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Consumption Effects of Agricultural Policies: Bread Prices in the Sudan

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EXECUTIVE SUMMARY

The growth in per capita consumption of bread in the Sudan in the last fifteen years and the concomitant growth in wheat imports have been an important issue in the Sudan's relations with the international donor community. Policy debates have centered on the pricing mechanisms for bread, wheat and wheat products and on the economic bases for allocating resources to domestic wheat production in the irrigated schemes. These debates are central to negotiations for donor assistance and to domestic resource mobilization as the Sudan continues its program of economic recovery. The productivity of domestic resources, the prospects for increased national income, and the continuing foreign exchange crisis can be significantly affected by policy decisions regarding bread pricing, wheat production and import policies.

This study focuses on the determinants of the rapid increase in urban per capita bread consumption. It is based on econometric analysis of the 1978/79 Household Budget Survey, a re-sampling (Minihousehold Survey) of the greater Khartoum conurbation in 1982 after the increase in the nominal price of bread, and available time series data on consumption, imports, production and prices. The analyses consist of econometric estimation of the urban demand structure, aggregate demand functions and the components of an import demand model. The study also uses simulation analyses to develop scenarios on alternative pricing and production policies and their impact on

import requirements.

The principal finding of the study is that bread demand is sufficiently elastic in middle and upper income households so that real economic gains can be obtained by the country by moving to a policy of maintaining the real price of bread at import parity. The price of bread has been declining since 1970 in spite of periodic and, at times, traumatic increases in the nominal price; the price of sorghum relative to the price of wheat bread has been rising since 1970. These factors have accounted for at least 20 percent of the growth of per capita bread consumption.

The policy has been generally regressive with respect to the size distribution of incomes and has been inefficient both as a nutritional and income transfer instrument. Implementation of a policy of import parity pricing at all points in the distribution chain would have some deleterious nutritional effects for the lowest income quartile of the urban population.

There appears to be little economic justification for maintaining the current bread pricing policy of fixing the nominal price of bread to consumers. Concern for nutritional impacts in the lowest quartile of the income distribution should be addressed through income generating or direct targetting initiatives. The labor-incomes effect of economic recovery could more than offset the nutritional impact of higher bread prices. In the absence of policy change, wheat import requirements will continue to grow. This dependence on imports and the foreign exchange crisis will continue to increase the Sudan's dependence

on food aid and concessionary imports of wheat. As such, the Sudan would become less secure in its food supplies.

Under one policy scenario, it was estimated that changing the retail price of bread to real import parity at trend values for the world price of wheat could reduce projected import requirements by about 13 percent. Another scenario which involves changes in pricing policies and increases in domestic production indicates that wheat imports could be reduced by 50 to 90 percent of the baseline level. Implementing this scenario would require substantial improvements to institutional and economic processes. They could only be implemented in the mid-term and may require substantial donor assistance and accommodation.

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The responsibility for the content of the study and its conclusions rests with the authors.

PREFACE

When the Sudan case study was designed in 1980 for the Consumption Effects of Agricultural Policies project, the central issue was to assess the consumption (nutrient intake) reduction which might have occurred from the elimination of the price subsidy in May of 1979. The study has revealed that rather than higher real prices, the Sudanese urban consumer faced lower real prices that continued to decline in real terms in spite of periodic upward revisions in the nominal price. The hypotheses that were formulated at the start are not relevant in their specific content, but do address some general issues which are discussed here.

The study showed that higher income households consume twice the per capita quantities of bread than do the lowest income households in urban Khartoum, and substantially more than do rural households. The study also showed that the own price elasticities vary by income stratum. The demand elasticities for the middle and upper income strata are 50 percent greater than for the lowest income stratum. The consumption effects, per se, of implementing the suggested new pricing policy would fall principally on the higher income strata. The lower consumption of bread by these groups would have no deleterious nutritional effects.

While 25 percent of the established urban population have appreciable caloric intake deficits, there are more effective tools which could be used to improve the nutritional well being

of these persons. Enhancements to the health system and revitalization of supplementary feeding programs could be targetted at the very poor, the refugees and other especially vulnerable groups. If the Sudan wishes to maintain some level of food subsidization for the poor, it could experiment with subsidizing the sorghum component of composite flour. Bread manufactured with a high sorghum content could be tried as a self-targetting mechanism on an experimental basis.

Female labor force participation was shown to be an important factor affecting the levels of per capita bread consumption even when total expenditure is held constant in the analysis. Undoubtedly, this results from the convenience of purchasing manufactured bread and the higher opportunity cost of the time of working women. It may also be significantly influenced by the Sudanese tradition of eating breakfast at mid-morning at the place of work. As the rate of labor force participation by women increases, the demand for bread or a substitute of equal convenience will continue to increase. Kisra cannot substitute for bread in the breakfast taken at work because of its physical properties. Perhaps food technologists can introduce a substitute that has a higher sorghum content. The work on composite flours at the Shambat Institute should be encouraged, although extensive market research should be undertaken.

Another factor which was not measured relates to the tastes and incomes of households having members who have migrated to the Gulf States for employment. This phenomenon could be

contributing to the rapid growth in per capita consumption of bread. If this is so, it does not materially affect the main conclusions of this study.

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1.0 INTRODUCTION

The purpose of this study is to present the results of econometric analyses regarding the demand for bread in urban Khartoum, simulation analyses of domestic production in the Gezira Scheme, and simulation analyses of import requirements under different bread pricing and other agricultural policies. The study represents the first statistical analysis of the 1978/79 Household Budget Survey (HBS), which has been augmented by a re-sampling of 600 households in urban Khartoum during April, May and June 1982 (the Minihousehold Survey).

1.1 Setting

Since 1972, significant changes in the consumption of wheat and in the sources of wheat supply have occurred. Increases in domestic wheat production have not kept pace with increases in consumption; the resulting gap has been filled by increasing concessional and commercial imports of wheat grain and wheat flour. From fiscal year (FY) 1972 through FY 1978, domestic wheat production rose from 124 thousand metric tons to 317 thousand metric tons and then declined to 164 thousand metric tons in FY 1982 (Table 1). During this period, wheat imports almost tripled from 161 thousand metric tons in FY 1972 to 465 thousand metric tons in FY 1982. In three of the last four years, approximately 70 percent of these imports have been supplied through concessional sales and food aid (Table 2).

Annual total and per capita consumption of wheat flour is shown in Table 3. Apparent wheat flour consumption increased 7.5 percent annually from 228 thousand tons in FY 1972 to 469

Table 1: Supply of Wheat ('000 MT)

	Domestic Production[a]	Imports[b]	Total[c]	Seed & Waste[d]	Net	Smoothed Series[e]
1971/72	124	160.7	284.7	20.6	264.1	227.5[f]
1972/73	152	158.9	310.9	20.0	290.9	297.8
1973/74	235	136.3	371.3	32.9	338.4	327.3
1974/75	269	126.4	395.4	43.0	352.4	357.2
1975/76	255	172.9	427.9	47.2	380.7	379.4
1976/77	294	157.6	451.6	46.6	405.0	401.2
1977/78	317	146.7	463.7	45.9	417.8	392.8
1978/79	168	225.3	393.3	37.7	355.6	437.4
1979/80	233	339.9	572.9	34.0	538.9	509.5
1980/81	170	494.4	664.4	30.3	634.1	592.0
1981/82	164	465.4	629.4	26.4	603.0	618.5[f]

[a]The data source for the period 1971/72 - 1977/78 is Sudan: Report of FAO Programming Mission, October 1980. For the period 1978/79 - 1981/82 the data source is the Ministry of Finance and Economic Planning.

[b]The data source for imports for the period 1971/72 - 1977/78 is the Annual Report of the Bank of Sudan, several issues. For the period 1979/80 - 1981/82 the data source is the Ministry of Cooperation, Commerce and Supply. Wheat flour imports were converted to wheat grain equivalents using an extraction rate of 0.72 since U.S. extraction rates range from 0.70 to 0.75 (personal communication from Dr. William Hoover, President of the American Baking Institute).

[c]Sum of domestic production and imports. Does not reflect amounts available for consumption, since seed and waste are not accounted for.

[d]Seed = 50 kg/feddan
Waste = 5% of total domestic production

[e]The smoothing technique is a 3-year moving average.

[f]Two year average.

Table 2: Composition of Wheat Grain Equivalent Imports ('000 MT)

	Concessional	Aid	Commercial	Total
1978/79	120.9	29.3	75.0	225.2
1979/80	213.8	26.2	100.0	340.0
1980/81	161.3	41.8	291.3	494.4
1981/82	192.2	133.2	140.0	465.4

Source: Private communications with the Ministry of Cooperation, Commerce and Supply.

Table 3: Apparent Wheat Flour Consumption[a]

	Local Production ('000 MT)	Imports ('000 MT)	Total ('000 MT)	Per Capita (kg)
1971/72	89.9	137.9	227.8	15.4
1972/73	114.8	136.8	251.6	16.6
1973/74	175.9	117.8	293.7	18.8
1974/75	196.7	108.5	305.2	19.1
1975/76	180.8	148.9	329.7	20.0
1976/77	215.3	136.4	351.7	20.8
1977/78	235.9	122.8	358.7	20.6
1978/79	113.4	189.3	302.7	16.8
1979/80	159.2	268.6	427.8	23.1
1980/81	111.7	379.9	491.6	26.0
1981/82	110.1	358.8	468.9	24.3

[a]The conversion factor for all domestically produced and imported wheat grain is 0.87 for the years 1971/72 - 1978/79; in the period 1979/80 - 1981/82 the conversion factor was reduced to 0.80 (personal communication from Dr. Abdus Sattar, UNDP Planning Assistance Project).

thousand tons in FY 1982. This growth rate is the result of two effects: a growing population and an increasing per capita consumption. Table 3 shows that per capita consumption rose from 15 kilograms in FY 1972 to 24 kilograms in FY 1982; this represents an annual growth rate of 4.7 percent. The difference between the growth rates of total consumption and per capita consumption, 2.8 percent, is the effect of population growth on total wheat flour consumption. Thus, the growth in per capita consumption has accounted for much of the growth in total consumption.

Data from the 1978/79 Household Budget Survey (HBS) and the 1982 Minihousehold Survey (MHS) were used to obtain estimates of urban and rural per capita consumption in these years. As Table 3 shows, the period from FY 1979 through FY 1982 was a time of rapid increases in both total and per capita wheat flour consumption. Total consumption increased at a rate of 15.7 percent annually from 303 thousand tons to 469 thousand tons. Per capita consumption grew at an annual rate of 13 percent from 17 kilograms to 24 kilograms. The 1982 MHS data indicated that the average per capita bread consumption in the greater Khartoum conurbation was about 8 kilograms in May, or 96 kilograms per year. This is equivalent to 67 kilograms of wheat flour per person per year. Multiplying this amount by the estimates of the urban population in 1981/82 from Appendix B, 341 thousand metric tons of wheat flour were consumed by the urban population of the Sudan. If the remainder of the 469 thousand tons consumed in that year is allocated to the rural population (Appendix B),

rural per capita wheat flour consumption was just over nine kilograms. Comparable figures estimated from the 1978/79 HBS data indicated that at official prices the per capita urban bread consumption was 72 kilograms, or 50 kilograms of wheat flour per year. Multiplying this amount by the 1978/79 population estimates in Appendix B, urban wheat flour consumption was 209 thousand metric tons out of a total of 303 thousand metric tons. If the difference was consumed by the rural population, rural per capita consumption was 6.9 kilograms of wheat flour in 1978/79.

Thus, between 1978/79 and May 1982, urban per capita wheat flour consumption increased by 33 percent from 50 kilograms to 67 kilograms; this represents a compound growth rate of 10 percent per year. Between 1978/79 and May 1982, rural per capita consumption increased almost 32 percent from 6.9 kilograms of wheat flour to 9.1 kilograms; this is equivalent to a compound growth rate of 9.6 percent annually. While the growth rates are similar, wheat flour consumption is concentrated in the urban areas; in both years urban consumption accounted for approximately 70 percent of total consumption.

In this same period, Table 1 shows that domestic production of wheat grain declined from 168 thousand metric tons to 164 thousand metric tons, while imports of wheat grain doubled from 225 thousand metric tons to 465 thousand metric tons. Of the increase in imports during this period, only 27 percent was met through commercial imports; the remaining 73 percent of the increase in imports came from concessional sales and food aid

(Table 2).

The rapid increase in recent years of urban per capita wheat flour consumption, the growth in imports to counter production shortfalls, and the increasing reliance on concessional sales and food aid in the import mix have been a focus for policy debates in the context of the Sudan's economic crises. This study analyzed the causes of the increase in per capita urban consumption of bread. Several factors could explain this phenomenon: urbanization, rising real incomes, increasing female labor force participation rates, and pricing policies. These factors are discussed in the following section.

1.2 Growth in Per Capita Wheat Consumption

1.2.1 Urbanization

Urbanization has been suggested as a significant variable in explaining increased wheat bread consumption. The urban population in the Sudan has been increasing at more than 2.25 times the rate of the total population (World Bank, 1981). A major contributing factor is the recent influx of refugees and seasonal migrant workers from Chad, the Central African Republic, Uganda and Ethiopia towards large urban centers. This has led to conclusions that any efforts to understand the demand for wheat bread should focus on the urban centers, and that the growing demand for wheat is as irreversible as the urbanization process. Since only two percent of the sampled households in the 1982 Minihousehold Survey had migrated to urban Khartoum, a formal test of the influence of urbanization on bread consumption was not feasible with these data.

Urbanization is a process in which urban populations grow through the migration of the rural populace to the cities. Upon arrival in the urban center, the new urbanite faces a set of relative prices and a budget constraint. The fact that the new urbanite chooses bread over other staples may be a result of the availability of bread at low prices relative to other staples rather than an intrinsic desire to consume bread upon arrival in the city. Furthermore, since the new urbanite would probably earn more than he did in the area from which he emigrated, his demand for a staple like bread would consequently increase. Thus, urbanization encompasses rational income allocation decisions based on a set of relative prices and a budget constraint; its effect on per capita bread consumption can be determined by analyzing price and income effects.

While a growing urban population would increase the total consumption of wheat as each new migrant to the city added the average urban per capita consumption to the total, urbanization alone does not explain the rapid and significant increase in urban per capita consumption. The reasons for this increase can best be determined by examining underlying causes such as higher female labor force participation rates and changes in relative prices and real income.

1.2.2 Growth in Real Incomes

A growth in real incomes would explain some of the increase in per capita wheat bread consumption. However, while per capita real GNP fluctuated over the years from 1970/71 through 1980/81,

as shown in Table 4, over the entire period the trend of per capita real GNP was flat; that is, it remained constant at a level of about LS.150 per person. In the years since 1978/79 when per capita urban bread consumption was rising rapidly, per capita real GNP declined from LS.158 to LS.148. While no specific time series information on rural and urban incomes was available, an analysis of the expenditure data in the 1978/79 Household Budget Survey and the 1982 Minihousehold Survey indicated that on average real urban incomes declined over this four year period. Thus, it is very unlikely that growth in real incomes contributed to the increase in per capita bread consumption.

1.2.3 Female Labor Force Participation

Female participation in the labor force, although currently of minor importance in explaining the growth of per capita bread consumption, appears to be a factor of increasing significance. Estimates of participation rates of urban adult women range from less than four percent in the 1978/79 Household Budget Survey to 13 percent in the 1982 Minihousehold Survey. This implies an annual growth rate of 48 percent, much higher than the growth rate of 9 percent cited by Zaki and Wahba (1981). Table 5 and regression analyses* suggest that households with women participants in the labor force consume 13 percent more bread per capita than do households without women in the labor force. If

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*This regression equation adjusts this estimate for total food expenditure and household size effects; households with women participants in the labor force consume 1.5 kgs more of bread per month per capita than do those households without women labor force participants.

Table 4: Real Per Capita Gross National Product

	Gross National Product (LS. millions in constant 1978 prices)[a]	Population (millions)[a,b]	Per Capita GNP (LS./person)
1970/71	2176.1	14.5	150.1
1971/72	2131.0	14.8	144.0
1972/73	1948.8	15.2	128.2
1973/74	2154.8	15.6	138.1
1974/75	2308.7	16.0	144.3
1975/76	2531.3	16.4	154.3
1976/77	2718.1	16.9	160.8
1977/78	2864.9	17.3	165.6
1978/79	2808.4	17.8	157.8
1979/80	2765.1	18.2	151.9
1980/81	2776.2	18.7	148.5

[a] The World Bank, Sudan: Investing for Economic Stabilization and Structural Change, Washington, D.C., February 1982.

[b] The World Bank, Accelerated Development in Sub-Saharan Africa: An Agenda for Action, Washington, D.C., 1981.

Table 5: Average Per Person Bread Consumption in Households With and Without Working Women (kg/month)

Households	Expenditure Stratum		
	Lowest 25%	Middle 50%	Upper 25%
With Women in Labor Force	4.42 (12)	8.98 (34)	13.04 (21)
Without Women in Labor Force	3.98 (79)	7.70 (157)	12.38 (71)

Numbers in parentheses are sample sizes.

Source: Minihousehold Survey of Khartoum, May 1982. Sigma One Corporation.

this difference is attributed to labor force participation by women exclusively, the higher levels of bread consumption in households with female labor force participants would account for 1.7 percent of the per capita bread consumption in urban Khartoum.*

1.2.4 Bread Price Policy

The official policy for pricing wheat has been to fix the price of wheat and wheat products at several points in the marketing chain. For example, in early 1979 the producers' price for domestic supplies was fixed at LS.75 per metric ton and the official price at which the government sold to the millers was fixed at LS.55 per metric ton. In turn, the bakers' price for flour was fixed at LS.75 per metric ton of flour. In early 1982 the producers' price was LS.160, which with transportation and taxes cost the government LS.173.67 per metric ton. The government sold wheat to the millers at LS.111.185 per metric ton (a subsidy of LS.62.485, or 56 percent of the millers' price) and the millers' price to the bakers was approximately LS.170 per metric ton of flour. In each of these years, there was a substantial subsidy of approximately 30 percent of the farmgate price paid by the government through the differential between producers' and millers' prices. The small margin allowed the

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*This percentage was calculated by assuming that 13 percent of the urban population consumed 13 percent more bread than individuals living in households without female labor force participants. Thus, this effect would account for 1.7 percent of the level of urban per capita consumption and not 1.7 percent of the increase in per capita consumption.

millers created incentives for higher-than-standard milling extraction rates, or for the millers to sell through unofficial channels.

The overvaluation of the exchange rate applicable to wheat grain and flour imports was another factor in the price structure for wheat bread. In the late 1970's, the exchange rate was overvalued by 40 to 60 percent (Youngblood et al., 1982). This represented a tax on domestic producers, since the producer price was effectively below the import parity price by this amount. Since an overvalued exchange rate also subsidizes imports by an amount equal to the overvaluation, the overvaluation increased the demand for wheat imports. This effect was somewhat diluted by the large proportion of concessional sales and food aid in the wheat import mix; wheat from these sources accounted for 40 to 70 percent of total wheat imports over the last four years (Table 2). The fixed nominal prices at each point in the wheat marketing system, the government subsidies, and the overvaluation of the exchange rate imply that the pricing structure for bread did not reflect the real resource costs of production and distribution. The public sector, and at times the wheat producers, have been subsidizing wheat bread consumption.

In November of 1981, the government announced a liberalization of supply policies that were to lead to open market pricing for wheat. As a step towards this, in March of 1982 the nominal price of bread was effectively increased by 60 percent. This action by itself, however, was similar to previous

price increases, since the new nominal price tended to restore the real price to earlier levels, and as such was nothing more than an adjustment for domestic inflation. As shown in Table 6, the food price index increased by over 400 percent from 1970 to 1980 while the nominal price of bread increased by 300 percent. Consequently, the real price of bread decreased at an average annual rate of 2.5 percent from 1970 to 1980. Since 1980, and up to the March, 1982 price increase, the rate of decline was about 11 percent per year due to accelerated inflation.

The real price of sorghum grain relative to the real price of wheat bread also increased from 1970 to 1982 at a rate of 3.4 percent annually (Table 6). Sorghum is the principal ingredient in kisra, a substitute for wheat bread; other inputs used to produce kisra are the costs of grinding and preparation time. Thus, the price of sorghum grain is a good proxy for the price of kisra and probably underestimates the actual relative price of kisra to wheat bread. Since 1977, the real price of sorghum has ranged from 66 to 116 percent of the real price of bread. This high and increasing relative price has made wheat bread a relatively more attractive commodity than kisra in the diets of urban dwellers. With the March 1982 price adjustments a government subsidy of approximately 51 percent of the price charged to millers was eliminated by charging the millers the effective farmgate price of LS.230 per metric ton, which in turn was set at import parity at the official exchange rate. Even with these price adjustments, the price of wheat grain in local markets was 20 to 30 percent below the price of sorghum. The

Table 6: Bread Price Data

Year	Nominal Retail Bread Price (mms/kg)[a]	Nominal Retail Sorghum Grain Price (mms/kg)[a]	Food Price Sub-Index[a]	Real Bread Price (mms/kg)[b]	Real Sorghum Grain Price (mms/kg)[b]	Real Relative Price: Sorghum Grain to Wheat Bread
1970	50	31	100.0	50	31	0.62
1971	57	31	99.3	57	31	0.54
1972	60	33	109.6	55	30	0.55
1973	74	39	127.5	58	31	0.53
1974	90	46	160.0	56	29	0.52
1975	100	67	205.1	49	33	0.67
1976	120	63	201.3	60	31	0.52
1977	120	80	239.3	50	33	0.66
1978	120	114	302.4	40	38	0.95
1979	175	120	398.6	44	30	0.68
1980	200	171	506.9	39	34	0.87
1981	200	227[c]	615.0[c]	32[c]	37[c]	1.16
1982 Before March 31	200	227[c]	659.0[c]	30[c]	34[c]	1.13
1982 After March 31	320	300[c]	723.0[c]	44[c]	41[c]	0.93

[a]Department of Statistics, Ministry of National Planning, Khartoum, 1981.

[b]Nominal price deflated by food price sub-index; base year is 1970.

[c]Sigma One Corporation estimates.

price of sorghum is uncontrolled and has benefitted from purchases made by Saudi Arabia at prices substantially above prevailing world prices. The 1981/82 crop year yielded record harvests of sorghum and market prices for sorghum have remained above the price of wheat in spite of the record levels of output. However, the agreement with Saudi Arabia expired in March 1983; this may lead to a decline in the price of sorghum relative to wheat.

In November of 1982, the exchange rate was further devalued from US $1.11/LS. to US $0.77/LS. If the government does not raise the nominal price of bread or wheat to reflect the new exchange rate, the policy of maintaining a fixed nominal price of bread implies that the real price of bread will continue to decline with inflation. Even if the government raises the price of wheat and bread by a percentage close to the percentage devaluation, the tendency for the real price to decline will continue so long as nominal prices remain fixed over prolonged periods (six months to a year) during periods of substantial domestic inflation.

From the discussion in this section, it appears that the declining real price of bread, the increasing price of sorghum relative to wheat, and growing female participation in the labor force may be significant determinants of growth in urban per capita bread consumption. Real per capita income appears to have declined, especially in the past four years, and thus did not contribute to the increase in per capita bread consumption. The next section presents an analysis of the price and income effects

in the demand for bread based on the 1978/79 Household Budget Survey, the 1982 Minihousehold Survey, and available time series data.

2.0 INCOME AND PRICE EFFECTS IN THE URBAN DEMAND FOR BREAD

Econometric analyses of the demand for bread and other commodities in the consumption patterns of Khartoum households were undertaken with data from the 1978/79 Household Budget Survey and from the 1982 Minihousehold Budget Survey. Time series data have also been used to estimate parameters for the national demand for wheat. Several econometric approaches were applied to the available data. This section presents the results which best meet the multiple criteria of consistency with theory, household budget data and aggregate empirical observation. Appendix A discusses the methods which were used in the econometric estimation and the rationale for the selection of the Linear Expenditure System as the most appropriate estimation method given the available data.

The analysis in this section begins with a presentation of the parameter estimates of the demand for wheat based on available time series data. Section 2.2 contains a discussion of household expenditures and budget shares based on the data in the 1978/79 Household Budget Survey and the 1982 Minihousehold Survey. The analytical results presented in these two sections constitute critical inputs in the estimation of demand parameters based on the two cross-sectional data bases; the methods of estimation and the results are given in Section 2.3. The implications of these results for the nutritional status of different urban population groups are discussed in Section 2.4.

2.1 Analysis of Time Series Data

The data on per capita wheat flour consumption in Table 3 were regressed on per capita real GNP (from Table 4), the real price of wheat bread, and the real price of sorghum grain (from Table 6). The results are shown in Table 7. The time series estimate of the own price elasticity in the demand for wheat flour is -0.39, and the cross price elasticity of the demand for wheat flour with respect to the price of sorghum is 0.47. Using these estimates, the real bread price decrease and the real sorghum grain price increase would account for approximately 20 percent of the growth in national per capita bread consumption from 1970 to 1982. These results indicate that the real price of bread has a statistically significant effect on the per capita consumption of wheat flour and that the real price of sorghum grain has a statistically significant impact on the quantity demanded of wheat flour. As discussed in Section 1.2.2, the effect of real per capita GNP on per capita wheat flour consumption is statistically insignificant.

2.2 Household Expenditures and Budget Shares

Tables 8 and 9 present the average expenditures per household for three expenditure strata in the Khartoum sample of the 1978/79 HBS and of the 1982 MHS. The lowest stratum represents the lowest 25 percent, the middle stratum the middle 50 percent, and the upper stratum the upper 25 percent of the distribution of per capita total expenditure as measured by the surveys. The study analyzed expenditure data for bread, kisra and other cereals, meats and meat products, fruits and

Table 7: Time Series Estimation of the Demand for Wheat Flour

Dependent Variable: Per Capita Wheat Flour Consumption	
Intercept	2.284 (1.06)
Price of Wheat Bread	-0.3916 (-1.27)[a]
Price of Sorghum Grain	0.4729 (2.32)[b]
Income	0.1827 (0.43)
N	11
R^2	0.65
Durbin-Watson	1.96

t-statistics in parentheses.

[a]Significant at the 0.15 level of significance.

[b]Significant at the 0.05 level of significance.

Source: Sigma One Corporation

Table 8: Average Monthly Household Expenditures, 1978/79 Household Budget Survey[a]

	Entire Sample	Expenditure Stratum Lowest 25%	Middle 50%	Upper 25%
Bread	7.43	6.18	7.67	8.20
Other Cereals	5.92	5.45	6.08	6.08
Meats	19.60	14.05	18.76	26.84
Fruits & Vegetables	18.16	13.93	18.04	22.62
Other Food	29.83	20.06	28.17	42.92
Food	80.94	59.67	78.72	106.66
Nonfood	62.99	32.47	51.73	116.03
Total	143.93	92.14	130.45	222.69
Average Household Size	6.6	8.4	6.6	4.7

[a] Sudanese pounds.

Source: Sigma One Corporation

Table 9: Average Monthly Household Expenditures, 1982 Minihousehold Survey[a]

	Entire Sample	Expenditure Stratum: Lowest 25%	Middle 50%	Upper 25%
Bread	19.55	15.60	20.63	21.34
Other Cereals	14.32	13.40	15.27	13.34
Meats	36.65	24.23	35.96	50.45
Fruits & Vegetables	40.69	26.01	41.80	53.16
Other Food	55.57	38.06	55.33	73.57
Food	166.78	117.30	168.99	211.86
Nonfood	98.44	49.54	84.53	175.18
Total	265.23	166.84	253.52	387.04
Average Household Size	7.5	9.3	7.6	5.5

[a] Sudanese pounds.

Source: Sigma One Corporation

vegetables, other foods and nonfood items. Average household expenditures almost doubled in nominal terms between the two survey periods, reflecting nearly 100 percent inflation during that time interval.

Tables 10 and 11 present the average budget shares as a percent of total expenditures for the three expenditure strata. The average food budget share increased for all strata between the two survey periods, while nonfood budget shares declined for all expenditure strata. This implies that real incomes ueclined over time for the population as a whole.

The budget shares for bread, other cereals, and fruits and vegetables increased for all expenditure strata, while the budget shares for meats and other foods remained fairly constant between the survey periods. Bread accounted for over seven percent of total household expenditures in Khartoum in 1982; this is up from five percent in 1978/79. The rising share of bread in total expenditures in the presence of falling incomes implies that declining real prices for bread made bread relatively more attractive vis-a-vis other food commodities.

2.3 Estimates of Expenditure and Price Elasticities

Estimating price elasticities from cross-sectional data requires that certain restrictive theoretical assumptions be imposed on the underlying model of consumer preferences. Several techniques were evaluated for appropriateness to this study's data. Of these, the Linear Expenditure System (Stone, 1954; Howe, 1976)) proved the most appropriate method. Another set of parameter estimates calculated by the Frisch technique (Frisch,

Table 10: Average Budget Shares as Percent of Total Expenditures, 1978/79 Household Budget Survey[a]

	Entire Sample	Expenditure Stratum: Lowest 25%	Middle 50%	Upper 25%
Bread	5.2	6.7	5.9	3.7
Other Cereals	4.1	5.9	4.7	2.7
Meats	13.6	15.3	14.4	12.0
Fruits & Vegetables	12.6	15.1	13.8	10.2
Other Food	20.7	21.8	21.6	19.3
Food	56.2	64.8	60.3	47.9
Nonfood	43.8	35.2	39.7	52.1

[a] Number of households in sample = 1609.

Source: Sigma One Corporation

Table 11: Average Budget Shares as Percent of Total Expenditures, 1982 Minihousehold Survey[a]

	Entire Sample	Expenditure Stratum Lowest 25%	Middle 50%	Upper 25%
Bread	7.4	9.4	8.1	5.5
Other Cereals	5.4	8.0	6.0	3.5
Meats	13.8	14.5	14.2	13.0
Fruits & Vegetables	15.3	15.6	16.5	13.7
Other Food	21.0	22.8	21.8	19.0
Food	62.9	70.3	66.7	54.7
Nonfood	37.1	29.7	33.3	45.3

[a] Number of households in sample = 606.

Source: Sigma One Corporation

1959) is also presented in this section for purposes of comparison. A more detailed discussion of the Linear Expenditure System (LES) and the Frisch technique is provided in Appendix A.

Both methods have several features in common. First, each method is based on the assumption that the marginal utility of each commodity (in this case, the five food groups and nonfood) varies only with changes in the quantity consumed of that commodity; that is, the utility function of every consumer is separable. Second, in both methods, total expenditures are used as a proxy for income. (In both surveys, expenditures sometimes exceeded reported household income; this undermined the reliability that could be placed on the quality of the income data and led to the use of total expenditures as a proxy for income.)

A third important feature is that both methods require a prior estimate of a key parameter in order to estimate the demand parameters. For the Frisch technique, this prior estimate is an assumed value of the money flexibility; for the linear expenditure system, it is the level of committed (subsistence) expenditures. As Appendix A shows, this prior estimate is a critical determinant of the magnitude of the resulting demand elasticities. Given a value of the money flexibility (Frisch technique) or the level of committed expenditures (LES approach), the own-price elasticities can be calculated as shown in Appendix A. Alternatively, given a prior value of one own-price elasticity, the equations in Appendix A are used to solve for the value of the money flexibility or the level of committed expendi-

tures. This value can then be used to calculate the remaining own-price elasticities. The approach used in this study was to use the time series estimate of the own-price elasticity for bread (Section 2.1) to determine the value of the money flexibility and the level of committed expenditures, which were then used to calculate the remaining own-price elasticities.

The other inputs required to estimate the system of demand functions using either the LES approach or the Frisch technique are the budget share and the expenditure elasticity for each commodity. The budget shares were presented in Section 2.2. Estimates of the expenditure elasticities are given in Section 2.3.1 and the set of own-price elasticities are shown in Section 2.3.2. The methods and equations used to estimate the expenditure and own-price elasticities are described in Appendix A.

2.3.1 Expenditure Elasticity Estimates

Table 12 presents the results of estimating Engel functions for the commodities in the expenditure patterns in 1978/79 and 1982. Overall, the results are consistent with economic theory and with the results of studies for similar income levels. The estimates presented in Table 12 are all statistically significant at the 0.01 level and all equations represent good statistical fits to the data according to goodness-of-fit criteria (see Appendix A). The marginal propensities to consume food increased for the entire sample from 0.43 in 1978/79 to 0.53 in 1982. This implies that of every additional Sudanese pound of income, 10 piasters more were expended on food in 1982 than were expended

Table 12: Marginal Propensities to Consume by Expenditure Stratum[a]

	Entire Sample	1978/79 HBS Expenditure Stratum: Lowest 25%	Middle 50%	Upper 25%
Food	.435	.584	.456	.246
Nonfood	.565	.416	.544	.754
Bread	.025	.040	.024	.014
Other Cereals	.018	.031	.018	.006
Meats	.125	.189	.121	.071
Fruits & Vegetables	.091	.128	.094	.046
Other Food	.175	.196	.199	.109
			1982 MHS	
Food	.534	.647	.554	.383
Nonfood	.466	.353	.446	.617
Bread	.077	.113	.074	.048
Other Cereals	.035	.062	.030	.020
Meats	.134	.138	.150	.098
Fruits & Vegetables	.119	.126	.119	.110
Other Food	.169	.208	.180	.107

[a]For a particular commodity, the table entry shows how much of an additional Sudanese pound of income would be spent on that commodity.

Source: Sigma One Corporation

from an additional Sudanese pound of income in 1978/79. This again implies that real incomes were decreasing over this period, forcing households to increase expenditures on this necessity from any additional nominal income. This conclusion is supported by a comparison of the average budget shares reported in Tables 10 and 11, which showed an increase in the share of food from 56 percent to 63 percent of total expenditures. As shown in Table 12, this increase in the marginal propensity to consume (MPC) food between the survey periods was primarily attributable to an increase in the MPC's for bread, which tripled, and for other cereals, which doubled.

Table 13 presents the expenditure elasticities for the two survey periods, which were calculated from the results in Table 12 as described in Appendix A. The expenditure elasticities for bread doubled for all expenditure strata between the 1978/79 survey period and the 1982 survey. The expenditure elasticities for other cereals also increased for all strata. The expenditure elasticity for meat declined for the lowest stratum, but increased for the middle and upper strata. The expenditure elasticity for fruits and vegetables was fairly stable for the lower and middle strata, but increased significantly for the upper stratum.

In the 1978/79 survey period, the expenditure elasticities for all food commodities except other food declined across expenditure strata. Thus, a ten percent increase in income would have induced a 5.9 percent increase in the quantity consumed of bread for the lowest expenditure stratum, a 4.1 percent increase

Table 13: Expenditure Elasticity Estimates by Expenditure Stratum

	Entire Sample	1978/79 HBS Expenditure Stratum: Lowest 25%	Middle 50%	Upper 25%
Food	.732	.902	.755	.514
Nonfood	1.343	1.181	1.372	1.446
Bread	.448	.592	.412	.377
Other Cereals	.381	.531	.390	.212
Meats	.877	1.238	.838	.593
Fruits & Vegetables	.667	.849	.682	.457
Other Food	.826	.898	.920	.565
			1982 MHS	
Food	.820	.920	.831	.699
Nonfood	1.308	1.189	1.339	1.364
Bread	.973	1.211	.904	.875
Other Cereals	.586	.773	.501	.567
Meats	.954	.949	1.059	.749
Fruits & Vegetables	.765	.809	.724	.803
Other Food	.782	.910	.827	.562

Source: Sigma One Corporation

for the middle stratum, and a 3.8 percent increase for the highest expenditure stratum. In the 1982 survey period, only bread and other food exhibited the same pattern of declining expenditure elasticities across strata. However, in both surveys the expenditure elasticities for the food category declined across expenditure strata.

The theoretical interpretation of the 1982 expenditure elasticity for bread in the lowest stratum is that bread is a luxury good because the elasticity is greater than one. The expenditure elasticity is the ratio of the MPC to the budget share (see Appendix A). For the lowest expenditure stratum, the MPC for bread shows that 11 piasters of an additional pound of income would be spent on bread. However, the budget shares for the lowest stratum reveal that bread has the second lowest share of the food commodities. It is this propensity to consume more of a marginal pound of income on a commodity than its average share in the budget that implies that the commodity is a luxury good; a necessity would receive less of each additional pound of income relative to its share in the budget.

In the lowest stratum, other cereals has the lowest expenditure elasticity, which implies that it is more of a necessity among food commodities; bread has the highest expenditure elasticity. In the middle stratum, the lowest expenditure elasticity is that for other cereals and the highest is for meats; since the elasticity for meats is greater than one, this implies that meat is a luxury good for this stratum. In the upper stratum, the lowest elasticity is that for other food and

the highest is the expenditure elasticity for bread.

2.3.2 Price Elasticity Estimates

Table 14 presents the LES estimates of own-price elasticities for the three expenditure strata. The bread price elasticities are very similar between the two survey periods for all strata. The average bread price elasticity for the entire sample is -0.39; the estimated elasticities for bread increase across the strata and range from -0.28 for the lowest stratum to -0.45 for the highest stratum in both survey periods. The price elasticities for other cereals, meats, fruits and vegetables decreased between the survey periods for all expenditure strata and for the entire sample. The average elasticities for total food became more inelastic over the period 1978/79 to 1982. Within each survey period, the demand elasticity for total food is very stable across strata.

Table 15 presents the own-price elasticities estimated by the Frisch technique for the three expenditure strata in the two survey periods. The price elasticities for bread increased slightly between 1978/79 and 1982. In general, the elasticities were more stable between the survey periods than were those estimated by the Linear Expenditure System. The Frisch estimates of the price elasticity for food increased slightly from 1978/79 to 1982.

The most striking difference between the LES and Frisch estimates is that the LES elasticities tend to increase (become more elastic) across expenditure strata while the Frisch

Table 14: Linear Expenditure System Estimates of Own-Price Elasticities

	Entire Sample	1978/79 Expenditure Stratum: Lowest 25%	Middle 50%	Upper 25%
Food	-.820	-.820	-.821	-.817
Nonfood	-1.360	-1.686	-1.336	-1.081
Bread	-.194	-.289	-.418	-.450
Other Cereals	-.427	-.387	-.443	-.436
Meats	-.780	-.727	-.779	-.837
Fruits & Vegetables	-.587	-.496	-.596	-.661
Other Food	-.851	-.796	-.856	-.895
			1982	
Food	-.710	-.688	-.726	-.698
Nonfood	-.765	-.567	-.783	-.928
Bread	-.392	-.277	-.429	-.433
Other Cereals	-.204	-.176	-.253	-.135
Meats	-.483	-.269	-.514	-.632
Fruits & Vegetables	-.434	-.177	-.484	-.590
Other Food	-.467	-.291	-.495	-.586

Source: Sigma One Corporation

Table 15: Frisch Technique Estimates of Own-Price Elasticities

	Entire Sample	1978/79 Expenditure Stratum: Lowest 25%	Middle 50%	Upper 25%
Food	-.642	-.736	-.655	-.522
Nonfood	-.724	-.629	-.711	-.844
Bread	-.382	-.391	-.381	-.374
Other Cereals	-.377	-.385	-.377	-.369
Meats	-.445	-.485	-.442	-.411
Fruits & Vegetables	-.423	-.447	-.425	-.395
Other Food	-.477	-.490	-.491	-.434
			1982	
Food	-.704	-.776	-.717	-.608
Nonfood	-.661	-.589	-.649	-.757
Bread	-.414	-.437	-.412	-.396
Other Cereals	-.388	-.405	-.385	-.378
Meats	-.450	-.453	-.461	-.427
Fruits & Vegetables	-.441	-.445	-.441	-.435
Other Food	-.473	-.497	-.480	-.433

Source: Sigma One Corporation

elasticity estimates tend to decrease. While both estimates of the bread price elasticities for the entire sample are -0.40 in both survey periods, the two techniques give different estimates for the three expenditure strata. As explained in Appendix A, the LES estimates are preferred to the Frisch estimates because the LES approach uses more of the information obtained from the data analysis (particularly in the Engel function estimates) than does the Frisch technique. Both sets of estimates are presented to illustrate the considerations involved in selecting an approach for estimating demand parameters from cross-sectional data.

Regardless of the method used, the estimated average elasticities represent lower bounds of the actual parameters. Given the decline in the real price of bread over time, the estimated bread price elasticity of -0.40 suggests that the excess demand conditions in the market for bread that result from fixing the nominal price of bread can be partially managed through price policies for bread and its substitutes. This issue is explored further in Section 3.

2.4 Calorie Consumption Patterns

Table 16 presents percentile discributions by expenditure strata for quantities of bread and kisra consumed by the households in the 1982 sample. The estimated annual average per capita bread consumption was 98.4 kilograms and the average kisra consumption was 39.6 kilograms per capita per year.

Data from the 1982 MHS was used to compute the calorie content in the diet. Table 17 presents the share of daily

Table 16: Percentile Distribution of Bread and Kisra Consumption in Urban Khartoum, 1982 MHS
(kg per household per month)

	Entire Sample	Expenditure Stratum Lowest 25%	Middle 50%	Upper 25%
Bread Percentile				
25th	30.0	20.0	34.4	31.1
50th	53.0	43.4	58.0	52.5
75th	82.5	63.9	90.5	85.1
Average	58.8	47.6	64.1	59.4
Average/Capita	8.2	5.1	8.4	10.8
Kisra Percentile				
25th	8.1	8.9	8.9	5.6
50th	17.8	16.5	21.0	12.8
75th	33.0	36.0	33.0	30.0
Average	24.1	24.1	25.2	21.7
Average/Capita	3.3	2.6	3.3	3.9

Source: Sigma One Corporation

Table 17: Average Percentage of Daily Calories by Commodity Group, 1982 MHS

Commodity	Expenditure Stratum Lowest 25%	Middle 50%	Upper 25%
Bread	37.0	41.0	41.0
Kisra	13.2	14.1	9.4
Other Cereal	7.6	6.0	3.9
Meat	5.5	5.5	8.0
Dairy	9.2	8.0	5.6
Fats & Oils	9.0	7.4	10.6
Fruits & Vegetables	1.2	1.2	2.3
Pulses	1.5	1.5	2.4
Sugar	15.5	15.0	16.5
Other Foods	0.3	0.3	0.3
Median Calories/Person/Day	1524	2253	2846
% of RDA	66.0	97.1	122.7

Source: Sigma One Corporation

calories provided by bread and other food groups for each of the three expenditure strata. Bread alone provides approximately 40 percent of the calorie intake for the population of Khartoum, while it only absorbs 7 percent of expenditures. The upper 25 percent of the expenditure distribution consumes nearly twice as many calories per person from bread than do the persons in the lower quartile. The persons in the upper quartile are appreciably above the FAO recommended daily caloric intake levels and all of the lowest quartile is below 80 percent of energy intake recommendations. (The risk of a nutritional deficit increases when energy intakes fall below 80 percent of the FAO recommended intake.) While bread is very important in the diets of the very poor, providing 30 percent of the recommended energy intake, the low bread price policy is an inefficient way of providing nutrients to that group since for every calorie provided to the lowest quartile, five calories must be provided to the middle and upper expenditure groups.

3.0 SIMULATIONS OF WHEAT IMPORT REQUIREMENTS

The growth in demand for wheat which the Sudan has experienced in the past decade, the concern for domestic resource utilization in the irrigated schemes and the Sudan's increasing dependence on concessionary wheat imports have highlighted the need to better understand the processes by which these factors interact to determine the Sudan's yearly wheat import requirements. This section presents the results of econometric and simulation analyses regarding the determinants of domestic wheat production and wheat import requirements. The import demand model which was developed for this study simulates the behavior of the Sudan's market for wheat in response to domestic prices and the world price of wheat. The model consists of a demand component, a domestic production component and an import demand component.

3.1 Import Demand Model

Fifteen years ago, production and consumption of wheat were regionally concentrated along the Nile River north of Khartoum. In 1972, the government established a goal of self-sufficiency in wheat production. The substantial increases in domestic production that this required would be realized by exploiting the potential of the irrigated schemes, particularly the Gezira Scheme. This policy was based in part on the expectation that yields in the new areas and the traditional wheat producing areas could be increased through the application of modern factors of production and improved agronomic practices.

During the decade of the seventies, areas sown to wheat more

than doubled, with the Gezira Scheme contributing most of the increase, approximately one half million feddans. Yield increases failed to materialize and in fact average yields declined. The increases in domestic production (Table 18) were far less than required to achieve self-sufficiency. This resulted from deficiencies in the structure of incentives facing domestic wheat producers, especially the tenants of the Gezira Scheme, as well as technical problems associated with the maintenance of the scheme's infrastructure (Euroconsult, 1982; Youngblood et al., 1982).

Table 18 presents time series data on areas planted, production, commercial imports and real world prices for wheat. As can be seen, land allocations to wheat in the Sudan increased sharply in the 1973/74 agricultural year, when wheat was introduced into the Gezira rotation. Since 1975/76 land allocations in the Gezira Scheme have been reduced, in part reflecting pressures to increase foreign exchange earnings from cotton production.

The simulation analysis concentrated on the Gezira Scheme, because it accounts for over 75 percent of domestic wheat production. The Gezira Scheme, with 2.1 million feddans, is the world's largest irrigated scheme. It is occupied by more than 100 thousand tenants and it is run by the Sudan Gezira Board (SGB), which decides on the cropping patterns and provides mechanization, seeds, fertilizer and plant protection inputs. The main binding resource constraint facing the scheme is the

Table 18: Data for the Wheat Import Demand Model

	Area ('000 fed.)[a]	Production ('000 MT)[a]	Imports ('000 MT)[b]	Real World Price ($/MT)[c]
1961/62	41	28	-	224.5
1962/63	54	31	-	228.6
1963/64	56	37	-	224.2
1964/65	136	56	-	237.3
1965/66	137	69	-	211.3
1966/67	172	79	-	221.0
1967/68	213	87	-	216.5
1968/69	262	123	-	218.7
1969/70	290	115	74.2	209.7
1970/71	290	163	134.5	191.9
1971/72	288	124	161.1	193.5
1972/73	248	152	159.2	195.8
1973/74	424	235	136.4	324.9
1974/75	591	269	126.7	341.0
1975/76	690	255	173.3	231.4
1976/77	639	294	157.7	201.8
1977/78	602	317	147.6	144.7
1978/79	586	177	261.3	159.9
1979/80	447	231	-	174.6

[a]FAO, Sudan: Report of FAO Programming Mission, October 1980, (Annex 4, Table 12).

World Bank, Sudan: Agricultural Sector Survey, Volume II: Annexes 1-4, 1979 (Annex 2, Table 10, p. 70).

[b]Bank of Sudan Annual Report. Several issues. Concessionary imports are not included.

[c]World Bank, Commodity Trade and Price Trends, 1981.

water capacity of the main canal. The available water supplies can accommodate just over 1 million feddans at any given time. In June and July, 500 thousand feddans in cotton and 500 thousand feddans in sorghum and groundnuts deplete the available water supplies. Cotton is harvested in February and March. Sorghum and groundnuts are harvested in mid-October. After the harvesting of sorghum and groundnuts, there is water available for 500 thousand feddans. At that time, wheat is usually planted. The water allocation to cotton automatically places an upper limit on the area that can be planted in wheat, because wheat can only be planted in October and November.

While the Gezira Scheme has provided at least three-fourths of domestic wheat production, a potential of seventy thousand metric tons can be produced in other schemes and in the traditional wheat producing areas in the Northern Region. Accordingly, the domestic production component of the import demand model analyzes the supply response of the country as a whole with a Nerlovian adaptive expectations model in which current land allocations were regressed on lagged world prices for wheat, lagged land allocations and a trend component. Results of the econometric estimation are presented in Table 19.

The world wheat price has a positive and significant impact on land allocations to domestic production of wheat; that is, higher world prices induce an increase in the area sown to wheat. This might be the result of expected higher domestic prices or the SGB's attempt to save foreign exchange by reducing wheat imports.

Table 19: Estimates of the Acreage Response Model for Wheat[a]

Dependent Variable: Wheat Acreage	
Intercept	-1588.27 (-3.19)
Lagged World Wheat Price	1.269 (4.63)
Lagged Acreage	0.3927 (2.17)
Trend	21.612 (2.91)
N	18
R^2	0.95
Durbin-Watson	2.40

[a]Sigma One Corporation estimates based on time series data in Table 18. The t-statistics are in parentheses.

Data from 1969/70 to 1978/79 were used to estimate the determinants of commercial imports. The estimated model in Table 20 indicates that commercial imports have not been responsive to world prices but have been highly responsive to domestic production. This indicates that Sudan's import policy has been to fill the gap between domestic demand and domestic production and that domestic production is the policy response variable that is implemented through the allocation of land and water resources in the irrigated schemes.

Given the empirical results noted above, the market for wheat in the Sudan appears to operate as follows:

- Demand is projected according to trends at constant nominal prices.
- World market prices for wheat are used to determine land allocations to wheat production.
- Commercial imports are purchased in the world market to fill the gap between projected demand and the sum of concessionary imports and domestic production.

In the past domestic prices have reflected institutional and political objectives and as such are only distally related to world and domestic market forces. Under this structure there is no guarantee that the market would achieve equilibrium; the most likely outcome is for demand to exceed available supplies, given the erosion of real prices in an inflationary environment. Furthermore, since concessionary aid is likely to be inversely related to world prices, such a system is likely to increase food insecurity, for in periods of high world prices, the Sudan would

Table 20: Estimates of Commercial Wheat Imports

Dependent Variable:	Commercial Wheat Grain Equivalent Imports (1969/70 - 1978/79)
Intercept	-1303.84 (-4.79)
World Wheat Price	0.0662 (0.48)
Domestic Production	-0.5696 (-3.77)
Trend	20.97 (5.55)
N	10
R^2	0.85
Durbin-Watson	2.06

t-statistics in parentheses.

Source: Sigma One Corporation

be hit by the double effect of reduced concessionary imports and higher cost commercial imports. Scobie (1981) estimated that concessionary wheat deliveries to Egypt were reduced by 6.5 percent for every 10 percent rise in the world market price for wheat. Currently, the world price for wheat is approximately 25 percent below trend in real terms. If similar donor behavior holds for the Sudan as for Egypt, then the Sudan is currently receiving about 16 percent more concessionary wheat than it would under more normal world market conditions.

3.2 Simulation Analyses

The econometric relationships have been used to develop scenarios of likely import requirements under alternative policies and world market conditions. The import demand model for this study is an excess demand model. The simulations for the Sudan's import requirements are developed using 1981/82 as a baseline case. As such, the import demand model is a policy simulation model and not a projections model.

In this study the policy simulations focus on the impact of alternative prices and land allocations and the effect of introducing a wheat/sorghum composite flour. Furthermore, the impact of land allocations to domestic wheat production is evaluated from scenarios on alternative technology levels in the Gezira Scheme. These technological alternatives were developed by Youngblood, Leonard and Sattar (1982) in a sensitivity analysis of resource allocation in the Gezira Scheme.

The import demand model assumes two alternative technologies that result in one of two yield levels, 450 kg. per feddan, the

average yield over the last 15 years, and 700 kg. per feddan, a plausible yield under improved agronomic practices. Achievement of this higher yield level in the irrigated schemes would require substantial enhancements to the structure of incentives facing the tenants and timely provision of inputs. For example, late planting of any crop in the Gezira rotation caused by delays in the availability of machinery and other resources increases the competition for water and labor resources among all crops. Wheat yields are particularly sensitive to the planting date in that the "temperature window" for planting is relatively short during October and November. In this study it has been assumed that the required technical and economic enhancements to achieve the higher yield levels will occur in a relatively short time.

In 1981/82 the Sudan consumed approximately 468.9 thousand metric tons of wheat flour, principally in the form of bread (Table 3). Domestically produced wheat flour amounted to 110.1 thousand MT, or 23.5 percent of total wheat flour availability; imports accounted for the remaining 76.5 percent of apparent wheat flour consumption. The total area devoted to wheat production was approximately 436 thousand feddans in the Gezira and New Halfa irrigation schemes and the Northern Region. Yields were approximately 0.33 MT of wheat grain per feddan, below the historical average of 0.45 MT per feddan.

The following policy scenarios assume a baseline consumption level of 468.9 thousand tons of wheat flour, a baseline production of 110.1 thousand tons of wheat flour, that the esti-

mated LES price elasticity for bread of -0.39 applies and that the acreage response regression estimates hold. Furthermore, an annual inflation level of 33 percent is assumed and no growth in real incomes is expected to take place.

3.2.1 Scenario 1: The Status Quo

Since no changes in pricing policies take place in this scenario, the 1982 food price sub-index of 723 (Table 6) would increase by 33 percent, the annual rate of inflation, to 962. Given the nominal bread price of 320 mms/kg, the new real bread price would be 33 mms/kg, a 25 percent decrease from its estimated 1982 level of 44 mms/kg (Table 6). Since the own-price elasticity of bread is -0.39, the 25 percent decrease in the real bread price implies that consumption would increase by almost 10 percent from the baseline level of 468.9 thousand tons to 514.6 thousand tons of wheat flour.

Domestic production remains at 110.1 thousand tons of wheat flour, so import requirements would be 404.5 thousand tons, approximately 13 percent above the baseline level of 358.8 thousand tons. If the wheat was imported as grain and converted to flour at the Sudanese extraction rate of 0.80, grain imports under this scenario would be 505.6 thousand tons. If the population increased by 2.6 percent, consumption would increase by an additional 13.4 thousand tons to 528.0 thousand tons of wheat flour. This would raise the import requirements to 417.9 thousand tons of flour.

3.2.2 Scenario 2: Real World Wheat Price at Trend Level

This scenario attempts to simulate what would happen if the

world wheat price were to return to its trend level in real terms and this increase were transmitted to consumers and producers. In this case, the real world price of wheat would increase by 25 percent and the domestic real price of bread would increase by 27 percent. As a result of the increased world price, land allocated to wheat production would increase in the fashion described by the estimated acreage response equation (Table 19) by 230 thousand feddans. The new land allocation would be 666.0 thousand feddans (a possible 500 thousand feddans in the Gezira and the remainder in the New Halfa Scheme and the Northern Region). The 27 percent higher real bread price would cause the quantity demanded to fall by almost 11 percent to 419.5 thousand MT of wheat flour.

If yields were 0.45 MT per feddan, domestic production of wheat grain would total 299.7 thousand metric tons. Given an extraction rate of 80 percent, domestic production of wheat flour would be 239.8 thousand MT; 179.7 thousand MT of wheat flour would have to be imported to meet the estimated consumption requirements of 419.5 thousand MT. If the structure of incentives and the infrastructure of the irrigated schemes were improved, thereby increasing the average yield to 0.7 MT feddan, domestic production of wheat flour would increase to 373 thousand MT and the import requirements would be further reduced to 46.5 thousand MT of wheat flour.

The reduction of wheat flour consumption in response to a 27 percent increase in the real price of bread would be allocated

among the different expenditure classes in the following way as indicated by the LES own-price elasticities: lowest 25 percent, -7.5 percent; middle 50 percent, -11.6 percent; upper 25 percent, -11.7 percent.

3.2.3 Scenario 3: Composite Bread

This scenario is based on the same assumptions used to derive the estimates in the first scenario. Because of the continued decline in the real price of bread, the Sudan would consume 514.6 thousand MT of wheat flour. If a composite flour were adopted for bread preparation (80 parts wheat flour and 20 parts sorghum flour), then the same amount of bread could be produced with 411.7 thousand MT of wheat flour (80 percent of 514.6 thousand tons). The implied import requirements would then be 301.6 thousand metric tons of flour. If a 70/30 blend of composite flour were used, consumption of wheat flour would fall to 360.2 thousand tons and the import requirement would be reduced to 250.1 thousand metric tons of wheat flour. This scenario supposes that all bread would have the same composition or that the new product is equivalent to that presently being produced, otherwise two markets may evolve.

3.2.4 Scenario 4: Retail Price Increases

A 25 percent increase in the real price of bread with no change in domestic production and no change in the present bread composition would reduce the quantity of wheat flour demanded from 468.9 thousand MT to 423.2 thousand MT. This would require imports of 313.1 thousand MT of wheat flour to meet the estimated level of consumption.

3.3 Summary of Wheat Import Simulations

Table 21 summarizes the results of the four scenarios discussed above. For each scenario, the consumption, domestic production, and imports of wheat flour are given. The percentage change in each of these quantities from the 1981/82 baseline levels are also shown. The results illustrate the variety of alternatives available to policy makers and the differential impacts these alternatives could have on consumption, production, and import requirements. The policy alternatives analyzed include maintenance of the current system of bread pricing (Scenario 1), policy changes affecting the demand for wheat flour (Scenarios 3 and 4) and policy changes affecting both the demand and supply of wheat flour (Scenario 2).

The greatest reduction in wheat flour imports occurs in Scenario 2 in which an increase in the world price of wheat is transmitted to producers and consumers. The quantity demanded of wheat flour would decrease by over 10 percent. If historical average yields are realized in the irrigated schemes, domestic production would increase over the baseline level by more than 100 percent; the combined effect of the changes in consumption and production would reduce import requirements by 50 percent of the baseline amount. If significant improvements in the structure of producer incentives and in the infrastructure of the irrigated schemes were made, production of wheat flour would triple and import requirements would drop by almost 90 percent.

The results obtained under the other three scenarios are

Table 21: Results of Policy Simulation Analysis

	Baseline	Scenario 1:[a] Status Quo	Scenario 2:[b] Trend Wheat Price Obtains		Scenario 3:[c] Composite Bread		Scenario 4:[d] Retail Price Increase
			Low yld	High yld	80/20 mix	70/30 mix	
Consumption							
Quantity (000 MT flour)	468.9	514.6	419.5	419.5	411.7	360.2	423.2
Percent change from baseline	--	9.7	-10.5	-10.5	-12.2	-23.2	-9.7
Domestic Production							
Quantity (000 MT flour)	110.1	110.1	239.8	373.0	110.1	110.1	110.1
Percent change from baseline	--	0.0	117.8	238.8	0.0	0.0	0.0
Imports							
Quantity (000 MT flour)	358.8	404.5	179.7	46.5	301.6	250.1	313.1
Percent change from baseline	--	12.7	-49.9	-87.0	-15.9	-30.3	-12.7

[a]Annual inflation of 33 percent increases food price sub-index and causes drop of 25 percent in real price of bread. Bread price elasticity = -0.39. No change in domestic production.

[b]Real world price of wheat increases by 25 percent to trend value. Land allocated to wheat production increases by 230,000 feddans to 666 thousand feddans. Low yield case: historical yields of 450 kg/feddan are realized. High yield case: enhancements to structure of producer incentives and irrigated scheme infrastructure increase average yields to 700 kg/feddan. Real retail price of bread increases by 27 percent. Bread price elasticity = -0.39.

[c]Real bread price declines as in Scenario 1. No change in domestic production. 80/20 mix case: composite bread flour produced with 80 parts wheat flour to 20 parts sorghum flour. 70/30 mix case: composite bread flour produced with 70 parts wheat flour to 30 parts sorghum flour.

[d]Real retail price of bread increases by 25 percent. Demand elasticity for bread = -0.39.

less dramatic because only the demand side is affected. If no change in the current bread pricing policy occurs (Scenario 1), the real price of bread will continue to decline, consumption will increase by about 10 percent and import requirements will increase by almost 13 percent. A real retail price increase of 25 percent (Scenario 4) will induce a 10 percent decrease in the quantity demanded and a consequent 13 percent decrease in import requirements. Production of a composite flour with no real price changes has a greater effect on consumption of wheat flour (the decreases range from 12 to 23 percent depending on the wheat/sorghum mix); however, since the price of sorghum has recently been high relative to the price of wheat bread, production of bread using a composite flour could increase real resource costs.

4.0 CONCLUSIONS

Under the present policy of fixed nominal prices for bread in the presence of substantial domestic inflation, per capita consumption of bread will continue to grow. Even if the maximum land allocations are planted to wheat in the Gezira and New Halfa Schemes and the Northern Region returns to historical levels of production, the bulk of the increased demand will have to be met by increased imports. The increased level of imports may have to be provided as flour, because effective milling capacity is low. Furthermore, the Sudan's continuing balance of payments difficulties imply that the Sudan will have to rely even more on concessionary sales and food aid to meet its wheat import requirement. To the extent that donors are responsive to world prices in their levels of aid (in part due to the donor countries fiscal budget constraints), the Sudan has become less secure in its wheat supplies, given the possibility of future increases in the world price of wheat.

The policy of declining real prices for bread has been implemented through a number of instruments in recent years. These instruments have included subsidies from the national treasury on the order of U.S. 10 million per year, negative effective protection to domestic production arising out of an overvalued official exchange rate, and retail price controls at fixed nominal prices. This policy has been facilitated by the provision of concessionary imports which currently represent over two-thirds of all imports. The incidence of the costs of this policy falls not only on the donor countries and on the national

treasury, but also on domestic producers of wheat and sorghum.

The benefits of the cheap bread policy have accrued primarily to the middle and upper income urban households. Replacing this policy with a policy of import parity pricing at all points in the distribution chain would yield few deleterious income and nutritional effects on the low income urban population. At the present time the middle and upper income strata consume five loaves of bread for every loaf consumed by the lowest income stratum. With the suggested policy change the upper and middle strata would consume one loaf less. Thus, the cheap bread policy is ineffective as either a nutritional or income distribution policy.

The policy change would benefit domestic producers of wheat and sorghum. Domestic production of wheat would be both privately profitable and internationally competitive and would represent an economically efficient use of the available land and water resources in the Gezira Scheme. These results are conditional on the adoption of improved technology, improvements in the structure of incentives, and timely provision of inputs. Domestic sorghum producers would benefit because the demand for wheat is cross-elastic with sorghum. The reduced consumption of wheat would be in part replaced by increased demand for sorghum.

The most important change required is that a policy of import parity pricing would require either a free and open market of wheat and wheat products or continual adjustment to the announced prices for wheat, flour, bread and other wheat pro-

ducts. Given the nature of the agricultural marketing system in the Sudan (Youngblood et al., 1982), it is not clear that a switch to an uncontrolled market would achieve a stable and economically efficient equilibrium in the short run. The alternative would be to announce the new policy and the mechanism for implementation and then pursue the new mechanism vigorously. A suggested mechanism would be to move to import parity pricing at the new exchange rate immediately and then adjust the relevant prices monthly to reflect movements in the world market price and domestic inflation. This would imply that nominal prices would have to change by three to five percent per month. Such a change may be difficult to implement in a commodity for which the basic unit is sold for less than ten piasters. Either price adjustments would be delayed until the small loaf could be adjusted by one piaster or the bakers would be allowed to adjust the size of the loaf within a specified range. The adjustments would have to be made at frequent but randomly chosen intervals to prevent speculative hoarding of wheat flour.

A further benefit of import parity pricing at all points in the market for wheat is that analyses of comparative advantage in the use of domestic resources to produce wheat versus other crops would be free of many of the distortions that have clouded this issue. While our analysis indicates that import parity pricing and improved technology and management could lead to a situation where private and social welfare could be maximized by allocating the maximum possible land area to wheat production in the Gezira, two important caveats must be considered.

First, consideration must be given to the continuing foreign exchange crisis. If the Sudan can expect to continue to receive large quantities of wheat as food aid or on highly concessionary terms, then the opportunity cost of the imported wheat is significantly below the import parity price and the economic comparisons made in this study would change materially. In this case, it would probably be socially optimal to allocate the productive resources of the Gezira Scheme according to the criterion of maximizing foreign exchange earnings, and to subsidize the tenants for their foregone private earnings from producing crops with lower private returns. This course of action would make the Sudan's food security highly dependent on the continued availability of aid and concessionary wheat imports.

The second important caveat relates to the higher yield levels which are thought to be possible with improved technology in the Gezira Scheme. The yield levels used in the simulations are about half of what research results indicate can be obtained in the Scheme. The experience with "green revolution" technology has been that, on average, yields in farmers' fields are about a third of experiment station results (Jennings, 1973). It is reasonable to expect that a well managed and highly mechanized irrigated scheme could out-perform the average. The problem of managing the clay soils of the Gezira may, however, be more difficult and costly than has been assumed. The timely and effective sowing of several hundred thousand feddans of wheat may

require different implements and farming techniques than those currently available there. There is reason for caution in expecting the current equipment and technologies to produce the desired results. Both of these caveats imply the need for an even better understanding of the production processes and costs for the various crops which may be grown on the Gezira Scheme. Until this further detailed research is undertaken, it would be unwise to expect enhancements to incentives and management to produce yields which are double the current level.

It must be emphasized that by maintaining the real price of bread at import parity, the Sudan can reduce domestic consumption and its import requirements, even if no increases in domestic production are achieved. Whether these reductions are significant enough to warrant a change in current bread pricing policies must be determined by policy makers. However, when compared with other policy alternatives, such as production of composite flour or the major investments needed to increase domestic wheat production, import parity pricing appears to be a cost-effective and viable policy.

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APPENDIX A: DEMAND ANALYSIS METHODOLOGY

The design of effective food policies requires an understanding of substitution in consumption among food commodities and between food commodities and nonfoods. The currently applied methods of demand analysis present serious conceptual and operational problems, particularly when applied to household survey data in developing countries.

For the purposes of econometric estimation, the data obtained by dietary surveys, food diaries, weighed food intakes, family food accounts, and household expenditure surveys have the same general form. That is, observations are obtained for a cross section of households, families or individuals on the quantities consumed of each food commodity. Since often only quantities are directly observed, prices are usually imputed from auxiliary surveys of local vendors or from the expenditures in the survey itself.

For instance, the data used in this study were derived from two cross-sectional household budget surveys (1978/79 Household Budget Survey and 1982 Minihousehold Budget Survey). Cross-sectional studies are based on the premise that observing individual household units under different conditions at the same point in time enables one to predict the behavior of those household units if different conditions were to exist at some future point in time. The cross-sectional data relevant to demand analysis include information on household expenditures, on individual food and non-food commodities, household incomes by

source, and demographic characteristics such as household size, age and sex composition of the household, schooling and education of the household members, etc. These two sets of cross-sectional data were primarily used to estimate Engel functions for individual food items or groups of food and non-food items. These analyses provided estimates of income elasticities while controlling for socio-demographic factors.

The next section presents an overview of the available methodologies for estimating demand parameters from cross-sectional data for individual food items disaggregated by expenditure class. The background to the section discusses neoclassical demand theory and the implied restrictions imposed by econometric models. Two estimation methods are then discussed, the Frisch technique and the Linear Expenditure System. Both methods are used to estimate own price elasticities in the analyses of the 1978/79 HBS and the 1982 MHS. This study shows that in spite of the strong restrictions on the structure of consumer preferences, useful estimates of the own price elasticities and income elasticities can be obtained for individual food items for consumers at different income levels from cross-sectional data.

A.1 Background

Neoclassical demand theory assumes that individuals maximize utility subject to a budget constraint:

$$\max_{\underline{q}} U = U(\underline{q}) \tag{1}$$

$$\text{s.t. } \underline{pq} \leq M \tag{2}$$

The maximization of utility (1) with respect to the n x 1 vector of quantities (q) subject to the restriction (2) on income, M, leads to a set of n + 1 reduced form equations which express the quantities as functions of predetermined prices (p) and income, and an additional first order condition in the Lagrangian multiplier, λ, the marginal utility of income. The set of demand equations

$$\underline{q} = \underline{q}\ (\underline{p},\ M) \tag{3}$$

involves n^2 price response parameters and n income parameters. Empirical application of such a system requires estimating a total of $n^2 + n$ parameters. However, general restrictions which apply to these parameters can be derived (e.g. Barten, 1968) and using elasticities, they can be stated as:

Engel Aggregation: $$\sum_i a_i n_i = 1 \tag{4}$$

Homogeneity Constraint: $$\sum_{j=1}^{n} n_{ij} + n_i = 0;\ i = 1, 2, \ldots, n. \tag{5}$$

Symmetry (or Slutsky) Constraint: $$n_{ij} = (a_j/a_i)\ n_{ji} - a_j\ (n_i - n_j) \tag{6}$$

where

a_i = the average budget or expenditure share ($p_i q_i/M$) of the i-th good;

n_i = the expenditure elasticity of demand for the i-th good;

n_{ij} = the elasticity of demand for the i-th good with respect to the price of the j-th good.

The estimated expenditure elasticity is obtained by:

$$n_i = \frac{m_i}{a_i}$$

where m_i is the marginal propensity to consume out of income and

a_i is the average budget share.

The restrictions reduce the number of independent parameters to be estimated from $n^2 + n$ to $1/2(n^2 + n - 2)$ which is still a very large number even for small n. Thus, econometric estimation of demand systems has further reduced the number of parameters by applying assumptions and techniques which have implications for the nature of the underlying utility function.

A.2 Separable Utility Functions and Their Implications

The nature of the assumptions in the various approaches relate to some condition on separability of the utility function. Operational descriptions of these various approaches are presented in George and King (1971) and Phlips (1974). Pollack (1971) reviews separability and Houthakker (1960) reviews additive preferences which underlie the Frisch (1959) technique.

A.2.1 The Frisch Technique

The Frisch technique has widespread application since it is parsimonious in its data requirements, allows the use of parameters obtained from various sources and produces estimates of all own and cross price demand elasticities in a multi-sectoral model with data obtained from cross-sectional household surveys. It is based on the assumption of want independence which implies that U is diagonal; that is, goods are related only through the general substitution effect of the Slutsky equation.

When goods are want independent, Frisch shows that knowledge of the expenditure elasticities, n_i, and budget shares, a_i, together with a parameter, ϕ, is sufficient to generate all the n^2 price elasticities:

$$n_{ii} = - n_i \, [a_i - (1 - a_i n_i)/\phi] \tag{7}$$

$$n_{ij} = - a_j n_i \, [1 + (n_j/\phi)], \; i \neq j \tag{8}$$

The parameter ϕ which appears in (7) and (8) is known as money flexibility and is the elasticity of the marginal utility of income with respect to income or

$$\phi = \frac{\partial(\partial U/\partial M)}{\partial M} \cdot \frac{M}{(\partial U/\partial M)} = \frac{\partial \lambda}{\partial M} \cdot \frac{M}{\lambda} \tag{9}$$

Budget shares and income (or Engel) elasticities are often available or estimable from cross-sectional household survey or aggregate time series data. In such circumstances a knowledge of ϕ is all that is required to synthesize the (n x n) matrix of n_{ij} according to (7) and (8), provided that the utility function is pointwise additive.

The accuracy of the elasticity estimates obtained from the Frisch technique are based on the stability and value of this money flexibility parameter as well as on the want independence assumption. In developing country settings, Scobie (1980) shows that the estimated parameters may be highly sensitive to the choice of the money flexibility parameter.

Several approaches to the estimation of the money flexibility have been adopted. If an estimate of any one own-price elasticity (n_{ii}) is available, equation (7) can be used to solve for ϕ. If several n_{ii} are available, equation (7) can be used to form estimates of ϕ_i, which will differ across commodities. In this analysis, the initial estimate of the own-price elasticity for bread of -0.4 obtained from the time series results in Section 2.1, the bread budget share from Table 11 and

the expenditure elasticity from Table 13 were used to solve equation (7) for ϕ. A value of -2.7 was obtained for the money flexibility parameter.

Thus, the Frisch technique requires a prior estimate of the own-price elasticity (or a cross price elasticity) in order to calculate the value of the money flexibility parameter. One could arbitrarily pick a value for the money flexibility parameter as some authors do. Using this method, the own-price elasticities are calculated as a simple function of the budget shares, expenditure elasticities and the arbitrarily assigned value of the money flexibility. Scobie (1980) has shown that varying the value of ϕ with cross-sectional data results in varied elasticity estimates. In comparison, the Linear Expenditure System also arbitrarily assumes a prior estimate of the own price elasticity; however, it is preferable to the Frisch technique because it also incorporates all of the regression parameter estimates in the solution of the elasticities.

A.2.2 <u>The Linear Expenditure System</u>

Howe (1977) employed the Linear Expenditure System in conjunction with the Stone-Geary utility function. The LES is based on an additive utility function of the following form:

$$U(q) = \sum_k b_k \ln(q_k - g_k) \qquad (10)$$

The b_k's are the marginal budget shares and the g_k's have been interpreted as "subsistence" or "committed" expenditures. The utility function is defined wherever $q_k - g_k$ is positive. The resulting theoretical expenditure equations are given by:

$$P_iQ_i = P_ig_i + b_i[E - (P_Fg_F + P_Ng_N)], \quad (11)$$

where

P_iQ_i = actual household expenditure on the ith commodity

P_ig_i = subsistence expenditure level of the ith commodity

E = total household expenditures

P_Fg_F = subsistence expenditure for food

P_Ng_N = subsistence expenditure for nonfood.

$i = 1, 2..., k$

Given expenditures, E, and prices $P_1,..., P_k$, the consumer first purchases "committed" quantities, g_k, and then allocates its "supernumerary" income, $(E - \sum_k P_k g_k)$ among different commodities in the proportion $b_1, b_2,..., b_k$.

The value of the first subsistence level is a function of the regression parameters of the linear expenditure system and a prior estimate of the own price elasticity. The subsistence levels for the remaining commodities are functions of this one commodity and the estimated regression coefficients. This approach is very similar to one in which a value of the money parameter is arbitrarily selected; however, selecting the subsistence expenditure from the data is more likely to yield a set of estimates appropriate to the population under study, since regression parameter estimates are also used in the calculation of subsistence level expenditures.

The average own price elasticity obtained by the LES and by the nested LES is given by:

$$n_{ii} = -1 + (1 - m_i)\frac{P_ig_i}{P_iQ_i} \quad (12)$$

where $P_i g_i$ is the subsistence expenditure for commodity i (i = 1,...,k), $P_i Q_i$ is the average expenditure for commodity i and m_i is the marginal propensity to consume commodity i out of income.

In order to examine the fine distinction between the LES and the nested LES, the LES was estimated for the 1978 data and a nested LES was estimated for the 1982 data. Tables A.1-A.4 present the LES regression estimates based on the 1978/79 HBS data for the entire sample, the lowest expenditure stratum, the middle stratum, and the upper stratum, respectively. Tables A.5-A.8 present the nested LES regression estimates based on the 1982 MHS data. The estimated model (adjusting for size of the household) is:

$$P_i Q_i = A_i + B_i (E) + C_i (H) \tag{13}$$

where A_i, B_i and C_i are estimated parameters and H is household size. Equating (13) to (11) yields:

$$A_i = P_i g_i - B_i (P_F g_F + P_N g_N) - C_i (H), \tag{14}$$

$$(P_F g_F + P_N g_N) = \frac{A_i - P_i g_i + C_i (H)}{-B_i} \tag{15}$$

and

$$P_i g_i = A_i + B_i (P_F g_F + P_N g_N) + C_i (H) \tag{16}$$

An initial value for $P_i g_i$ is obtained by assuming a prior estimate of the own price elasticity for bread (from time series results) and solving equation (12) for $P_i g_i$; for 1982, $P_i g_i$ = 12.71. Once this initial value of $P_i g_i$ is obtained, the remaining $P_i g_i$ are obtained recursively. This value of $P_i g_i$ is employed in equation (15) (setting household size to the sample mean) to obtain an estimate of the sum $(P_F g_F + P_N g_N)$ which is

Table A.1: LES Estimates for Entire Sample, 1978/79 HBS[a]

	Intercept	Total Expenditures	HH Size	F	R^2
Bread	2.039	.0225	.426	249	.43
Other Cereals	1.017	.0138	.395	123	.27
Meats	3.465	.1003	.377	523	.27
Fruits, Veg.	6.677	.0655	.330	325	.50
Other Food	4.126	.1560	.435	476	.59
Nonfood	-17.324	.6410	-1.962	1982	.82

[a]All coefficients are statistically significant at the .01 level of significance. Sample size = 1606.

Table A.2: LES Estimates for Lowest 25% Expenditure Stratum, 1978/79 HBS[a]

	Intercept	Total Expenditures	HH Size	F	R^2
Bread	1.940[b]	.0397	.536	132.2	.45
Other Cereals	0.809	.0314	.353[b]	63.2	.28
Meats	2.323[b]	.1888	.195[b]	260.2	.61
Fruits, Veg.	5.674	.1284	.139[b]	200.2	.55
Other Food	0.175[b]	.1956	.270[b]	324.0	.66
Nonfood	-10.923	.4158	-1.494[b]	622.9	.79

[a]All coefficients are statistically significant at the .01 level of significance except those noted. Sample size = 403.

[b]Not significant at the .05 level.

Table A.3: LES Estimates for Middle 50% Expenditure Stratum, 1978/79 HBS[a]

	Intercept	Total Expenditures	HH Size	F	R^2
Bread	2.201	.0242	0.461	45.2	.41
Other Cereals	0.921	.0182	0.412	72.0	.26
Meats	1.891	.1205	0.186[b]	202.5	.32
Fruits, Veg.	4.643	.0943	0.142[b]	198.8	.49
Other Food	0.281[b]	.1986	0.310[b]	336.0	.58
Nonfood	-11.813	.5400	-1.521	589.5	.81

[a]All coefficients are statistically significant at the .01 level of significance except those noted. Sample size = 808.

[b]Not significant at the .05 level.

Table A.4: LES Estimates for Upper 25% Expenditure Stratum, 1978/79 HBS[a]

	Intercept	Total Expenditures	HH Size	F	R^2
Bread	2.772	.0139	0.789	67.8	.47
Other Cereals	0.913[b]	.0058	0.913	40.5	.34
Meats	5.956	.0715	1.692	86.5	.53
Fruits, Veg.	9.383	.0464	0.919	44.4	.36
Other Food	10.269	.1088	2.119	61.0	.44
Nonfood	-29.293	.7534	-6.399	406.3	.84

[a]All coefficients are statistically significant at the .01 level of significance except those noted. Sample size = 383.

[b]Not significant at the .05 level.

Table A.5: Nested LES Estimates for Entire Sample, 1982 MHS[a]

	Intercept	Total Exp.	HH Size	F	R^2
Food	12.516	.506	2.959	983.0	.76
Nonfood	-12.516	.493	-2.959	816.9	.73
	Intercept	**Food Exp.**	**HH Size**	**F**	**R^2**
Bread	-3.130	.109	.614	216.8	.45
Other Cereals	3.054	.041	.605	44.0	.14
Meats	-2.828[b]	.259	-.457	635.6	.70
Fruits, Veg.	2.478[b]	.254	-.582	628.8	.70
Other Food	0.476[b]	.337	-.180[b]	779.9	.75

[a]All coefficients are statistically significant at the .01 level of significance except those noted. Sample size = 612.

[b]Not significant at the .05 level.

Table A.6: Nested LES Estimates for Lowest 25% Expenditure Stratum, 1982 MHS[a]

	Intercept	Total Exp.	HH Size	F	R^2
Food	8.854[b]	.647	-.027[b]	275.0	.78
Nonfood	-8.854[b]	.352	.027[b]	82.4	.52
	Intercept	**Food Exp.**	**HH Size**	**F**	**R^2**
Bread	-4.628[b]	.175	-.020[b]	50.8	.43
Other Cereals	-1.737[b]	.096	.392[b]	22.8	.25
Meats	1.635[b]	.213	-.210[b]	63.1	.48
Fruits, Veg.	2.836[b]	.195	.027[b]	55.6	.45
Other Food	1.894[b]	.321	-.188[b]	115.2	.63

[a]All coefficients are statistically significant at the .01 level of significance except those noted. Sample size = 153.

[b]Not significant at the .05 level.

Table A.7: Nested LES Estimates of Middle 50% Expenditure Stratum, 1982 MHS[a]

	Intercept	Total Exp.	HH Size	F	R^2
Food	14.866	.554	1.726[b]	614.7	.80
Nonfood	-14.866	.446	-1.726[b]	287.7	.65
	Intercept	**Food Exp.**	**HH Size**	**F**	**R^2**
Bread	-3.098[b]	.133	.145[b]	122.3	.48
Other Cereals	6.040	.054	.021[b]	15.1	.10
Meats	-2.823[b]	.271	-.886	257.3	.66
Fruits, Veg.	2.681[b]	.215	.281[b]	185.8	.58
Other Food	-2.800[b]	.326	.439[b]	383.1	.74

[a]All coefficients significant at the .01 level of significance except those noted. Sample size = 306.

[b]Not significant at the .05 level.

Table A.8: Nested LES Estimates for Upper 25% Expenditure Stratum, 1982 MHS[a]

	Intercept	Total Exp.	HH Size	F	R^2
Food	4.553	.383	1.299	157.9	.68
Nonfood	-4.553	.617	-1.299	147.4	.67
	Intercept	**Food Exp.**	**HH Size**	**F**	**R^2**
Bread	-2.154[b]	.126	-0.509[b]	44.3	.43
Other Cereals	1.709[b]	.051	0.141[b]	14.0	.19
Meats	-5.730	.255	0.392	173.8	.70
Fruits, Veg.	1.544	.288	-1.675	186.0	.76
Other Food	4.622[b]	.279	1.652	121.0	.68

[a]All coefficients are statistically significant at the .01 level of significance except those noted. Sample size = 153.

[b]Not significant at the .05 level.

then used to obtain each $P_i g_i$ in equation (16) for the remaining commodities, except nonfood. The subsistence level for nonfood, $P_N g_N$ is defined by subtracting subsistence food expenditures from subsistence total expenditures $(P_N g_N + P_F g_F)$.

A.2.3 The Nested LES

Stone (1970) has shown that the linear expenditure system can be nested, and a two-step procedure can be followed. This procedure postulates that in the first stage the household allocates its total expenditure among S groups of commodities. In the second stage, the household allocates the group expenditure among the commodities in that group. In this analysis, two groups of expenditures exist: food and nonfood. Consequently, the first stage expenditure equations are:

$$P_F Q_F = P_F g_F + b_T [E - (P_F g_F + P_N g_N)] \quad (17)$$

The second stage demand equations have the following form:

$$P_i Q_i = P_i g_i + b_F (P_F Q_F - P_F g_F); \quad (18)$$

where

$P_F Q_F$ = total household expenditure on food

$P_i Q_i$ = household expenditure for the ith commodity

$P_i g_i$ = subsistence level household expenditure for the ith commodity

E = total household expenditure

$P_N g_N$ = subsistence level household expenditure on nonfood

$P_F g_F$ = subsistence level household expenditure on food

The estimated equations for the first and second stages adjusted for household size are, respectively:

$$P_F Q_F = A_T + B_T(E) + C_T(H) \quad (19)$$

and

$$P_iQ_i = A_{iF} + B_{iF}(P_FQ_F) + C_{iF}(H) \tag{20}$$

Setting equation (20) equal to equation (18) yields:

$$A_{iF} = P_ig_i - B_{iF}(P_Fg_F) - C_{iF}(H) \tag{21}$$

and

$$P_Fg_F = \frac{A_{iF} - P_ig_i + C_{iF}(H)}{-B_{iF}} \tag{22}$$

and

$$P_ig_i = A_{iF} + B_{iF}(P_Fg_F) + C_{iF}(H). \tag{23}$$

As in the Linear Expenditure System, an initial value of P_1g_1 is obtained by assuming a prior estimate of n_{ii} and solving equation (12). This estimate of P_1g_1 is then used to solve for P_Fg_F in equation (22) and this P_Fg_F is used in equation (23) for each commodity, except nonfood. In order to obtain the estimate of subsistence expenditure on nonfood, P_Ng_N, equation (19) is equated to the theoretical equation (17) to yield:

$$P_Ng_N = \frac{A_T - (1 - B_T)\ P_Fg_F + C_T\ (H)}{-B_T}$$

Thus, both the LES and the nested LES employ the regression parameters obtained from the entire sample of data (Tables A.1 and A.5) and the initial estimate of the own price elasticity to obtain subsistence levels for each commodity (P_ig_i). These subsistence levels based on the data for each year sampled, together with the marginal propensities to consume, m_i, (Table 12) and the average household expenditures, P_iQ_i, (Table 9) yield the own price elasticities for the three expenditure strata. The elasticities for the entire sample are a weighted average of the three expenditure stratum elasticities.

The own price elasticities presented in Tables 14 and 15 show the results obtained from both the Linear Expenditure System method and the Frisch technique. Both results are presented in order to show the discrepancy in estimates that results from the arbitrariness of the prior estimate of n_{ii} or ϕ.

Overall, the results appear intuitively plausible and consistent with the underlying theory. The nested LES performed significantly better, probably since the expenditure variable was used only in the first stage of the estimation, and thus its impact on the estimated parameters was significantly reduced. The best estimates in the sense of theoretical and empirical consistency were obtained with the LES system and the nested LES system rather than the Frisch technique.

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APPENDIX B: URBAN AND RURAL POPULATION ESTIMATES

Table B.1: Urban and Rural Population Estimates (millions)

	Total[a]	Urban[b]	Rural[c]
1969/70	14.1	2.31	11.79
1970/71	14.5	2.47	12.03
1971/72	14.8	2.64	12.16
1972/73	15.2	2.82	12.38
1973/74	15.6	3.01	12.59
1974/75	16.0	3.21	12.79
1975/76	16.4	3.43	12.97
1976/77	16.9	3.66	13.24
1977/78	17.3	3.91	13.39
1978/79	17.8	4.18	13.62
1979/80	18.2	4.46	13.74
1980/81	18.7	4.77	13.93
1981/82	19.2	5.09	14.11
Annual Growth (%)	2.60	6.80	1.50

[a]Population for 1969/70 and growth rate of 2.6 percent taken from The World Bank, Sudan: Investing for Economic Stabilization and Structural Change, Washington, D.C., February 1982.

[b]1969/70 estimate of percentage of urban population to total population (16.4 percent) from Sudan: Investing for Economic Stabilization and Structural Change. Growth rate of 6.80 percent from World Bank, Accelerated Development in Sub-Saharan Africa: An Agenda for Action, Washington, D.C., 1981.

[c]Calculated as the difference between total population and urban population.