capability of the aggregate and the disaggregate versions of the model in tracking the historical data improved considerably when Real Oil Revenues were considered to be exogenous rather than endogenous (Chapter 7, Tables 7.2, 7.5, 7.8, and 7.11, p180, 184, 188, and 192).

21. The capability of the model to track historical data for both versions (aggregate and disaggregate) is improved when the Two Stage Least Square method (2SLS) was applied, rather then the Ordinary Least Square Method (OLS) (Chapter 7, Tables 7.5 and 7.11, , p.184 and p.192).

22. The final version of the model is stable to an exogenous impulse shock of the Oil Revenues, Money Supply and Total Government Spending. The shock effects diminish throughout the model over time (Graphs 8.1, 8.2, 8.3 and 8.4, p.213-214).

23. A maintained increase in Oil Revenues results in higher impact, intermediate and long-run elasticities of Gross Domestic Product, Private Consumption Expenditure and Total Government Investment Expenditure (Chapter 8, Tables 8.1, 8.2 and 8.3, , p.203, 205 and 206). On the other hand, a maintained increase in Money Supply results in higher elasticities in Consumer Price Index and *GDP* Deflator (Chapter 8, Tables 8.4 and 8.5, p.209 and p.210).

24. The model predicts the data beyond its historical data reasonably well, as the RMSPE values indicate (Chapter 9, Table 9.1, p.220).

10.2.2 Policy Conclusions

1. Adopting an import substitution strategy, particularly for those industries which depend on local inputs, will improve the capability of the Libyan economy to substitute a considerable amount of imported Raw Material and Intermediate Goods, Consumption Goods and even Capital Goods (Chapter 9).

2. The model is very sensitive to any shock in Oil Revenues. This indicates the high dependency of the Libyan economy on Oil Revenues as a source of foreign exchange and government revenue. Therefore, it is very important to generate other sources of foreign currency by stimulating export industries and expanding import substituting industries which depend on local raw materials as far as possible.

10.3 Difficulties Encountered and Proposals for Future Research

10.3.1 Difficulties

Limitations of data were the main obstacle faced by the researcher. For example, data on the following variables were not available: Private Consumption of Durable and Non-Durable Goods, Investment Expenditure on Machinery, Wages, Profit Margins, data on Financial Market Assets, Private Investment, a capacity Utilisation Index, a reasonable measure of cost of capital, Unemployment, and Labour Force in general.

Data on Libya during the period 1992-1996 is very restricted and classified and is therefore not available. This data is very important for ex-post and ex-ante forecasts. The researcher was forced to attempt to gather this data from different sources. The unavailability, or the limitation of the availability, of such import data put serious restrictions on the level of disaggregation of the model and sometimes caused important variables to be ignored. Thus, the model presented is only a beginning and there will always be room for its improvement, as more statistical data become available.

10.3.2 Proposals

In relation to the model, it may be useful to make some suggestions that should be taken into consideration in future research, in order to correct some imperfections and deficiencies that are present in this version of the model.

1. It is advisable to use input-output technical coefficients and final demand components to form the production function for the economy as a whole and at a sectoral level. This would not only link the final demand in the model to the production system, but also the intermediate, or inter-sectoral, demands would be included and linked to the model, as determinants of sectoral production.

2. Education and the nature of the rural population should be taken into consideration in the employment equation.

3. A financial model needs to be constructed and linked to the real sector in the macroeconometric model of Libya. In the financial model, detailed endogenous information about internal and external capital flows and the inclusion of monetary policy instruments among the policy variables, would permit the impact of monetary policy to be measured much more accurately and to be compared with the results of fiscal policy.

4. The disposition of internal sectoral models, such as industrial models, construction sector model and others, could also be of great support to the macroeconometric model.

APPENDIX

APPENDIX 1

1.1 List of Variables

ADY_t = Adjusted Disposable Income (Million L.D.).

$AGRCST_t$ = Capital Stock in the Agricultural Sector (Million L.D.).

$AGRDE_t$ = Government's Annual Appropriation for Investment in the Agriculture Sector (Million L.D.).

$AGRI_t$ = Gross Investment in the Agricultural Sector (Million L.D.).

$AGRNK_t$ = Population Employed in the Agricultural Sector (Thousands).

$AGRVAL_t$ = Value-Added Generated in the Agricultural Sector (Million L.D.).

$BARREL_t$ = Oil Production (Mbd).

$CONS_t$ = Private Consumption Expenditure (Million L.D.).

$COTCST_t$ = Capital Stock in the Construction Sector (Million L.D.).

$COTDE_t$ = Government's Annual Appropriation for Investment in the Construction Sector (Million L.D.).

$COTI_t$ = Gross Investment in the Construction Sector (Million L.D.).

$COTNK_t$ = Population Employed in the Construction Sector (Thousands).

$COTVAL_t$ = Value-Added Generated in the Construction Sector (Million L.D.).

CST_t = Total Capital Stock (Million L.D.).

$DISY_t$ = Personal Disposable Income (Million L.D.).

$DTAX_t$ = Direct Tax Revenue (Million L.D.).

$GCONS_t$ = Government Consumption Expenditure (Million L.D.).

GDP_t = Gross Domestic Product (Million L.D.).

GNP_t = Gross National Product (Million L.D.).

$ECHRATE_t$ = Official Exchange Rate.

$IMPCAPT_t$ = Imports of Capital Goods (Million L.D.).

$IMPCONS_t$ = Imports of Consumption Goods (Million L.D.).

$IMPINT_t$ = Imports of Raw Materials and Intermediate Goods (Million L.D.).

$INTAX_t$ = Indirect Tax Revenue (Million L.D.).

$INVDX_t$ = Capital Formation Price Index (Million L.D.).

$MANCST_t$ = Capital Stock in the Manufacturing Sector (Million L.D.).

$MANDE_t$ = Government's Annual Appropriation for Investment in the Manufacturing Sector (Million L.D.).

$MANDE_{t-1}$ = Government's Annual Appropriation for Investment in the Manufacturing Sector lagged one year.

$MANI_t$ = Gross Investment in the Manufacturing Sector (Million L.D.).

$MANI_{t-1}$ = Gross Investment in the Manufacturing Sector lagged one year (Million L.D.).

$MANNK_t$ = Population Employed in the Manufacturing Sector (Thousands).

$MANVAL_t$ = Value-Added Generated in the Manufacturing Sector (Million L.D.).

$MANVAL_{t-1}$ = Value-Added Generated in the Manufacturing Sector lagged one year.

$MONEY_t$ = Money Supply (Million L.D.).

$NATY_t$ = National Income (Million L.D.).

$NOEXP_t$ = Non-Oil Exports (Million L.D.).

$NOKT_t$ = Non-Oil Capital Stock (Million L.D.).

$NONK_t$ = Non-Oil Total Population Employed (Thousands).

$NOQT_t$ = Non-Oil Value-Added (Million L.D.).

$OEXP_t$ = Oil Exports (Million L.D.).

$OILCST_t$ = Capital Stock in the Oil Sector (Million L.D.).

$OILNK_t$ = Population Employed in the Oil Sector (Thousands).

$OILPRI_t$ = Oil Price (L.D.).

$OILREV_t$ = Oil Revenues (Million L.D.).

$OILREV_{t-1}$ = Oil Revenues lagged one year.

$OILVAL_t$ = Value-Added Generated in the Oil Sector (Million L.D.).

$OILVAL_{t-1}$ = Value-Added Generated in the Oil Sector lagged one year.

$PGDPIDX_t$ = Gross Domestic Product Deflator.

PIM_t = Import Price Index.

POP_t = Total Population.

$PSDX_t$ = Consumer Price Index.

$SERCST_t$ = Capital Stock in the Services Sector (Million L.D.).

$SERDE_t$ = Government's Annual Appropriation for Investment in the Services Sector (Million L.D.).

$SERDE_{t-1}$ = Government's Annual Appropriation for Investment in the Services Sector lagged one year.

$SERI_t$ = Gross Investment in the Services Sector (Million L.D.).

$SERI_{t-1}$ = Gross Investment in the Services Sector lagged one year.

$SERNK_t$ = Population Employed in the Services Sector (Thousands).

$SERVAL_t$ = Value-Added Generated in the Services Sector (Million L.D.).

$TEXPORT_t$ = Total Exports (Million L.D.).

$TCONS_t$ = Total Consumption Expenditure (Million L.D.).

$TCONS_{t-1}$ = Total Consumption Expenditure lagged one year.

TDE_t = Total Government's Annual Appropriation for Investment (Million L.D.).

$TGSP_t$ = Total Government Expenditure (Million L.D.).

$TIME_t$ = Time

$TIMP_t$ = Total Imports (Million L.D.).

$TINVS_t$ = Total Investment Expenditure (Million L.D.).

$TINVS_{t-1}$ = Total Investment Expenditure lagged one year.

TNW_t = Total Population Employed in the Libyan Economy (Thousands).

$TREVN_t$ = Government Total Revenue (Million L.D.).

1.2 The Historical Data Used in the Model

Table 1.1 Historical Data of the Model

YEAR	ADY	AGRCST	AGRDE	AGRI	AGRNK	AGRVAL	BARREL
1962	130.500	2.400	1.100	2.400	145.700	14.900	0.182
1963	148.090	4.460	1.300	2.300	145.500	15.100	0.442
1964	162.500	6.614	1.900	2.600	145.300	16.700	0.865
1965	190.520	11.553	7.200	5.600	142.500	25.200	1.212
1966	246.400	19.297	10.100	8.900	140.000	27.300	1.508
1967	288.710	25.468	17.300	8.100	135.300	30.900	1.733
1968	394.920	33.020	14.400	10.100	130.500	33.400	2.606
1969	473.930	41.119	13.200	11.400	125.000	37.400	3.108
1970	506.110	48.607	23.600	11.600	126.000	33.100	3.300
1971	594.150	77.346	48.000	33.600	127.000	33.000	2.800
1972	691.660	107.512	64.300	37.900	127.700	43.600	2.300
1973	867.540	176.160	90.000	79.400	129.000	60.000	2.200
1974	1210.100	312.644	224.900	154.100	131.400	64.700	1.521
1975	1475.900	431.280	245.900	149.900	133.400	82.900	1.480
1976	1533.900	559.052	296.700	170.900	141.200	99.700	1.933
1977	1858.000	691.547	277.600	188.400	144.900	90.000	2.063
1978	1819.200	839.892	289.100	217.500	147.900	122.100	1.983
1979	2556.800	990.103	385.900	234.200	150.100	140.400	2.092
1980	3628.500	1225.293	489.900	334.200	153.400	183.000	1.827
1981	4113.700	498.400	487.500	375.900	162.400	210.700	1.109
1982	3727.200	297.500	308.600	247.700	167.500	220.700	1.017
1983	3543.200	267.200	252.900	237.400	173.000	255.000	1.030
1984	3252.000	268.200	262.300	241.500	185.500	258.800	0.957
1985	3611.800	200.300	182.800	173.500	177.000	283.200	1.024
1986	4024.900	162.500	130.500	142.500	178.500	320.000	1.034
1987	4751.700	162.300	115.700	146.000	180.000	348.500	0.973
1988	5560.900	159.000	92.400	142.800	186.900	366.500	1.030
1989	6748.700	167.300	83.000	151.400	191.600	395.500	1.101
1990	7808.700	175.600	68.200	158.900	188.900	423.500	1.372
1991	8757.900	192.400	56.000	174.800	188.000	480.500	1.515

Table 1.1 Continued

YEAR	ECHRATE	CONS	COTCST	COTDE	COTI	COTNK	COTVAL
1962	2.800	137.300	5.900	3.600	1.400	32.400	10.300
1963	2.800	143.000	7.310	4.100	2.000	32.400	12.700
1964	2.800	159.000	9.379	7.500	2.800	32.400	21.700
1965	2.800	188.800	11.641	12.100	3.200	33.000	34.900
1966	2.800	239.200	18.377	23.000	7.900	34.000	45.300
1967	2.800	280.000	22.500	32.100	6.000	35.900	66.200
1968	2.800	319.800	26.200	34.100	5.900	38.000	89.200
1969	2.800	376.400	29.500	39.300	5.900	41.000	87.100
1970	2.800	395.500	28.700	37.500	2.200	49.000	87.800
1971	3.040	468.600	37.300	39.400	11.500	59.500	116.800
1972	3.040	543.300	48.100	72.200	14.500	69.500	182.800
1973	3.378	702.700	65.700	60.900	22.400	90.400	261.200
1974	3.378	927.100	90.200	146.900	31.100	121.600	376.600
1975	3.378	1193.500	109.600	128.300	28.400	152.600	434.700
1976	3.378	1336.600	124.900	138.300	26.300	167.800	515.100
1977	3.378	1482.600	143.700	175.100	31.200	171.400	602.000
1978	3.378	1665.200	145.600	152.700	16.300	164.300	682.800
1979	3.378	1894.700	151.000	167.800	20.000	168.800	726.700
1980	3.378	2868.900	158.700	224.000	22.800	173.000	935.700
1981	3.378	3887.400	40.900	296.300	25.000	244.500	1002.500
1982	3.378	3617.900	34.000	230.100	30.000	317.400	914.900
1983	3.378	3453.800	36.400	198.000	33.000	371.300	879.000
1984	3.378	3094.200	43.600	186.600	40.000	179.000	851.400
1985	3.378	3108.900	54.400	143.900	50.000	152.000	920.500
1986	3.186	3525.500	46.900	131.200	41.500	149.700	895.000
1987	3.695	4026.100	46.600	109.200	41.900	149.200	850.000
1988	3.505	4646.100	45.700	117.900	41.000	148.100	892.500
1989	3.425	5449.900	46.400	108.900	41.800	156.300	920.000
1990	3.705	6125.700	50.600	100.500	46.000	157.100	1020.500
1991		6787.300	55.200	92.800	50.100	155.700	1124.500

Table 1.1 Continued

YEAR	CST	DISY	DTAX	GCONS	GDP	GNP	IMPCAP
1962	64.400	126.100	6.600	26.000	145.50	210.80	55.700
1963	84.930	179.100	10.700	32.900	235.30	293.40	63.200
1964	185.367	205.400	9.613	45.000	364.80	363.10	74.800
1965	242.240	280.000	11.705	61.300	492.10	481.70	85.200
1966	336.596	346.100	13.913	82.700	634.90	638.80	105.600
1967	438.188	385.600	17.623	101.400	747.80	768.80	121.600
1968	620.298	481.000	24.641	148.400	1072.60	1065.60	174.400
1969	765.749	581.900	28.277	198.600	1223.00	1266.20	182.300
1970	797.154	570.700	29.931	259.900	1288.30	1420.50	132.100
1971	916.949	1280.700	24.611	318.400	1586.10	1756.60	165.600
1972	1229.254	1372.500	31.044	359.100	1753.00	1928.70	242.100
1973	1714.268	1710.400	37.760	465.400	2182.00	2424.50	387.200
1974	2492.081	3244.300	55.744	864.800	3795.70	4370.60	605.500
1975	3275.013	3132.800	74.250	1044.300	3674.30	4218.40	781.500
1976	4148.392	4154.400	96.492	1185.000	4768.10	4922.10	727.200
1977	5078.213	4994.300	130.253	1400.300	5612.70	6163.40	832.300
1978	6061.831	4975.700	173.366	1691.800	5496.10	6351.80	1036.300
1979	7325.218	6965.400	191.951	1929.000	7603.00	8922.90	1205.400
1980	8987.347	9916.400	282.208	2298.000	10277.30	12020.40	1461.500
1981	3799.000	8456.700	336.300	2539.000	8869.10	11745.90	1856.300
1982	2988.500	8074.500	398.100	3005.000	8780.60	10755.30	1639.600
1983	2666.500	7563.700	441.400	3113.000	8481.90	10245.60	1287.600
1984	2585.900	6945.300	391.900	2849.000	7681.10	9056.60	1408.700
1985	2289.700	7506.600	352.800	2851.000	8050.20	9548.60	911.600
1986	2067.900	6005.300	328.100	2851.000	6577.00	7712.00	1151.800
1987	2069.500	6305.600	317.000	2285.000	6871.80	7708.10	914.900
1988	1529.400	6179.500	329.800	2354.000	6693.50	7525.20	1265.200
1989	1691.400	6797.500	336.396	2323.000	6781.50	9585.00	1031.300
1990	1628.300	7137.400	343.124	2371.000	7672.00	11462.20	1029.600
1991	1752.000	8350.800	349.986	2435.000	8900.00	12198.20	994.900

	Table 1.1					Continued	
YEAR	IMPCONS	IMPINT	INTAX	INVDX	MANCST	MANDE	MANI
1962	8.400	9.300	17.600	58.600	1.600	1.000	1.600
1963	11.900	10.200	20.400	61.800	3.840	1.000	2.400
1964	16.100	13.500	21.400	62.500	6.956	2.000	3.500
1965	15.800	13.400	27.281	68.300	11.560	2.300	5.300
1966	22.700	16.400	33.449	75.200	19.304	4.700	8.900
1967	31.000	17.400	35.537	75.400	27.174	7.400	9.800
1968	31.700	24.200	46.278	84.900	32.657	7.400	8.200
1969	34.200	24.800	52.671	93.100	39.091	6.300	9.700
1970	44.600	21.300	50.538	100.000	44.582	15.000	9.400
1971	55.600	29.200	54.852	106.000	70.624	29.000	30.500
1972	67.100	34.000	70.391	118.000	118.461	65.100	54.900
1973	96.400	56.300	96.457	115.000	181.815	62.500	75.200
1974	141.800	75.000	155.579	126.700	290.934	107.000	127.300
1975	179.600	87.600	198.239	133.000	383.340	100.000	121.500
1976	140.400	83.100	221.897	141.800	516.206	165.500	171.200
1977	209.000	75.800	240.511	150.600	629.186	160.700	164.600
1978	246.400	79.900	281.124	157.700	729.467	157.100	163.200
1979	263.100	103.900	360.574	171.600	926.320	210.200	269.800
1980	387.700	157.700	460.100	194.600	1265.488	583.200	431.800
1981	449.800	175.300	575.800	206.900	569.400	530.900	442.900
1982	339.000	145.700	528.000	211.800	399.600	409.700	342.700
1983	316.400	180.800	470.000	215.600	436.500	455.700	396.500
1984	295.400	137.600	562.200	219.100	390.800	381.500	347.200
1985	206.800	96.000	670.700	221.300	313.600	289.200	274.500
1986	239.200	109.000	457.600	227.000	255.900	211.600	224.500
1987	227.100	136.100	448.000	232.900	254.000	166.100	228.400
1988	263.200	157.000	602.000	239.000	248.900	134.500	223.500
1989	297.900	145.700	548.000	245.200	270.800	164.800	245.900
1990	342.600	138.700	561.400	251.500	296.100	143.200	268.000
1991	354.400	156.100	559.400	258.100	317.600	124.500	288.100

Table 1.1 **Continued**

YEAR	MANNK	MANVAL	MONEY	NATY	NOEXP	NOKT	NONK
1962	23.800	9.000	28.700	147.700	2.400	27.700	341.400
1963	23.800	9.900	33.033	222.500	1.700	56.630	345.800
1964	23.800	11.500	42.266	286.300	3.100	96.267	350.500
1965	23.700	12.600	64.300	410.500	2.900	151.440	357.600
1966	23.100	14.400	88.567	530.200	2.200	242.696	365.700
1967	22.000	16.400	115.766	618.500	2.600	358.388	375.000
1968	20.800	20.000	146.600	844.300	2.400	485.698	386.400
1969	19.400	20.800	196.733	1009.000	2.100	597.449	400.800
1970	20.400	22.500	239.800	1072.300	3.000	686.754	419.500
1971	21.400	24.500	359.433	1257.700	1.700	876.249	444.800
1972	22.900	32.000	421.267	1372.500	3.900	1193.954	473.600
1973	25.900	43.800	490.970	1710.400	5.300	1676.568	522.800
1974	29.300	55.000	753.840	3244.300	2.200	2463.881	590.900
1975	32.900	65.500	844.450	3182.100	2.600	3243.813	659.800
1976	37.400	90.600	1139.370	4197.000	3.000	4118.692	714.200
1977	41.500	124.700	1443.760	5038.800	3.600	5027.513	745.600
1978	47.400	148.700	1687.810	5008.300	3.300	5954.731	752.300
1979	52.800	185.800	2223.000	7030.000	2.600	7224.718	768.500
1980	58.000	192.200	2856.900	9929.900	2.800	8823.747	789.600
1981	64.000	219.300	3512.100	8479.200	1.300	3623.200	922.800
1982	73.700	243.700	3232.300	8097.600	2.100	2669.000	1059.300
1983	80.500	274.600	2894.400	7590.300	1.500	2306.000	1154.800
1984	72.000	298.300	2711.300	6970.900	2.500	2082.300	907.100
1985	75.000	365.100	3492.200	7520.000	3.400	1647.800	873.700
1986	77.000	401.800	3041.400	6204.000	2.700	1337.800	884.100
1987	79.000	442.500	3438.600	6514.200	1.200	1330.000	895.500
1988	85.800	487.500	3032.700	5758.600	118.800	1303.500	939.900
1989	92.200	539.000	3521.500	6248.100	210.000	1348.000	971.800
1990	99.400	595.500	4452.300	6498.000	180.000	1426.000	993.200
1991	101.100	667.500	4293.000	5978.200	125.500	1530.200	988.200

Table 1.1 Continued

YEAR	NOQT	OEXP	OILCST	OILNK	OILPRI	OILREV	OILVAL
1962	106.900	47.500	36.700	14.600	0.072	14.000	38.600
1963	135.000	117.500	28.300	14.700	0.700	38.500	100.300
1964	168.300	218.200	89.100	14.800	0.689	75.300	196.500
1965	221.000	281.300	90.800	14.800	1.074	125.400	271.100
1966	277.700	355.200	93.900	14.500	0.649	178.000	357.200
1967	344.000	417.400	79.800	14.300	0.663	224.100	403.800
1968	422.500	664.600	134.600	14.100	0.703	352.700	650.100
1969	466.800	772.200	168.300	13.800	0.688	415.100	756.200
1970	474.000	853.200	110.400	14.000	0.707	484.000	814.300
1971	655.800	961.800	40.700	14.200	0.971	652.318	930.300
1972	823.000	964.200	35.300	14.400	1.193	624.575	930.000
1973	1038.200	1194.300	37.700	15.300	1.505	604.108	1143.800
1974	1394.900	2445.000	28.200	16.300	4.495	1474.100	2400.800
1975	1692.500	2003.000	31.200	17.600	3.835	1323.995	1981.800
1976	1993.900	2151.900	29.700	18.500	3.184	2077.336	2774.200
1977	2308.300	3077.000	50.700	19.200	4.339	2625.846	3304.400
1978	2654.100	2927.400	107.100	20.400	4.324	2183.483	2842.000
1979	3016.200	4728.500	100.500	20.500	6.589	3682.176	4586.800
1980	3657.300	6486.400	163.600	23.200	10.497	5951.100	6620.000
1981	4180.700	4608.500	175.800	23.800	11.884	4461.200	4688.400
1982	4248.000	4054.100	319.500	24.400	11.401	4129.200	4532.600
1983	4343.200	3654.200	360.500	24.700	10.679	2520.000	4138.700
1984	4536.600	3262.300	503.600	20.000	9.226	2125.000	3144.500
1985	4704.300	3592.200	641.900	20.500	11.046	1846.000	3345.900
1986	4744.000	2428.600	730.100	20.600	6.459	1074.000	1833.000
1987	4731.900	1663.600	739.500	20.700	7.384	1029.700	2139.900
1988	4919.000	1496.700	225.900	23.200	5.625	898.000	1774.500
1989	5153.000	1969.200	343.400	23.700	5.487	1181.500	1628.500
1990	5542.500	3034.500	202.300	25.400	5.940	1600.000	2129.500
1991	6123.500	2794.200	221.800	25.200	6.437	1411.200	2776.500

	Table 1.1					Continued	
YEAR	PGDPIDX	PIM	POP	PSDX	SERCST	SERDE	SERI
1962	63.134	98.900	1.451	59.712	17.800	6.200	22.300
1963	69.600	105.100	1.504	64.173	41.020	7.100	25.000
1964	75.115	101.700	1.560	68.634	73.318	13.000	36.400
1965	78.341	106.200	1.617	74.331	116.686	31.100	50.600
1966	85.300	113.000	1.677	88.607	185.718	44.500	80.700
1967	89.900	104.500	1.739	94.303	283.246	61.300	116.100
1968	97.235	108.400	1.803	96.020	393.821	84.600	138.900
1969	99.100	110.600	1.869	110.364	487.739	53.300	133.300
1970	100.000	100.000	1.986	100.000	564.865	68.400	125.900
1971	120.700	109.100	2.069	97.804	690.979	115.900	182.600
1972	128.111	123.900	2.155	104.393	919.881	168.000	298.000
1973	153.900	151.178	2.247	116.953	1252.893	171.800	425.000
1974	267.300	193.300	2.344	122.512	1770.103	330.400	642.500
1975	245.200	208.100	2.446	123.041	2319.593	396.100	726.500
1976	259.400	210.800	2.554	124.638	2918.534	519.400	830.900
1977	279.700	228.600	2.666	127.797	3563.080	599.300	936.400
1978	267.300	265.300	2.785	143.240	4239.772	692.400	1033.000
1979	342.400	307.100	2.910	176.321	5157.295	1011.500	1341.500
1980	460.800	336.700	3.043	198.421	6174.266	1199.200	1434.400
1981	502.300	335.000	3.182	220.522	2514.500	1500.500	1897.100
1982	479.300	323.900	3.327	242.691	1937.900	1392.300	1686.400
1983	474.700	317.900	3.476	268.428	1565.900	1113.800	1372.100
1984	456.200	309.800	3.630	301.922	1379.700	980.100	1223.100
1985	442.400	309.800	3.786	329.513	1079.500	784.100	941.500
1986	439.100	348.200	3.942	340.357	872.500	650.800	764.600
1987	435.600	379.100	4.095	355.182	867.100	663.800	779.800
1988	432.100	383.200	4.245	366.301	849.900	650.500	763.200
1989	428.700	402.000	4.395	371.036	863.500	637.500	747.900
1990	425.200	482.800	4.545	375.909	903.700	624.800	732.900
1991	421.800	464.600	4.706	387.509	965.000	612.300	718.200

Table 1.1 Continued

YEAR	SERNK	SERVAL	TEXPORT	TCONS	TDE	TGSP	TIME
1962	139.500	72.700	49.90	163.300	11.900	53.70	1
1963	144.100	97.300	119.20	175.900	13.500	64.60	2
1964	149.000	118.400	221.30	196.542	24.400	102.11	3
1965	158.400	148.300	284.20	233.077	52.700	142.99	4
1966	168.600	190.700	357.40	296.924	82.300	189.10	5
1967	181.800	230.500	420.00	349.818	118.100	241.40	6
1968	197.100	279.900	667.00	474.701	140.500	311.50	7
1969	215.400	321.500	774.30	597.223	112.100	358.90	8
1970	224.100	330.600	856.20	694.060	118.000	409.00	9
1971	236.900	481.500	963.50	845.475	200.900	576.60	10
1972	253.500	564.600	968.10	1017.594	335.600	764.40	11
1973	277.500	673.200	1199.60	1247.827	350.900	1067.40	12
1974	308.600	898.600	2447.20	1655.173	753.500	1819.80	13
1975	340.900	1109.400	2005.60	2035.608	783.100	2070.60	14
1976	367.800	1288.500	2154.90	2320.346	1010.000	2384.30	15
1977	387.800	1491.600	3080.60	2818.762	1086.400	2720.90	16
1978	392.700	1700.500	2930.70	3070.832	1141.600	3121.80	17
1979	396.800	1963.300	4731.10	3917.545	1543.800	3794.50	18
1980	405.200	2346.400	6489.20	5122.414	2382.900	4619.50	19
1981	451.900	2748.200	4609.80	5927.850	2471.800	5279.90	20
1982	500.700	2868.700	4056.20	6100.394	2081.800	5311.80	21
1983	530.000	2934.600	3655.70	6136.580	1821.900	5152.00	22
1984	470.600	3128.100	3264.80	5979.434	1612.700	4700.80	23
1985	469.700	3135.500	3595.60	6195.971	1184.000	4290.50	24
1986	478.900	3127.200	2431.30	6349.992	884.000	4024.10	25
1987	487.300	3090.900	1664.80	6707.851	768.100	3481.10	26
1988	519.100	3172.500	1615.50	7137.022	641.000	3524.50	27
1989	531.700	3298.500	2179.20	7901.908	696.800	3540.60	28
1990	547.800	3503.000	3214.50	8791.921	610.900	3661.30	29
1991	543.400	3851.000	2919.70	9577.159	536.100	3822.60	30

Table 1.1 Continued

YEAR	TIMP	TINVS	TNW	TREVN
1962	73.400	27.700	356.000	52.100
1963	85.300	31.700	360.500	79.000
1964	104.400	57.109	365.300	117.000
1965	114.400	81.687	372.400	171.900
1966	144.700	106.400	380.200	231.100
1967	170.000	140.000	389.300	284.200
1968	230.300	163.100	400.500	430.000
1969	241.300	160.300	414.600	507.700
1970	198.000	149.100	433.500	577.800
1971	250.400	258.200	459.000	828.500
1972	343.200	405.300	488.000	831.265
1973	539.900	602.000	538.100	852.700
1974	822.300	955.000	607.200	1861.300
1975	1048.700	1026.300	677.400	1784.744
1976	950.700	1199.300	732.700	2689.500
1977	1117.100	1320.600	764.800	3375.801
1978	1362.600	1430.000	772.700	3007.221
1979	1572.400	1865.500	789.000	4704.153
1980	2006.900	2321.500	812.800	5964.889
1981	2481.400	2740.900	946.600	4476.970
1982	2124.300	2306.800	1083.700	4147.178
1983	2657.700	2039.000	1179.500	3448.100
1984	2505.700	1851.800	927.100	3090.200
1985	1706.000	1439.500	894.200	2798.600
1986	1396.800	1173.100	904.700	1994.100
1987	1556.200	1196.100	916.200	1964.500
1988	1685.400	1170.500	963.100	2029.800
1989	1475.000	1217.600	995.500	2382.800
1990	1510.900	1290.300	1018.600	2860.000
1991	1505.500	1387.600	1013.400	2984.859

1.3 Simulation Results of the Aggregate Version of the Model

Table 1.2 Simulation Results of the Aggregate Version of the Model Using OLS Method and Oil Revenues Endogenous

YEAR	LnRCONS	LnGCONS	LnRTINVS	LnRTGSP	LnPSDX	LnINVDX
1962	5.438	3.2581	3.8559	5.6816	4.0895	4.0707
1963	5.406	3.4935	3.9376	5.6874	4.1616	4.1239
1964	5.400	3.7906	4.3000	5.7000	4.2130	4.1900
1965	5.430	4.1063	4.6000	5.8000	4.3000	4.2700
1966	5.570	4.3996	4.8410	6.0000	4.3340	4.3300
1967	5.681	4.6737	5.1000	6.0300	4.4000	4.4000
1968	5.870	4.9718	5.3000	6.2000	4.5000	4.4600
1969	6.000	5.2293	5.1000	6.3440	4.5400	4.5241
1970	6.070	5.4900	5.0000	6.5000	4.6050	4.6000
1971	6.150	5.7562	5.8000	6.6102	4.6000	4.6315
1972	6.221	5.9700	5.8900	6.7000	4.7000	4.7000
1973	6.350	6.1358	6.0000	6.7332	4.8000	4.7421
1974	6.600	6.4096	6.2000	7.0000	4.9000	4.8011
1975	6.710	6.6296	6.3430	7.0322	4.9700	4.8630
1976	6.700	6.9000	6.4420	7.2000	5.0000	4.9223
1977	6.823	7.1500	6.6000	7.3340	5.1000	5.0000
1978	6.800	7.3236	6.7000	7.4000	5.2000	5.0410
1979	6.943	7.5306	6.8000	7.5300	5.2800	5.1010
1980	7.200	7.7680	7.0000	7.7043	5.3600	5.2000
1981	7.300	7.9190	7.0000	8.0000	5.4400	5.2200
1982	7.230	8.0290	6.9300	8.0000	5.5100	5.3000
1983	7.134	8.0421	6.8700	7.7000	5.5770	5.3224
1984	7.010	8.0100	6.7700	7.6000	5.6320	5.3633
1985	7.000	7.9900	6.6900	7.5000	5.7000	5.3974
1986	7.022	7.8700	6.5000	7.2330	5.7400	5.4300
1987	7.110	7.7720	6.3800	7.1000	5.8000	5.4600
1988	7.213	7.6800	6.2300	7.0000	5.8300	5.4900
1989	7.300	7.6500	6.2000	7.0000	5.9000	5.5100
1990	7.400	7.6800	6.2000	6.8000	5.9160	5.5400
1991	7.550	7.6900	6.2030	6.9000	5.9560	5.5700

Table 1.2 Continued

YEAR	LnPGDPIDX	LnRTIMP	LnRNOQT	LnTNW	LnRINTAX	LnROILVAL
1962	4.1453	4.3070	5.1875	5.8749	3.384	4.1132
1963	4.3000	4.3964	5.3489	5.8875	3.459	4.9706
1964	4.3000	4.6000	5.4360	5.9110	3.403	5.6400
1965	4.3660	4.7600	5.6100	5.9400	3.463	5.9000
1966	4.4700	4.9300	5.7800	5.9800	3.587	6.0900
1967	4.5400	5.0880	5.9300	6.0200	3.719	6.2000
1968	4.6200	5.3000	6.0700	6.0800	3.884	6.5700
1969	4.7000	5.4100	6.1690	6.1380	4.030	6.6900
1970	4.7500	5.0000	6.2000	6.1900	4.150	6.7300
1971	4.8200	5.6000	6.4120	6.2400	4.260	6.7000
1972	4.9400	5.6900	6.5670	6.2900	4.360	6.7000
1973	5.0700	5.8000	6.7740	6.3400	4.450	6.8000
1974	5.2220	5.9040	7.0200	6.4090	4.600	7.4000
1975	5.4000	6.0000	7.2100	6.4700	4.730	7.2000
1976	5.5000	6.1000	7.3710	6.5210	4.822	7.2300
1977	5.6000	6.1400	7.4700	6.6000	4.923	7.4000
1978	5.6000	6.2000	7.5120	6.6330	4.983	7.3000
1979	5.7900	6.2000	7.5000	6.6900	5.100	7.7000
1980	5.9040	6.3870	7.6000	6.7600	5.214	8.0000
1981	6.0000	6.4300	7.5100	6.8200	5.310	7.6000
1982	6.1000	6.4210	7.5000	6.8600	5.340	7.4000
1983	6.0700	6.4000	7.3000	7.0000	5.309	7.2000
1984	6.0500	6.3400	7.3050	6.9100	5.300	7.0000
1985	6.0400	6.2990	7.1960	6.9000	5.200	7.1000
1986	6.0000	6.2000	7.1300	6.9200	5.130	6.7000
1987	6.0000	6.0800	7.1500	6.9110	5.080	6.2000
1988	6.1000	6.0000	7.1980	6.8880	5.050	6.0800
1989	6.0000	5.8760	7.2500	6.9000	5.000	6.2000
1990	6.0000	5.8700	7.2940	6.9000	5.082	6.6000
1991	6.0000	5.8600	7.3100	6.9000	5.100	6.5000

Table 1.2 Continued

YEAR	LnROILREV	LnRGDP
1962	3.1547	5.975
1963	4.0942	6.034
1964	4.8050	6.230
1965	5.1510	6.400
1966	5.3970	6.592
1967	5.5470	6.718
1968	5.9930	7.024
1969	6.1650	7.222
1970	6.2320	7.221
1971	6.2920	7.257
1972	6.2300	7.232
1973	6.3650	7.389
1974	7.0560	7.878
1975	6.9090	7.702
1976	6.8730	7.709
1977	7.1570	7.886
1978	7.0830	7.891
1979	7.4860	8.298
1980	7.8140	8.562
1981	7.4430	8.392
1982	7.1620	8.399
1983	6.9340	8.431
1984	6.7130	8.449
1985	6.7000	8.593
1986	6.2490	8.381
1987	5.7130	8.126
1988	5.4520	8.132
1989	5.6420	8.259
1990	6.0830	8.407
1991	6.0400	8.348

Table 1.3 Simulation Results of the Aggregate Version of the Model Using OLS Method and Oil Revenues Exogenous

YEAR	LnRCONS	LnGCONS	LnRTINVS	LnRTGSP	LnPSDX	LnINVDX
1962	5.4378	3.2581	3.8559	3.4678	4.0895	4.0707
1963	5.4064	3.4935	3.9376	3.7246	4.1616	4.1239
1964	5.3955	3.7960	4.3000	4.2112	4.2130	4.1900
1965	5.4525	4.1220	4.6000	4.6600	4.3000	4.2700
1966	5.5941	4.4400	4.8300	5.0330	4.3340	4.3300
1967	5.7020	4.7000	5.0423	5.3500	4.4000	4.4000
1968	5.8996	5.0000	5.3000	5.6700	4.5000	4.4600
1969	6.0403	5.3300	5.0000	5.9124	4.5400	4.5241
1970	6.0927	5.5900	5.0000	6.0000	4.6050	4.6000
1971	6.1706	5.8000	5.8000	6.3800	4.6000	4.6315
1972	6.2480	6.0000	5.9000	6.5421	4.7000	4.7000
1973	6.3739	6.2000	6.0000	6.6370	4.8000	4.7421
1974	6.5779	6.5000	6.2141	7.0000	4.9000	4.8011
1975	6.7261	6.7000	6.4000	7.0200	4.9700	4.8630
1976	6.8000	7.0000	6.5100	7.2110	5.0000	4.9223
1977	6.9000	7.2000	6.7000	7.4000	5.1000	5.0000
1978	6.8143	7.3200	6.7400	7.5000	5.2000	5.0410
1979	6.9730	7.5300	6.9000	8.0000	5.2800	5.1010
1980	7.2000	7.7700	7.0033	8.0000	5.3600	5.2000
1981	7.3000	7.9000	7.0220	8.0000	5.4400	5.2200
1982	7.2400	8.0500	7.0000	8.0000	5.5100	5.3000
1983	7.1500	8.0800	6.9000	8.0000	5.5770	5.3224
1984	7.0000	8.0000	6.7800	8.0000	5.6320	5.3633
1985	7.0100	8.0500	6.6000	7.4500	5.7000	5.3974
1986	7.0000	8.0000	6.4000	7.2400	5.7400	5.4300
1987	7.1000	7.8000	6.3000	7.1000	5.8000	5.4600
1988	7.2000	7.7700	6.2000	7.0000	5.8300	5.4900
1989	7.3000	7.7400	6.2000	7.0000	5.9000	5.5100
1990	7.4000	7.8000	6.2000	7.0000	5.9160	5.5400
1991	7.5550	7.8000	6.2000	7.0000	5.9560	5.5700

Table 1.3 **Continued**

YEAR	LnPGDPIDX	LnRTIMP	LnRNOQT	LnTNW	LnRINTAX	LnROILVAL
1962	4.1453	4.3070	5.1875	5.8749	3.384	4.1132
1963	4.2428	4.3964	5.3489	5.8875	3.459	4.9706
1964	4.3000	4.6000	5.4360	5.9080	3.400	5.6472
1965	4.3660	4.7000	5.6110	5.9420	3.500	5.9070
1966	4.4700	4.9000	5.7800	5.9700	3.600	6.0900
1967	4.5400	5.0630	5.9300	6.0000	3.700	6.2000
1968	4.6200	5.2300	6.0700	6.0700	3.890	6.5700
1969	4.7000	5.3600	6.1000	6.1000	4.000	6.6900
1970	4.7500	5.4000	6.2000	6.1700	4.100	6.7300
1971	4.8200	5.6000	6.4120	6.2000	4.200	6.7000
1972	4.9400	5.7000	6.5670	6.2800	4.300	6.7000
1973	5.0700	5.8000	6.7740	6.3000	4.400	6.8000
1974	5.2220	6.0000	7.0200	6.4030	4.620	7.4000
1975	5.4000	6.0010	7.2100	6.5000	4.744	7.2000
1976	5.5000	6.1200	7.3710	6.5400	4.900	7.2000
1977	5.6000	6.2000	7.4700	6.6100	5.000	7.4000
1978	5.6000	6.3000	7.5120	6.6600	5.020	7.3000
1979	5.7900	6.3000	7.5000	6.7000	5.113	7.7000
1980	5.9040	6.4000	7.6000	6.8000	5.300	8.0000
1981	6.0000	6.5300	7.5100	6.8612	5.400	7.6000
1982	6.1000	6.5000	7.5000	6.9100	5.380	7.4000
1983	6.0700	6.5000	7.3000	7.0000	5.300	7.2000
1984	6.0500	6.4000	7.3050	6.9000	5.280	7.0000
1985	6.0400	6.3000	7.1960	6.9000	5.220	7.1000
1986	6.0000	6.0000	7.1300	6.9200	5.100	6.7000
1987	6.0000	6.0200	7.1500	6.9125	5.000	6.2000
1988	6.1000	6.0000	7.1980	6.8900	5.100	6.0800
1989	6.0000	5.9000	7.2500	6.9000	5.000	6.2000
1990	6.0000	5.8000	7.2940	6.8800	5.080	6.6000
1991	6.0000	5.8300	7.3100	6.8720	5.000	6.5000

Table 1.3 Continued

YEAR	LnRGDP
1962	5.975
1963	6.034
1964	6.229
1965	6.378
1966	6.594
1967	6.720
1968	7.025
1969	7.223
1970	7.222
1971	7.260
1972	7.233
1973	7.400
1974	7.800
1975	7.700
1976	7.711
1977	7.889
1978	8.000
1979	8.290
1980	8.500
1981	8.300
1982	8.400
1983	8.430
1984	8.440
1985	8.590
1986	8.380
1987	8.130
1988	8.132
1989	8.300
1990	8.410
1991	8.400

Table 1.4 Simulation Results of the Aggregate Version of the Model Using 2SLS Method and Oil Revenues Endogenous

YEAR	LnRCONS	LnGCONS	LnRTINVS	LnTGSP	LnPSDX	LnINVDX
1962	5.4378	3.2581	3.8559	3.4678	4.0895	4.0707
1963	5.4064	3.4935	3.9376	3.7246	4.1616	4.1239
1964	5.3955	3.8000	4.3100	4.2600	4.2100	4.2000
1965	5.4525	4.1110	4.6300	4.7000	4.2620	4.2700
1966	5.5941	4.4100	4.9000	5.1300	4.3210	4.3400
1967	5.7020	4.6700	5.1230	5.4600	4.4000	4.4000
1968	5.8996	5.0000	5.3000	5.7800	4.5000	4.4700
1969	6.0403	5.2400	5.0000	6.0000	4.5200	4.5338
1970	6.0927	5.5000	5.0000	6.2000	4.6000	4.6000
1971	6.1706	5.7613	5.8000	6.4000	4.6000	4.6400
1972	6.2480	5.9000	5.9000	6.6000	4.7300	4.7000
1973	6.3739	6.1410	6.0300	6.7000	4.8000	4.7000
1974	6.5779	6.5000	6.2400	6.9100	4.8800	4.8120
1975	6.7261	6.6320	6.4000	7.0421	4.9000	4.9000
1976	6.8000	7.0000	6.5000	7.2000	5.0000	4.9400
1977	6.9000	7.2000	6.6000	7.3000	5.1000	5.0000
1978	6.8143	7.3212	6.7000	7.3330	5.1900	5.0600
1979	6.9730	7.5300	6.8000	7.5000	5.2000	5.1200
1980	7.2000	7.7600	6.9300	8.0000	5.3500	5.2000
1981	7.3000	7.9000	7.0000	8.0000	5.4300	5.2400
1982	7.2400	8.0200	6.9100	8.0000	5.5100	5.3000
1983	7.1500	8.0400	6.8600	8.0000	5.5730	5.3400
1984	7.0000	8.0000	6.7600	8.0000	5.6300	5.3800
1985	7.0100	7.9700	6.6000	8.0000	5.7000	5.4000
1986	7.0000	7.9000	6.5000	8.0000	5.7400	5.4400
1987	7.1000	7.7700	6.3000	7.9000	5.8000	5.4700
1988	7.2000	7.7000	6.2000	7.0000	5.8300	5.5000
1989	7.3000	7.7000	6.2000	6.8322	5.8700	5.5200
1990	7.4000	7.7000	6.2200	7.0000	5.9150	5.5500
1991	7.5550	7.7000	6.2300	7.0000	5.9560	5.5800

Table 1.4 Continued

YEAR	LnPGDPIDX	LnRTIMP	LnRNOQT	LnTNW	LnRINTAX	LnROILVAL
1962	4.1453	4.3070	5.1875	5.8749	3.384	4.1132
1963	4.2428	4.3964	5.3489	5.8875	3.459	4.9706
1964	4.2880	4.6000	5.5000	5.9100	3.411	5.6510
1965	4.3580	4.7800	5.6400	5.9400	3.500	5.9160
1966	4.4700	4.9500	5.8000	5.9800	3.610	6.1050
1967	4.5300	5.1000	5.9500	6.0000	3.700	6.2000
1968	4.6150	5.3000	6.0860	6.0800	3.900	6.5900
1969	4.6800	5.4200	6.0000	6.1000	4.000	6.7100
1970	4.7200	5.0000	6.2000	6.1900	4.100	6.7500
1971	4.8020	5.6000	6.4320	6.2400	4.200	6.8000
1972	4.9300	5.7000	6.5800	6.2000	4.300	6.7000
1973	5.0800	5.7880	6.7800	6.3400	4.470	6.8600
1974	5.2420	5.9210	7.0170	6.4100	4.620	7.4000
1975	5.4000	6.0100	7.2040	6.4750	4.744	7.2000
1976	5.5000	6.1000	7.3700	6.5300	4.840	7.2400
1977	5.5800	6.1500	7.4640	6.6000	4.940	7.0000
1978	5.7000	6.2000	7.5010	6.6430	5.000	7.4000
1979	5.8290	6.2800	7.5000	6.7000	5.100	7.7000
1980	5.9490	6.3880	7.6300	6.7700	5.230	8.0000
1981	6.0330	6.4300	7.5000	6.8300	5.320	7.6000
1982	6.1000	6.4210	7.4000	6.9000	5.340	7.4000
1983	6.0800	6.5000	7.3000	7.0000	5.300	7.2000
1984	6.0600	6.3400	7.3020	6.9000	5.300	7.0900
1985	6.0400	6.3000	7.1930	6.9000	5.203	7.1000
1986	6.1000	6.0000	7.1210	6.9300	5.000	6.7000
1987	6.0000	6.0900	7.1000	6.9200	5.000	6.2000
1988	6.1000	6.0000	7.1840	6.9000	5.100	6.0800
1989	6.1000	5.8860	7.2440	6.9000	5.060	6.0000
1990	6.2000	5.8000	7.2700	6.9000	5.000	6.4000
1991	6.3000	5.8600	7.2800	6.8720	5.000	6.5790

1.4 Simulation Results of the Dissaggregate Version of the Model

Table 1.5 Simulation Results of the Dissaggregate Version of the Model Using OLS Method and Oil Revenues Endogenous

YEAR	LnRCONS	LnGCONS	LnRTINVS	LnRMANI	LnRAGRI	LnRSERI
1962	5.438	3.2581	3.8559	0.986	0.9856	3.6390
1963	5.406	3.4935	3.9376	1.319	1.3191	3.7001
1964	5.400	3.7906	4.3000	1.622	1.3432	4.0300
1965	5.430	4.1063	4.6000	1.759	2.0300	4.6000
1966	5.570	4.3996	4.8410	2.173	2.3000	4.8000
1967	5.681	4.6737	5.1000	2.519	2.6000	5.0800
1968	5.800	4.9718	5.3060	2.585	2.5000	5.2800
1969	6.020	5.2293	5.1000	2.474	2.5200	4.8000
1970	6.070	5.4900	5.0100	2.895	2.8000	5.0100
1971	6.150	5.7562	5.8000	3.356	3.3220	5.3000
1972	6.221	5.9700	5.8900	3.913	3.6000	5.5900
1973	6.350	6.1358	5.9940	4.017	3.8400	5.6000
1974	6.600	6.4096	6.2110	4.310	4.5000	6.0000
1975	6.710	6.6296	6.3430	4.317	4.6300	6.1000
1976	6.743	6.9000	6.4420	4.562	4.8200	6.2300
1977	6.823	7.1500	6.6000	4.575	4.8300	6.3000
1978	6.800	7.3236	6.7000	4.522	4.8000	6.3330
1979	6.943	7.5306	6.8000	4.627	5.0330	6.5660
1980	7.200	7.7680	6.9290	5.197	5.1830	6.6300
1981	7.300	7.9190	7.0000	5.270	5.2000	6.7500
1982	7.230	8.0290	6.9250	5.105	4.9000	6.6380
1983	7.134	8.0421	6.8700	5.081	4.7000	6.4180
1984	7.000	8.0100	6.7700	4.941	4.6310	6.2800
1985	6.900	7.9900	6.6000	4.708	4.3330	6.0500
1986	7.000	7.8700	6.5000	4.431	4.0220	5.8700
1987	7.100	7.7720	6.3800	4.182	3.8300	5.8500
1988	7.200	7.6800	6.2300	3.963	3.6000	5.8000
1989	7.300	7.6500	6.2000	3.989	4.3000	5.7000
1990	7.460	7.6800	6.2000	3.891	4.1650	5.7000
1991	7.550	7.6900	6.2030	3.758	3.9350	5.6600

Table 1.5 Continued

YEAR	LnRCOTI	LnPSDX	LnINVDX	LnPGDPIDX	LnRTIMP	LnTNW
1962	3.6390	4.0895	4.0707	4.1453	4.3070	5.8749
1963	3.7001	4.1616	4.1239	4.2428	4.3964	5.8875
1964	4.0000	4.2125	4.1990	4.2960	4.5830	5.9100
1965	4.1000	4.3000	4.2700	4.3600	4.7000	5.9400
1966	4.0000	4.3340	4.3380	4.4700	4.9300	5.9800
1967	5.0250	4.4000	4.4030	4.5400	5.0880	6.0000
1968	5.1100	4.5000	4.4650	4.6000	5.2600	6.0800
1969	4.2100	4.5400	4.5240	4.7000	5.4000	6.1300
1970	4.2000	4.6050	4.5800	4.7500	5.5000	6.1900
1971	5.1790	4.6000	4.6315	4.8200	5.6000	6.2400
1972	5.5000	4.7000	4.6900	4.9400	5.6900	6.2900
1973	5.4400	4.8000	4.7421	5.0700	5.8000	6.3400
1974	5.9020	4.9000	4.8011	5.2220	5.9040	6.4090
1975	5.9340	4.9000	4.8800	5.4000	6.0000	6.5000
1976	6.0000	5.0000	4.9223	5.5000	6.0540	6.5210
1977	6.1020	5.1000	4.9814	5.6000	6.1400	6.6000
1978	6.0300	5.2000	5.0410	5.6700	6.1900	6.6330
1979	6.0240	5.2800	5.1008	5.7800	6.2700	6.6900
1980	6.1400	5.3600	5.1700	6.0000	6.3870	6.7000
1981	6.3000	5.4400	5.2191	6.0000	6.4300	6.8200
1982	6.2000	5.5000	5.2740	6.1000	6.4200	6.9000
1983	6.0200	5.5700	5.3224	6.1000	6.4000	7.0000
1984	6.0000	5.6320	5.3633	6.1000	6.3390	7.0000
1985	5.7000	5.7000	5.3974	6.0400	6.3000	6.9000
1986	5.5030	5.7400	5.4309	6.0900	6.2000	6.9000
1987	5.3000	5.8000	5.4620	6.1000	6.0800	6.9200
1988	5.2300	5.8300	5.4910	6.1000	6.0000	6.9110
1989	5.1200	5.9000	5.5170	6.0000	5.8800	6.9000
1990	5.9960	5.9150	5.5450	6.0000	5.8000	7.0000
1991	5.8770	5.9560	5.5730	6.0000	5.8600	6.9000

Table 1.5 Continued

YEAR	LnRIMCONS	LnRIMPINT	LnRIMPCAP	LnRNOQT	LnRINTAX
1962	2.1393	2.7457	4.0310	5.1875	3.384
1963	2.4268	2.7660	4.0966	5.3489	3.459
1964	2.7080	2.8300	4.3000	5.4400	3.403
1965	2.9110	2.9000	5.5000	5.6110	3.463
1966	3.1100	3.0000	5.6000	5.7800	3.590
1967	3.2510	3.1000	4.8400	5.9000	3.710
1968	3.4240	3.2600	5.0010	6.0700	3.884
1969	3.5850	3.3000	5.1400	6.0000	4.030
1970	3.6750	3.4000	5.0000	6.2000	4.100
1971	3.7650	3.5000	5.3000	6.4100	4.260
1972	3.8100	3.5500	5.3900	6.6000	4.300
1973	3.8630	3.6020	5.4530	6.7740	4.450
1974	3.9820	3.8000	5.5860	7.0200	4.596
1975	4.0900	3.8200	5.7720	7.2100	4.725
1976	4.0800	3.8000	5.7120	7.3710	4.822
1977	4.1000	4.0000	5.7850	7.4700	4.923
1978	4.0010	3.9000	5.8300	7.5120	4.983
1979	4.0570	4.0510	5.9120	7.5000	5.080
1980	4.2290	4.2000	6.0200	7.6000	5.214
1981	4.3400	4.2000	6.0410	7.5100	5.309
1982	4.3140	4.1000	6.0210	7.5000	5.350
1983	4.2320	4.1000	5.9770	7.0000	5.309
1984	4.1100	3.9000	6.0000	7.3100	5.225
1985	4.0320	3.9000	5.8000	7.2000	5.195
1986	4.0060	3.8000	5.8000	7.1300	5.100
1987	4.0370	3.6500	5.6000	7.1500	5.080
1988	4.0990	3.5100	5.5100	7.2000	5.050
1989	4.1960	3.5000	5.4350	7.2500	5.050
1990	4.2880	3.4000	5.4000	7.2940	5.082
1991	4.3610	3.5000	5.4400	7.3100	5.100

Table 1.5 Continued

YEAR	LnROILVAL	LnROILREV	LnRGDP
1962	4.1132	3.1547	5.9746
1963	4.9706	4.0942	6.0343
1964	5.6400	4.8048	6.2280
1965	5.9000	5.1509	6.3772
1966	6.0900	5.3979	6.5922
1967	6.2000	5.5476	6.7183
1968	6.5700	5.9926	7.0236
1969	6.6900	6.1657	7.2216
1970	6.7300	6.2320	7.2209
1971	6.7800	6.2917	7.2570
1972	6.7000	6.2296	7.2321
1973	6.8000	6.3648	7.3892
1974	7.4000	7.0563	7.8700
1975	7.0000	6.9091	7.7024
1976	7.2000	6.8734	7.7094
1977	7.4000	7.1572	7.8860
1978	7.0000	7.0829	7.8911
1979	7.7000	7.4860	8.2970
1980	8.0000	7.8141	8.5600
1981	7.0000	7.4426	8.3900
1982	7.4000	7.1620	8.3900
1983	7.2000	6.9337	8.4300
1984	7.0000	6.7129	8.4490
1985	7.1000	6.7091	8.5930
1986	6.0000	6.2497	8.3808
1987	6.2700	5.7131	8.1262
1988	6.0800	5.4522	8.1324
1989	6.0000	5.6416	8.2600
1990	6.6000	6.0825	8.4071
1991	6.6000	6.0426	8.3500

Table 1.6 Simulation Results of the Dissaggregate Version of the Model Using 2SLS Method and Oil Revenues Exogenous

YAER	LnRCONS	LnGCONS	LnRTINVS	LnRMANI	LnRAGRI	LnRSERI
1962	5.438	3.2581	3.856	0.986	0.9856	3.6390
1963	5.406	3.4935	3.938	1.319	1.3191	3.7001
1964	5.410	3.8000	4.310	1.630	1.4000	4.0400
1965	5.500	4.1130	4.700	1.800	2.0300	4.6000
1966	5.600	4.4100	4.980	2.210	2.3000	4.9000
1967	5.700	4.6800	5.230	2.500	2.6000	5.1000
1968	5.900	4.9840	5.400	2.600	2.5000	5.3000
1969	6.000	5.2430	5.500	2.500	2.5400	4.9000
1970	6.100	5.5010	5.000	2.900	2.8000	5.0000
1971	6.200	5.7700	5.800	3.450	3.4000	5.3000
1972	6.300	5.9000	5.900	4.000	3.6000	5.6000
1973	6.500	6.1500	6.100	4.143	3.9000	5.6000
1974	6.700	6.4300	6.301	4.435	4.5000	6.0200
1975	6.862	6.7000	6.500	4.443	4.6000	6.1000
1976	6.900	7.0000	6.600	4.700	4.9000	6.2430
1977	6.980	7.2000	6.730	4.800	4.8500	6.3000
1978	7.000	7.3400	6.800	4.643	4.8000	6.3400
1979	7.100	7.5420	6.903	5.000	5.0400	6.6000
1980	7.300	7.7700	7.061	5.310	5.2000	6.6000
1981	7.412	7.9000	7.104	5.360	5.1800	6.7440
1982	7.340	8.0300	7.000	5.000	4.9000	6.6300
1983	7.200	8.0470	6.900	5.100	5.0000	6.4100
1984	7.100	8.0000	6.800	5.000	4.6130	6.3000
1985	7.000	7.9800	6.600	4.700	4.3120	6.0520
1986	7.100	7.9000	6.400	4.400	4.0000	5.8700
1987	7.100	7.7000	6.300	4.200	3.8000	5.8000
1988	7.200	7.6927	6.199	4.010	3.6000	5.8000
1989	7.300	7.6639	6.200	4.014	3.4000	5.7000
1990	7.400	7.7000	6.200	4.000	4.1000	5.7000
1991	7.540	7.7020	6.122	3.743	4.0000	5.6600

	Table 1.6			Continued	
YAER	LnRCOTI	LnPSDX	LnINVDX	LnPGDPIDX	LnRTIMP
1962	3.6390	4.08953	4.0707	4.1453	4.3070
1963	3.7001	4.16158	4.1239	4.2428	4.3964
1964	4.0000	4.20000	4.2000	4.3000	4.6000
1965	4.0000	4.24000	4.2700	4.3600	4.7000
1966	4.0000	4.30000	4.3300	4.5000	4.9000
1967	4.1104	4.33000	4.4000	4.5000	5.1000
1968	4.2414	4.40000	4.4600	4.6000	5.3000
1969	4.3419	4.43300	4.5321	4.7000	5.4000
1970	4.4000	4.50000	4.6000	4.7800	5.0000
1971	4.3426	4.50000	4.6540	4.8000	5.6000
1972	6.0000	4.60000	4.7200	5.0000	5.7000
1973	6.0000	4.70000	4.7000	5.1000	5.8000
1974	6.0000	4.80000	4.8300	5.2414	5.9310
1975	6.0200	4.82000	4.8900	5.3119	6.0130
1976	6.1000	4.90000	4.9432	5.4051	6.1300
1977	6.1400	4.98000	5.0000	5.5100	6.2000
1978	6.1000	5.00000	5.0530	5.6000	6.2800
1979	6.1000	5.15000	5.1100	5.8330	6.3000
1980	6.1400	5.24037	5.2000	6.0000	6.5000
1981	6.3000	5.33109	5.2102	6.0200	6.6000
1982	6.2000	5.40169	5.3000	6.1000	6.5000
1983	5.0400	5.50000	5.3031	6.1184	6.5000
1984	6.0000	5.53129	5.3440	6.1000	6.4000
1985	6.0000	5.61000	5.3830	6.0000	6.3000
1986	5.0000	5.70000	5.4200	6.0000	6.0000
1987	5.4000	5.73000	5.4521	6.1000	6.0000
1988	5.3000	5.80000	5.4800	6.0000	6.0000
1989	5.2000	5.90000	5.5000	6.0000	5.8000
1990	5.1000	5.92429	5.5400	6.0000	5.7800
1991	5.0000	5.98000	5.5600	6.0000	5.8000

	Table 1.6			Continued	
YAER	LnRIMPCONS	LnRIMPINT	LnRIMPCAP	LnRNOQT	LnTNW
1962	2.1393	2.7457	4.5356	5.1875	5.8749
1963	2.4268	2.7660	4.5899	5.3489	5.8875
1964	2.7200	2.8000	4.6400	5.5000	5.9000
1965	2.9000	2.8000	4.7600	5.6440	5.9000
1966	3.0000	3.0010	4.9000	5.8000	5.9210
1967	3.3900	3.0000	5.0000	5.9000	5.9500
1968	3.5000	3.2300	5.2000	6.0840	5.9900
1969	3.7000	3.0000	5.0000	6.0000	6.0250
1970	3.8000	3.0000	5.0000	6.2000	6.0700
1971	3.9400	3.4000	5.5000	6.4200	6.1200
1972	4.0000	3.5000	5.6000	6.6000	6.1600
1973	4.1000	3.6000	5.7000	6.7800	6.2000
1974	4.2000	3.7400	6.0000	7.0220	6.3000
1975	4.2430	4.0000	6.0000	7.2110	6.3200
1976	4.0000	3.9340	6.1000	7.3710	6.4000
1977	4.4200	4.0000	6.2000	7.5000	6.5000
1978	4.5000	4.0000	6.2030	7.5100	6.5100
1979	4.5000	4.1000	6.3200	7.5000	6.6000
1980	4.6200	4.3000	6.5000	7.6000	6.7000
1981	4.7000	4.2400	6.5100	7.5100	6.7340
1982	4.6600	4.0000	6.5000	7.5000	6.8000
1983	4.6000	4.1100	6.3000	7.0000	7.0000
1984	4.5540	3.9000	6.2000	7.3040	6.8700
1985	4.4000	3.8000	6.0000	7.2000	6.9000
1986	4.3790	3.7200	5.8000	7.1300	6.9100
1987	4.2800	3.6200	5.7000	7.1430	6.9160
1988	4.2000	3.6000	6.0000	7.2000	6.9200
1989	4.2000	3.5500	5.5320	7.2500	6.9230
1990	4.2000	3.6000	5.5000	7.2900	6.9380
1991	4.1300	4.0000	5.5000	7.3000	6.9000

Table 1.6 Continued

YAER	LnRINTAX	LnROILVAL	LnRGDP
1962	3.384	4.1132	5.9746
1963	3.459	4.9706	6.0343
1964	3.430	5.6000	6.2840
1965	3.511	5.9000	6.4300
1966	3.660	6.1000	6.6600
1967	3.800	6.2200	6.8000
1968	4.000	6.5900	7.0400
1969	4.000	6.7000	7.2200
1970	4.300	6.7600	7.2000
1971	4.400	6.8000	7.1711
1972	4.600	6.7000	7.2000
1973	4.700	6.8000	7.4000
1974	4.800	7.4000	7.8000
1975	5.034	7.0000	7.8000
1976	5.150	7.2000	7.7443
1977	5.270	7.4000	7.9000
1978	5.300	7.0000	8.0000
1979	5.400	7.7000	8.3000
1980	5.500	7.9000	8.6000
1981	5.660	7.0000	8.0000
1982	5.600	7.4000	8.5000
1983	5.000	7.2000	8.5100
1984	5.500	7.0000	8.5000
1985	5.432	7.0900	8.5600
1986	5.000	6.0000	8.3804
1987	5.000	6.2000	8.1200
1988	5.200	6.1000	8.2000
1989	5.000	6.0000	8.2311
1990	5.200	6.6000	8.4000
1991	5.000	6.5000	8.4000

1.6 The Forcasing Results

Table 1.7 The Ex-Post Forecast Results for the Period 1992-1996

YEAR	lnRCONS	lnGCONS	lnRTINVS	lnRTGSP	lnRMANI	lnRAGRI
1992	7.498	7.774	6.160	6.784	3.739	3.121
1993	7.485	7.782	6.155	6.754	3.715	2.977
1994	7.462	7.796	6.157	6.731	3.718	2.877
1995	7.436	7.820	6.175	6.719	3.730	2.808
1996	7.408	7.849	6.197	6.710	3.743	2.761

YEAR	lnRSERI	lnRCOTI	lnPSDX	lnINVDX	lnPGDPIDX	lnRTIMP
1992	5.717	3.332	6.046	5.571	6.243	5.723
1993	5.800	3.477	6.100	5.595	6.296	5.711
1994	5.881	3.569	6.157	5.619	6.340	5.702
1995	5.963	3.685	6.212	5.642	6.374	5.700
1996	6.044	3.791	6.268	5.664	6.403	5.699

YEAR	lnRIMPCONS	lnRIMPINT	lnRIMPCAP	lnRNOQT	lnTNW	lnROILVAL
1992	4.181	3.612	5.551	7.365	6.945	6.431
1993	4.151	3.617	5.527	7.442	6.954	6.268
1994	4.129	3.627	5.511	7.523	6.962	6.178
1995	4.114	3.645	5.506	7.610	6.970	6.253
1996	4.104	3.664	5.503	7.700	6.978	6.237

YEAR	lnRINTAX
1992	5.114
1993	5.149
1994	5.151
1995	5.134
1996	5.109

Table 1.8 The Empirical Results of the Ex-Ante Forecast (1996-2005)

(Million L.D.)

YEAR	Scenario 1 CONS	Scenario 2 CONS	Scenario 1 GCONS	Scenario 2 GCONS	Scenario 1 TINVS	Scenario 2 TINVS
1996	9062.705	8403.805	2048.236	2025.456	1928.015	1807.760
1997	11158.842	9374.003	2161.939	2093.437	1858.984	1654.926
1998	12605.309	9489.856	2288.529	2151.891	1871.577	1544.786
1999	13593.962	9127.625	2428.413	2201.626	1897.877	1462.184
2000	14294.339	8543.613	2582.137	2243.399	1955.349	1381.564
2001	14823.879	7881.827	2750.375	2277.907	1986.795	1307.224
2002	15248.188	7215.450	2933.927	2305.777	2020.114	1243.264
2003	15612.992	6578.817	3133.716	2327.565	2056.969	1180.009
2004	15941.215	5986.276	3350.787	2343.761	2091.147	1120.243
2005	16246.185	5442.289	3586.312	2354.793	2144.233	1063.689

YEAR	Scenario 1 TGSP	Scenario 2 TGSP	Scenario 1 PSDX	Scenario 2 PSDX	Scenario 1 TIMP	Scenario 2 TIMP
1996	3837.830	4300.475	434.176	429.380	1717.440	1675.884
1997	4039.327	4223.239	462.068	450.854	1767.088	1494.827
1998	4281.091	4174.003	491.850	472.397	1834.948	1347.230
1999	4561.364	4143.794	523.658	493.934	1918.089	1223.493
2000	4879.613	4126.188	557.636	515.389	2014.630	1117.389
2001	5236.220	4116.510	593.939	536.682	2123.376	1024.759
2002	5632.314	4111.307	632.735	557.734	2243.623	942.753
2003	6069.644	4108.008	674.202	578.467	2375.014	869.357
2004	6550.518	4104.681	718.534	598.802	2517.453	803.123
2005	7077.751	4099.876	765.938	618.661	2671.040	742.966

Continued

YEAR	Scenario 1 IMPCONS	Scenario 2 IMPCONS	Scenario 1 IMPINT	Scenario 2 IMPINT	Scenario 1 IMPCAP	Scenario 2 IMPCAP
1996	533.272	479.249	202.605	120.621	494.505	416.480
1997	489.594	393.362	204.404	90.678	347.741	257.684
1998	465.822	333.315	212.861	78.976	281.556	188.865
1999	455.241	289.296	225.681	74.280	250.410	154.857
2000	453.948	255.678	241.729	72.700	237.089	136.736
2001	459.554	229.078	260.440	72.610	234.038	126.765
2002	470.545	207.379	281.554	73.243	237.548	121.327
2003	485.931	189.211	304.999	74.210	245.639	118.544
2004	505.054	173.664	330.813	75.311	257.191	117.362
2005	527.471	160.116	359.111	76.431	271.551	117.151

YEAR	Scenario 1 NOQT	Scenario 2 NOQT	Scenario 1 TNW	Scenario 2 TNW	Scenario 1 OILVAL	Scenario 2 OILVAL
1996	10579.65	9444.95	1222.716	1220.156	2810.229	2573.007
1997	11236.14	8970.96	1231.610	1223.892	2924.095	2420.982
1998	12224.55	8722.26	1241.191	1225.783	3065.037	2290.413
1999	13481.58	8586.69	1251.464	1225.906	3216.474	2168.863
2000	14983.64	8506.07	1262.431	1224.340	3375.988	2054.168
2001	16728.94	8451.33	1274.099	1221.165	3543.493	1945.700
2002	18724.92	8405.32	1286.474	1216.464	3719.307	1843.079
2003	20993.97	8358.27	1299.563	1210.320	3903.824	1745.977
2004	23563.19	8307.70	1313.375	1202.817	4097.473	1654.090
2005	26467.97	8249.07	1327.918	1194.038	4300.704	1567.131

Continued

YEAR	Scenario 1 GDP	Scenario 2 GDP	Scenario 1 ADY	Scenario 2 ADY
1996	13389.876	12017.953	11174.48	10110.25
1997	14160.232	11391.945	11733.21	9604.73
1998	15289.584	11012.677	12319.87	9124.50
1999	16698.057	10755.553	12935.86	8668.27
2000	18359.626	10560.239	13582.65	8234.86
2001	20272.436	10397.028	14264.79	7823.12
2002	22444.223	10248.403	14974.88	7431.96
2003	24897.795	10104.246	15723.62	7060.36
2004	27660.661	9961.788	16509.80	6707.34
2005	30768.672	9816.198	17335.29	6371.98

APPENDIX 2

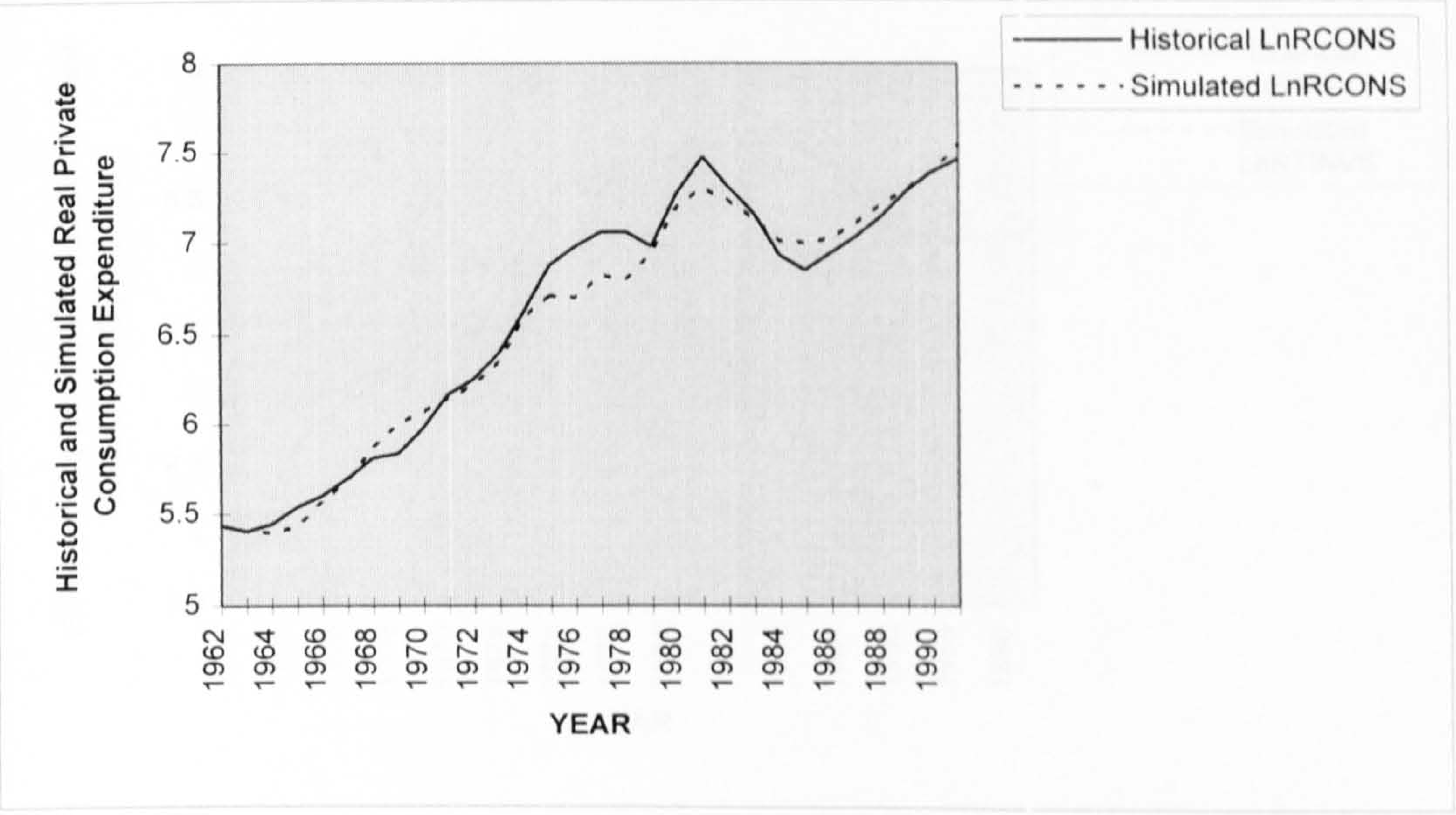
Graphs 2.1 to 2.8 represent the aggregate version of the model using OLS method with Oil Revenues endogenous.

Graphs 2.9 to 2.14 represent the aggregate version of the model using OLS method with Oil Revenues exogenous.

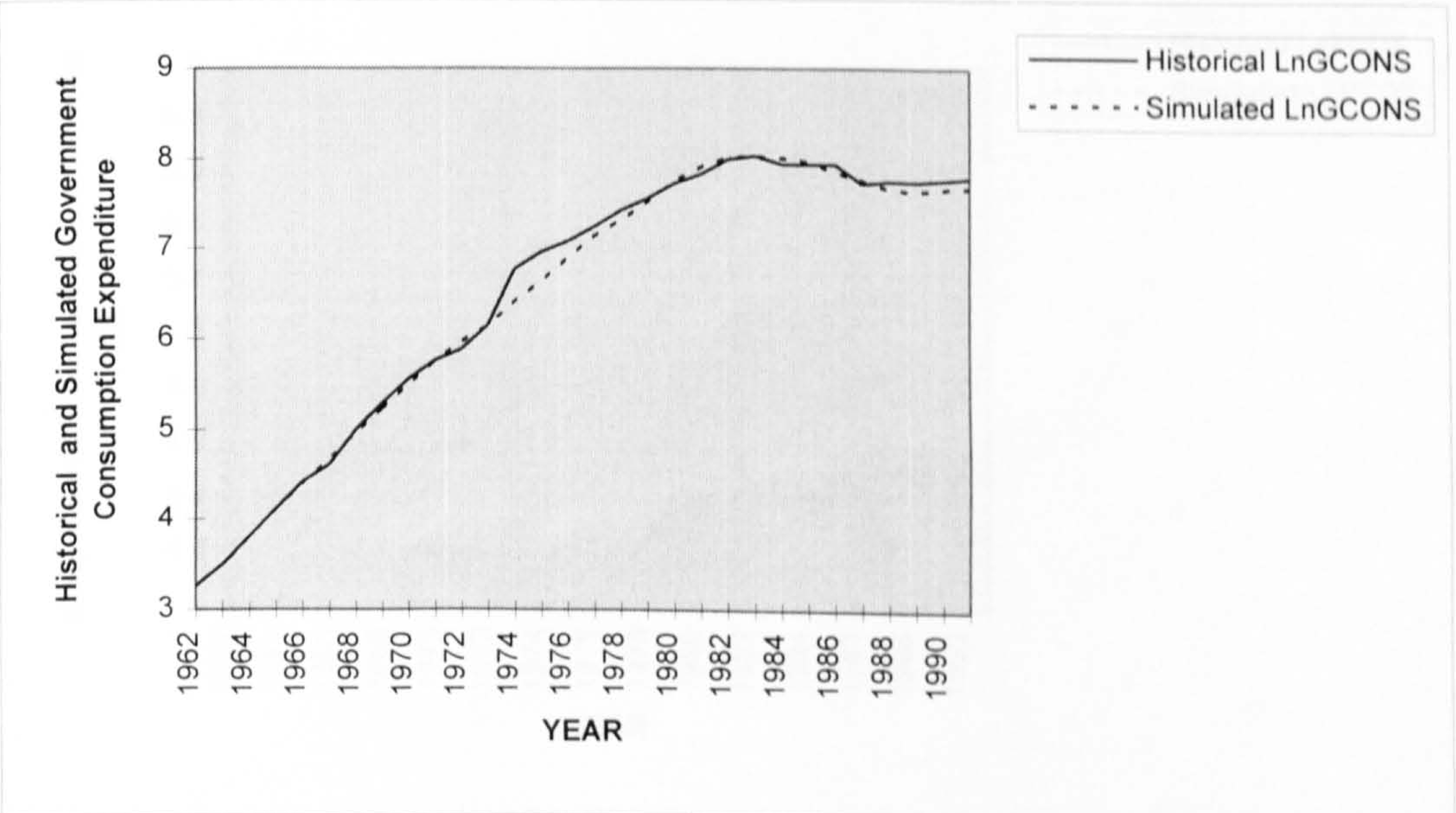
Graphs 2.15 to 2.21 represent the aggregate version of the model using 2SLS method with Oil Revenues endogenous.

Graphs 2.22 to 2.32 represent the disaggregate version of the model using 2SLS method with Oil Revenues exogenous.

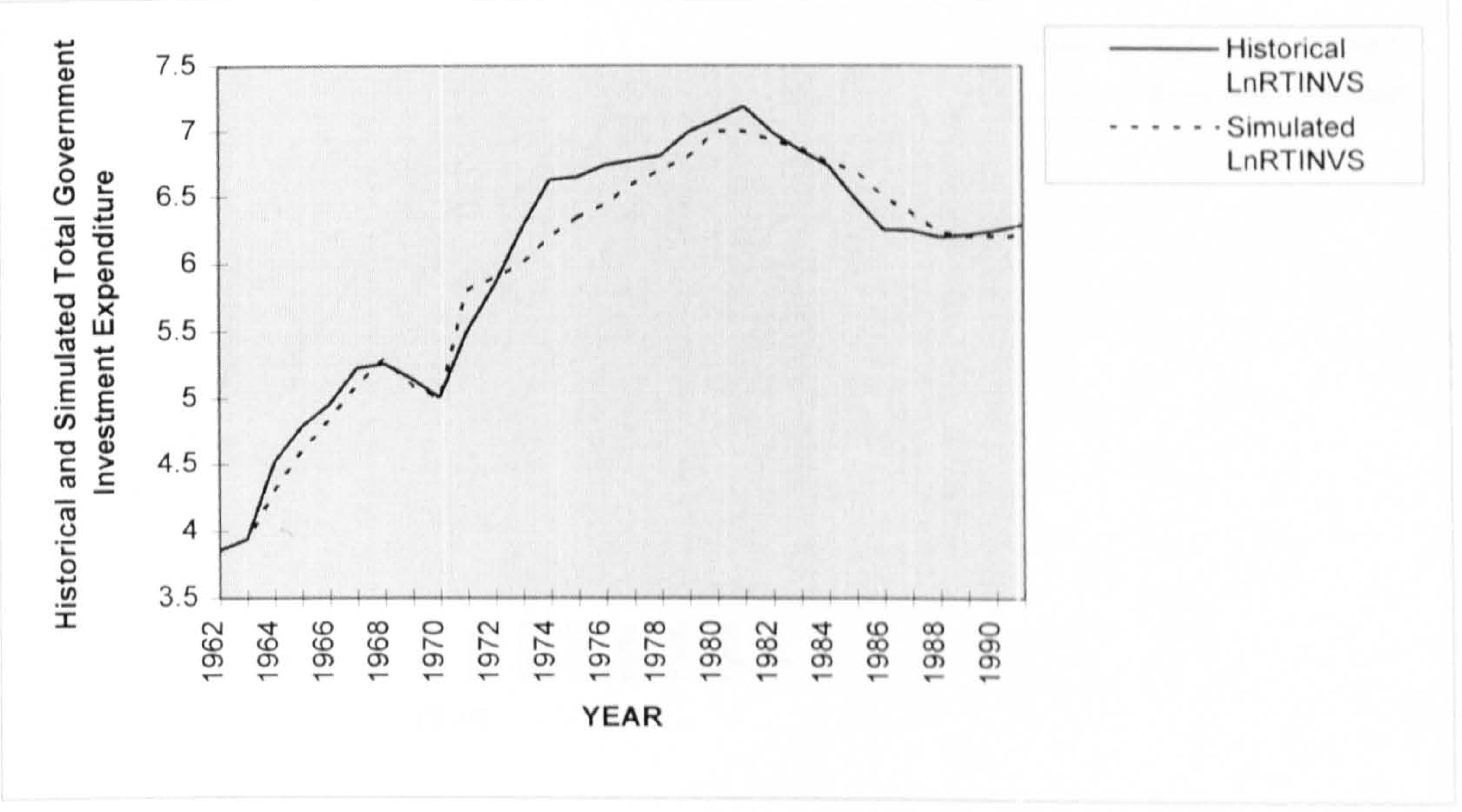
Graph 2.1 Historical and Simulated Real Private Consumption Expenditure (1962-1991)



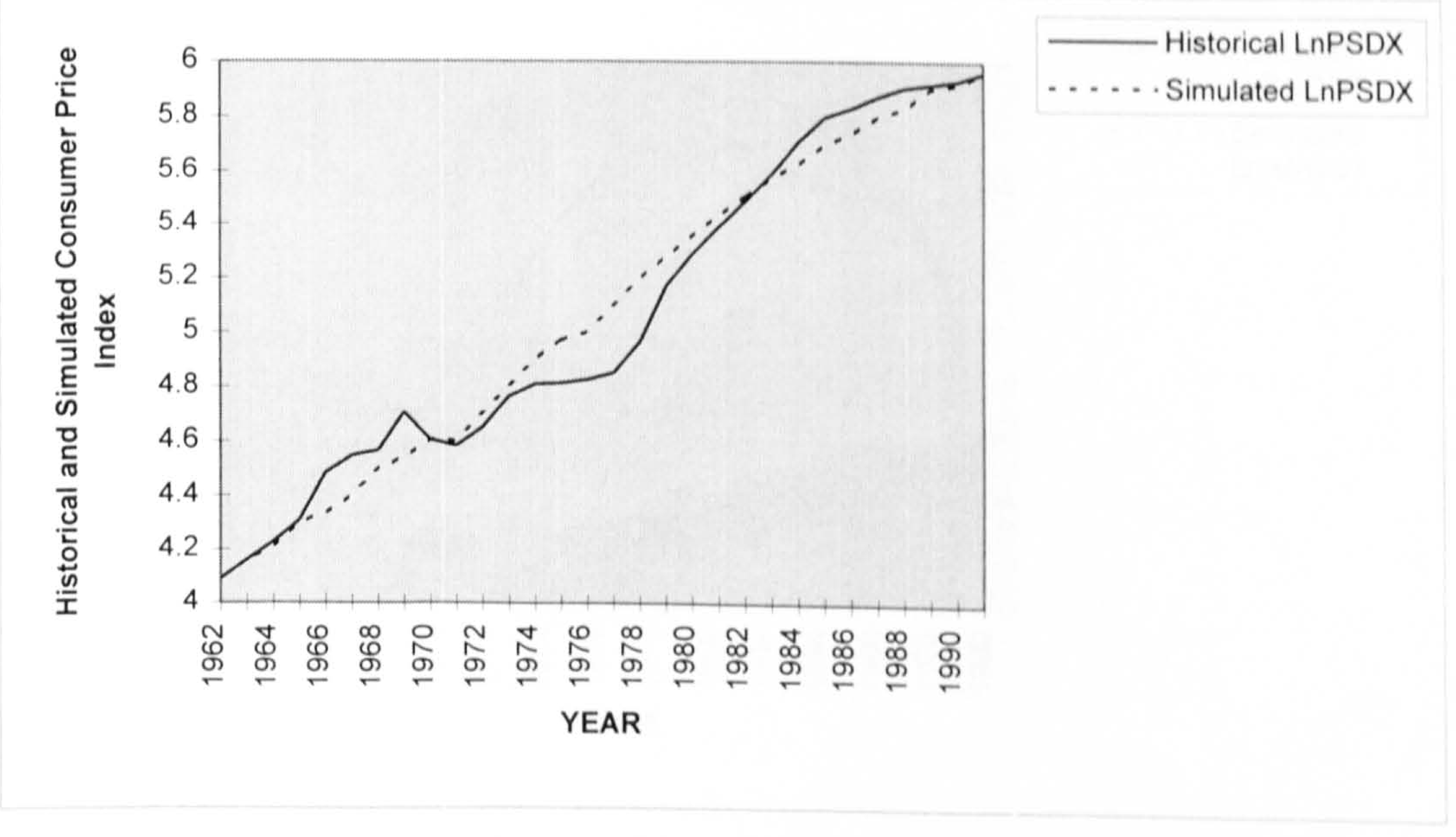
Graph 2.2 Historical and Simulated Government Consumption Expenditure (1962-1991)



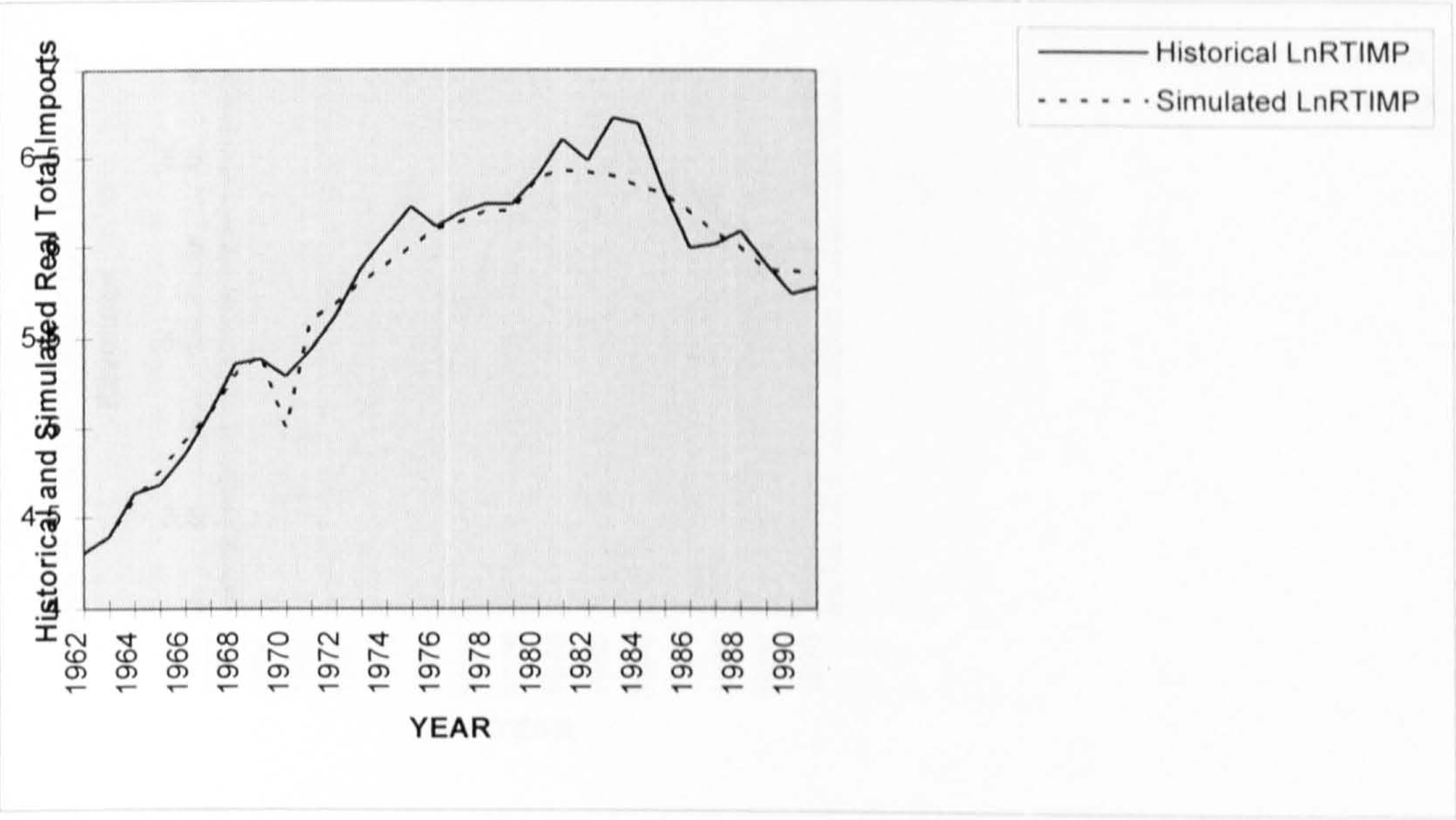
Graph 2.3 Historical and Simulated Total Government Investment Expenditure (1962-1991)



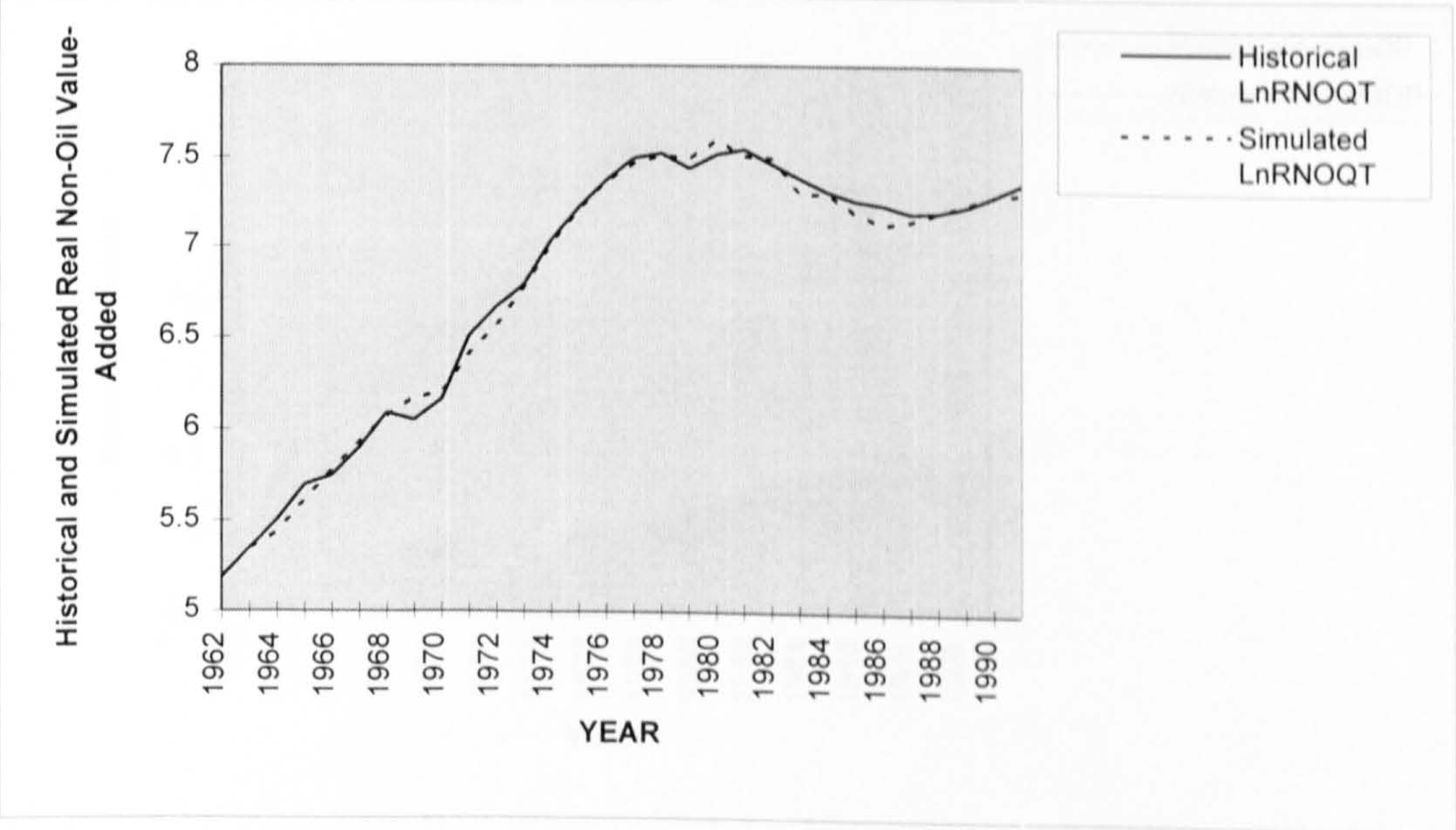
Graph 2.4 Historical and Simulated Consumer Price Index (1962-1991)



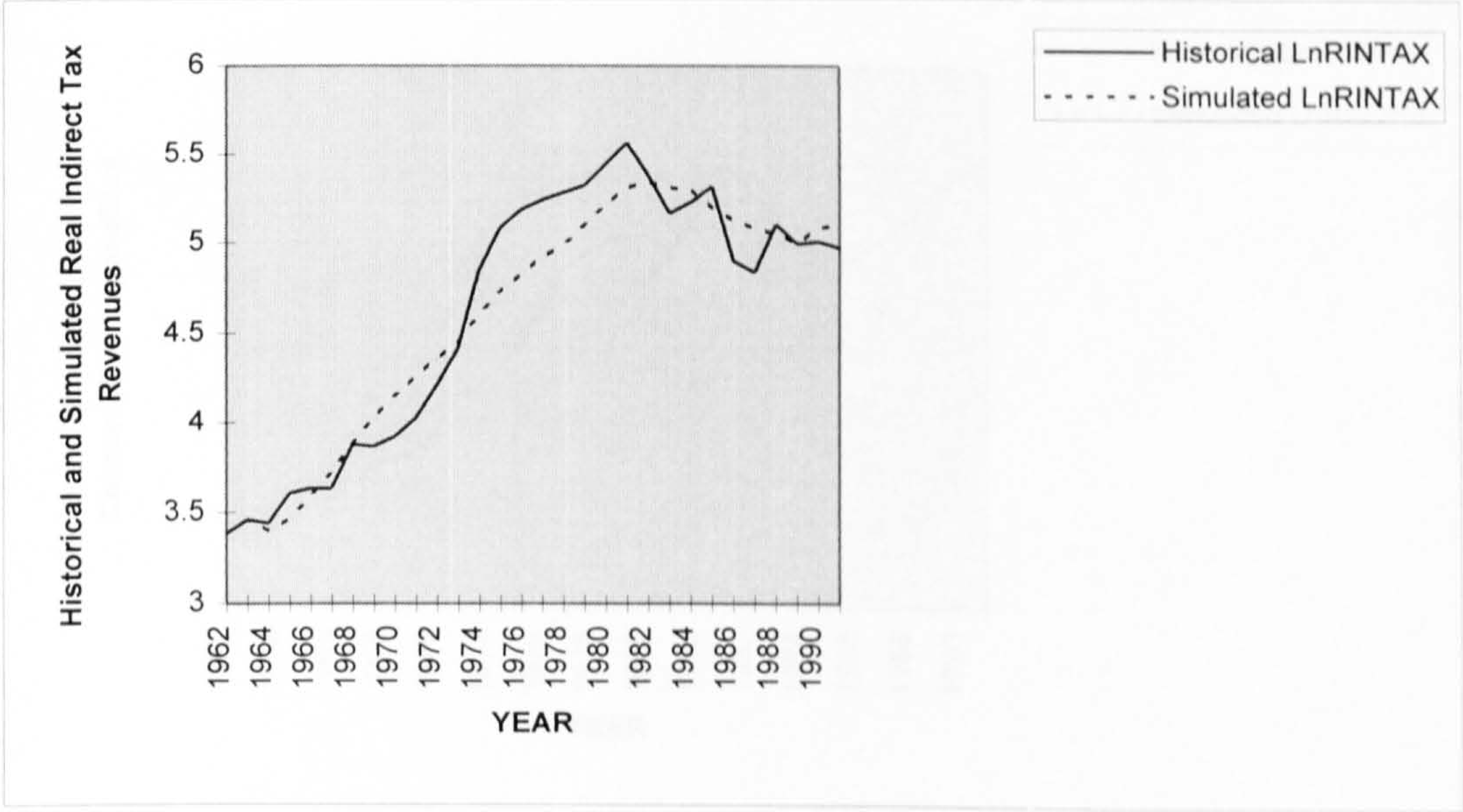
Graph 2.5 Historical and Simulated Real Total Imports (1962-1991)



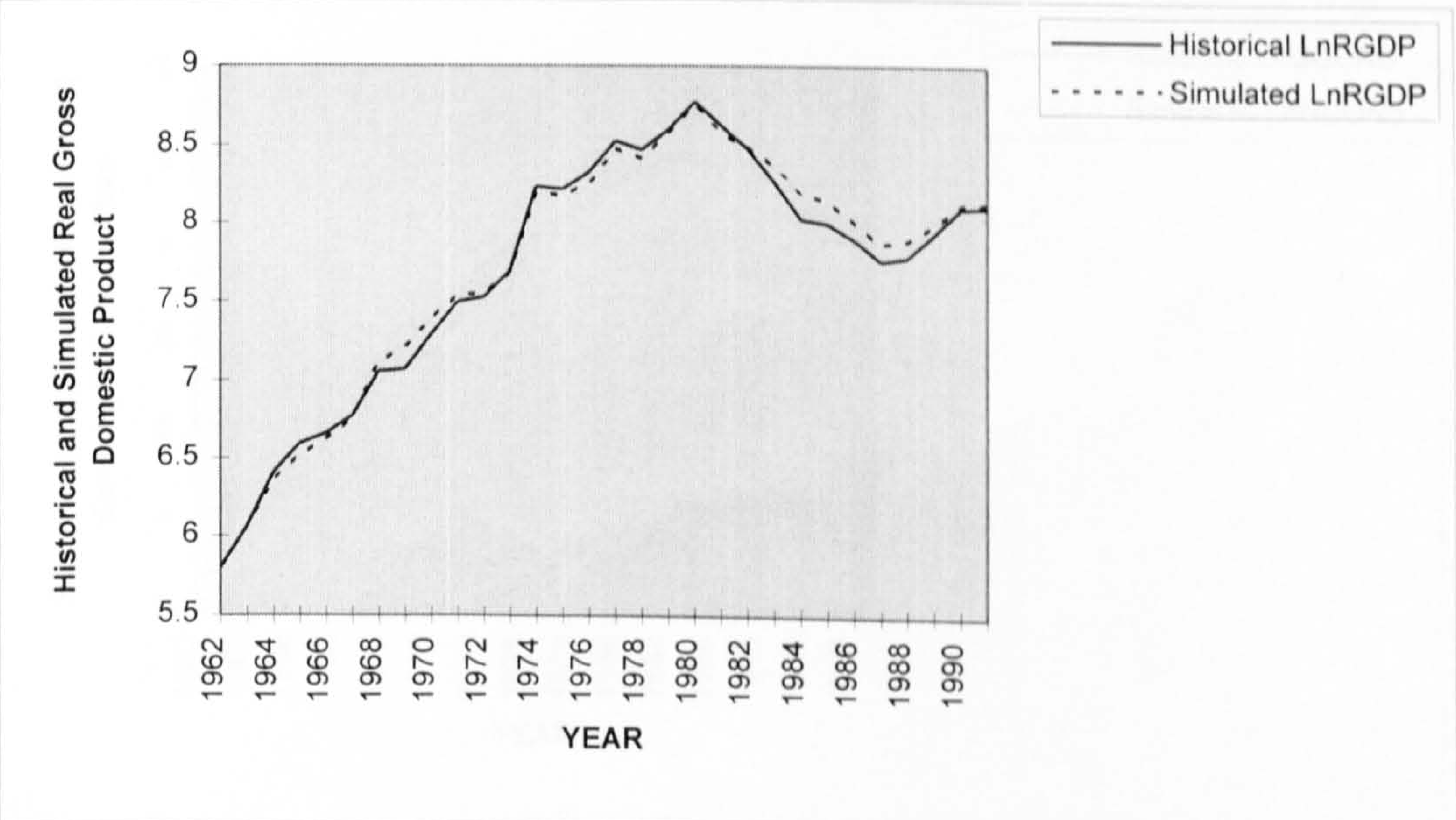
Graph 2.6 Historical and Simulated Real Non-Oil Value-Added (1962-1991)



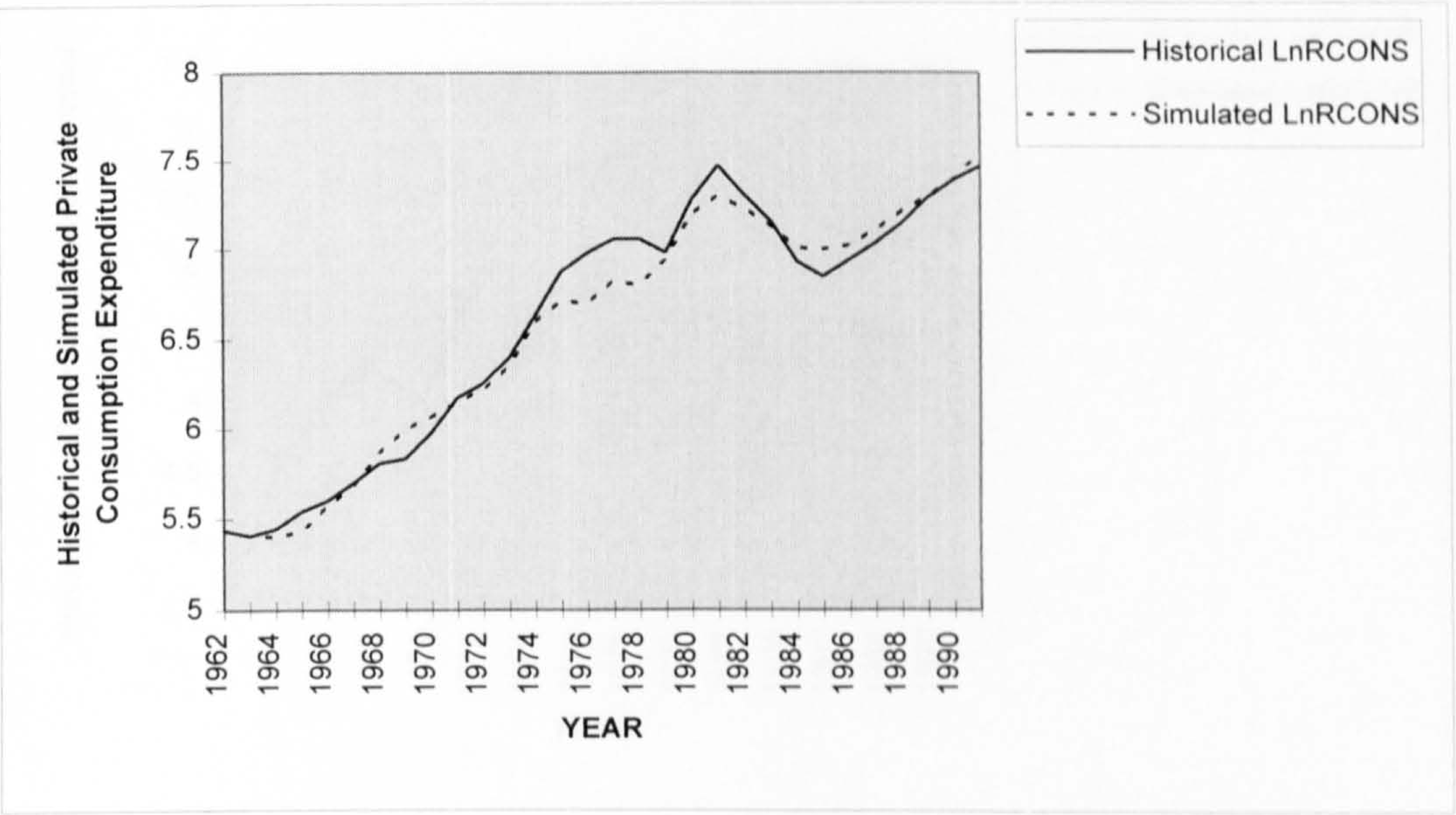
Graph 2.7 Historical and Simulated Real Indirect Tax Revenues (1962-1991)



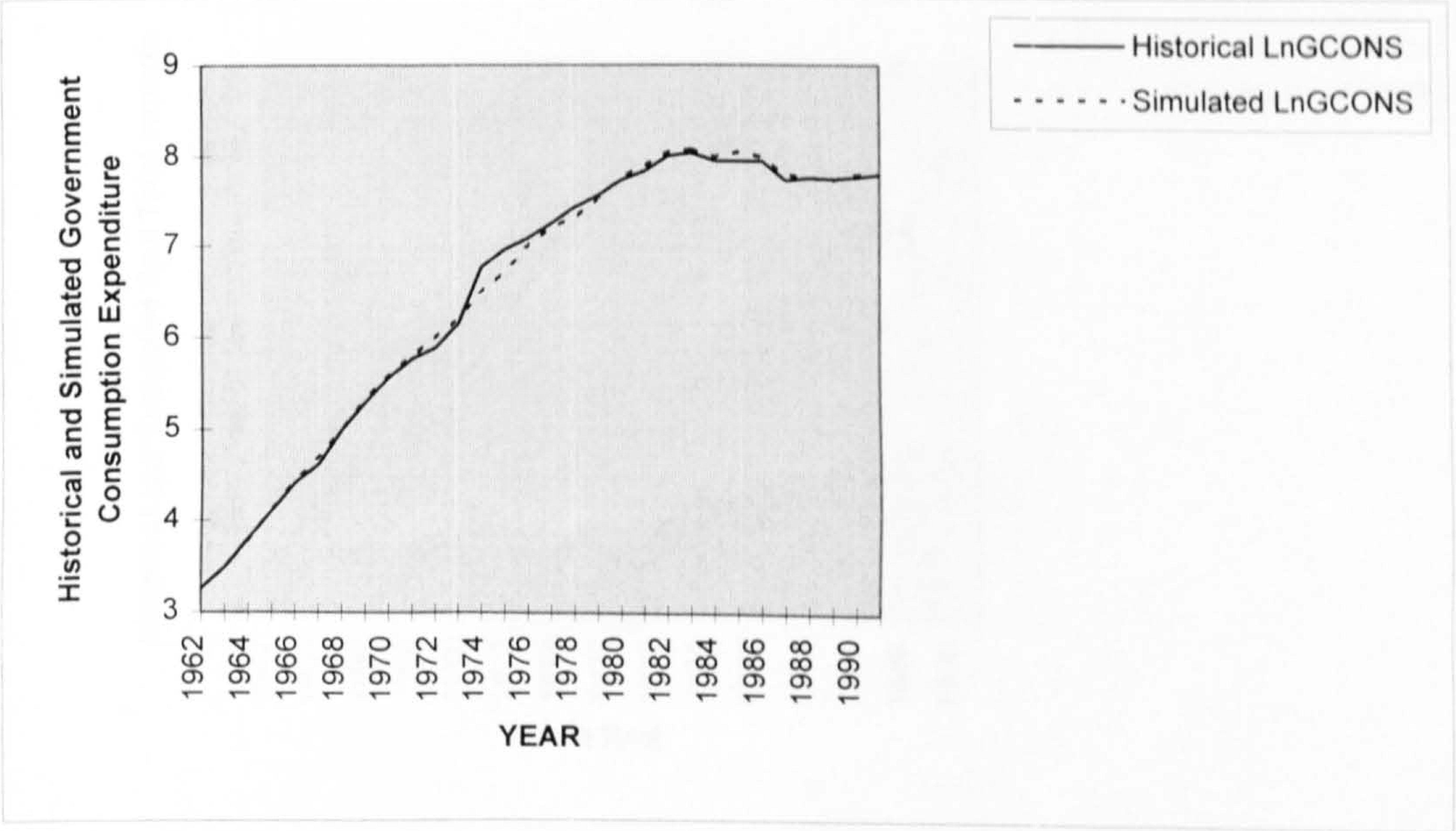
Graph 2.8 Historical and Simulated Real Gross Domestic Product (1962-1991)



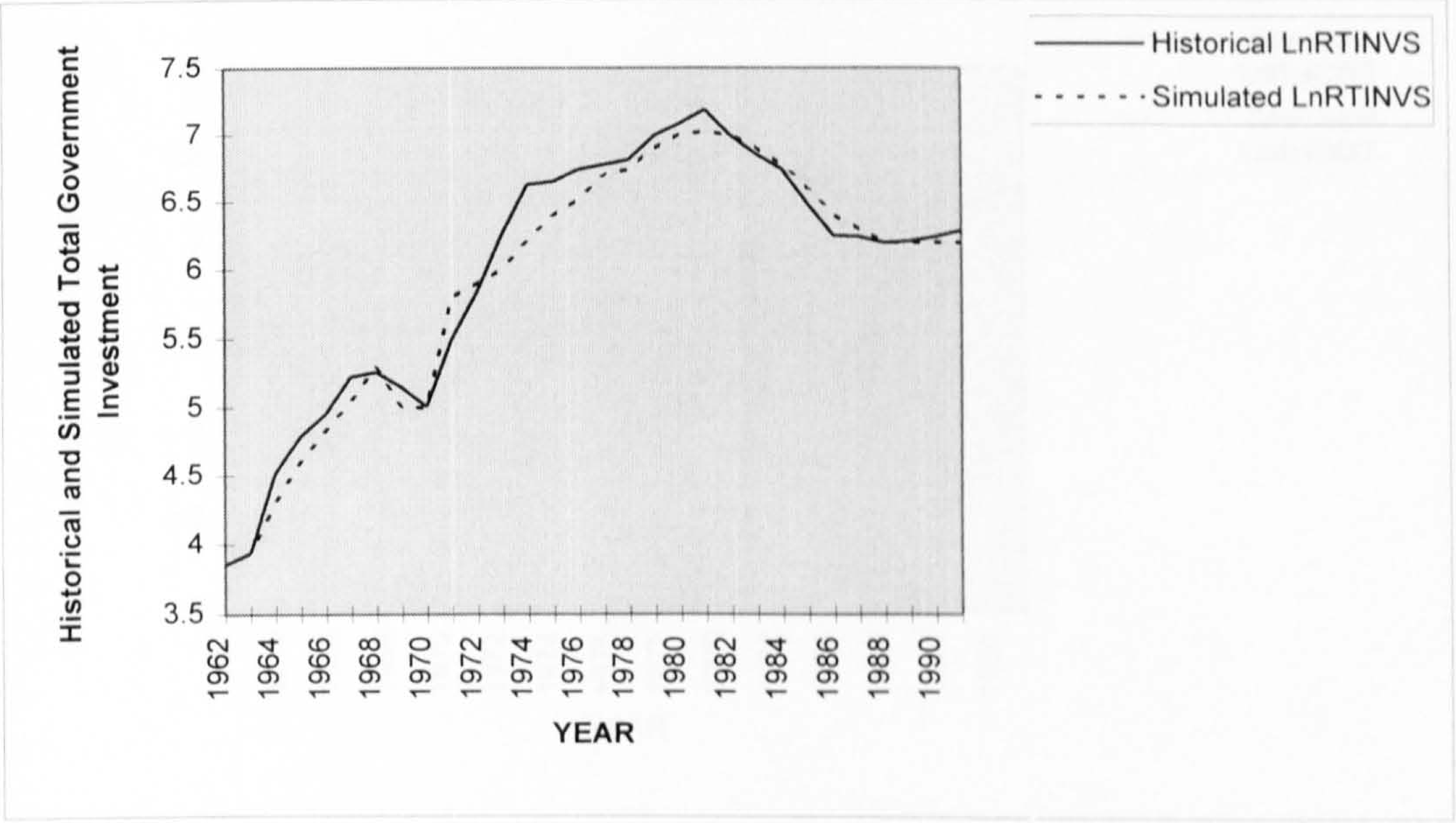
Graph 2.9 Historical and Simulated Real Private Consumption Expenditure (1962-1991)



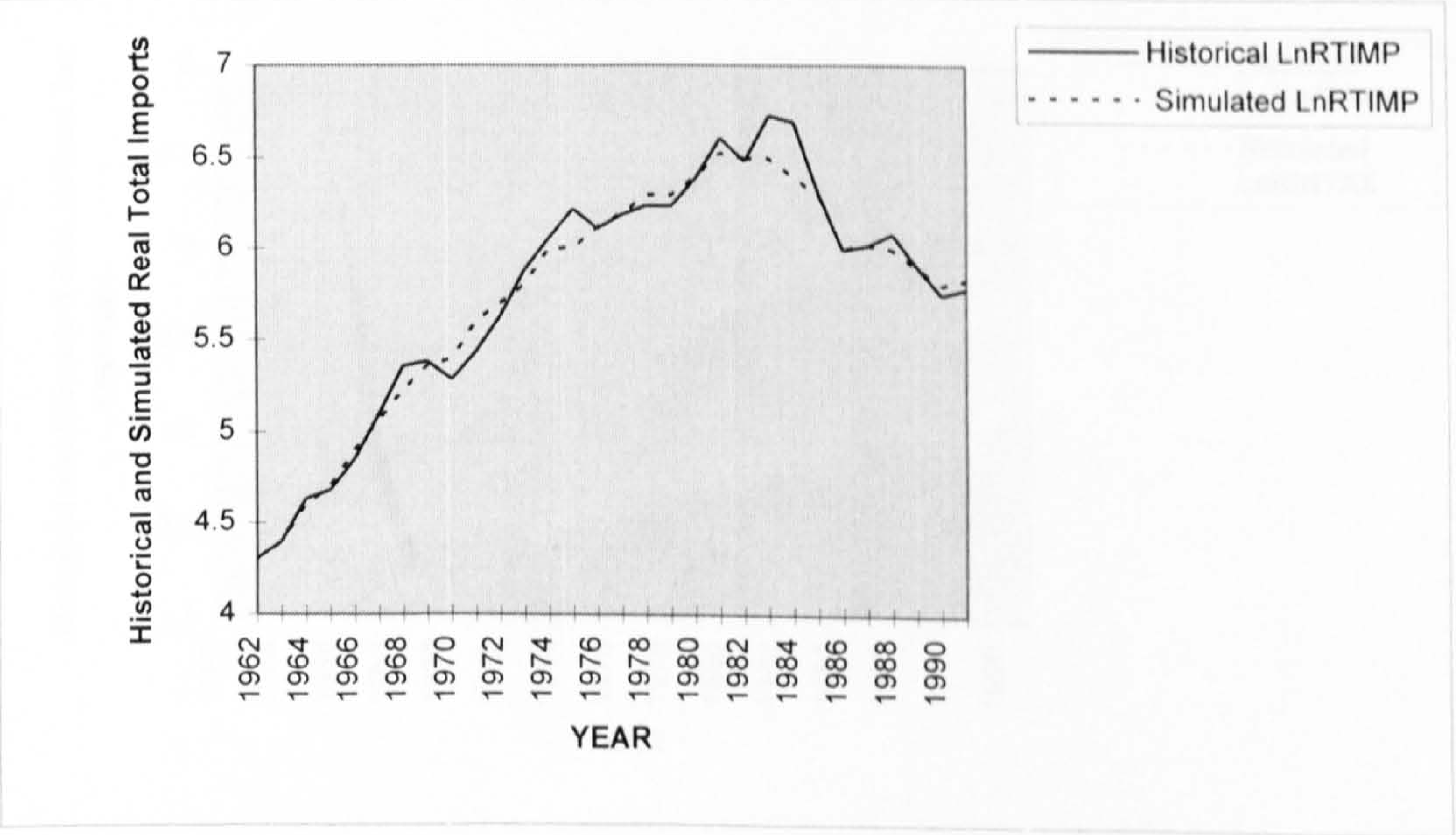
Graph 2.10 Historical and Simulated Government Consumption Expenditure (1962-1991)



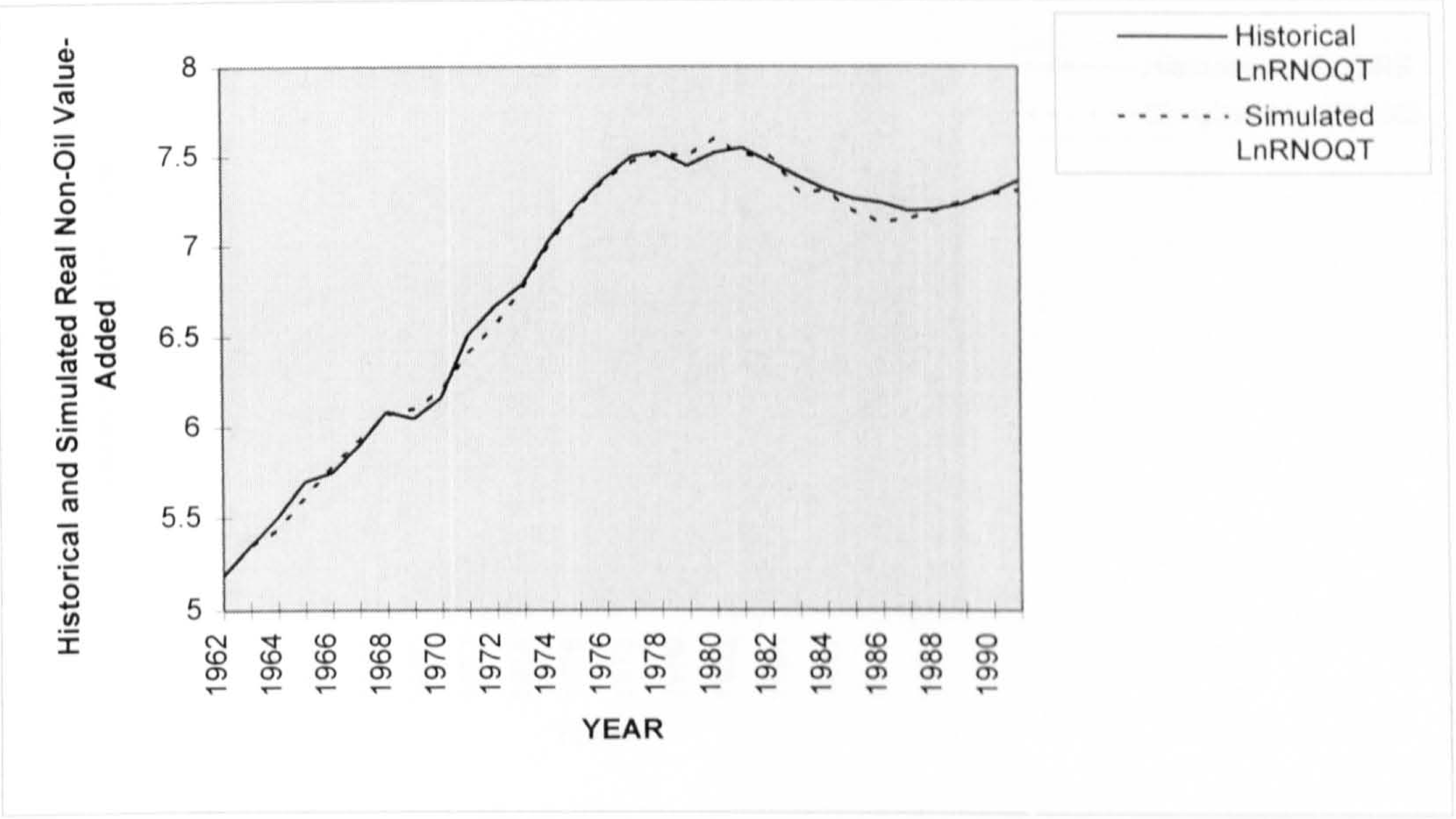
Graph 2.11 Historical and Simulated Total Government Investment Expenditure (1962-1991)



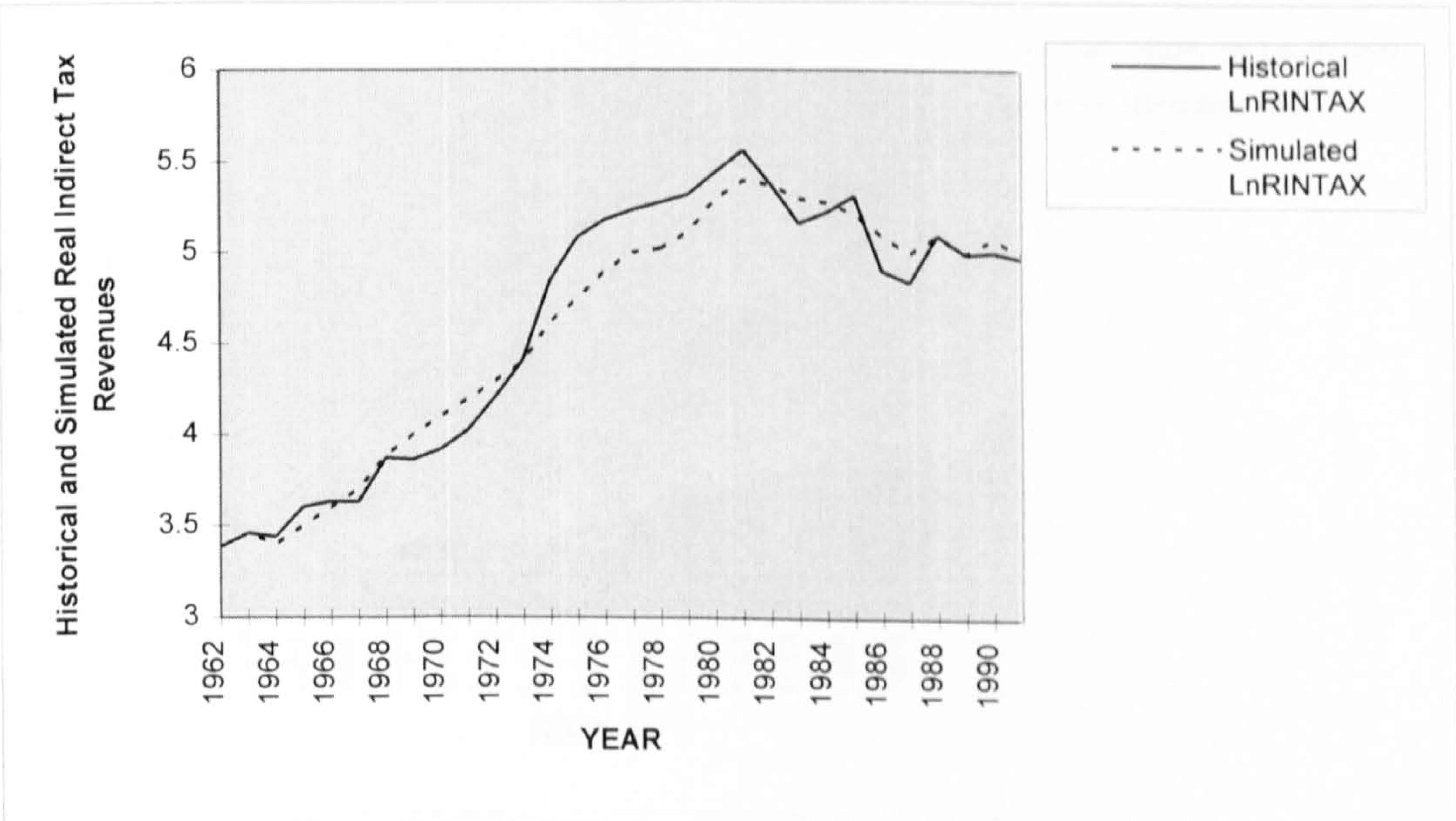
Graph 2.12 Historical and Simulated Real Total Imports (1962-1991)



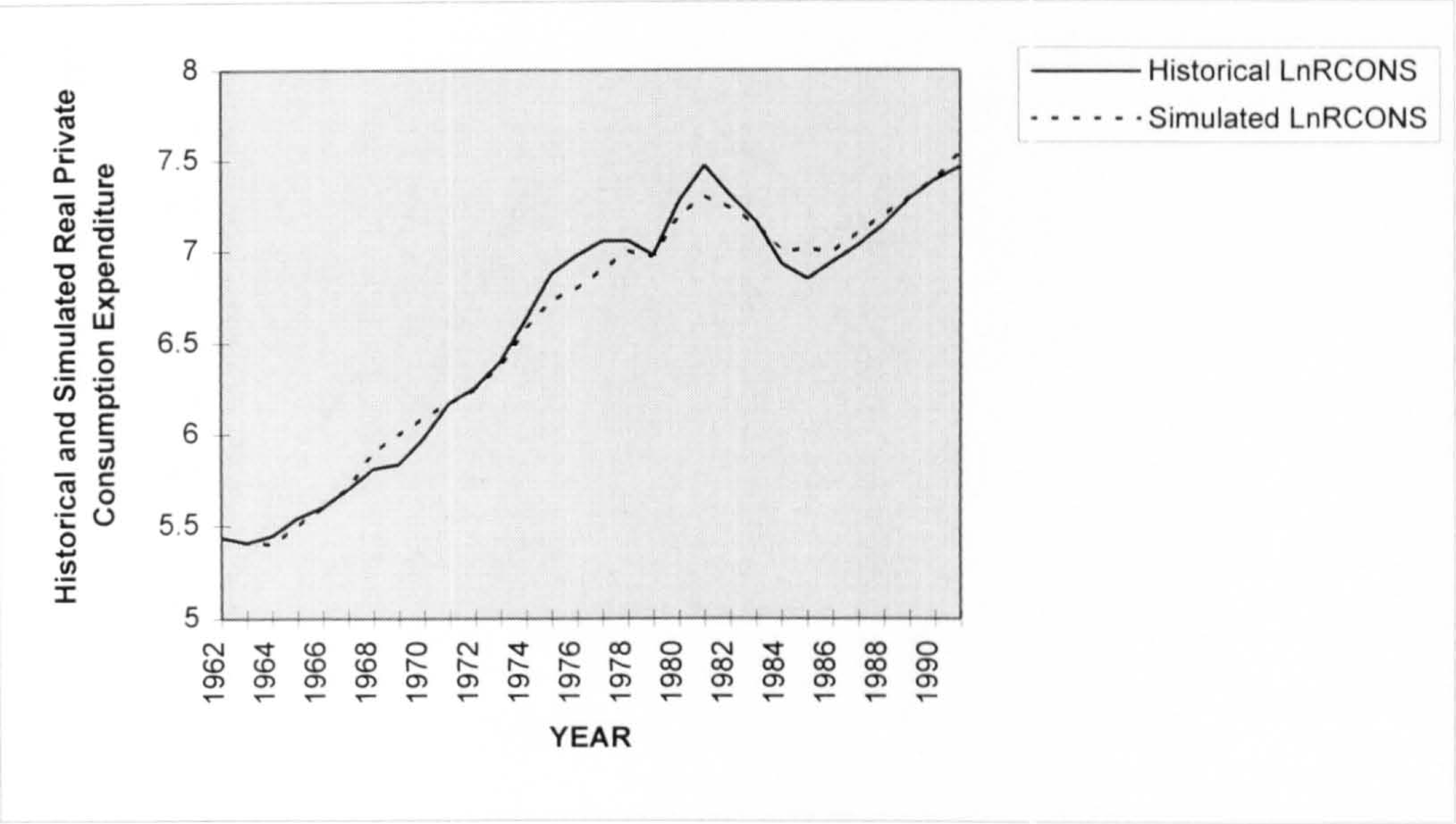
Graph 2.13 Historical and Simulated Real Non-Oil Value-Added (1962-1991)



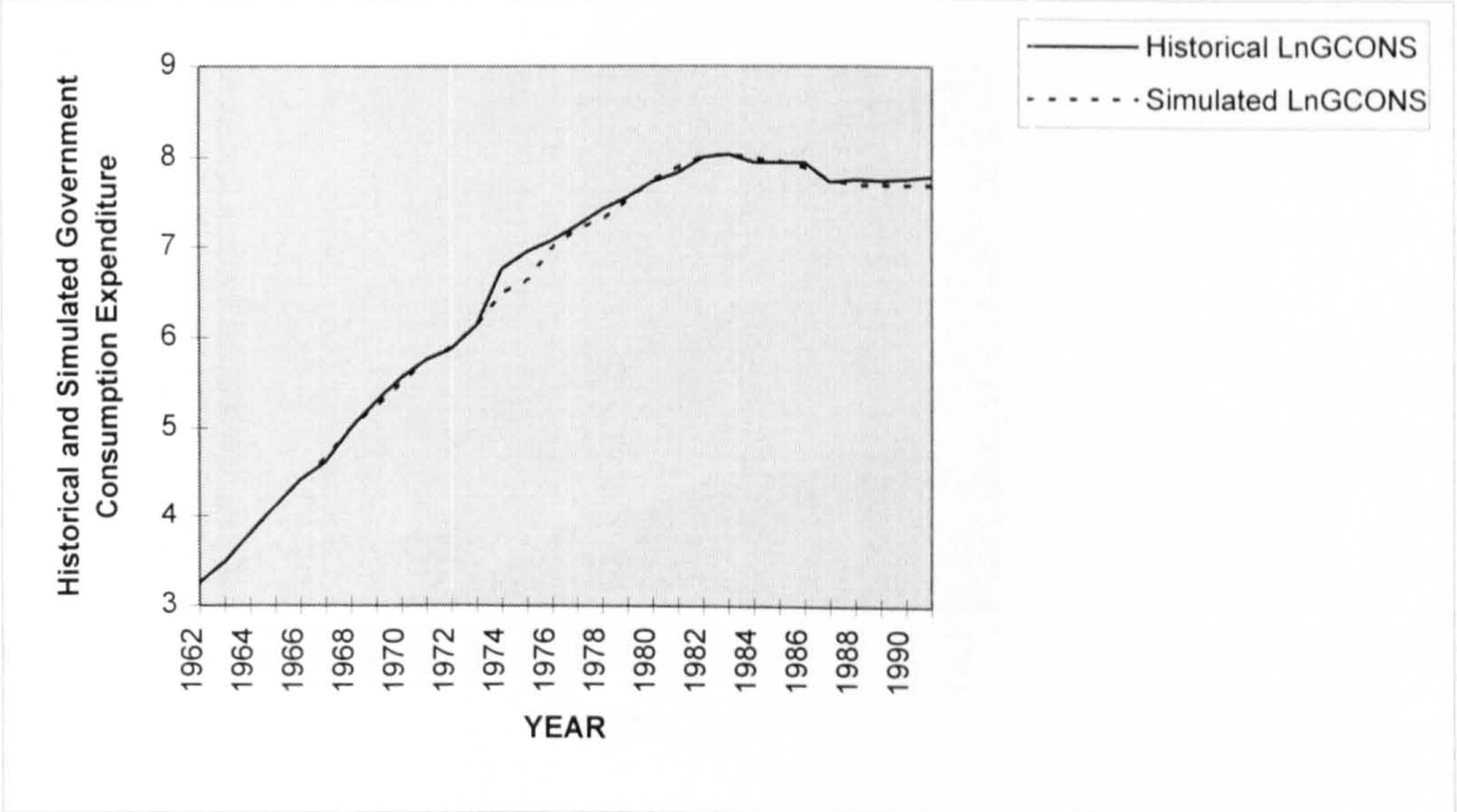
Graph 2.14 Historical and Simulated Real Indirect Tax Revenues (1962-1991)



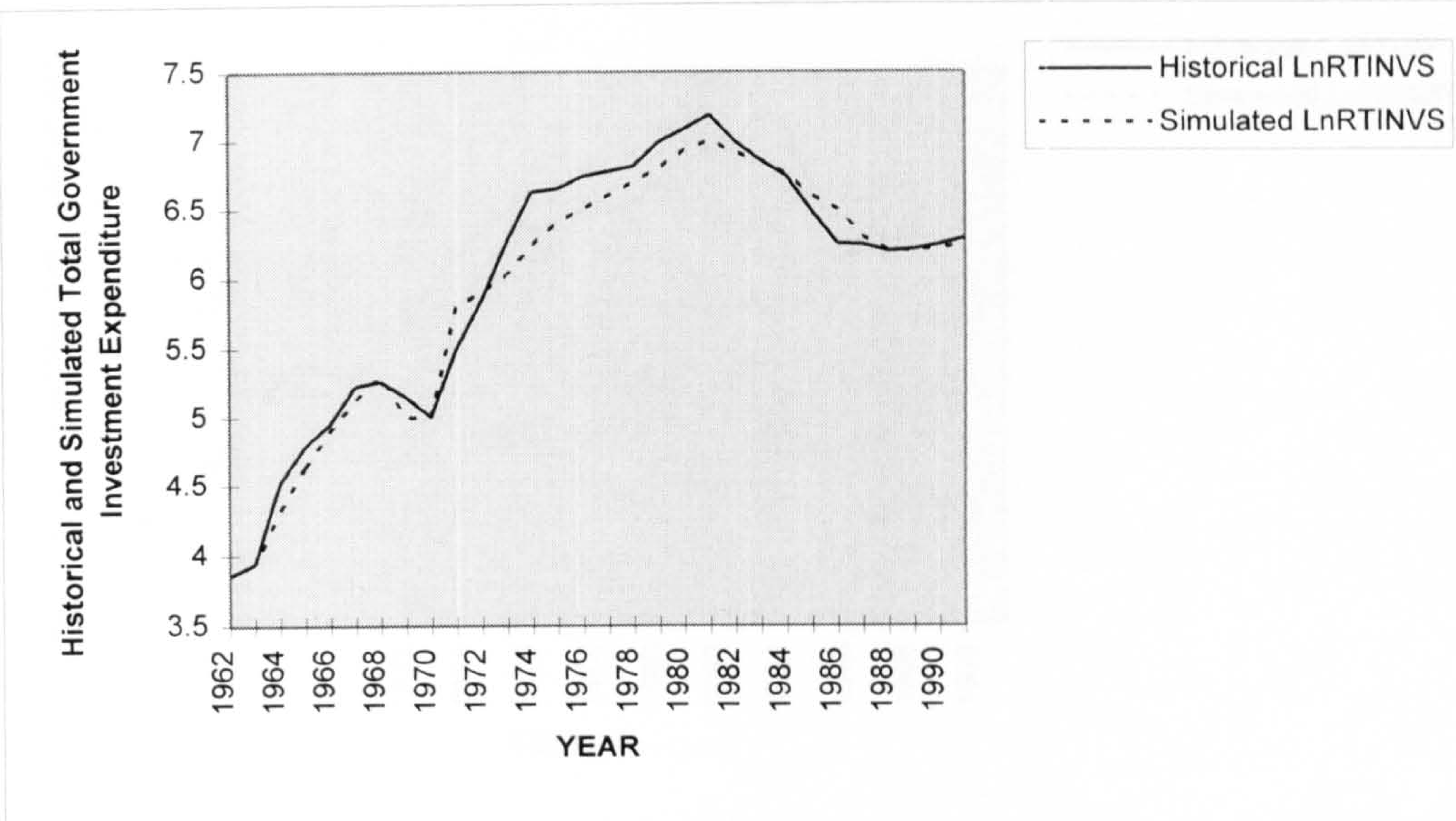
Graph 2.15 Historical and Simulated Real Private Consumption Expenditure (1962-1991)



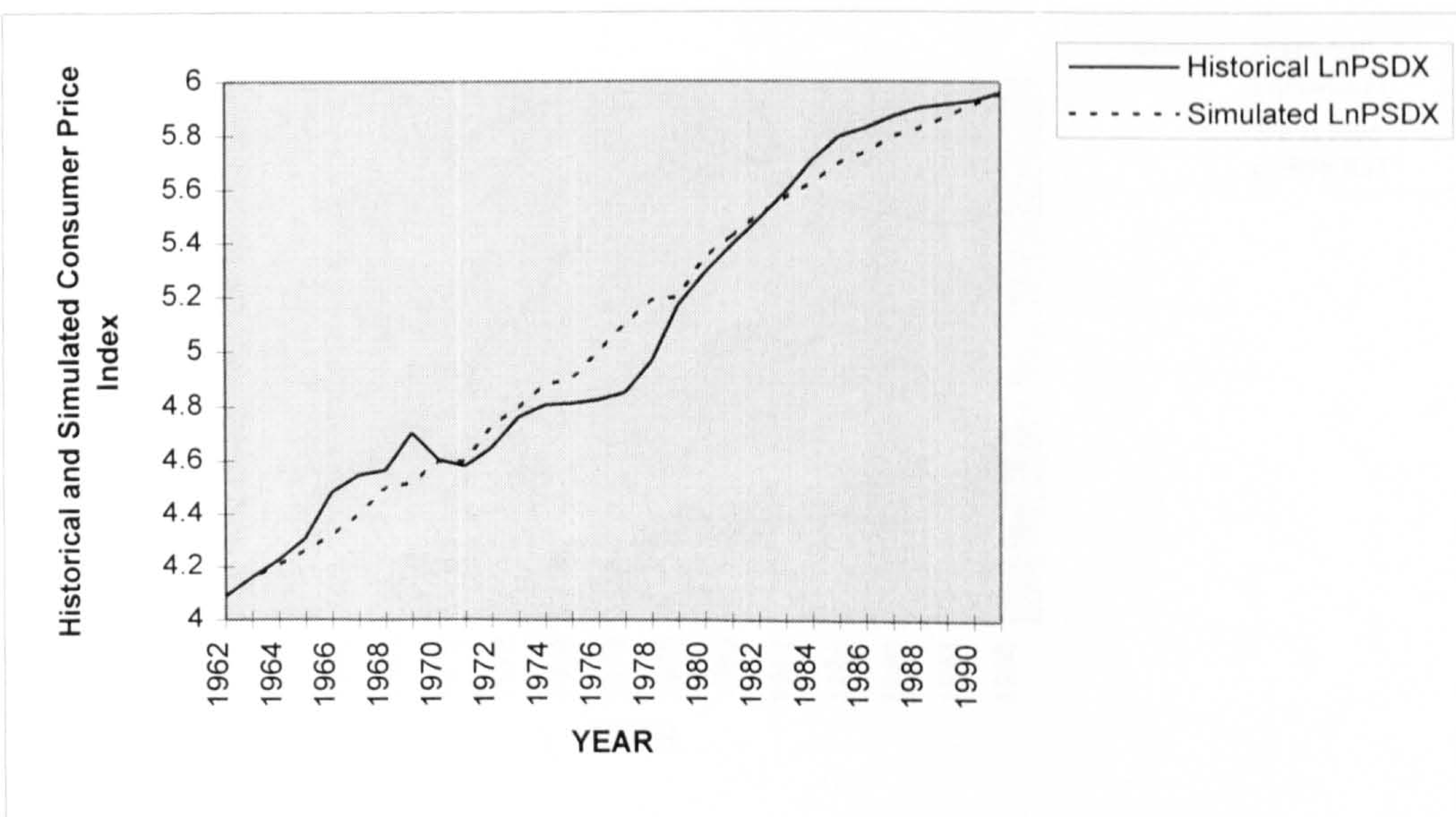
Graph 2.16 Historical and Simulated Government Consumption Expenditure (1962-1991)



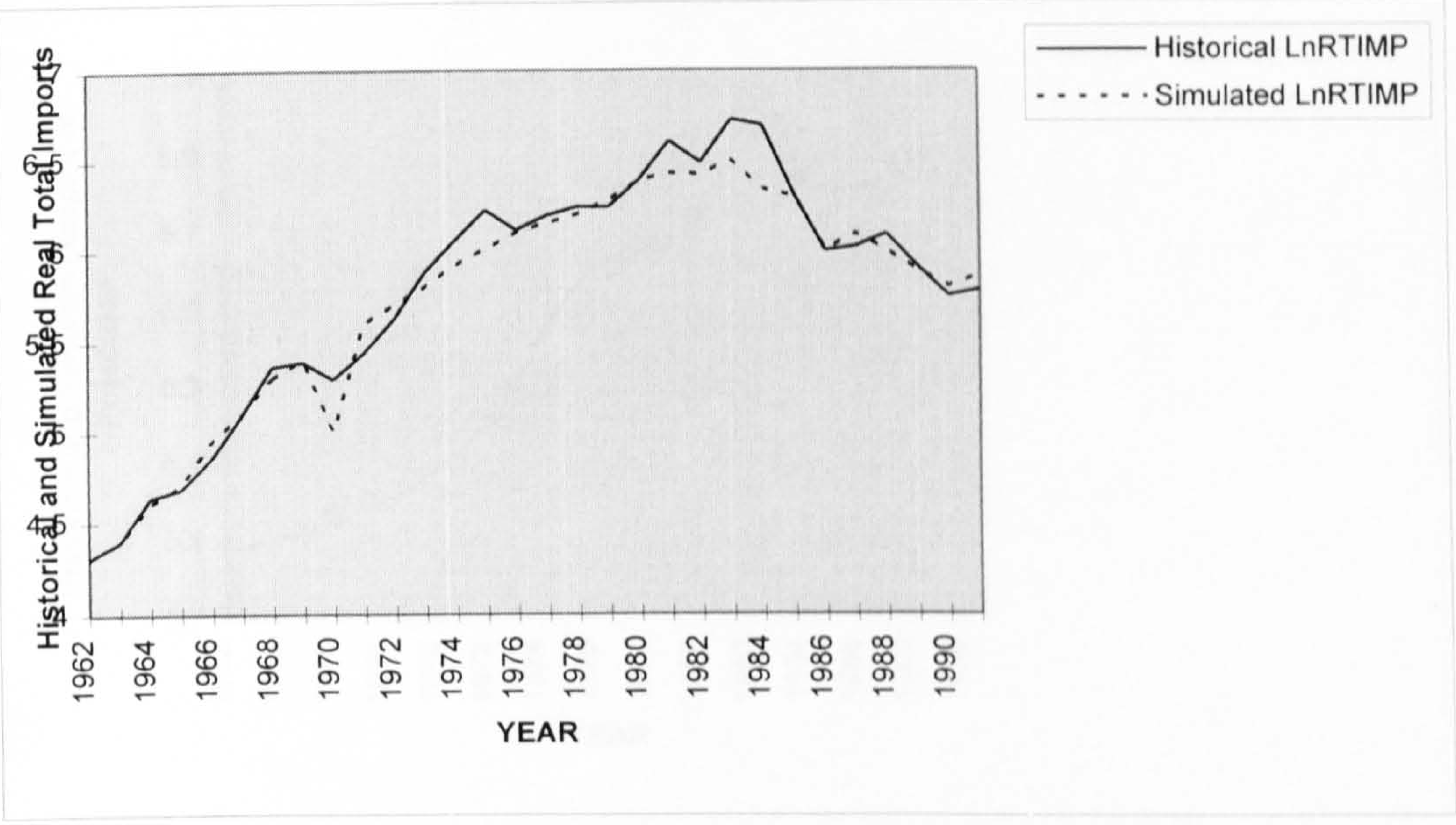
Graph 2.17 Historical and Simulated Total Government Investment Expenditure (1962-1991)



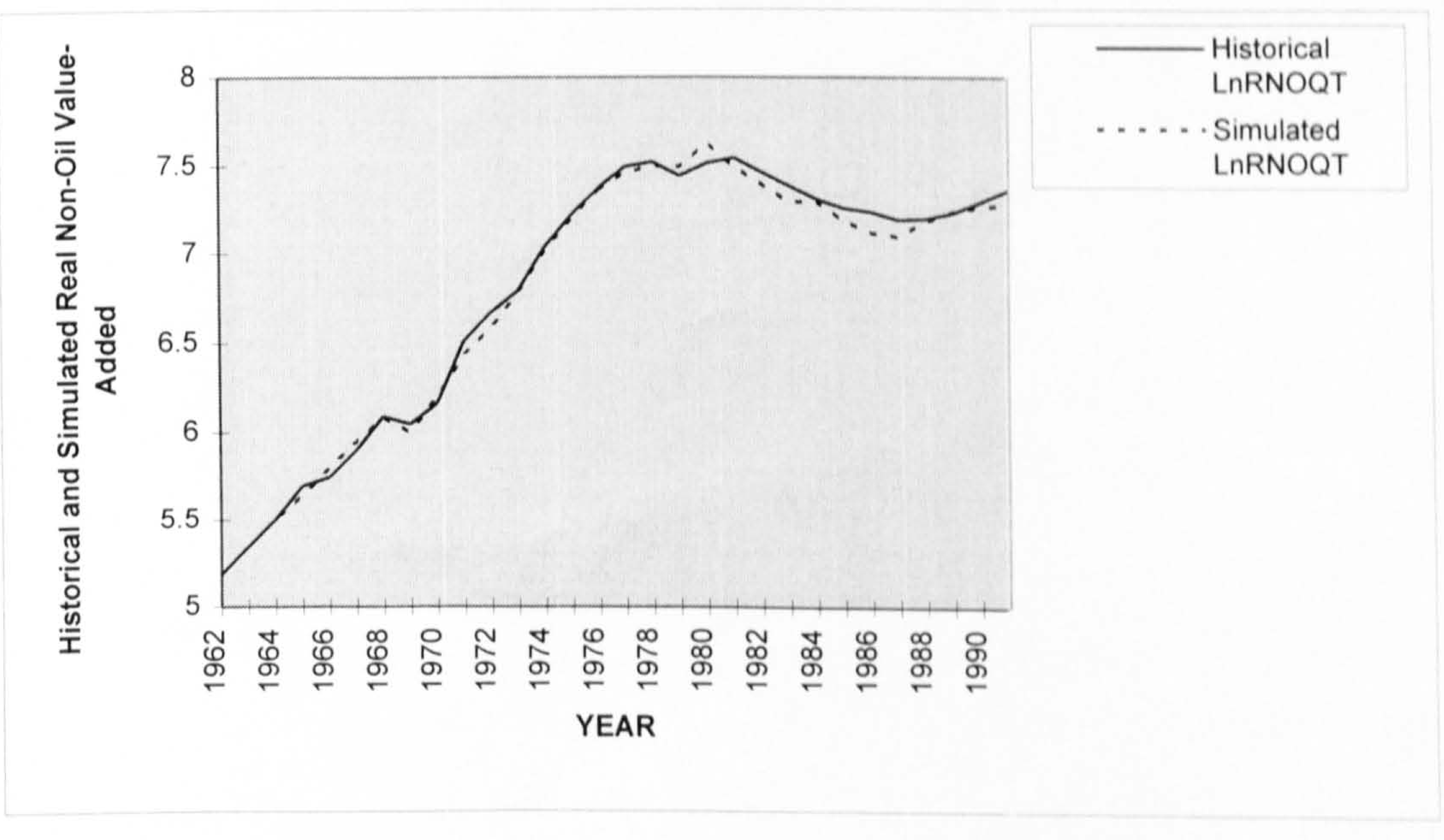
Graph 2.18 Historical and Simulated Consumer Price Index (1962-1991)



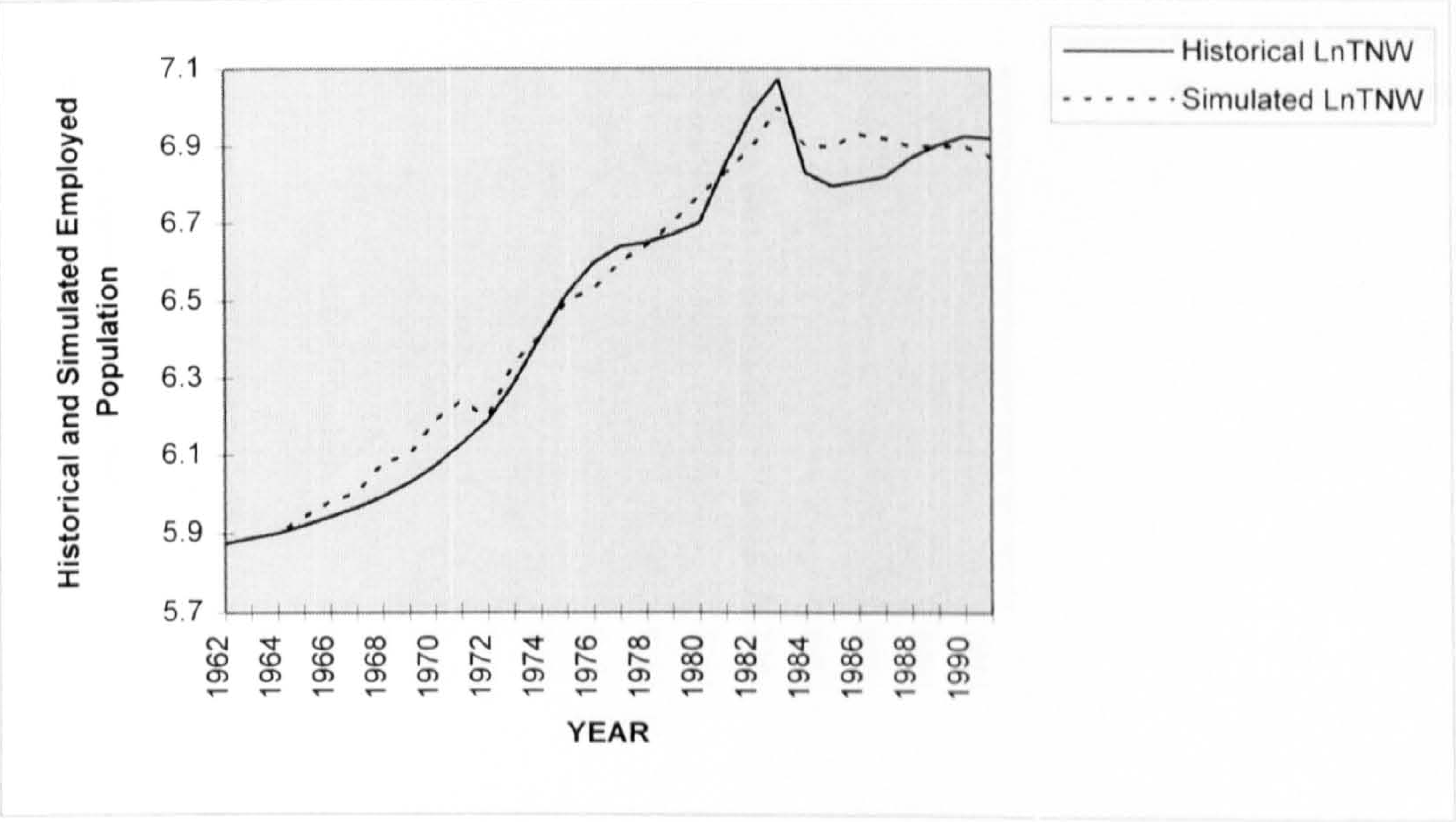
Graph 2.19 Historical and Simulated Real Total Imports (1962-1991)



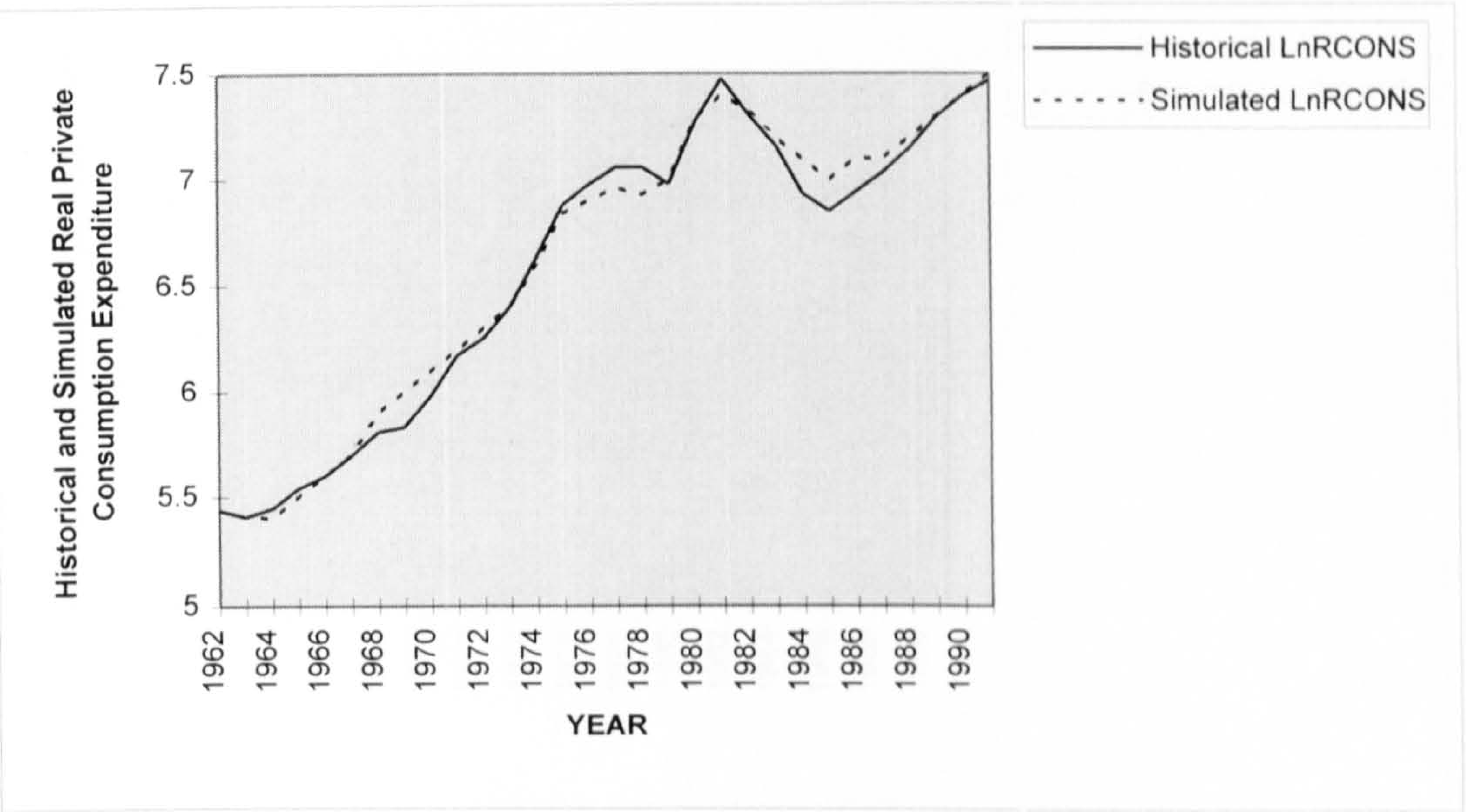
Graph 2.20 Historical and Simulated Real Non-Oil Value-Added (1962-1991)



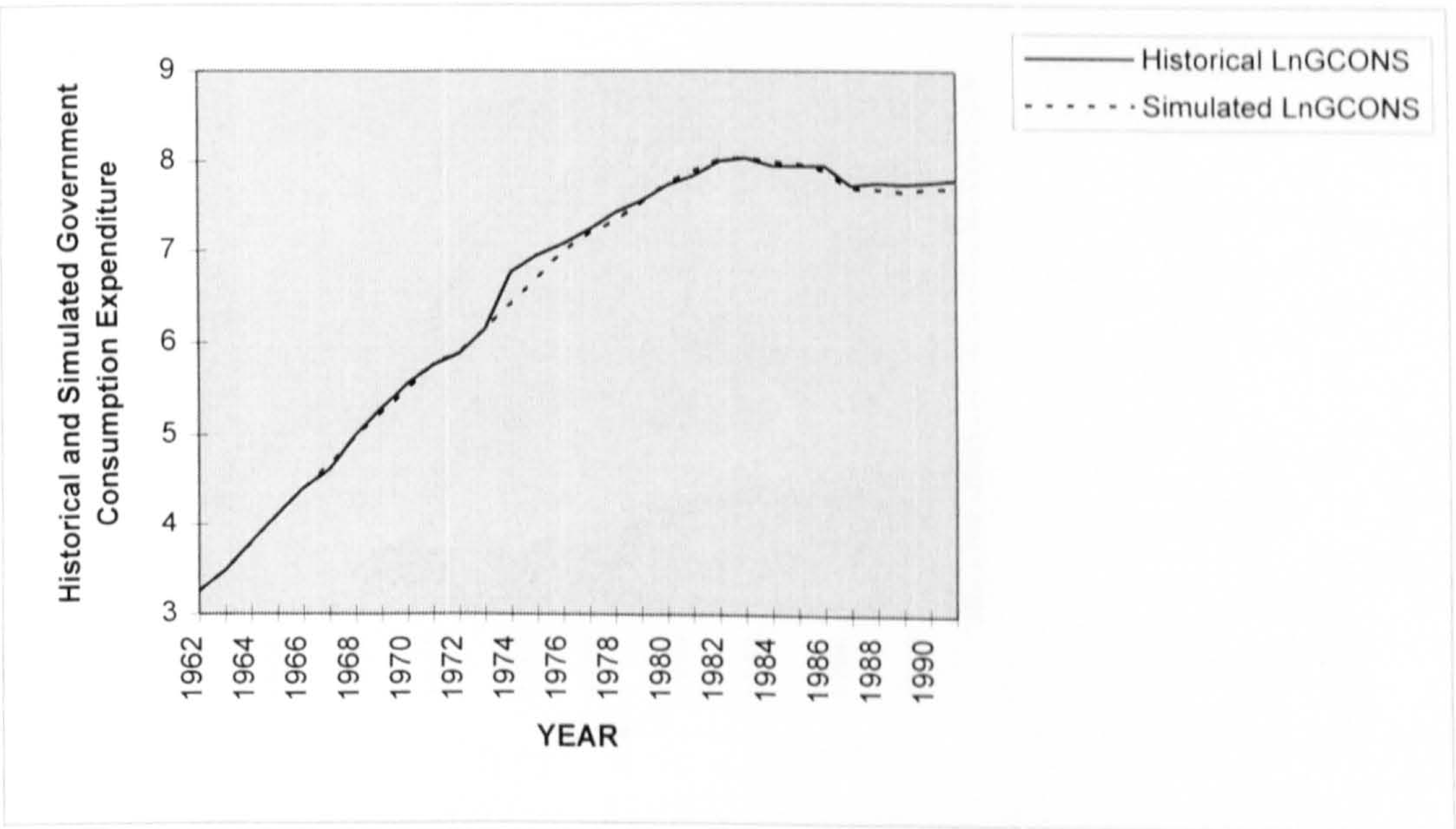
Graph 2.21 Historical and Simulated Employed Population in the Libyan Economy (1962-1991)



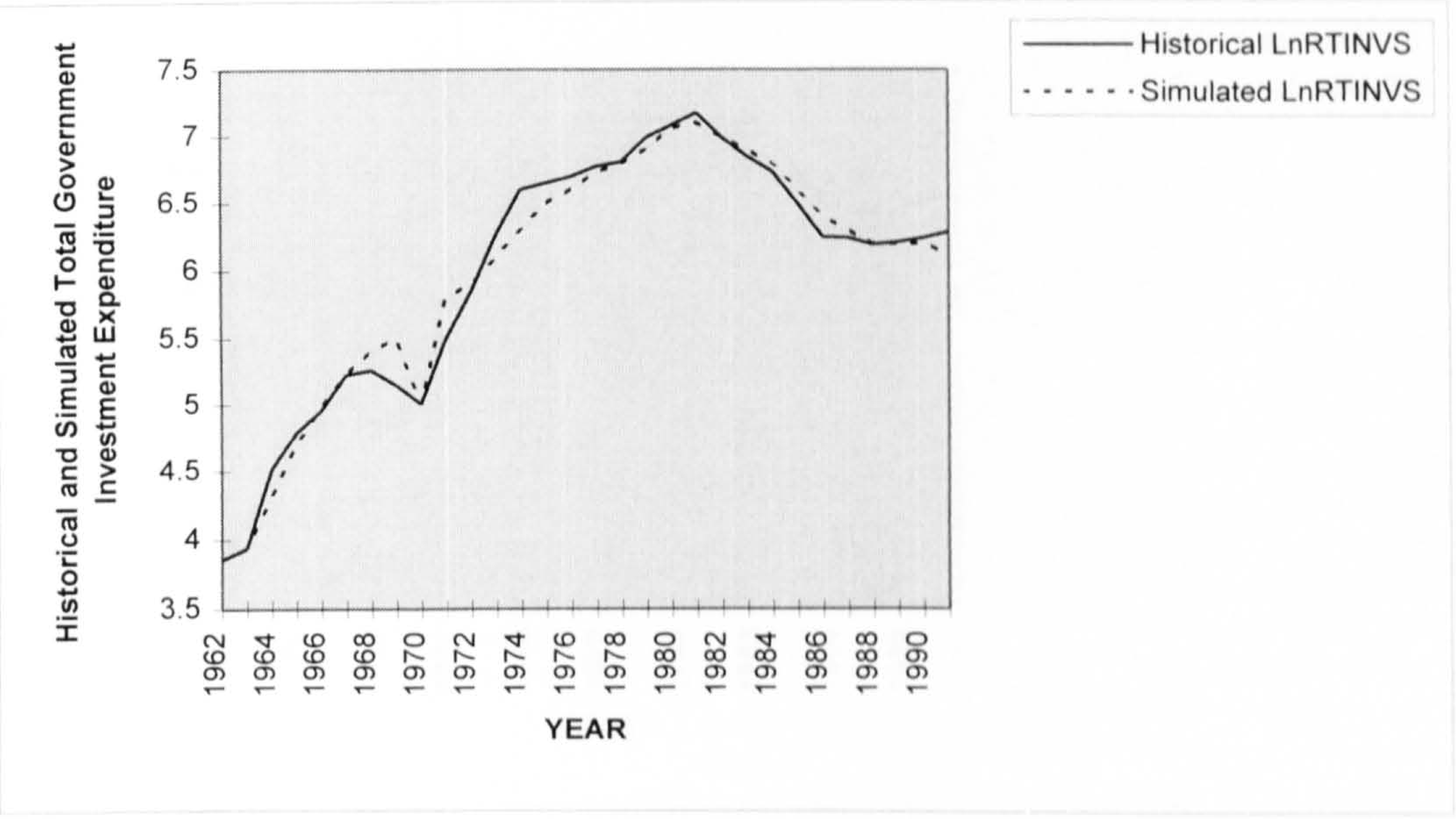
Graph 2.22 Historical and Simulated Real Private Consumption Expenditure (1962-1991)



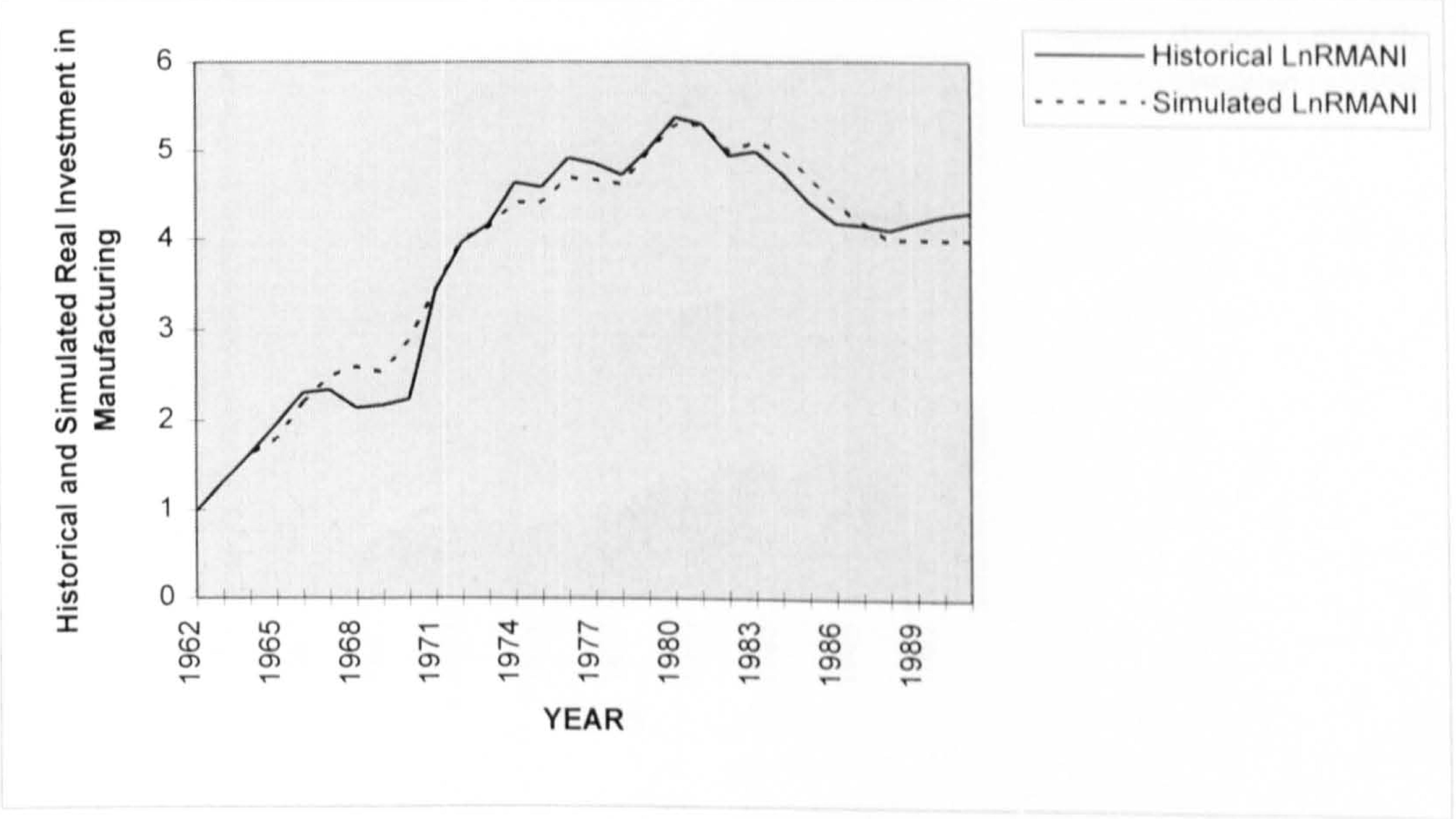
Graph 2.23 Historical and Simulated Government Consumption Expenditure (1962-1991)



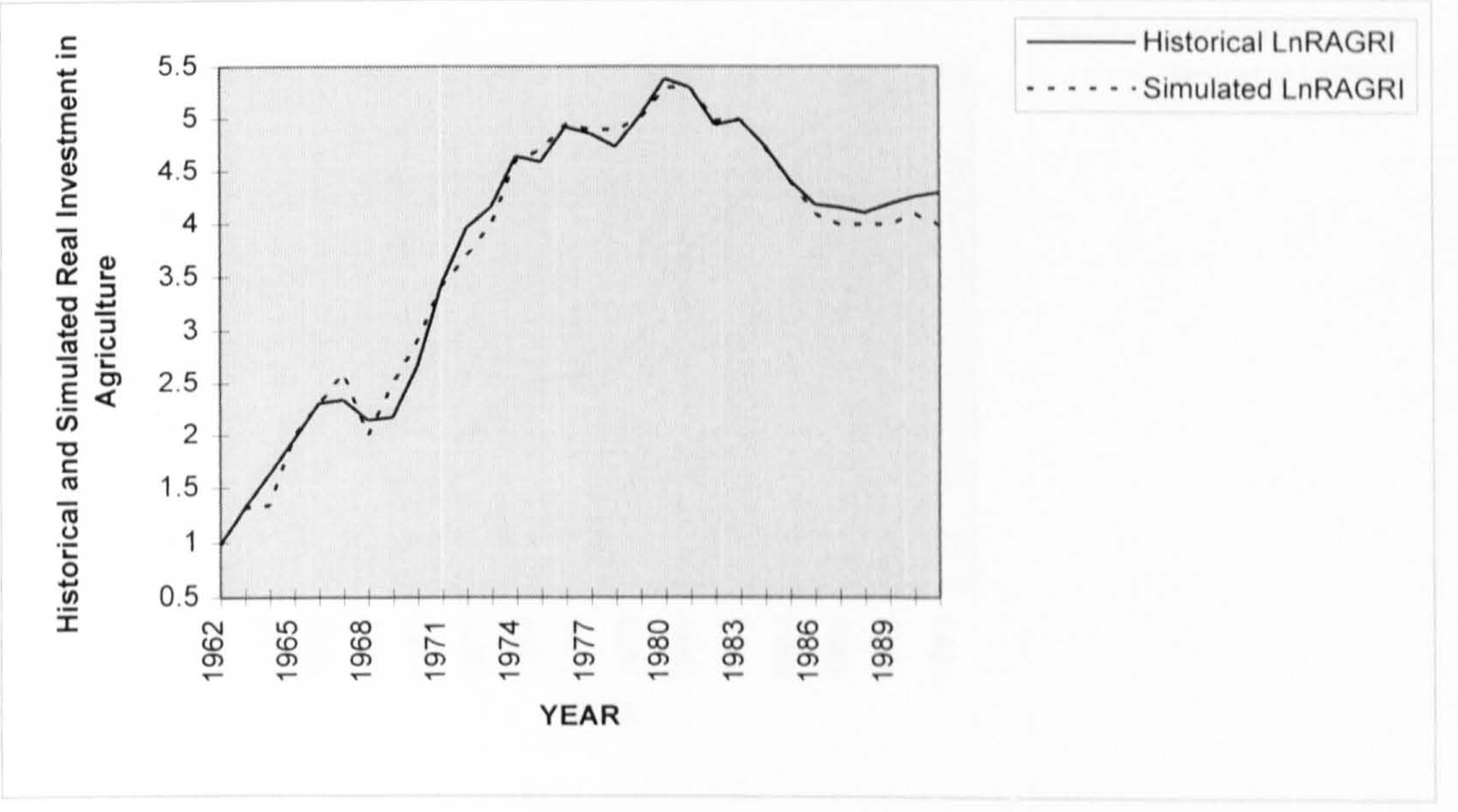
Graph 2.24 Historical and Simulated Total Government Investment Expenditure (1962-1991)



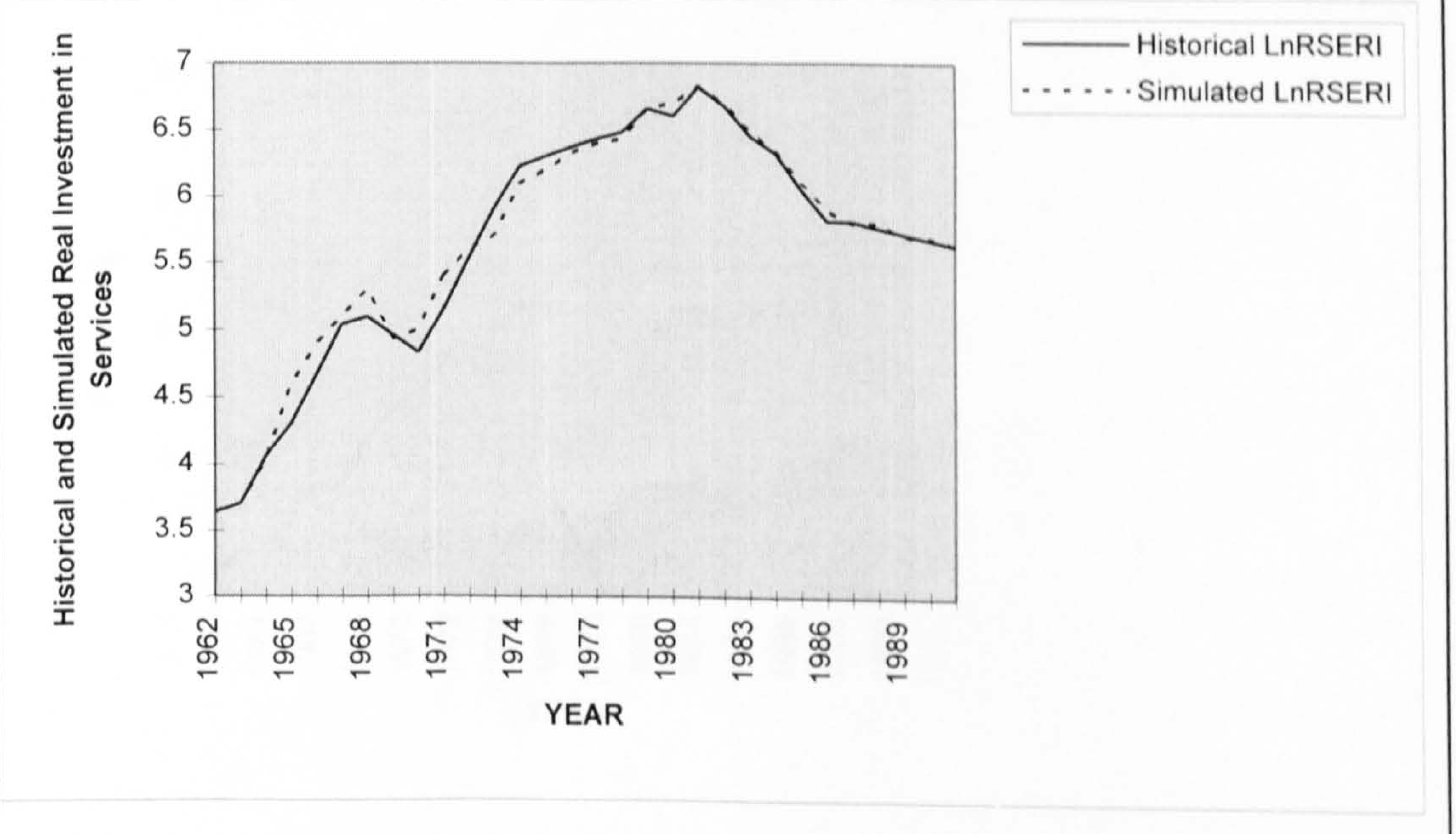
Graph 2.25 Historical and Simulated Real Investment Expenditure in the Manufacturing Sector (1962-1991)



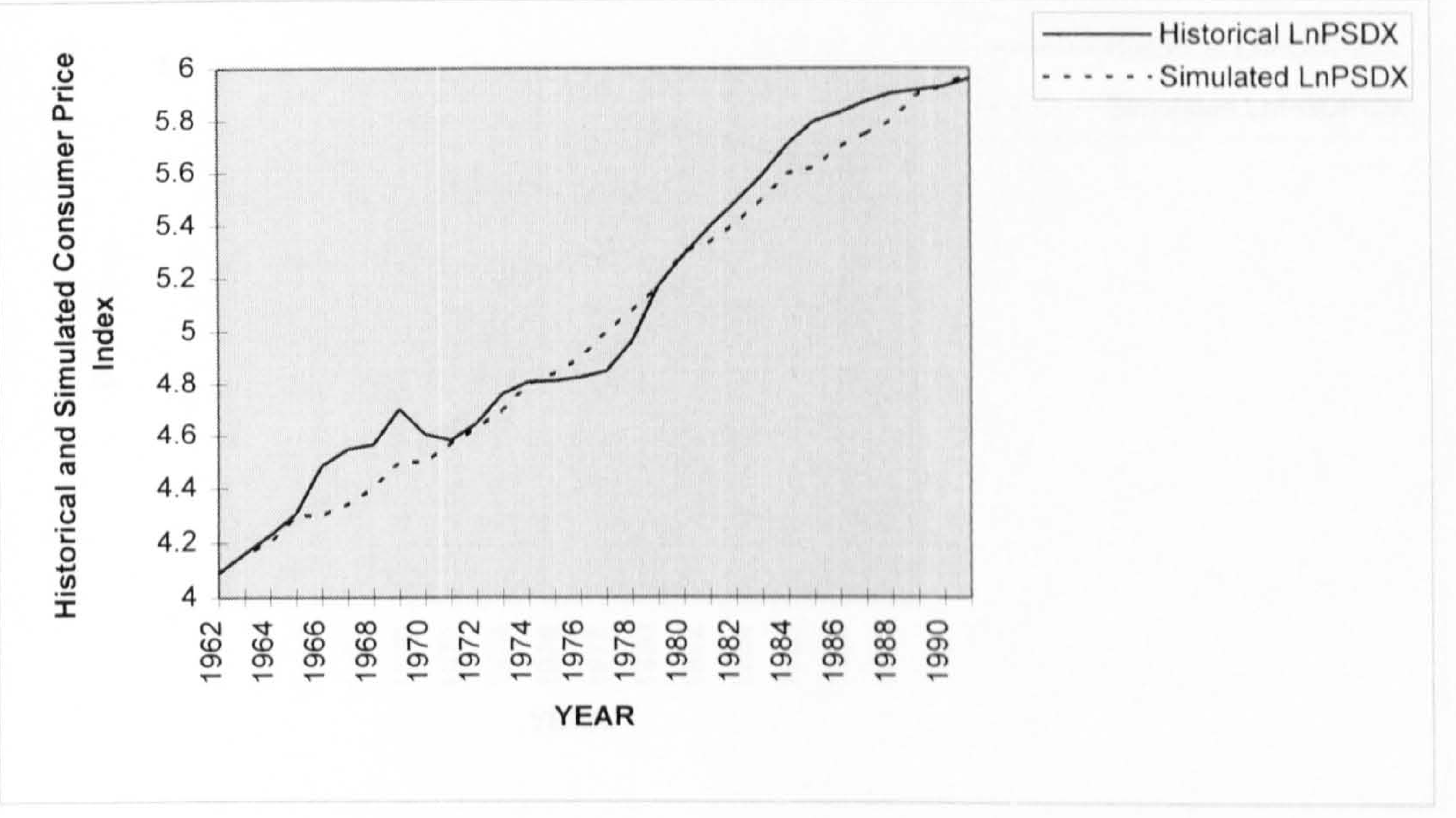
Graph 2.26 Historical and Simulated Real Investment Expenditure in the Agriculture Sector (1962-1991)



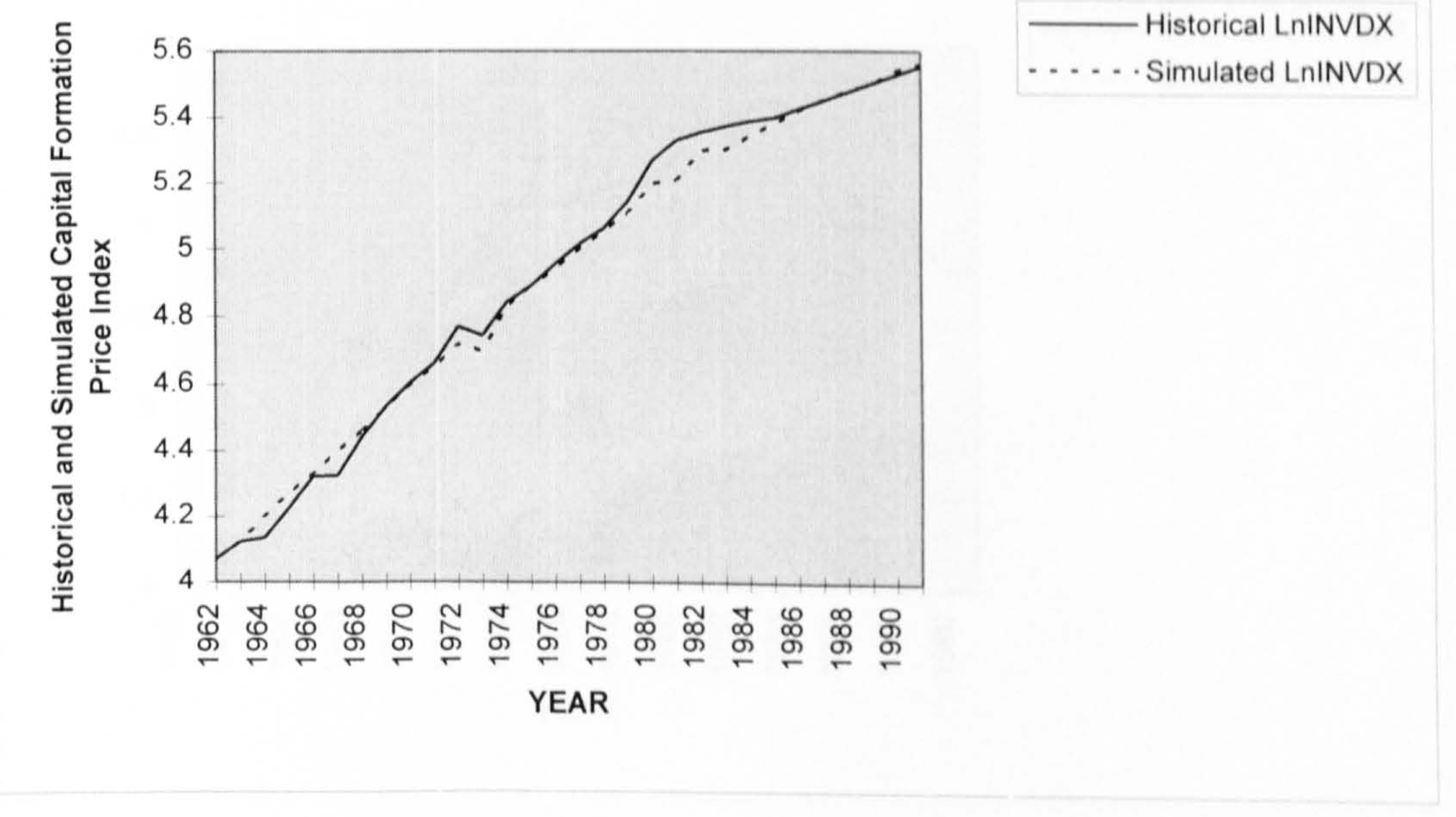
Graph 2.27 Historical and Simulated Real Investment Expenditure in the Services Sector (1962-1991)



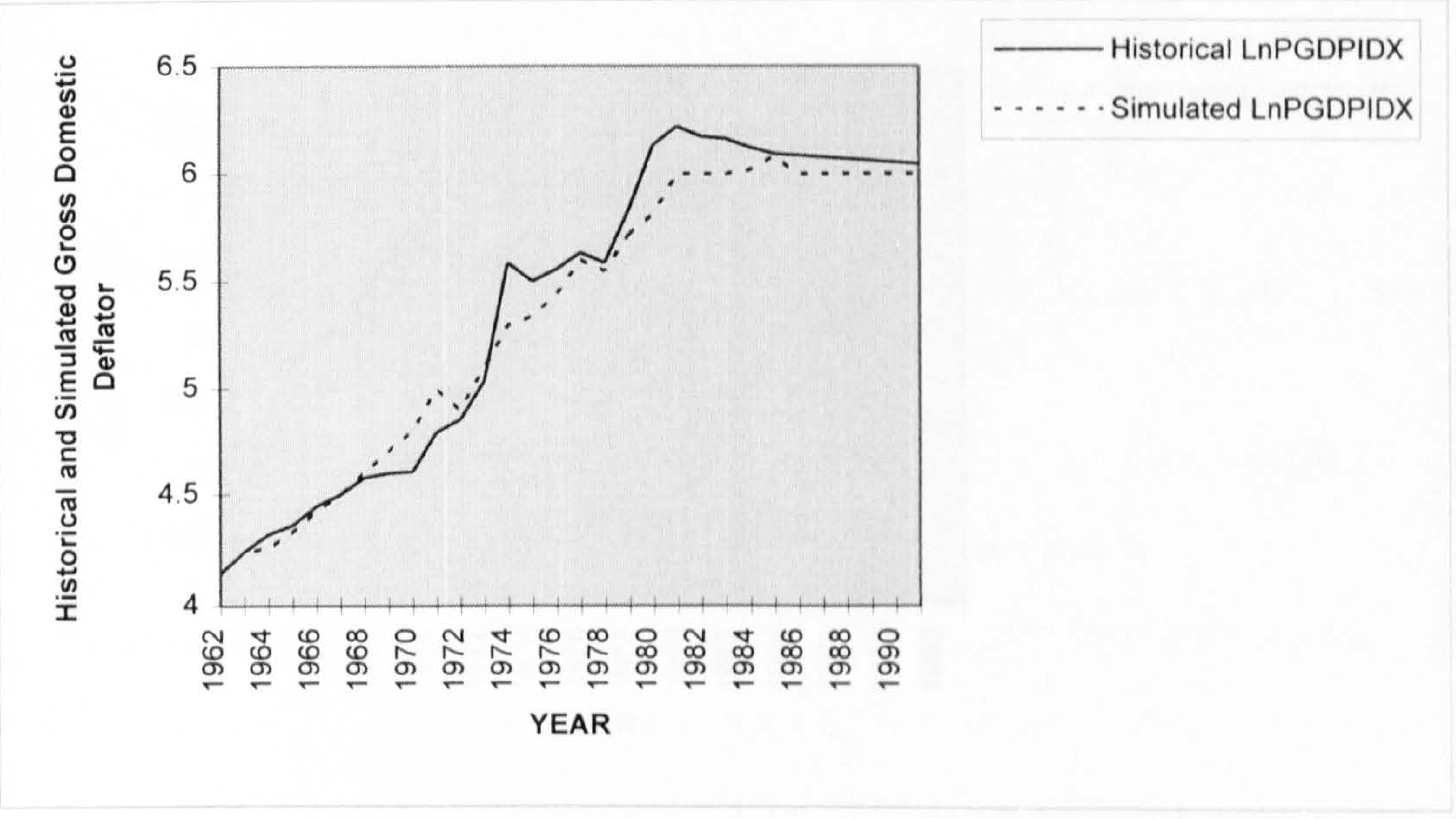
Graph 2.28 Historical and Simulated Consumer Price Index (1962-1991)



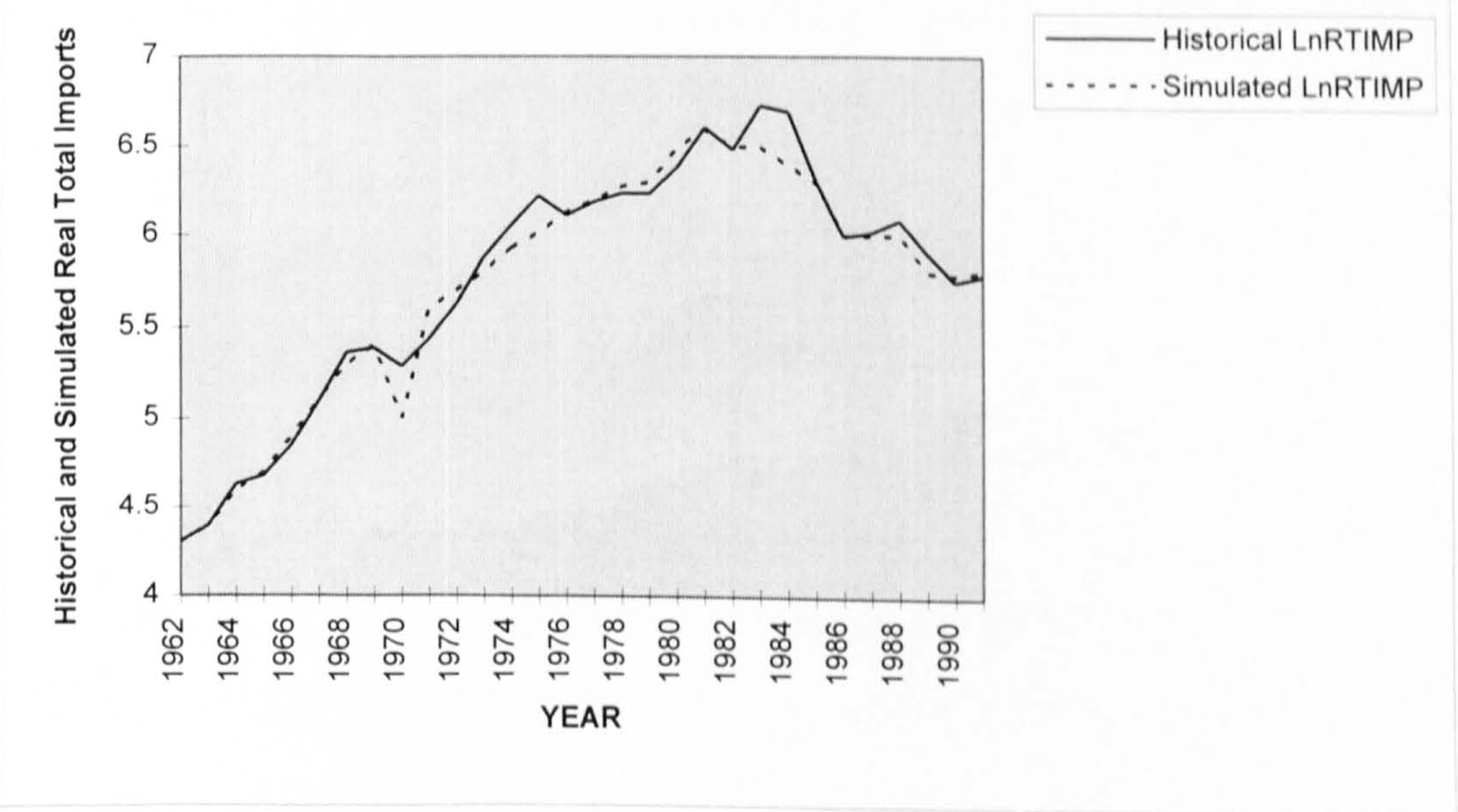
Graph 2.29 Historical and Simulated Capital Formation Price Index (1962-1991)



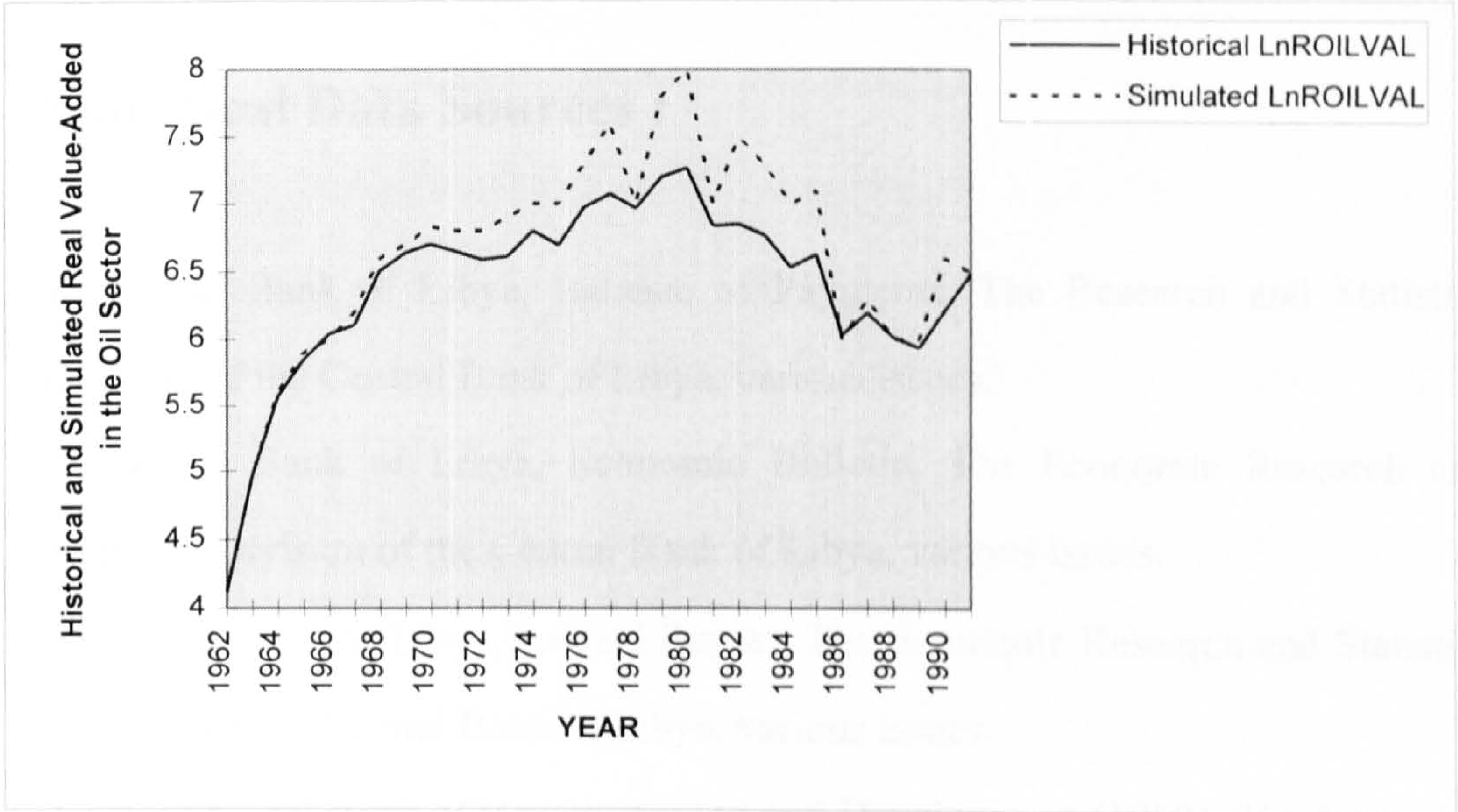
Graph 2.30 Historical and Simulated Gross Domestic Deflator (1962-1991)



Graph 2.31 Historical and Simulated Real Total Imports (1962-1991)



Graph 2.32 Historical and Simulated Value-Added in the Oil Sector (1962-1991)



Appendix 3

Statistical Data Sources :

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2. Central Bank of Libya, Economic Bulletin, The Economic Research and Statistics Division of the Central Bank of Libya, various issues.

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21. Socialist People's Libyan Arab Jamahiriya, Secretariat of Planning, National Account 1971-1977, April, 1979, (in Arabic).

22. The Economist Intelligence Unit (E.I.U) Country Profile: Libya, London-United Kingdom, different issues.

23. United Nations, Monthly Bulletin of Statistics, New York, (relevant issues).

24. United Nations, Statistical Yearbook, New York, (relevant issues).

25. United Nations, Yearbook of Industrial Statistics, New York, (relevant issues).

26. United Nations, Yearbook of National Accounts Statistics, New York, (relevant issues).

27. World Bank, World Tables, various issues.

28. Ministry of Planning (1989), General Development Program, The first General Framework of the Social and Economic Transformation, Libya.

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