ANALYSIS OF THE DEMAND AND SUPPLY FUNCTION OF WHEAT IN SAUDI ARABIA

PROJECTION OF SUPPLY AND CONSUMPTION THROUGH 1985

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In the name of Allah, the Beneficent, the Merciful

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CHAPTER I

INTRODUCTION

Statement of the Problem

With the recent rapid increase in urbanization, wealth, and foreign technicians and labor in Saudi Arabia, wheat is becoming an important diet staple. A sufficient wheat supply and stabilization of its price are vital to the society. Yet because of industrial development and economic growth, the total area used for wheat production in Saudi Arabia dropped from 125,000 hectares in 1972 to 45,000 hectares in 1973. Consequently the Kingdom has become increasingly dependent on imported wheat.

Meeting the rapidly growing demand for wheat is a serious challenge to policy makers in Saudi Arabia for the following reasons:

1. Dependence on unreliable sources of imported wheat
2. Limited amounts of cultivable land (2% of the total area)
3. A 3% annual rate of population growth

Objectives of this Study

The objectives of this study are to:

1. Select appropriate variables to establish an estimated supply equation
2. Select appropriate variables to establish an estimated demand equation
3. Apply these two estimated equations to make demand and supply projections

Location and Climate

The Kingdom of Saudi Arabia is located on the Arabian Peninsula between the Red Sea and the Arabian Gulf. It occupies about four-fifths of the peninsula with a total area of approximately 870,000 square miles--about the size of the United States east of the Mississippi River. It is bordered on the north by Jordan, Iraq, and Kuwait; on the northeast by the Arabian Gulf; on the east and southeast by Qatar, the United Arab Emirates, and Oman; on the south by Yemen; and on the west by the Red Sea.

Nearly all the land of Saudi Arabia is desert; less than one percent of the total area is suitable for settled agriculture. It has a hot climate with an average annual temperature of 35°C in summer and 25°C in winter, yet temperatures vary widely from region to region. In the central part of the country temperatures range from below zero at night to a maximum of 50°C during the summer; in the northern part of the country temperatures are very high in summer and peak in July; and the southeast regions are hottest in June and coldest in January. Rainfall also varies, with an annual average of 30mm to 50mm in the northwest, 40mm to 90mm in the northeast, and 110mm to 85 mm in the Riyadh Region. Rainfall conditions in the Hijaz Mountains and Asir Regions in the west and southwest differ completely, by exceeding 300mm in the mountains and averaging 250mm along the Red Sea coast south of Jeddah.

Agricultural Situation in Saudi Arabia

Land

The total area of Saudi Arabia amounts to approximately 219.8 million hectares. Of this land, 39% is used as ranges for animals and livestock. Only 4.7 million hectares, or about 2.1% of all the land, are suitable for agriculture. Land under actual cultivation is only

0.53 million hectares, or 0.24% of the total land in the country and 11% of the agriculturally suitable land. Of the total cultivated land, 75% or 0.4 million hectares are rainfed and the rest are irrigated. Even with this low quantity of cultivated land, lack of rain, capital, or manpower may decrease it even further.

LAND CLASSIFICATION

Class	Area in Thousand Hectares	Percentage
Agricultural total land	4,705	2.14
Cultivated land	534	0.24
Uncultivated land	4,171	1.90
Range	85,000	38.68
Forests	1,680	0.77
Non-agricultural land	123,684	56.27

Population

Because of the scattered population in the country, it has been difficult to establish the correct number of people. According to a survey conducted by the Central Department of Statistics of the Ministry of Finance, in 1974 the total number of residents was 7,658,413. The Commission determined that the growth rate was 3.0%. The total urban population was estimated at 2,748,356, or 39%, and 61% of the people lived in rural areas.

Not all of the rural population engages in agricultural production. The 230,000 people who live in deserts and take care of livestock comprise 27% of the total population, and another 16% of the rural people are not actively involved in farming. Hence, only 18% can be called agriculturalists.

Manpower in Agriculture

The total number of agricultural workers amounts to 650,671, which includes 216,012 or 33% female workers. These are the people who carry out agricultural production, including agriculture planning and management, irrigation, and agricultural construction. Of these, 68% work year round, 29% work seasonally, and 3% are involved in agriculture for only three to six months of the year.

Agricultural Input into GNP

Agricultural revenue has been increasing gradually over the last several years. The revenues generated by agriculture in 1967 were 846.3 million Saudi riyals. By 1975 this increased to 1,409 million Saudi riyals and amounted to a net 166.5% increase in agricultural revenues, or an annual increase of about 5.8%. Despite the increase in total revenues, the input into GNP has decreased from 6.4% in 1967 to 1.0% in 1975--the decline being attributed to massive oil production revenues. In those same years, oil revenues increased by 1132%, from 13.1 billion to 148.8 billion riyals. Oil production and oil-related industry were the major contributors to the growth of GNP. Their share jumped from 54.5% in 1970, to 70,3% in 1973, to 86.8% in 1975. The agricultural contribution mentioned earlier, 1,409 million riyals in 1975, would be an 8.6% share of growth of GNP if the oil contribution is excluded.

Wheat Production

General View

Wheat is one of the most important cereal crops in Saudi Arabia. Since local varieties averaged out to yield only 1.5 ton/hectare,

a research program was started in 1965 to increase production. The availability of advanced technology and new high yielding varieties of wheat helped the Ministry of Agriculture and Water to initiate, in 1971-72, a four year improvement plan whereby direct and indirect subsidies were offered in the central part of the country and then expanded into all important regions of wheat cultivation. During this study, the average total area used for wheat production was 88,400 hectares, the average yield per hectare was 154 kg, and the average total production per year was 134,600 metric tons. The average quantity demanded per capita during this period was 54.2 kg.

Wheat Development Program

In the first phase, over 1,000 different varieties of wheat under irrigation at the wheat breeding station at Dirab (35 km from Riyadh) were examined every season. Concurrently, under rain fed conditions at Abha, about 300 wheat varieties were under observation.

The most promising varieties grown under local farming conditions were then selected from five or six locations and introduced in such a way that all farmers could adopt them. Some farmers were given fertilizers and seeds free of charge and advised to follow the guidelines under the guidance of extension agents. These farmers in turn educated other farmers of the area. Only farmers who satisfied the following criteria were chosen:

1. Farmers must have grown wheat in the past years so they could recognize the benefits of new seeds, methods, and procedures

2. Farmers had to have high reputations in their communities and among other farmers so that others would be drawn to learn from them

3. Their land could not be less than 40 hectares nor exceed 60

4. Their water supply for irrigation had to be available at the needed time

5. Their soil had to be appropriate for agricultural use

6. Farm owners were required to cooperate with extension agents and follow their instructions fully in all procedures. They had to be aware of the objectives of the program and be willing to accept and cooperate with other farmers who visited their farms

7. Farmers had to be aware of the necessity to protect the seeds for future use

8. Their farms had to be accessible to the agricultural machinery

From these trials, the one wheat variety introduced in 1971-71 that most farmers adopted was Mexi Pak.

Introduction of Mexi Pak

Mexi Pak is a new, short-stemmed wheat developed by Mexico and Pakistan. Its high yield, high resistance to disease, and high response to fertilizers and water control made it popular among farmers. In spite of the fact that it required more fertilizers, more labor, and thus demanded practices contrary to the traditional farming methods, farmers adopted the new variety primarily because it produced such high yields.

Taxation and Subsidy

Zakat is the form of taxation in Saudi Arabia, and is prescribed upon Muslims by virtue of their Islamic religion.

Definition and Explanation of Zakat

An obligatory duty to be paid by Muslims according to their wealth, Zakat is one of the five basic pillars of Islam. The Qur'an (2:43)

mentions that one must definitely pay the poor their due. The prophet of Islam, Mohammed (peace be upon him), said to one of his companions who was being sent to Yemen as one of his representatives that he should "tell the people there that God has prescribed Zakat upon them. It should be paid by their wealthy people to their poor people."

The Zakat required is 2.5% of a man's money. It need not be paid until a man has possessed that money for one year. A man must pay, for example, one sheep for every 40-120 owned. If there are less than 40 sheep, there is no obligatory Zakat. A farmer must pay 1/10th of his total crop if it was irrigated by water from rivers, springs, or rain. If irrigation involved some kind of labor and capital cost, the Zakat would be 1/20th. A farmer pays no Zakat if he produced less than 1,600 Iraqi pounds.

Poor people do not have to pay Zakat, for Zakat is given to them. It can be paid to one's relative, but this relative should not be the one who can inherit the giver's property. So according to Islamic principles, a relative who inherits property must be taken care of with non-Zakat money if he is poor.

It is an order by God as prescribed in the Qur'an (6:141) that the Zakat of cereal crops must be paid off on the day of harvest. Near harvest time, the government will send appraisers out to estimate the amount which farmers will pay.

Subsidy

After the increase in oil revenues in 1973, people were more interested in businesses other than agriculture. This whole phenomenon, which had a great effect on agriculture overall, will be discussed in

more detail in the section dealing with variables affecting wheat supply.

The government wanted to pay a subsidy to encourage the farmers to continue and expand agriculture. They decided to pay 1/4 Riyal on every kilogram of wheat produced, and similarly, they also helped the farmers in paying part of their input. This subsidy on crops produced was calculated by estimating each farmer's Zakat.

Methodology and Data Collection

Methodology

The method used to obtain knowledge about supply and demand relationships of wheat requires knowledge of both economic theory and statistical tools.

In this study, we will take a brief look at the wheat industry in Saudi Arabia. Then, using the ordinary least squares method to estimate the supply and demand functions of wheat for Saudi Arabia, we will evaluate these equations according to the statistical properties and economic theories.

Data Collection

Data are generated in time series from 1963 to 1977. Total consumption in year t is derived by summing up the domestic production in year t and imported wheat and flour in wheat equivalent in year t. This proxy is not quite accurate because wheat stocks are not taken into account, but here we will assume that stocks are relatively stable over time.

All prices of wheat, barley, and corn are deflated by general cost of living indexes. Wheat production is in thousands of tons and per capita consumption is in kilograms.

CHAPTER II

THE FACTORS OF SUPPLY AND THE ESTABLISHMENT OF THE SUPPLY EQUATION OF WHEAT

In this chapter we will discuss the factors that affect the quantity of wheat supplied, namely, price of wheat, price of barley, a substitute commodity, rainfall, the effect of increased oil revenues since 1973, and improved technology.

Two methods will be used to estimate the supply equation for wheat. Then the two methods will be evaluated on the basis of statistical properties of the estimated coefficient, the expectation from the economic theory, and the knowledge of wheat production in Saudi Arabia.

Selection of Variables

Price of Wheat

From economic theory we know that in a competitive market economy farmers use prices as one factor to determine what and how much to produce. Because of the nature of agricultural production there is a lagged response to last year's price. The higher the price, the greater the supply of the commodity. Normally in a supply equation, farmer price is used, but due to lack of data on farmer price in this study, the wholesale price of wheat is used to determine supply. This is done because of the constant difference between imported price and farmer price, the latter of which is higher.

Price of Barley (A Substitute for Wheat in Production)

Since farmers have limited resources of labor, land, and capital, and we assume they have profit maximization as their goal, they allocate these resources in the best way to achieve that goal. Because relative prices have a significant effect on profits, we must consider not only the price of the commodity under study but also the price of close substitutes. In this study, barley competes with wheat all over Saudi Arabia, and farmers choose to grow one or the other or both, depending on their perception of profitability. For the same reasons mentioned under wheat prices, we are here again substituting imported wholesale barley prices for the farmer's price of this commodity.

Rainfall

In Saudi Arabia some wheat is grown under rainfall conditions and even irrigated wheat is affected by the amount of rainfall. A shortage of rain in any year affects the upland wheat production directly. It also affects indirectly the production of irrigated wheat since, in the long run, the water table is lowered. This raises production costs and, in turn, will reduce supply.

On the other hand, excessive rainfall also has a negative effect on supply by destroying wheat crops. This occurs more often in the south where farmers irrigate wheat by utilizing a system of walls to block the water that runs off the mountains. The excess rainfall washes down the wheat and washes out the soil on which it grows.

The Effect of Oil Revenue Increases Since 1973

A dummy variable is used to measure the effect of differential rates of economic activity during the study period. More specifically,

the value zero was given to the period 1964-1972 and the value one to the period 1973-77. The division is necessary because from 1973 through the end of the study period there was a dramatic increase in oil revenue for the country. This in turn led to the opening of many opportunities outside agriculture, especially with foreign companies operating in the country, and in government, business, and industry. In some cases land use shifted from agricultural to urban and industrial uses--especially with the increase in the opportunity cost of holding land for farming purposes because of the boom in alternative economic activities. The influx of foreign personnel into the country put great pressure on cities to use agricultural land surrounding the cities for residential housing. These differences form the rationale for using a dummy variable. We expect the dummy variable to have a negative effect on supply of wheat.

Technology

To investigate the effect of technology, a dummy variable is used from 1972 to the end of the study. This is to reflect the introduction of Mexi Pak, which increased the yields from $1\frac{1}{2}$ to 1 tons per hectare of the local varieties to 4 to 5 tons. Introduction of Mexi Pak demanded complementary inputs such as increased levels of certain fertilizers (because Mexi Pak responds greatly to fertilizer application) as well as improved water control and pest and disease management. These factors are likely to affect overall wheat supply and thus require a dummy variable to take them into account.

Supply of Wheat

Using the variables affecting the supply of wheat discussed in the previous section, a number of formulations including different

functional forms and/or different variables were used to estimate the supply of wheat function.

Generally, the formulation revolved around two methods.

Method I. To estimate the supply of wheat two equations were used. One was for the acreage under wheat and the other was for the yield per hectare.

Total wheat supply is the product of these two functions. Formally the model was of the form:

1. $Q^{A}w = f\ (Pw_{t-1}, Pb_{t-1}, D_1, RFT_1, Aw_{t-1})$
2. $Q^{Y}w = f\ (D, T, RFT)$

where

$Q^{A}w$ = the acreage under wheat in thousands of hectares

Pw_{t-1} = deflated last year's wholesale price of wheat (R/Ton)

Pb_{t-1} = deflated last year's wholesale price of barley (R/Ton)

Aw_{t-1} = the acreage under wheat in thousands of hectares for t-1

C = Constant

D_1 = Dummy variable representing the effect of increase in oil revenue since 1973

RFT_1 = Rainfall in Fall season (mm)

$Q^{Y}w$ = yield kg per he

D = Dummy variable representing technology

T = time trend

RFT = Rainfall in Winter season (mm)

3. $Q^{S}w = Q^{A}w \times Q^{Y}w$

where this identify equation represents the total supply of wheat as a product of the above discussed two equations.

The author had a preference for this type of model because it showed the effects of the variables in the supply of wheat as they affect the acreage or yield separately. But for the different formulations used in this model the results were statistically not significant and questionable from an economic standpoint. Table 1 shows examples of some of these formulations.

TABLE 1

	Acreage Equation Q^A_w						Yield Equation Q^Y_w			
	Pwt-1	Pbt-1	RFT_1	D_1	AwT-1	C	T	RFT_2	D	C
Model I Coeff	-.047	-.058	.057	-47.2	-.10	142.39	-51.04	.995	698.36	1512.5
SE	.071	.085	.04	8.799	.255		23.97	.612	193.5	
t-value	.66	.683	1.412	5.379	.395		2.13	1.62	3.61	
R^2	.88						.65			
F	10.63						6.28			
D.W.	2.04						2.8			
Model II Coeff	-.033	-.076		-49.21	-.015	142.13		.602	359.85	1316.6
SE	.074	.089		9.188	.262			.671	126.75	
t-value	.44	.86		5.356	.055			.898	2.84	
R^2	.85						.497			
F	11.38						5.425			
D.W.	1.84						2.46			
Model III Coeff	.069	-.106	.091		.600	22.0	-39.31		663.84	1604.13
SE	.142	.178	.084		.464		24.51		206.17	
t-value	.487	.593	1.088		1.292		1.60		3.22	
R^2	.40						.56			
F	1.35						7.06			
D.W.	1.395						2.96			

$RFT_1 \longrightarrow$ Sept., Oct., Nov., & Dec.

$RFT_2 \longrightarrow$ Dec., Jan., Feb. & March

Method II. With this method one equation is used to estimate the supply of wheat. Generally, the equation used was of the form:

$Q^S_{wt} = f$ (Pwt-1, Pbt-1, RFT, T, D)

where

Q^S_{wt} = total supply of wheat in time t (thousand ton)

Some of the models used under this method gave satisfactory results. A number of these formulations are shown in Table 2.

TABLE 2

Quantity Supplied Equation Q^S_w

	Model	Pwt-1	Pbt-1	RFT	D	T	C
1	Coeff	.107	-.191	.011	-38.134		149.887
	SE	.057	.068	.025	7.963		
	t-value	1.887	2.809	.447	4.789		
	R^2	.74					
	F	6.409					
	D.W.	2.539					
2	Coeff	.125	-.166	.004	-45.671	1.397	132.4
	SE	.060	.092	.046	14.10	2.084	
	t-value	2.09	1.80	.09	3.24	.670	
	R^2	.75					
	F	4.85					
	D.W.	2.4					
3	Coeff	.121	-.201	.014	-38.03		149.38
	SE	.057	.072	.041	8.03		
	t-value	2.11	2.77	.351	4.73		
	R^2	.74					
	F	6.33					
	D.W.	2.44					

Rainfall in Model I total annual mm
Rainfall in Models II & III total for Dec., Jan., & Feb.

From Table 2 a representative model for the supply of wheat was chosen. The selection criteria involved two broad categories:

1. The statistical properties of the different models were considered. Normally the overall (R^2), the SE of the regression, the statistical significance (t-value) of the different coefficients, D.w., and F-value for the regression are possible criteria.

2. From our knowledge of the general economic theory and our particular knowledge of wheat production in the regions of Saudi Arabia, we incorporated these to choose among the statistically acceptable models.

Considering the above in selecting a representative model for the supply of wheat, Model III seems to be the more appropriate.

Detailed discussion follows for the model selected.

Model III: The General Form

QwT = f (Pwt-1, Pbt-1, RF, D)

where

QwT = Total production of wheat (thousands of tons) at time t

Pwt-1 = last year's deflated wholesale price of imported wheat (R/Ton)

Pbt-1 = last year's deflated wholesale price of barley (R/Ton)

RFT = Total amount of rainfall for December, January, and February in mm

D = The effect of an increase of oil revenue since 1973

Using data from Saudi Arabia, the equation was estimated by the TSP.* Results were as follows:

Qwt = 149.3 + .121	Pwt-1 - .201	Pbt-1 + .014	RFT - 38D	
SE	(.057)	(.072)	(.041)	(8.03)
t	(2.11)	(-2.77)	(.35)	(4.0)

R^2 = .738

D.W. = 2.4

F = 6.3

*TSP stands for the statistical program for time series processing.

Statistical Properties of the Model

The estimated results indicate that 74% (R^2 = .738) of the variation in the quantity of wheat supplied is associated with the variables included (i.e., price of wheat and barley both lagged one year, RFT, dummy variable for the effect of increase in oil revenue since 1973).

The coefficient for the lagged price of wheat has the value of +.121 with a relatively small SE and is statistically significant at approximately 7% level (t-value = 2.11). This coefficient tells us that a one unit (Saudi Riyal) increase in the last year's price would be associated with a .121 thousand ton increase in the quantity of wheat this year.

The coefficient for the lagged price of barley has a value of -.201 and is statistically significant also at approximately 3% level. (t-value = 2.71) This indicates that an increase of one unit (Saudi Riyal) in the last year's price of the competitive crop of barley would be associated with a reduction of the wheat quantity supplied this year by .201 thousand tons.

The rainfall coefficient has a positive value of .014, indicating that the increase in rainfall by one unit (mm) would be associated with an increase in the wheat supply of .014 thousand tons. But the coefficient has a relatively high SE and is therefore not statistically significant (t-value = .35).

The last variable, the dummy variable, has a negative value of -38 and is statistically significant at 1% level (t-value = 4), which indicates that since 1973 production of wheat has declined by 38 thousand tons/year.

The D.W. statistic (D.W. = 2.4) is not far from the value 2, which indicates there is no serious autocorrelation among the residuals.

As mentioned earlier, 74% of the variation in the quantity of wheat supplied is associated with the variables included.

The F test of this regression (F-value = 6.4) is statistically significant at 2% level, indicating that such association of the variation in wheat supply and the variables could occur by chance in only 2 out of 100 cases.

The overall statistical properties of this model seem reasonable. The statistical non-significance of the rainfall coefficient may be due to poor quality of data used--a fact that should be taken into consideration when using the results of this model for policy recommendations.

Economic Interpretation

As mentioned before, the combined knowledge of economic theory and the particular knowledge of the production nature and regions in Saudi Arabia were the factors that led to the choice of this model. As can be seen from the results, the main price effect in this supply equation was positive, and the price of the competitive crop of barley has a negative effect.

The data used for estimating the effect of rainfall showed observations below the critical limit. (Rainfall above this limit can detrimentally affect the yield of wheat.) Yet these data may not be reliable in representing the region, and might result in the statistical non-significance of the rainfall coefficient. But because rainfall must be considered an important factor in production, the variable has been retained in the equation despite its statistical non-significance.

The coefficient of the dummy variable is important here. Earlier in the discussion of variables affecting the quantity of wheat production, we postulated that changes associated with the increased oil revenue

since 1973 have affected the use of both manpower and land use. We hypothesized that the resulting increase in revenue has diverted labor from agricultural production towards the higher paying oil and oil-related industries. Similarly, land around cities and urban centers has been diverted from agriculture to residential and industrial uses.

These known changes are consistent with the negative coefficient (-38.0) of the dummy variable in this regression.

Because data was unavailable at the time, a separate variable for the cost of production (such as labor and fertilizer use) was not included in this model. Such variables could probably improve the results. Note that the dummy variable most likely captures an important part of production costs since these costs would be affected by land use around urban centers and by manpower. Inclusion of more appropriate or more accurate production costs in the future might improve the model used to estimate wheat production in Saudi Arabia. Still, use of the model in extrapolation and policy recommendations would be subject to the quality of data used.

Discussion

After checking the coefficients of these independent variables, we have shown that total production of wheat is positively affected by the changes in the price of wheat. It is negatively affected by the change in the price of barley--which indicates that farmers are responsive to price change if the government of Saudi Arabia initiates policies that will increase wheat prices for wheat producers. This would result in increased production.

The increase in oil revenues as a proxy to the increase in income, coupled with the increase in urbanization and foreign labor, indicates

that wheat imports should be increased to compensate for the decrease in local wheat production and to meet the new demand created by the sharp increase in oil revenue.

The above discussion indicates that the subsidization policy seems to have minimized the possible decrease in wheat production after the 1973 sharp increase in oil revenue. This study shows that the introduction of Mexi Pak significantly increased the yield. (See Model I on the yield equation in Table 1.) But due to the lack of enough data we cannot give more details or investigate further the effect of this variable.

CHAPTER III

THE FACTORS OF DEMAND AND THE ESTIMATION OF THE DEMAND EQUATION FOR WHEAT

This chapter discusses analytical procedures of the demand equation. The first part describes the variables that affect quantity demanded per capita (i.e., price of wheat, price of a substitute commodity, income per capita, and time trend). The second part evaluates the model selected as representative of the demand equation. Selection of the appropriate model was based on statistical and economic criteria.

Selection of Variables

Price of Wheat

Economic theory suggests that there is an inverse relationship between the price of a commodity and the quantity of the commodity demanded. This is true except for a few types of goods called inferior goods. Based on Saudi Arabian experience, wheat is a normal good. A normal good in this sense refers to any commodity for which demand increases with an increase in income.

The retail price of wheat, which directly affects consumer demand, should be the appropriate price to use in constructing a demand equation model. Given our knowledge of retail price variation among cities in Saudi Arabia, however, to take the retail price for any one city would be inappropriate and would lead to a large bias. We have observed that the retail price in each city varies directly with the wholesale import

price of wheat and thus the latter may be a better indicator of the average price of wheat. We have therefore developed models using the two prices, both deflated by a general cost of living index.

Lagged Price of Wheat. Consumer demand is affected not only by current prices of wheat but also by price lagged one year. With this in mind, we have included lagged price as a variable.

Price of Corn as a Substitute in Consumption

Two commodities are said to be substitutes if an increase in the price of one leads to an increase in the demand for the other. In Saudi Arabia, bread is made either from wheat or corn. If the price of wheat increases, people tend to make bread more from corn and vice versa. Hence, we have included the price of corn as the main substitute good in our model. Corn price, like the price of wheat, is also deflated.

G.N.P. Income Per Capita

Income per capita is probably not the ideal measure of individual income that determines demand for goods, particularly in the case of Saudi Arabia, where the dichotomy between the public sector and the private sector is so great (Al-Bashir, p. 55). But since we are constrained by lack of an alternative measure of income, we will use income per capita as the income measure in our models. The unsatisfactory use of income per capita might be the reason why some of the coefficients of income turned out to be negative. Note also that the income per capita is deflated by the same cost of living index.

Time Trend

Time trend is included as a variable to allow for changes of taste over time. Tastes could change either towards increases in wheat

consumption or decreases. The results indicated a tendency toward reduction in the demand for wheat over time. In the author's opinion, this may be due to the tendency to shift towards consumption of meats, vegetables, fruits and other food items.

The Demand for Wheat

From the variables affecting the demand for wheat discussed above, one general model was specified. Different combinations of variables were tried with the model, which is:

$Q^d_{wt} = f(Pwt, Pwt\text{-}1, Pc_t, YP_t, Q^D_w t\text{-}1, T)$

where

Q^d_{wt} = quantity demanded per capita of wheat in time t

Pwt = deflated wholesale price of wheat (R/ton)

Pwt-1 = deflated lagged wholesale price of wheat (R/ton)

Pct = deflated wholesale price of corn at time t (R/ton)

YPt = per capita income of time t (thousands Riyal/capita)

^{1}Qwt-1 = quantity demanded per capita last year (kg)

t = time trend

Table 3 shows the results obtained from the model.

TABLE 3

Quantity Demanded Per Capita Equation Q_w^D

Model		Pw	Pw-1	YP	PC	T	C
1	Coeff	-.149	-.036	1.141	.112	-.862	100.152
	SE	.031	.036	2.376	.041	1.057	
	t-value	4.764	1.011	.480	2.744	.815	
	R^2	.78					
	F	4.971					
	D.W.	2.67					
2	Coeff	-.137		-.791	.100		81.284
	SE	.027		.872	.368		
	t-value	5.072		.918	2.734		
	R^2	.75					
	F	8.827					
	D.W.	2.85					
3	Coeff	-.481	-.258	3.055	.143		81.246
	SE	.141	.209	1.728	.121		
	t-value	3.402	1.237	1.768	1.183		
	R^2	.66					
	F	3.85					
	D.W.	2.598					

In Model III we use the retail prices of wheat and corn.

Considering the results and background economic theory as well as the statistical characteristics of the model, we used the table above in selecting the most satisfactory formulation, which is:

$$Q_D = 100.152 - .149P_w - .036P_{w-1} + 1.140\ YP$$

SE (.031) (.036) (2.376)

t-value (4.764) (1.011) (.480)

$$+ .112P_c - .862T$$

SE (.041) (1.057)

t-value (2.744) (.815)

$R^2 = .78$

D.W. = 2.78

F-value = 4.97

Statistical Properties of the Model

The results show that 78% of the variation in wheat demand is associated with the variables included in the model (deflated price of wheat and corn, deflated per capita income, and the time trend).

The coefficient of the deflated price of wheat turned out to be significant at 1% level (t-value = 4.764) with a value of -.149. This means that a unit increase in the price of wheat leads to a decrease in the quantity demanded per capita by .149 units. In other words, an increase in the wholesale price of wheat by one Saudi Riyal is associated with a decrease in quantity demanded of wheat per capita by .149 kg.

The coefficient of the lagged price of wheat is -.036 with a t-value of 1.011, which is not significantly different from zero.

The coefficient of per capita income has the value of 1.140 with a relatively high standard error. So t-value was non-significant (t-.480). However, this variable was retained because of its importance in the economic theory of demand. The value of the coefficient of the per capita income indicates that an increase in YP of one thousand Saudi Riyal is associated with an increase in quantity demanded per capita of 1.140 kilograms of wheat.

In the case of corn price the coefficient has a positive value of 5.112, as expected, with a significant t-value at 4% level (t-2.744). This means that a one Riyal increase in the wholesale price of corn, substituted for wheat, is associated with an increase in wheat consumption by .112 kg.

The coefficient of the time trend T has a value of -.862T, with a relatively high standard error and a non-significant t-value. This coefficient suggests that during the study there was a decrease in the quantity of wheat demanded per capita of .862 kg per year.

The D.W. statistic (D.W. = 2.78) is in the indeterminate range so that no conclusion can be drawn as to autocorrelation.

As mentioned earlier, 78% of the variation in the quantity of wheat demanded was associated with the included variables.

The F-test of this regression is F = 4.97 and is statistically significant at 7%, which means that such association of the variation in the quantity demanded per capita of wheat and the variables could not be random at 93% significant level.

The overall statistical properties of this model seem reasonable in terms of correct signs of coefficients and consistency with economic theory. While the significant levels of the coefficients were disappointing, the overall F-test does suggest the presence of explanatory properties.

Economic Interpretation

Here we will look at the signs of coefficients to determine the relationship between dependent and independent variables.

The coefficient of PW, deflated price of wheat, is negative, which means there is an inverse relationship between per capita consumption of wheat and the deflated wholesale price of wheat. Therefore, this coefficient goes with the economic theory.

The coefficient of YP per capita real income is positive, indicating that when per capita real income increases, per capita consumption of wheat will increase. This result is consistent with the belief that wheat is a normal good in Saudi Arabia.

The coefficient of Pc deflated price of wheat is positive, which means that when the price of corn goes up people will consume more wheat. This result is consistent with the assumption that corn is a substitute for wheat.

Finally, the coefficient of T, the time trend, is negative, suggesting that there is a trend toward reduced per capita consumption of wheat over time.

Conclusion

The study shows that there is a negative relationship between the price of wheat and its quantity demanded per capita. It indicates also that there is a positive relationship between both price of corn, a close substitute, and income per capita on the one hand, and the quantity demanded per capita on the other hand. The relationship between income per capita and quantity demanded per capita indicates that wheat is a normal good with a very low income elasticity (.05). Per capita income is not significant.

CHAPTER IV

PROJECTION OF DEMAND AND SUPPLY OF WHEAT

In this chapter we will try to establish the quantity of wheat demanded and the quantity supplied from domestic production in Saudi Arabia. From such projections we will determine the deficit which has to be covered by imported wheat.

Projection of Quantity Demanded

As mentioned before, the following model would be used for prediction purposes:

$Q^{D}_{W} = 100.152 - .149\ Pw - .036\ Pw\text{-}1 + 1.14\ YP + .112\ Pc - .862T$

Based on a population growth rate of 3% (the established level for the last few years, which we think will continue until 1985), and an income per capita growth rate of .21 (the average growth for the last nine years), the formula is as follows:

$D_t = Do\ (1 = d)^t$

$t = 0, 1, \ldots.$

where t = 0 for 1976

d = pop + NY (Annual rate of growth in the consumption of a food product)

d = Annual rate of growth in the consumption of a food product

Pop = Rate of growth in population (.03)

n = Income elasticity of demand

Y = Annual rate of growth in income per capita (.21)

Income elasticity = .05

TABLE 4

THE PROJECTION OF TOTAL CONSUMPTION THROUGH 1985

Year	Quantity Projection (Thousand M.T.)
79	692
80	720
81	749
82	779
83	810
84	842
85	876

Supply Projection

The following estimated equation of supply should be the basic framework to make the projection.

$Qwt = 149.3 + .121\ Pwt - 1 - .201\ Pbt - 1 + .014\ RFT - 38D$

Using the above equation we will keep rainfall and the prices of wheat and barley constant at their average value. Based on that our projection of total production will be constant at 110 thousand M.T. through 1985. But we are not satisfied with this result because the effect of shifting agricultural land to residential and industrial uses had a negative impact on quantity produced. During the same period, however, subsidies were paid to farmers as an incentive to boost production. When the negative dummy variable is used in the supply equation, the effect of shifting land to non-agricultural uses dominates the effect of the subsidy. Also, we should note that our supply equation does not reflect technology, variable costs, and agricultural credit effects.

The inadequate prediction power of the above supply model calls for other means of arriving at a forecast of production through 1985. The projection of quantity supplied will be based on a 19% rate of

production growth (.19 has been the rate of production growth from 1973, when wheat production reached its minimum, to 1978).

TABLE 5

ILLUSTRATION OF PROJECTION FOR THE SUPPLY OF WHEAT THROUGH 1985

Year	Supply Thousand M.T. Based on Estimated Supply Equation (Method I)	Supply Thousand M.T. Using the Rate of Production Growth (Method II)
79	110	208
80	110	248
81	110	295
82	110	351
83	110	418
84	110	497
85	110	591

The second five year plan for Saudi Arabia projected wheat production for 1980 to be 250 thousand M.T., which is not far from our projection (Method II) of 248 thousand M.T. for the same year.

At the equilibrium level, quantity demanded equals quantity supplied. The two sources of wheat supply in Saudi Arabia are: 1) domestic production, and 2) imported wheat. Therefore our equilibrium condition is as follows:

1. $Q^s_{wt} = Q^d_{wt}$
2. $Q^s_{wt} = Q^P_{wt} + Q^I_{wt}$
3. $Q^d_{wc} = Q^P_{wt} + Q^I_{wt}$

where

Q^s_{wt} = total quantity wheat supplied at time t

Q^d_{wt} = total quantity demand at time t

Q^P_{wt} = total production at time t

Q^I_{wt} = total imported wheat at time t

From this prediction of both quantity demand and quantity of domestic production through 1985, we can calculate the quantity of wheat that will be needed to get the equilibrium. Table 6 shows the quantity that will be imported through 1985.

TABLE 6

THE QUANTITY OF IMPORTS THROUGH 1985

Year	Imports	
	Based on Method I (Estimated Supply Equation)	Based on Method II (Using Rate of Production Growth)
1979	582	484
1980	612	472
1981	639	454
1982	669	428
1983	700	392
1984	732	345
1985	766	285

The study shows that there will be deficits in local wheat production. The author prefers Method II, the quantity supplied projection that was based on the rate of production growth, because it agrees more with the actual situation (according to his experience).

CHAPTER V

CONCLUSION AND POLICY IMPLICATION

Wheat is an important commodity to farmers as well as consumers. The average total area used for wheat in the Kingdom during the study period (1963-1977) was 88.4 thousand hectares and the average total production per year during the same period was 134.6 thousand metric tons.

With the new riches of Saudi Arabia and the increased population, both domestic and foreign, wheat is becoming a more important diet staple. This study has estimated the relationship of supply and demand on quantity produced and consumed from 1963 to 1977, and projected supply and demand through 1985.

The results show a positive relationship between the lagged price of wheat and total production. The total production is negatively related to changes in price of barley, which is a close substitute.

Rainfall has a positive effect on total production. Although the coefficient of this variable was not significant, our knowledge of wheat production in Saudi Arabia tells us rainfall is a significant factor.

The new high yielding variety of Mexi Pak significantly increased the yield.

The study shows that there is a negative relationship between the price of wheat and its quantity demanded per capita. On the other hand, there is a positive relationship between price of corn, a close

substitute, and quantity demanded per capita of wheat. Wheat is a normal good with a very low income elasticity of demand (.05).

The results of this projection indicate that there will be a deficit in local supply in the future. Hence, import of wheat seems necessary.

TABLE 7

PROJECTION OF SUPPLY AND DEMAND OF WHEAT

(THOUSAND METRIC TONS) THROUGH 1985

Year	Demand	Supply		Imports	
		Method I	Method II	Method I	Method II
79	692	110	208	582	484
80	720	110	248	612	472
81	749	110	295	639	454
82	779	110	351	669	428
83	810	110	418	700	392
84	842	110	497	732	345
85	876	110	591	677	285

Policy Implication

On the basis of observations, Mexi Pak is the high yielding wheat variety. Hence the Ministry of Agriculture should facilitate ways and means to encourage farmers to adopt this particular variety. Since the yield of this variety depends heavily on complementary imputs like fertilizer and other related materials, these should be made available in the market.

Lack of water constrains crop production; rainfall is sometimes wasted. Building dams and introducing modern irrigation systems may help to increase the wheat supply.

Small machinery can be used to improve total production. Because most farms are too small to use big machinery efficiently, I would suggest that policy makers of the Ministry of Agriculture facilitate and encourage the use of small machinery among the farmers.

During the time that oil revenues multiplied, subsidies were introduced to diminish the effect of oil revenues on agricultural practices. To keep subsidies alive and effective, I would suggest that the ratio of subsidies be increased to keep pace with increases in oil revenue.

Wheat is an important food to the people of Saudi Arabia, and if private enterprises do not produce sufficient quantities, the government should undertake wheat production.

This study indicates that undoubtedly there will be a short supply of wheat in the near future. To assure Saudi Arabia of a continuous supply of wheat and protect it from international market manipulation, policy makers should enter into some kind of long term contract with wheat producing countries.

Data Shortcomings

Lack of data is a common problem in developing countries. The shortage of both quality and quantity of data in Saudi Arabia adds another constraint to economists who want to carry out research. In this study, for example, whereas wholesale imported price of wheat was used in the supply equation, farmer price should have been used. Whereas wholesale price was used in demand equations, retail price should have been used. The necessary data was unavailable. Also, GNP per capita income in the demand equation was used due to lack of a more appropriate measure.

If farm prices, retail prices, and more accurate income data had been available, then supply and demand models would be improved.

Suggestions for Further Research

Saudi Arabia is a large country with great differences in climate and agricultural production patterns and practices. There are wide differences in consumption patterns and tastes. Since this study is at a high level of aggregation and has overlooked detailed differences across regions, perhaps a clearer picture would be obtained by disaggregating the nation into four regions. If, for purposes of study, the country were divided into the north, the east, the central, and the southwest regions, different commodities would be used as substitutes for wheat. In this study we have used primarily corn, but with disaggregation, rice could be used as a substitute in the central and eastern regions. Changes would also emerge in production substitution; in the central and eastern region we might substitute onions for wheat instead of barley. With disaggregation the effect of rainfall would most likely be more precise because the aggregate rainfall figures used in this study concealed a great variation within regions.

Inclusion of labor and fertilizer costs would also improve the model. Not only are labor costs high in Saudi Arabia--an unusual situation for a developing country, but also the introduction of Mexi Pak requires higher inputs of fertilizer and must be taken into account.

APPENDIX 1

DATA FOR DEMAND EQUATIONS

Year	QD	Pwt	Pct	Pop	GNP	G.I
62	296.2	414		6263	5969.9	
63	294.4	438	348	6416	6484.7	100
64	291.6	501	293	6579	7257.2	102.8
65	392.5	422	325	6750	8057.5	103.2
66	375.2	457	355	6930	8936.6	104.8
67	476.9	396	350	7119	10117.6	107.0
68	317.1	466	304	7317	11254.1	108.7
69	408.1	449	358	7524	12318.2	112.5
70	476.8	437	419	7740	13410.1	112.7
71	474.5	445	382	7965	17241.5	118.2
72	512.2	460	311	8199	20588.7	123.2
73	347.7	631	382	8443	30094.5	143.1
74	396.4	1014	771	8697	82551.6	173.8
75	484.4	922	720	8966	120008.6	233.9
76	615.2	830	700	9238	145431.6	307.7

SOURCES: QD, Pop from F.A.O. Pwt, Pct from Saudi Arabia Statistical Year Book. GI from A Structural Econometric Model of the Saudi Arabian Economy, 1963-1974; 1975-1976 from national accounts of Saudi Arabia.

Pop ⟹ the population

GNP ⟹ Gross National Product (million Saudi Riyals)

APPENDIX 2

DATA FOR SUPPLY EQUATIONS

Year	Qwt	Pwt	Pbt	RFT	Ywt	Awt
63	135	438	318	82		
64	125	501	336	199	1471	85
65	148	422	301	58	1479	100
66	149	457	301	82	1488	100
67	150	396	356	0	1500	100
68	130	466	337	113	1300	100
69	150	449	227	250	1500	100
70	150	437	274	186	1500	100
71	150	445	411	40	1230	122
72	150	460	414	255	1200	125
73	90	631	232	281	2000	45
74	132	1014	512	47	1800	50
75	132	922	496	147	2126	62
76	93	830	480	69	1255	74
77				196	1800	75

Sources: Qwt, Ywt and Awt from F.A.O. Pwt and Pbt from Saudi Arabia Statistical Year Book. RFT from a report of the Ministry of Agriculture and Water.

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