A SIMULATION STUDY OF THE IMPACT OF WORLD OIL PRICES ON THE DEVELOPMENT OF THE LIBYAN ECONOMY

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This study is concerned with examining the effects of recent developments in the world oil market on the development of Libya, which is heavily dependent on revenues from its oil exports. Our goal in this study is to determine quantitatively how sensitive and vulnerable the Libyan economy's aggregates are to fluctuations in world oil prices.

In order to achieve our goal, a macroeconomic model of the Libyan economy was constructed using annual data from 1962-1978. The model contains 36 relations, of which 19 are behavioral equations and 17 are identities. The model was validated by both historical simulation and a one-period out-of-sample forecast.

Having established the predictive ability of the model, alternative future scenarios of the Libyan economy were examined from 1980-1987 by performing an ex-ante simulation for this period. This simulation was divided into two sections. The first covers the

period 1980-1983, for which actual data for Libyan oil prices and the volume of Libyan oil exports are available. The second section covers the period 1984-1987. In this section the future of the Libyan economy was simulated under a basic price scenario which reflects the most likely forecast regarding the world oil price level from 1984-1987. In addition, a sensitivity analysis was perfomed by establishing a new scenario for the world oil price level from 1984-1987. A comparison of the results of these simulations shows the effects resulting from changes in the world oil price level on the Libyan economy. A 10% increase in the world oil price level as compared to our basic scenario was found to stimulate the economy at a decreasing rate. It was also found that the expansion of the economy would have little side effects in terms of higher levels of the consumer price index. The wage rate in the non-oil sector showed more sensitivity with respect to changes in world oil price level than did the wage rate in the oil sector. In addition, government total expenditures and money supply were found to be relatively insensitive to changes in world oil price level.

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CHAPTER I

INTRODUCTION

The past two decades have witnessed a drastic change in the world oil market. In the 1960s, most of the increase in world energy consumption was met by an increase in oil production, while the nominal price of oil remained mostly constant. During the 1970s, the world witnessed "an end to oil's ever-increasing dominance of the energy supply mix."[1] This was due to the drastic and sharp increase in the price of oil of 1973-74 and 1979-80. The Organization of Petroleum Exporting Countries (OPEC) marker crude price went up from less than $3 a barrel in 1973 to reach $34 a barrel in 1981. It has been argued that such an increase in the price of oil has been so drastic that it eventually resulted in a structural change in oil use. "Higher prices began to cut demand for oil--encouraging both increased conservation and fuel-switching--and made it economical to produce new, higher cost oil supplies."[2] Faced with a world-wide falling demand for crude oil and with an increasing downside squeeze on world oil prices, OPEC members had to come up with a strategy to defend their benchmark price of $34 a barrel. Accordingly, in March 1982, OPEC came up with a quota system that set limits on the production level of each OPEC member. Nonetheless, the organization's attempt to maintain the price of its marker crude by managing output failed as OPEC members found that this price was indefensible. Actually, the world oil market responded to the laws of supply and demand and OPEC members had no option but to lower their price. In March 1983, OPEC members agreed to lower their benchmark crude price to $29 a barrel from their previous $34 a barrel. This marked the first time in the organization's history where OPEC had reduced its benchmark price.

Purpose of the Study

This study is concerned with examining the effects of the recent developments in the world oil market on the development of Libya, a country in which oil revenues form the primary source of its income. Our goal in this study is to examine and evaluate the economic effects of favorable or unfavorable circumstances regarding the future level of world oil prices on the Libyan economy.

While Libya's oil revenues have increased during most of the 1960s and 1970s, the latest estimates show a huge decline in oil revenues. It is estimated that during the period from mid-1981 till mid-1982, oil revenues declined to almost half as much as the previous twelve months.[3] This has resulted from the decline in worldwide demand for oil and the decrease in the price of oil that followed. It should be emphasized that it is not my intention in this study to suggest that such a trend will continue. Determination of world demand for oil and the price of oil are very complicated matters that are influenced by both political factors and economic factors. Nonetheless, it is the intention of this study to provide the economic planners in Libya with quantitative analysis of the possible impacts, that could come from changes in world oil prices, on the Libyan economy aggregates.

This will enable the economic planners in Libya to understand and evaluate the consequences of such impacts and therefore allow them to react effectively to changes that may occur. For instance, the economic planners have some flexibility, at least in the short run, to minimize the economic effects associated with any unfavorable economic consequences.[4] The planners can rely on the country's accumulated international financial reserve to lessen the impact of such unfavorable consequences. In addition, the economic planners can also reduce the country's expenditures on some of its less crucial commitments or can arrange for borrowing in the Eurocurrency market. These are forms of options that are available to the planners. Nevertheless, given the limited information about the planners' preference among those alternatives, our study is not intended to point out which option or which combination of those options should be followed by the planners. Actually, this will depend on different factors which are beyond the scope of this study.

Methodology

In order to analyze how sensitive and vulnerable the Libyan economy is to fluctuation in world oil price level, a macroeconomic model describing the aggregate structure of the Libyan economy is constructed. The model is based on annual data from

1962-78. A start is made by specifying a system of structural equations that describe the different components of the Libyan economy. In achieving this, several alternative specifications which are justified theoretically and which reflect the peculiar characteristics of an oil-based economy like Libya are experimented with. The final specifications which appear in the model are not only the ones that prove to be theoretically sound, but also the ones that meet the traditional statistical tests. These include R-squared, t ratio, F ratio, Durbin-Watson, and Durbin h.

Since oil revenues constitute the main economic resource for the country, the model is built to capture this important characteristic of the Libyan economy. In the model, the economy is divided into two sectors--the oil and the non-oil sectors. This division will enable us to break down the impacts of changes in world oil price levels into those affecting the oil sector and the subsequent impacts in the non-oil sector. In addition, it will provide us with a better understanding of the mechanism of such impacts. In other words, any macroeconomic consequences in the non-oil sector could be traced to their real causes in the oil sector.

In estimating the different specifications of equations that appear in the model, the ordinary least squares (OLSQ) technique has been used. Nonetheless, due to the simultaneous nature of our model, the two-stage least squares (TSLS) was used whenever necessary to remove the simultaneous bias introduced by the application of OLSQ. However, since our sample is very small, 1962-78, a problem was encountered in applying the TSLS method. Stage one can't be estimated since the number of our predetermined variables is greater than those of observations. This problem was bypassed by the use of a truncated first stage.[5] Accordingly, a subset of the predetermined variables was used to estimate stage one. Nonetheless, for the TSLS estimators to be consistent, two conditions had to be fulfilled. First, the subset of the predetermined variables must include all predetermined variables in the structural equation being estimated. Second, one must include enough predetermined variables from other structural equations to make the structural equation that is being estimated identified.

Organization of the Study

This study is divided into five chapters, as follows: Chapter I consists of this chapter, which serves as an introduction. Chapter II will present the alternative specifications tried for the stochastic equations appearing in the Libyan macroeconomic model. This is divided into five parts. Aggregate supply components form the first part. The second part is concerned with the determination of the various components of aggregate demand. These include consumption, investment, and foreign trade relations. The third part contains government sector equations. The monetary sector and price equations are described in the fourth part. Finally, the determinants of employment and wages will be studied in the final part.

In Chapter III the full model will be presented and its predictive ability will be established. This is to be achieved by carrying out two experiments. First, a dynamic simulation of the full model will be performed for the period 1964-78. In order to evaluate the results of this simulation, different statistical tests will be calculated for all the endogenous variables of the model. These include the RMSE (root-mean-square error), RMS percent error, mean error, mean percent error, Theil's inequality coefficient and its decompositions. The second experiment will consist of an ex-post forecast for 1979.

In Chapter IV, the model will be used to determine the sensitivity of the Libyan economy to fluctuations in world oil prices. Accordingly, an ex-ante simulation will be performed under two scenarios regarding the future trends of world oil prices. The assumptions of these scenarios will be discussed in this chapter. In addition, a comparison of the results of the two scenarios will enable us to determine the sensitivity of the Libyan economy to fluctuation in world oil prices.

Chapter V will summarize the results of this study.

Data in the Libyan Model

As with most macroeconomic modeling studies of developing countries, data availability forms the first problem to be dealt with. The first data problem encountered in this study relates to the small size of sample used in estimating the stochastic equations of the model. Data, which are annual, are only available for the period 1962-78. This was the largest sample of all variables used in the model that could be utilized. Even though some data were available for 1979 and 1980, we could not use them in this study. This is because they were available for only a few variables which appear in our study. In addition, data for 1980 were only estimates. Accordingly, our sample was limited to cover the period 1962-78.

The data used on the Libyan model were obtained from various sources. The basic source is the national accounts statistics of Libya, for which data for most of our variables were obtained for the period 1962-77. Data for 1978 were obtained from two sources. These include the Statistical Abstract of Libya of 1979 and a Summary Report of National Accounts for 1975-1980. Data for consumer price index, money supply, and high powered money were taken from the International Financial Statistics published by the International Monetary Fund.

A problem was encountered in obtaining data for wages in the oil and non-oil sectors between 1975-78. While the total amount of wages and salaries was available for that period, no division as to the share of the above-mentioned two sectors was available. Accordingly, and since a small portion of this goes to the oil sector, which employs a very small percentage of the labor force, it was assumed that wages in the oil sector will follow their historical trend in generating their values for 1976-78. Of course, the rest was assigned to wages in the non-oil sector.

CHAPTER I

NOTES

[1]The Chase Manhattan Bank, N.A., The World Energy Outlook Through 2000: A Time of Transition. Prepared by the National Resource Economics Section of the Energy Economics Division, October 1981, p. 8.

[2]Standard and Poors, Industry Surveys, Oil, November 10, 1983 (Vol. 151, No. 43, Sec. 1), p. 61.

[3]J. A. Allan, "Libya Accommodates to Lower Oil Revenues: Economic and Political Adjustments." International Journal of Middle East Studies, Vol. 15, No. 3, August 1983, p. 377.

[4]U.S. General Accounting Office. "Possible Energy Effects of a U.S. Ban on Libyan Oil Imports." Report prepared February 24, 1982, pp. 33-35.

[5]Robert McNown, Notes from Class "Seminar in Mathematic Economics and Econometrics." Economics 784, University of Colorado, Spring 1983.

CHAPTER II

A MACROECONOMIC MODEL OF LIBYA

The purpose of this chapter is to develop a macroeconomic model of the Libyan economy that enables us to quantify the nature and magnitudes of the mechanisms at work in that economy. Our goal is to use this model as the basis for studying and forecasting the impacts of possible changes in the country's oil sector earnings on the major economic aggregates. Since the Libyan economy depends heavily on revenues from oil exports, the model is developed to capture this crucial feature of the economy. Therefore, the model is divided into two major sectors. These are the oil sector and the non-oil sector.

The model is divided into five parts. Estimates of aggregate supply components, which are divided into gross domestic product in the oil sector and gross domestic product in the non-oil sector, will form the first part. The second part describes aggregate demand components, which include consumption, investment, and foreign trade relations. The third part contains government sector equations, while the fourth contains the monetary sector and price equations. Finally, the fifth part contains labor market equations, where determinants of employment and wages in the oil sector and non-oil sector are discussed. All equations in the model are computed on the basis of annual data for the period 1962-1978. The unavailability of all required data beyond that year has limited our sample to that period.

Aggregate Supply Components

The basic concern of this study is to investigate the contribution of the oil sector growth in the development of the Libyan economy. Specifically, our goal is to study the implications of favorable or unfavorable circumstances, regarding the future path of the price of oil, in the Libyan economy. In order to achieve this, gross domestic product in Libya was disaggregated into two components: gross domestic product in oil and gross domestic product in the non-oil sector. Here our concern is the determination of these two components.

Real Gross Domestic Product in the Non-Oil Sector

In order to explain growth of output, economists rely usually on estimating a production function. A production function is usually defined as "a technical relationship between outputs (of goods and services) and, generally, efficiently combined inputs of the services of factor of production."[1] In a country like Libya, one might argue that with abundant capital and with labor shortage in almost all sectors of the economy, a production function should show labor as the only binding constraint on production. Nonetheless, this might not be true when one bears in mind that in the case of Libya the richness of the country cannot be taken to imply physical capital abundance, as distinguished from financial capital. El-Jehaimi, in his study of the absorptive capacity of Libya, states that "as far as capital is concerned, the richness of the government does not translate into instant capital abundance. Nearly all capital equipment and machinery have to be imported with, at times, considerable time lag."[2]

Given the above features of the Libyan economy, a Cobb-Douglas production function was used to estimate the output in the non-oil sector. The Cobb-Douglas production function is generally specified as follows:

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

where

Q = total output

K = capital stock

L = labor input

A = a constant term

α = elasticity of output with respect to capital

β = elasticity of output with respect to labor

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 real investment in the non-oil sector was used as a proxy for real capital stock in that sector. A 10% rate of depreciation was employed in calculating this series. This rate is comparable to that used in other studies of the Libyan economy.[3] Therefore, the above function was estimated in a log linear form which gave us the following results:

$$\log(RGDPN) = -3.480 + \underset{(8.8)}{1.382} \log(LABN) + \underset{(4.4)}{.2187} \log(RKNO)$$

$$R^2 = .99 \qquad (1)$$

$$DW = 1.5$$

where

RGDPN = real gross domestic product of non-oil sector at factor cost

LABN = labor force in the non-oil sector

RKNO = real capital stock in the non-oil sector

As the above equation shows, elasticity of output with respect to labor in the non-oil sector is found to equal 1.382, while that for capital is found to be smaller and equal to .2187. In addition, during our sample period, increasing returns to scale were present in the Libyan economy. Equation (1) is chosen to be used in the full model.

Real Gross Domestic Product in the Oil Sector

Thus far RGDPN has been determined. This leaves us with real gross domestic product of the oil sector, which is determined as a residual from the following identities:

GDPO = SGDP - GDPN

where

SGDP = DGDP - NITX

NITX = ITX - SUBS

and

$$RGDPO = GDPO/PGDPO$$

$$GDPN = RGDPN \times PGDPN$$

where

GDPO = nominal gross domestic product of the oil sector at factor cost

SGDP = nominal total gross domestic product at factor cost

GDPN = nominal gross domestic product of non-oil sector at factor cost

DGDP = nominal gross domestic product at market prices.

NITX = nominal net indirect taxes

ITX = nominal indirect taxes

SUBS = nominal government subsidies

RGDPO = real gross domestic product of the oil sector at factor cost

PGDPO = oil gross domestic product price index (1970 = 1.0)

PGDPN = non-oil gross domestic product price index (1970 = 1.0).

It should be noted that DGDP and NITX are determined in other parts of the model.

Aggregate Demand Components

Aggregate demand, which includes consumption, investment and foreign trade relations, is disaggregated in accordance with the purpose of this study and is given by the following identity:

$$DGDP = (PCON + GCON) + (OIV + NOIV) + (ROEX \times PGDPO + NEX - IMP) + DST$$

where

DGDP = nominal gross domestic product at market prices

PCON = nominal private consumption

GCON = nominal government consumption

OIV = nominal oil investment

NOIV = nominal non-oil investment

ROEX = real oil exports

PGDPO = oil gross domestic product price index (1970 = 1.0)

NEX = nominal non-oil exports

IMP = nominal imports

DST = nominal changes in stocks.

Investment in the Non-oil Sector

Following our division of the Libyan economy into an oil sector and a non-oil sector, investment is disaggregated into those two sectors. Economic literature provides different theories that are concerned with the determination of investment expenditures. Profit maximization theory, theories that emphasize retained profits, and theories that are based on the acceleration principles are among the well-established theories in economic literature. Nonetheless, an application of such theories to our study is restricted by two factors. First, such theories are postulated for developed countries. Therefore the application of them to a less-developed country could be questionable. This is especially true in a case like Libya, where the country depends heavily on revenues from oil exports as a main source of its income. Second, data unavailability forms a constraint to the extent that one can test the applicability of such theories. For instance, no data are available for profit expectations or sales.

As a first attempt to explain investment in the non-oil sector, the real gross domestic product in the non-oil sector (RGDPN) and real government oil revenues

(GOR/PGDP) were used as the explanatory variables. The hypothesis is that the higher level of real output in the non-oil sector implies a higher level of aggregate demand which will increase the rate at which the economy's capacity is being utilized and eventually, as full capacity is approached, new investment will be needed to meet any increase in demand. In addition, real government oil revenues are added to test the hypothesis that, as those revenues increase, more resources are made available for the economy to finance investment expenditures. The estimates obtained for this function are:

$$\left(\frac{NOIV}{PGDP}\right) = 16.86 + \underset{(7.4)}{.3523}\ RGDPN - \underset{(.69)}{.0638}\left(\frac{GOR}{PGDP}\right) \qquad (2)$$

$R^2 = .95$

$DW = .7$

This estimated equation shows unsatisfactory results. The sign of the estimated coefficient of the (GOR/PGDP) is not consistent with our expectations regarding this variable. While our hypothesis suggests that an increase in government oil revenues should have a positive effect on NOIV/PGDP, the obtained result contradicts this. In addition, DW's low value suggests a high degree of autocorrelation.

Going a step further, (NOIV/PGDP) lagged one year was added to equation (2). The rationale behind this is as follows: in a less-developed country like Libya, where most of investment is directed toward infrastructure projects, social overhead and sectoral development, investment in a specific year is related to what has been accomplished in the previous year. In other words, some investment projects can't be started till others have been completed. Real investment in non-oil sectors is therefore specified to be a function of real gross domestic product in the non-oil sector, real government oil revenues and real investment in the non-oil sector lagged one year. The following estimated relation was obtained:

$$\left(\frac{NOIV}{PGDP}\right) = 17.65 + \underset{(2.9)}{.2444}\ RGDPN + \underset{(1.7)}{.3867}\left(\frac{NOIV}{PGDP}\right)_{-1} - \underset{(.87)}{.0762}\left(\frac{GOR}{PGDP}\right) \qquad (3)$$

$R^2 = .96$

$DW = 1.22$

$h = 12.6$

While this equation is stronger than (2), the sign of the estimated coefficient of (GOR/PGDP) is still opposite to our expectation. In addition, the value of Durbin h (12.6) was found to be greater than the critical value (= 1.96), which indicates the existence of autocorrelation. Since a lagged dependent variable was introduced, the Durbin h statistic will be used to test for autocorrelation. This is because the DW statistic is shown to be biased toward 2 when a lagged dependent variable is introduced.

In another attempt to specify this function, a use of total government revenues instead of government oil revenues in equation (3) was in order. It was thought that the fit of equation (3) might improve. Nonetheless, as shown below, the t ratio for the coefficient in (TGR/PGDP) was still insignificant with a wrong sign.

$$\left(\frac{NOIV}{PGDP}\right) = 16.86 + \underset{(2.7)}{.2500}\ RGDPN + \underset{(1.6)}{.3647}\left(\frac{NOIV}{PGDP}\right)_{-1} - \underset{(.67)}{.0558}\left(\frac{TGR}{PGDP}\right) \qquad (4)$$

$R^2 = .97$

DW = 1.28

h = 52.7

Faced with a problem in specifying the investment function for the non-oil sector, it was thought that use of a revised form of the simple acceleration principle might improve the fit of this function. The simple acceleration principle is modified by making investment in the non-oil sector a function of the changes in real gross domestic product in the non-oil sector, real government oil revenues, and real investment in the non-oil sector lagged one year. This specification gave the following results:

$$\left(\frac{NOIV}{PGDP}\right) = 7.253 + \underset{(3.5)}{.6239} \left[\left(RGDPN - RGDPN_{-1}\right)\right] + \underset{(5.9)}{.8090} \left(\frac{NOIV}{PGDP}\right)_{-1} - \underset{(.67)}{.0558} \left(\frac{GOR}{PGDP}\right) \qquad (5)$$

$R^2 = .97$

$DW = 2.1$

$h = -.15$

A drawback of this equation is indicated by the wrong sign for the coefficient of (GOR/PGDP). Again, real government total revenues were used instead of real government oil revenues in the above equation and the fit did not improve. Since both variables (GOR/PGDP) and (TGR/PGDP) were tried as an explanatory variable and found to be insignificant, they were deleted from this function. The use of a time trend variable as an additional explanatory variable besides changes in real gross domestic product in the non-oil sector and lagged real non-oil investment was tried. The rationale behind using a time trend variable is to capture any technological changes which could affect the volume of investment, especially in a less-developed country like Libya. The resulting regression estimates were found to be:

$$\left(\frac{NOIV}{PGDP}\right) = -\,4.395 + \underset{(2.8)}{.5189}\left[\left(RGDPN - RGDPN_{-1}\right)\right] + \underset{(1.4)}{9.115}\,T + \underset{(3.1)}{.5965}\left(\frac{NOIV}{PGDP}\right)_{-1} \qquad (6)$$

$R^2 = .98$

DW = 2.1

h = -.054

Since all coefficients have the right sign, with a significant t-ratio and an acceptable h statistic was obtained, this equation is considered satisfactory in explaining the behavior of investment in the non-oil sector and will be used in the full model.

Investment in the Oil Sector

Investment in the oil sector forms the second component of aggregate investment in this study. While investment in the oil sector has increased for most of the period during 1962-69, it decreased considerably in 1970 and 1971 and fluctuated largely since then. The increase in oil investment during 1962-69 is attributed to the country's policy during that period which aimed at attracting oil companies to explore for oil. During such a period, oil revenues were needed badly and domestic resources were very limited to meet investments of large magnitude that are usually required by oil exploration activities. Therefore, the country's oil legislation at that time was directed in line with this policy. This policy had changed drastically with the September 1, 1969, revolution. The new government adopted a new policy with respect to the country's oil sector which aimed at obtaining full control of this sector. These events have caused a large fluctuation in investment in the oil sector and therefore a problem was faced on specifying this function.

As a first step in deriving investment in the oil sector, a modified version of the acceleration principle was tried. Therefore, real investment in the oil sector is specified to depend on changes in real gross domestic product in the oil sector, oil price index, and a dummy to capture the effects of change in government policy with respect to this sector (it assumes a value of one for 1970 and after, and a value of zero otherwise). This specification gives rise to the following regression estimate:

$$\left(\frac{OIV}{PKM}\right) = 68.92 + \underset{(2.6)}{.2458}\left(RGDPO - RGDPO_{-1}\right) - \underset{(2.0)}{5.954}\, PGDPO + \underset{(.01)}{.2506}\, D \qquad (7)$$

$R^2 = .71$

$DW = .90$

where

OIV = investment in the oil sector

PKM = capital goods import price index

$(RGDPO - RGDPO_{-1})$ = change in real gross domestic product of the oil sector

PGDPO = oil gross domestic product price index (1970 = 1.0)

D = dummy variable

This equation indicates that only 71% of the variations on (OIV/PKM) is explained by our explanatory variables. This suggests that other explanatory variables are not included in our specification. In addition, a wrong sign for the coefficients of D and PGDPO is obtained. Therefore, many other specifications for investment in the oil sector function were tried, giving rise to the following results:

$$\left(\frac{OIV}{PKM}\right) = \underset{}{17.04} + \underset{(2.9)}{.1655}\left(RGDPO - RGDPO_{-1}\right) + \underset{(1.1)}{2.791}\,PGDPO - \underset{(3.2)}{57.93}\,D + \underset{(4.9)}{.1933}\,\frac{KO}{PKM} \qquad (8)$$

$R^2 = .90$

DW = 1.6

$$\left(\frac{OIV}{PKM}\right) = 64.28 + \underset{(3.3)}{.1554}\,\frac{GOR}{PGDP} - \underset{(3.2)}{11.57}\,PGDPO - \underset{(4.2)}{75.83}\,D \qquad (9)$$

$R^2 = .76$

DW = 1.7

$$\left(\frac{OIV}{PKM}\right) = 53.53 + \underset{(3.2)}{.1612}\,\frac{GOR}{PGDP} - \underset{(3.1)}{11.76}\,PGDPO - \underset{(3.5)}{71.88}\,D + \underset{(.5)}{.0366}\,DNW \qquad (10)$$

$R^2 = .76$

DW = 1.6

$$\left(\frac{OIV}{PKM}\right) = \underset{}{27.17} + \underset{(1.1)}{.0565}\ \frac{GOR}{PGDP} - \underset{(.2)}{.7970}\ PGDPO - \underset{(5.8)}{95.52}\ D + \underset{(2.7)}{.1779}\ \frac{KO}{PKM} \qquad (11)$$

$R^2 = .85$

$DW = 2.2$

$$\left(\frac{OIV}{PKM}\right) = 30.58 + \underset{(2.1)}{.0607}\left(\frac{GOR}{PGDP}\right) + \underset{(4.8)}{.5952}\left(\frac{OIV}{PKM}\right)_{-1} - \underset{(4.1)}{61.42}\ D \qquad (12)$$

$R^2 = .85$

$DW = 2.4$

$h = -.81$

where KO equals accumulated investment in the oil sector and DNW equals the number of completed wells.

Equation (12) was found to be the best in terms of the different statistical considerations, R^2, t-ratio, and Durbin h. It is therefore chosen to describe investment in the oil sector in the full model.

Private Consumption

While the share of aggregate private consumption in gross national product in Libya has declined from 84% in 1962 to 32% in 1978, its share is still one of the largest components in GNP. In addition, such a decline is attributed to the huge increase in GNP that is associated with the increase in oil revenues. Different theories have been advanced in the economic literature to explain the determinants of aggregate private consumption. Some of the most well-established consumption function theories include Keynes' absolute income hypothesis, Duesenberry's relative income hypothesis, Modigliani's life cycle hypothesis and Friedman's permanent income hypothesis.

Our analysis of the aggregate private consumption function starts with the simple Keynesian consumption hypothesis. Accordingly, aggregate private consumption is assumed to depend on the absolute level of disposable income. Nevertheless, and in order to capture the effects of change in the consumer price index and to account for population growth, real per capita private consumption is estimated as a function of real per capita personal disposable income. The following regression estimates are obtained:

$$\left[\left(\frac{PCON}{CPI}\right)/POP\right] = .0230 + \underset{(14.9)}{.6229}\left[\left(\frac{PDY}{CPI}\right)/POP\right] \quad (13)$$

$R^2 = .94$

DW = 1.4

where

PCON = aggregate private consumption

CPI = consumer price index

POP = population

PDY = personal disposable income, which is defined by the following identities:

PDY = DGNP - (DTX + ITX + GOR + NNR) + (SUBS + GTRH)

and

DGNP = DGDP - NFI

where

DGNP = nominal gross national product at market prices

DTX = nominal direct taxes

ITX = nominal indirect taxes

GOR = nominal government oil revenues

NNR = nominal government non-oil, non-tax revenues

SUBS = nominal government subsidies

GTRH = nominal government transfer to households

DGDP = nominal gross domestic product at market prices

NFI = nominal net factor payments to abroad

In order to incorporate Brown's[4] hypothesis, which postulates that present consumption is dependent not only on the level of present income but also on the past level of consumption that consumers get accustomed to, real per capita private consumption lagged one year was added to equation (13). The following regression estimates were obtained:

$$\left[\left(\frac{PCON}{CPI}\right)/POP\right] = .0135 + \underset{(5.5)}{.3583}\left[\left(\frac{PDY}{CPI}\right)/POP\right] + \underset{(4.5)}{.4460}\left[\left(\frac{PCON}{CPI}\right)/POP\right]_{-1} \qquad (14)$$

$R^2 = .98$

$DW = 1.7$

$h = .58$

As equation (14) shows, all the statistical criteria are acceptable, a higher R^2, a significant t-ratio and a significant Durbin h test which indicates no autocorrelation. The short run marginal propensity to consume is equal to (.36). The low level of MPC in Libya, as is the case in most rich oil exporting countries, is probably caused by the high level of per capita income.

Government Consumption

Since variation in government consumption can't be explained by the same determinants as private consumption, total consumption was disaggregated into two components. Government consumption refers to government expenditures on goods and services for its operational and administrative purposes. Our first attempt to explain the behavior of government consumption involves using government total revenues as the only explanatory variable. The rationale behind this relies on the fact that as government total revenues increase, more resources will be available to finance any increase in government consumption. Hence government per capita consumption was regressed against per capita government total revenues. The following equation was obtained:

$$\left[\frac{GCON}{POP}\right] = -.0128 + \underset{(17.0)}{.4881}\left(\frac{TGR}{POP}\right) \qquad (15)$$

$R^2 = .95$

$DW = 2.2$

where

GCON = aggregate government consumption

TGR = total government revenues

The obtained results of (OLSQ) estimation are acceptable given the values of the different statistical criteria. Nonetheless, as an alternative approach of estimating this function and to account for the fact that government consumption could be influenced to a great extent by the level of previous government consumption, per capita government consumption lagged one year was added to equation (15) and the following regression estimate is obtained:[5]

$$\left(\frac{GCON}{POP}\right) = -.0002 + \underset{(2.8)}{.1927}\left(\frac{TGR}{POP}\right) + \underset{(4.4)}{.7052}\left(\frac{GCON}{POP}\right)_{-1} \qquad (16)$$

$R^2 = .98$

$DW = 1.5$

$h = 1.35$

Again, since a lagged dependent variable was introduced on the right hand side of equation (16), the DW test is no longer applicable. The value of Durbin h (= 1.35) was found to be less than the critical value (= 1.96), which indicates no auto-correlation problem. In addition, a high R^2 and a significant t-ratio was found to be acceptable. Therefore, this equation will be used in our model to forecast changes in government consumption.

Total Imports

The huge increase in Libya's revenues, which resulted from an increase in oil exports during the sixties and an increase in the price of oil during the seventies while the quantity of oil exports declined, has provided Libya with the needed resources to finance its import needs. Libya, as most oil rich countries, relies heavily on imports to satisfy the excess of demand for consumption goods and services over domestic production and also to satisfy the demand for capital and intermediate goods which are either not available domestically or for which domestic production comes short of meeting its aggregate demand. Imports grew substantially during the sample period from 119.9 million Dinars (MD) in 1962 to 2199.5 MD in 1978 (in current prices).

In order to estimate the demand for imports of Libya, a variable representing domestic absorptive capacity was constructed. This is defined as "the utilization of the flow of goods and services in the economy for the purpose of domestic consumption and investment."[6] Accordingly, domestic absorptive capacity (GDA) is defined as

$$GDA = PCON + GCON + OIV + NOIV$$

In addition to domestic absorptive capacity, another variable was used to capture the effect of change in the relative price of imports. The sign on the coefficient of GDA/CPI is expected to be positive, showing that an expansion on the country's domestic absorptive capacity will result in an increase in the volume of imports. Our expectation with regard to the sign on the coefficient on PIM/CPI is negative (PIM = import price index 1970 = 1.0). As relative price of imports increases, everything else being equal, one would expect the volume of import to decline. The following regression estimate was obtained.

$$\left(\frac{IMP}{PIM}\right) = 369.2 + \underset{(25.7)}{.3519} \left(\frac{GDA}{CPI}\right) - \underset{(3.1)}{277.5} \left(\frac{PIM}{CPI}\right) \qquad (17)$$

$R^2 = .98$

$DW = 1.6$

Since both coefficients have the right sign and all statistical tests are significant, this equation will be used in the full model to describe the behavior of imports.

Government Sector

The dependence of the Libyan economy on oil revenues can't be overemphasized. Since the discovery of oil, the country's economy has been heavily dependent on revenues derived from oil exports as its main source of income. Libyan crude oil production and exports are shown in Table 2.1, while Table 2.2 shows government oil revenues and its total revenues. As Table 2.2 shows, the share of government oil revenues to government total revenues has jumped from 27% in 1962 to 84% in 1970. This is attributed basically to an increase in the volume of oil exports. Nonetheless, this ratio has declined for the most part during 1970-78, reflecting the change in government policy following the September revolution in 1969 which adopted a new policy aiming at conserving Libya's oil resources by reducing oil production while aiming a. increasing oil prices.

Table 2.1

Crude Oil Production and Exports in Libya (1962-81)

	Production (Thousand Barrels)				Exports
Year	Daily average	Total	Cumulative	Annual % change in daily production	(Thousand barrels per day)
1962	182.3	66,543	73,185	901.6	179.5
1963	441.8	161,272	234,457	142.3	459.5
1964	862.4	315,621	550,078	95.2	856.4
1965	1,218.8	444,862	994,940	41.3	1212.7
1966	1,501.1	547,902	1,542,842	23.2	1499.6
1967	1,740.5	635,285	2,178,127	15.9	1717.3
1968	2,602.1	952,357	3,130,484	49.5	2582.4
1969	3,109.1	1,134,839	4,265,323	19.5	3069.5
1970	3,318.0	1,211,086	5,476,409	6.7	3312.1
1971	2,760.8	1,007,692	6,484,101	-16.8	2747.4
1972	2,239.4	819,619	7,303,720	-18.9	2214.2
1973	2,174.9	793,854	8,097,574	-2.9	2174.5
1974	1,521.3	555,291	8,652,865	-30.1	1490.3
1975	1,479.8	540.129	9,192,994	-2.7	1431.1
1976	1,932.6	707,336	9,900,330	30.6	1846.6
1977	2,063.4	753,129	10,653,459	6.8	1943.0
1978	1,982.5	723,613	11,377,072	-3.9	1854.8
1979	2,091.7	763,471	12,140,543	5.5	1966.0
1980	1,830.0	669,780	12,810.323	-12.5	1691.4
1981	1,109.2*	404,858	13,215,181	-39.4	959.2*

*Estimated

Source: Organization of Petroleum Exporting Countries (OPEC), Annual Statistical Bulletin, 1981; Table 16, p. 14 and Table 51, p. 89.

Table 2.2

Government Total Revenues and Share of Oil Revenues
(Millions of Libyan Dinars)

Year	Total Revenue	Oil Revenue	% of Total
1962	52.10	14.00	27
1963	79.00	38.50	49
1964	117.00	75.30	64
1965	171.90	125.40	73
1966	231.10	178.00	77
1967	284.20	224.10	79
1968	430.00	352.70	82
1969	507.70	415.10	82
1970	577.80	484.00	84
1971	828.50	652.30	79
1972	831.30	624.60	75
1973	852.70	604.10	71
1974	1861.30	1474.10	79
1975	1784.70	1324.00	74
1976	2689.50	2077.40	77
1977	3375.80	2625.80	78
1978	3003.10	2183.50	72

Sources: Libyan Arab Republic, Ministry of Planning, National Accounts, 1962-1971, October 1972.

Socialist People's Libyan Arab Jamahiriya, Secretariat of Planning, National Accounts, 1971-1977, December 1979.

Socialist People's Libyan Arab Jamahiriya, Statistical Abstract, 1979.

As a first approximation for estimating government oil revenues, real gross domestic product in the oil sector, oil price index and a dummy variable to capture the change in government oil policy following the 1969 revolution were used as explanatory variables. As real gross domestic product in the oil sector increases, assuming everything else being equal, government oil revenues will increase. The sign of the coefficient on the oil price index is also positive, since it is expected that, as the price of oil increases, everything else being equal, government oil revenues will increase. As mentioned earlier, government policy with regard to the oil companies operating in Libya has changed following the September revolution in 1969. This suggests using a dummy variable, which takes the value of 1 for the years 1970 and after and 0 otherwise. The above specifications gave rise to the following equation:

$$GOR = -397.9 + \underset{(2.2)}{.8102}\ RGDPO + \underset{(9.2)}{292.5}\ PGDPO - \underset{(.08)}{13.22}\ D \qquad (18)$$

$R^2 = .94$

$DW = 1.0$

In addition to obtaining the wrong sign with respect to the coefficient on the dummy variable, the DW statistic implies the existence of an autocorrelation problem. As an alternative to equation (18) and in an attempt to improve the results, a lagged dependent variable of GOR was added to the explanatory variables. The estimated results are found as follows:

$$\begin{aligned} GOR = -301.2 &+ \underset{(2.0)}{.6257}\ RGDPO + \underset{(5.4)}{220.0}\ PGDPO \\ &- \underset{(.28)}{41.19}\ D + \underset{(2.4)}{.3123}\ GOR1 \end{aligned} \qquad (19)$$

$R^2 = .96$

$DW = 2.0$

$h = .009$

This equation is stronger than the previous one. Nonetheless, the wrong sign for the coefficient on the dummy variable did not change. The dummy variable was deleted and equation (19) was run without it, which gave the following results:

$$GOR = -287.0 + \underset{(2.2)}{.5813}\ RGDPO + \underset{(6.2)}{215.0}\ PGDPO + \underset{(2.4)}{.3095}\ GOR1 \quad (20)$$

$R^2 = .96$

$DW = 2.0$

$h = .009$

This equation is satisfactory as the right signs for the coefficients were obtained and the t-ratio on these coefficients suggests that they are significant. In addition, the h value suggests no autocorrelation problem. Nevertheless, a problem was encountered when this equation was used in the full model. Here, the dynamic simulation process of the model eliminated our choice to the following equation:

$$LOG(GOR) = -\ 1.650 + \underset{(10.3)}{.9955}\ LOG(GDPO) + \underset{(2.2)}{.1771}\ LOG(GDPO)_{-1} \quad (21)$$

$R^2 = .99$

$DW = 1.9$

Direct Taxes

In order to explain variation in direct taxes, they are related to the income on which they are imposed. Therefore, direct taxes are postulated to depend on the absolute level of income. The regression estimates of direct taxes were found to be:

$$DTX = -6.220 + \underset{(12.0)}{.0296}\ DGNP \qquad (22)$$

$$R^2 = .91$$

$$DW = 1.0$$

As is the case in most oil-rich exporting countries, the marginal propensity to tax out of income is very low. This is not surprising, though, since the Libyan government relies primarily on its oil revenues as its main source of income.

Indirect Taxes

During our sample period 1962-78, 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 are 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, they were postulated as a function of total imports. As the volume of imports increases or as new forms of tariffs and commodity duties are imposed or as the old ones increase, indirect taxes will increase. Accordingly, the following regression estimate was obtained.

$$ITX = -2.041 + \underset{(38.0)}{.1360}\ IMP \qquad (23)$$

$$R^2 = .99$$

$$DW = 1.3$$

This equation will be used in our full simulation model.

In addition to the above three equations describing government oil revenues, direct taxes and indirect taxes, government total revenues are described by the following identity:

$$TGR = (DTX + ITX) + (NNR + OTHR) + GOR$$

where

OTHR = nominal government revenues from other sources

Money Supply and Prices

Libya's money supply has increased substantially during our sample period, to reach 1688 million dinars (MD) in 1978, compared with 29 MD in 1962. The rise in Libya's oil revenues and its subsequent effect on the economy's money supply growth can't be underestimated. The factors affecting the growth in domestic liquidity usually involve studying the consolidated accounts of the banking system. Accordingly, changes in net domestic and foreign assets are taken to be the primary determinant of changes in domestic liquidity. The applicability of such an approach to an oil-based economy like Libya has been questioned. Jakublack and Dajani (1976), in their study of "Oil Income and Financial Policies in Iran and Saudi Arabia," showed the inapplicability of employing the consolidated accounts of the banking system in determining changes in domestic liquidity in those two countries.[7] They argued that employing this approach does not provide a full explanation of how money supply expands or contracts in these two countries. Robert Looney, following Jakublack and Dajani's approach in studying the determinant of domestic liquidity of Iran, states the following shortcoming of the consolidated accounts of the banking system approach:

> The consolidated accounts of the banking system, while yielding insights into the country's monetary mechanism, are somewhat limited in providing a full explanation of the precise manner in which the country's money supply expands and contracts. The main shortcoming of these accounts is that the main factor underlying the rise in net foreign assets--the receipts of oil revenues by the government--has no immediate monetary effect (as is true for the other oil-exporting countries). These revenues simply are counterbalanced in the consolidated accounts by an equivalent rise in government deposits.[8]

Under such circumstances, an alternative approach suggested by Jakublack and Dajani to deal with the peculiarity of oil exporting countries is employed. This alternative approach identifies the growth of government net domestic expenditures as the main determinant affecting the rate of monetary expansion. Accordingly, the increase in government expenditures, whether for consumption or investment purposes, which comes about an increase in government oil revenues, results in an increase in domestic liquidity. This approach has been adopted by El-Fakhery in a previous study of the Libyan economy[9] and is employed in this study. Accordingly, high-powered money is assumed to be a function of government net domestic expenditure. This is being defined as the difference between government total expenditures and its non-oil revenues. In addition, the multiplier effect of an increase in the high-powered money on the growth of money supply was shown by El-Fakhery to be constant in the case of Libya. This still holds true in our sample data and, therefore, money supply was taken to be a function of high-powered money.

Based on the above discussion, our analysis of the monetary sector in Libya will involve estimating two equations. In the first equation, high-powered money will be assumed to depend solely on government net domestic expenditures. In the second equation, money supply is regressed against high-powered money. The regression estimates obtained for those two equations are as follows:

$$HP = 18.84 + \underset{(16.6)}{.3820}\ NGEJ \qquad (24)$$

$R^2 = .95$

$DW = .8$

$$MS = .3818 + \underset{(32.7)}{1.662}\ HP \qquad (25)$$

$R^2 = .99$

$DW = 1.4$

Thus far our analysis is left with no explanation for prices. Nevertheless, four price indexes appeared in our estimation of the different equations. Those include consumer price index (CPI), non-oil gross domestic product price index (PGDPN), oil gross domestic product price index (PGDPO), and gross domestic product price index (PGDP). The latter is being determined by an identity as a weighted average as follows:

$$PGDP = \frac{(RGDPO \times PGDPO + RGDPN \times PGDPN)}{RGDPO + RGDPN}$$

The price index of oil (PGDPO) is treated as exogenous. The forces by which this price index is determined are, to a great extent, external forces that affect world aggregate demand and supply of oil. This leaves us with two price indexes. Consumer price index (CPI) is assumed to depend on money supply and CPI lagged one period. The estimated equation is the following:

$$CPI = .3098 + \underset{(2.2)}{.0003}\ MS + \underset{(1.8)}{.5994}\ CPI_{-1} \quad (26)$$

$R^2 = .95$

$DW = 1.7$

$h = .58$

In estimating non-oil gross domestic product price index, different specifications were experimented with. The following was found to provide the best results and it is therefore used in the full model.

$$PGDPN = .6558 + \underset{(17.7)}{.4539}\ WN \quad (27)$$

$R^2 = .96$

$DW = .84$

The Labor Market

The labor market is considered a crucial sector of any macroeconomic model. It is through the mechanism of supply and demand in this market that wages and employment levels are determined, and those two variables have an important effect in any economy through their linkage to other macroeconomic variables. This is especially true in a country like Libya, where labor shortage is considered one of the main obstacles facing the country's development. The country has to rely heavily on foreign labor to fill the gap between aggregate demand of labor and domestic labor supply.

Economic theory suggests that forces affecting the demand and supply of labor are to be considered the sole variables in determining employment and wages. Demand for labor is usually taken to be a function of the real wage rate and real output level. As the real wage rate increases, everything else being constant, less labor will be demanded. In contrast to this, employment is supposed to increase with the increase in output, since more labor will be needed. In estimating employment in the non-oil sector, the above two variables were used as explanatory variables and the following estimate was obtained:

$$LABN = 241.2 - \underset{(.3)}{11.27} \left(\frac{WN}{PGDP}\right) + \underset{(20.0)}{.3263}\ RDGPN \qquad (28)$$

$R^2 = .97$

$DW = .9$

where

WN = nominal non-oil wage rate, thousands of dinars per person

As the equation indicates, right signs for both coefficients were obtained. Nevertheless, the t-ratio for the coefficient on WN/PGDP was found to be insignificant. In addition, another shortcoming of this equation is the low value obtained for the DW statistic suggesting autocorrelation. In an attempt to improve the fit of equation (28), a time trend variable was added as an explanatory variable and the following estimate was obtained:

$$LABN = 267.8 - \underset{(5.4)}{171.3} \left(\frac{WN}{PGDP}\right) + \underset{(9.4)}{.1937}\ RDGPN + \underset{(6.9)}{19.18}\ T \qquad (29)$$

$R^2 = .99$

$DW = 1.5$

The fit of this equation is stronger than that of (28). A higher DW and R^2 and a significant t-ratio on all the coefficients is reported. Therefore, it was decided to use equation (29) in the full model.

In estimating the demand for labor in the oil sector, different considerations were recognized as opposed to the non-oil sector. The oil sector, being a capital intensive sector, has employed a relatively small percentage of total labor force (1.5% in 1978). Output in this sector was determined to a great extent by the conditions of supply and demand in the international oil market and by the Libyan government policy with regard to this sector. Therefore, output generated in this sector could not be used as an appropriate variable in explaining demand for labor in this sector. Nonetheless, and as is the case in the non-oil sector, the real wage rate in the oil sector is thought to have the same effects on demand for labor in the oil sector. In addition to the real wage rate in the oil sector, two other explanatory variables were used. These include real investment in the oil sector and labor in the oil sector lagged one year. An increase in real investment in the oil sector is expected to increase demand for labor in that sector. Finally, labor in the oil sector lagged one year was used as an additional explanatory variable. This specification is similar to that used by Moustafa in his study of the Libyan economy.[10] When this specification was used, the following regression estimate was obtained:

$$LABO = 5.242 - \underset{(6.3)}{.7689}\left(\frac{WO}{PGDP}\right) + \underset{(5.7)}{.0115}\left(\frac{OIV}{PKM}\right) + \underset{(16.2)}{.6349}\, LABO_{-1} \qquad (30)$$

$R^2 = .98$

$DW = 2.8$

$h = -1.52$

Since all the statistical considerations are satisfied, this equation will be used in the full model.

As in the case of demand, aggregate supply of labor is divided into two components. Those are supply of domestic labor force and supply of foreign labor force. This division of aggregate supply of labor has been used in a previous study of the Libyan economy and is adopted in this study.[11] Accordingly, domestic labor supply is taken as a function of population. The rationale behind this is given by the fact that since Libya suffers from a shortage of labor force, domestic labor force is affected to a great extent by demographic and social factors rather than by real wage, which has little effects on domestic labor force. The second component of aggregate supply of labor, foreign labor, is taken to be determined by the difference between total aggregate demand for labor and domestic labor force. This implies that adjustment to an increase in aggregate demand in the labor market is met by employing more foreign workers. As aggregate demand for labor exceeds labor supply, real wages will increase till labor supply equals labor demand, which comes about by employing more foreign labor.

The following estimate was obtained for domestic labor supply, which is taken as a function of population.

$$LABC = 3.866 + \underset{(49.4)}{.1866}\ POP \qquad (31)$$

$R^2 = .99$

$DW = 1.5$

The above treatment of foreign labor force has an impact on the determination of the wage rate on the non-oil sector. As aggregate demand for labor increases, real wages will increase and this will result in employing more foreign labor. Therefore, a positive relationship between the wage rate in the non-oil sector and foreign labor is expected. In addition, two other explanatory variables were used to determine the wage rate in the non-oil sector. Those are labor productivity in the non-oil sector and consumer price index lagged one year. This gave the following results:

$$WN = -.9333 + \underset{(3.2)}{.0017}\ LABF + \underset{(4.8)}{.6203}\left(\frac{RGDPN}{LABN}\right) + \underset{(2.5)}{.7768}\ CPI_{-1} \qquad (32)$$

$R^2 = .99$

$DW = 1.1$

where

LABF = foreign labor force, thousands of persons

CPI_{-1} = consumer price index lagged one year (1970 = 1.0)

The factors determining the wage rate in the oil sector differ from those in the non-oil sector. While economic theory suggests that changes in wage rates depend on the level of unemployment and changes in the price level,[12] the peculiarity of the oil sector in a country with labor shortage eliminates unemployment as a factor determining the wage rate. Therefore, the wage rate in the oil sector is taken to depend on the consumer price index lagged one year. The high level of skills that is usually required in the oil sector suggests that workers in the oil sector will at least try to maintain their share of national income, especially if it has been declining due to rising prices. The high demand for skilled workers in the oil industry suggests a fast adjustment in wage rate to changes in the price level. Therefore, the estimated form of wage rates in the oil sector is found as follows:

$$WO = -.1905 + \underset{(10.4)}{3.602}\ CPI_{-1} \qquad (33)$$

$R^2 = .89$

$DW = 1.8$

In an attempt to test for the possibility that the effect of CPI_{-1} on WO is distributed over time, WO_{-1} was added as an additional explanatory variable in equation (33). Nonetheless, as shown below, equation (34) was found unsatisfactory given the low t-ratio on WO_{-1}, and therefore equation (33) was chosen to describe the wage rate in the oil sector.

$$WO = -.1245 + \underset{(2.8)}{2.938}\ CPI1 + \underset{(.7)}{.1848}\ WO1 \qquad (34)$$

$R^2 = .88$

$DW = 2.0$

$h = .33$

CHAPTER II

NOTES

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[5]The private and government consumption functions specifications are similar to those estimated by S. Moustafa, An Econometric Model of the Libyan Economy, 1962-75. Unpublished Ph.D. dissertation. Southern Methodist University, 1979.

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[9] El-Fakhery, pp. 124-127.

[10] Moustafa, op. cit., p. 32.

[11] Moustafa, op. cit., p. 56.

[12] M. K. Evans, Macroeconomic Activity: Theory, Forecasting, and Control (New York: Harper and Row, 1969), p. 267.

CHAPTER III

COMPLETE MODEL PRESENTATION AND VALIDATION

In the previous chapter estimates of the several stochastic equations appearing in the different components of the model were presented. As discussed earlier, alternative specifications which are justified theoretically were examined and estimated. The final specifications which appear in the complete model are not the ones that only meet the traditional statistical tests, but also the ones that prove to be theoretically sound. In this chapter two goals are to be achieved. First, the chosen set of the estimated stochastic equations are combined with the system identities to make up the complete model. The second goal consists of establishing the predictive ability of the model before using it in the next chapter, where our concern will be studying the future consequences associated with different assumptions regarding the Libyan oil price level.

The Complete Model

The model under consideration contains 36 relations, of which 19 are behavioral equations and 17 identities. There are 51 variables, of which 36 are endogenous and 15 exogenous. The ordinary least squares and the two-stage least squares method estimators are presented below. As usual the student t values, which show the statistical significance of the individual coefficients, are shown in parentheses under each coefficient. R^2, measuring the total variation in the dependent variable that is explained by the independent variables, is also reported. Finally, the Durbin-Watson test is used for checking for autocorrelation. Nonetheless, when a lagged dependent variable is included among the explanatory variables, the Durbin-h test is used. Specifically, when the equation includes a lagged dependent variable, the procedure is to correct for the autocorrelation problem by the inclusion of a relevant variable in order to avoid the bias that is caused by the coexistence of the autocorrelation problem and the lagged dependent variable. Since the autocorrelation problem in the equations with no lagged dependent variables produces

THE FINAL SPECIFICATION OF THE LIBYAN MACROECONOMIC MODEL

1. $DGDP = (PCON+GCON) + (OIV+NOIV) + (ROEX \cdot PGDPO+NEX-IMP) + DST$
2. $\left[\left(\frac{PCON}{CPI}\right)/POP\right] = a_0 + a_1 \left[\left(\frac{PDY}{CPI}\right)/POP\right] + a_2 \left[\left(\frac{PCON}{CPI}\right)/POP\right]_{-1}$
3. $\left(\frac{GCON}{POP}\right) = b_0 + b_1 \left(\frac{TGR}{POP}\right) + b_2 \left(\frac{GCON}{POP}\right)_{-1}$
4. $PDY = DGNP - (DTX + ITX + GOR + NNR) + (SUBS + GTRH)$
5. $DGNP = DGDP - NFI$
6. $DTX = C_0 + C_1\ DGNP$
7. $ITX = d_0 + d_1\ IMP$
8. $LOG(GOR) = e_0 + e_1\ LOG(GDPO) + e_2\ LOG(GDPO)_{-1}$
9. $NFI = f_0 + f_1\ LABF + f_2\ (RSGDP/LABT)$
10. $TGR = (DTX + ITX) + (NNR + OTHR) + GOR$
11. $(OIV/PKM) = g_0 + g_1\ (GOR/PGDP) + g_2\ (OIV/PKM)_{-1} - g_3\ D$
12. $(NOIV/PGDP) = h_0 + h_1\ (RGDPN - RGDPN_{-1}) + h_2 T + h_3\ (NOIV/PGDP)_{-1}$
13. $(IMP/PIM) = i_0 + i_1\ (GDA/CPI) - i_2 (PIM/CPI)$
14. $GDA = PCON + GCON + OIV + NOIV$
15. $SGDP = DGDP - NITX$
16. $RSGDP = SGDP/PGDP$
17. $NITX = ITX - SUBS$
18. $GDPO = SGDP - GDPN$
19. $RGDPO = GDPO/PGDPO$
20. $GDPN = RGDPN \times PGDPN$
21. $LOG(RGDPN) = j_0 + j_1\ LOG(LABN) + j_2\ LOG(RKNO)$
22. $RKNO = RKNO_{-1} + (NOIV/PGDP) - .1(RKNO_{-1})$
23. $LABN = k_0 - k_1\ (WN/PGDP) + k_2\ RGDPN + k_3 T$
24. $LABO = L_0 - L_1\ (WO/PGDP) + L_2\ (OIV/PKM) + L_3\ LABO_{-1}$
25. $LABT = LABO + LABN$
26. $LABF = LABT - LABC$
27. $LABC = m_0 + m_1\ POP$
28. $WN = n_0 + n_1\ LABF + n_2 (RGDPN/LABN) + n_3\ CPI_{-1}$
29. $WO = p_0 + p_1\ CPI_{-1}$
30. $PGDPN = q_0 + q_1\ WN$
31. $PGDP = (RGDPO \times PGDPO + RGDPN \times PGDPN)/(RGDPO + RGDPN)$
32. $CPI = r_0 + r_1\ MS + r_2\ CPI_{-1}$
33. $MS = s_0 + s_1\ HP$
34. $HP = t_0 + t_1\ NGEJ$
35. $NGEJ = TGEX - (NNR + OTHR) - (ITX + DTX)$
36. $TGEX = GCON + GIV + SUBS + GTRH + OGP$

List of Endogenous Variables:

1. DGDP = nominal gross domestic product at market prices, millions or dinars.
2. PCON = nominal private consumption, millions of dinars.
3. GCON = nominal government consumption, millions of dinars.
4. OIV = nominal oil investment, millions of dinars.
5. NOIV = nominal non-oil investment, millions of dinars.
6. IMP = nominal imports, millions of dinars.
7. CPI = consumer price index (1970 = 1.0).
8. PDY = nominal personal disposable income, millions of dinars.
9. TGR = nominal total government revenues, millions of dinars.
10. DGNP = nominal gross national product at market prices, millions of dinars.
11. DTX = nominal direct taxes, millions of dinars.
12. ITX = nominal indirect taxes, millions of dinars.
13. GOR = nominal government oil revenues, millions of dinars.

List of Endogenous Variables, continued

14. NFI = nominal net factor income to abroad, millions of dinars.
15. GDPO = nominal gross domestic product of oil sector at factor cost, millions of dinars.
16. GDPN = nominal gross domestic product of non-oil sector at factor cost, millions of dinars.
17. SGDP = nominal total gross domestic product at factor cost, millions of dinars.
18. LABF = foreign labor force, thousands of persons.
19. LABT = total labor force, thousands of persons.
20. PGDP = gross domestic product price index (1970 = 1.0).
21. PGDPN = non-oil gross domestic product price index (1970 = 1.0).
22. RGDPO = real gross domestic product of oil, millions of dinars.
23. RGDPN = real gross domestic product of non-oil, millions of dinars.
24. RSGDP = real gross domestic product at factor cost, millions of dinars.

List of Endogenous Variables, continued

25. NITX = nominal net indirect taxes, millions of dinars.
26. LABN = labor force in non-oil sector, thousands of persons.
27. WN = nominal non-oil wage rate, thousands of dinars per person.
28. WO = nominal oil wage rate, thousands of dinars per person.
29. LABO = labor force in oil sector, thousands of persons.
30. LABC = local labor force, thousands of persons.
31. MS = nominal money supply, millions of dinars.
32. HP = nominal high powered money, millions of dinars.
33. NGEJ = nominal net government domestic expenditures, millions of dinars.
34. TGEX = nominal total government expenditure, millions of dinars.
35. GDA = nominal domestic absorptive capacity, millions of dinars.
36. RKNO = real capital stock in the non-oil sector.

List of Exogenous Variables

1. PGDPO = oil gross domestic product price index (1970 = 1.0).
2. ROEX = real oil exports, millions of dinars.
3. NEX = nominal non-oil exports, millions of dinars.
4. DST = nominal change in stocks, millions of dinars.
5. POP = population, thousands of persons.
6. SUBS = nominal government subsidies, millions of dinars.
7. GTRH = nominal government transfer to households, millions of dinars.
8. NNR = nominal government non-oil, non-taxes revenues, millions of dinars.
9. OTHR = nominal government revenues from other sources, millions of dinars.
10. PKM = capital goods import price index (1970 = 1.0).
11. D = dummy for the change of government (D = 0 for 1962 to 1969, D = 1.0 otherwise).
12. PIM = import price index (1970 = 1.0).

List of Exogenous Variables, continued

13. GIV = nominal government investment, millions of dinars.
14. T = time trend.
15. OGP = other government payments (nominal), millions of dinars.

THE OLS AND TSLS ESTIMATES OF THE FINAL FORM OF STOCHASTIC EQUATIONS OF THE MODEL:

Per Capita Real Private Consumption

(OLS)

$$\left[\left(\frac{PCON}{CPI}\right)/POP\right] = .0135 + \underset{(5.5)}{.3583}\left[\left(\frac{PDY}{CPI}\right)/POP\right] + \underset{(4.5)}{.4460}\left[\left(\frac{PCON}{CPI}\right)/POP\right]_{-1}$$

$$R^2 = .98 \quad DW = 1.7 \quad h = .58$$

(TSLS)

$$\left[\left(\frac{PCON}{CPI}\right)/POP\right] = .0134 + \underset{(5.5)}{.3608}\left[\left(\frac{PDY}{CPI}\right)/POP\right] + \underset{(4.5)}{.4425}\left[\left(\frac{PCON}{CPI}\right)/POP\right]_{-1}$$

$$R^2 = .98 \quad DW = 1.7 \quad h = .56$$

Per Capita Nominal Government Consumption

(OLS)

$$\left[\left(\frac{GCON}{POP}\right)\right] = -.0002 + \underset{(2.8)}{.1927}\left(\frac{TGR}{POP}\right) + \underset{(4.4)}{.7052}\left(\frac{GCON}{POP}\right)_{-1}$$

$$R^2 = .98 \quad DW = 1.5 \quad h = 1.35$$

(TSLS)

$$\left[\left(\frac{GCON}{POP}\right)\right] = -.0003 + \underset{(2.8)}{.1946}\left(\frac{TGR}{POP}\right) + \underset{(4.3)}{.7009}\left(\frac{GCON}{POP}\right)_{-1}$$

$$R^2 = .98 \quad DW = 1.5 \quad h = 1.35$$

Direct Taxes

(OLS)

$$DTX = -6.220 + \underset{(12.0)}{.0296}\, DGNP$$

$$R^2 = .91 \quad DW = 1.0$$

(TSLS)

$$DTX = -5.248 + \underset{(12.7)}{.0294}\, DGNP$$

$$R^2 = .91 \quad DW = .98$$

Indirect Taxes

(OLS)

$$ITX = -2.041 + \underset{(38)}{.1360}\, IMP$$

$$R^2 = .99 \quad DW = 1.3$$

(TSLS)

$$ITX = -1.671 + \underset{(40)}{.1358}\, IMP$$

$$R^2 = .99 \quad DW = 1.3$$

Government Oil Revenues

(OLS)

$$LOG(GOR) = -1.650 + \underset{(10.3)}{.9955}\, LOG\,(GDPO) + \underset{(2.2)}{.1771}\, LOG\,(GDPO)_{-1}$$

$$R^2 = .99 \quad DW = 1.9$$

(TSLS)

$$LOG(GOR) = -1.697 + \underset{(10.1)}{1.029}\, LOG\,(GDPO) + \underset{(1.8)}{.1500}\, LOG\,(GDPO)_{-1}$$

$$R^2 = .99 \quad DW = 1.8$$

THE OLS AND TSLS ESTIMATES, Continued

Net Factor Payments Abroad

$$\text{(OLS) } NFI = -78.49 + \underset{(12.6)}{1.538}\, LABF + \underset{(3.4)}{74.56} \left(\frac{RSGDP}{LABT}\right)$$

$$R^2 = .94 \quad DW = 1.6$$

$$\text{(TSLS) } NFI = -73.45 + \underset{(12.5)}{1.546}\, LABF + \underset{(3.3)}{72.11} \left(\frac{RSGDP}{LABT}\right)$$

$$R^2 = .94 \quad DW = 1.6$$

Real Investment in the Oil Sector

$$\text{OLS } \left(\frac{OIV}{PKM}\right) = 30.58 + \underset{(2.1)}{.0607} \left(\frac{GOR}{PGDP}\right) + \underset{(4.8)}{.5952} \left(\frac{OIV}{PKM}\right)_{-1} - \underset{(4.1)}{61.42}\, D$$

$$R^2 = .85 \quad DW = 2.4 \quad h = -.81$$

$$\text{TSLS } \left(\frac{OIV}{PKM}\right) = 31.37 + \underset{(2.0)}{.0574} \left(\frac{GOR}{PGDP}\right) + \underset{(4.8)}{.5944} \left(\frac{OIV}{PKM}\right)_{-1} - \underset{(4.1)}{60.14}\, D$$

$$R^2 = .85 \quad DW = 2.3 \quad h = -.76$$

Real Investment in the Non-Oil Sectors

$$\text{(OLS) } \left(\frac{NOIV}{PGDP}\right) = -\ 4.395 + \underset{(2.8)}{.5189} \left(RGDPN - RGDPN_{-1}\right) + \underset{(1.4)}{9.115}\, T + \underset{(3.1)}{.5965} \left(\frac{NOIV}{PGDP}\right)_{-1}$$

$$R^2 = .98 \quad DW = 2.0 \quad h = -.054$$

$$\text{(TSLS) } \left(\frac{NOIV}{PGDP}\right) = -\ 3.923 + \underset{(3.0)}{.5747} \left(RGDPN - RGDPN_{-1}\right) + \underset{(1.2)}{8.209}\, T + \underset{(3.1)}{.6041} \left(\frac{NOIV}{PGDP}\right)_{-1}$$

$$R^2 = .98 \quad DW = 2.0 \quad h = -.071$$

Total Imports

$$\text{(OLS) } \left(\frac{IMP}{PIM}\right) = 369.2 + \underset{(25.7)}{.3519} \left(\frac{GDA}{CPI}\right) - \underset{(3.1)}{277.5} \left(\frac{PIM}{CPI}\right)$$

$$R^2 = .98 \quad DW = 1.6$$

$$\text{(TSLS) } \left(\frac{IMP}{PIM}\right) = 368.4 + \underset{(25.7)}{.3518} \left(\frac{GDA}{CPI}\right) - \underset{(3.1)}{276.8} \left(\frac{PIM}{CPI}\right)$$

$$R^2 = .98 \quad DW = 1.6$$

THE OLS AND TSLS ESTIMATES, Continued

Real Gross Domestic Product of Non-Oil Sector (at Factor Costs)

(OLS) $LOG(RGDPN) = -3.480 + \underset{(8.8)}{1.382} LOG(LABN) + \underset{(4.4)}{.2187} LOG(RKNO)$

$R^2 = .99 \quad DW = 1.5$

(TSLS) $LOG(RGDPN) = -3.488 + \underset{(8.8)}{1.384} LOG(LABN) + \underset{(4.4)}{.2181} LOG(RKNO)$

$R^2 = .99 \quad DW = 1.5$

Employment in Non-Oil Sectors

(OLS) $LABN = 267.8 - \underset{(5.4)}{171.3} \left(\frac{WN}{PGDP}\right) + \underset{(9.4)}{.1937} RGDPN + \underset{(6.9)}{19.18} T$

$R^2 = .99 \quad DW = 1.5$

(TSLS) $LABN = 267.8 - \underset{(5.4)}{170.9} \left(\frac{WN}{PGDP}\right) + \underset{(9.4)}{.1938} RGDPN + \underset{(6.9)}{19.16} T$

$R^2 = .99 \quad DW = 1.5$

Employment in the Oil Sector

(OLS) $LABO = 5.242 - \underset{(6.3)}{.7689} \left(\frac{WO}{PGDP}\right) + \underset{(5.7)}{.0115} \left(\frac{OIV}{PKM}\right) + \underset{(16.2)}{.6349} LABO_{-1}$

$R^2 = .98 \quad DW = 2.8 \quad h = -1.52$

(TSLS) $LABO = 5.346 - \underset{(6.2)}{.7987} \left(\frac{WO}{PGDP}\right) + \underset{(5.6)}{.0118} \left(\frac{OIV}{PKM}\right) + \underset{(15.9)}{.6301} LABO_{-1}$

$R^2 = .98 \quad DW = 2.8 \quad h = -1.58$

Local Labor Force

(OLS) $LABC = 3.866 + \underset{(49.4)}{.1866} POP$

$R^2 = .99 \quad DW = 1.5$

Wages in the Non-Oil Sectors

(OLS) $WN = -.9333 + \underset{(3.2)}{.0017} LABF + \underset{(4.8)}{.6203} \left(\frac{RGDPN}{LABN}\right) + \underset{(2.5)}{.7768} CPI_{-1}$

$R^2 = .99 \quad DW = 1.1$

(TSLS) $WN = -.9288 + \underset{(3.3)}{.0017} LABF + \underset{(4.8)}{.6171} \left(\frac{RGDPN}{LABN}\right) + \underset{(2.5)}{.7745} CPI_{-1}$

$R^2 = .99 \quad DW = 1.1$

Wages in the Oil Sector

(OLS) $WO = -.1905 + \underset{(10.4)}{3.602} CPI_{-1}$

$R^2 = .89 \quad DW = 1.8$

THE OLS AND TSLS ESTIMATES, Continued

Non-Oil Gross Domestic Product Price Deflator

(OLS) PGDPN $= .6558 + .4539\ WN$
(17.7)
$R^2 = .96 \quad DW = .84$

(TSLS) PGDPN $= .6558 + .4539$
(17.7)
$R^2 = .96 \quad DW = .84$

Consumer Price Index

(OLS) $CPI = .3098 + .0003\ MS + .5994\ CPI_{-1}$
$(2.2) \quad (1.8)$
$R^2 = .95 \quad DW = 1.7 \quad h = .58$

(TSLS) $CPI = .3083 + .0003\ MS + .6014\ CPI_{-1}$
$(2.2) \quad (1.8)$
$R^2 = .95 \quad DW = 1.7 \quad h = .58$

Money Supply

(OLS) $MS = .3818 + 1.662\ HP$
(32.7)
$R^2 = .99 \quad DW = 1.4$

(TSLS) $MS = .3561 + 1.662\ HP$
(32.7)
$R^2 = .99 \quad DW = 1.4$

High Powered Money

(OLS) $HP = 18.84 + .3820\ NGEJ$
(16.6)
$R^2 = .95 \quad DW = .8$

(TSLS) $HP = 18.80 + .3820\ NGEJ$
(16.6)
$R^2 = .95 \quad DW = .8$

inefficiency but no biasedness in the estimated coefficients, it is left the way it is if there were no other relevant variables to be included in order to correct for the problem.

Validation of the Model

Up until now our interest was limited to establishing the theoretical and statistical validity of each stochastic equation appearing in the model. In this section, our concern is to establish and evaluate the forecasting performance ability of the model. In order to achieve this goal, two experiments will be carried out. These include a dynamic simulation of the model for the period 1964-1978 and an ex-post forecast for 1979.

In the first experiment the simulated values of the endogenous variables are obtained by solving the complete model simultaneously, using the simulated values rather than the actual values of all lagged endogenous variables. The goal of such dynamic simulation is to observe how closely the simulated values of the endogenous variables track their corresponding actual values. The closer the simulated values to the actual values, the more confidence that the model is a stable description of the Libyan economy. Since any small error could get larger if such an error expanded over the simulation period, the historical simulation will enable us to observe if any systematic error is present in the complete model. If such a problem is present, a respecification of the model structure will be needed to get rid of such a problem.

The results of the historical simulation are reported in Table 3.1 and Figures 1-16. As the table and figures indicate, the actual time paths of most of the endogenous variables have been reproduced rather closely. In addition, different statistical tests were used to measure how closely the simulated values track their actual values. Those include RMSE (root-mean-square error), RMS percent error, mean error, mean percent error, and Theil's inequality coefficient and its decompositions. The results of these tests for all the endogenous variables are reported in Table 3.2 and the following formulas were used to calculate these statistics:[1]

Table 3.1

Simulated and Actual Values of Key Endogenous Variables
1964-1978

	DGNP		SGDP		GDPO		GDPN	
Year	Simulated	Actual	Simulated	Actual	Simulated	Actual	Simulated	Actual
1964	328.1	306.5	391.7	364.6	198.2	195.7	193.5	168.9
1965	422.1	435.7	500.9	492.1	268.8	270.1	232.2	222.0
1966	530.3	559.7	626.3	634.9	349.2	356.1	277.0	278.8
1967	607.6	648.5	709.6	747.8	382.6	402.5	326.9	345.3
1968	887.9	882.4	1039.8	1072.6	651.3	648.6	388.4	424.0
1969	1058.5	1053.2	1232.6	1223.0	787.2	754.7	445.4	468.3
1970	1172.4	1113.3	1358.6	1288.3	843.4	812.6	515.3	475.7
1971	1381.4	1415.9	1570.0	1586.5	918.4	922.7	651.7	663.8
1972	1479.5	1524.1	1681.2	1753.0	908.1	920.6	773.1	832.4
1973	1878.8	1928.0	2102.5	2182.3	1118.8	1131.8	983.7	1050.5
1974	3700.3	3414.2	3997.4	3792.0	2510.2	2390.0	1487.1	1402.0
1975	3409.1	3348.3	3737.0	3674.3	2062.3	1961.1	1674.7	1713.2
1976	4441.6	4389.5	4780.2	4768.1	2734.4	2750.0	2045.8	2018.1
1977	539[illegible].5	5246.3	5748.9	5612.7	3279.3	3275.9	2469.6	2336.8
1978	5201.5	5245.7	5564.3	5496.1	2852.4	2808.7	2711.9	2687.4

Table 3.1 (Continued)

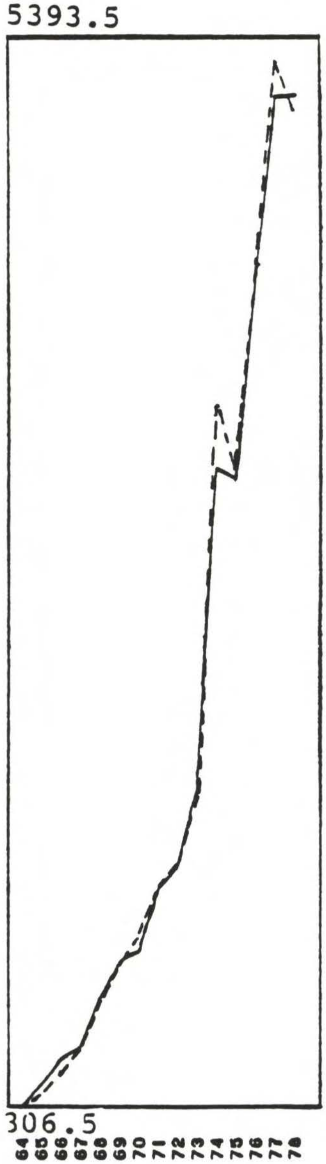
	GCON		PCON		IMP		OIV	
Year	Simulated	Actual	Simulated	Actual	Simulated	Actual	Simulated	Actual
1964	46.5	45.0	166.8	159.0	152.1	163.3	57.4	63.4
1965	65.9	61.3	195.6	188.8	190.1	183.4	77.9	81.5
1966	90.8	82.7	231.6	239.2	233.0	222.9	98.4	83.9
1967	115.7	101.4	266.9	280.0	281.3	252.6	87.2	69.4
1968	166.5	148.4	327.8	319.8	352.0	332.6	103.8	125.7
1969	229.1	198.6	373.9	376.4	423.5	419.2	139.1	154.0
1970	285.6	220.7	417.6	395.5	439.4	403.2	75.1	93.0
1971	356.1	318.4	456.4	468.6	517.9	436.0	44.5	28.5
1972	411.1	359.1	516.3	543.4	587.6	552.4	25.5	29.5
1973	485.5	465.4	636.6	702.8	752.2	826.5	13.6	32.3
1974	763.4	864.8	974.6	927.1	1399.3	1427.9	22.5	22.1
1975	940.3	1044.3	1113.9	1193.5	1453.5	1665.7	29.2	26.1
1976	1191.5	1184.6	1334.3	1336.6	1738.1	1671.4	44.3	24.2
1977	1500.5	1400.3	1552.3	1482.2	2112.5	1948.6	68.8	45.4
1978	1674.4	1691.8	1730.1	1665.2	2049.2	2199.5	81.9	99.1

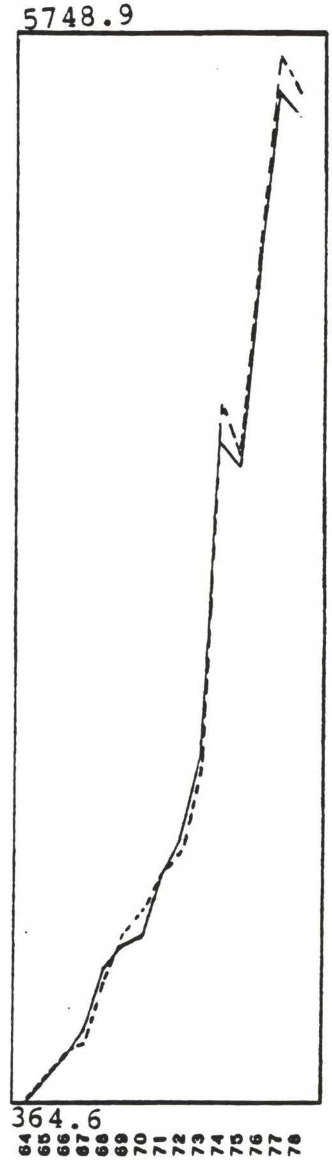
Table 3.1 (Continued)

Year	NOIV Simulated	NOIV Actual	GOR Simulated	GOR Actual	TGR Simulated	TGR Actual	CPI Simulated	CPI Actual
1964	55.8	45.6	84.4	75.3	118.5	117.0	.7618	.7210
1965	69.6	65.2	128.1	125.4	166.8	171.9	.7920	.7620
1966	90.5	107.3	175.5	178.0	221.6	231.1	.8197	.8240
1967	113.6	141.0	200.5	224.1	256.6	284.2	.8473	.8530
1968	146.2	164.0	351.4	352.7	424.8	430.0	.8742	.8900
1969	165.0	161.2	462.6	415.1	555.8	507.7	.8974	.9610
1970	194.5	149.7	510.8	484.0	611.3	577.8	.9223	1.0000
1971	296.9	259.4	563.5	652.3	762.1	828.5	.9462	.9950
1972	354.4	407.1	564.1	624.6	780.5	831.3	.9946	.9930
1973	515.9	603.9	698.1	604.1	956.8	852.7	1.0622	1.0720
1974	1210.9	957.3	1654.3	1474.1	2105.3	1861.3	1.1814	1.1510
1975	1035.5	1028.6	1525.6	1324.0	1973.5	1784.7	1.3076	1.2560
1976	1247.2	1201.6	1980.1	2077.4	2599.7	2689.5	1.4385	1.3240
1977	1450.3	1322.9	2490.4	2625.8	3269.1	3375.8	1.5753	1.4080
1978	1289.9	1432.9	2217.1	2183.5	2957.6	3003.1	1.7343	1.8220

Table 3.1 (Continued)

	MS		LABT		LABF		LABC	
Year	Simulated	Actual	Simulated	Actual	Simulated	Actual	Simulated	Actual
1964	60.9	45.0	322.8	315.8	27.1	17.1	295.7	298.7
1965	86.1	67.0	334.8	333.1	26.9	35.5	307.8	297.6
1966	118.2	91.0	350.3	351.3	30.0	30.4	320.3	320.9
1967	154.9	117.0	366.9	370.2	33.5	37.9	333.4	332.3
1968	189.8	150.0	387.1	389.4	40.3	45.6	346.8	343.8
1969	213.4	202.0	402.9	410.9	41.9	45.6	361.0	365.3
1970	250.3	241.0	422.3	434.5	46.5	45.6	375.8	388.9
1971	280.3	365.0	462.7	459.0	71.7	64.0	391.1	395.0
1972	395.1	413.0	492.1	488.0	85.2	81.0	406.9	407.0
1973	524.6	514.0	540.6	538.3	117.1	118.4	423.5	419.9
1974	789.0	754.0	643.4	607.2	202.5	169.8	440.9	437.4
1975	972.9	868.0	661.2	677.1	202.4	223.0	458.8	454.1
1976	1157.9	1139.0	710.0	732.7	232.4	262.6	477.6	470.1
1977	1353.5	1444.0	759.2	765.0	264.6	266.2	494.6	498.8
1978	1612.3	1688.0	777.9	772.7	260.9	252.3	517.0	520.4





Historical Simulation Results

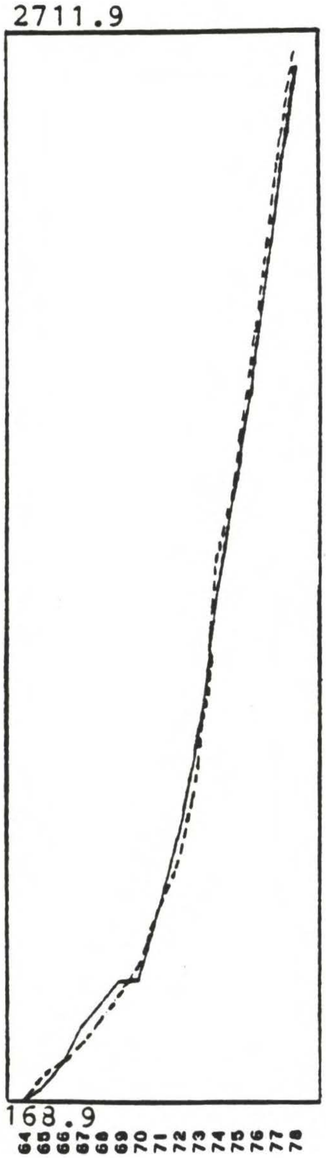
Figure 1
DGNP

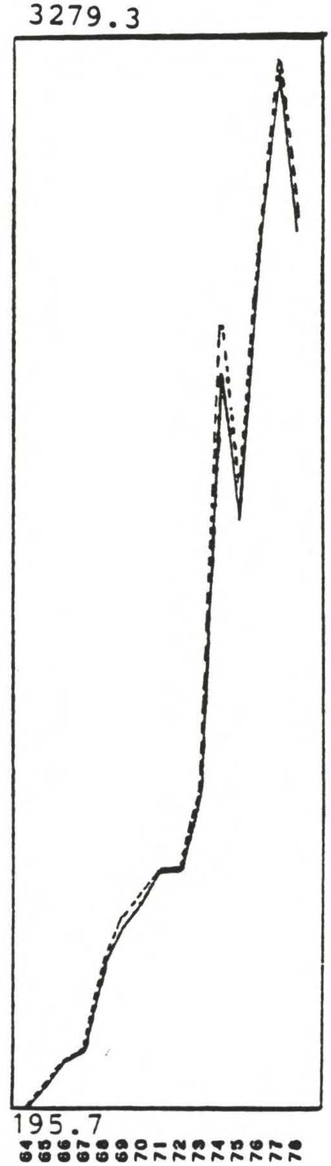
MD = millions of dinars

Figure 2
SGDP

MD = millions of dinars

Actual__________
Simulated__ __ __





Historical Simulation Results

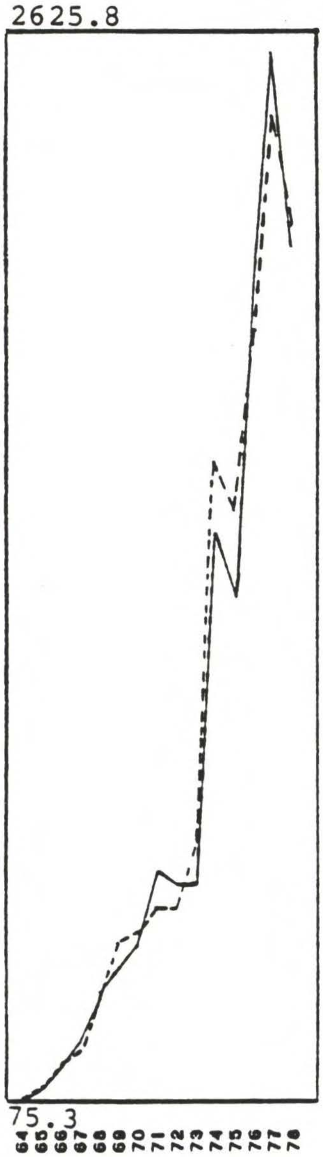
Figure 3
GDPN

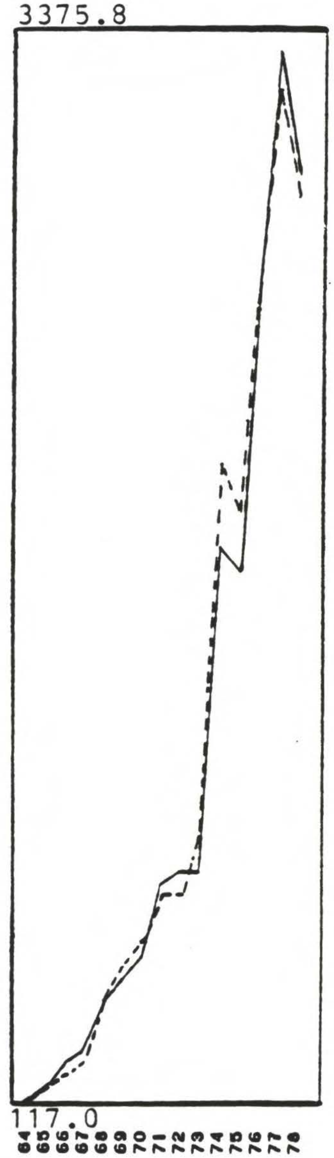
MD = millions of dinars

Figure 4
GDPO

MD = millions of dinars

Actual__________
Simulated__ __ _





Historical Simulation Results

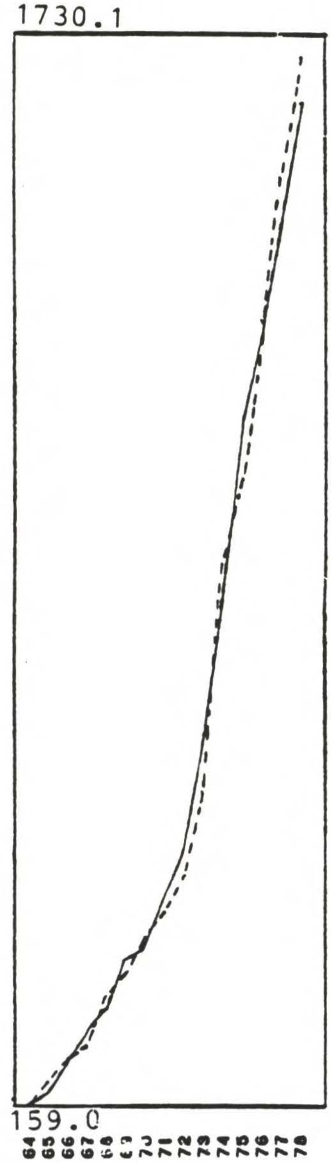
Figure 5
GOR

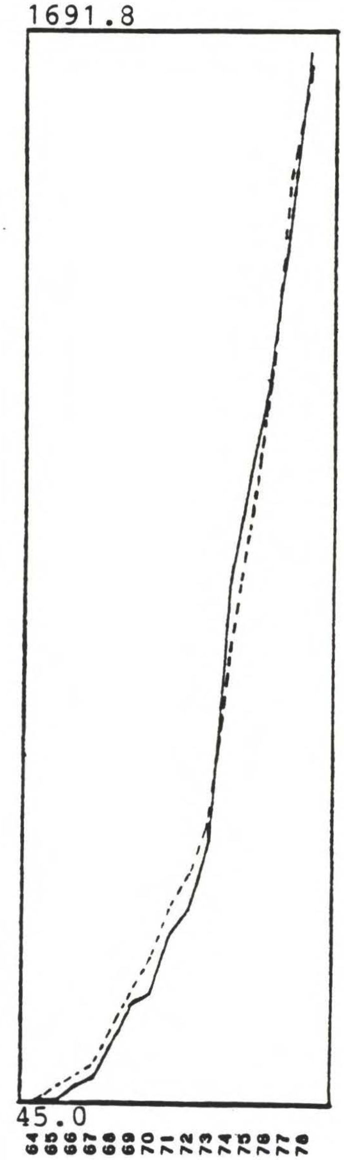
MD = millions of dinars

Figure 6
TGR

MD = millions of dinars

Actual__________
Simulated__ __ __





Historical Simulation Results

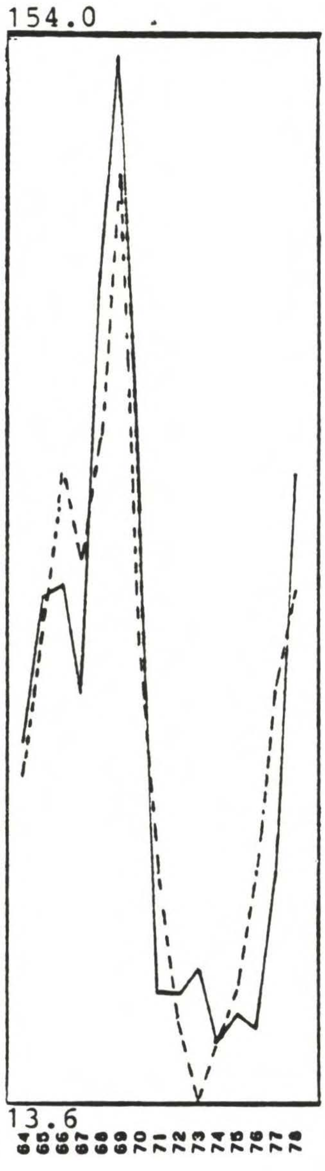
Figure 7
PCON

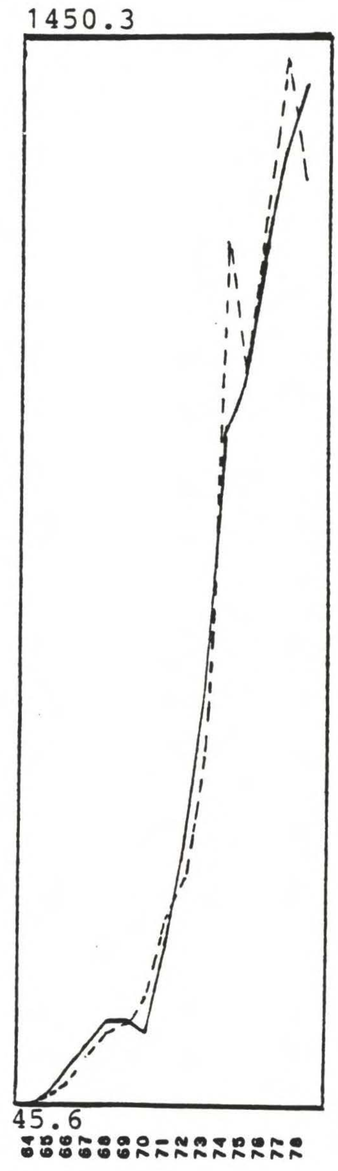
MD = millions of dinars

Figure 8
GCON

MD = millions of dinars

Actual__________
Simulated__ __ __





Historical Simulation Results

Figure 9
OIV

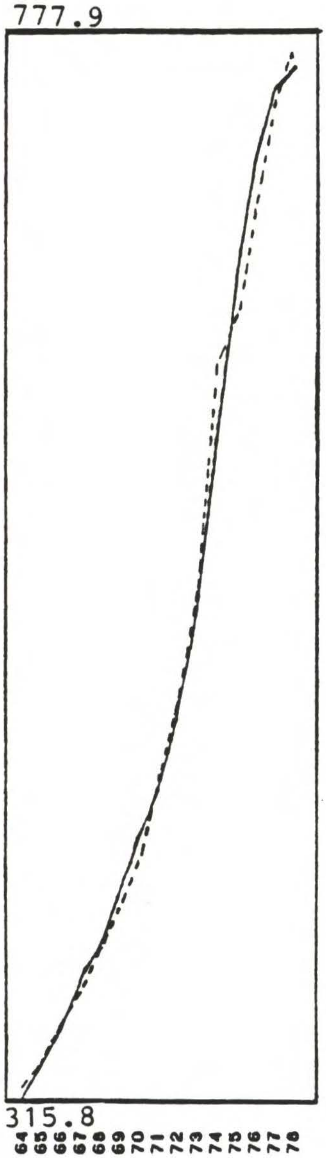
MD = millions of dinars

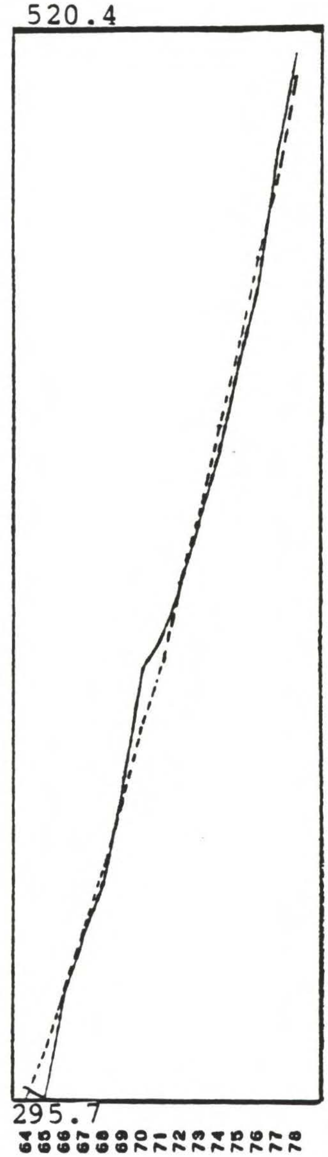
Figure 10
NOIV

MD = millions of dinars

Actual ________

Simulated __ __ __





Historical Simulation Results

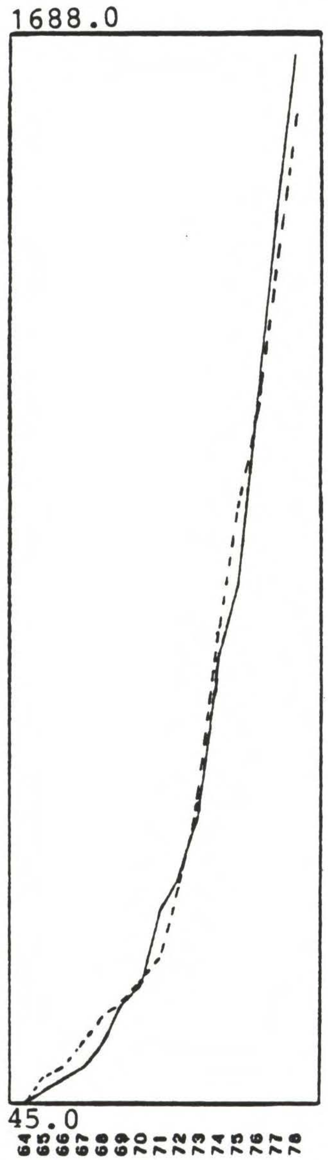
Figure 11
LABT

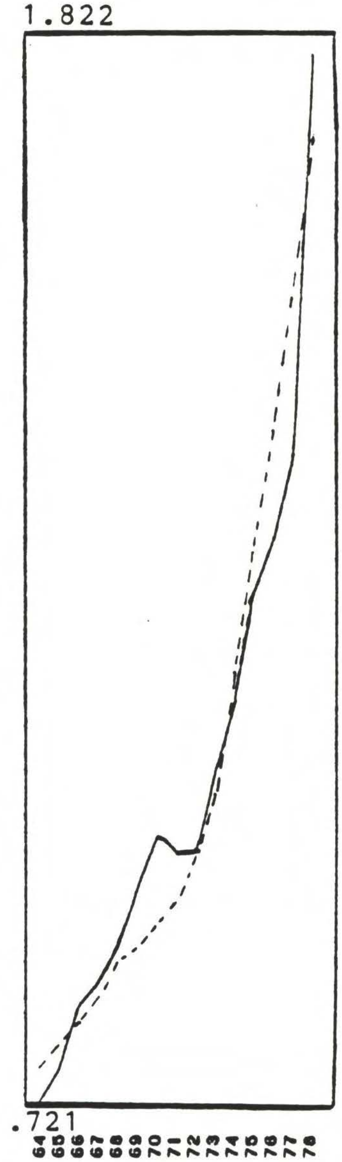
Figure 12
LABC

TP = thousands of persons

TP = thousands of persons

Actual__________
Simulated__ __ __





Historical Simulation Results

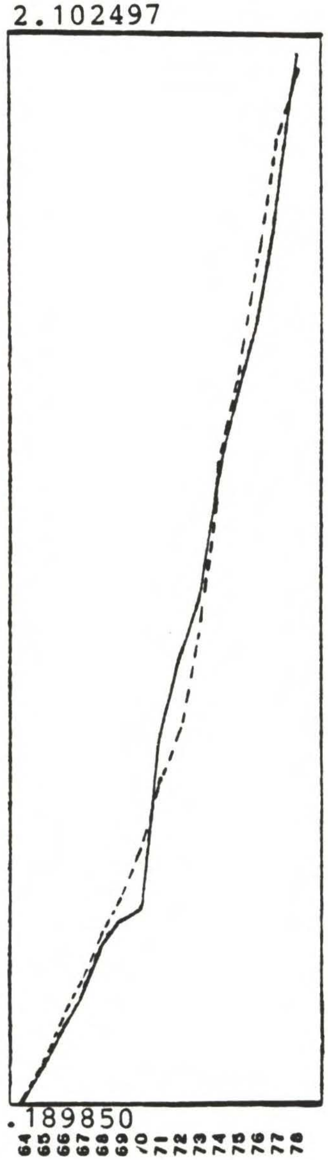
Figure 13
MS

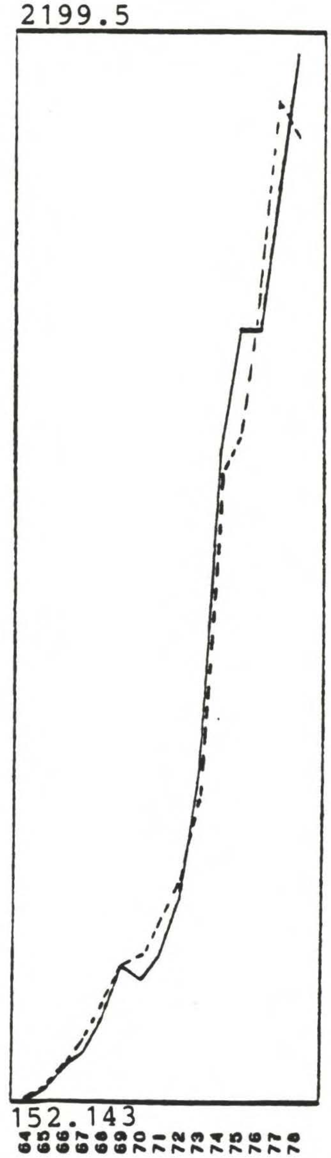
MD = millions of dinars

Figure 14
CPI

Index 1970 = 1

Actual__________
Simulated_ _ _





Historical Simulation Results

Figure 15
WN

Figure 16
IMP

TD = thousands of dinars per person

MD = millions of dinars

Actual ______

Simulated __ __ __

Table 3.2

Summary of Test Statistics Results

Variable	Mean	Mean error	RMSE	Mean percent error	RMS percent error	U	UM	UR	UD
DGNP	2100.750	25.42	91.00	.28	4.16	.0337	.0783	.2097	.7120
SGDP	2312.550	23.51	77.34	.54	3.62	.0264	.0924	.3148	.5928
DGDP	2382.920	23.72	81.67	.52	3.49	.0271	.0844	.2585	.6571
GDPN	1005.810	5.94	51.81	.31	6.31	.0400	.0129	.2204	.7667
GDPO	1306.740	17.57	44.47	.72	2.84	.0270	.1556	.1547	.6897
PCON	685.207	1.11	39.90	-.13	4.73	.0473	.0009	.1353	.8638
GCON	545.787	9.07	52.78	7.16	12.30	.0695	.0295	.0122	.9583
NOIV	536.513	12.57	88.90	2.20	15.67	.1221	.0199	.1019	.8782
OIV	65.207	-.59	15.22	6.55	35.14	.1998	.0015	.0244	.9741
TMP	847.013	-1.55	87.94	2.37	8.56	.0800	.0004	.0219	.9777
NFI	282.167	-1.72	34.52	2.23	12.15	.1077	.0025	.0018	.9957
NITX	70.367	.19	13.89	2.17	15.80	.1595	.0002	.0031	.9967
DTX	55.567	1.63	17.72	-2.05	29.67	.2301	.0084	.0016	.9900
ITX	112.947	.19	13.89	1.33	10.87	.0938	.0002	.0300	.9698
GOR	894.693	12.41	91.67	2.02	9.59	.0762	.0184	.0000	.9816
TGR	1169.770	14.23	96.22	.82	7.32	.0608	.0219	.0006	.9775
RKNO	1152.420	11.05	46.07	.22	5.24	.0327	.0578	.3078	.6344
LABT	509.680	-.73	12.80	-.09	2.18	.0245	.0032	.0014	.9954
LABO	10.360	.00	.30	-.01	2.89	.0292	.0000	.0932	.9068
LABN	499.320	-.73	12.77	-.08	2.22	.0244	.0033	.0020	.9947
LABF	113.000	-.80	13.66	1.40	18.47	.0939	.0035	.0035	.9930
LABC	396.680	.07	5.55	.04	1.49	.0138	.0002	.0000	.9998
WO	3.406	.04	.41	1.56	11.29	.1164	.0096	.2296	.7608
WN	.946	.01	.07	1.63	8.14	.0605	.0219	.0807	.8974
TGEX	1074.810	9.07	52.78	3.77	6.60	.0354	.0298	.0264	.9438
NGEJ	799.733	7.25	59.00	7.15	11.75	.0529	.0153	.0033	.9814
HP	324.300	2.78	53.42	4.74	14.76	.1200	.0027	.0101	.9872
MS	539.867	4.08	50.80	9.62	19.23	.0684	.0065	.1165	.8770
PGDPN	1.090	.00	.05	.35	4.85	.0458	.0000	.0530	.9470
PGDP	1.556	.01	.05	.42	2.57	.0300	.0149	.0268	.9583
CPI	1.069	.01	.07	.60	5.44	.0608	.0148	.1054	.8798
PDY	1002.640	11.18	93.46	.31	6.90	.0760	.0143	.1702	.8155
GDA	1832.710	22.17	125.28	1.64	5.72	.0530	.0314	.0378	.9308
RSGDP	1289.670	2.27	57.14	.18	4.42	.0416	.0016	.0015	.9969
RGDPN	808.155	-1.76	48.09	.07	6.27	.0511	.0013	.0054	.9933
RGDPO	481.512	4.03	14.76	.72	2.84	.0289	.0744	.2006	.7250

$$\text{RMSE} = \sqrt{\frac{1}{T} \sum_{t=1}^{T} (X_t - Y_t)^2}$$

$$\text{RMS percent error} = \sqrt{\frac{1}{T} \sum_{t=1}^{T} \left(\frac{X_t - Y_t}{Y_t} \right)^2}$$

$$\text{Mean error} = \frac{1}{T} \sum_{t=1}^{T} (X_t - Y_t)$$

$$\text{Mean percent error} = \frac{1}{T} \sum_{t=1}^{T} \frac{X_t - Y_t}{Y_t}$$

$$U = \left[\frac{1}{T} \Sigma (X_t - Y_t)^2 / \frac{1}{T} \Sigma Y_t^2 \right]^{1/2}$$

$$UM = (\bar{X} - \bar{Y})^2 / \frac{1}{T} \Sigma (X_t - Y_t)^2$$

$$UR = (S_x - r S_y)^2 / \frac{1}{T} \Sigma (X_t - Y_t)^2$$

$$UD = (1 - r^2) S_y^2 / \frac{1}{T} \Sigma (X_t - Y_t)^2$$

where Y and X denote actual and simulated values of the endogenous variable and $\bar{Y}$, $\bar{X}$, S_x, S_y and r are the mean and standard deviations of the two series and r is the correlation coefficient between the two series.

The RMSE measures "the deviation of the simulated variable from its actual time path. Of course, the magnitude of this error can be evaluated only by comparing it with the average size of the variable in question."[2] RMS percent error, as its formula indicates, measures the same deviation as RMSE except it is calculated in percentage terms. Generally, the closer the value of RMS percent error to zero implies a good simulation performance for the variable under consideration. This is also true in the case of mean error and mean percent error. Nonetheless, "the problem with mean errors is that they may be close to 0 if large positive errors cancel out large negative errors."[3] Finally, Theil's inequality coefficient U and its decompositions UM, UR and UD were also utilized. The coefficient U is expected to equal zero only in the extreme case of perfect simulation fit. UM and UR also tend toward zero for a perfect simulation fit, while UD tends to unity since the three add up to 1.

Table 3.2 and Figures 1 through 16 indicate that most of the key variables in our model, such as

DGNP, SGDP, GDPN, GDPO, TMP, GOR, and LABT, did fairly well in reproducing their historical series. In addition, the model simulated most of the turning points in the historical data for those variables. Nonetheless, the historical simulation of the model showed some endogenous variables to have performed less favorably in terms of the above statistics. The least favorable were those of oil investment and direct taxes. In both cases, new specifications for both of these equations were experimented with and the full model was rerun several times. Those equations used in the final form of the model were the ones that produced the best simulation performance of the entire model.

The second experiment which was used to establish the model forecasting ability consists of an ex-post forecast for the year 1979. The goal of such an exercise is to show how closely the simulated values of our endogenous variables track their actual values beyond the sample period. The results of this exercise are given in Table 3.3. As the table indicates, most of the simulated endogenous variables were very close to their actual ones. This indicates that the model is a stable description of the Libyan

Table 3.3

Ex-post Forecast for 1979
(Millions of Libyan Dinars)

Variable	Projected	Actual
DGNP	7276.0	7293.3
DGDP	7895 9	7846.4
SGDP	7608.6	7603.0
PCON	2118.5	1894.8
GCON	2042.9	2006.6
ITX	437.2	393.3
GDPO	4084.5	4545.3
GDPN	3524.2	3057.7
LABN	845.6	777.3
LABO	11.8	11.7
LABT	857.4	789.0
LABC	537.5	529.6
LABF	314.8	259.4
NOIV	1929.0	1767.9
OIV	125.5	87.4
IMP	3231.8	2821.7
MS	1956.4	2247.0

economy and increases the confidence and reliability in its forecasting ability.

CHAPTER III

NOTES

[1]R. Pindyck and D. Rubinfeld, Econometric Models and Economic Forecasts (New York: McGraw-Hill Book Company, 1981), p. 362.
C. Granger and P. Newbold, "Some Comments on the Evaluation of Economic Forecasts," Applied Economics, Vol. 5, 1973, pp. 35-47.
C. Ash, B. Udis, and R. McNown, "Enlistments in the All-Volunteer Force: A Military Personnel Supply Model and Its Forecasts," American Economic Review, Vol. 73, March 1983, pp. 145-155.

[2]R. Pindyck and D. Rubinfeld, op. cit., p. 362.

[3]Ibid., pp. 362-363.

CHAPTER IV

THE IMPACT OF CHANGE OF OIL PRICE LEVEL ON THE LIBYAN ECONOMY

The previous two chapters center around developing and evaluating an aggregate macroeconomic model of the Libyan economy. Two goals thus far have been achieved. First, some knowledge of the mechanisms at work in the Libyan economy was obtained. Second, the predictive ability of the model was established by performing different statistical tests. Therefore, the model can now be put to use to forecast the future values of Libya's major economic aggregates under different assumptions regarding the future level of world oil prices. Accordingly, this chapter will contain the results of an ex-ante simulation of the full model till 1987. This ex-ante simulation will be divided into two sections. The first section will cover the years 1980-1983, for which actual data are available for Libyan crude oil prices and the volume of Libyan oil exports up to the third quarter of 1983. Since no drastic changes are expected to occur between now and the end of 1983 in the world oil market, it is assumed that the above two variables will maintain their same levels until the end of 1983. The second section of our ex-ante simulation will cover the years 1984-1987.

In this section the future of the Libyan economy will be simulated under a basic price scenario which reflects the most likely forecast regarding the world oil price levels from 1984-87. This forecast of world oil prices, as in most forecasts, depends on the realization of the different assumptions that underlie it. These assumptions in effect reveal the uncertainty involved in such forecasts. Therefore, in addition to our basic price scenario, a sensitivity analysis will be performed by establishing a new oil price scenario. This new scenario will reflect changes in the assumptions underlying our basic price scenario.

Simulation Assumptions

In carrying out the above mentioned simulation experiments, actual data for 1978 will still be used as our initial values, since that year corresponds to the end of our sample period. Since data for most of the model's exogenous variables were not available for

1980 and thereafter, they were generated assuming that they will continue their historical trends, with the following exceptions. The oil gross domestic product price index (PGDPO) is assumed to follow the same trend as Libyan crude oil price level from 1980-1983. This is justified by the fact that most of the Libyan crude oil is being exported. For 1984-1987, two different scenarios, which will be explained later, will be used for this variable. Real oil exports (ROEX) during 1980-1983 are assumed to follow the same trend as changes in the volume of Libyan crude oil exports. Between 1984-1987, the model will be simulated under two assumptions with respect to ROEX. First, ROEX will be assumed to decline at an annual rate of 7.5, which is what the country's five-year development plan (1981-1985) calls for,[1] and it will continue to decline at the same rate for 1986 and 1987. Second, ROEX will be used as a policy variable and will be varied at different rates of growth between 1984-1987 and these will in turn be used with our basic price scenario in order to determine the level of ROEX which will enable the country to achieve an annual 10.3% rate of growth in the real gross domestic product of the non-oil sector between 1980-1987. This rate is what the country's development plan aims at achieving between 1980-1985. An additional two years were added to allow for the effects of the decline of PGDPO in 1982 and 1983 and for the huge decline in oil exports level of 1981.

Other exogenous variables include government subsidies, which are assumed to grow at a 35% annual rate during our ex-ante simulation. This rate is actually lower than the average rate during our sample period. Nonetheless, we are looking at a period in the future where PGDPO is likely to grow at a lower rate than that of the 1970s, and therefore it is assumed that the government will aim at maintaining a reasonable rate of growth in subsidies during 1980-1987. This argument also holds for government transfers to households, which are assumed to grow at an annual rate of 31%. Non-oil exports are assumed to grow at an annual rate of 30%. The country's development plan calls for it to grow at an annual compound growth rate of around 25% between 1980 and 1985, at 1980 constant prices. Our 30% rate is therefore conservative, since it implies relatively little change in the price of non-oil exports, which mostly consist of oil refining products and petrochemicals. Nonetheless, considering the current situation in the world oil market, it was felt that a low rate of growth in the price of non-oil exports is a reasonable assumption to make.

Prior to presenting and analyzing the results of our ex-ante simulation for 1980-1983, two remarks are in order. First, the ability of the model to predict the outcomes for that period will depend on how closely the actual values of the exogenous variables are to our projection of those variables. Second, changes in the world oil market in recent years have made it necessary to break down our ex-ante simulation into the two above-mentioned subsequent periods. Had PGDPO and ROEX been relatively stable up to 1983, it would have been possible to start our simulation experiments of the different scenarios regarding PGDPO from 1980 on. Nonetheless, the change in the balance of forces in the world oil market in recent years has made it necessary to use up-to-date proxies for PGDPO and ROEX in order for our simulation of the model up to 1983 to reflect such changes.

Results and Analysis of Ex-Ante Simulation of the Model from 1980-1983

This section will present the results of our ex-ante simulation of the Libyan economy for the period 1980 till 1983. The results are summarized in Table 4.1 and are presented in terms of the rate of change in the model key endogenous variables.

As Table 4.1 shows, the Libyan economy is heavily dependent on oil revenues, and changes in its value have great effects on the key variables of our model. For example, in 1980 the boost in oil prices which caused PGDPO to increase by 63% had worked its direct and indirect effects to increase DGDP, which in turn caused DGNP to grow by 44%. As the different components of DGDP increased and the change in PGDPO worked its effect throughout the model, RGDPN increased by 22%. Nonetheless, RGDPO declined by 8%, mostly due to the increase in PGDPO and in part due to the moderate decline in ROEX. The 22% increase in RGDPN, the 22% increase in PGDP, and the 16% increase in WN resulted in a 13% increase in LABN. LABO also increased by 4%, as WO, PGDP, and OIV shifted upward. The increase in LABN and LABO caused LABT to grow at 13% between 1979 and 1980, and with LABC

Table 4.1

Percentage Changes in Key Endogenous Variables in Response to Changes in Crude Oil Prices and Libyan Real Oil Exports Between 1980-1983

Variable	1980	1981	1982	1983
DGNP	44	-18	2	-6
PCON	31	11	13	9
GCON	34	8	3	-2
NOIV	53	-28	-5	-15
OIV	53	8	-2	-14
IMP	42	-5	4	-2
GOR	60	-30	-14	-23
TGR	54	-24	-7	-13
ITX	42	-5	4	-2
DTX	46	-18	2	-6
RGDPO	-8	-40	3	-8
RGDPN	22	1	5	.6
RSGDP	17	-4	5	0
CPI	14	16	15	15
PGDP	22	-13	-2	-5
PGDPN	10	4	7	6
LABN	13	-.4	2	0
LABO	4	-1.6	-4	-7
LABF	28	-6	-.3	-7
LABC	4	4	4	4
MS	30	25	19	20
NGEJ	31	25	20	20
TGEX	32	19	18	17
HP	30	25	19	20
WN	16	7	10	8
WO	9	14	16	15
RKNO	15	8	6	4

growing at only 4%, LABF grew at 28%. The high rate of growth in LABF contributed to the 16% growth in WN. However, the low size of the coefficient of LABF in the WN equation suggests that changes in LABF contributed slightly to the change in WN. Most of the change in WN is therefore explained by the other variables explaining WN, which include RGDPN/LABN and CPI_{-1}. Oil sector wage rate grew at 9%, showing a lower rate of growth than did the non-oil wage rate. This is because WO is completely explained by CPI_{-1}. Since MS coefficient on CPI equation was found to be .0003, the 30% rate of growth in MS did not translate into a high rate of growth in CPI. The growth in MS came about as NGEJ grew by 31%, which in turn caused HP to grow by 30%.

In summary, the huge increase in oil revenues in 1980, which came as a result of the 63% increase in PGDPO, has had a tremendous expansionary effect on the Libyan economy's aggregates. It compensates for the relatively small decline in ROEX, and it was the cause for a successful performance of the non-oil sector real gross domestic product, which grew at 22%. Oil revenues in 1980 were still the main determinant of the growth in the economy. The increase in PGDPO during that year showed that the economy is very sensitive to such changes in PGDPO and, while 1980 turned out to be a good year for the Libyan economy, the results show that the country must adopt a policy aiming at reducing its dependence on oil revenues. Actually, in 1981 as economic activities in most industrialized countries weakened and as conservation measures spread in response to the price shock of oil that resulted from the oil market disruptions of 1979-1980, Libyan ROEX declined by 38%. This in turn has affected GOR, which our model forecast to decline by 30% in 1981 as compared to 1980. As the decline in GOR worked its effect throughout the model, DGNP was forecast to decline by 18% in 1981 as compared with the previous year. The decline in DGNP would have been larger if PGDPO did not show a moderate rate of increase of 11% during that year.

It is interesting to notice that the events of 1981 have had a dramatic impact on the non-oil sector. RGDPN is forecasted to grow at only 1% in 1981, as compared with a 22% increase in 1980. This rate of growth in RGDPN is well below the 10% which the country's development plan aimed at achieving annually between 1980-1985. In 1982, and as a result of a 3.7%

increase in ROEX while PGDPO decreased by 11%, the overall performance of the economy has improved to a little extent when compared with 1981, as DGNP is projected to grow by 2% in 1982. This is attributed mostly to the moderate decline in GOR in that year, which declined by 14%, as compared with a 30% decline in 1981. The 1983 forecast is restricted by our prior assumption regarding a continuation of ROEX and PGDPO levels as they were in the third quarter of 1983. If this turns out to be true, not much improvement would be achieved in the economy's growth. Actually, GOR will decline by 23% as compared with 1982, and this will eventually be transmitted into a 6% decrease in the level of DGNP.

Forecast of the Future Values of Libya's Major Economic Aggregates Under Two World Oil Price Scenarios From 1984-1987

Since all of our exogenous variables for this simulation period are generated, this section will in effect present the first true forecast of our system. In this section, two goals are to be achieved. First, we aim at determining quantitatively the impact on the different components of the Libyan economy resulting from changes in the price level of oil. This will be achieved by allowing only PGDPO to vary, while holding all other exogenous variables at the same level. Our second goal is to determine that level of ROEX which will enable the country to achieve a 10% annual growth rate in RGDPN between 1980-1987.

Basic World Oil Price Scenario
Definition and Assumptions

The first step in our analysis is to determine the different PGDPO scenarios to be used in simulating our model. Forecasters' opinions vary with respect to future trends in world oil prices in the 1980s. For the purpose of this study, a use of the Data Resource, Inc., projection of world export-weighted price of oil will be in effect.[2] Table 4.2 shows their projection from 1984 to 1995. Of course, those figures were converted to our set of PGDPO series when 1970 formed our base year, before using them in our simulation experiments.

As the table indicates, the world oil price level would remain through 1984 at about the same level as 1983. In 1985, it will begin to increase slightly at 3.3% in nominal terms and then it will increase by slightly over 6% in 1986 and 1987. From 1988 till 1995, the world oil price level is projected to

Table 4.2

Projected Oil Price Trajectory
(world export-weighted)

	Contract crude oil price			
	Dollars of the day		†Real 1981 dollars	
Year	Dollars per barrel, FOB	Yr-to-yr % change	Dollars per barrel, FOB	Yr-to-yr % change
1995	73.49	10.3	34.29	3.9
1994	66.63	10.6	32.99	4.1
1993	60.27	10.5	31.69	4.0
1992	54.52	10.7	30.46	4.2
1991	49.27	9.7	29.23	3.3
1990	44.93	9.9	28.29	3.7
1989	40.90	8.9	27.29	2.8
1988	37.57	9.4	26.54	3.4
1987	34.34	6.4	25.66	1.1
1986	32.28	6.2	25.38	1.1
1985	30.39	3.3	25.11	-1.4
1984	29.43	-1.3	25.47	-5.4

†Adjusted by U.S. deflator.

Source: Standard and Poors, Industry Surveys, Oil, November 1, 1983 (Vol. 151, No. 43, Sec. 1) p. 59.

increase at a faster rate than that of inflation. It should be emphasized that our choice of the above projections of world oil price level is not arbitrary. Admittedly, trends of the future price of oil are very uncertain. Nonetheless, the above projections rest on a variety of assumptions which represent a reasonable perception of the factors that shape oil future price levels. Their projections are based on a 1% annual growth in the "demand for oil in the free world"[3] till the end of this century. This rate is lower than their forecast for total energy consumption in the free world, which is predicted to grow at 2.6% between 1983-1990 and 2.2% thereafter till the year 2000. The rationale for such a lower rate of growth in demand for oil than that of energy consumption is given as follows:

> For one, petroleum usage has responded in classic textbook fashion to the laws of price elasticity. Two oil price "shocks"--the response in 1973-74 to the Arab oil embargo and in 1979-80 to the Iranian revolution--saw representative Mideast crude prices (as depicted by Saudi light) soar to $34 a barrel in 1981, from less than $3 a barrel in 1973. The result has been widespread energy conservation and fuel-switching at all levels of industrial, commercial, and consumer activity. Much of this change in energy usage is not reversible; the new patterns will tend to stay in place despite economic recovery and plentiful petroleum supplies. Secondly, it is

> believed that the thrust of future economic growth in the major developed countries will be in high technology, communications, and services. These industries obviously are much less energy-intensive than the basic "smoke-stack" industries that traditionally powered economic growth.[4]

On the supply side, their projection foresees a return to the search for conventional oil and gas by the major oil companies. A drastic change in their policy with respect to synthetic fuels and other energy supplies is expected, as the following quotation indicates:

> Starting in 1981, the major oil companies began to face up to the realities of the situation. Cost-cutting and cash generation replaced ambitious, futuristic spending programs. Synfuels programs were stopped dead in their tracks in most instances. Diversification moves ceased. A marked return to the search for conventional oil and gas reserves replaced the more exotic ventures considered when the industry was cash heavy and prospect short.[5]

In addition, the above projection of world crude oil prices assumes no major changes with respect to the three-year-old war between Iran and Iraq. Conflict and hostilities are assumed to continue; neither an end nor an escalation of such hostilities is foreseen in the near future. Therefore, such a projection is very sensitive to any changes in this conflict. Drastic changes in world oil supplies and prices would likely occur if such a conflict ended or accelerated.

> If the war were to wind down, Iran and Iraq could probably add another 2.5 million-3 million barrels a day to the oil markets over an 18-month period. This obviously would disrupt price stability. On the other hand, if Iraq (with new, sophisticated war planes and missiles bought from France) chooses to escalate the war against Iran, that country has threatened to expand the war to its Persian Gulf neighbors and possibly block the narrow Strait of Hormuz at the mouth of the Gulf. All oil that moves out of the Persian Gulf by tanker must pass through this narrow opening. This threat, too, is seen as a negative to the industry, since it might push oil prices up more than is justified by economic factors and reduce long-term demand for oil even further. While all of this is strictly conjecture, it does point up the layers of possibilities for altering the outlook of the oil business--an outlook that could change overnight.[6]

The above projection of world oil prices would establish our basic scenario with respect to oil price level from 1984-1987. In effect, we will simulate our model under a condition of undisrupted world oil market between 1984-1987. Our additional assumption is that ROEX will decline during the same period by an annual rate of 7.5%. The country's five-year development plan, which ends in 1985, calls for such a decline. For simplicity, a continuation of this same rate is assumed till 1987. All other exogenous variables are assumed to continue their same rate of growth as outlined earlier.

Libya's Economy Aggregates Under the Basic World Oil Price Scenario

The output of our simulation of the Libyan economy's aggregates when the basic price of oil scenario is used is given in Table 4.3. Throughout the rest of this section, the growth rate in our model key endogenous variables will form our main macroeconomic indicators in studying the impacts of the different scenarios regarding PGDPO in the Libyan economy. As Table 4.3 indicates, if our assumption with regard to PGDPO and ROEX is realized, DGNP will grow at an annual average rate of 18% between 1983 and 1987. Most of the growth in GNP will occur in 1986 and 1987, where it will grow by 22% and 27%, respectively. RSGDP will achieve an annual average rate of growth of 9.8 during the same period. A 6% annual average increase in employment in the non-oil sector and 6.7% increase in real stock of capital in the non-oil sector will result in 9.9% rate of growth in the real level of output in that sector between 1983-1987. During the same period, real output in the oil sector will grow by an annual rate of 7%. It is interesting to note that most of the

Table 4.3

The Libyan Economy Key Variables Under Basic World Oil Price Scenario and With Real Oil Exports Declining by 7.5% Between 1984-1987

Year	DGNP	PCON	GCON	NOIV	OIV	IMP
1984	8956	4323	2978	1952	147	4758
1985	10333	5090	3084	2399	137	5349
1986	12574	6259	3340	3095	147	6276
1987	15943	8031	3769	4105	179	7618

Year	GOR	TGR	ITX	DTX	RGDPO	RGDPN
1984	2199	4140	645	258	202	2718
1985	2408	4697	724	298	214	2954
1986	2853	5614	851	364	234	3288
1987	3486	6866	1033	463	262	3744

Year	RSGDP	CPI	LABN	LABO	LABF	MS
1984	2920	4.0256	1007	9.5	364	5507
1985	3168	4.7565	1060	8.5	390	6828
1986	3522	5.7291	1133	7.7	435	8623
1987	4006	7.030	1227	6.9	500	11035

Year	NGEJ	TGEX	HP	WN	WO	RKNO
1984	8624	10565	3313	4.0451	12.281	4320
1985	10705	12994	4108	4.5799	14.310	4565
1986	13533	16293	5188	5.2948	16.942	4902
1987	17331	20712	6639	6.2525	20.446	5355

stimulation would occur in the economy's aggregates between 1986 and 1987. It is the moderate rate of increase in PGDPO during those two years, as compared to 1984 and 1985, that results in a relatively moderate rate of growth in the economy's aggregates as compared to those of 1981-1983.

Optimistic World Oil Price Scenario Definition and Assumptions

Thus far, one step has been completed in establishing our first goal of studying the impacts associated with changes in PGDPO. Our second step involves resimulating our model under a new level of PGDPO while holding all of our exogenous variables at their same levels. Accordingly, PGDPO values will assume new levels which are 10% higher as compared to those values used in our previous simulation. In other words, our basic PGDPO figures between 1984-1987 are multiplied by 110%. This new projection of world oil prices would form our optimistic scenario with respect to oil price levels from 1984-1987. This new level of PGDPO could result from any changes in the world oil market that could cause the assumptions underlying our basic price scenario to be an inaccurate description of the forces affecting the world oil price level. A change in the balance of forces regarding the ongoing conflict between Iran and Iraq, or an evaporation of oil conservation measures as economic recovery in most industrialized countries escalates, could result in an upward shift in PGDPO.

Effects of Change in World Oil Price Level on the Libyan Economy

The result of our simulation under the new PGDPO scenario is given in Table 4.4. The table is constructed in terms of the growth rate of our key endogenous variables as compared with their values under our previous simulation. Therefore, Table 4.4 presents the percentage growth rates in those variables due to an additional 10% increase in PGDPO.

The 10% increase in PGDPO will have a relatively moderate impact on RGDPN, which will be about 2% higher between 1984-1987 as compared with its value for the same period under the basic price scenario. The rate of growth in RGDPN tends to increase over time, but by a relatively small amount. RGDPN is therefore relatively insensitive to changes in PGDPO. This, in effect, shows that the linkages between changes in PGDPO and RGDPN are not very strong. In contrast to this, we find that the rate of growth in real output in

Table 4.4

Percentage Changes in Key Endogenous Variables
in Response to 10% Increase in
World Oil Price Level

Year	DGNP	PCON	GCON	NOIV	OIV	IMP
1984	4.2	1.6	1.2	7.6	4.8	3.1
1985	3.9	2.2	2.1	5.3	8.8	3.0
1986	3.4	2.5	2.3	3.9	9.5	2.9
1987	2.9	2.7	2.4	3.0	7.3	2.6

Year	GOR	TGR	ITX	DTX	RGDPO	RGDPN
1984	7.2	4.6	3.1	4.3	-2.5	2.0
1985	6.8	4.2	3.1	4.0	-4.2	2.1
1986	5.0	3.2	2.9	3.6	-5.6	2.1
1987	2.8	2.0	2.6	3.0	-7.3	2.2

Year	RSGDP	CPI	LABN	LABO	LABF	MS
1984	1.7	.03	1.3	1.0	3.8	.07
1985	1.7	.14	1.3	2.4	3.8	.29
1986	1.6	.22	1.3	1.3	3.4	.34
1987	1.5	.23	1.3	1.4	3.4	.26

Year	NGEJ	TGEX	HP	WN	WO	RKNO
1984	.08	.35	.09	.85	.00	.72
1985	.29	.51	.29	.84	.03	1.10
1986	.33	.50	.35	.86	.14	1.30
1987	,27	.42	.27	.85	.22	1.40

the oil sector is dramatically affected by the higher level of PGDPO between 1984-87. RGDPO is found to be 2.5% lower in 1984 when compared with our basic PGDPO price scenario results. This rate goes up during 1984-87 to reach 7.3% lower in 1987.

In terms of the government sector, our simulation results show the dependency of TGR on GOR. In 1984, GOR increased by 7.2%, as compared with our basic price scenario, showing a substantial increase in GOR with respect to the 10% increase in PGDPO. Nonetheless, this rate declines to reach 2.8% in 1987. Percentage growth in TGR follows very much the same trend, even though it is always below that of GOR. Percentage change in ITX and DTX also declined over our ex-ante simulation from 1984-1987. This underlies a tax structure that could be described as an oil dependent structure. Increases in oil prices not only cause the level of GOR to increase, but further affect GNP and IMP, which results in a higher level of taxes. This suggests that the government should adopt a policy that aims at increasing its other sources of income besides oil and taxes, which are less sensitive to changes in GOR that could come about as PGDPO changes.

The 10% increase in PGDPO did stimulate the different components of aggregate demand in our model. NOIV, OIV and IMP have increased in the first year by 7.6%, 4.8% and 3.1%, respectively. Nonetheless, this rate showed a decreasing trend with respect to NOIV and IMP. To the contrary, OIV grew 8.8% and 9.5% in 1985 and 1986, respectively, when compared with our basic scenario. It eventually declined to 7.3% in 1987. It is interesting to note that even though PGDPO was not used as one of the explanatory variables in the (OIV/PKM) equation, nonetheless, OIV was found to be very sensitive to changes in PGDPO. GCON and PCON were the only components of aggregate demand which showed an increasing rate of change over the entire period of 1984-1987. This is, of course, in line with the specifications of those two variables where their lagged values were found to be very significant in explaining them.

Changes in the money supply were found to be relatively insensitive to changes in PGDPO. As mentioned earlier, the basic determinant governing monetary expansion in our model is net government injection to the economy (NGEJ). This is taken as being the difference between total government expenditures (TGEX) and government non-oil revenues. The overall effect of the above variables resulted in a rather small change in NGEJ. This in turn transmitted to about the same changes in HP and subsequently MS. Therefore, this simulation shows that government total expenditures and money supply is relatively very insensitive to changes in PGDPO. This in effect suggests that Libya is rather successful in neutralizing its oil revenues that exceed its absorptive capacity.

Finally, the 10% increase in PGDPO was not reflected in a higher CPI. The latter changed at a very low rate. This is to be expected, since MS showed no significant sensitivity with respect to changes in PGDPO. This is not true when one considers WN. This has increased by an average of .85 from 1984-1987. On the other hand, WO showed a relatively lower response with respect to changes in PGDPO. This is explained by the lower rate of change in consumer price index, which in turn gave workers in the oil sector little to be compensated for in terms of higher CPI.

In sum, the results of our simulation from 1984-1987 under higher levels of PGDPO show that higher levels of PGDPO will stimulate the growth of the Libyan economy at a decreasing rate. Gross national product of the country will be higher when compared with those of the basic scenario by 4.2% in 1984 and 2.9% in 1987. It is also found that the expansion in the economy would have no side effects in terms of higher levels of consumer price index. The wage rate in the non-oil sector showed more sensitivity with respect to changes in PGDPO than did CPI and WO. In addition, government total expenditures and money supply were found to be relatively insensitive to changes in PGDPO.

Additional Policy Simulation Under the Basic Oil Price Scenario with Varying Levels of Real Oil Exports of Libya

Thus far, our first goal of studying the effects of change in the world oil price in the Libyan economy's aggregates has been achieved. The second goal of this section is to determine the ROEX level which will enable the country to achieve a 10% annual compound rate of growth in its real non-oil gross domestic product between 1980-1987. This, in effect, assumes a continuation of the economic planners' goal with respect to the rate of growth in this variable up to 1987. In order to achieve this, our model was simulated with different levels of ROEX, keeping the same PGDPO figures which respond to our basic price scenario. When ROEX assumed a 10% annual compound rate of growth from 1983 through 1987, RGDPN realized an average rate of growth of 8.6% between 1980-1987. Most of the growth in RGDPN occurred in 1980 and between 1984-1987. This, in effect, made up for the low rate of growth in this variable between 1981-1983. Assuming that this rate of growth is close to what the economic planners aim at achieving between 1980-1987, the country should aim at increasing the volume of its oil exports by 10% annually between 1983-1987. Of course, if PGDPO in the coming four years turns out to be higher than those of our basic price scenario, the country will be able to achieve the same rate of growth in RGDPN with a lower level of ROEX.

One should point out that our above ex-ante simulation of the model in which ROEX was allowed to vary does not imply that ROEX is the only source that affects the rate of growth in RGDPN. Our goal was simply to determine that level of ROEX which will enable the country to achieve a given rate of growth in its real non-oil gross domestic product. In addition, it should be noted that the usefulness of our model is not restricted by the ex-ante simulation experiments performed in this chapter. Actually, the model could be simulated in different directions in accordance with the different goals to be achieved. For example, the model could be used to test whether there exist any inconsistencies in the country's development plan. Specifically, one can simulate the model to check whether the level of real oil exports suggested in the plan are consistent with the government goals concerning the growth rate of the different key variables of the economy. Such an experiment was not performed in this study due to the unavailability of all needed data.

CHAPTER IV

NOTES

[1]Socialist People's Libyan Arab Jamahiriya, Secretariat of Planning, Summary of the Socio-Economic Transformation Plan, 1981-85, p. 50.

[2]Standard and Poors, Industry Surveys, Oil, November 10, 1983 (Vol. 151, No. 43, Sec. 1).

[3]Ibid., p. 57.

[4]Ibid.

[5]Ibid., p. 58.

[6]Ibid., p. 60.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study is concerned with examining the impacts of change in world oil prices on the development of Libya, which is heavily dependent on revenues from the sale of its oil. The major goal of the study was to determine quantitatively the sensitivity and vulnerability of the Libyan economy to fluctuations in the country's oil revenues, which could result from fluctuations in world oil prices. In order to achieve this goal, a macroeconomic model describing the aggregate structure of the Libyan economy was developed using annual data for the period 1962-1978. Since the oil sector is the source of most of Libya's income, our model was developed to capture this crucial feature of the economy. Therefore, in the model the economy was divided into two sectors, the oil and the non-oil sectors. This division enabled us to disaggregate the impacts of change in world oil prices into those affecting the oil sector and the non-oil sector. This provides us with a better understanding of the mechanism of such impacts. In other words, any macroeconomic consequences in the non-oil sector could be traced to their real causes in the oil sector. The model consists of five parts. These include aggregate supply equations, aggregate demand equations, government sector equations, monetary sector and price equations, and labor market equations. The model contains 36 relations, of which 19 are behavioral equations and 17 are identities. There are a total of 51 variables, of which 36 are endogenous and 15 are exogenous.

Validation of the model forecasting ability was achieved by the use of a simulation package, SIMULATE program, developed by the Social System Research Institute of the University of Wisconsin, headed by Professor Charles C. Holt in 1967. SIMULATE program is a special purpose simulation package which enables simulation to be executed with models of economic systems. This program is divided into two parts. SIMULATE A, which determines the recursive ordering of the equations of the model and SIMULATE B, which solves the equations of the model and calculates residual errors and other statistics which are optional. Using the above mentioned simulation package, a dynamic simulation of the model for the period 1964-1978 was carried out. The overall results of this dynamic simulation were found to be quite satisfactory. In addition to this test, the model was used to forecast 1979 and the simulated values for this year tracked closely their actual values, suggesting that the model is a stable description of the Libyan economy.

Having established the predictive ability of the model, alternative future scenarios of the Libyan economy were examined from 1980-1987 by performing an ex-ante simulation for this period. This simulation was divided into two sections. The first covers the period 1980-1983, for which actual data for Libyan oil prices and the volume of Libyan oil exports are available up to the third quarter of 1983. Since no major changes are expected between now and the end of 1983, a continuation of the above two variables at their 1983 third quarter was assumed. The purpose of this simulation was to reflect the major changes of the above two variables during that period in our model. The second section of our ex-ante simulation covers the period 1984-1987. In this section, the Libyan economy future was simulated using a basic world oil price scenario which reflects the most likely forecast regarding the world oil price level from 1984-1987.

This forecast of world oil prices, as in most forecasts, depends on the realization of the different assumptions underlying it. Those assumptions in effect reveal the uncertainty involved in such forecasts. Accordingly, in addition to our basic world oil price scenario, a sensitivity analysis was performed by establishing a new world oil price scenario. This new scenario reflects changes in the assumptions underlying the basic scenario. Under this new scenario, world oil prices are 10% higher as compared with those of the basic scenario.

A tabular comparison of the results of our simulation experiments under the two scenarios shows the sensitivity and vulnerability of the Libyan economy to changes in world oil prices. The main conclusion of such comparison shows that a 10% higher level of world oil prices would stimulate the Libyan economy's aggregates at a decreasing rate between 1984-1987. Gross national product of the country will be higher when compared with those of the basic scenario by 4.2% in 1984 and 2.9% in 1987. It is also found that the expansion of the economy due to the higher level of world oil prices would have little side effect in terms of higher level of the consumer price index. The wage rate in the non-oil sector showed more sensitivity with respect to changes in world oil price level than did the consumer price index and the wage rate in the oil sector. In addition, government total expenditures and money supply were found to be relatively insensitive to changes in world oil price level. Nonetheless, government total expenditures showed more effects to the higher level of world oil prices than did the money supply.

Finally, in addition to studying the effects of change in the world oil price level on the Libyan economy, the model was used to determine the volume of oil exports during 1984-1987, which will enable the country to achieve a 10% annual compound rate of growth in its real gross domestic product of the non-oil sector between 1980-1987. This rate is what the country's economic and social plan (1981-1985) aims at achieving. An additional two years were added to allow for the unfavorable effects of the oil price decline of 1983 and for the huge decline in oil exports of 1981. When the volume of oil exports was allowed to assume a 10% annual compound rate of growth between 1983-1987, RGDPN realized an 8.6% growth rate between 1980-1987. Therefore, if the world oil price level during 1984-1987 follows the basic scenario, the country should aim at increasing the volume of its oil exports by 10% annually to come close to achieving its goal with respect to real gross domestic product of the non-oil sector.

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