1989

A temporary general equilibrium model with endogenous money for economic policy analysis in Sudan

Rashid M. Hassan
Iowa State University

Order Number 9014905

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Hassan, Rashid M., Ph.D.

Iowa State University, 1989

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300 N. Zeeb Rd.
Ann Arbor, MI 48106

A temporary general equilibrium model with endogenous money for economic policy analysis in Sudan

by

Rashid M. Hassan

A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY

Major: Economics

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

For the Major Department

Signature was redacted for privacy.

For the Graduate College

Iowa State University
Ames, Iowa

1989

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DEDICATION

To the sweet memory of my parents

Mekki Hassan and Dihaiba Abdean

ABSTRACT

The question of what policy options Sudan can choose to emerge from its current economic crisis of persistent inflation, unsustainable external and internal imbalances, and negative growth in real output is addressed in this study. An empirical general equilibrium model is constructed, validated and used to research the nature, causes and possible remedies for the economic problems of Sudan. The model is based on the multi-sector Walrasian equilibrium structure. Keynsian macro-features recognizing short-run adjustment dynamics, sticky prices and an endogenous monetary mechanism are also incorporated. The model allows for less than perfect flexibility in some markets such as the foreign exchange and domestic capital markets due to price rigidities. Partial adjustment in some agricultural sectors where supply lags exist are also modelled. The economy is disaggregated into 16 sectors. Detailed supply and demand specifications are given for each sector in the model. The general price level together with other nominal and real flows are endogenously determined in this model.

Econometric methods are used to estimate the model parameters. This provided superior statistical basis for model predictions over calibration. A jacobian algorithm (GAMS/MINOS) is employed to solve the model for equilibrium in the product market. Validation and policy analysis are conducted using dynamic simulation. The model showed powerful performance in recovering the historical path of the economy.

Policy experiments indicated that the economy is non-responsive to movements in nominal interest rates as the domestic credit market is highly controlled. Removal of the institutional rigidities in the domestic capital market is therefore necessary for effective monetary control and efficient allocation of capital resources in Sudan. Simulation results also provided further empirical support to the argument that expansionary fiscal and monetary policies have worked against stabilization and economic recovery in Sudan. The thesis objecting to removal of indirect taxation for budgetary reasons is challenged by the tax policy experiment results. The results of the six policy experiments suggested that for positive growth and improved performance of the Sudan economy, monetary control and minimal indirect taxation are required to support exchange rate adjustments.

CHAPTER 1. INTRODUCTION

Preamble

Various efforts have recently been made by Sudan in coordination with donor organizations and governments to overcome the severe internal and external imbalances facing the economy. The economic recovery programs of the late seventies and early eighties failed to achieve their intended objectives and in some instances led to perverse results. After almost a decade of economic adjustments and policy reforms, mainly in the direction of the IMF/World Bank prescriptions, Sudan continues to suffer from persistant inflation, unsustainable balance of payments deficits, and negative growth in real output.

While the need for fiscal improvements and monetary control was well recognized by donor initiated stabilization programs, special emphasis was placed on liberalizing the foreign trade and payments regimes of Sudan. Several devaluations and removals of various foreign exchange and trade controls were undertaken. However, devaluation and partial liberalization were introduced in the presence of a number of other distortions in the economy. Although Sudan's experience is yet to be adequately evaluated, the presence of unfavorable macro-economic environments has been considered one major factor behind the failure of trade liberalization in many countries (Sjaastad, 1983; Mussa, 1986; Fischer, 1986; and Corbo and de Melo, 1987).

On the other hand simultaneous introduction of stabilization measures along with structural adjustment programs has been blamed for

the unsatisfactory results of liberalization in some developing countries (Krueger, 1984 and Fischer, 1986). It has been argued that the two programs may contain conflicting objectives or use instruments that generate offsetting effects. Whereas the short term macro reforms of stabilization may be contractionary, structural adjustment packages aim at expanding the productive capacity and promoting allocative efficiency and growth (Cline, 1983 and Krueger, 1984). Moreover, elimination of price controls and indirect taxes with liberalization may conflict with stabilization efforts particularly in developing countries where these are the main anti-inflationary measures and sources of fiscal revenues (Mussa, 1986 and Fischer, 1986). Another, fundamentally different view of the third world economic crisis is provided by the structuralists critique of orthodox stabilization policies. Structuralists argue that tight monetary restraints and devaluation are inflationary and inconsistent with the structural nature of developing countries' economic problems which, on the contrary, call for expansionary policies and increased investment (Taylor, 1981 and Ahluwalia and Lysy 1981).

The sequencing and speed at which liberalization is introduced has also been considered an important factor in its success (Krueger, 1984; McKinnon, 1982; Frenkel, 1982; and Edwards, 1984). It is therefore essential for an adequate evaluation of Sudan's economic experience and for conducting useful policy analysis, to incorporate the complex structural interactions outlined above in an integrated analytical framework. This is an objective towards which the present study intends to contribute.

A wide range of analytical models have been employed in conducting the empirical search for the second best economic strategy in distorted economies. The social costs of economic distortions have been analyzed in isolated markets as well as with economy wide models. While partial equilibrium analyses do not capture the intermarket effects, multi-sector Walrasian models disregard short term adjustments and adjustment costs and suppress the nominal sectors of the economy. On the other hand, the monetary mechanism and short run dynamics are explicitly modelled in the usually demand driven macro-econometric models (Robinson and Roland-Holst, 1987a, 1987b). Limited information, however, is obtained from aggregated macro models on sectoral adjustments and micro-based responses in disaggregated markets.

Hybrid models that incorporate Walrasian supply structures into Keynesian macro models have also been developed to endogenize supply and demand simultaneously, recognize the role of the financial sectors and generate sectoral responses (Dungan, 1980 and Feltenstein, 1984). These models are, however, equilibrium models and do not provide for the endogeneity of money, an important phenomenon in developing countries.

Two tasks are, therefore, intended for the present research. First, the study aims at identifying the gaps in existing methods and approaches of policy analysis in developing countries. A model that attempts to overcome the deficiencies of current methods will be developed. Important structural rigidities and adjustment dynamics will be recognized in a reasonably disaggregated general equilibrium model with endogenous money. Explicit modelling of the macro sectors together with

the real spheres of the economy will allow for comprehensive representation of various tax structures as well as other fiscal, monetary and commercial policy instruments.

The second task is empirical. Parameters of the model will be measured econometrically to verify the important thesis of structural rigidities and inelastic short run responses to policy changes that questions the efficacy of monetarists' stabilization policies in semi-industrialized countries. The model will then be used to analyze the economy wide impacts of sector-specific as well as macro-economic policies in Sudan. The net effects of alternative fiscal, monetary, pricing, and foreign trade and payments regimes will be evaluated with the model, with the aim of delineating the appropriate course of actions for economic recovery in Sudan.

Organization of the Study

The study consists of seven chapters. Chapter one defines the research problem and motives of the study. The structural features and performance of Sudan economy and the debate over the current economic crisis are summarized in Chapter two. Chapter three reviews current methods of economic policy analysis in developing countries and defines specific objectives and methods of the study. A general equilibrium model for the Sudan economy is developed in Chapter four. Chapter five discusses alternative estimation procedures and presents estimates of the parameters of the model. Policy simulations and validation of the

model are performed in Chapter six. Chapter seven summarizes the findings and derives policy recommendations.

CHAPTER 2. ECONOMIC CRISIS AND THE CURRENT DEBATE OVER POLICY REFORMS IN SUDAN

The nature and origins of the present economic crisis in Sudan are analyzed in this chapter. Structural features and performance of the economy under various policies over the last two decades are summarized in part one. Part two reviews the available relevant literature and presents different views about the soundness of devaluation and liberalization policies in Sudan. The structure of economic incentives and internal terms of trade between economic sectors are discussed in part three. Part four summarizes the discussion in this chapter and defines the contribution of the present study.

Structure and Performance

Sectoral structure

Contributions of the major economic sectors of Sudan to domestic production, value of exports and employment are given in Table 2.1. According to Table 2.1, agriculture is the biggest employer and foreign exchange earner for the country. A significant share of GDP (37%) is also generated in the farming sector. This clearly indicates the importance of agriculture to the Sudan economy. Moreover, agriculture provides a vital backward linkage to industrial development in Sudan since manufacturing is mainly agro-based. The fact that only 20% of the total arable land in the country is currently utilized points out the potential of Sudanese agriculture for economic growth (Ali, 1984a).

Table 2.1 also reflects upon the sectoral growth pattern and inter-industry flow of resources in the Sudan. The share of agriculture in the labor force went down, whereas, the other sectors continued to use more labor over the same period. Given the rate of growth in total supply of labor, a declining share may not necessarily imply reduced employment, it nevertheless, indicates that larger proportions of the additional labor are being absorbed by the steadily growing services sector. The growing share of the services sector in GDP (57%) is relatively high compared to 31% and 40% in low and upper- middle income countries respectively (World Bank, 1983). This imbalance may reflect the long term effects of a sectorally biased economic policy (such as an overvalued exchange rate) that distorts

Table 2.1. Distribution of GDP, value of exports and labor force by economic sector in the Sudan, 1970-1983 (percentages)[a]

	Agriculture			Manufacturing[b]			Services[c]		
	70/71	77/78	82/83	70/71	77/78	82/83	70/71	77/78	82/83
Share in GDP(%)	38.6	36.5	34.4	9.1	7.5	7.9	52.3	56.0	57.7
Contribution to Value of Exports (%)	88.6	94.7	90.1	11.4	5.3	9.9	--	--	--
Distribution of Labor Force (%)	69.8	68.5	64.8	3.3	4.46	4.5	26.9	27.04	30.7

[a]Ministry of Finance, "Economic Survey," and Bank of Sudan, "Annual Report," various issues.

[b]Includes mining.

[c]Consists of trade, construction, transport and other services.

the structure of incentives to producers of traded goods and leads to reallocation of resources away from tradables into home goods sectors.

Internal balance

The rapidly mounting deficits of the public sector shown in Table 2.2 (row 5) indicates the serious internal imbalance facing the Sudan economy. The heavy reliance on indirect taxation to generate revenue for the government and the use of deficit financing and external borrowing to close the internal resource gap are two basic features of Table 2.2. These are common to most developing economies where the institutional difficulties associated with direct taxation and the absence of efficient capital markets limit governments' abilities to use alternative measures (income taxes and borrowing from the public) to mobilize other domestic financial resources and curb private consumption. Whereas indirect taxation distorted market prices during the period covered in the table, significant pressures were placed on domestic inflation by deficit financing and external borrowing. The short and long term effects of these policies on economic incentives, the real exchange rate and resource allocation were certainly substantial as the wrong signals were communicated to economic agents through distorted relative prices.

On the other hand, alternative instruments of monetary control other than borrowing from the non-bank public, were inefficiently utilized. Table 2.3 shows that negative real rates of interest were maintained over the same period. The lack of positive real interest rates coupled with the absence of efficient markets for financial assets (bonds) and low

Table 2.2. Internal balance and the financial performance of the public sector in the Sudan (1971-1986)[a]

	71/72	73/74	75/76	77/78	79/80	80/81	82/83	85/86
1) Cent. Govmt. Revenue (Ls mil.)	163.7	209.5	332.0	451.6	691.8	760.9	1469.0	1790.4
Indirect Tax. (% of revenue)	63.4	67.5	74.5	68.1	68.9	66.4	61.1	68.2
2) Cent. Govmt. Tot. Spend (Ls mil)	201.2	231.4	416.3	595.4	808.0	909.5	2130.7	3747.3
oDevelop. Expend. (% tot. exp.)	14.8	28.1	37.2	36.4	28.4	24.5	22.9	10.1
3) Central Govmt. Balance (1-2)	-37.5	-21.9	-84.3	-143.8	-116.2	-148.6	-661.7	-1956.9
4) Other Pub. Entities Pos. (net)	-2.1	-50.3	-46.0	4.5	-34.4	-131.5	-92.2	-69.6
5) Overall Position, Pub. Sec. (3&4)	-39.6	-72.2	-130.3	-139.3	-150.6	-280.1	-753.9	-2026.5
6) Financing-Overall Def. (Ls mil)	39.6	72.2	130.3	139.3	150.6	280.1	753.9	2026.5
o/w Central Bank Financing (%)	80.8	58.0	82.7	96.8	60.7	75.3	24.3	59.9
Foreign Borrowing (%)	9.2	33.8	17.3	3.2	39.3	24.7	75.7	40.1
Sales, Govmt. Securities (%)	10.0	8.2	0.0	0.0	0.0	0.0	0.0	0.0

[a]Bank of Sudan, "Annual Report," various issues.

Table. 2.3. GDP, total spending and the inflationary pressures of the current resource gap in Sudan 1974-1986 (Ls million)[a]

	74/75	75/76	77/78	79/80	80/81	81/82	83/84	85/86
1) GDP (Y)	1510.8	1848.0	2882.7	4122.6	5431.7	7246.1	11493.0	14920.0
2) Consumption (C)	1418.2	1604.8	2700.2	3837.1	5256.0	7384.2	10787.0	14090.0
o/w Private (%)	85.4	85.7	87.8	83.4	83.3	87.1	84.8	85.9
3) Gross dom. savings (S=1-2)	92.6	243.2	182.5	285.4	175.7	-138.1	706.0	830.0
4) Gross domestic investment (I)	265.1	427.5	413.7	735.0	899.0	1161.0	1792.0	2114.0
5) Resource gap (3-4)=Exp-Imp[b]	-172.5	-184.3	-231.2	-449.6	-723.3	-1299.1	-1086.0	-1284.0
6) Gross domestic spending (C+I) as a % of GDP (Y)	111.4	110.0	108.2	110.9	113.3	117.9	118.8	111.3
7) Rate of inflation	22	1.6	18	30	25	25	32	46
8) Nominal rate of interest (average deposits)	7.5	8.0	8.0	8.0	10.0	10.0	13.0	15.0

[a]Bank of Sudan, "Annual Report," various issues and World Bank, 1983.

[b]Equivalent to the trade balance in the balance of payments (BOP) and represents a net inflow of capital (external borrowing).

income taxation discouraged private savings and stimulated consumption and excess demand (Table 2.3).

The government rather chose to impose quantitative restrictions in order to allocate credit and manage aggregate demand. Private borrowing, however, was reported to expand from Ls206 million in 1975 to Ls 2716.0 million in 1980 (Table 2.4). Most of this borrowing is believed to have been invested in directly unproductive activities such as speculative hoarding of goods and holdings of foreign currencies (Ali and Hussein, 1986). Increased private investment in residential construction is one more example of the unproductive use of scarce capital resources (World Bank, 1983). The flow of capital resources into the steadily expanding services sector represents another feature of the sectoral growth imbalance of the Sudanese economy.

Due to the expansionary fiscal and monetary policies of Sudan, money supply rose from Ls 309.5 million in 1975 to Ls 7265 million in 1986--a 2347% increase (Table 2.4). This increase in turn led to excessive domestic inflation. Taken together, the above mentioned fiscal and monetary practices were among the main forces behind the failure of the IMF initiated stabilization programs of the late seventies in the Sudan. Also, real GDP shows very low to negative rates of growth for most of the last decade (column 9, Table 2.4).

External balance

Another important feature of the economic crisis in the Sudan is the steadily growing balance of payments deficit (Table 2.5). While

Table 2.4. Factors affecting money supply (Ls millions), 1975 - 1986[a]

	75	77	79	81	82	83	84	85	86
1) Net foreign assets	-172.4	-208.3	-286.0	-871.2	-1121.3	-2218.5	-2220.4	-2367.0	-2797.0
2) Net claims on public sector	338.2	610.8	930.3	1340.5	1214.2	1659.6	3315.1	5883.0	7166.0
3) Net claims on private sector	206.6	287.6	483.9	807.5	1173.1	1422.0	1665.8	1843.0	2716.0
4) Other	-62.9	-158.3	-191.7	292.8	895.1	1964.0	501.0	-86.0	180.0
5) Money supply (M2)	309.5	531.8	937.2	1569.6	2161.1	2827.1	3261.5	5273.0	7265.0
6) % age change in M2	-	39.8	29.2	27.4	37.7	30.8	15.4	61.7	37.8
7) % age change in CPI (inflation)	-	23.0	32.0	24.0	26.0	31.0	32.0	45.4	29.0
8) % age change in GDP	-	24.6	12.9	23.4	38.2	32.6	18.7	29.8	34.1
9) % age change in real GDP (8-7)	-	1.6	-19.1	-0.6	-12.2	1.6	-13.3	-15.6	5.1

[a]Bank of Sudan, "Annual Report" and Ministry of Finance, "Economic Survey," various issues.

Table 2.5. Sudan's balance of payments (U.S.$ million), 1972-1986[a]

	Exports	Imports	Trade Balance	Net Factor Income	Private Transfers	Current Balance	External[b] Terms of Trade	Developing[c] Countries Terms of Trade
1972/73	434.2	428.7	5.5	-26.4	9.5	-11.4	.87	.97
73/74	479.6	618.6	-139.0	-26.2	24.4	-140.8	.95	1.1
74/75	526.7	1022.1	-495.4	-43.1	66.1	-472.4	.79	1.0
75/76	639.3	1169.2	-529.3	-51.2	150.7	-429.8	.56	.95
76/77	708.9	1134.0	-425.1	-51.0	172.0	-304.1	.58	.99
77/78	691.1	1360.0	-663.9	-51.1	221.0	-494.0	.68	1.13
78/79	699.4	1321.3	-621.8	-69.0	240.0	-450.8	.83	1.05
79/80	798.4	1563.5	-765.1	-58.8	209.0	-614.9	.78	1.03
80/81	698.9	1850.4	-1151.5	-70.0	305.0	-916.5	.57	.99
81/82	704.2	2165.7	-1461.5	-157.0	350.0	-1268.5	.42	.90
82/83	839.0	2042.5	-1203.5	-142.0	430.0	-915.5	.48	.90
83/84	848.0	1649.0	-801.0	-458.0	395.0	-864.0	.83	.91
84/85	734.0	1500.0	-766.0	-478.0	430.0	-814.0	.90	.87
85/86	695.0	1336.0	-641.0	-559.0	350.0	-850.0	.66	.93

[a]World Bank (1983, 1987), Bank of Sudan, "Annual Report," various issues.

[b]Ratio of exports to imports price index constructed by author for Sudan (see Appendix A).

[c]The IFS ratio of exports to imports price index for non-oil exporting developing countries.

continuous deterioration in the terms at which Sudan trades with the rest of the world, particularly in the late seventies and the eighties (Table 2.5) was one strong factor. Besides unfavorable external economic conditions, several internal factors contributed significantly to the severe trade imbalance. In addition to the negative impacts of the expansive fiscal and monetary policies discussed in the previous section, an adverse foreign trade and payments regime was adopted by Sudan as well. The basic properties of the exchange rate and commercial policies of the country are described in the next section. It is important to note though, that a massive investment program undertaken by the government in the seventies was financed by large external borrowing. The failure of those projects to pay back when foreign debt payments fell due in the late seventies led to the clearly unsustainable imbalance of the eighties.

The foreign trade and payments regimes of Sudan

Three distinct periods are considered to represent the evolution of Sudan's foreign exchange and trade regimes. These include two phases of high government control and intervention (before 1978 and after 1984) with a liberalization era in-between (1978-1984).

Pre-liberalization period (prior to 1978) Since before independence in 1956 and until the seventies, Sudan exercised full exchange control under a system of fixed exchange rates. All capital and current international transactions were carried at the fixed nominal rate of Ls 0.35 per U.S.$ until 1972. No private dealings in foreign exchange were allowed and all export proceeds were to be surrendered to the Bank of

Sudan at the official rate. A strict import system was also maintained over the same period where the Central Bank provided the foreign exchange at a specified rate.

An exchange tax/subsidy system for non-cotton exports, imports, and remittances of Sudanese nationals working abroad (SNWA) was introduced in the early seventies (Table 2.6). As is common to almost all developing economies, multiple exchange rates are used to promote exports, encourage private transfers, and provide protection to domestic industries. Such protectionist strategies of economic development are founded in the import substitution--export promotion doctrines of industrial growth. New import systems were also introduced to mobilize additional foreign exchange resources, namely the Town-barter (TB) and the Nil-value (NV) systems. Under the TB system exporters of marginal products (other than cotton and gum arabic) were allowed to use 50% of their foreign exchange revenues to finance imports and surrender the other half to the Central Bank at the official exchange rate. The TB has been considered an export-promotion system. Additional imports, to be financed from the savings of SNWA, were also allowed via NV licensing. Importers could obtain the necessary foreign exchange from non-bank sources under the NV system, e.g., they were allowed to buy foreign exchange from SNWA.

Apart from a limited success in attracting private transfers to official banking channels, the above described payments and trade regimes failed to improve the balance of payments position. It has been argued that the overvalued exchange rate, inflationary internal imbalances and protectionism distorted the structure of incentives in Sudan in favor of

Table 2.6. Exchange rate and foreign trade policies in Sudan since 1970[ab]

	OR	ER_1 (NG-NC)	ER_2 (GVTIMP)	ER_3 (CN-INP)	RR	Trade and Payment Regimes
1970/71	.35	.35	.35	.35	.35	Strict import against payment system All foreign exch. proceeds from exports are to be surrendered to the Bank of Sudan. All transactions at the OR.
1972	.35	(.40)	.35	.35	.35	Exch. tax/subsidy (ETS) introduced to all exports except cotton and gum arabic
July '73	.35	.40	.35	.35	(.40)	Premium rate for remittances of SNWA (RR)
Jan. '74	.35	.40	.35	.35	(.56)	RR adjusted, nil value system for imports introduced
May '75	.35	(.40)	.35	.35	.56	Gum arabic exports moved to ETS rate (ER_1)
June '78	(.40)	(.50)	(.40)	(.40)	.56	1st devaluation, ER_1 adjusted
March '79	.40	.50	.40	.40	(.67)	RR adjusted
July '79	.40	.50	.40	(.50)	.67	ETS extended to cotton (CN-INP)
Sept. '79	(.50)	(.50)	(.50)	(.50)	(.50)	2nd devaluation, more liberalized trade (nil-value system abolished), unification of exch. rates (all ETS and RR removed), a parallel rate of Ls .8 for selected exports and imports
Sept. '80	.50	(.80)	.50	.50	.50	All exports and imports except CN-INP & GVTIMP at parallel rate
June '81	.50	.80	.50	(.80)	.50	CN-INP moved to parallel market rate (PR)
July '81	.50	.80	.50	.80	.50	Exch. dealers (ED) licensed and black market legalized

Nov. '81	(.90)	(.90)	(.90)	(.90)	(.90)	3rd devaluation (OR & PR unified), all trade except 1/4th of NC exports at PR, the rest at free market rate (FR).
1982	(1.3)	(1.3)	(1.3)	(1.3)	(1.3)	4th devaluation.
Fb/Mar '83	1.3	(1.61)	1.3	(1.61)	1.3	Commercial banks (CB) licensed to deal at FR 25% of exports at FR.
May '83	1.3	1.61	1.3	1.61	1.3	Licenses for ED & CB revoked, then reinstated for CB in May & ED in June 1983.
Oct. '84	1.3	(2.4)	1.3	1.61	1.3	Exports of NG-NC at FR and 50% of export revenues (100% for sesame) to be transferred to Central Bank.
Feb. '85	(2.5)	(2.5)	(2.5)	(2.5)	(3.0)	5th devaluation, stringent import licensing & currency control (39 import items banned, licenses of ED revoked), RR to be operated by CB (crawling rate).
1986	2.5	2.5	2.5	2.5	(4.10)	CB committee to allocate foreign exch. by priority list. Imports ban list extended to more than 100 items.
1987	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)	6th devaluation, more liberal import system (similar to the nil value).

[a]World Bank (1983), Elbadawi (1987), Ministry of Finance, "Economic Survey, 86/87."

[b]OR is the official exchange rate; ER_1 is the exchange tax/subsidy adjusted rate (ETSAR) for non-government imports and non-cotton exports (NG-NC); ER_2 is the ETSAR for government imports (GVTIMP), which consists of petroleum, wheat, and sugar mainly; ER_3 is the cotton exports and imported inputs rate (CN-INP) and RR is the premium rate for SNWA remittances. Exchange rates are measured as units of local currency (Sudanese Pounds, Ls) per a US$.

home goods and import competing sectors and against exportables. This fact led to a steady deterioration in the external balance (IMF, 1977). The illegal foreign exchange market grew bigger attracting larger shares of the savings of SNWA as the premium on their official remittances was much lower than the black market rate, despite its frequent adjustments. The high demand for the private transfer funds was mainly a derived demand for foreign exchange to finance the NV import licenses. Accordingly, an IMF initiated stabilization strategy was adopted by the Sudan government in the late seventies, inspite of wide professional and political objections. While a review of the conflicting views in this regard will wait for the next section, the basic characteristics of the IMF inspired foreign trade and payments regime is discussed here.

Liberalization era (1978-1984) Gradual liberalization of trade, removal of exchange controls and movement towards a unified exchange rate were the main objectives of the IMF program. Several steps were taken by the government in this direction between 1978 and 1984 (Table 2.6). Four devaluations of the Sudanese pound took place during this period, often referred to as the liberalization era (1978-1984). In 1979 all the exchange tax/subsidy schemes and nil-value system of imports were abolished. Instead only two exchange rates were established: an official (Ls .50/US$) and a parallel (Ls .80/US$) rate for selected exports and imports. In 1980, all non-cotton exports (NC) and all non-government imports (NG) except pharmaceuticals were moved to the parallel market. Later cotton joined other exports at the parallel rate. These adjustments were meant to give foreign exchange its scarce value

and align domestic with world border prices. The policies were expected to improve the structure of incentives to producers of exportables and manage the excess demand for imports.

Further steps were taken by the government to remove exchange controls. The black market for foreign exchange was legalized and licenses were issued to private exchange dealers in 1981. Commercial banks were also licensed in 1983 to deal at the free market rate. Exports and imports were again gradually shifted to the free market. The purpose of the mentioned liberalization policies was to eliminate the black market for foreign exchange, unify exchange rates and improve external balance. Due to other economic distortions, however, the wedge between the free and official exchange rates continued to grow bigger and the balance of payments position worsened. The parallel market assumed the functions of the old NV system in converting the excess demand for imports into an excess demand for SNWA savings leading to larger premiums in the free market. The parallel market continued to finance the steadily growing current account deficit.

Post Liberalization Period (1984-1987) In response to the failure of the liberalization policies to promote exports, discourage imports, and eliminate disequilibria in the balance of payments and foreign exchange markets, the government decided to exert more control on the system. Private dealing in foreign exchange was again prevented and licenses revoked in 1985. Other stringent import licensing and currency controls were imposed. More than 39 import items were banned in 1985 and higher tariffs were used to ration imports. Administrative restrictions

were extended to more than 100 import items in 1986. While tight import controls reduced imports in 1985 and 1986, black market rates stayed higher by more than 20% over the premium rate on remittances of Ls 4.10/$. Consequently, the share of the official banking channels in total private transfers continued to decline from an estimated annual average of 20% between 1981-1984, to less than 15% in 1986/87 (Elbadawi and Hussein, 1988). A new nil-value system was introduced in 1986, which reestablished once again, the current account link to the black market for foreign exchange.

The Devaluation Controversy in the Sudan

As documented by Ali (1984b), an undated IMF memorandum, believed to have been written in early 1977, began the devaluation debate in the Sudan. The IMF memo provided the basis and directives for what was known later as the stabilization program. The document argued that Sudan experienced an inflation rate higher than its main trading partners in the mid-seventies, causing the fixed nominal exchange rate to appreciate in real terms. Coupled with expansionary fiscal and monetary policies and other structural rigidities, overvaluation of the Sudanese pound was believed to be the main cause of the external and internal imbalances facing the Sudan economy. Accordingly, the memo recommended a 44% reduction in the official exchange rate to become Ls .5/US$. The proposed devaluation was believed to be adequate to realign domestic prices with their international equivalents, restore the profitability of export production, and promote better utilization of the country's comparative

advantage, particularly in agriculture. It was argued by the IMF memo that, the stabilization program would have a positive impact on the trade balance and negligible effects on domestic prices and government budget if the suggested devaluation was supported with several policy adjustments such as fiscal and monetary controls, liberalization of foreign trade, and removal of institutional rigidities in the irrigated agricultural sector.

In spite of large disagreement with the IMF analysis by many Sudanese professionals and political institutions, the government adopted the stabilization program in 1978. After that successive policy adjustments were introduced to implement the IMF recommendations to liberalize Sudan's foreign trade and payment regimes, as described in the previous section.

The major disagreement with the IMF package was on its devaluation component. Ali (1984b) documented several criticisms advanced by El Hassan (1977) against the devaluation proposal. The counter devaluation argument emphasized the importance of export/import elasticities of supply and demand in determining the net impact of an exchange rate adjustment on the balance of payments. It was pointed out that for a devaluation to have desirable effects on the trade balance it is necessary that exports and imports be price responsive (El Hassan, 1977). The IMF did not attempt to investigate this requirement.

Some empirical evidence on the inelasticity of demand for exports and imports of consumer goods is provided by the findings of Marzouk (1975). Imports of raw materials and capital goods, on the other hand, were believed by some authors to be inelastic as quantitative restrictions

had already reduced imports to essentials. Moreover, the supply of exportables, which are highly dominated by agricultural products, was expected to be non-responsive to price incentives in the short run due to several structural rigidities particularly in the irrigated sector. Accordingly, these authors concluded that the results of an exchange rate depreciation would at least be ambiguous, if not adverse on the economy. The anti-devaluation view also suggested that Sudan suffered from an economic management crisis, not a structural imbalance and admitted to the need for fiscal and monetary improvements rather than a devaluation for a remedy (Ali, 1984b).

A study of the cost structure and competitiveness of Sudan's major export crops was another source of support to the IMF devaluation proposal. El Nashashibi (1980) calculated competitiveness indices for the six major export crops of the Sudan using the domestic resource cost (DRC) criterion. The average shadow price of foreign exchange obtained from the DRC indices of El Nashashibi suggested a depreciation of the Sudanese pound would restore the profitability of Sudanese exports.

Nashashibi's framework and results have been questioned on several grounds by Hussein (1984b) and Ali (1984c). Hussein (1984b) argued that devaluation could lead to a deterioration in the profitability and net foreign exchange earnings of domestic resources in their current uses. He concluded this based on the low elasticity of supply and high elasticity of foreign and domestic prices to the price of Sudanese currency. Ali (1984c), on the other hand, using Nashashibi's own supply framework, showed that the actual 1978-1983 devaluations were either in

the wrong direction or at the wrong magnitudes. He also argued that the exchange rate should have been revalued effective 1981 according to the competitiveness criteria rather than devalued.

Contrary to the IMF argument of an overvalued currency, Hussein (1984a) showed that the Sudanese pound was undervalued in the 4 years prior to the first devaluation of 1978. Table 2.7 calculates the purchasing power parity (PPP) price of the Sudanese pound (E_R). While PPP does not generally hold under extensive import controls and restrictions, it is used here as a proxy to the equilibrium exchange rate. If E_R is considered the equilibrium rate, it is interesting to note that the 1978 and 1979 devaluations were almost on target. By comparing columns 1 and 3 of Table 2.7 we also note that the 1982 devaluation was very excessive and higher by about 50% than necessary. Since then, the nominal exchange rate has remained undervalued throughout the 80's rendering all subsequent devaluations irrelevant. This observation is in line with the results of Ali (1984c). One could further argue that the unnecessary devaluations were a major force driving the out of proportion inflation and the serious monetary disequilibrium in Sudan in the 80's. Thus, contrary to what they were intended for, the 1982-85 devaluations destabilized the economy and worsened the already severe internal and external imbalances.

Column 4 of Table 2.7 indicates the strong association between the free market rate and the PPP rate. The appreciation of E_R in 1976 and 1977 was reflected in a corresponding appreciation in the black market rate (E_B). While there is a high positive correlation between the

Table 2.7. Nominal and real exchange rates (Ls/US$) and exports/imports protection ratios in the Sudan (1970-1986)[a]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	E_o	DINFR $(\pi-\pi^*)$	E_R	E_B	NPR_X	$RNPR_X$	RPR_m	NTB	Share of Production Imports[b]
1970	.35	0.00	.35	----	.983	.983	1.658	.593	.50
71	.35	.02	.357	----	.975	.956	1.632	.586	.47
72	.35	.063	.373	----	.986	.910	1.585	.575	.49
73	.35	.08	.402	.64	1.002	.857	1.380	.621	.53
74	.35	.03	.414	.67	1.002	.831	1.369	.607	.55
75	.35	.18	.489	.74	1.001	.704	1.070	.657	.57
76	.35	-.13	.426	.66	.994	.809	1.303	.621	.61
77	.35	-.06	.401	.66	.949	.815	1.647	.500	.55
78	.38	.06	.425	.72	.989	.847	1.541	.550	.56
79	.43	.186	.504	.77	1.014	.827	1.410	.587	.51
80	.50	.10	.554	.88	1.223	1.054	1.705	.618	.46
81	.50	.10	.610	1.03	1.274	.995	1.697	.587	.41
82	.90	.14	.695	1.45	1.011	1.246	1.60	.778	.42
83	1.30	.23	.854	1.93	1.047	1.512	1.97	.767	.41
84	1.30	.25	1.068	2.44	1.151	1.325	2.274	.582	.42
85	2.50	.37	1.463	3.60	1.019	1.643	2.942	.559	.43
86	2.50	.135	1.661	4.28	1.022	1.452	2.644	.549	.44

[a]The official (E_o) and black market (E_B) rates were compiled from Bank of Sudan, Ministry of Finance and the IMF, "International Financial Statistics," various issues. The differential inflation rate (DINFR), PPP rate (E_R), nominal and real net protection rates for exports (NPR_X, $RNPR_X$) and imports (RPR_m) and the net trade bias index (NTB) are constructed by author (see Appendix B). $NTB=NE_X/E_m$; $NPR_X=NE_X/E_o$; $RNPR_X=NE_X/E_R$ and $RPR_m=E_m/E_R$ where E_m and E_X are the effective exchange rates for imports and exports and NE_X is the net effective rate for exports adjusted for subsidies on imported input.

[b]Represents the share of imported production inputs (capital and intermediate goods and 40% of petroleum) in total value of imports.

movement of the two rates, E_B maintained a substantial wedge over E_R throughout the whole period. The high free market premium represents, besides the scarcity value of foreign exchange, a risk premium on speculative holdings of foreign currencies, a suppressed excess demand for imports and a monopolistic rent to foreign exchange dealers. An analysis of the forces behind the emergence and persistence of the black market for foreign exchange in Sudan is given in Elbadawi and Hussein (1988), Elbadawi (1988a), Ali and Hussein (1986), and Umbada (1986). Elbadawi (1988a) examined the behavior of the black market for foreign exchange in Sudan and the viability of devaluation policies under currency inconvertibility and collapsing exchange rates. The study argues that black markets emerge due to currency inconvertibility and in turn provide the necessary and sufficient conditions for an indirect speculative attack on official reserves. The paper arrived at the conclusion that success of the devaluation-liberalization style of IMF policies is highly unlikely in presence of severe fiscal deficits, monetary imbalances and imperfections in the illegal market for foreign exchange.

A low price elasticity for imports (-.04) was estimated by Elbadawi (1987) in support of earlier results (El Hassan, 1977). This explains the failure of the successive devaluations to affect the price inelastic import demand. The high share of production imports shown in Table 2.7 contributes to the inelasticity of import demand. On the other hand, the high income elasticity (1.18) of demand for imports reported by the same study led to the conclusion that administrative controls and

protectionism tend to induce further expansions in the parallel market activities and stimulate smuggling.

The Structure of Economic Incentives and Internal Terms of Trade in the Sudan

To examine the impact of commercial and exchange rate policies on the structure of economic incentives in Sudan, Elbadawi (1987) derived nominal protection ratios for various products. The study found that Sudan's foreign trade and payments regimes tend to discriminate against agricultural exportables. Except for wheat and sorghum, the results showed that producers of exportables are paid far less than the border price equivalents. The extent of the sectoral bias was further investigated using the ratios of the effective exchange rates for exportables to the average rate applied to imports. The bias against agricultural tradables was again supported and estimated to range between 38% for wheat and 62% for livestock.

Columns 5 to 8 of Table 2.7 calculate the aggregate net protection ratio indices for exports and imports and derive the net trade bias (NTB). The NTB provides further support to Elbadawi's results. According to the real protection ratio for imports index (RPR_m), high tariffs were imposed on importables throughout the period under study. The real net protection ratio for exports ($RNPR_X$), however, indicates that while exportables were not paid their PPP values in the 70s, they enjoyed some protection in the 80s. This is attributed mainly to the undervalued exchange rate as a result of the previously observed excessive devaluations of the 80s.

An economy wide analysis of the indirect effects of the adverse trade and macro-economic policies on agriculture was performed by Elbadawi (1987) using the real exchange rate concept. The study showed that the implicit (indirect) impact of Sudan's commercial and foreign exchange policies further confound the direct bias against exportables in favor of non-tradables and import competing industries. The real exchange rate bias reflects the long run effects of adverse economic policies on agriculture. The study found that, on average, agricultural exportables bear an implicit tax amounting to 40% of the net import tariff, whereas only 60% of its intended protection effect goes to import substitutes. The long term effects of suppressed agricultural prices relative to the price of home goods (real exchange rate appreciation), the study observed, was the steadily increasing outflow of productive resources (labor and capital) from the farm sector into the urban based services and manufacturing sectors.

Table 2.8 derives the structure of incentives for the three main economic sectors in the Sudan for the last eleven years. Due to several limitations of the quality of data employed to construct these indices, the results of Table 2.8 should be taken with reservation and need further qualifications. They, however, represent a substantial improvement on the commonly used indices. The results of Table 2.8 generally support the findings obtained earlier. Columns 2 to 5 indicate that prices of agricultural tradables (PAGTRD) have grown slower than those of non-agricultural tradables (PNAT) and homegoods (PHG) (Figure 2.1). Prices of agricultural tradables and urban wages have been

deteriorating in real terms when deflated with the consumer price index (Figure 2.2). Real prices of home goods and non-agricultural tradables on the other hand, stayed almost constant over time. Prices paid by farmers (PRPAID) for imported intermediate goods, capital and domestic resources (land and irrigation water) increased faster than prices received (PAGTRD). The gap becomes larger when the index of prices paid by farmers includes prices of consumers goods (FTPDX) as is clear from Figure 2.3.

The above results provided further support to the argument that the internal terms of trade (relative prices and real exchange rate) were biased against agricultural producers and the urban poor and in favor of urban based manufacturing and home goods sectors over the last decade. While internal terms of trade are in line with the protection ratios findings, the subsidies realized by exporters due to the undervalued exchange rate in the 80s (Table 2.7) were not reflected in farm gate prices. This again indicates the high margin of profits accruing to trading in exports.

Chapter Summary and Directives for the Present Research

Several internal and external factors combined to bring about the current economic crisis in Sudan. Massive public investment outlays, financed primarily through extensive external borrowing, were made in the early seventies. Failure of these projects to pay off when foreign debt repayments fell due, together with a considerable deterioration in the country's external terms of trade led to the substantial balance of

Table 2.8. Prices paid and received by farmers, manufacturers and home goods sectors, 1976 - 1986[ab]

OBS	(1) CPI	(2) PHG	(3) PNAT	(4) PAGTRD	(5) PRPAID	(6) FTPDX	(7) UWINDX
1971	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1972	1.10	1.10	1.10	1.15	1.09	1.12	1.07
1973	1.30	1.40	1.20	1.63	1.39	1.37	1.35
1974	1.60	1.70	1.40	2.22	1.59	1.60	1.47
1975	2.10	2.10	2.10	1.83	1.97	2.03	1.54
1976	2.30	2.40	2.10	1.84	2.30	2.30	1.59
1977	2.80	2.90	2.70	2.54	2.82	2.75	1.77
1978	2.90	3.10	2.90	2.79	2.27	2.24	1.96
1979	3.60	3.80	3.50	3.04	4.18	4.10	2.02
1980	4.50	4.70	4.40	3.44	4.91	5.12	3.06
1981	5.40	5.90	5.20	3.65	6.93	6.69	3.79
1982	7.30	7.80	6.90	5.33	8.78	9.01	4.11
1983	8.80	9.20	8.50	7.45	11.53	11.35	4.59
1984	11.81	12.30	11.70	9.37	13.76	15.14	5.02
1985	17.70	17.40	16.40	13.21	22.94	21.45	5.31
1986	22.60	22.50	21.10	12.54	26.44	24.71	5.47

[a]Constructed by author, see Appendix C for details.

[b]Labels denote the consumer price index (CPI), price of home goods, (PHG), price of non-agricultural tradables (PNAT), price of agric. tradables (PAGTRD), prices paid by farmers (PRPAID), total paid farmers prices (FTPDX) and an urban wage index (UWINDX).

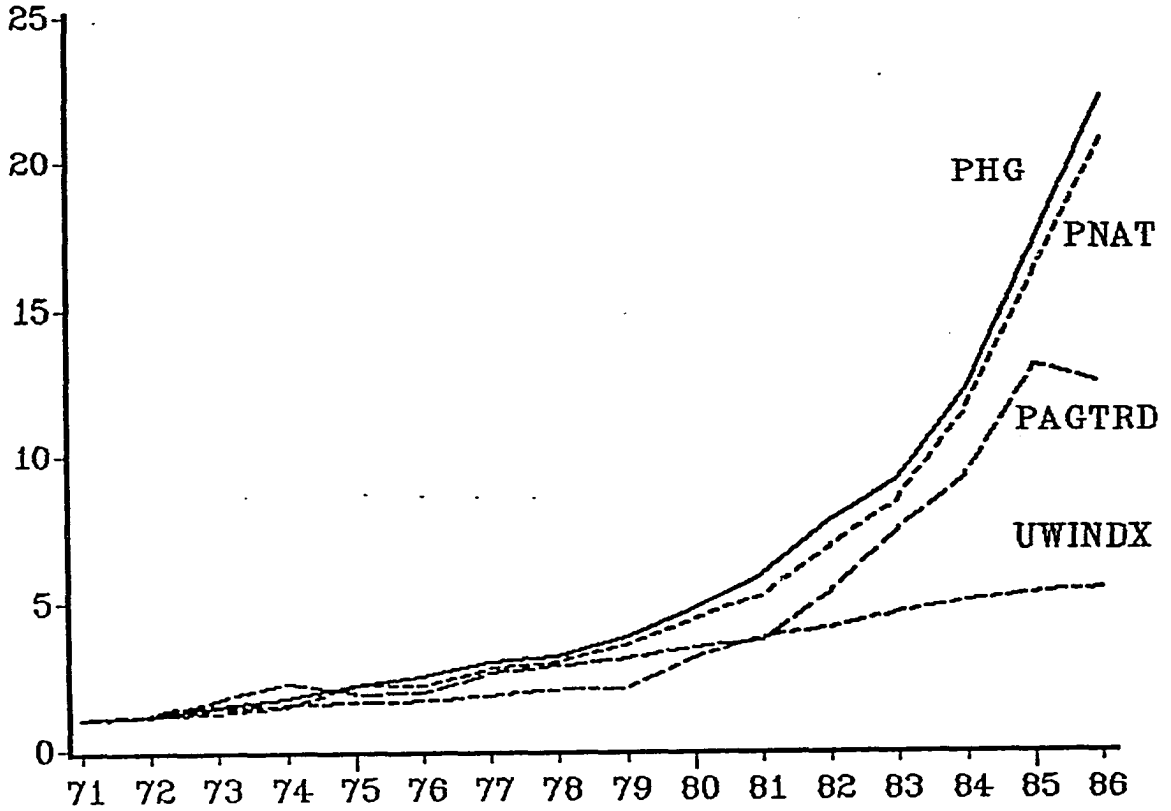

Figure 2.1. Prices of agricultural and non agricultural tradables, homegoods, and urban wage (1971-1986)

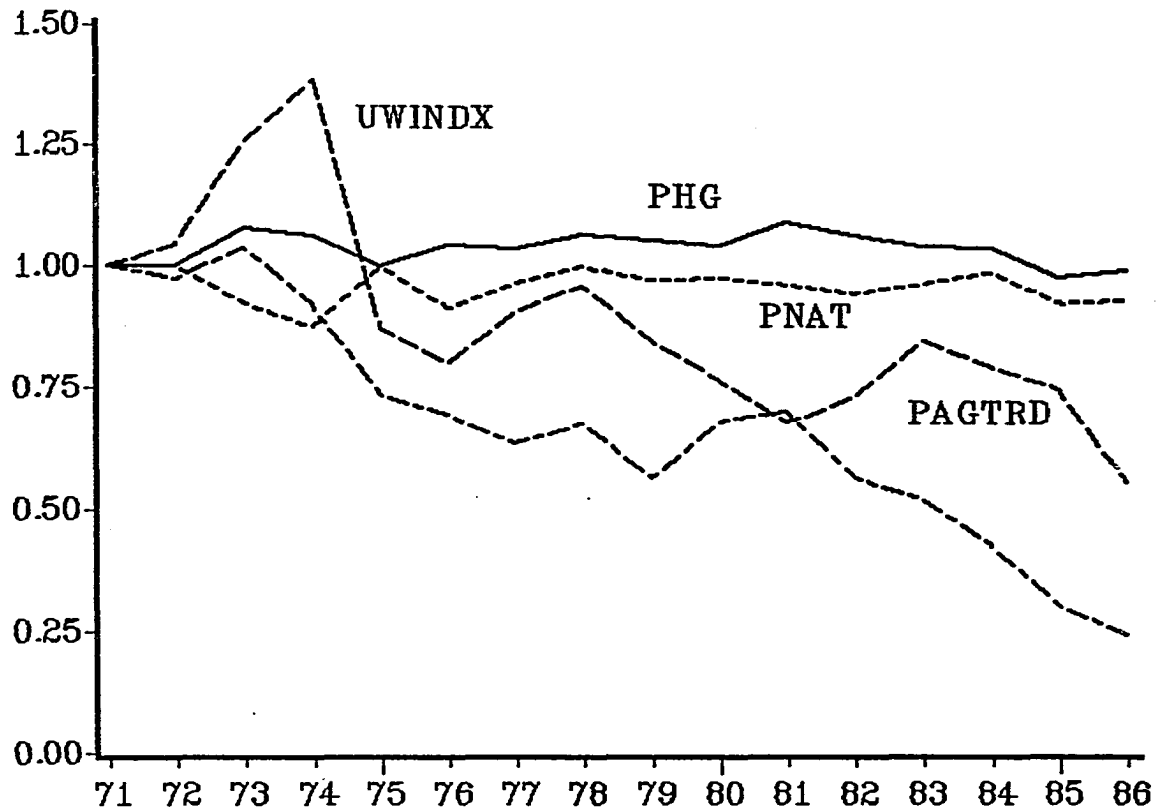

Figure 2.2. Real prices of agricultural and nonagricultural tradables, homegoods, and urban wage (1971-1986)

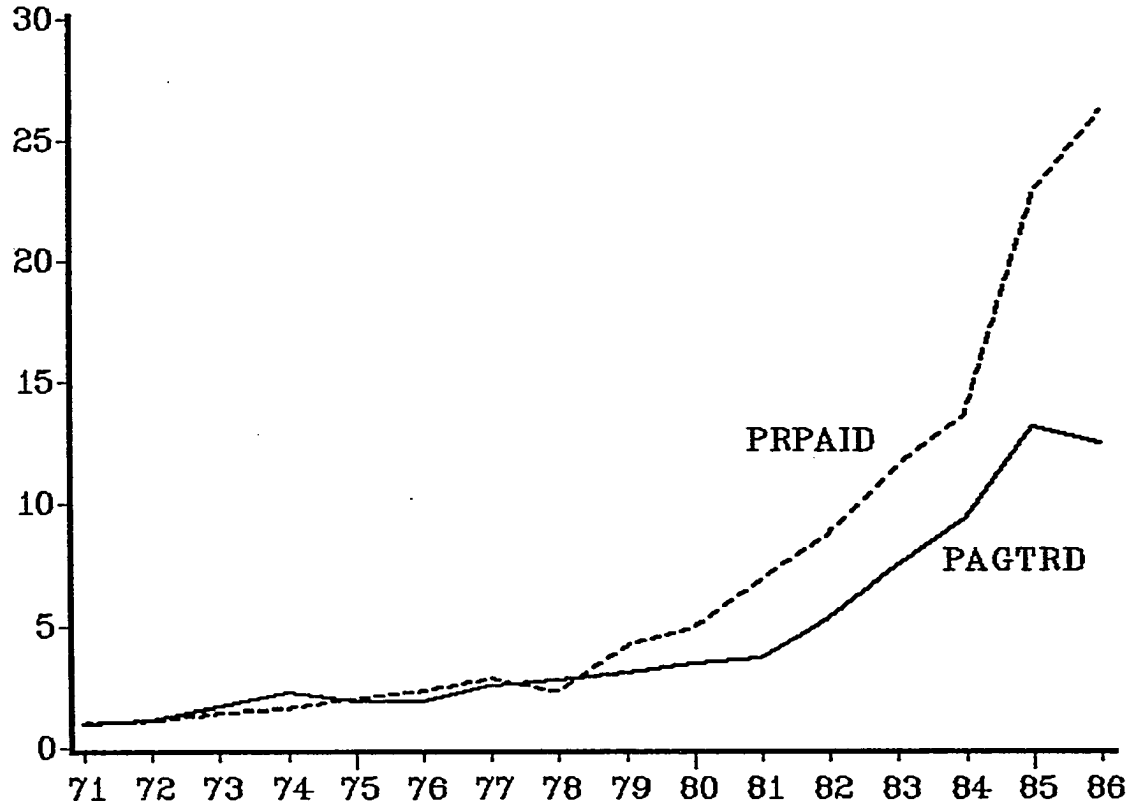

Figure 2.3. Prices paid and received by farmers (1971-1986)

payments deficits of the late seventies. Deficit financing and external borrowing, on the other hand, continued to support a steadily growing domestic resource gap caused by expansionary fiscal policies and negative real interest rates. During the same period (1971-1978) the government maintained protective commercial policies and payments regime. Full exchange control was exercised under a fixed exchange rate. Multiple exchange rates were used to promote exports, encourage private transfers and provide industrial protection.

A structural adjustment and economic stabilization program inspired by donor organizations was undertaken by the government. This characterized the liberalization period of 1978-84 in Sudan. The economic recovery program argued that the expansionary fiscal and monetary policies of Sudan led to excessive domestic inflation and thus an overvalued nominal exchange rate which in turn, distorted relative prices against exportables and in favor of imports and non-tradables. These factors were believed to be the main forces behind the unsustainable balance of payments deficits facing Sudan. Protectionists trade policies were also criticized for imposing additional implicit tax on exportables and further distorting the internal structure of economic incentives. Devaluation of the nominal exchange rate and liberalization of the foreign trade and payments regimes were therefore recommended by the stabilization program.

The desirability of devaluation for Sudan has been questioned on several grounds. Anti-devaluation views emphasized the inelasticity and structural rigidities arguments. Empirical evidence for inelastic supply

of and demand for Sudan's exports has been provided. Demand for imports has also been shown to be non-responsive to price shocks. The liberalization and devaluation measures of 1978-84 were not successful to bringing about the desired changes. On the contrary, Sudan continued to suffer from severe internal and external imbalances, a high black market premium for foreign exchange, persistent inflation and a negative rate of growth in real output. In 1985 liberalization policies were reversed and the country went back to a system of complete control of the foreign trade and payments.

Using PPP further evidence was provided in this chapter in support of the first two devaluations (1978 and 1979). The results of Table 2.7 also show that the rest of the devaluations (1981-1985) were higher than necessary as argued by Ali (1984c). The bias against agricultural exportables in favor of non-agricultural tradables and homegoods measured by Elbadawi (1987) was further supported by the results of Tables 2.7 and 2.8 and Figure 2.1 of this chapter. The net effect on agricultural producers and the urban poor, of the various commercial and macro-economic policies was measured by the prices paid and received indices of Table 2.8 (Figures 2.2 and 2.3).

While the appropriateness of the various devaluations administered in Sudan has been extensively discussed in the literature, the liberalization experience has not yet been adequately analyzed. It has been observed, by this (Tables 2.2-2.5) as well as other studies (Elbadawi, 1988a) that liberalization was introduced in presence of expansionary fiscal and monetary policies and distorted relative prices and interest

rates. The implications, however, of the simultaneous opening of the current and capital accounts along with successive devaluations in such inflationary environment and with the domestic capital market rationed at negative real rates of interest, were not addressed systematically.

The debate over the soundness of liberalization in Sudan was conducted in a partial equilibrium framework. Several important intermarket and intersectoral linkages were therefore not captured. The expenditure-absorption real exchange rate approach of Elbadawi (1987), however, was one step in the direction of general equilibrium analysis. While the incidence of policy on relative prices and incentive structures was measured, real responses and micro supply/demand adjustments to such shocks were not investigated. This is the task that the present research intends to take.

The important elasticity question raised by the counter-devaluation arguments requires more rigorous empirical verifications, an objective to which the present work also plans to contribute. The parameter estimation will be conducted in a general equilibrium context. Moreover, the consensus on the significance of the monetary disequilibrium and internal imbalances to developing economies in general, and the central role they play in the Sudan in particular, calls for adequate modelling of the monetary phenomena (Taylor, 1979; Aghevli and Khan, 1978; and Feltenstein, 1984). Consequently, the present study aims at explicity incorporating the nominal sectors in the empirical model. In recognition of the fact that the economy of the Sudan must have been out of a full Walrasian equilibrium at least for the last 15 years due to extensive price controls and rationing regimes, the study uses the temporary equilibrium

approach. The model will then be used to evaluate the economy wide impacts of several policy regimes. Performance of the economy under fiscal, monetary, exchange rate and trade policies that eliminate domestic economic distortions will be examined.

CHAPTER 3. ECONOMIC POLICY MODELS: A SURVEY OF LITERATURE

This chapter reviews several current methods of policy analysis. The structural features of various analytical models are outlined and compared. Drawbacks and advantages of each modelling approach are discussed and gaps identified. Specific objectives and contributions of the present research to modelling economic systems in developing countries are then defined.

Methods of Policy Analysis

A wide range of analytical tools have been employed to study the impacts of various policy measures on the behavior of economic variables. Available models are classified into partial and general equilibrium approaches to policy analysis. Important members in each group are discussed below.

Partial equilibrium models

Comparative advantage measures such as the nominal and effective protection ratios and domestic resource costs are often used to calculate the economic value of goods and primary resources for project evaluation and policy analysis purposes. While these concepts measure market distortions and generate shadow prices for optimal allocation of resources, they fail to evaluate the welfare costs of intervention policies. Protection measures have been shown to be inadequate in

presence of other distortions in the economy and when market interactions are important (Bhagwati and Srinivasan, 1973, 1980a).

Welfare measures (consumer and producer surpluses), on the other hand, are used to evaluate the social costs of economic interventions as compared to the free trade position. Surplus concepts, however, are generally used in isolated markets and do not capture the effects of multiple price changes. Substitution possibilities in demand and supply are often ignored by these measures (Harberger, 1971 and Tolley et al., 1982).

Multi-market models were thus developed to allow for substitution effects in interdependent markets. The multi-market framework has mainly been used by the World Bank staff to analyze the impacts of agricultural pricing and marketing policies in developing countries (Braverman, et al., 1985, 1986 and 1987; Singh, Squire, and Krichner, 1984). This approach models the supply and demand components of agricultural commodity markets according to the neo-classical theory of producer and consumer behavior. The impact of various agricultural policies on the level and composition of agricultural output and farmers' incomes are analyzed. This type of model also allows for examining the effects of agricultural policies on the government budget and foreign trade. This is, however, a unidirectional relationship, since feedback effects are not modelled in this approach. Therefore, the effects of policies directed towards other sectors of the economy (macro and non-farm policies) on agriculture cannot be handled with multi-market models.

General equilibrium methods

These models capture the economy-wide effects of sector specific as well as macroeconomic policies. This group includes mainly the multi-sector, Walrasian, and macro-econometric models as well as various combinations of them.

Linear multi-sector models (LMS) Input/output and linear programming models are the most important methods in this group. They represent a general equilibrium framework with a special focus on the production side of the economy. Both methods use the fixed coefficient structure pioneered by Leontief (1953), which implies constant returns to scale.

Multi-sector input/output models contain no policy variables and no behavioral rules are followed. The exogenously determined final demands are handed to the fixed-coefficient accounting matrix of intermediate demands to deliver sectoral outputs. Internal consistency of the generated sectoral production is ensured by the material balance system that describes the economy wide interdependancies. The static input/output model has been extended to handle foreign trade (Chenery and Clark, 1959 and Robinson and Song, 1972), primary factor requirements (Leontief, 1953), dynamics (Leontief, 1970 and Gupta, 1977) and technological change within its general linear structure (Almon, 1967; Adelman, 1969; and Stone, 1970).

While input/output models were generally used to generate compatible physical production plans, they were also employed to evaluate

consistency of concomitant value flows and as a price determination mechanism (Dervis et al., 1982). They provided a powerful planning tool for centralized economies.

A decision rule that determines the best production plan is introduced by Linear Programming techniques (LP). The full capacity operation assumption implicit in the input/output model structure is also relaxed by introducing the inequality constraints of the LP formulation. This allows for capacity underutilization and endogenous make-or-buy decisions (Dervis et al., 1982). Static as well as multi-period models can be developed to determine optimal production and trade flows and to price fixed resources (the LP duals). As primal price weights are taken, as given in the LP formulation, the endogenously determined shadow prices (income) do not feed back into the model. A non-linear structure of the objective criterion is required to allow for a simultaneous determination of prices and quantities endogenously. Also, LP models solve for efficient resource allocation plans according to the central planners objective function and do not necessarily represent an equilibrium point in decentralized markets (Heal, 1973 and Dixon, 1975). Non-linear programming models, however, can be used to achieve market allocations by maximizing consumer and producer surpluses. Policy variables need to be explicitly incorporated in order for such models to experiment with non-command systems, where policy makers can only influence economic activity indirectly.

Walrasian general equilibrium models The Walrasian family of applied general equilibrium models represent an important movement towards full general equilibrium analysis in decentralized economies. Two major extension are made on the traditional input/output system to allow for endogenous determination of all prices and quantity flows in the economy simultaneously. First, final demand is endogenized by using an income-expenditure identity linkage (feedback mechanism) to close the open Leontief model. Walras Law is then used to eliminate imbalances and guarantee full equilibrium. Second, more flexible demand supply structures are used to allow for subsitution effects. Various demand system (e.g., the Linear, Addilog and Almost Ideal expenditure systems) are commonly utilized to allocate total consumption to admissible commodity demand functions. The supply side, on the other hand, employs non-linear production technologies such as the Cobb-Douglas and the constant elasticity of substitution (CES) structures. Multi-stage budgeting is often used to generate weakly separable components of the supply/demand response structure. The production and consumption spheres of the economy are modeled according to the neo-classible theory of producer/consumer behavior (Dervis, de Melo, and Robinson, 1982).

Given the technical, behavioral and institutional set up of the economy, Walras Law is invoked to obtain a fixed point solution. An equilibrium vector of relative prices that clear all factor and commodity markets (satisfy Walras Law) is derived. Accordingly, equilibrium quantities and trade flows consistent with the autonomous production and

consumption plans of the various economic agents in the economy, are determined simultaneously.

Johansen (1960) was able to obtain the first numberical solution for a full general equilibrium model. The system was linearized by logarithmic differentiation and solution values gave rates of change in endogenous variables. More advanced solution algorithms were then developed which enabled direct solutions for the levels rather than growth rates of all endogenous variables (Scarf and Hansen, 1973; Eaves, 1972; Shoven and Whalley, 1974; and Todd, 1976). A large number of empirical general equilibrium models were developed and solved for various analytical purposes as solution algorithms became available. This group is commonly referred to as the computable general equilibrium models (CGE).

CGEs are employed for economic policy analysis in both industrialized and developing countries. Income distribution issues, trade policy and economic structure and growth are analyzed in a number of studies for developing economies (Adelman and Robinson, 1978; Lysy and Taylor, 1980; de Melo, 1979; Dervis and Robinson, 1978; Ahluwalia and Lysy, 1979; and de Janvry and Sadoulet, 1987a). Dixon et al. (1982) and Shoven and Whalley (1974) provide some examples from devloped economies. Multi-country models have also been developed to address issues of international trade (Spencer, 1986; Harrison, 1986; Whaley, 1985; and de Janvry and Sadoulet, 1987b).

In spite of the comprehensive characterization of the ecnomic system and the strong theoretical basis on which they are founded, Walrasian equilibrium models suffer from three main weaknesses. First,

disequilibrium phenomena cannot be analyzed within this structure as they are inconsistent with Walras Law. Problems such as Keynesian unemployment, sticky prices and quantity adjustments in rationed markets can only be handled with disequilibrium models.

The second deficiency of Walrasian multi-sector systems relates to modelling the macro-economy, specifically the monetary mechanism. Walrasian models are concerned basically with real phenomena and relative price movements where the nominal sectors of the economy are either absent or represented in such a way that money is neutral. These specifications correspond respectively to an exogenously specified general price level or endogenous absolute price, determined jointly by commodity and money market equilibria. Money supply is extraneously set in the latter, and all prices adjust fast enough such that dichotomy between the real and nominal sectors of the economy is preserved (Adelman and Robinson, 1978). This separation of the micro/macro subsystems coupled with the full equilibrium assumption, make Walrasian CGEs appropriate only for medium to long run analysis of structural change and economic growth. Therefore, the dynamics of short run adjustment towards full equilibrium, where some markets are slow to clear and where inflation has real effects in the short run, cannot be studied within this framework (Dewatripont and Robinson, 1985 and Taylor, 1983).

Empirical estimation of the model parameters presents the third difficulty in working with CGE models. Calibration to benchmark year data, augmented by borrowing from other sources (literature search) or

educated guessing of key parameters such as elasticities, is generally followed. Due to the full simultaneity of the observed endogenous data in Walrasian CGE systems, proper stochastic estimation of the model faces several difficulties, a lengthy discussion of which is left for Chapter 5. Calibration, however, represent a deterministic method for the numerical selection of parameter values, where all possible measurement and specification errors are assumed away. Moreover, the use of a single data point (e.g., the base year data set) poses serious identification problems for calibration techniques (Lau, 1984). More appropriate procedures have been recently suggested for the stochastic specification and estimation of CGE models (Mansur and Whalley, 1984 and Jorgenson, 1984).

Macro-econometric methods Economic processes are characterized as an integrated stochastic system of reduced form response functions in these macro-econometric class of models. Time-series observations on the set of endogenous and predetermined variables are employed in the econometric estimation of the systems parameters. Simulations are then performed on the model to experiment with economic policies and forecast future behavior of the economy. Issues such as the causes and implications of inflation, unemployment, budget deficits, monetary control and price rigidities are studied. Unlike Walrasian models, disequilibrium, non-neutrality of money and formation of expectations are allowed in order to examine the short run adjustment dynamics of the system when outside of its full equilibrium path. These models are

generally used to study the interactions between the nominal and rural spheres of the economy and evaluate the impacts of various fiscal and monetary policies on economic stability.

A huge number of macro-econometric models exist in the literature. The Philips Curve-Business Cycle studies comprise the most important and the biggest member of this group. The real exchange rate models developed in Salter (1959), Sjaastad (1980), and Dornbusch (1972) and recently adopted by the International Food Policy and Research Institute (IFPRI) to anlyze the impacts of commercial and foreign exchange policies in several countries (Valdes, 1986; Garcia, 1981; Scobie, 1983; and Cavallo and Mundlak, 1982) provide another example. The vast majority of these models are generally demand driven and belong to the Keynesian-monetarists disequilibrium approach to macro analysis. High aggregation of sectors into two to three composite commodity and asset markets is common. They are accordingly lacking in terms of studying relative price effects and sectoral adjustment.

Advanced computation techniques realized in the early sixties permitted extensive disaggregation of the macro-econometric models into many consuming, producing and financial sectors (Duesenberry et al., 1965; Ando, 1974; Choudhry et al., 1972; Ball, 1973; McCracken, 1973; and Almon et al., 1974). In spite of the significant disaggregation adopted in macro models, they remained demand driven. While producing sectors are incorporated in considerable detail in the model, supply plays no role in determining prices and output. Prices are determined by separate regression equations and fed into the demand sectors to generate total

output, which is then thrown into an input/output matrix to allocate sectoral production (Robinson and Roland-Holst, 1987a).

Mixed models This class represents an attempt towards integrating demand based macro models with the micro founded neo-classical supply structure. Walrasian CGE models that incorporate detailed macro structures have been applied to less developed countries (Adelman and Robinson, 1978; Ahluwalia and Lysy, 1979; Lysy and Taylor, 1980; Taylor, 1983; and Dewatripont and Robinson, 1985), developed economies (Dungan, 1980; Robinson and Ronald- Holst, 1987b; and Adelman and Robinson, 1987), as well as multi-country models of international trade (Deardorff and Stern, 1986). Supply behavior is given an equivalent role in deriving relative prices and output as Walras theory requires. On the other hand, the rudimentary structure of financial sectors and exogeneity of money supply renders these models inadequte to experiment with various fiscal and financial policies that influence budget deficits and monetary movements. Macro shocks, however, are allowed to affect relative prices and real activity through partial adjustment in factor markets, inflexibility of prices, money illusion and the saving-investment imbalances in the "macro closure" rule (Robinson, 1989).

The important linkage between monetary disequilibrium and public debt in developing countries, where financial assets markets are non-existent or inefficient, has been emphasized in a number of studies (Taylor, 1979; Aghevli and Khan, 1978; Tanzi, 1978; Feltenstein, 1984;

and Scobie, 1983). Specific behavioral assumptions are employed by Feltenstein to incorporate the portfolio balance condition into a Walrasian CGE model. On the other hand, a reduced form of the monetary equilibrium rule is econometrically estimated to establish the connection between domestic credit expansion and government deficits in the other studies.

The assumption of competitive Walrasian equilibrium is relaxed in Harris (1986) where an increasing returns to scale production technology is employed. Keyzer (1986), on the other hand, violated the instantaneous adjustment assumption of Walras Law by using supply lags in agricultural production. Temporary equilibrium models have also been developed to capture the dynamics of disequilibrium phenomena (Grandmont, 1977, and Neary, 1980). Economy wide adjustments to exogenous shocks are also examined under uncertainty with a dynamic CGE model by Adelman, Sarris and Roland-Holst (1986).

Methods and Objectives of the Present Research

The main objective of this study is to develop an empirical general equilibrium model for Sudan in order to evaluate the economy wide impacts of various economic policies feasible for the country. The study intends to adapt the latest methods in applied general equilibrium analysis to Sudan's economic system. The following specific goals are set for this study to achieve:

1. A model which recognizes the significance of the macro-economic structure, particularly the monetary mechanism to the Sudan economy as discussed in Chapter 2, will be constructed.

The relationship between the government sector and an endogenous money creation mechanism will be explicitly modelled in the present study. An absolute price level will be determined simultaneously with other nominal and real flows within the system. This together with a detailed tax/subsidy stru ture will enable the model to evaluate the economy wide impacts of alternative sector specific and macro economic policies.

2. Less than perfect flexibility in some markets will be assumed to reflect the various rigidities introduced in the economy by government interventions. The fixed exchange rate and currency inconvertibility, import controls, inflexible interest rate, credit rationing and price and income supports provide a case for disequilibrium in Sudan economy. While the emergence of directly unproductive (DUP) rent-seeking sectors (Krueger, 1974, and Bhagwati and Srinivasan, 1980b) will not be modelled explicitly as in Grais, de Melo and Urata (1986), the parallel market premium will be used to represent the opportunity cost of holding domestic money.

3. Supply lags in some agricultural commodity markets will be specified. This is due to the fact that production plans, and land allocations in particular, on the irrigated public farms of Sudan are usually made ex-ante and stay unaltered over the production cycle. Various price expectation schemes will be employed to model the partial adjustment mechanism in agricultural supply and private investment functions.

4. Inflexibilities and differential adjustment rates among the different markets lead to non-neutrality of movements in nominal aggregates and macro shocks. This provides an option for the government to affect economic activity and allows the model to evaluate the short-run effects of macro-economic policies. The fact that some markets are less quick and efficient to clear than others violates the full equilibrium assumption of Walras theory. Walras Law, however, is assumed to hold in a sequence of temporary equilibria as defined in Hicks (1946).

5. Time-series data will be used to estimate the model's parameters econometrically. Estimation of the import/export supply and demand elasticities is necessary to verify the inelasticity arguments against devaluation and trade liberalization discussed in Chapter 2. The argument that agriculture provides the tax base for industrialization in developing countries due to its inelastic supply structures will also be examined. The elasticity structuralists' views of limited substitution possibilities in production and trade and thus low response elasticities (Robinson, 1989) can thus be evaluated for the Sudan economy. Stochastic simulation as well as calibration of the model to the observed history of the economy will be used for validation.

Chapter four develops the general equilibrium model. Estimation of the model is done in Chapter five. Chapter six performs the model validation and policy simulations and the findings are summarized in Chapter seven.

CHAPTER 4. A GENERAL EQUILIBRIUM MODEL FOR THE SUDAN ECONOMY

This chapter develops a general equilibrium model for Sudan (GEMS) and describes the market clearing mechanisms for a succession of temporary Walrasian equilibria. The model is built around the multi-sector Walrasian structure of decentralized economies with the macro components and financial sectors explicitly integrated. Domestic supply is discussed first followed by the foreign sector. Income, expenditure and final demands are then derived. Conditions for product market equilibrium and the macro-economic closure and nominal spheres of the economy are discussed last.

Supply Structure

There are ten agricultural tradables in the model, produced in four distinct regions. A non-agricultural tradables sector, representing the domestic manufacturing industry and a home goods sector contribute to total value added. Eight of the ten agricultural products and the manufactured output are sold in both domestic and foreign markets. Four import categories are distinguished, namely intermediate and capital goods and two consumers imports. The supply sector, also derives demand for intermediate inputs and primary factors. The supply structure is neo-classical in nature, where production functions are used by producers to maximize profits. Micro-economic theory of the firm then generates the sectoral output supply and factor demand functions.

Agricultural tradables

Sudan is predominantly an agricultural country. The economic significance of the farming sector to the country was discussed in Chapter Two. Accordingly, agricultural production represents the main focus of modelling supply adjustment in Sudan. The farm sector is highly disaggregated into ten commodity markets and four producing regions. The ten crops modelled here contribute to more than 80% of the foreign exchange earnings and provide most of the food supply in the country. On average, about 85% of the total value of food is contributed by the modelled agricultural sectors over the period covered by this study (1971-1986). The remaining 15% of the total value of food consumption came from domestic and imported manufactured goods which are also modelled here.

The modelled crops are produced under different farming systems representing different technologies and institutional environments. Table (4.1) summarizes the basic features of the production and marketing organization for each crop. There are two main producing regions, the irrigated and the dry land subsectors. The public schemes, region 1 (mainly in Central Sudan), generate most of the output in the irrigated sector. A sizable proportion of wheat production, however, comes from private irrigation farms in the northern parts of the country (region 2). Besides traditional agriculture (region 3), mechanized farming (region 4) is also an important producer of dura (sorghum) in the rainfed sector.

Decision making is highly centralized in the public irrigation schemes. Allocations of land areas and chemical inputs between the

Table 4.1. Production and marketing systems for the major agricultural tradables

	PRODUCTION SYSTEMS			
	Dry Land		Irrigated	
	Traditional	Mechanized	Public	Private
Crops[a]	CN,GN,SS,GM, DR and STOZ	DR and SS	CN,GN,DR,WT	DR, WT, BNS
Modern Technology				
Chemical inputs	Not used	Not used	CN and WT	WT
Mechanical power	CN	DR and SS	CN,GN,WT	DR, WT, BNS
Decision Making				
Land allocations	Decentralized	Decentralized	Centralized	Decentralized
Modern inputs	Decentralized	Decentralized	Centralized	Decentralized
Market Organ.				
Competitive	GN, SS and DR	DR and SS	GN and DR	DR and WT
Non-competitive	CN and GM		CN and WT	
Rotation	Flexible	Flexible	Fixed	Flexible

[a]Crops are cotton (CN), groundnuts (GN), sesame (SS), gum arabic (GM), sorghum (Dura DR), wheat (WT), beans (BNS), and livestock and other products (STOZ).

different crops and the timing of the major mechanical operations are made by the scheme administration. A fixed cropping pattern is imposed on the tenancies allotted to individual farmers. Limited credit is provided by the production corporations for cotton production. Farmers are in turn required to hand over the cotton and wheat crops to the corporation. Cotton is then sold to the cotton marketing board which

sets the procurement price, while wheat is delivered to the government at the official price for distribution to flour mills. On the other hand, groundnuts and dura are sold by the individual tenants to private traders.

A land rent, together with charges for water, materials (intermediate inputs) and services (cost of mechanical operations) provided by the corporation are deducted from the farmers cotton proceeds. The corporations perform the critical mechanical operations and monopolize the procurement and supply of most of the non-labor inputs, e.g., fertilizers, pesticides, etc. These inputs are supplied according to the rates recommended by research stations for cotton and wheat primarily.

Farmers, on the other hand, control basically the allocation of family and hired labor between various crops in the fixed rotation. Accordingly, farmers decisions are assumed to influence yields rather than production, since areas are decided by the government agency. Individual tenants are, therefore, assumed to choose the optimal allocation of their labor resources that will maximize expected net returns per unit area, given their yield technology (production function) and the fixed allocations of land and intermediate inputs. Yield response (rather than output supply) functions and factor demands are then derived from the optimality conditions of this expected profit maximization problem. The following yield response equations are thus specified for the four crops grown in the public irrigation schemes (region 1):

$$Y1_{it} = Y(EN1_{it}, W1_t, GIA1_{t-1}, WH1_t) \qquad i=1, \ldots 4 \qquad (4.1)$$

where i refers to crops, t denotes time and 1 refers to Region 1.

Four yield equations as in (4.1) are estimated for cotton, groundnuts, dura and wheat. Yield at t in region 1 ($Y1_{i,t}$) is specified as a function of expected real net returns ($EN1_{it}$) of the four crops, the real wage rate ($W1_t$), a weather variable ($WH1_t$), and government investment in agriculture lagged one year ($GIA1_t$). Lack of data on crop specific or the general stock of farm capital precluded the use of physical capital as a regressor in (4.1). Aggregate government investment in agriculture, lagged one period ($GIA1_{t-1}$) is alternatively used to represent changes in farm capital. Various expectations formation schemes and dynamic adjustment structures (lags) are employed to find the best representation of farmers' expected returns ($EN1_t$). Expected returns from crop i at period t is a weighted average of the previous behavior of returns ($N1_{t-s}$) as follows:

$$EN1_{it} = E(N1_{i,t-s}, \phi 1_i; s=1, \ldots T) \qquad i=1,\ldots,4 \qquad (4.2)$$

where ϕ is the adjustment weight and T defines the length (duration) of the adjustment. Actual real net returns per unit area of crop i ($N1_{it}$) t is defined as:

$$N1_{it} = P1_{it}(1-t_{it})Y1_{it} - \Sigma_n \alpha_{ni} P1_{nt} - WR_{it} \qquad i=1,\ldots,4 \quad (4.3)$$

where Pl_{it} and Pl_{nt} represent real producers prices[1] of crop i and intermediate input n (procurement or market farm gate prices) in Region 1. α_{ni} is the amount of input (n) used per unit area of crop i, and WR_{it} is the land and water rate for crop i collected by the scheme administration. The indirect tax rate on crop i is given by (t_i).

Area allocations to wheat and cotton in the irrigated schemes, on the other hand, are decided by the government. The main objective of the government in setting crop areas is to minimize wheat imports and generate foreign exchange from cotton, being the major export earner for the country. Accordingly, wheat and cotton areas are not chosen by optimizing economic agents and thus proper response functions can not be estimated. A decision rule can be specified, however, to characterize the objectives of the controlling government agency. The problem with such modelling practice is the maintained assumption of a stable objective criteria for all governments. Alternatively, time series methods can be used to fit the historical data without the need for behavioral specification. The same problem of structural change is again faced by time series methods. Wheat and cotton area can also be set exogenously outside the model.

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[1]Note that all variables in the model are real. Nominal variables are deflated by the consumer price index (the general price level) which is endogenously determined in the money market. Accordingly, all real prices and their effects are endogenous. This allows for the evaluation of the economy wide effects of macro shocks and movements in nominal and real variables transmitted by the general price level to real price movements.

The present study has chosen to model government policy assuming that promotion of sufficient wheat supply to the politically powerful urban population and higher export earnings through increased cotton production will continue to be the main objective of decision makers in Sudan in the short to medium runs. These two goals have motivated agricultural policies in Sudan for at least the period covered by this study. Area response functions for wheat ($AWT1_t$), cotton ($ACN1_t$) and total land ($TA1_t$) are therefore specified to move with world prices and other domestic supply factors in the irrigated sector (region 1):

$$AWT1_t = W1(AWT1_{t-1}, PWT^*_{t-1}, PCN^*_{t-1}, WTRiO_{t-1}, TA1_t) \quad (4.4)$$

$$ACN1_t = C1(ACN1_{t-1}, PWT^*_{t-1}, PCN^*_{t-1}, STCN_t, TA1_t) \quad (4.5)$$

$$TA1_t = A1(TA1_{t-1}, GIA1_{t-1}) \quad (4.6)$$

Equation (4.4) defines current wheat area in region 1 as a function of area under wheat in the previous year ($AWT1_{t-1}$), real international wheat (PWT^*_{t-1}) and cotton (PCN^*_{t-1}) prices lagged one year, total area planned for region 1 in the current year ($TA1_t$) and the ratio of domestic production to total wheat supply in the preceding year ($WTRiO_{t-1}$). The same factors, in addition to beginning period stock of cotton ($STCN_t$) are specified to determine cotton area in (4.5). Total area planned for region one in the current season is defined as a function of last years land ($TA1_{t-1}$) and real government investment in agriculture one year back ($GIA1_{t-1}$).

Farmers have partial control over the allocation of the remaining area (after cotton and wheat allocations are made) between groundnuts and dura. Therefore a groundnuts area response function is specified in (4.7) to depend on last years area ($AGN1_{t-1}$) and expected net returns from groundnuts ($ENGN1_t$) and dura ($ENDR1_t$) plus total land ($TA1_t$).

$$AGN1_t = G1(AGN1_{t-1}, ENGN1_t, ENDR1_t, TA1_t) \qquad (4.7)$$

Area under dura is then derived as a residual in (4.8) below.

$$ADR1 = TA1_t - AWT1_t - ACN1_t - AGN1_t \qquad (4.8)$$

A significant share of domestic wheat supply is produced on the private irrigated farms of Northern Sudan. Area and yield response equation are specified below for wheat in the private farms (region 2).[2]

$$YWT2_t = Y2(ENPW2_t, ENPB2_t, WH2_t) \qquad (4.9)$$

$$AWT2_t = W2(ENPW2_t, ENPB2_t, AWT2_{t-1}, GOL2_t) \qquad (4.10)$$

$$ENP2_{it} = EW(NP2_{i,t-s}, \phi 2_i: \; s=1,\ldots T) \qquad (i=1,2) \qquad (4.11)$$

Expected real net prices ($ENP2_{it}$) of wheat and broad beans which is the competitive crop in this region, plus weather ($WH2_t$) determine the yield of wheat in region 2 as in equation (4.9). Wheat area in this region is also a function of last years area, expected prices and

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[2]Due to a lack of data on beans production, no supply response functions were specified. The equilibrium quantity of beans is, therefore, determined by the demand side and the nominal price is set exogenously (perfectly elastic supply curve).

quantity of gasoil[3] allocated to this region ($GOL2_t$). Price expectations for wheat and broad beans are defined in (4.11) as a function of the history of net market prices ($NP2_i$). Net prices represent per unit area value added (net of intermediate costs). Here ($P2_i$) and (t_{it}) are the real market price and indirect tax rate on crop i, respectively.

$$NP2_{it} = P2_{it}(1-t_{it}) - \sum_{n} ni(P2_{nt}) \qquad (4.12)$$

Like private irrigation schemes, decision making in dryland farming is decentralized and assumed to represent the optimal choices of profit maximizing farmers. Area and yield response functions for crop i in the traditional rainfed agriculture (region 3) are thus specified as follows:

$$Y3_{it} = Y3(ENP3_{it}, W3_t, GIA3_{t-1}, WH3_t) \quad (i=1,...,5) \qquad (4.13)$$

$$A3_{it} = A3(ENP3_{it}, GIA3_{t-1}, W3_t, A3_{i,t-1}) \quad (i=1,...,5) \qquad (4.14)$$

$$ENP3_{it} = E3(NP3_{i,t-s}, \; 3_i: \; s=1, \ldots T) \quad (i=1,...,5) \qquad (4.15)$$

Equations (4.13) and (4.14) define the yield and area response functions for 5 of the 6 crops grown in region 4[4]. The wage rate ($W3_t$), weather ($WH3_t$), lagged government investment in agriculture,

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[3]Gasoil is the name of tractor diesel in Sudan.

[4]In the absence of adequate information on livestock production, livestock is grouped together with other minor agricultural products in one sector (STOZ), the supply of which is set exogenously to be infinitely elastic. Equilibrium quantity of STOZ is again, like beans, demand driven in the model.

last years area ($A3_{i,t-1}$), and expected net prices in region 3 ($ENP3_{it}$) are the regressors. Price expectations for farmers in region 3 are given in (4.15). Similar assumptions are used to specify the supply response functions for the mechanized rainfed farms (region 4).

$$Y4_{it} = Y4(ENP3_{it}, WH3_t, GOL_t) \qquad (i=1,2) \qquad (4.16)$$

$$A4_{it} = A4(ENP3_{it}, A4_{i,t-1}, TA4_t) \qquad (i=1,2) \qquad (4.17)$$

$$TA4_t = T4(TA4_{t-1}, GOL_t, PIN4_{t-1}, AGBL_t) \qquad (4.18)$$

GOL_t represent the amount of gasoil allocated to mechanized farmers, and $PIN4_{t-1}$ measures real private investment in region four lagged one year. Availability of gas oil is assumed to affect crop yields and total land area cultivated in the mechanized farming sector. Last years' investments (PIN4) in tractors, farm equipment, land reclamation, etc., are also allowed to influence changes in total area. Short-term loans given by the Agricultural Bank of Sudan to mechanized farmers ($AGBL_t$) are also used to explain total land area cultivated in region 4 ($TA4_t$). Short-term loans are assumed to measure availability of working capital for hiring labor and other variable inputs. The same price expectations are assumed for regions 3 and 4 ($ENP3_{it}$).

Although expected net returns, the wage rate and weather are the common supply forces in the farming sector, other factors specific to the different farming systems are included. Gas oil allocations or prices, for example, represent an important supply factor for regions two and

four where pumping irrigation water and mechanization are vital fuel using operations in those two regions, respectively. Private investment and short-term loans provide other important determinants of agricultural production in region 4.

The above specified yield and area response functions reflect partial adjustment in domestic production of agricultural tradables. Production plans, whether exogenously set by the government (areas in region 1) or controlled by individual agents, are made at the beginning of the season according to some price expectations scheme and remain unaltered over the year. Except for the effects of weather (WH_t), the wage rate (W_t) and the exogenously fixed levels of intermediate inputs (Z_t, GOL_t, $GOL2_t$), agricultural production is non-responsive to current period shocks. Agricultural output is accordingly predetermined with respect to current market forces (prices) except for the real wage effect. Disequilibrium is therefore allowed in agricultural tradables markets when firms' production plans are incompatible with observed prices, due to price forecasting errors, e.g., desired plans are not fulfilled. Agricultural tradables markets, however, are assumed to adjust in a sequence of temporary equilibria along which agricultural producers adjust their expectations and production plans to the desired levels.

Aggregate production and value added by region and crop are given below:

$$Q_{it} = \Sigma_j A^j_{it} \cdot y^j_{it} \qquad (i=1,\ldots,6) \qquad (4.19)$$

$$VA^j_t = \Sigma_i [NP^j_{it} \cdot Q^j_{it} + GR^j_{it}] \qquad (j=1,\ldots,4) \qquad (4.20)$$

$$VAA_t = \Sigma_j VA_t^j \qquad (4.21)$$

(4.19) derives total production of crop i (Q_{it}) from all regions, and (4.20) calculates total value added from all crops accruing to region j (VA_t^j), where GR_{it}^j denotes total collection of indirect taxes on crop i from region j. Total value added in agriculture (VAA_t) is given by (4.21). Cotton seed (QCS) is produced in fixed proportion to cotton lint (QCN_t) in this model.

$$QCS_t = \alpha_{cs}(QCN_t) \qquad (4.22)$$

where QCN_t is given in (4.19) above.

Non-agricultural tradables (NAT)

This sector represents the manufacturing industry in Sudan. It comprises mainly the textile, sugar, and oil industries plus food processing. The manufacturing sector uses cotton lint, oil seeds as well as non-tradables (transport, etc.) as intermediate inputs. Other intermediate imports such as fuel are utilized in manufacturing. Labor is the only primary factor modelled. Investments in imported capital goods and physical structures from the homegoods sector are endogenously determined. Manufacturing output for the profit maximizing firm is defined as:

$$NAT_t = NA(NPNAT_t, UW_t, PINM_{t-1}, GINM_{t-1}) \qquad (4.23)$$

Production of non-agricultural tradables (NAT_t) is a function of net output price ($NPNAT_t$), urban wage rate (UW_t), private and

government investment in manufacturing, lagged one year ($PINM_{t-1}$ and $GINM_{t-1}$ respectively). The unit value added ($NPNAT_t$) and total value added for this sector are given by:

$$NPNAT_t = PNAT_T(1-tc_t) - \Sigma_n \alpha_n(P_n) \quad (4.24)$$

$$VAM_t = NPNAT_t \cdot NAT_t + GRM_t \quad (4.25)$$

where α_n is the amount of intermediate input (n) per unit of output, and P_n is its respective price. The indirect tax rate on NAT is given by tc_t. While there are no capacity constraints, private and public investments in the previous period reflect the change of capital stock in this sector. GRM_t calculates total indirect taxes collected from the manufacturing sector.

Home goods sector (HG)

All non-tradables belong to this sector. Services, transport and construction are the major economic activities in the home goods sector. Labor is used to produce HG. Private investment in HG is determined endogenously like in the NAT sector and represents investment demand for imported capital goods and the sectors own production of physical structures. Intermediate imports are represented by a fixed coefficient technology. Supply of non-tradables (HG_t) is derived, similar to other producing sectors, from profit maximizing behavior. Accordingly supply is defined as a function of real net output price ($NPHG_t$), the real urban wage (UW_t), and lagged real private ($PINH_{t-1}$) and public investment ($GINH_{t-1}$).

$$HG_t = HG(NPHG_t, UW_t, PINH_{t-1}, GINH_{t-1}) \qquad (4.26)$$

As in other sectors government investment is set exogenously whereas private investment is determined endogenously. Net price ($NPHG_t$) and nontradables value added (VAH_t) are defined as:

$$NPHG_t = PHG_t(1-th_t) - \Sigma_n \alpha_n(P_n) \qquad (4.27)$$

$$VAH_t = NPHG_t \cdot HG_t + GRH_t$$

where th_t is the indirect tax rate on home goods, and GRH_t is total taxes (subsidies) on the HG sector.

Demand for inputs

Primary factors Demand for primary factors (land and labor) is similarly derived as part of the dual representation of the supply structure specified above. Area response functions defined earlier represent demand for land. Demand for labor, on the other hand, is obtained like output supply, from the first order condition system of the profit maximization problem described earlier. Accordingly demand for labor by sector i in region j (DL^j_{it}) is specified as a fuction of the corresponding expected prices (EP^j_{it}) and wage rates (W^j_t).

$$DL^j_{it} = DL^j_i(EP^j_{it}, W^j_t) \qquad (4.28)$$

Supply of land and labor, on the other hand, are set exogenously. There is only one type of labor in this model, namely, unskilled labor.

Labor groups, however, are distinguished by region and as urban and rural labor, e.g., j refers to the region and also distinguishes labor groups. The nominal wage rate for each group is set exogenously to define an infinite supply of labor for region j (SL_t^j).

$$SL_t^j = SL^j(\bar{W}_t^j) \tag{4.29}$$

The labor market for each category (or region j) clears by equating total supply to total demand for labor group j.

$$SL_t^j = \Sigma_i \, DL_{it}^j \tag{4.30}$$

Land is assumed abundant in region 3 (traditional rainfed), whereas, upper bounds are set on areas in the other regions.

$$\overline{TA}_t^j = \Sigma_i \, TA_{it}^j \tag{4.31}$$

The markets for land and labor, however, are suppressed due to data problems. No time series are available on labor hours supplied to or demanded by crop, region or sector.

The model does not have a market for loanable funds, as the capital market in Sudan is controlled and institutional credit is highly regulated and rationed. There is, however, a money market in the model that clears to determine the general price level. The current account balance, on the other hand, provides an equilibrating mechanism in the saving-investment closure with fixed nominal interest and exchange rates, e.g., the current account balance is the endogenously determined variable

when neither the nominal exchange nor interest rates are allowed to adjust for equilibrium in the foreign exchange market. Solutions to the model will, therefore, be generated by clearing the goods and money markets simultaneously. The model can readily be extended to factor markets with data available on supply and utilization and can then derive functional distribution of income and intersectoral flows of resources.

Investment demand The largest agricultural investment is public. Allocation of government investments between the three economic sectors (agriculture, industry and non-tradables) is exogenously determined. Private investment is endogenous. In agriculture, private investment is defined for the mechanized rainfed subsector (region 4) only, by:

$$PIN4_t = N4[AGBR_t, ENP3_{it}, ENPHG_t, ENPNAT_t, E(e_{bt}-e_{ot})] \qquad (4.32)$$

Private demand for capital by region 4 ($PIN4_t$) is defined in (4.32) to depend on the real rate of interest on the Agricultural Bank of Sudan long-term (investment) credit ($AGBR_t$), expected producers prices of the two crops grown, expected net price of home goods ($ENPHG_t$) and non-agricultural tradables ($ENPNAT_t$) and the expected black market premium for foreign exchange $E[e_{bt}-e_{ot}]$, where e_{bt} and e_{ot} are the free market and official rates of exchange respectively. The last 3 variables represent the opportunity cost of private capital in agriculture as proxies of the rate of return on competitive investments. Private investment in NAT ($PINM_t$) and non-tradables ($PINH_t$) are similarly defined.

$$PINM_t = PM[BR_t, ENPNAT_t, ENPHG_t, ENP3_{it}, E(e_{bt} - e_{ot})] \qquad (4.33)$$

$$PINH_t = PH[BR_t, ENPNAT_t, ENPHG_t, ENP3_{it}, E(e_{bt} - e_{ot})] \qquad (4.34)$$

where BR_t is the real rate of interest on bank credit. Price expectations for good i (HG, NAT) are given by:

$$ENP_{it} = E(NP_{i,t-s}; \phi_i: \quad s=0, \ldots, T) \qquad (i=1,2,3) \qquad (4.35)$$

The endogenous private demand for capital (PIN_t^k) plus the exogenous allocation of government investments to sector k (GIN_t^k), generate total investment by sector of destination k (TIN_t^k).

$$TIN_t^k = PIN_t^k + GIN_t^k \qquad (k=1,2,3) \qquad (4.36)$$

The main sector of origin for investment in this model is imported capital goods (IM1). Physical structures, however, are produced domestically in the home goods sector. Allocation of sectoral investment between sectors of origin (imported and home good) is determined as fixed proportions, where α_1 measures the average share of IM1 in total investment by sector k.

$$ZM1_t^k = TIN_t^k \cdot \alpha_1 / PM1_t \qquad (k=1,2,3) \qquad (4.37)$$

Equation (4.37) derives investment demand for imported good 1 (IM1) by sector k, as a fraction of total investment in sector k. Investment demand for home good (ZHG_t^k) by sector k is thus given by:

$$ZHG_t^k = (1 - \alpha_1^k)\, TINV_t^k / PHG_t \qquad (k=1,2,3) \qquad (4.38)$$

Then total investment demand for good j (IM1 and HG) by all sectors is defined as:

$$Z_{jt} = \Sigma_k Z^k_{jt} \qquad (j=1,2) \qquad (4.39)$$

Intermediate inputs A fixed coefficient technology is used to derive demand for intermediate inputs. The amount of intermediate input (n) per unit area of crop i is denoted by α_{ni} in the net price equations defined above. Total intermediate demand for input (n) by region k is thus given by:

$$V^k_{nt} = \Sigma_i \alpha_{ni} * A^k_{it} \qquad (n=1,2,\ldots,N)(k=4) \qquad (4.40)$$

And total demand for intermediate input (n) by NAT and HG sectors are:

$$V^j_{nt} = \alpha_{nj} Q_{njt} \qquad (j=HG \text{ and } NAT) \qquad (4.41)$$

Total demand for intermediate input (n) is thus derived:

$$V_{nt} = \Sigma_j V^j_{nt} + \Sigma_k V^k_{nt} \qquad (n=1,\ldots N) \qquad (4.42)$$

There are seven intermediate input categories (N=7), namely cotton seeds (CSD), sesame (SS), groundnuts (GN), cotton lint (QCN), home goods (HG), non-agricultural tradables (NAT) and intermediate imports (IM2).

Foreign Trade

Imports

Four import commodities are distinguished in the model; specifically, capital imports (IM1), imported intermediate goods (IM2), wheat (IM3) and other consumer goods (IM4). The first two are non-competitive, whereas imported wheat is considered a perfect substitute to domestic wheat. Consumer imports, on the other hand, are treated as an imperfect substitute to locally manufactured products, e.g., non-agricultural tradables (NAT). The small country assumption is employed for Sudan imports. Accordingly, Sudan faces a perfectly elastic supply of imports given by 4.43 for IM1, IM2, and IM3. As a significant part of IM4 is financed through the parallel market for foreign exchange, PM4 is obtained in (4.44).

$$PM_{jt} = PM^{*}_{jt}(1 - tm_{jt})e_{jt} \qquad (j=1,2,3) \qquad (4.43)$$

$$PM_{4t} = e_{bt}\, PM^{*}_{4t}(1 - tm_{4t}) + \beta_{4t}(e_{4t} - e_{bt})PM^{*}_{4t}(1 - tm_{4t}) \qquad (4.44)$$

The price of imported good j denominated in local currency (PM_j) is defined in (4.43) to be equal to the foreign price (PM^{*}_j) multiplied by the effective exchange rate (e_j) adjusted for import tariffs (tm_j). β_{4t} in (4.44) measures the proportion of IM4 imported via private licensing and assumed to be financed through the free foreign exchange market. The effective exchange rate for import k is set in

(4.45) as the exchange tax/subsidy (te_j) adjusted official exchange rate:

$$e_{jt} = e_{ot}(1 - te_{jt}) \qquad (j=1,...4) \qquad (4.45)$$

where e_0 converts U.S.$ into Sudanese pounds. The specification of prices and exchange rates in (4.43) to (4.44) introduces commercial policy in the model. There are no domestic substitutes for foreign capital (IM1) and foreign intermediate (IM2) goods, and thus, demand for these non-competitive imports is derived from the intermediate and investment by sector of origin demand equations. Wheat imports (IM3) on the other hand, are obtained as a residual from the wheat supply-demand balance equation. Demand for IM4 is obtained from the consumption demand system discussed below.

Exports

Manufactured products plus all agricultural tradables except wheat, are exported from Sudan. The small country assumption is maintained for non-agricultural tradables, sesame, sorghum, cotton seeds, short staple cotton, groundnuts, and livestock and others (STOZ). Long staple cotton and gum arabic exports, on the other hand, are assumed to face a sloping demand, as Sudan delivers a large share of those products to the world market. Export prices for non-agricultural tradables (NAT), sesame (SS), sorghum (DR), cotton seeds (QS), short staple cotton (SSCN), STOZ and groundnuts (GN) are determined by world prices (P_i^*), commercial and exchange rate policies:

$$P_{it} = P^*_{it} (1 - tx_{it}) e_{it} \qquad (i=1,...,7) \qquad (4.46)$$

where tx_i is the export tax/subsidy rate and e_{it} is the effective rate of exchange for commodity i.

$$e_{it} = e_{ot} (1 - te_{it}) \qquad (i=1,...,7) \qquad (4.47)$$

The specification in (4.45) and (4.46) defines a perfectly elastic demand for NAT, SS, DR, QCS, SSCN, STOZ, and GN exports. Domestic supply in excess of domestic absorption (intermediate and final demand) represent exports in the mentioned sectors (E_{it}). Export prices of long staple cotton and gum arabic, on the other hand, are determined endogenously by the equilibrium dollar price of Sudan exports (EP_i) and commercial policies.

$$P_{it} = EP_{it} (1 - tx_{it}) e_{it} \qquad (i=1,2) \qquad (4.48)$$

Supply and demand functions (SE_i and DE_i respectively) for Sudan exports of long staple cotton (LSCN) and gum arabic (GM) are therefore specified to determine EP_i endogenously.

$$SE_{it} = SE_{it} (EP_{it}, ST_{it}) \qquad (i=1,2) \qquad (4.49)$$

$$DE_{it} = DE_{it} (EP_{it}, P^*_{it}) \qquad (i=1,2) \qquad (4.50)$$

The beginning of period stock of crop i (ST_{it}), and world prices (P^*_{it}) are used together with export prices to explain supply and demand shifts in cotton and gum arabic exports. Over- and under-invoicing of exports and imports as well as smuggling activities are not modelled because of data problems.

Income and Final Demand

Income

Value added is divided between wages, interest and taxes. Wage income (YL_t) is given by:

$$YL_t = \Sigma_j \, YL_t^j \tag{4.51}$$

where YL_t^j denotes income paid to labor j by all sectors i.

$$YL_t^j = W_t^j * SL_t^j \tag{4.52}$$

and SL_t^j is the supply of labor j as defined earlier. Government income (T_t) is defined as the sum of direct and indirect taxes.

$$T_t = td_t \cdot \Sigma_j \, NP_{jt} - \beta \cdot e_o \cdot tr_t \cdot RT_t + \Sigma_i \, GR_{it} \tag{4.53}$$

where GR_i calculates total indirect taxes on commodity i as follows:

$$GR_{it} = e_o \, [\Sigma_n \, \alpha_{ni} \, P_n^* \, J_n - P_i^*(J_i - t_i - t_i \cdot J_i)] \tag{4.54}$$

$$(i=1,\ldots,15)$$

where:

$$J_i = (te_i \cdot x_i - te_i - x_i) \tag{4.55}$$

and
$$x_i = tm_i \quad \text{for imports}$$
$$= tx_i \quad \text{for exports} \tag{4.56}$$

$$(x_i,\ te_i,\ P_i^*,\ e_0) = (0,\ 0,\ PHG,\ 1) \qquad (4.57)$$

for the home goods sector.

Interest income (RN_t) is then derived as a residual

$$RN_t = VAD_t - YL_t - T_t \qquad (4.58)$$

where VAD_t is total value added.

Functional distribution of value added among owners of primary factors is not derived due to data limitations, as discussed earlier. All income generated in this model is, therefore, paid to a single household sector. From this income the government collects tax revenues. Accordingly, there are only two sectors of final demand in this model: households and a government sector. The after tax returns to primary factors (labor, capital and land) plus total private remittances (TRT_t) denominated in Sudanese pounds and net factor income (NFI_t), represent the household sector income (HH_t).

$$HH_t = (1 - td_t)\ \Sigma_j\ NP_{jt}\ Q_{jt} + \beta(e_{rt} - e_{bt})\ TRT_t + e_{bt}\ TRT_t + NFI_t \qquad (4.59)$$

Here NP_j is the net price and Q_j is the output level of commodity j (j=12, e.g., 10 agricultural tradables, NAT and HG), e_{rt} is the effective exchange rate for remittances of SNWA, and β is the proportion of total remittances transferred via official channels, e.g., at e_{rt}.

$$e_{rt} = e_o\ (1 + tr_t) \qquad (4.60)$$

tr_t measures the exchange subsidy on SNWA remittances, and td_t is the

direct tax rate. Government taxes or subsidies are subtracted and added according to the corresponding tax structure (tx, te, tm, td, ti, and tr).

Consumption

The model contains seven consumption goods for final demand, namely, wheat, sorghum, beans and vegetables (BNS), meats and other (STOZ), consumer imports (IM4), home goods and agricultural non-tradables. There are two consuming sectors, private households and the government sector. The government is assumed to buy home goods, and NAT only, for final consumption. Government investment and consumption spending are exogenously set (GIN_t and GCN_t respectively). Total government spending is therefore defined as:

$$G_t = GIN_t + GCN_t \tag{4.61}$$

where:

$$GIN_t = \Sigma_k \, GIN_t^k \qquad (k=1,2,3) \tag{4.62}$$

GIN_t is the sum of government investments in all sectors (k), and GCN_t represents government consumption demand. The government collects taxes and disposes of its revenues according to (4.61) and (4.62).

Private demand for the seven consumption goods in the model is derived in (4.63) using flexible demand systems:

$$F_{it} = F_i \, (P_{it}, E_t) \qquad (i=1,\ldots,7) \tag{4.63}$$

where final demand for commodity i (F_i) is a function of prices (P_i) and total consumption expenditure (E_t), which is endogenously determined by

$$E_t = E(HH_t, SR_t, e_{bt}) \tag{4.64}$$

where SR_t is the expected real saving rate of interest, HH_t is disposable income (as defined in 4.59) and e_{bi} is the parallel market exchange rate.

Equation (4.63) is consistent with demand theory and represents optimal choices of utility maximizing consumers, subject to an expenditure constraint. The Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980) is used to estimate model (4.63). Properties of AIDS and equation (4.63) are derived in Appendix D.

Equilibrium Conditions

Product market equilibrium

As mentioned earlier, an equilibrium solution is obtained in this model by clearing product markets. Equilibrium in factor markets is maintained and is not derived explicitly due to data limitations that precluded adequate modelling of factor markets. Total demand for product j (D_{jt}) should match total supply (S_{jt}) at each time period t; such that

$$S_{jt} - D_{jt} = 0 \qquad (j=1,\ldots,15) \tag{4.65}$$

where D_{jt} is the sum of intermediate (V_{jt}), investment (Z_{jt}), private

(F_{jt}), and government final demands(GCN_t) plus export demand (EX_{jt}) for product j.

$$D_{jt} = V_{jt} + Z_{jt} + F_{jt} + GCN_{jt} + EX_{jt} \qquad (4.66)$$

EX_{jt} is obtained as a residual from (4.66) for all products except for cotton and gum arabic where EX is an equilibrium quantity in the export market; such that:

$$SE_{it} = DE_{it} \qquad (i=CN \text{ and } GM) \qquad (4.67)$$

Total supply of product j is the sum of domestic production (Q_{jt}), inventory changes ($ST_t - ST_{t-1}$) and imports (IM_{jt}).

$$S_{jt} = Q_{jt} + IM_{jt} - (ST_{jt} - ST_{j,t-1}) \qquad (4.68)$$

Again, wheat imports ($IM3_t$) is obtained as a residual in (4.66).

The Macro-economic Closure

The macro-structure of Sudan economy is specified such that excess aggregate demand is allowed in the model. The domestic resource gap is made of two components. Total private investment ($TPIN_t$) in excess of private savings (PS_t) represents the first structural imbalance (PD_t) in this model:

$$TPIN_t - PS_t = PD_t \qquad (4.69)$$

where:

$$TPIN_t = \Sigma_k \, PIN_t^k \qquad \text{for all sectors } k=1,2,3 \tag{4.70}$$

$$PS_t = HH_t - E_t \tag{4.71}$$

The fiscal deficit (GD_t), on the other hand, contributes the second part of the resource gap in our model.

$$G_t - T_t = GD_t \tag{4.72}$$

Private (PD_t) and public deficits (GD_t) represent the domestic resource gap or excess aggregate demand (in local currency), which is balanced as follows:

$$PD_t + GD_t = e_o F_t \tag{4.73}$$

where F_t represent the foreign resource gap or net foreign borrowing given by:

$$\Sigma_j \, PM_{jt}^* \cdot IM_{jt} - \Sigma_i \, P_{it}^* \cdot EX_{it} = F_t \tag{4.74}$$

With a fixed exchange regime, the specification in (4.74) allows for disequilibrium in foreign trade. As net capital inflow (F_t) is not rationed, the model assumes that foreigners are willing to hold an unlimited size of Sudan's debts. This assumption is used in simulating the observed performance of the economic system for model validation. Different specifications will be used, however, to solve the model for policy analysis. A zero trade balance or fixed supply of foreign loans are assumed to determine the equilibrium exchange rate under a flexible exchange regime.

As there is practically no bond market in Sudan, internal imbalances are financed by creation of domestic credit. The limited ability of the central authority in monetary control through open market operations, is thus recognized in making money supply endogenous to the system. Change in money supply ($M_t - M_{t-1}$), according to (4.75), is a function of fiscal deficits (GD_t), expected real saving rate (SR_t), and income (VAD_t):

$$M_t - M_{t-1} = M(GD_t, SR_t, VAD_t) \qquad (4.75)$$

Similar specifications are used by various authors to allow for endogeneity of money supply in studying the important link between fiscal deficits and inflation in developing countries (Aghevli and Khan, 1978; Taylor, 1979; and Scobie, 1983).

A money demand function is specified in (4.76). Demand for real money balances (MD/P) is explained by real gross national product (Y_t), the expected rate of inflation (π_t), and the expected black market premium $E(e_b - e_o)$.

$$\frac{MD_t}{P_t} = m_t[Y_t, \pi_t, E(e_{bt} - e_{ot})] \qquad (4.76)$$

The specification in (4.76) follows closely the model used by Domowitz and El Badawi (1987) to estimate demand for money in Sudan. The fact that the nominal interest rate in Sudan is an exogenously set constant led to its exclusion from (4.76). The same argument was employed by Domowitz and ElBadawi (1987) to disregard the interest rate as empirically irrelevant. It has also been argued by the same authors,

that the interest rate does not reflect the true opportunity cost of holding money due to the redundancy of the assets market in Sudan. Investment in physical assets is considered the alternative substitute to holding money. The inflation rate is thus used to represent the economic cost of holding money in the portfolio balance. Where

$$\pi_t = \left[P_t - P_{t-1}\right] \Big| P_t \tag{4.77}$$

$$Y_t = (HH_t + T_t)/P_t \tag{4.78}$$

The only difference between (4.76) and the Domowitz/ElBadawi study is in the specification of the exchange rate component. Holding of foreign currencies is considered a major substitute to domestic money. The official market exchange rate is thus used in the mentioned study, as the opportunity cost of holding local currency. The study did not lend empirical support to the statistical significance of the exchange rate effect. The expected wedge between the free market and official exchange rate is alternatively used in the present study.

To close the model and clear the financial assets market, equality of demand and supply of money is required.

$$M_t = MD_t \tag{4.79}$$

The equilibrium condition in (4.79) determines the general price level (P_t) endogenously, e.g., the price of money. In this model, where domestic production-absorption disequilibrium is allowed, Walras Law is satisfied by the trade balance (current account deficit) as shown

in 4.73 and redefined by

$$\Sigma_i P_{it} D_{it} - Y_t = e_o F_t \qquad (i=1,\ldots,12) \qquad (4.80)$$

Equation 4.80 gives the budget constraint of the economy. Accordingly, the n+1 equations (the n commodity and money market equilibria plus the budget constraint) determine n+1 prices (the n prices and the nominal exchange rate). As the nominal exchange rate e_o is fixed in Sudan, the current account deficit (F_t) is determined endogenously. Alternatively F_t can be set exogenously to determine the equilibrium exchange rate endogenously.

While domestic money provides an additional product market in the economy, production of M_t does not use real resources directly in this model, e.g., no production function is specified. The cost of money supply (cost of inflation), however, is born by all economic agents, as inflation imposes an indirect tax on real resources (through P_t being the numeraire). The impact of excess public demand (fiscal deficit) on inflation and economic activity is given by the money supply linkage 4.75.

Short run non-neutrality of money is therefore allowed as some prices and quantities are slow to adjust in this model, e.g., agricultural supply, and the exchange and interest rates.

Figure 4.1 gives a schematic representation of the GEMS structure. There are four segments of the model (supply, final demand, foreign, and macro sectors) plus the product and factor markets. Given relative prices, the supply sector delivers domestic production, and intermediate

and primary factor demands to the product and factor markets. Foreign trade and international prices flow through the foreign sector to the products market. The final demand sectors (private households and the government) allocate total resources from value added, remittances, plus domestic and foreign borrowing among final demand categories (consumption and investment) given relative prices.

Given total supply and demand for goods and money the general price level and relative prices are determined in the product market. Value added is thus determined and paid to the final demand sectors. The macro sector receives excess aggregate demand from the product market and adjusts money supply accordingly. Prices of goods and money and the corresponding equilibrium quantities are thus determined simultaneously within the model.

The labor market equilibrium is maintained implicitly and the exogenous wage rate sets an unlimited supply of labor. The GEMS has 16 sectors and 187 equations in 187 endogenous variables as enumerated in Table 4.2.

The solution strategy and algorithms are discussed in Chapter 6 where validation and policy simulations are performed. Chapter 5 estimates the model parameters.

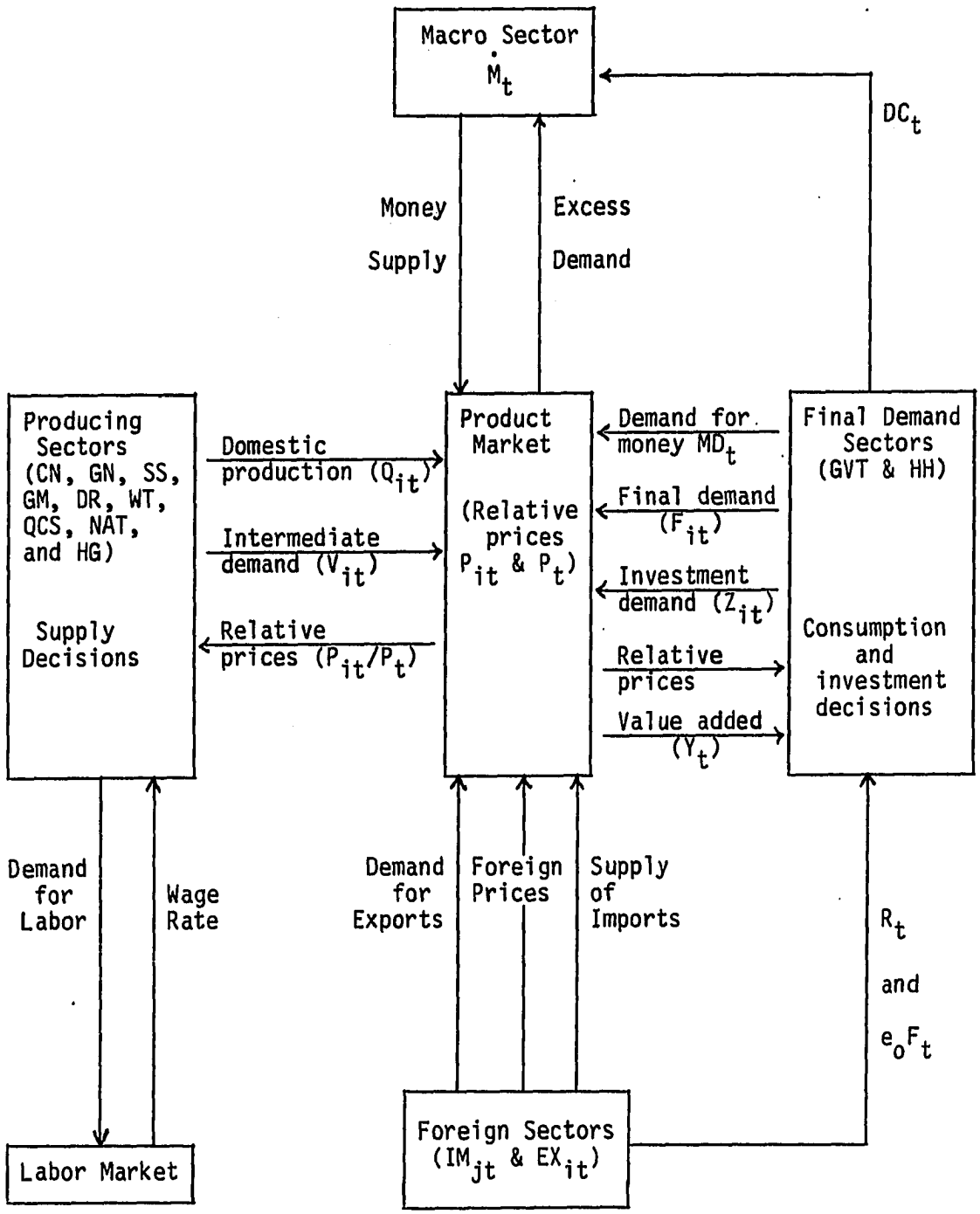

Figure 4.1 The General Equilibrium Model for Sudan (GEMS)

Table 4.2 Variables of the GEMS

Variable Names		Number of Variables and Equations	
Endogenous variables			
Y^k_{it}	Agricultural yield	4 agric. regions (K=4)	4+1+5+2=12
A^k_{it}	Crop areas	and six crops (i=6)	4+1+5+2=12
Q^k_{it}	Agricultural output		5+2+7+2=16
$N1_{it}$	Net returns in region 1		= 5
NAT_t	Non-agricultural tradables		= 1
HG_t	Home goods		= 1
NP^k_{it}	Net prices	4+2+6+2+2(NAT&HG)	=16
P_{it}	Product prices		=12
V^k_{nt}	Intermediate demand		=14
PIN_{kt}	Private investment by sector of destination	k=3	= 3
PZ_{jt}	Private investment by sector of origin	j=2	= 2
F_{it}	Final demand		= 7
D_{it}	Total demand		=16
S_{it}	Total supply		=16
HH_t	Household income		= 1
T_t	Government income		= 1
EP_{it}	Export price	i=2 (cotton and gum arabic)	= 2
SE_{it}	Export supply	i=2 (cotton and gum arabic)	= 2
DE_{it}	Demand for export	i=2 (cotton and gum arabic)	= 2
EX_{it}	Exports		= 9

Table 4.2 Continued

Variable Names		Number of Variables and Equations
Endogenous variables		
IM_{jt}	Imports	= 4
E_t	Private consumption expend.	= 1
PS_t	Private savings	= 1
PD_t	Private deficit	= 1
GD_t	Government deficit	= 1
M_t	Money supply	= 1
MD_t	Demand for money	= 1
P_t	General price level	= 1
ST_{it}	Beginning stock	= 2
F_t	Trade balance	= 1
$WTRIO_t$	Ratio of domestic production to imports of wheat	= 1
VAD_t	Value added (GDP)	= 1
Y_t	National income (GNP)	= 1
ENP^k_{it}	Net price expectations	=16
TA^k_t	Total land area	= 4
	TOTAL	=187
Exogenous Variables		
GIN^k_t	Government investment by sector of destination	3
GZ_{jt}	Government investment by sector of origin	2

Table 4.2 Continued

Variable Names		Number of Variables and Equations
Exogenous Variables		
GF_{it}	Government consumption	1
WR_{it}	Water rates	4
W_t	Wage rate	2 (rural/urban)
WH_t	Weather	1
t_{it}	Indirect tax rate	9
e_{ot}	Exchange rate	1
P^*_{it}	International prices	12
PBB_t	Price of broad beans	1
e_{jt}	Effective exchange rates	5
e_{bt}	Parallel market exhange rate	1
tx_{it}	Export tax/subsidy	7
tm_{jt}	Import tax/subsidy	4
t	Direct tax rate	1
GOL^k_t	Gasoil allocations	2
$AGBL_t$	Agricultural bank loans	1
TA^k_t	Total land area	3
$AGBR_t$	Agricultural bank long term credit rate	1
		TOTAL = 66

ϕ^k_i, α_i, α_n, β, s, δ, δ, d, e are vectors of parameters in the model.

CHAPTER 5. ESTIMATION OF THE MODEL PARAMETERS

Two approaches to numerical specification of applied general equilibrium models are generally found in the literature. Calibration is the standard and most commonly used procedure among general equilibrium modelers. Econometric estimation, on the other hand, is rare and in most cases used to supplement calibration. This chapter describes and compares these two methods. Parameter values for our model obtained by econometric methods are then presented. We refer to the two estimation criteria under consideration hereafter as deterministic (calibration) and stochastic (econometric) approaches to numerical specification of general equilibrium models.

Deterministic Specification Method

The following representation is used to illustrate the numerical specification issue:

$$F_t(Y_t, X_t, \beta, \varepsilon_t) = 0 \qquad (5.1)$$

Model 5.1 defines a system of M equations with a vector of M endogenous variables (Y_t), a vector of exogenous variables (X_t), a vector of unknown parameters (β), and a (1XM) vector of random errors (ε_t). The problem is to choose a numerical value for the unknown parameter vector β. As defined by Lau (1984), calibration is equivalent to setting ε_t equal to zero in 5.1. Using a single observation on Y_t

and X_t that represents an equilibrium benchmark period t, the system in 5.1 is then solved for the corresponding values of β.

Calibration is thus parsimonious as it uses only one data point to compute the system parameters. One other important advantage of calibration is the fact that deterministic specification of β guarantees an exact solution for the benchmark values of Y given X with all the equilibrium constraints holding. This is true by definition since the system

$$F_t(Y_t, X_t, \hat{\beta}, 0) = 0 \qquad (5.2)$$

solves exactly for the same values of Y used to generate $\hat{\beta}$ given the corresponding values of X. This generally does not hold when β is estimated econometrically ($F_t \neq 0$).

Calibration, however, assumes away all the legitimate reasons behind incorporating an error term ε_t in the model. The assumption that the model is perfectly specified with all influencing factors included and all data measured without errors, is rather strong. Moreover, with only one observation to use, parameter values obtained by calibration are not unique. While econometric methods face identification problems as well, they are easier to handle. It is also important to note that model 5.2 can solve for only M independent parameters (the number of equations). This restriction has led to the use of less flexible functional forms. Often, however, other methods are used to augment calibration. Educated guessing or borrowing from the literature and sometimes econom tric estimation are widely used to select numerical values for the key parameters of the model. Finally, the strongest criticism to calibration

is that it does not provide any statistical measure of reliability of the estimated model and its parameters (Mansur and Whalley, 1984; Lau, 1984).

Stochastic Methods of Estimation

With appropriate assumptions about the distribution of the disturbance term $_t$ and the function F_t in 5.1, available time series on Y and X can be used to generate estimates of the parameter vector β econometrically. Given enough exogenous variables and non-sample information to identify the model, the only limitation on the number of independent parameters to be estimated with this approach is the number of data points available. Hence, the option for using more flexible functional forms. In presence of non-linear restrictions imposed on the model parameters and equations for consistency with demand and firm theories as well as budget and fixed endowment constraints, full information maximum likelihood or other alternative system procedures (iterative 3 stage least squares) are required for consistent estimation of model 5.1. The biggest advantage of econometric procedures is the useful error statistics generated for evaluating reliability and confidence in results. Within and out of sample simulation experiments can also test the predictive power and stability of the econometric models.

Stochastic specification of parameter values in a general equilibrium (GE) context, however, face some problems which has limited its use and led to the popularity of deterministic approaches among producers of GE models. The most important difficulty with econometric

estimation is defining the likelihood function for a large number of GE models where error terms are not independent (Mansur and Whalley, 1984). Moreover, GE models usually involve estimation of a large number of parameters and thus longer data series are required. The parsimony problem multiplies with the level of sectoral detail and disaggregation in the model as well as the degree of flexibility of the functional forms used.

An alternative strategy for stochastic specification of GE models is the full information subsystem methods suggested and implemented by Mansur and Whalley (1984), and Jorgenson (1984). In this approach, model 5.1 is partitioned into subsystems of N equations, where N is necessarily smaller than the total number of equations (M) in the complete model. Subsystems are chosen such that structural equations most likely to be interdependent are grouped together. Subgroups must also form consistent systems where possible theoretical cross-equation restrictions can be accommodated. A natural choice of partitioning used in both of the above studies was the supply and demand components of the GE formulation.

One problem with subsystems estimation is the implicit assumption of exogeneity of some variables that are endogenous to the full specification of the model. Examples are income and prices in estimating the demand subsystem. Instrumental variables, however, can be used to estimate each subsystem using the consistent non-linear 3 stage least squares estimator (Mansur and Whalley, 1984; Jorgenson, 1984).

Estimation of the GEMS Parameters

Subsystems estimation is employed to generate parameter values for this study. Supply-demand subdivision of the model is followed.

Supply systems

As discussed in the preceding chapter, supply structures are specified as response functions of expected net prices (or returns) plus other exogenous factors. Naive price expectations schemes are used such that expected net price (or return) of product i in region j is given by last year's realization:

$$ENP^{j}_{it} = NP^{j}_{i,t-1} \tag{5.3}$$

It is assumed that economic agents do not possess full information about the complex structure of the economy described by the GE representation given in chapter 4, and so do not use the rational expectations hypothesis. Moreover, the short series of observations available precluded adoption of adaptive expectations schemes with more lags. As mentioned earlier, current prices are not in the information set of agricultural producers when production plans are made. This specification implies lags in agricultural supply and thus current agricultural prices are demand determined. While the supply of agricultural tradables is given at period t according to 5.3, price expectations adjust next period's supply.

Accordingly all regressors in the agricultural supply subsystems are considered predetermined except for real wages. This in addition to the

fact that the small country assumption is used for all agricultural tradables except for long staple cotton, support exogeneity of prices for suppliers in these sectors. Nevertheless, instrumental variable system estimation (3 stage least squares) as well as Zellner seemingly unrelated regressions (SUR) are performed on the supply systems. Better statistical results, however, were obtained with the SUR estimator and in many cases the instrumental variable procedure generated inconsistent signs. Results of the SUR estimations are given in Tables 5.1 through 5.7 below. All supply and demand response functions are estimated in the log linear (Cobb Douglas) form. Only 16 annual observations were available (1971-1986) limiting the flexibility of the used functional forms. The estimated equations represent response rather than proper supply functions and hence no theoretical restrictions were imposed on the system. Significance levels on the t-statistic of estimated coefficients are indicated by stars in all tables where one, two, and three stars denote 10%, 5%, and 1% levels, respectively.

Column 4 in Table 5.2 deals with the fact that not all the wheat produced in the irrigated public sector (region 1) is handed over to the government at the procurement price as required. The proportion of wheat delivered (PWD) by tenant farmers is found to vary inversely with the gap between the market price of wheat (PWHT) and the procurement price of wheat (PPW). As farmers in region 1 sell part of their wheat production (QW1) in the market, they receive the following price (PW1) on their wheat supply:

$$PW1 = PWD * PPW + (1 - PWD) * PWHT \qquad (5.4)$$

Table 5.1. Systems estimates of yield response parameters for the public irrigation schemes (Region 1)[a]

	LSCN	DRA	GNT	WHT
Constant	-6.449 (-1.98)*	1.374 (6.66)***	2.814 (132.3)***	1.424 (1.89)*
$LSCN_{t-1}$	.172 (4.845)***	.128 (10.165)***	-.045 (-5.747)***	-.028 (-1.55)
DRA_{t-1}		.179 (7.506)***		
GNT_{t-1}	-.089 (-1.192)		.06 (3.31)***	-.046 (-1.26)
WHT_{t-1}			-.073 (-3.319)***	.26 (5.44)***
WG	-.11 (-1.44)	-.058 (-2.465)**	-.068 (-3.395)***	-.086 (-2.83)**
FLDX	1.617 (2.287)**			.189 (.68)
WH		.115 (3.39)***		
R Squared	.704	.884	.93	.78
Durbin-Watson	2.03	2.15	1.72	1.13

[a]Columns denote yields of long staple cotton (LSCN), sorghum (DRA), groundnuts (GNT) and wheat (WHT) in Region 1. Rows refer to regressors: lagged real net prices (t-1), real wage rate (WG), rainfall (WH) and flooding index (FLDX).

*Figures between brackets are t-statistics.

Table 5.2. SUR estimates of area response parameters in Region 1[a]

	LSCN	GNT	WHT	PWD
Constant	6.904 (40.77)***	2.878 (3.556)***	5.67 (26.35)***	.513 (1.824)*
DRA_{t-1}		-.346 (-3.317)***		
GNT_{t-1}		.177 (2.348)**		
$GIAG_{t-1}$	.084 (2.97)**			
BSTK	-.034 (-1.97)*			
TIME	-.007 (-4.29)***			
$AGNT_{t-1}$		.484 (3.549)***		
$DSWR_{t-1}$			.626 (6.56)***	
WPW_{t-1}			.454 (4.158)***	
PWHT				-2.84 (-3.314)***
PPW				2.598 (2.91)**
R Squared	.68	.48	.78	.545
Durbin-Watson	1.83	1.5	1.35	1.25

[a]Columns refer to areas of long staple cotton (LSCN), groundnuts (GNT), wheat (WHT), and to proportion of wheat delivered (PWD). Rows define the regressors: lagged real net prices of sorghum (DRA) and groundnut (GNT), lagged real government investment in agriculture (GIAG), beginning stock of cotton (BSTK), time, lagged area under groundnuts (AGNT), domestic supply of wheat ratio (DSWR), world price of wheat (WPW), market price and procurement price of wheat (PWHT and PPW, respectively).

*Figures in brackets are t-statistics.

Since wheat yield in Region 1 is specified to vary with PW1 which in turn is a function of PWHT (according to 5.4), the supply of wheat in Region 1 (QW1) is therefore a function of the market price of wheat. Wheat supply in Region 2 (QW2), on the other hand, is a direct function of the market price (Table 5.3) as all supply is sold in the free market. Accordingly, domestic supply of wheat (DSW) and area planted to wheat in Region 1, being a function of the domestic supply ratio are responsive to the market price of wheat. Total supply of wheat, however, consists of the domestic component (DSW) plus government imports (IM3).

Except for the treatment of producers prices in Region 1 discussed above, the wheat sector specification corresponds largely to the supply equations of Damous' wheat sector model (1986). His supply functions also do not contain a wage effect and are estimated by ordinary least squares equation by equation. While both models generate similar results, the systems estimators of the present study gave much better statistical performance than Damous'. Demand for wheat, however, is estimated as part of a complete demand system in this study, whereas, Damous (1986) estimated a demand for wheat equation in a partial equilibrium context and independent of other consumption goods.

Export demand and supply functions for long staple cotton are given in Table 5.6. Two stage least squares is used to correct for endogeneity of the exort price (EXPLS). Lack of data on the world gum arabic market and prices led to the use of the small country assumption of perfectly elastic demand for its exports.

Table 5.3. Systems estimates of wheat supply elasticities in the private irrigation schemes (Region 2)[a]

	Yield	Area
Constant	-6.64 (-2.597)**	1.68 (1.895)*
$PWHT_{t-1}$	.29 (2.29)**	.145 (2.5)**
$PBNS_{t-1}$	-.115 (-2.33)**	-.082 (-3.62)***
TMP2	-.713 (-6.63)***	
WG	-.197 (-3.46)***	-.087 (-3.898)***
FLDX	2.72 (5.6)**	.367 (1.91)*
R-squared	.91	.59
Durbin-Watson	2.02	2.49

[a]Rows refer to regressors: lagged real prices of wheat (PWHT) and beans (PBNS), temperature in Region 2 index (TMP2), real wages (WG) and a flooding index (FLDX).

*Figures in brackets denote t-statistics.

No data was available on private investment by sector of destination and hence investment demand by sector is not estimated. Instead, reduced form representations of the domestic manufacturing (DMNF) and homegoods sectors (HMG), and Region 4 (the private dryland mechanized farming) supply functions are estimated directly with arguments in their respective private investment functions substituted in the reduced supply forms. Table 5.7 reports the results.

Demand system estimation

Private consumption and private investment functions are also given in Table 5.8. Estimates of the parameters of the share equations in the demand system are also summarized in Table 5.9. Symmetry and adding up (Engel aggregation) restrictions (discussed in Appendix D) are imposed on the almost ideal demand system (AIDS). The beans equation (the dropped equation) is derived using demand theory restrictions imposed on the structural parameters. Restrictions of the demand theory are not tested in this study.

The money market

Table 5.10 presents estimates of the supply and demand for money equations. The money demand equation follows closely the error correction model estimated by Domowitz and Elbadawi (1987), using a different data set. Very similar results are obtained with the present series (1971-1986). This indicates the stability of their model which covered the 1958-1977 period. The parallel market exchange rate and the

real savings interest rate gave poorer statistical performance than the in official exchange and inflation rate. We use, however, the rate of change in the official exchange rate rather than the exchange rate level. We also replace gross domestic product in their money demand equation with national income. Inspite of the shorter series used to fit the equation, the model performed better with these modifications made.

Tables 5.1 through 5.5 reveal interesting substitution possibilities in the yield and area response functions in all regions. Results presented in these tables indicate that agricultural supply is more responsive to economic policy and movement in relative prices in the private holdings of Regions 2 to 4 than under the rigid institutional arrangements of public irrigation schemes (Region 1). Total area cropped in the mechanized rainfed sector is found to be highly responsive, particularly to the availability of short-term bank loans, the amount of gasoil allocated to the region and the expected premium on holding foreign assets, e.g., the lagged discrepancy between the official and parallel rates of foreign exchange (Table 5.5). Also, cotton area in the traditional rainfed sector proved to be highly sensitive to prices of competitive crops (Table 5.4).

The data also indicated that the amount of rainfall is a very important supply factor, particularly for dry farming systems (Table 5.4). Tables 5.1 to 5.5 contain some evidence for the inelasticity of agricultural supply in Sudan. This result supports the argument for using agriculture as the tax base for industrialization in developing countries. It is also important to note that the composition of

Table 5.4. Systems estimates of area and yield response parameters for the traditional rainfed sector (Region 3)[a]

	Constant	$SSCN_{t-1}$	DRA_{t-1}	GNT_{t-1}	SSM_{t-1}	GUM_{t-1}	WG	WH	R^2	DW
1-Yield										
SSCN	-4.522 (-3.035)**	.077 (.726)	-.348 (-1.93)*				-.29 (-3.7)***	.658 (2.73)**	.55	2.3
DRA	-2.56 (-3.2)***	-.054 (-1.52)	.11 (.715)	-.112 (-2.358)**	-.053 (-1.38)		-.06 (-3.133)	.71 (5.08)***	.64	2.02
GNT	-2.528 (-2.864)**		-.126 (-1.15)	.026 (.399)			-.116 (-2.873)**	.684 (4.784)***	.61	2.68
SSM	-1.954 (-2.13)*		-.334 (-2.77)**	-.093 (-1.615)	.151 (2.26)**		-.062 (-2.46)**	.493 (3.31)***	.55	2.87
GUM	4.91 (5.82)***		-.236 (-3.12)***			.028 (.682)		.258 (1.94)*	.53	2.09
2-Area										
SSCN	3.684 (2.09)*	.363 (3.479)***	-.708 (-3.97)***	-0.215 (-3.13)***				.109 (.383)	.66	1.7
DRA	4.02 (2.47)**	-.413 (-3.43)***	.285 (1.138)	-.139 (-1.16)	.59 (4.26)***			.66 (2.504)**	.75	1.78

GNT	7.983 (70.56)***	-.175 (-3.168)***	-.11 (-.57)	.254 (3.71)***		-.268 (-5.065)***		.003 (.32)	.43	2.09
SSM	3.164 (4.183)***		-.168 (-1.58)	-.112 (-2.17)*	.232 (3.64)***			.639 (5.18)***	.65	1.76

[a]Columns define regressors; lagged real prices of short staple cotton (SSCN), sorghum (DRA), groundnuts (GNT), sesame (SSM), gum arabic (GUM), real wages (WG) and rainfall (WH). Rows refer to dependent variables (yield and areas) as defined above.

*Figures in brackets denote t-statistics.

Table 5.5. Systems estimates of supply parameters in the mechanized rainfed sector (Region 4)[a]

	DRA	SSM	PRDRA	TA4
Constant	1.814	-.15	-.71	6.2
	(4.49)***	(-.423)	(-1.964)*	(4.26)***
DRA_{t-1}	.032	-.039	.161	.321
	(.637)	(-.858)	(2.98)**	(3.06)***
SSM_{t-1}	-.077	.091	-.046	.175
	(-2.04)*	(2.649)**	(-1.13)	(.97)
WG	-.057	-.01	-.052	
	(-2.72)**	(-.56)	(-2.448)**	
WH	.032	.214	.096	.193
	(.471)	(3.64)***	(1.614)	(.88)
PGOL	-.116	-.048		
	(-3.75)***	(-1.93)*		
$AGBL_{t-1}$				.625
				(3.21)***
GOL4				1.296
				(4.96)***
$DMNF_{t-1}$				-.544
				(-.93)
$EXDIF_{t-1}$				-.199
				(-1.34)
R-squared	.58	.73	.76	.97
Durbin-Watson	1.7	2.08	1.32	2.29

[a]Columns define yield of sorghum (DRA) and sesame (SSM), proportion of area under sorghum (PRORA) and total area in Region 4 (TA4). Rows define the regressors lagged real prices of sorghum, sesame and domestic manufacturing (DMNF), real wages (WG), rainfall (WH), real price of gasoil (PGOL), lagged real total agricultural bank loans to mechanized farmers (AGBL), amount of gasoil allocated to Region 4 index (GOL4) and lagged expected parallel market exchange rate premium ($EXDIF_{t-1}$).

*Figures in brackets are t-statistics.

Table 5.6. Two-stage least squares estimates of the long staple cotton export demand (EXDLS) and price (EXPLS) equations[a]

	EXDLS	EXPLS
Constant	9.48 (3.123)***	.838 (.56)
BSTK		-.264 (-1.82)*
WPLS	2.08 (1.26)	1.178 (4.68)***
EXPLS	-2.65 (-1.86)*	
R-squared	-.10	.65
Durbin-Watson	.95	.74

[a]Regressors are beginning stock of cotton (BSTK), world price of cotton (WPLS), and export price of cotton (EXPLS).

*Figures in brackets denote t-statistics.

Table 5.7. The domestic manufacturing (DMNF) and homegoods (HMG) sectors supply equations[a]

	DMNF	HMG
Constant	5.153 (684.4)***	5.84 (31.098)***
UWG	-.006 (-.55)	-.186 (-2.74)**
$DMNF_{t-1}$	.169 (2.102)*	-.346 (-.678)
$GINA_{t-1}$	.01 (2.47)**	
$FINT_t$	-.046 (-2.44)**	
$FCAP_{t-1}$	-.026 (-1.47)	
HMG_t		.643 (.754)
HMG_{t-1}		.713 (1.04)
$GIHG_{t-1}$		.17 (2.09)*
R-squared	.75	.82
Durbin-Watson	2.43	1.63

[a]Rows denote the regressors: real urban wage (UWG), lagged real price of domestic manufacturing ($DMNF_{t-1}$), homegoods ($GIHG_{t-1}$), foreign capital ($FCAP_{t-1}$), current real price of HMG and foreign intermediate (FINT).

*Figures in brackets represent t-ratios.

Table 5.8. Private consumption (PCN) and private investment (PIN) parameter estimates[a]

	PCN	PIN
Constant	.27 (1.56)	4.32 (9.35)***
RSR_{t-1}	-.0006 (-.302)	
REB_{t-1}	.002 (1.13)	.061 (3.574)***
DIN	.946 (40.25)***	
RLR_{t-1}		-.014 (-.46)
HMG_{t-1}		8.675 (1.071)
$DMNF_{t-1}$		2.065 (.314)
R-squared	.997	.70
Durbin-Watson	2.27	1.14

[a]Regressors are lagged real saving, lending and parallel market exchange rates (RSR, RLR and REB, respectively), disposable income (DIN), lagged real homegoods (HMG) and domestic manufacturing (DMNF) prices.

*Figures in brackets denote t-ratios.

Table 5.9. Parameter estimates of the almost ideal demand system (AIDS)[a]

	DRA	WHT	STOZ	DMNF	FMNF	HMG	BNS
Constant	0.135 (1.2)	0.119 (2.3)**	0.205 (1.04)	0.767 (4.52)***	0.117 (1.96)*	-0.304 (-1.64)	-0.0683
DRA	-0.06 (-3.06)***	0.011 (1.23)	0.0265 (2.67)**	0.058 (2.69)**			
WHT	0.011 (1.23)	-0.042 (-3.414)***	0.005 (0.734)	-0.02 (-1.4)	0.016 (1.6)		0.002 (0.65)
BNS		0.002 (0.65)	.003 (.15)	-0.027 (-3.31)***		0.0254 (2.87)***	-0.0192
STOZ	0.0265 (2.67)**	0.005 (0.734)	-0.006 (-1.7)*	0.025 (1.03)	0.007 (0.64)		.003 (.15)
DMNF	0.058 (2.69)**	-0.02 (-1.4)	0.025 (1.03)	-0.127 (-2.8)***	0.038 (1.98)**	-0.096 (-2.31)**	-0.027 (-3.31)***
FMNF		0.016 (1.6)	0.007 (0.64)	0.038 (1.98)**	-0.043 (-3.54)***	-0.026 (-1.16)	

HMG				-0.096 (-2.31)**	-0.026 (-1.16)	-0.033 (-.71)	0.0254 (2.87)***
PCN	-0.0214 (-1.07)	-0.018 (-1.82)**	0.007 (0.19)	-0.08 (-2.8)***	-0.0115 (-1.1)	0.107 (2.57)**	0.016
URB	0.09 (10.64)***	-0.0195 (-2.23)**		-0.135 (-9.58)***		0.052 (2.39)**	0.012
R-squared	.88	.66	.47	.95	.64	.81	

[a]Columns define sectoral share equations for sorghum (DRA), wheat (WHT), beans (BNS), meats and vegetables (STOZ), domestic manufactured (DMNF), foreign manufactured (FMNF) and homegoods (HMG). Regressors are the respective real prices, consumption spending (PCN) and urbanization index (URB).

*Figures in brackets denote t-ratios.

agricultural output is very responsive to policy changes and movements in relative prices as indicated by the high substitution and other elasticities of crop areas, especially in the private farming systems (Regions 2 to 4). This indicates a high potential for the appropriate policy measures to influence cropping mix in the desired direction. Supply of non-agricultural products, particularly home goods is more elastic than agricultural commodities (Table 5.7). Also, results of Table 5.6 did not support the argument of inelastic demand for Sudan exports.

Estimates of the share equations' parameters reveal important characteristics of the structure of aggregate demand in Sudan (Table 5.9). Results indicate that wheat substitutes for sorghum (DRA), whereas, animal protein (STOZ) substitutes for basic food staples (wheat and sorghum) in Sudanese diets. On the other hand, domestic manufactured goods (DMNF) compete with manufactured imports (FMNF) for household budgets. Table 5.9 also shows that the share of food except protein supplying items in consumption spending declines with higher expenditures. The fact that the shares of domestic and foreign manufactured goods also decline with higher consumption spending can be explained by their high food components. Spending on home goods (housing, transportation and services) increase with increased income. The demand system results have important policy implications.

Linear input-output coefficients for intermediate use and allocation of government consumption and investment spending by sector are derived by simple arithmetic (data presented in appendices). Chapter six will use dynamic simulations to validate the model and conduct policy experiments.

Table 5.10. Money supply (MNYSP) and demand (MNYDM) parameters' estimates[a]

	MNYSP		Change in MNYDM	
Constant	-.855	(-1.25)	-.4554	(-2.96)**
$MNYSP_{t-1}$	.317	(1.08)		
GB	.136	(2.26)**		
GDP	.594	(2.09)*		
RSR_{t-1}	.0034	(1.36)		
INFR			.045	(2.741)**
GNP			4.241	(2.475)**
REO			.052	(4.297)***
ERR			-.163	(-3.267)***
$INFR_{t-1}$			-.036	(-1.675)
REO_{t-1}			-.185	(-3.473)***
R-squared	.996		.86	
Durbin-Watson	2.06		2.23	

[a]Regressors are lagged money supply, government balance (GB), gross national product (GNP), lagged real saving rate (RSR_{t-1}), current and lagged inflation rate (INFR), current and lagged rate of change in official exchange rate (REO), and the error correction component (ERR).

*Figures in brackets denote t-ratios.

CHAPTER 6. MODEL VALIDATION AND POLICY ANALYSIS SIMULATIONS

This chapter tests the performance of the model with regard to recovering the historical records of the economy and conducts several policy analysis experiments. Dynamic simulation is used to implement these two tasks. An adapted version of the non-linear optimizer MINOS called GAMS/MINOS (Brooke, Kendrick, and Meeraus, 1988) is employed in solving the model. Section one describes the solution procedure and discusses some adjustments and decisions made before simulation on the basis of information revealed by the preliminary control runs. Validation and policy simulations are then undertaken in sections two and three, respectively.

Solution Procedure and Algorithm

A price adjustment procedure is generally used to solve for the equilibrium price vector which clears all product markets in the model allowing for small divergence (close to zero) in excess demands. The full model is reduced by substitution to a compact system of simultaneous non-linear excess demand functions. This strategy minimizes the required computation as a smaller number of variables and equations are handled. A solution algorithm is then employed to solve for equilibrium values of the endogenous variables iteratively. An initial guess on equilibrium values of prices is used to calculate sectoral excess demands. The solution algorithm then adjusts prices according to some rule iteratively

until iteration terminates (no revision of prices) when excess demands are close to zero.

Two strategies, namely, the factor market and product market strategies, are generally used in solving CGE models. They are based on separating factor from product markets and solving for equilibrium in only one set of markets after substituting out the other. Adelman and Robinson (1978) compare the two approaches and give more detailed discussion of the weaknesses and advantages of each. A significant reduction in dimensionality is usually expected with the factor market strategy. The product market arrangement of the model equations, on the other hand, provides a more flexible framework for incorporating various behavioral specifications (Dervis et al., 1982). The choice in this study, however, to adopt the product market strategy was based entirely on data limitations in modelling the factor markets in Sudan, as discussed earlier in chapter four.

In addition to Johansens' (1960) strategy to reduce the model to a linear system of equations, Dervis et al. (1982) distinguished three solution algorithms used to solve CGE models:

1. The fixed-point theorem algorithms; the major advantage of which is the guaranteed solution for models satisfying the fixed-point theorem conditions. It is, however, very expensive to use for moderate size models and not applicable to models violating the fixed-point theorem assumptions such as homogeneity of degree zero in prices.

2. The tatonnement process algorithms, where prices in each sector are adjusted up or down depending on whether excess demands are positive

or negative while searching for market clearing prices. While this technique is easy to implement, it is user tuned and hence model specific, although more efficient once tuned to a particular model.

3. The Jacobian algorithms: these represent iterative search procedures that unlike the tatonnement process, evaluate the derivatives of the model functions and use that information to determine the direction and step size of adjustment in their search for market clearing prices. Consider the solution problem for the vector of variables y given by:

$$G(y) = 0 \tag{6.1}$$

the function vector G is usually evaluated at each k^{th} iteration and the search continues according to some rule, like:

$$y^{k+1} = y^k + \alpha^k d^k \tag{6.2}$$

The direction of the search for the next iteration (d^k) is simply given by the sign of G(y) and the size of adjustment (α^k) to be taken in that direction is the user's choice in the tatonnement process. Jacobian algorithms on the other hand, utilize information contained in the derivatives of the function G(y) to determine the direction vector d^k and step size α^k. The Newton-Raphson and steepest descent methods are some examples of a family of Jacobian algorithms. The line search formula of the steepest descent algorithm is given in 6.3.

$$y^{k+1} = y^k - 2\alpha^k D' G(y^k) \tag{6.3}$$

where D is the Jacobian matrix defined as:

$$D_{ij} = \frac{\partial G_i}{\partial y_i} \qquad (6.4)$$

These algorithms are thus more efficient than the tatonnement process. They are, however, more expensive to solve as numerical computation of the derivative matrix is to be performed for every solution. The Jacobian technique is chosen for the present study as it stands between the fixed-point algorithms and the tatonnement process representing a reasonable compromise between efficiency and cost effectiveness. There was also a desire to avoid tuning the solution algorithm to a particular model specification like the GEMSE that has a number of deficiencies and, hence, needs further adjustments as data permits in the future.

The computer program GAMS/MINOS employed in this study uses the projected Lagrangian algorithm of Murtagh and Saunders (1982, 1987). Their algorithm is developed to handle non-linearly constrained optimization problems. The non-linear constraint vector given by:

$$f(x) = 0 \qquad (6.5)$$

is transformed to its linear approximation

$$\bar{f}(x) = f_k + J_k(x - x_k) \qquad (6.6)$$

where f_k and J_k are the constraint vector and Jacobian matrix evaluated at x_k. A sequence of major iterations are then executed during each

of which an "augmented Lagrangian" objective function is optimized subject to the linearized version of the non-linear constraint vector as defined in 6.6. The reduced-gradient algorithm is used to solve the linearized subproblem in a sequence of minor iterations within each major iteration.

GAMS/MINOS establishes feasibility of the solution before optimizing the objective function which is a redundant constant in the GEMSE case. Feasibility is attained when the linearized and non-linear constraints are satisfied to within a given feasibility tolerance. GAMS/MINOS then starts evaluating the objective function. The GEMSE model was set such that the objective is to maximize a constant term. This makes the search to be practically for a feasible solution to the non-linear system of equations (constraint equations) in the model which will always be optimal given the inactive objective function specified.

Control runs Due to the size and non-linear structure of the model, control experiments were performed in order to explore behavior of the model and the difficulty and cost of solving the system. Another reason was to experiment with various settings and parameter controlling the execution of the algorithm operations. Very useful information was revealed and several decisions and adjustments were made on the basis of the control runs results.

It was found that the average time required to solve the model with the default settings of GAMS/MINOS on the University's mainframe computer (a NAS 9160 which is IBM 370 compatible machine) for a single year was 13.6 CPU seconds. This, in addition to 15 more seconds of compilation,

generation and execution time cost above $25.00 per one year run. Currently available PC versions of GAMS/MINOS, on the other hand, can only use 640k of memory on personal computers. The workspace required by GAMS/MINOS to process the present model could allow solving for only one year at a time on the personal computer with partial adjustment effects of lagged endogenous variables fed manually every year. While it is possible to update the current year model for the next year with the GAMS/MINOS save and restart file options, this however, can only be used once every two years. The average run time on the personal computer was estimated to be eight minutes per year and completes in an average of 140 minor iterations and 15 major iterations.

As limited funds and time were available for the completion of this research, the following decisions and adjustments had to be made:

a) It is first of all decided to conduct simulations on the 1981-86 period since liberalization and economic recovery programs were launched effectively in 1979/80. In addition to saving on time and resources, this strategy enables focusing on evaluating specific policy packages and proposals advocated by donor organizations.

b) It was decided to solve the model consecutively on the personal computer feeding solution values of lagged endogenous variables into the next year to enable dynamic simulation.

c) Several adjustments were also made on the model structure to reduce its size.

(1) The small country assumption used for imports and most exports is extended to the long staple cotton and gum arabic sectors.

The model is thus being made smaller by two foreign trade markets.

(2) As cotton and wheat areas on the public irrigation schemes (region 1) are determined by the government, area response functions estimated to represent government decision in these two sectors were dropped. Land allocations to cotton and wheat in region 1 are thus given exogenously.

(3) The fact that there is no data on capital stocks nor on demand for private investment by sector of destination led to the estimation of an aggregate nominal private investment spending function. Returns on alternative investment opportunities are used to explain private investment spending as discussed in Chapter 5. The private investment equation showed poor performance with substantial deviations from observed private investment spending. Since this was the second best alternative to controlling changes in capital stocks given the data limitations, it is decided to drop the private investment equation until better data is available. Total investment thus becomes exogenous to the model. This eliminates the spill over effects of the large discrepancy between the fitted and observed private investment on other sectors particularly equilibrium in the homegoods sector where investment demand is a large part of total demand. Another effect of this divergence works through the domestic product-income identity (the budget constraint) which transmits a hidden indirect influence to all sectors of the economy. Investment demand for homegoods is thus derived as a residual after subtracting capital imports from total investment demand.

d) Two main problems were encountered while solving with the default settings of GAMS/MINOS. Those were namely termination due to infeasibilities and/or illegal operations such as undefined log operations, exponential overflow, etc. After experimenting with different values of the control parameters of the algorithm, normal completion of feasible solutions were obtained with the following alternative settings:

(1) Illegal operations disappeared completely with the number of minor iterations reduced to 20 from the default of 40.

(2) A feasibility tolerance parameter (r) of 0.01 is used. If the linearized constraints are satisfied to within the tolerance r, the associated subproblem is declared feasible.

(3) The row tolerance parameter which measures feasibility with respect to the non-linear constraints themselves is set at 1.0E-4. This specifies a lower bound on the accuracy at which the non-linear constraints are to be satisfied. The row tolerance is actually the parameter that controls how close to zero excess demands should be for a solution to be considered feasible.

Model Validation

To test the ability of the model to generate the observed history of the economy, in-sample forecasting was conducted using dynamic simulation for the period of 1981-86. The already short series (1971-1986) available for estimation precluded use of some data for out-of-sample reliability tests. Two standard statistics are computed for selected variables in Table 6.1 to assess the performance of the model for the simulated period. The Root Mean Square error (RMSE) and percent error (PRMSE) given in Table 6.1 are calculated using the following formulae:

$$RMSE = \left[\frac{1}{n}\Sigma_t\left(\frac{\hat{y}_t - y_t}{y_t}\right)^2\right]^{\frac{1}{2}} \qquad (6.7)$$

$$PRMSE = \left(\frac{1}{\bar{y}}\right)(RMSE)(100) \qquad (6.8)$$

where y_t and $\bar{y}$ denote the solution and mean values respectively, of the endogenous variable y_t at t=1,2,...,n.

Except for government revenue and the government balance (with RMSE values of 1.05 and .47, respectively) the model gave very close forecasts of the actual path of the economy during the 1981-86 period (Table 6.1). It is also clear from Table 6.1 that the divergence between the solution and actual values increase with time. This is, however, not unusual with dynamic models as dynamic simulation uses solution values of lagged endogenous variables to update the model for the next period and thus divergence compounds as time passes. This fact renders dynamic model formulations to be suitable for short to medium term policy analysis while their long run forecasts are taken with caution.

Policy Analysis

The scheme for policy analysis adopted in this section is based on the basic components of the economic recovery and stabilization programs initiated by donor institutions during the late seventies. It has been argued in Chapter 2 that partial introduction of liberalization and other structural adjustment measures in presence of other distortions in the economy was the major reason behind its failure in Sudan. Various policy scenarios are designed to evaluate the impact of measures believed to have supported devaluations and liberalization accomplish success if adopted. Accordingly the following policy options are examined:

1. Fiscal improvements and monetary control Expansionary fiscal and monetary policies are blamed for the failure of stabilization programs and excessive inflation that whipped away the positive effects of devaluation and liberalization. To investigate the effects of fiscal

Table 6.1 Model validation solutions (1981-1986) and error statistics for selected variables

Variables	1981	1982	1983	1984	1985	1986	Mean	RMSE	PRMSE
Nominal GDP (Ls. Billion)	4.91	7.09	9.68	11.49	15.22	21.56	11.66		
Solution Value	4.95	6.14	9.2	12.09	14.66	22.44		.66	5.66
Money Supply (Ls. Billion)	1.53	2.09	2.33	2.76	4.37	5.4	3.08		
Solution Value	1.44	1.88	2.52	3.28	4.55	6.83		.14	4.55
Pvt. Consump. (Ls. Billion)	4.0	5.15	7.85	9.15	12.11	17.7	9.43		
Solution Value	4.12	4.72	7.4	9.67	11.46	18.73		.06	.59
Govmt. Revenue (Ls. Billion)	.5	.85	1.19	1.55	1.05	1.33	1.08		
Solution Value	.54	1.11	1.21	1.45	1.23	1.02		1.05	97.4
Govmt. Balance (Ls. Billion)	.71	.71	.52	.57	1.46	1.76	.96		
Solution Value	.68	.44	.51	.62	1.08	2.07		.47	49.27
Trade Balance (Ls. Billion)	-.72	-.89	-1.22	-1.09	-.98	-1.37	-1.05		
Solution Value	-.81	-1.41	-1.27	-1.01	-.94	-1.51		.25	23.92
Gen. Price Lvl Index (1971=1)	5.4	7.3	8.8	11.8	17.7	22.6	12.27		
Solution Value	5.59	7.6	9.6	12.67	18.41	23.8		.06	.46
Price Non-Trad. Index (1971=1)	5.9	7.8	9.2	12.3	17.4	22.5	12.52		
Solution Value	5.82	7.61	9.57	14.5	18.5	21.6		.08	.66
Price of Wheat (Ls./Kantar)	9.8	13.8	18.7	19.1	19.8	21.3	17.08		
Solution Value	9.68	13.4	16.02	20.97	22.94	28.4		.17	.98
Inflation Rate (100%)	20	35	21	34	50	28	31.3		
Solution Value	18	36	26	41	45	30		.18	.57

and monetary control the following experiments are performed:

a) Experiment 1: Liberalization of domestic capital markets and positive real rates of interest represent one way of achieving monetary equilibrium. Therefore, the real interest rate is forced to be greater than 5% in this experiment.

b) Experiment 2: Reduced government is an alternative measure for achieving balanced budgets and consequently monetary control. Government consumption spending is reduced by 20% every year in this experiment.

2. Price subsidies (experiment 3) To allow for the full impact of the government spending policy, wheat pricing and importation policies are changed. In this experiment Sudan is assumed to face an infinite supply of foreign wheat at the world price converted to Sudanese Pounds (small country assumption). The tax/subsidy structure in the wheat sector is eliminated such that all wheat is traded at its full price (e.g., the indirect tax levied via official procurement price on domestic producers as well as the subsidy to consumers are lifted). This wheat policy is adopted together with the reduced government spending in this experiment.

3. Tax policies (experiment 4) Whereas indirect taxes distort relative prices, they are the main source of government revenue (particularly taxes on foreign trade) in developing countries. An experiment reducing taxes on foreign trade by 50% and increasing direct taxes from 5% to 10% (value added tax) is implemented.

4. Exchange rate policy (experiment 5) Gradual devaluation and unification of the nominal exchange rate is adopted in this experiment. It is generally believed that the parallel market price of foreign exchange is higher than the equilibrium price by a margin paying the risk

premium on dealing in illegal markets under currency inconvertibilities plus a market power rent in an imperfect market (Elbadawi, 1988 and Pinto, 1988a). Accordingly a unified exchange rate defined to move as the average of the official and free market rates is used for all foreign trade in this experiment.

5. Experiment 6 This is a combination of experiments 5 and 3. This experiment adopts the unified exchange rate of experiment 5 above together with the government spending and wheat policies of experiment 3.

Results of the three years simulations--summarized in Tables 6.2 and 6.3--indicate various effects in different directions. In absence of an objective criterion such as a welfare function, it is difficult to draw conclusions from this information. Evaluation, however, is left to the weights policy makers place on the different aspects and variables of the economy and their priority ordering. The analysis will, however, compare the direction of change and discuss the negative and positive impacts of the various policies in reference to the short-term objectives of economic recovery and stabilization programs.

Experiment 1: The interest rate policy was not effective and is not reported here as the control solutions were not significantly altered. The impotency of interest rate is due to the institutional rigidity and redundancy of an almost completely rationed domestic credit market as discussed in Chapters 2 and 4. The very small elasticity of private spending (and thus saving) and money supply to real interest rate plus its statistical insignificance in the money demand equation in addition to eliminating its effect through the dropped private investment equation

made the model structure insensitive to real interest shocks. To improve the role of interest rate in allocating loanable funds, several institutional changes are required in order to liberalize the domestic credit market and allow the market system determine the scarcity value of capital. Among other factors, controlling domestic rates of interest at low to negative real levels, is an important cause of the observed capital flight with opening up the capital account and foreign exchange markets in many developing countries including Sudan (Edwards, 1984; Frenkel, 1982; Pinto 1988; and Elbadawi, 1988a).

Experiment 2: Table 6.2 presents the results of the reduced government consumption spending simulation. The government consumes only homegoods and domestic manufactured goods in this model. Reduced spending therefore directly affects total demand for these two commodities. Other things equal, the endogeneously determined price and supply of homegoods are expected to move in response to this shock, whereas, reduced government demand for domestic manufactured goods leaves more supply of this product for exports. The indirect impact of reduced spending on the other hand, works through the budget deficit, money supply, price of money and real prices linkages. It therefore, extends to all sectors of the economy. Income also moves with the spending shock as value added change with adjustments in sectoral output in response to relative price movements. Private spending, tax revenues and consumption demand consequently adjust as well. There is a small instantaneous effect on agricultural supply through the real wage rate. Due to the

partial adjustment structure of supply response in agriculture the important effect of relative price changes is realized a year later.

According to Table 6.2, the net effect of reduced government spending on the economy can be summarized generally in lowering of nominal values such as GDP, money, prices (except for wheat), and inflation, thus improving real variables (GDP, prices and exports). The government balance measuring the size of the budget deficit is reduced significantly and moved towards an almost balanced budget in 1983. The positive impact of this improvement in the domestic resource gap was substantial on money supply, the general price level and inflation. Movements in the trade balance were favorable the first two years, whereas, it deteriorated in 1983. The positive impact of a lower inflation rate on real net returns and consequently on supply and exports is realized in the last two years. Higher real prices, however, produced negative effects on the demand for imported consumer goods which, together with the increased demand for imported intermediate goods when supply adjustments were larger in 1983 leading to a bigger trade deficit. This effect is probably due to the institutional rigidities in the irrigated public schemes where areas under intensive users of intermediate imports such as cotton and wheat are fixed by the government and do not respond to movements in economic incentives. No attempt was made on changing the fixed crop rotations in this region, an issue that deserves further investigation particularly for a very important foreign exchange earner such as cotton and import substitute as wheat.

Table 6.2 Results of policy simulation experiments 2, 3, and 4

	Year	Control Solutions	Reduced Spending Level	Reduced Spending % Change[a]	Reduced Spending Wheat	Tax Policy Level	Tax Policy[a] % Change
Nominal GDP (Ls.Billion)	1981	4.95	4.92	-0.61	4.9	5.17	+4.4
	1982	6.14	5.69	-7.3	6.43	5.93	-3.4
	1983	9.2	8.17	-11.2	7.87	8.91	-3.2
Price Money (Idx,1971=1)	1981	5.59	5.1	-8.8	5.33	5.7	+1.97
	1982	7.6	6.6	-13.2	7.0	6.9	-9.2
	1983	9.6	7.9	-17.7	7.7	8.9	-7.3
Real GDP	1981	.886	.965	+8.9	.92	.91	+2.7
	1982	.808	.862	+6.7	.92	.86	+6.4
	1983	.958	1.034	+7.9	1.02	1.00	+4.4
Money Supply (Ls. Bill.)	1981	1.44	1.40	-2.8	1.41	1.43	-.69
	1982	1.88	1.62	-13.8	1.72	1.74	-7.5
	1983	2.52	2.10	-16.7	1.74	2.18	-13.5
Inflation Rate	1981	24.3	13.3	-45.3	18.4	26.7	+9.9
	1982	36	29.4	-18.3	31.3	21.1	-41.4
	1983	26	19.7	-24.2	10.0	29.0	+11.5
Private Consumption (Ls. Bill.)	1981	4.12	3.99	-3.2	3.94	4.12	0.0
	1982	4.72	4.09	-13.4	4.86	3.93	-16.7
	1983	7.4	6.59	-10.9	6.23	7.33	-.95
Government Balance (Ls. Bill.)	1981	.68	.535	-21.3	.55	.50	-27.2
	1982	.44	.216	-50.9	.34	.51	+7.6
	1983	.51	.048	-90.6	.06	.48	-5.9
Value of Exports (Ls. Bill.)	1981	.356	.386	+8.4	.37	.36	-.28
	1982	.762	.913	+19.8	.64	.92	+21.1
	1983	.712	1.063	+49.3	1.08	.89	+25.0
Value of Imports (Ls. Bill.)	1981	1.163	1.047	-9.97	1.05	.98	-16.2
	1982	2.176	2.152	-1.1	1.90	1.75	-19.6
	1983	1.983	2.530	+27.6	2.52	2.36	+19.0
Trade Balance (Ls. Bill.)	1981	-.81	-.66	-18.5	-.68	-.62	-23.5
	1982	-1.414	-1.239	-12.4	-1.26	-.83	-41.3
	1983	-1.27	-1.465	+15.4	-1.44	-1.47	+15.8
Price of Homegoods (Idx,1971=1)	1981	5.82	4.2	-27.8	6.6	6.5	+
	1982	7.61	6.98	-8.3	9.2	6.4	+
	1983	9.57	7.7	-19.5	8.1	9.5	-
Wheat Price (Ls./Kantar)	1981	9.68	59.4	+513.6	7.8	8.6	-
	1982	13.4	16.25	+21.3	7.5	22.6	+
	1983	16.02	45.6	+184.6	11.1	9.8	-
Domestic Supply of Wheat Ratio	1981	.37	.364	-1.6	.24		
	1982	.42	.443	+5.5	.07		
	1983	.228	.241	+5.7	.18		

[a]Percentage change is measured against the control (validation) run solutions in column 2.

Deterioration in the supply of domestic manufactured goods and homegoods as well as the lower price of non-tradables (a sector that makes nearly 50% of the total value added) are considered the main factors behind the lower nominal GDP. Due to the partial adjustment structure of agricultural supply the effect of improved wheat prices on the proportion of domestic production in total wheat consumed improved in the last two years only. This is one reason for the shooting wheat price in 1981 as demand increased with higher real prices of competing goods (relative to the subsidized wheat price), whereas wheat imports are fixed exogenously. Domestic wheat supply, however, is not very responsive to movements in relative prices due to several factors including the fixed area allocation in public schemes, the low investment in irrigation and other wheat inputs, the continuously declining area suitable for cultivation in the private irrigation schemes due to various physical and technological factors.

Experiment 3: In Sudan the government controls wheat importation and supports wheat production on the public irrigation schemes (region 1). Wheat growers in the public schemes are required to deliver their produce at an official procurement price lower than the import price. Government wheat is thus rationed and distributed to local mills at a subsidized price. There is also a free market price for wheat which happens to be higher than its world price due to controlled importation. Wheat producers in the private irrigation schemes sell in the free market. Moreover, part of the wheat produced on the public scheme finds its way to private traders as a result of the price differential. In

this experiment wheat imports are endogenous and only one price for wheat is applied, namely the import price. As a result of this, prices paid to public scheme farmers rise, whereas prices received by private wheat producers fall as at the same time the foreign substitute (wheat imports) is assumed to be in unlimited supply.

Table 6.2 gives the results of the reduced spending and wheat policy simulation. Results are similar to the reduced spending experiment. Important differences are the negative impact of lifting the wheat imports quota (and consequently the artificially high free market price) on domestic supply of wheat ratio as private wheat producers now realize lower returns. The long run effects of the free wheat policy on nominal GDP, inflation, and trade balance are better compared to the reduction under the wheat import control regime.

Experiment 4: While liberalization calls for reducing indirect taxes and price controls which distort the structure of economic incentives, some authors argue that this strategy works against stabilization programs since indirect taxes are the main anti-inflationary means of financing budget deficits in most countries (Musa, 1986 and Fischer, 1986). The alternative of increasing direct taxation with reduced taxes on trade is investigated in this experiment. Taxes on foreign trade are reduced by 50% and the value added (direct) tax is increased simultaneously from 5% to 10%. Results are given in Table 6.2.

Real GDP improved with the new tax policy. This is because the favorable effects on the general price level are larger than the decline in nominal GDP plus the positive change in nominal GDP in 1981.

Substitution of direct for indirect taxation also did not produce inflationary pressures on the economy as money supply and the general price level followed slower growth patterns. Private consumption declined slightly but was higher in real terms in 1983 with the new policy. The government balance continued to improve after showing a small deterioration in 1982, a fact that negates the argument against removal of indirect taxes for budgetary reasons. The policy also improved the balance of trade during the first two years until demand for intermediate and consumers imports rose significantly in 1983 with higher real incomes and net returns to domestic suppliers. The above scenario, however, assumes the existence of an efficient tax agency and institutional setup that ensures successful implementation of the policy given the difficulty of administering direct tax collection in LDCs.

Experiment 5: Several devaluations have been administered on the nominal exchange rate in Sudan. Multiple exchange rates are also used for various purposes. In this experiment the exchange rate on all foreign trade is unified at an assumed equilibrium rate. The new rate moves with the evolution of the official and free market rates as an average of the two. Results are summarized in Table 6.3.

According to Table 6.3 the exchange rate policy led to higher nominal levels in general but a deterioration in real terms due to the large inflationary pressures of devaluation. Significant improvements are realized in the government and trade balances (except for 1983). This is due to the positive impact of the higher nominal exchange rate on returns to producers, and consequently supply and exports. The increased

demand for intermediate imports was greater than the negative demand efect of higher prices on imported manufactured goods, especially in 1983 when the trade balance started to deteriorate. The results of Table 6.3 indicate that while improving supply incentives and promoting exports, devaluation policy placed large inflationary pressures on the economy.

Experiment 6: To mitigate the inflationary effects of adjusting the nominal exchange rate, reduced government spending and the wheat importation and price policies of experiment 3 are simultaneously adopted in this experiment together with the exchange rate regime of experiment 5. Results are given in Table 6.3.

With reduced government spending working in an opposite direction on nominal variables the benefits of adjusting the nominal exchange rate are better realized. The inflation rate is curbed at lower levels and larger improvements are realized on exports, and the government and trade balances. The combination of controlled budgets and removal of currency overvaluation produced favorable demand management and supply and export promotion results. Lower inflation rates and thus better results can, however, be obtained with smaller adjustments in the nominal exchange rate and/or tighter fiscal and monetary policies.

Lessons learned from the policy simulations results support the argument that expansionary fiscal and monetary policies and other distortions in the structure of economic incentives were important factors behind the failure of devaluation and liberalization policies in Sudan. Reduced spending and lower trade and exchange rate taxes showed large potential for improving the performance of Sudan economy.

Table 6.3 Results of policy simulation experiments 5 and 6

	Year	Exchange Rate Policy		Exchange Rate, Reduced Spending & Wheat Policies	
		Level	% Change[a]	Level	% Change[a]
Nominal GDP (Ls. billion)	1981	5.4	+9.1	5.2	+5.1
	1982	8.5	+38.4	8.3	+35.2
	1983	8.7	-5.4	8.95	-2.7
Price of Money (1971=1)	1981	6.3	+12.7	6.2	+10.9
	1982	11.0	+44.7	10.3	+35.5
	1983	13.8	+43.8	11.4	+18.8
Priv. Consumption (Ls. billion)	1981	4.5	+9.2	4.2	+1.9
	1982	6.96	+47.5	6.8	+44.1
	1983	7.1	-4.1	6.94	-6.2
Govmt. Balance (Ls. billion)	1981	.66	-?.9	.48	-29.4
	1982	.26	-40.9	.16	-63.6
	1983	.25	-51.0	.12	-76.5
Inflation Rate	1981	42	+75.0	37	+52.3
	1982	72	+100.0	66	+83.3
	1983	26	0.0	11	-57.7
Price of Homegoods (1971=1)	1981	6.3	+8.3	6.1	+4.8
	1982	13.8	+81.3	13.1	+72.1
	1983	8.9	-7.1	10.1	+4.3
Value of Exports (Ls. billion)	1981	.44	+23.6	.55	+54.5
	1982	.94	+23.4	1.10	+44.4
	1983	1.19	+67.2	1.34	+88.2
Trade Balance (Ls. billion)	1981	-.723	-10.7	-.60	-25.9
	1982	-1.26	-10.9	-1.22	-13.7
	1983	-1.48	+16.5	-1.06	-16.5

[a]Percentage change is measured against the control run solutions.

Particular features of the Sudan economy and structure of the present model have important implications on policy analysis. While short run dynamics were modelled, partial adjustment occur in the product market only in this model. With factor markets suppressed, important adjustment dynamics and their policy implications in terms of factor mobility and intersectoral movement of resources, distributional effects, and technological change were not addressed. The impact of which on sectoral growth and economic performance may have been significant.

The rigid foreign exchange and domestic capital market, on the other hand, led to the use of macro-closure rules that allow for disequilibrium in the saving-investment balance (excess aggregate demand). The use of an important equilibrating mechanism such as the illegal foreign exchange market was precluded for lack of data. The role of the two asset prices was, however, assumed by the general price level in the model. Impulses of resource-imbalances on the various sectors of the economy were transmitted by the endogenously determined price of money. Other limitations of the study are discussed in Chapter seven.

CHAPTER 7. SUMMARY AND CONCLUSIONS

After almost a decade of economic adjustments and policy reforms initiated mainly by donor organizations, Sudan continues to suffer from persistent inflation, unsustainable balance of payments deficits, and negative growth in real output. While Sudan's experience is yet to be adequately evaluated, factors usually blamed for similar failure experiences were suggested in chapter one for the unsuccessful attempts of the country to overcome its economic crisis. Presence of unfavorable macro-economic environments is considered one major barrier to devaluation and partial liberalization measures in many countries. Simultaneous introduction of contractionary stabilization policies along with expansionary structural adjustment programs as well as the sequencing and speed of the liberalization process are also often referenced as important failure reasons. Moreover, elimination of price controls and indirect taxes are also believed to conflict with fiscal improvements and stabilization efforts as they are the main anti-inflationary measures and sources of fiscal revenues in most developing countries (Mussa, 1986; Fischer, 1986; Krueger, 1984; Edwards, 1984; McKinnon, 1982; and Taylor, 1981). The inelastic demand for imports and exports and the rigid supply structures in the country's export sectors were also used to explain the failure of and object to devaluation policies in Sudan (Ali, 1984b; El Hassan, 1977; and Elbadawi, 1987).

While evidence for or against devaluation, such as the inelasticity and structural rigidities, the presence of severe monetary disequilibrium

and distorted relative prices and interest rates has been provided by a number of studies, the liberalization experience in Sudan has not yet been adequately analyzed. For one reason, the debate over the soundness of liberalization and devaluation policies in Sudan was conducted in a partial equilibrium framework where several important intermarket and intersectoral linkages were not captured. Although the incidence of policy on relative prices and incentive structure was measured in some studies, real responses and micro supply-demand adjustments to such shocks were not systematically investigated. Moreover, the implications of the simultaneous opening of the current and capital accounts along with successive devaluations in such an inflationary environment and with the domestic capital market rationed at negative real rates of interest, were not addressed.

An integrated analytical framework that incorporates the above mentioned complex structural interactions essential for a proper evaluation of Sudan's experience was, therefore, developed and utilized to conduct policy analysis in this study. The general equilibrium representation of economic systems was considered to be the most appropriate approach to modelling interactions between the various sectors of the economy as compared to other analytical models. A computable general equilibrium model for Sudan was thus constructed in this study to perform the intended investigation.

A preliminary tabular analysis of the nature and origins of the present economic crisis and the structural features and performance of the economy under various policies over the last two decades was given.

The divergent views on devaluation and liberalization in the literature on Sudan were then discussed in light of new empirical results on distorted relative prices and internal terms of trade between economic sectors in Chapter two of this study. A general equilibrium model that attempts to overcome some of the deficiencies of applied Walrasian equilibrium models was then developed for Sudan economy.

The model extends the multi-sector Walrasian equilibrium structure to integrate Keynesian macro features that recognize short run adjustment dynamics and an endogenous monetary mechanism. The model is built with detailed supply-demand specifications for 16 sectors. There are ten agricultural tradables produced in four different farming systems and four non-agricultural tradable sectors; namely, domestic manufacturing, foreign intermediate goods, capital, and consumer goods. The model also contains a homegoods sector and money. Macro-sectors of the economy as well as the important structural rigidities and adjustment dynamics of the system are explicitly modelled. A comprehensive representation of the various tax structures and other fiscal, monetary and commercial policy instruments are also included in the model. The relationship between the government sector and an endogenous money creation mechanism, an important phenomenon in developing countries including Sudan, is also specified. The general price level together with other nominal and real flows are endogenously determined in this model.

In addition to explicitly modelling the macro sectors of the economy and the endogenous money creation rule, the model allows for less than perfect flexibility in some markets. The fixed nominal exchange and

interest rates provide some examples of disequilibrium in the official foreign exchange and domestic capital markets. Price expectation schemes were employed to model partial adjustment in some agricultural markets where supply lags exist. Differential adjustment rates among the different markets lead to non-neutrality of movements in nominal aggregates and macro shocks. This provided an option for the government to affect economic activity. The fact that rigidities exist in some markets violates the full equilibrium assumption of Walras' theory. Walras Law, however, is assumed to hold in a sequence of temporary equilibria in the Hicksian sense and all markets clear either through quantity or price or both.

Time series data were used to choose numerical values for the model parameters. Econometric estimation provides superior statistical basis for the model specifications over calibration and deterministic methods. Difficiencies of the model are discussed below. Parameter estimates supported the inelasticity of agricultural supply argument which justifies the use of agriculture as the tax base for industrialization. The econometric results, on the other hand, indicated the large room for policy influences on the composition of agricultural output as crop areas were very responsive to movements in relative prices of competing crops and changes in policy instruments.

The product market strategy was employed to solve the model using Jacobian algorithms. Dynamic simulation with the computer program GAMS/MINOS was used to solve the model for validation and policy analysis. Equilibrium values for the endogenous variables of the model

were found to within a feasibility tolerance of 1.0E-4. Due to time and resource limitations, the model was solved over six years only starting in 1981 for validation purposes and solutions for three consecutive years beginning in 1981 were obtained for each policy experiment. Root mean square erors (RMSE) and percent RMSE were computed to test the model's ability to recover the historical records of the economy. The calculated statistics showed a powerful performance of the model in portraying the history of most economic data.

Experiments for policy analysis were designed to address the important issues in the liberalization-devaluation debate in Sudan, presented earlier, and evaluate alternative policy options for economic reform. Six policy experiments were conducted as follows:

1. A lower bound of 5% on the real rate of interest was imposed for monetary control.
2. Government consumption spending reduced by 20% every year to investigate the impact of fiscal improvements.
3. Reduced government spending was applied along with a free wheat pricing and importation policy.
4. Indirect taxes on foreign trade reduced by 50% and direct tax rate raised from 5% to 10% simultaneously.
5. Gradual devaluation and unification of the nominal exchange rate at the average of the ruling official and free market rates.
6. The exchange rate policy (5) plus the reduced spending and wheat policy (3) were jointly applied.

Results of the policy simulation runs indicate that the economy is non-responsive to movements in nominal interest rates. The institutional rigidities in a highly rationed and controlled domestic credit market are important reasons behind the impotency of interest rates. This result

calls for serious institutional improvements in the domestic credit market. Reduced government spending, on the other hand, generated favorable results as smaller budget deficits and slower growth in money supply, inflation and other nominal variables including GDP and the price of homegoods were realized. Real GDP, exports and the domestic supply of wheat ratio were higher under reduced spending. These results support the argument that expansionary fiscal and monetary policies worked against stabilization and economic recovery in Sudan.

Lifting the wheat imports quota and administered prices in the free wheat policy scenario had negative impacts on domestic wheat supply. The long term effects of the free wheat policy on nominal GDP, inflation and trade balance, however, were better than under wheat import control regimes. The tax policy experiment led to slower growth patterns in money supply and inflation and improved real GDP and the budget balance refuting the argument against removal of indirect taxes for budgetary reasons.

Higher nominal values and faster inflation, on the other hand, were realized with devaluation apart from its positive demand management and export promotion effects. Better results, however, were obtained when the exchange rate policy was supported with reduced government spending. Slower inflation and larger improvements on exports and the government and trade balances were realized. The results again indicate the need for fiscal improvements, monetary control and minimal indirect taxation to go along with nominal exchange rate adjustments to improve relative prices to suppliers and eliminate the bias against exportables and

agriculture in the structure of economic incentives in Sudan. Whereas, no objective criteria are available in this study to conduct welfare evaluations of the alternative policies examined, useful information is generated by the policy simulations to guide policy makers to choose the desired direction of change.

The major limitation of the model is posed by scarcity of data. Supply in an important industry such as the livestock sector in Sudan is given exogenously in this model for lack of data. Factor markets in the model are also suppressed as information on labor use and capital stocks by sector is not available. Accordingly, labor and capital demand equations could not be estimated and the product market strategy is thus employed in solving the model for equilibrium prices. While an infinitely elastic supply of labor at a fixed wage rate is assumed, data could only allow for the estimation of an aggregate private investment spending function. Endogenizing livestock supply as well as labor and capital demand by sector represent important agenda for future work in improving the general equilibrium model. With data available to allow estimation of factor demands, functional distribution of income and spending can easily be modelled and thus enhance the model's ability to handle distributional as well as nutritional and poverty aspects among the various income recipients.

Further disaggregation of the domestic manufacturing sector is desirable and useful in investigating import substitution and industrialization issues. The same applies to the homegoods sector. Demand data was poorer than supply information as there is no systematic

collection of consumption data in Sudan except for two recent consumer survey reports covering three years and mainly the Khartoum area. Better data on consumption is needed to allow for better disaggregation of consumption categories. Consumption demand by income groups and thus distributional effects of policies can be analyzed with better data available on factor markets in the future.

Once more, lack of data precluded proper modelling of the loanable funds and the foreign exchange markets. While holding foreign assets is a real alternative to holding domestic money or assets, it has been illegal for most of the period covered by this study. Illegal holding and dealing in foreign exchange outside the banking system naturally does not release information to enable modelling the supply and demand for foreign assets as part of a more complete portfolio balance framework. The parallel market price of foreign exchange was, nevertheless, used as an opportunity cost of holding domestic assets to reflect the hidden effects of an invisible market for foreign assets.

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ACKNOWLEDGEMENTS

Many people have contributed, in various ways, to the completion of this work. The largest appreciation goes to my major professor, Dr. Arne Hallam, for his patient guidance and motivating discussions. The intelligent teaching of Dr. Hallam and the confidence he placed in me in handling difficult research assignments introduced me to challenging academic horizons and helped sharpen my technical knowledge and skills. I would also like to thank professors D. Starleaf and L. Fletcher for their valuable comments and suggestions on several research and policy issues. I am also thankful to professors W. Fuller and R. Mahayni for serving on my committee. My sincere gratitude is extended to Dr. B. D'Silva for his advice and continued support throughout my graduate studies.

My wife, Entisar, and son, Mekki, sacrificed a good deal of family communion and suffered much neglect due to my constant absence over the last two years; this they did with patience, love and sympathy. In spite of the long hours away from home, their happy eyes and joyful laughter upon my return gave more meaning to my life and strong purpose and determination in my work. I have received an unceasing amount of love, encouragement, and moral and financial support from my late parents, brothers, and sisters--of which I am very grateful.

Finally I would like to thank the World Food Institute of Iowa State University and the Sudan Irrigated Sector Project for providing partial funding for this research. The careful typing of Pat Monroe was an essential component of this work.

APPENDIX A

Data used in constructing aggregate price indices for Sudan's exports, imports and external terms of trade are presented below.

Sources: Bank of Sudan Annual Reports, Cotton Marketing Corporation, Oil Seeds Company, Ministry of Agriculture, International Financial Statistics (IFS), Gum Arabic Corporation, Meat and Livestock Marketing Corporation, Ministry of Economic Planning. The IFSEXP and IFSIMP are respectively the IFS export and import price index of non-oil exporting developing countries. EXINDX and IMINDX are the calculated export and import price indices. The DMNF price index is constructed in Appendix C and converted into U.S.$ equivalent by the relevant effective exchange rate.

1) Exports are grouped into long and medium staple cotton (LSCN), short staple cotton (SSCN), sorghum (DRA), groundnuts (GNT), cotton seed (CSD), sesame (SSM), gum arabic (GUM), domestic manufactured goods (DMNF) and livestock and other products (STOZ).

2) Imports (IM) are measured in 000 kantars for wheat (IMWHT) and unit indices for imported capital (IM1), intermediate (IM2) and manufactured consumer (IM4) goods.

The IFS export price index of industrialized countries is used as a proxy for the price of capital imports (WPM1). Unit value indices are for FINT (WPM2) and FMNF (WPM4). World price of wheat (WPWHT) is taken from the Agricultural Statistics of the Ministry of Agriculture.

The EXINDX and IMINDX series are constructed as follows:

$$INDX = \Sigma \gamma_i P_i$$

where γ_i is sector i's share in total value of exports or imports and P_i is the respective price.

Table A.1. World prices (FOB) for exports, U.S.$ per unit

DRA	SSM	CSD	GNT	GUM	STOZ	DMNF	SSCN	LSC
3.20	8.20	13.50	6.80	39.00	3.28	1.00	21.00	32.00
3.50	9.50	15.50	6.90	44.00	3.82	1.01	24.00	33.00
3.70	11.90	17.70	7.30	51.30	4.27	1.05	39.00	49.00
4.40	13.60	20.60	8.10	62.30	5.27	1.23	38.00	74.00
7.10	17.60	20.60	12.30	58.90	5.18	1.84	42.00	62.00
6.80	16.90	26.50	11.80	56.80	5.84	1.84	39.00	66.00
7.10	17.30	32.40	13.80	55.70	6.42	2.36	43.00	84.00
8.60	22.80	31.40	15.70	54.00	7.42	2.26	34.00	96.00
9.80	28.50	32.90	16.10	47.70	9.49	2.45	41.00	92.00
11.80	26.60	28.40	18.30	64.00	8.60	2.26	42.00	98.00
11.90	25.30	23.50	24.10	68.30	8.27	2.28	46.00	95.00
13.40	22.60	23.60	16.30	79.30	9.71	2.54	40.00	88.00
10.40	26.10	21.20	20.60	95.70	8.63	2.12	38.00	82.00
10.80	29.80	23.70	23.20	95.40	4.85	1.64	44.00	85.00
10.00	33.70	16.30	21.20	102.30	8.54	2.30	47.00	92.00
10.30	35.50	17.90	20.20	105.30	8.80	2.95	43.00	78.00

Table A.2. Volume of exports (000 kantars)[a]

LSCN	SSCN	DRA	GNT	SSM	CSD	STOZ	GUM	DMNF
6203.00	204.92	2289.00	3326.00	2879.00	448.00	5.33	764.00	7400.00
5193.00	157.13	2432.00	2772.00	1986.00	406.00	21.58	738.00	4272.73
4160.00	141.81	2115.00	3114.00	2293.00	337.00	18.63	764.00	10250.00
1340.00	186.97	2007.00	2230.00	1879.00	102.70	26.47	468.00	3428.57
2640.00	189.11	1015.00	4613.00	1274.00	0.00	23.27	352.00	4333.33
3277.00	214.44	1676.00	6363.00	1998.00	0.00	24.27	589.00	3047.62
3430.00	154.84	2326.00	3224.00	2093.00	6.66	25.80	750.00	4333.34
2644.00	192.78	1123.00	2187.00	1710.00	0.00	10.83	872.00	5379.31
3526.00	160.78	3870.00	842.00	360.00	0.00	15.69	994.00	3485.71
2142.00	119.80	6441.00	497.00	1287.00	0.00	6.76	590.00	5318.18
1096.00	116.42	5430.00	2124.00	1321.00	0.00	16.38	741.00	6711.54
1540.00	96.29	9288.00	2003.00	1368.00	0.00	11.34	673.00	4695.65
3932.00	86.77	5765.00	407.00	1487.00	0.00	3.07	943.00	5494.12
3382.00	84.97	563.00	506.00	1818.00	0.00	0.96	864.00	6760.68
1786.00	114.24	0.00	299.00	396.00	0.00	28.99	392.00	1993.90
3213.00	138.99	686.00	25.00	655.00	0.00	7.88	432.00	2379.15

[a]Except for STOZ and DMNF where units represent indices obtained from dividing value of exports by a price index.

Table A.3. World prices (WP) in U.S.$ per unit and units (IM) of imports

WPM1	WPM2	WPWHT	WPM4	IM1	IM2
2560.00	531.00	2.90	1474.00	10.00	86.16
2636.80	573.48	3.20	1470.32	9.94	80.85
3046.40	716.85	6.50	1769.54	14.90	83.59
3814.40	743.40	9.30	2162.91	19.37	130.88
5094.40	939.87	8.10	2891.62	25.81	140.87
5145.60	1125.72	6.60	2921.28	25.46	97.40
5452.80	1412.46	5.20	3415.26	24.51	85.62
6316.80	1677.30	6.00	2765.22	22.28	101.03
7221.76	1836.20	7.70	3583.44	16.75	99.32
8225.28	1970.01	8.80	3537.71	34.91	124.73
8960.00	2011.83	8.70	3427.51	36.30	228.08
9039.65	2145.54	7.40	3521.61	42.37	288.20
8960.00	2198.75	7.60	3514.27	50.03	391.03
8753.23	2294.53	6.90	3785.67	42.96	451.04
8755.71	2320.15	6.40	4700.00	32.62	484.62
9035.27	2368.47	5.90	5955.34	28.75	533.91

IMWHT	IM4	EXINDX	IMINDX	IFSEXP	IFSIMP
1931.03	26.49	100.00	100.00	100.00	100.00
2000.00	26.55	90.52	102.10	103.16	106.67
1087.69	22.38	123.64	130.16	142.11	131.43
921.51	31.55	125.50	159.26	198.95	198.10
1111.11	30.12	128.33	228.72	201.05	211.43
1863.66	30.47	141.75	243.41	210.53	211.43
1248.08	33.94	183.66	270.44	246.32	218.10
1500.00	47.30	223.69	268.44	253.68	240.95
2851.95	42.34	225.77	289.07	300.00	290.48
4120.45	61.87	204.42	361.58	356.84	359.05
6137.93	68.70	144.30	340.68	321.05	357.14
7527.03	91.14	160.66	338.06	307.37	342.86
11907.90	179.39	260.14	315.07	295.79	327.62
11260.87	109.46	268.15	299.20	295.79	326.67
23140.63	116.51	193.56	292.31	270.53	312.38
20423.73	127.14	255.23	322.78	277.89	299.05

APPENDIX B

Construction of Average Rates of Protection Indices for Sudan's Exports and Imports (1970-1986)

Tables B.1 and B.2 derive the nominal and real effective and net protection ratios for the exports and imports of Sudan.

Table B.1 Exchange rates in Sudan (1970-1986)[a]

YEAR	CPI	WDPI	DINFR	$E_0=ER_2$	E_R	E_B	ER_1	ER_3	t_m+t_{QR}	t_{CN}	t_{NC}
1970	100	100	0.00	.35	.35	--	.35	.35	.658	.08	.12
1971	108	106	0.02	.35	.357	--	.35	.35	.663	.09	.135
1972	121	112	0.063	.35	.373	--	.38	.35	.627	.09	.142
1973	142	123	0.08	.35	.402	.64	.40	.35	.530	.08	.147
1974	169	143	0.03	.35	.414	.67	.40	.35	.564	.09	.149
1975	222	161	0.18	.35	.489	.74	.40	.35	.443	.10	.138
1976	225	185	-0.13	.35	.426	.66	.40	.35	.515	.11	.146
1977	263	227	-0.06	.35	.401	.66	.40	.35	.815	.13	.244
1978	315	259	0.06	.38	.425	.72	.45	.38	.649	.13	.169
1979	412	291	0.186	.43	.504	.77	.50	.45	.598	.10	.178
1980	518	337	0.100	.50	.554	.88	.80	.50	.521	.06	.150
1981	644	384	0.100	.50	.610	1.03	.90	.65	.551	.05	.255
1982	809	431	0.140	.90	.690	1.45	1.02	1.28	.218	.05	.287
1983	1056	466	0.230	1.30	.854	1.93	1.61	1.30	.219	.05	.161
1984	1417	507	0.250	1.30	1.068	2.44	1.87	1.50	.621	.05	.192
1985	2060	546	0.370	2.50	1.463	3.60	2.93	2.50	.679	.05	.181
1986	2488	587	0.135	2.50	1.661	4.28	2.98	2.50	.698	.05	.188

[a]The official (E_0) and Black Market (E_B) exchange rates, domestic consumer price index (CPI), effective exchange rates for non-government imports/non-cotton exports (ER_1), government imports (ER_2) and cotton exports (ER_3) are compiled from Bank of Sudan, Ministry of Finance, and World Bank (1983). The World price index (WDPI) is taken from IFS. The import tariff equivalent (t_m+t_{QR}) is borrowed from Elbadawi (1987). The tax ratio on cotton (t_{CN}) and non-cotton (t_{NC}) exports are derived as the ratio of tax collections to total value of exports. The differential inflation rate (DINFR) represent the difference between domestic and world inflation rates.

The Purchasing Power Parity (PPP) exchange rate (E_R) is calculated from the PPP condition:

$$E_R = P/P^* \tag{B.1}$$

where P is the domestic and P^* the foreign price.

$$\text{Log } E_R = \pi - \pi^* \tag{B.2}$$

Table B.2. Nominal and real protection ratios for Sudan exports and imports (1970-1986)[a]

YEAR	EX	NEX	EM	EPRX	REPRX	NPRM	RPRM	NPRX	RNPRX	NTB	GTB
1970	.33	.35	.60	.91	.90	1.66	1.66	.98	.98	0.592	0.545
1971	.32	.35	.60	.89	.86	1.66	1.63	.98	.96	0.585	0.536
1972	.33	.36	.62	.91	.84	1.72	1.58	.99	.91	0.574	0.529
1973	.34	.36	.58	.93	.80	1.61	1.38	1.00	.86	0.621	0.577
1974	.34	.36	.59	.93	.77	1.65	1.37	1.00	.83	0.607	0.564
1975	.34	.36	.55	.93	.65	1.52	1.07	1.01	.70	0.657	0.610
1976	.33	.36	.58	.92	.75	1.60	1.30	.99	.81	0.620	0.574
1977	.31	.34	.69	.86	.74	1.92	1.65	.95	.82	0.495	0.446
1978	.35	.38	.68	.91	.78	1.80	1.54	.99	.85	0.549	0.507
1979	.41	.44	.74	.95	.77	1.73	1.41	1.01	.83	0.586	0.548
1980	.62	.61	.99	1.25	1.07	1.98	1.71	1.22	1.05	0.618	0.630
1981	.66	.64	1.09	1.32	1.03	2.17	1.69	1.27	1.00	0.586	0.607
1982	.85	.91	1.17	.94	1.16	1.30	1.60	1.01	1.25	0.777	0.726
1983	1.29	1.36	1.77	.99	1.44	1.37	1.97	1.05	1.51	0.767	0.729
1984	1.49	1.50	2.57	1.14	1.32	1.98	2.27	1.15	1.33	0.582	0.579
1985	2.40	2.55	4.56	.96	1.54	1.82	2.94	1.02	1.64	0.558	0.523
1986	2.40	2.56	4.65	.96	1.36	1.86	2.64	1.02	1.45	0.549	0.515

[a]Calculated as follows:

Effective exchange rate for exports (EX)

$$EX = \alpha_{CN}\, ER_{CN} + (1 - \alpha_{CN})ER_{NC} \tag{B.3}$$

Where α_{CN} is the share of cotton in total value of exports and ER_{CN} (ER_{NC}) represents the effective exchange rate for cotton (non-cotton) exports.

$$ER_{CN} = ER_3(1-t_{CN}) \qquad (B.4)$$

$$ER_{NC} = ER_1(1-t_{NC}) \qquad (B.5)$$

Net effective exchange rate for exports (NEX) (this is the effective rate for exports net of subsidies on imported production inputs.)

$$NEX = \beta * ER_2 + (1-\beta)EX \qquad (B.6)$$

Where β is set equal to 0.3, i.e., imports contribute to 30% of total value added of exports (modified from World Bank, 1983, and Sudan Gezira Board Annual Reports).

Net effective exchange rate for imports (EM)

$$Em = ER_m(1 + t_m + t_{QR}) \qquad (B.7)$$

$$ER_m = 0.5(ER_1 + ER_2) \qquad (B.8)$$

Nominal (EPRX) and real (RPRX) effective protection ratios for exports

$$EPRX = EX/E_o \qquad (B.9)$$

EPRX is not adjusted for import subsidies and compared to the nominal exchange rate (E_o). However, RPRX corrects for under- or over-valuation of exchange rate but not adjusted for import subsidies.

$$RPRX = EX/E_R \tag{B.10}$$

Nominal (NPRX) and real (RNPRX) net protection ratios for exports

$$NPRX = NEX/E_o \tag{B.11}$$

$$RNPRX = NEX/E_R \tag{B.12}$$

NPRX is net of import subsidies but does not account for under- or overvaluation of E_o. RNPRX on the other hand corrects for both.

Nominal (NPRM) and real (RPRM) protection ratios for imports

$$NPRM = EM/E_o \tag{B.13}$$

$$RPRM = EM/ER \tag{B.14}$$

Gross and net trade biases (GTB and NTB) are obtained from

$$GTB = EX/EM \tag{B.15}$$

$$NTB = NEX/EM \tag{B.16}$$

APPENDIX C

Structure of Economic Incentives and Relative Prices in Sudan (1971-1986)

Table C.1 calculates price indices for agricultural tradables, non-agricultural tradables (manufacturing) and home goods (non-tradables) sectors as well as prices paid and received by farmers in Sudan.

Prices paid (PRPAID) and received (PAGTRD) by agricultural producers

Aggregate indices for farmers terms of trade with the rest of the economy in Sudan are constructed as a weighted average of prices received and paid by agricultural producers. The shares of the various agricultural products in total returns or costs per feddan in the irrigated sector are used as the respective weights in forming the price index. The weights are obtained from the Gezira and Rahad Schemes and the Ministry of Agriculture and presented with the irrigated sector data appendices (Appendix E).

Structure of incentives among economic sectors

An aggregate price index is constructed for agricultural tradables (PAGTRD), non-agricultural tradables (PNAT) and home goods (PHG) in the table below. The indices are derived as follows:

i. PAGTRD: discussed in section (a) above.

ii. PNAT: for this group it is assumed that clothing and shoes (CLTH) make 45% of total value added. The rest is assumed to come from food (FOD=25%) and other manufactured goods and non-tradable services (OTH=30%).

iii. PHG: 25% is attributed to housing costs (HSHG), other non-tradeable services, e.g. transport, component, etc., (OTH) and food are assumed to contribute 45% and 30%, respectively.

iv. FTPDX: represents an index for prices paid by farmers including expenditures on consumers goods. This index is obtained as follows:

$$FTPDX = 0.6\ PRPAID + .4\ CNSMN \qquad (C.1)$$

$$CNSMN = 0.86\ FRMFD + .06\ PNAT + .08\ PHG \qquad (C.2)$$

$$FRMFD = .57\ PDR + .43\ PFOD \qquad (C.3)$$

Here the overall price paid index is made of 60% production expenditure and 40% consumption (CNSMN). Consumption expenditure is distributed between food (86%), manufactured goods (6%) and non-tradables (8%) according to C.2. Fifty-seven percent of the food consumed (FTPOX) is produced on farm (mainly sorghum - PDR) while the rest is purchased (FOD) as C.3 shows. The weights for construction of FRMPIND are taken from Rashid M. Hassan (1982).

Table C.1 Price indices[a]

CPI	PNAT	PHG	PAGTRD	PRPAID	FTPDX	UWINDX	PCLTH	PHSNG	PFOD	POTH
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.10	1.10	1.10	1.15	1.09	1.12	1.07	1.10	1.10	1.10	1.10
1.30	1.20	1.40	1.63	1.39	1.37	1.35	0.96	1.40	1.40	1.40
1.60	1.40	1.70	2.22	1.59	1.60	1.47	1.03	1.70	1.70	1.70
2.10	2.10	2.10	1.83	1.97	2.03	1.54	2.10	2.10	2.10	2.10
2.30	2.10	2.40	1.84	2.30	2.30	1.59	1.73	2.40	2.40	2.40
2.80	2.70	2.90	2.54	2.82	2.75	1.77	2.46	2.90	2.90	2.90
2.90	2.90	3.10	2.79	2.27	2.24	1.96	2.66	3.10	3.10	3.10
3.60	3.50	3.80	3.04	4.18	4.10	2.02	3.13	3.80	3.80	3.80
4.50	4.40	4.70	3.44	4.91	5.12	3.06	4.03	4.70	4.70	4.70
5.40	5.20	5.90	3.65	6.93	6.69	3.79	4.35	5.90	5.90	5.90
7.30	6.90	7.80	5.33	8.78	9.01	4.11	5.80	7.80	7.80	7.80
8.80	8.50	9.20	7.45	11.53	11.35	4.59	7.65	9.20	9.20	9.20
11.81	11.70	12.30	9.37	13.76	15.14	5.02	10.97	12.30	12.30	12.30
17.70	16.40	17.40	13.21	11.94	21.45	5.31	15.18	17.40	17.40	17.40
22.60	21.10	22.50	12.54	26.44	24.71	5.47	19.39	22.50	22.50	22.50

[a]Price indices for food (PFOD), housing (PHSNG), cloth and shoes (PCLTH) and other manufactured and non-tradable goods (POTH), as well as the weights used for construction of the consumer price index (CPI), the home goods (PHG) and manufacturing (PNAT) prices indices and the urban wage rate (UWINDX) are compiled from Ministry of Finance "Economic Survey," various issues.

APPENDIX D

The Almost Ideal Demand System (AIDS)

The Almost Ideal Demand System (AIDS) is used to estimate the demand parameters in this study. The AIDS model is introduced by Deaton and Muellbauer (1980) to provide an arbitrary first-order approximation to any demand system. From the dual formulation of the decision problem of a consumer with price-independent, generalized logarithmic (PIGLOG) preferences, they specified the following cost function

$$\text{Log } C(U, P) = a(P) + U\, b(P) \qquad \text{(D.1)}$$

where a(P) and b(P) are positive, linear homogenous functions of prices (P) and U denotes utility. A locally flexible functional form was selected for a(P) with sufficient parameters to allow the desired flexibility of second-order Taylor series approximations:

$$a(P) = \alpha_o + \Sigma_i\, \alpha_i \text{ Log } P_i + \frac{1}{2} \Sigma_i\, \Sigma_j\, \alpha_{ij} \text{ Log } P_i \text{ Log } P_j \qquad \text{(D.2)}$$

a(P) can be regarded to denote the cost of subsistence. Engel curves form provided a convenient choice for b(P)

$$b(P) = \beta_o\, \pi\, P_i^{\beta_i} \qquad \text{(D.3)}$$

Substituting D.2 and D.3 in D.1 we obtain the following form for C

$$\text{Log } C = \alpha_o + \Sigma_i\, \alpha_i \text{ Log } P_i + \frac{1}{2} \Sigma_i\, \Sigma_j\, \alpha_{ij} \text{ Log } P_i \text{ Log } P_j + U\, \beta_o\, \pi\, P_i^{\beta_i} \qquad \text{(D.4)}$$

The Hicksian demand function for commodity i in share form is derived by Shephard's Lemma from D.4.

$$W_i = \alpha_i + \Sigma_j \alpha_{ij} \text{ Log } P_j + \beta_i U \beta_o \pi P_j^{\beta_j} \qquad (D.5)$$

Where W_i is the budget share of commodity i.

$$W_i = \partial \text{ Log } C/\partial \text{ Log } P_i = \frac{P_i Q_i}{C} \qquad (D.6)$$

Since the indirect utility function U (Y, P) is unobservable, the cost function and share equations D.4 and D.5 cannot be estimated. From the duality relation that Y = C(U, P), however, the corresponding utility function U(Y, P) can be obtained by inverting D.4.

$$U(Y,P) = \text{Log } Y - (\alpha_o + \Sigma_i \alpha_i \text{ Log } P_i + \frac{1}{2} \Sigma_i \Sigma_j \alpha_{ij} \text{ Log } P_i \text{ Log } P_j)/\beta_o \pi P_i^{\beta_i} \qquad (D.7)$$

Substituting D.7 into D.5 gives the Marshallian demand for commodity i in the share form

$$W_i = \alpha_i + \Sigma_i \alpha_{ij} \text{ Log } P_j + \beta_i \text{ Log } (Y/P^o) \qquad (D.8)$$

The price index P^o is defined by

$$\text{Log } P^o = \alpha_o + \Sigma_i \alpha_i \text{ Log } P_i + \frac{1}{2} \Sigma_i \Sigma_j \gamma_{ij} \text{ Log } P_i \text{ Log } P_j \qquad (D.9)$$

with $\gamma_{ij} = \frac{1}{2} (\alpha_{ij} + \alpha_{ji}) = \gamma_{ji}$.

It is argued that model D.8 satisfies the axioms of choice exactly and successfully aggregates over consumers (Deaton and Muellbauer, 1980). The AIDS model preserves the desired generality and flexibility of both the Rotterdam and translog models. The theoratical restrictions of homogeneity, Engel aggregation and Slutsky symmetry can be imposed directly on D.8. Consistency of the demand system D.8 with utility maximization is, therefore, tested directly using the:

a) adding up restrictions (Engel agregation)

$$\Sigma_i \alpha_i = 1, \ \Sigma_i \alpha_{ij} = 0, \ \Sigma_i \beta_i = 0 \qquad \text{(D.10)}$$

b) homogeneity restrictions $\Sigma_j \alpha_{ij} = 0$ (D.11)

c) and symmetry $\alpha_{ij} = \alpha_{ji}$.

Another important feature of the AIDS model in contrast with the translog system is that it posseses the ease of estimation property of the liner expenditure system (LES) without being directly additive. Ordinary least squares can generate consistent estimators for the parameters in each equation of the AIDS model if the price index P^o is directly available. The AIDS system then becomes linear in parameters. Stone's index given in D.12, is commonly used to construct P^o directly when prices are relatively collinear.

$$\text{Log } P^o = \Sigma_i W_i \text{ Log } P_i \qquad \text{(D.12)}$$

Share elasticities with respect to income are obtained directly from D.8.

$$\frac{\partial \text{ Log } W_i}{\partial \text{ Log } Y} = \beta_i / W_i \qquad \text{(D.13)}$$

Equation D.13 implies that good i is a necessity if $\beta_i < 0$ and a luxury for $\beta_i > 0$. The share elasticities for prices are also derived from D.8 to be

$$\frac{\partial \text{ Log } W_i}{\partial \text{ Log } P_j} = \frac{\alpha_{ij}}{W_j} - \frac{\beta_i}{W_i} (\alpha_j - \Sigma_k \alpha_{jk} \text{ Log } P_k) \qquad \text{(D.14)}$$

Own and cross price elasticities of demand are derived below

$$e_{ii} = -1 + \frac{\alpha_{ii}}{w_i} - \beta_i \qquad \text{(D.15)}$$

$$e_{ij} = \frac{\alpha_{ij}}{w} - \beta_i \left(\frac{w_j}{w}\right) \qquad i \neq j \qquad \text{(D.16)}$$

$$d_{ii} = -1 + \frac{\alpha_{ii}}{w_i} + w_i \qquad \text{(D.17)}$$

$$d_{ij} = \frac{\alpha_{ij}}{w_i + w_j} + w_j \qquad i \neq j \qquad \text{(D.18)}$$

where e refers to the Marshallian and d denotes the income compensated Hicksian elasticities. Expenditure elasticities are given by:

$$e_{ix} = 1 + \frac{\beta_i}{w_i} \qquad \text{(D.19)}$$

APPENDIX E

Data

Table E.1. Sectors of the GEMS

Sector	Name
Agricultural Tradables	
LSCN	long and meium staple cotton
SSCN	short staple cotton
DRA	sorghum (dura)
GNT	groundnuts
WHT	wheat
CSD	cotton seed
BNS	beans
SSM	sesame
GUM	gum arabic
STOZ	livestock and other agricultural products
Non-Agricultural Tradables	
DMNF	domestic manufacturing
FMNF	foreign manufactured goods (IM4)
FCAP	foreign capital goods (IM1)
FINT	foreign intermediate goods (IM2)
Non-Tradables	
HMG	home goods
Financial Sectors	
MNY	money

Table E.2. Region 1 (Public Irrigation Schemes) data[a]

HLSCN[b]	FLSCN[b]	HDRA	FDRA	HGNT	FGNT	HWHT	FWHT	YLSCN[c]
18.03	8.40	1.58	1.28	11.38	4.16	1.85	3.33	4.40
27.95	11.78	1.52	1.00	12.18	4.08	2.84	3.28	5.10
44.70	16.35	1.60	1.43	14.42	4.11	3.10	3.16	4.80
55.28	26.40	2.09	4.09	17.17	6.85	3.40	5.35	4.50
56.45	33.39	2.58	5.89	18.42	8.90	4.30	7.34	4.90
46.01	23.48	2.87	2.88	20.62	9.77	4.66	8.40	3.20
66.55	34.24	3.70	3.47	33.58	11.42	6.50	8.93	3.70
77.02	38.47	4.53	5.47	51.73	17.03	6.55	10.10	3.40
82.82	40.88	10.84	6.05	62.39	23.52	8.25	12.97	2.90
103.54	51.36	13.24	7.53	65.11	24.13	9.85	17.18	3.10
123.59	60.63	18.88	14.01	98.51	46.26	11.51	28.15	2.80
168.14	96.78	16.17	12.67	107.29	44.75	12.87	29.93	3.50
254.75	137.99	24.62	19.24	157.67	81.95	14.31	34.26	4.40
288.39	156.57	38.34	25.42	208.76	117.71	24.99	56.18	4.10
315.32	207.36	43.21	30.40	256.66	142.96	26.79	48.79	3.90
334.65	242.32	41.36	28.72	288.20	174.46	36.43	63.74	4.60

[a]Gezira Board, Rahad Corporation, Ministry of Agriculture, Cotton Marketing Board, Oil Seeds Company, Ministry of Commerce. Intermediate costs other than the cost of foreign inputs and wages in crop's budgets are grouped as the intermediate costs of home goods. Wage rate is constructed from data on labor costs and mandays per feddan.

[b]Intermediate Use: 1) Cost of foreign intermediate goods in Sudanese pounds (Ls.) per feddan (FLSCN, FDRA, etc.); 2) Cost of home goods in Ls. per feddan (HLSCN, HDRA, etc.).

[c]Yield in Kantars per feddan (YLSCN, YDRA, etc.).

Table E.2. Continued

YDRA	YGNT	YWHT	ALSCN[d]	ADRA	AGNT	AWHT	WGI[e]	WHI[f]
9.30	13.70	9.10	967.00	629.00	261.00	262.00	1.85	315.00
9.40	14.30	9.70	895.87	511.00	252.00	267.00	2.84	328.00
8.70	14.60	9.40	973.00	506.00	325.00	227.00	3.10	239.00
9.80	15.10	10.20	974.00	536.00	363.00	395.00	3.40	322.00
10.70	14.60	11.10	968.00	629.00	412.00	558.00	4.30	377.00
9.10	17.10	9.70	771.00	628.00	478.00	660.00	4.66	329.00
7.80	17.40	9.10	845.00	471.00	380.00	590.00	6.50	378.00
7.40	16.80	8.90	906.00	539.00	346.00	538.00	6.55	277.00
8.90	16.60	9.30	885.00	591.00	363.00	542.00	8.25	437.00
7.80	17.20	8.70	909.00	443.00	299.00	418.00	9.85	336.00
8.10	17.60	9.90	814.00	502.00	387.00	421.00	11.51	372.00
7.20	17.90	9.50	838.00	579.00	411.00	289.00	12.87	257.00
9.30	16.80	10.40	833.00	579.00	244.00	204.00	14.31	145.00
8.80	16.50	10.80	874.00	719.00	272.00	315.00	24.99	261.00
11.40	17.60	8.70	863.00	766.00	326.00	265.00	26.79	246.00
9.38	18.30	8.40	783.00	1123.00	296.00	300.00	36.43	293.00

[d]Area under crops in 000 feddans (ASSCN, ADRA, etc.).

[e]Wage rate in Ls. per man day (WG1).

[f]Amount of rainfall in mm. per annum (WH1).

Table E.2. Continued

PPWHT[g]	PWD[h]	FLDX[i]	WLSCN[j]	WDRA	WGNT	WWHT	BSTK[k]	XLSCN[l]	XPLSCN[m]
1.70	0.85	104.00	12.00	0.90	3.20	2.10	4233.00	6203.00	32.00
1.80	0.35	112.00	12.00	1.20	4.60	2.20	2060.00	5193.00	33.00
2.00	0.58	110.00	13.00	1.60	6.60	3.10	1662.00	4160.00	49.00
2.80	0.59	98.70	14.00	1.80	6.60	3.40	2615.00	1340.00	74.00
2.90	0.67	100.00	15.00	2.50	7.10	3.60	5194.00	2640.00	62.00
2.90	0.70	99.50	21.00	2.80	7.60	4.20	5866.00	3277.00	66.00
3.40	0.69	102.00	26.00	2.80	8.60	4.40	4593.00	3430.00	84.00
3.40	0.45	95.60	26.00	3.10	10.00	4.40	3091.00	2644.00	96.00
4.20	0.57	93.40	28.50	3.50	10.00	6.90	2584.00	3526.00	92.00
5.00	0.19	98.20	28.50	3.50	11.00	8.40	1396.00	2142.00	98.00
7.30	0.48	97.90	28.50	5.00	14.00	11.60	1842.00	1096.00	95.00
10.20	0.59	98.70	28.50	7.00	14.00	18.00	2371.00	1540.00	88.00
12.50	0.24	102.00	38.00	19.00	19.00	18.00	3761.00	3932.00	82.00
13.80	0.32	98.00	50.00	25.00	25.00	24.00	3240.00	3382.00	85.00
13.90	0.27	96.00	65.00	32.50	32.50	36.00	2990.00	1786.00	92.00
15.70	0.30	97.00	80.00	40.00	40.00	40.00	3760.00	3213.00	78.00

[g]Procurement price of wheat in Ls. Per kantar (PPWHT).

[h]Proportion of wheat delivered to mills at the government price.

[i]Flooding index (FLDX).

[j]Land and water charges in Ls. per feddan (WLSCN, WDRA, etc.).

[k]Beginning stock of cotton in 000 kantars (BSTK).

[l]Long and medium staple cotton exports in 000 kantars (XLSCN).

[m]Export price of cotton (XPLSCN) in $ per kantar.

Table E.3. Region 2 data (Private Irrigation Schemes)[ab]

AWHT	YWHT	WG2	TMP2	PWHT
29.20	14.90	0.88	107.00	2.20
30.00	20.00	0.96	91.00	2.50
28.00	15.90	1.21	102.00	2.60
29.40	13.30	1.32	111.00	3.30
29.80	14.70	1.38	100.00	3.60
29.30	16.70	1.43	78.00	3.80
28.60	16.90	1.51	111.00	4.70
28.60	12.30	1.62	116.00	5.30
27.50	9.80	1.74	138.00	6.00
28.20	13.30	2.16	93.00	8.50
28.80	14.20	2.70	96.00	9.80
26.70	15.60	2.87	100.00	13.80
29.60	22.20	3.14	73.00	18.70
30.80	19.00	3.42	84.00	19.10
31.90	15.10	3.87	92.00	19.80
29.70	17.10	4.61	88.00	21.30

[a]Ministry of Agriculture, Northern Agricultural Corporation, Ministry of Commerce.

[b]Columns are: (1) area under wheat (AWHT) in 000 feddans; (2) yield of wheat (YWHT) in kantars per feddans; (3) wage rate in Ls per man days (WG2), the same wage rate constructed for Region 1 is used as a proxy to wage rate in this region for lack of data; (4) temperature (TMP2); and (5) price of wheat (PWHT).

Table E.4. Region 3 data (Traditional Rainfed Sector)[ab]

ASSCN	ADRA	AGNT	ASSM	YSSCN	YDRA	YGNT	YSSM	QGUM	WG3
246.00	1565.00	1288.00	1446.00	0.98	5.20	6.20	3.70	790.00	0.70
234.00	1442.00	1146.00	1362.00	0.79	5.60	6.60	3.50	765.00	0.80
194.00	1318.00	1085.00	1376.00	0.86	4.70	5.80	3.30	733.00	1.14
188.00	1743.00	1298.00	1436.00	1.17	4.90	6.30	3.90	788.00	1.16
206.00	2060.00	1174.00	1614.00	1.08	5.10	6.10	4.10	812.00	1.20
212.00	2421.00	1207.00	1701.00	1.19	5.40	6.70	3.80	793.00	1.20
198.00	2388.00	1384.00	1638.00	0.92	6.10	7.20	4.30	826.00	1.24
189.00	2036.00	1395.00	1612.00	1.20	5.70	6.50	3.70	707.00	1.30
195.00	2380.00	1323.00	1642.00	0.97	5.50	6.30	4.10	737.00	1.60
162.00	2978.00	1249.00	1690.00	0.87	5.90	6.10	3.70	676.00	1.98
128.00	3020.00	1430.00	1643.00	1.07	6.30	6.80	4.00	743.00	2.20
118.00	2820.00	1658.00	1450.00	0.96	5.80	6.40	3.80	774.00	2.30
116.00	2686.00	1623.00	1170.00	0.88	5.20	5.90	3.20	711.00	2.50
119.00	2647.00	1205.00	1260.00	0.84	4.10	4.60	2.80	582.00	2.90
120.00	3195.00	1312.00	1537.00	1.12	5.40	7.10	3.30	633.00	3.30
112.00	2468.00	1466.00	1342.00	1.46	5.70	7.40	3.80	689.00	3.90

[a]Nuba Mountains Agricultural Corportion, Mechanized Farming Corporation, Ministry of Agriculture, Gum Arabic Corporation, Livestock and Meat Marketing Corporation, Oil Seeds Company, Cotton Marketing Board.

[b]Columns are: (1) area in 000 feddans (ASSCN, ADRA, AGNT, ASSM); (2) yield in kantars per feddan (YSSCN, YDRA, YGNT, YSSM), QGUM represents production of gum arabic; (3) wage rate in Ls per feddan (WG3); (4) rainfall in mm per annum (WH3); (5) intermediate use: cost of FINT in Ls per feddan (FSSCN, FDRA, FGNT, FSSM), cost of home goods in Ls per feddan (HSSCN, HDRA, HGNT, HSSM), for gum arabic HGUM and FGUM define cost in Ls per unit of output.

Table E.4. Continued

WH3	HGUM	FGUM	HSSCN	HDRA	HGNT	HSSM	FSSCN	FDRA	FGNT	FSSM
522.00	2.11	0.68	3.68	1.26	3.89	2.14	1.92	0.44	1.70	1.14
501.00	2.38	0.79	3.23	1.31	4.11	2.39	2.66	0.42	1.84	1.24
463.00	2.94	0.91	4.91	1.53	4.34	3.11	2.91	0.57	1.51	1.59
492.00	3.83	1.20	13.55	2.63	5.41	3.49	4.69	0.45	2.03	1.76
536.00	3.87	1.27	13.46	2.45	5.49	4.61	5.62	0.56	2.24	2.44
576.00	3.93	1.18	19.20	3.05	6.23	5.12	6.51	0.81	2.67	2.61
562.00	3.74	1.17	11.98	3.37	10.13	6.28	6.82	0.91	4.44	3.21
596.00	4.05	1.29	25.79	4.18	16.30	6.82	8.10	1.06	6.89	3.40
447.00	4.10	1.18	17.50	3.96	17.80	8.16	7.10	1.11	7.96	4.29
513.00	5.11	1.79	12.53	6.39	18.07	8.08	7.72	2.24	7.31	3.92
586.00	7.53	3.35	23.06	8.18	24.76	10.25	14.49	3.66	17.39	7.10
490.00	11.58	5.70	19.31	11.91	25.76	11.02	18.44	6.72	19.00	8.30
412.00	20.69	12.46	20.57	12.61	42.35	13.43	24.77	5.70	31.54	11.40
382.00	30.68	19.10	21.65	14.32	61.19	18.61	28.95	8.07	38.83	15.89
524.00	33.85	19.13	47.61	17.73	90.08	43.56	34.62	7.17	51.01	29.15
506.00	38.85	20.28	133.25	16.06	109.40	41.04	41.47	8.13	63.35	21.53

Table E.5. Region 4 data (Mechanized Rainfed Sector)[ab]

ADRA	ASSM	YDRA	YSSM	WG4	AGBL
1941.42	547.58	7.30	3.60	0.70	1.26
1899.94	417.06	7.10	3.50	0.80	1.44
2493.42	372.58	7.00	3.40	1.14	1.78
2212.56	421.44	7.30	3.54	1.16	1.64
2548.07	314.93	7.40	3.76	1.20	1.89
2468.70	274.30	7.60	3.47	1.20	2.30
3205.02	316.98	7.80	3.65	1.24	2.56
2686.85	474.15	7.60	3.60	1.30	2.40
3365.16	502.84	7.80	3.63	1.60	2.70
3316.72	452.28	7.60	3.80	1.98	3.50
4001.08	347.92	7.70	3.70	2.20	5.30
4263.10	526.90	7.40	3.64	2.30	8.10
5096.68	325.32	7.60	3.37	2.50	11.40
4069.68	306.32	6.80	3.24	2.90	11.10
5574.60	293.40	7.30	3.80	3.30	29.80
5718.96	365.04	7.50	3.70	3.90	39.90

[a]Ministry of Agriculture, Ministry of Energy and Mining, Mechanized Farming Corporation, Agricultural Bank of Sudan.

[b]Columns are: (1) area under crops in 000 feddans (ADRA, ASSM); (2) yield in kantars per feddan (YDRA, YSSM); (3) intermediate use in Ls per feddan (FDRA, HDRA, FSSM, HSSM); (4) wage rate in Ls per man day (WG4), same index as Region 3; (5) rainfall mm pr annum (WH4), same index as in Region 3; (6) price of gasoil in Region 4 index (PGOL); (7) gasoil allocation to Region 4 index (GOL4); and (8) agricultural bank loans to mechanized farmers in Ls million (AGBL).

Table E.5. Continued

HDRA	HSM	FDRA	FSSM	PGOL	GOL4
1.21	1.17	0.74	0.72	1.00	1.00
1.16	1.48	0.71	0.91	0.98	0.99
1.26	2.44	0.77	1.50	1.05	1.10
1.05	2.48	0.65	1.52	1.10	1.07
1.86	3.32	1.14	2.03	1.22	1.16
1.46	3.59	0.90	2.20	1.33	1.29
2.48	3.13	1.52	1.92	2.20	1.48
3.54	3.93	2.17	2.41	2.16	1.50
4.02	5.12	2.47	3.14	2.45	1.60
6.07	6.02	3.72	3.69	3.54	1.71
4.86	3.74	8.08	6.23	7.10	1.83
4.48	3.94	8.21	7.22	9.50	1.84
5.61	5.15	13.27	12.18	11.56	1.76
8.73	9.15	20.26	21.24	11.76	1.68
8.02	12.01	12.23	18.31	18.50	1.88
10.88	15.11	14.50	20.14	18.50	1.94

Table E.6. Non-agricultural tradables and home goods sectors data[ab]

VDMNF	VHMG	PHMG	UWG	VFCAP	VFINT	VFWHT	VFMNF	VIMTX
94.20	367.73	1.00	0.98	25.60	45.75	5.60	39.05	38.06
97.00	414.82	1.10	1.05	26.20	46.37	6.40	39.03	38.49
116.00	436.87	1.40	1.32	45.40	59.92	7.07	39.61	47.70
154.00	646.34	1.70	1.44	73.90	97.30	8.57	68.23	78.79
163.00	756.53	2.10	1.51	131.50	132.40	9.00	87.10	111.60
181.00	968.58	2.40	1.56	131.03	109.65	12.30	89.02	105.19
213.00	1146.19	2.90	1.73	133.67	120.94	6.49	115.90	120.11
237.00	1510.39	3.10	1.92	140.74	169.46	9.00	130.80	144.30
283.00	1731.27	3.80	1.98	120.93	182.38	21.96	151.73	154.36
357.00	2175.44	4.70	3.00	287.15	245.72	36.26	218.87	243.41
415.00	2534.52	5.90	3.71	325.27	458.85	53.40	235.48	331.54
525.00	3999.86	7.80	4.03	383.00	618.34	55.70	320.96	433.63
671.69	5632.86	9.20	4.50	448.30	859.77	90.50	630.43	662.47
812.99	6760.56	12.30	4.92	376.00	1034.92	77.70	414.38	611.37
1071.00	8655.57	17.40	5.20	285.60	1124.38	148.10	570.92	694.29
1456.00	11969.76	22.50	5.36	259.80	1264.56	120.50	757.14	809.52

[a]Ministry of Planning Economic Survey, Bank of Sudan Annual Reports and Foreign Trade Statistics, Ministry of Industry, Oil Seeds Company, Cotton Marketing Board, World Bank (1983, 1987).

[b]Columns are: (1) value added in Ls million (VDMNF, VHMG); (2) price of home goods index (PHMG); (3) urban wage rate (UWG) in Ls per mandays; (4) value of imports in Ls million (VFCAP, VFINT, VFMNF, VFWHT). (5) value of import taxes (VIMTX) in Ls million; (6) intermediate use per unit of DMNF of (NALSCN, NAGNT, NACSD, NASSM, NAHG, NAFINT); and (7) intermediate use per unit of HMG of (HDMNF, HFINT, HGHG).

Table E.7. Demand data[a]

DMNF[b]	HMG	DRA	WHT	BNS	STOZ	FMNF	UINDX[c]	PWHT[d]
145.6	149.4	17.9	11.7	10.4	170.5	39.1	1.0	1.5
148.2	159.7	29.7	13.5	11.7	171.3	39.0	1.1	1.6
168.6	177.8	33.8	15.3	14.2	184.6	39.6	1.2	1.8
293.4	366.2	39.7	23.2	23.5	265.7	68.2	1.2	2.4
302.7	391.7	70.7	32.9	26.2	390.2	81.3	1.3	2.5
295.4	451.7	79.1	39.8	32.2	353.1	87.7	1.4	2.7
388.4	635.1	89.8	35.2	38.9	502.3	120.3	1.5	3.3
404.8	919.3	92.9	36.2	45.7	756.3	130.8	1.7	3.5
466.0	1018.9	164.8	57.2	49.0	759.2	151.7	1.8	3.9
575.9	1238.1	206.5	73.4	62.7	881.6	179.7	1.9	4.9
645.9	1356.4	276.8	98.6	79.6	1219.3	246.1	2.0	5.9
872.3	1913.5	384.8	105.8	103.8	1465.0	300.8	2.2	8.8
1250.8	2838.8	583.4	179.4	159.8	2343.0	491.5	2.2	10.5
1410.8	3234.7	693.0	153.9	168.0	3074.0	414.4	2.4	18.8
2273.5	4632.0	1066.0	212.8	231.6	3149.3	541.8	2.5	20.7
2850.8	6661.5	1437.1	185.0	330.0	5483.0	757.0	2.4	25.7

[a]Consumption is derived from physical balance and disappearance, e.g., total supply (import and domestic) minus intermediate use, exports, investment demand and other uses. World Bank (1983, 1987), Bank of Sudan Annual Reports and Foreign Trade Statistics, Ministry of Planning Economic Survey, Ministry of Commerce and Supplies, Department of Statistics, and Ministry of Agriculture.

[b]Consumption spending in Ls million on DRA, WHT, BNS, STOZ, DMNF, FMNF, and HMG.

[c]Urbanization index (UINDX).

[d]Official consumers' price of wheat in Ls. per kantar.

Table 5.8. Income accounts and other data (Ls million)[ab]

GNP	GDP	PCN	GCN	PIN	GIAG	GIHG	GINA	TIN
765.70	761.00	544.60	162.00	32.00	9.20	7.80	2.10	55.40
838.10	833.00	573.20	176.60	47.00	10.40	11.60	1.50	76.80
901.60	897.00	634.00	171.20	62.00	11.10	13.83	1.90	91.60
1248.80	1246.00	1079.94	167.00	81.00	13.00	18.36	12.70	125.06
1519.00	1511.00	1295.60	208.50	112.00	22.00	42.50	37.00	214.40
1882.70	1848.00	1339.00	230.00	249.00	31.00	45.70	36.00	428.00
2382.10	1340.00	1810.00	277.80	157.00	42.00	56.00	32.00	399.00
2942.10	2883.00	2386.00	330.70	138.00	43.00	62.30	39.00	414.00
3313.60	3254.00	2666.86	407.44	177.00	56.00	83.70	34.00	424.00
4053.70	3972.00	3218.00	672.70	178.00	47.00	79.00	38.00	598.00
4981.50	4924.80	4002.00	874.80	216.00	60.00	96.50	32.00	764.00
7137.00	7086.30	5146.00	1186.30	909.00	60.00	133.40	89.00	1649.00
9809.02	9682.32	7846.98	1264.35	1306.00	127.00	159.60	72.00	1789.00
11377.80	11493.70	9149.00	1638.70	1551.00	125.00	189.00	122.00	1792.00
14823.70	14920.00	12107.00	1983.30	1527.00	118.00	274.00	105.00	2114.00
10795.70	21357.00	17704.61	2664.79	1871.00	112.00	232.00	74.00	2556.40

[a]World Bank (1983, 1987), Ministry of Planning Economic Survey, Bank of Sudan Annual Report.

[b]Gross national and domestic products (GNP, GDP), private consumption (PCN), government consumption (GCN), private investment (PIN), government investment in agriculture (GIAG), in domestic manufacturing (GINA) and home goods (GIHG), total investment (TIN), trade balance (TB), net factor income (NFIN), government revenue (GRV), transfers (TRNS), export taxes (VEXTX), total tax (TOTX), money supply (MNY), nominal saving rate of interest (NSR), nominal lending rate (NLR).

Table E.8 Continued

TB	NFIN	GRV	TRNS	VEXTX	TOTX	MNY	NSR	NLR
-1.00	-3.60	164.96	8.30	7.20	110.10	115.00	3.50	7.50
6.40	-4.30	194.61	9.40	7.80	118.80	144.00	3.50	7.50
0.20	-4.60	205.41	9.20	9.70	142.80	175.00	4.50	8.50
-126.00	-6.30	194.90	9.10	10.80	187.89	237.00	4.50	8.50
-207.50	-15.00	243.00	23.00	12.10	235.00	281.00	6.00	10.00
-149.00	-17.80	269.37	52.50	16.00	266.37	350.00	6.00	10.00
-146.80	-17.80	330.03	59.90	20.80	309.70	497.00	7.00	11.00
-247.70	-17.80	367.03	76.90	22.80	358.40	634.00	8.50	12.50
-244.30	-24.00	264.33	83.60	25.60	310.50	837.00	8.50	12.50
-516.70	-41.10	398.56	122.80	22.90	388.80	1097.00	8.50	12.50
-716.00	-135.50	502.65	192.20	41.70	502.65	1531.00	11.00	15.00
-895.00	-260.70	847.33	311.40	31.20	738.10	2091.00	13.00	17.00
-1218.00	-383.80	1195.11	510.50	22.00	1067.10	2334.00	15.00	19.00
-1086.00	-742.90	1546.69	627.00	23.80	1232.30	2764.00	16.00	20.00
-1284.30	-959.80	747.23	863.50	19.10	1047.20	4373.00	16.00	20.00
-1568.80	-1568.80	1129.27	953.70	33.60	1329.20	5397.00	16.00	20.00

Table E.9. Foreign trade taxes and effective exchange rates[a]

TDRA[b]	TGNT	TSSM	TCSD	TFCAP	TFINT	TGUM	TFWHT	TFMNF	TDMNF
0.10	0.14	0.13	0.15	-0.23	-0.33	0.20	-0.12	-0.42	0.15
0.10	0.14	0.14	0.15	-0.23	-0.33	0.18	-0.12	-0.42	0.15
0.13	0.14	0.14	0.15	-0.23	-0.33	0.19	-0.12	-0.42	0.15
0.13	0.16	0.14	0.15	-0.23	-0.33	0.12	-0.12	-0.42	0.15
0.24	0.18	0.16	0.15	-0.23	-0.33	0.14	-0.12	-0.42	0.15
0.18	0.10	0.18	0.15	-0.23	-0.33	0.17	-0.12	-0.42	0.15
0.15	0.12	0.10	0.15	-0.23	-0.33	0.16	-0.12	-0.42	0.15
0.15	0.10	0.12	0.15	-0.23	-0.33	0.15	-0.12	-0.42	0.15
0.15	0.15	0.10	0.15	-0.23	-0.33	0.21	-0.12	-0.42	0.15
0.22	0.19	0.15	0.15	-0.23	-0.33	0.18	-0.12	-0.42	0.15
0.28	0.12	0.19	0.15	-0.23	-0.33	0.17	-0.12	-0.42	0.15
0.13	0.11	0.15	0.15	-0.23	-0.33	0.14	-0.12	-0.42	0.15
0.10	0.10	0.14	0.15	-0.23	-0.33	0.10	-0.12	-0.42	0.15
0.17	0.10	0.14	0.15	-0.23	-0.33	0.10	-0.12	-0.42	0.15
0.15	0.10	0.13	0.15	-0.23	-0.33	0.10	-0.12	-0.42	0.15
0.15	0.10	0.13	0.15	-0.23	-0.33	0.10	-0.12	-0.42	0.15

TCN	ECN[c]	EDRA	EGNT	ESSM	EGUM	EDMNF	ECSD	EFCAP	EFINT	EFWHT	EFMNF
0.10	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
0.10	0.35	0.38	0.38	0.38	0.35	0.38	0.38	0.35	0.35	0.35	0.40
0.10	0.35	0.40	0.40	0.40	0.35	0.40	0.40	0.35	0.35	0.35	0.40
0.10	0.35	0.40	0.40	0.40	0.35	0.40	0.40	0.35	0.35	0.35	0.40
0.10	0.35	0.40	0.40	0.40	0.40	0.40	0.40	0.35	0.35	0.35	0.40
0.10	0.35	0.40	0.40	0.40	0.40	0.40	0.40	0.35	0.35	0.35	0.40
0.10	0.35	0.40	0.40	0.40	0.40	0.40	0.40	0.35	0.35	0.35	0.40
0.10	0.37	0.45	0.45	0.45	0.45	0.45	0.45	0.40	0.40	0.40	0.45
0.10	0.45	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
0.10	0.50	0.68	0.68	0.68	0.68	0.68	0.68	0.50	0.50	0.50	0.68
0.10	0.68	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
0.10	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.90	0.90	0.90	1.30
0.10	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.30	1.30	1.30	1.60
0.10	1.40	2.50	2.50	2.50	2.10	2.50	2.50	1.30	1.30	1.30	2.00
0.10	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.40
0.10	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50

[a]Ministry of Planning Economic Survey, World Bank (1983, 1987), Elbadawi (1987).

[b]Tax rates on foreign trade, e.g., cotton, sorghum, etc. exports (TCN, TDRA, etc.) and imports (TFINT, TFCAP, etc.).

[c]Effective exchange rates (ECN, EDRA, EFINT, etc.).