DISSERTATION

USING ECONOMETRICALLY-ESTIMATED IMPORT DEMAND SYSTEMS TO ANALYZE DOMESTIC AND INTERNATIONAL ISSUES: A CASE STUDY OF SAUDI ARABIAN AGRICULTURAL IMPORTS

Submitted by

MAHDI M. AL-SULTAN

Department of Agricultural and Resource Economics

In partial fulfillment of the requirements

For the Degree of Doctor of Philosophy

Colorado State University

Fort Collins, Colorado

Fall 2002

UMI Number: 3075338

UMI

UMI Microform 3075338

ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

COLORADO STATE UNIVERSITY

October 18, 2002

WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY MAHDI M. AL-SULTAN ENTITLED USING ECONOMETRICALLY-ESTIMATED IMPORT DEMAND SYSTEMS TO ANALYZE DOMESTIC AND INTERNATIONAL ISSUES: A CASE STUDY OF SAUDI ARABIAN AGRICULTURAL IMPORTS BE ACCEPTED AS FULFILLING IN PART OF REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

Committee on Graduate Work

Adviser

Acting Department Chair

ABSTRACT OF DISSERTATION

USING ECONOMETRICALLY-ESTIMATED IMPORT DEMAND SYSTEMS TO ANALYZE DOMESTIC AND INTERNATIONAL ISSUES: A CASE STUDY OF SAUDI ARABIAN AGRICULTURAL IMPORTS

With dramatically growing food consumption, combined with the country's climatic conditions and water scarcity, Saudi Arabia depends heavily on food imports to cover the gap between domestic demand and local production. This increasing reliance on imports, along with expected effects of the World Trade Organization (WTO) negotiations on agriculture, and declining domestic production due to changes in domestic policy are the main problems facing the Saudi agricultural sector. This suggests the need to evaluate effects of domestic and international policy change on imports, local production and local demand for key products in the sector.

The objectives of this research are, first, to empirically analyze the demand for food imports using recent methodological developments in the implementation of demand systems. Then, these estimated demand parameters are utilized to analyze domestic and international policy issues. To attain these objectives, a demand system for imports was estimated using several systems (Rotterdam, AIDS, CBS, and NBR), which are all nested alternatives in a general model, and then expenditure and price elasticities were calculated.

The CBS model was found to be the best model for analyzing import behavior in this study, and it was used to compute expenditure elasticities, own-price elasticities, and

cross price elasticities. The estimated expenditure elasticities imply that if aggregate consumer expenditure allocated to agricultural imports was to increase, the demand for imports would increase. Also, prices show unitary elasticities for six of eight categories.

In order to link domestic and international effects across a variety of alternatives, a restricted regression using the CBS import model was developed to estimate domestic demand elasticities in the presence of alternative supply elasticities. With these matrices of elasticities in hand, a policy analysis framework was developed and simulations of three different issues were made.

The first simulation deals with the effect of world price increases from WTO effects, and most import quantities are seen to decline, with the highest decrease for vegetables and fruit (72 percent). There is also an increased incentive for local production, as for example, feed grains expand by 46 percent in response to the WTO price increases. The second simulation deals with the impact on domestic supply due to changes in input prices (water and a subsidy on imported live animals). The results show declining local production because of increasing input prices, with the greatest decline in feed grains (45.5 percent). The reduction in production varies according to input supply elasticities, output supply elasticities, and the local production share in domestic demand. The third simulation shows the effect of increased expenditures on imported goods. The results differ between groups depending on expenditure elasticities and a group's import share in local demand. Once again, feed grains show the highest response (18 percent).

Mahdi M. Al-Sultan
Department of Agricultural
and Resource Economics
Colorado State University
Fort Collins, Co 80523
Fall 2002

ACKNOWLEDGEMENTS

All praise and thanks belongs to ALLAH, lord of the world and the most merciful, for his providence and divine direction through my life. Then, my thanks are to my beloved parents for their love and sincere prays to ALLAH during my life for my success.

I would like to express my deepest thanks and appreciation to my adviser and committee chairman, Prof. Stephen P. Davies for his valuable advice and encouragements during my Ph.D program from early years until the completion of this dissertation. Moreover, his patience and understanding, his continuous cooperation and valuable suggestions, his knowledge of the subject, econometrics and computer programs were enabling me to complete this dissertation. I gratefully acknowledge his open door policy, his meaningful contribution in the dissertation research and his willingness to help. In sum, he did a lot of things, which really are appreciated.

Also, I would like to express my very special thanks to my committee members: Dr. Dawn Thilmany, Dr. James Pritchett and Prof. Laing-Shing Fan for their valuable comments and suggestions that contributed to the improvement of the dissertation.

I gratefully recognize the support provided to me from the Department of Agricultural and Resource Economics (DARE) and Department of Economics Faculty who taught and advised me during my studying era. Also, staff and graduate students in both departments helping and cooperation are highly appreciated.

My acknowledgment is also extended to faculty and staff in the Department of Agricultural Economic, King Saud University (KSU), Riyadh, Saudi Arabia for their encouragement, support, and granted me the chance to complete my Ph.D. My special and deepest thanks are expressed to my masters' adviser, Prof. Mohammed Al-Qinaibit, Chairman of Economic Affairs Committee, Shura Council, Saudi Arabia, for his unlimited encouragement, helping, guiding, cooperation and moral support during my graduate study, which cannot be counted in a paragraph.

As well, I would like to express my thanks and appreciation to the people who stand with me during my studying period. My father, my mother, my brothers, my sisters, and all my relatives for their encouragement, helping, praying and support. Special thanks go to brother Hussian AL-Sultan for all things he did for me and his helping in collecting research data and references.

Finally, I would like to express my gratefulness and thankfulness to my wife Aum Mohammad and my beloved children, Wafa, Mohammad, Mona, Abdulaziz, Fahad and Ahmad who accompany me at Fort Collins, for all the sacrifices, understanding, patience, encouragement, and constant support they have made throughout my Ph.D at CSU, Fort Collins and I hope that I can compensate them some of their sacrifices.

DEDICATION

This dissertation is dedicated to:

- My father and mother.
- My wife and Children.
- My brothers and Sisters.
- My relatives and.
- All my friends.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The kingdom of Saudi Arabia is located on the Arabian Peninsula and comprises around eighty percent of it. a landmass constituting a distinct geographical entity. which is bordered on the west by the Red Sea. on the south by the Indian Ocean and on the east by the Arabian Gulf. In southwestern Asia. the country is at the crossroads of three continents: Europe. Asia and Africa. The kingdom. which occupies approximately 2.250.000 square kilometers (868.730 square miles) is bounded by the Red Sea to the west. Egypt and Jordan to the northeast. Iraq and Kuwait to the north. the Persian Gulf. Qatar and the United Arab Emirates to the east. Oman to the southeast and south as well as Yemen to the south and southwest.

The country is divided into four geographical regions: the Red Sea escarpment from Hejaz in the north to Asir in the south; the central plateau that extends to the Tuwaiq Mountains and further; the sand deserts of Dahana and Nafud; and the Rub al-Khali Desert. which is the largest sand desert in the world. The country has no rivers or other permanent bodies of water.

Saudi Arabia has a hot and dry climate with frost and freezing temperatures in winter while the Red Sea coast experiences high humidity and temperatures. Rainfall is sparse with an average annual precipitation of approximately 100 mm (4 inches). The prevailing winds often bring severe dust storms. Average temperature ranges in Riyadh (capital city) are from 8 to 21 degrees Celsius (46 to 70 degrees Fahrenheit) in January and from 26 to 42 degrees Celsius (79 to 108 degrees Fahrenheit) in July.

According to the 1992 census, the Kingdom's population was just 17 million. However, since then, by all accounts the population has grown dramatically. More recent estimates (Demographic Survey 2000, Ministry of Planning) give a figure of 21 million, of which approximately 75% were Saudi nationals with an average 3% annual increase in overall population.

The oil economy is the backbone of the country's economy, representing 35%-40% of GNP, and providing the bulk of the country's foreign earnings, and about 80% of government income. Saudi Arabia possesses the largest oil reserves in the world (more than 25% of the world's known reserves) and it is the largest producer among the OPEC countries, supplying more than an eighth of the world's oil exports.

It has long been recognized that the importance of agriculture to the Kingdom extends beyond that of its contribution to national output alone. At the end of the Third Plan period, almost half of the Kingdom's population was living in rural areas and a significant proportion of total Saudi employment was in agriculture. The planned development of agriculture was to increase domestic food production for a growing population in addition to fulfilling other important roles. The Kingdom of Saudi Arabia has achieved this target, despite the fact that the country faces many constraints, such as difficulties due to scarce rain, insufficient water sources, limited local manpower and widely dispersed cultivatable lands. It generates employment both within the sector and in closely related agro-industries. Moreover, it contributes to the diversification of the economic base and to import substitution, while raising income levels and improving rural living standards for both settled and nomadic communities alike. This helps prevent population drift to urban centers. A further important aspect of agricultural development in the Kingdom is its role in maintaining the ecological balance by combating desertification. As a result, the country has become self-sufficient in wheat, producing some four million tons in 1991, up from 3,000 tons in 1970 and added significant livestock, eggs and vegetables production. However, other food production is still far less than consumption needs, which must be covered through imports.

Even with this change, agricultural production is expected to decline over time. The scarcity of water and World Trade Organization (WTO) are the main factors that will affect the sector. For example, subsidies and tariffs on commodities such as wheat and dairy products will be reduced and the producers will face competition from foreign products. At present, the usable water, aside from desalinization, is expected run out within twenty-five years. Accordingly, an analytical framework that can assess issues that come from both trade and domestic sources is required.

1.1 Problem Statement

Saudi Arabia's food consumption, which is provided through local production and imports, has grown dramatically since 1980. There has been a sharp increase in food consumption and significant changes in the composition of food consumed despite decreasing real per capita income during the 1990s. Population growth, which is estimated to be 3%, combined with changes in standards of living and consumption preferences, have collectively explained this change. Therefore, it is important that the government of Saudi Arabia anticipate further effects of these changes on growth of food demand and to focus on food policies that contribute to development goals.

The migration of agricultural labor from rural to urban regions with limited agricultural productivity had reduced agricultural production before the 1980s, when the government adopted policy tools to increase agricultural production. Giving free land to farmers, subsidizing agricultural production and granting long term interest free loans are some examples of these policies. As a result, the production of some agricultural products was raised and the country reached self-efficiency in agricultural products like wheat, eggs, poultry and vegetables. However, because of the nature of the country and climatic conditions, in addition to water scarcity, these actions led to a reduction in the groundwater level. The unbalanced growth in other product lines, because wheat had the largest share of support, is another side effect of these policies. Consequently, these outcomes led to calls for changing these policies and restricting planting of wheat. In addition to the shortage of water resources, growing other products as fruit or oilseed products, is constrained because of climatic and topographic conditions or high production costs.

Thus, the reduction in groundwater reserves as well as a comparative advantage issue has caused the government to change policies directed to agricultural products. This policy change caused a reduction in some production categories. This decline in production, combined with population growth has led Saudi Arabia to depend heavily on food imports to cover the gap between domestic demand and local production. The increased reliance on imports as a source of food will increase the country's import demand. Furthermore, the presence of World Trade Organization (WTO) will affect the Saudi import demand and the world market as well.

The main problems facing the Saudi agricultural sector suggest the need for an analytical framework that can evaluate effects of policy and resource change on imports, local production and local demand. It should also account for substitution and income effects across products that might arise from changes in consumption and production patterns in the sector. This suggests that the analysis should cover multiple products and reflect interactions between domestic production and imports.

One method would be to construct a full set of supply and demand equations for the domestic agricultural sector. This is often limited by data availability, quality and expense. Other approaches that can handle these dimensions include computable general equilibrium (CGE) models and agricultural sector models. These often have complex data collection requirements and demand specialized abilities from analysts, often beyond what can be expected in many cases. Thus, the determination of a method that can easily show how impacts emanating from local production, demand, or imports affect all commodities is not so easy to provide. It is a primary objective of this dissertation to develop an effective method to examine these issues at reasonable cost but with sufficient accuracy and richness to be useful in numerous circumstances.

In essence, the method proposed here would be to use restricted import demand models, which will permit econometric estimations that are based on trade data, which is, at least in developing countries, often the best data available. Imposing supply elasticities on the import demand model allows a direct estimation of local demand elasticities. Using an identity that ties import, supply and demand elasticities together, it will be possible to develop from this estimation a full set of elasticities needed for policy analysis, and to observe the consistency among them. While there have been a large number of import demand models developed for many countries, they have almost always been used to examine the effects of increased income on the patterns of imports, or to look at changes in the international policies, such as tariffs or subsidy reduction. Rarely, if ever, have they been used to provide the empirical basis for the range of policy and resource issues to be examined in this research. Only the Janda, McCluskey, and Rausser (2000) article even considers the use of import demand functions as inputs into large CGE or partial equilibrium models. However, it does not actually use the results in this manner.

In this research, a simulation model, adapting and extending a structure given in an important article by Piggott, Piggott and Wright (1995), will be constructed. It will be capable of showing linkages and effects across a wide variety of policy alternatives.

1.2 Objectives of the Study

The main objectives of this research are, first, to empirically analyze the demand for food imports in Saudi Arabia in light of recent methodological developments in the implementation of demand systems. Secondly, the estimated demand parameters will be used to analyze domestic and international policy issues faced by decision makers in Saudi Arabia. Specific objectives of the research include:

1. Specification and review of theoretical models for analysis of the demand systems.
2. Investigate food import demand in Saudi Arabia by estimating a general import demand model from Lee, Brown and Seale (1994), and testing whether specific nested alternatives are appropriate.

3. Estimation of direct and cross price elasticities and income elasticities of the demand for food imports in Saudi Arabia using different demand system models. Then, test the empirical validity of theoretical restrictions on demand equations.
4. Develop a policy analysis framework by extending the Piggott, Piggott and Wright (1995) model.
5. Use the results and framework obtained to evaluate the consequences on import change, local production and consumption from the WTO accession and domestic policies directed to water use on imports, and changes in expenditures on agricultural imports.

1.3 Data Description

Quarterly time series data will be used to estimate the demand systems for agricultural imports. The period that will be investigated is from 1990.1 to 2000.4. These data were collected from the Ministry of Planning, Foreign Trade Statistics, Saudi Arabia. Other data was collected from the Food and Agriculture Organization of the United Nations (FAO).

1.4 Preview of the Dissertation

Following this introductory chapter, a description of agricultural production in Saudi Arabia is given in Chapter 2, including agricultural policy, agricultural production, food consumption, agricultural imports, the effects of WTO accession and WTO-related changes in world markets on Saudi agriculture, and water issues in Saudi Arabia. In Chapter 3, a literature review of the Saudi Arabian demand estimation, import demand estimation, and demand system specifications are presented. Chapter 4 contains an illustration of consumer demand theory.

Chapter 5 presents the development of the econometric model and policy analysis framework. The concepts of differential demand systems, demand equations, method of estimation and the evaluation of demand systems are first presented and discussed. Following that, a trade elasticities model is developed based on McCalla and Josling (1985) and a framework of how to use elasticities to examine import and domestic policy change based on Piggott, Piggott and Wright (PPW) is developed.

Empirical results are described in chapter 6. Five demand systems models, which are the Rotterdam model, the Almost Ideal Demand System (AIDS) Model, the Dutch Central Bureau of Statistics (CBS) Model, the National Bureau of Research (NBR) Model and a general model are estimated. Based on these results, the CBS model is chosen and estimated with different restrictions. The findings from the local and international policy simulations are also presented. Finally, Chapter 7 discusses the conclusion and recommendations.

CHAPTER II

AGRICULTURAL PRODUCTION, POLICY AND TRADE IN SAUDI ARABIA

2.1 Introduction

Prior to oil discovery in Saudi Arabia, the agricultural sector was the cornerstone of the Saudi economy and the principal occupation of most of the population. The discovery of oil in commercial quantities changed the Saudi economic structure dramatically. As a result, agriculture's contribution to gross domestic product (GDP) decreased and the number of employees in the agricultural sector fell. Despite this decline, policy makers and planners have recognized the importance of agricultural sector development. The development of the agricultural sector provides one source to meet the increasing food demand resulting from population growth, changes in preferences, and growth in the number of guest workers and higher education levels. Moreover, it assists the country in reaching self-sufficiency beside providing national food security as well as fulfilling other important roles. It contributes to the diversification of the economy and a reduced dependence on oil as the main source of national income. It stimulates growth and employment in other economic sectors through its demand for farm inputs and other agricultural services, and through its supply of agricultural raw materials for the food industry. Finally, it raises the incomes and welfare of citizens in rural areas, thereby reducing migration to urban areas and contributing to balanced regional development.

To enhance the value of these attributes, the government adopted a system of comprehensive planning in 1970 to guide development in a coordinated and balanced direction. Therefore, seven continuous economic development plans have been developed, each having a five-year span, from 1970-2005 (Ministry of Planning, Achievements of Development Plans).

The objectives of these development plans were to expand agricultural output, raise living standards, and increase the level of agricultural employment. The emphasis of the first plan 1970-1975 was on diversification of the sources of national income, and a decrease in the reliance on importing basic foodstuffs by expanding domestic output, which led to increases in the growth rate of the agricultural sector. The second development plan 1975-1980 was designed to increase food self-sufficiency, improve living standards and encourage private investment. The third development plan's 1980-1985 objective was diversifying the economic base in Saudi Arabia. The goals were to increase the economic growth rate, increase production efficiency and encourage private investment. The concern about resources subsequently became an issue, and thus, later plans increased their emphasis on conservation of resources. Thus, the fourth development plan's 1985-1990 objectives were to extend the agricultural and manufacturing sectors, and use natural resources more efficiently. The fifth development plan's 1990-1995 major objectives were to contribute to the security of the nation's food supplies, to achieve a satisfactory growth in yields at minimum cost and to attain a high level of productivity and marketing efficiency. The sixth development plan's 1995-2000 objectives were to contribute to the country's food supply through products that are appropriate to the country's available natural resources and achieve the optimum long-term use of water, and to raise economic efficiency in the agricultural sector in general. The seventh development plan's 2000-2005 main objectives are to develop the agricultural sector to cover the expected increase in domestic demand for food while conserving critical water resources to achieve a balance between water and food security.

In conclusion, these development policies resulted in significant growth in the agricultural sector for different products. Self- sufficiency has been achieved in some products, such as wheat and dairy products, which implies significant progress from a national security view, as Saudi Arabia exists in a very politically instable region. At the same time, there are some negative implications from these development policies. The most significant problem that faces planners is the rapidly decreasing ground water level, which dictated a changing of policy to programs that use water more efficiently. In addition to the water issue, environmental degradation has become an important issue, where the agricultural sector may create environmental pollution that should be reduced to a socially optimal level. Moreover, the concern about financial support directed to the sector has become an issue and the support for some crops, like wheat, has been reduced.

This chapter describes the agricultural policy, agricultural production, food consumption and agricultural imports trends in Saudi Arabia. Then, WTO and Saudi agriculture and water issues in Saudi Arabia are discussed

2.2 Agricultural Policy in Saudi Arabia

The Saudi government has established a strong agricultural policy aimed at developing the agricultural sector into one of the important economic sectors in the country. The government undertook multifaceted programs to modernize and commercialize agriculture. These programs and supports have provided direct and indirect supports, which resulted in the development of the agricultural sector.

The government adopted a group of support policies toward farmers and agricultural investors, which have had a considerable impact in attracting national private capital to participate in agricultural investment. The agricultural policy programs are directed at improving the agricultural sector by first, granting fallow lands to individuals and companies free of charge. The total areas allocated from 1980 to 1998 amounted to 2.55 million of 53 million hectares. In addition, the government granted short, medium, and long term interest free loans. The total value of loans was more than 28 billion Saudi Riyals (SR) (1$ = 3.75 SR) during the period 1964-1995.

Additionally, the government offers generous subsidies for agricultural inputs, equal to 45% for equipment and 50% for machinery, pumps, seeds and fertilizers, while also covering payment for the transportation costs of high productivity cows from the country of origin to Saudi Arabia. The total value of subsidies paid for agricultural inputs were more than 10 billion SR during the period 1973-1995. Moreover, crops such as wheat, barley and dates, are purchased at attractive prices. The total value of price support programs paid for wheat and barley reached 50 billion SR during the period 1973-1995. Customs have been imposed on some imported goods to protect local production, such as table eggs, chicken and dairy products. For example, 20 percent tariffs are imposed on the imports of eggs and chicken and 12 percent tariffs on milk imports. In addition to this direct support, there is indirect support, which involve substantial expenditures on infrastructure, i.e. electricity supply, irrigation, drainage, secondary road system and other transportation facilities for distributing and marketing products. These multiple policies have a significant effect on agricultural production. The evidence of this effect can be seen in increased animal and crop production, and the attainment of self-sufficiency in some products.

Although these policies have beneficial consequences to the agricultural sector, they have negative side effects. These negative side effects can be summed up in the following points. First, there has been a high cost to the government budget, which adds to 60 billion SR during the period 1964-1995. Secondly, an unbalanced subsidy distribution within the agricultural sector, where wheat has the largest share, led to an extraction of groundwater at a non-optimal rate. Thirdly, using inputs at high levels affected the environment and water quality in different ways. Fourthly, machinery that used in wheat production became uneconomic after the reduction in wheat subsidies and production. Finally, the rural – urban migration rate was still high because large farmers and companies benefited from these policies more than small farmers.

2.3 Agricultural Production

Agricultural production has changed over the last decades. The expansion of agricultural production over the past fifteen years has been one of the most remarkable dimensions of the overall economic development effort in Saudi Arabia. The agricultural sector plays an important role in the diversification of the economy. Agriculture's highest contribution to gross domestic product (GDP) was 7.2 percent in 1998 while the lowest was 6.18 in 1991 and 1996. The average annual share was 6.6 percent at nominal prices. Also, its highest share of non-oil GDP reached 10.98 percent and the average annual share was 10.4 percent. Value added in the agricultural sector rose from 25.14 billion SR in 1990 to 34.4 billion SR in 1999, a growth of 27 percent during this period. Moreover, the average annual growth rates of agricultural GDP grew faster than the non-oil GDP in the same period table 2-1.

The production of cereals within the development plans has changed over time. Before 1994, there was substantial increase in cereals production as a response to the support policy directed to the agriculture. Recently, these policies were modified because of water scarcity. As a result, the production of cereals fell by 47 percent between 1995 and 1993, in conformity with government policy directed to reduce production of wheat and barley to levels not exceeding domestic consumption. Also, the production of oil crops and vegetables fluctuated over the period 1990-1999, with a 1.71 percent average annual growth. Vegetables and fruit production increased by 0.03 percent annually until reached a peak in 1997 and declined. Animal fats, meat and milk are growing over time by 5.15% annually, and no policy change has affected them. Other products increased by an average 9.47% annual rate, as seen in table 2-2. The total quantity produced in agriculture increased during the early 1990s. After 1994, its volatility increased, as the average annual growth rate was -1.1 percent during the period.

The different food groups' shares in total agricultural production were unstable during this period. Before 1994, cereals share was around 50 percent while the vegetables and fruits' held a 32 percent share. After that, due to policy change, cereals' share declined to around 30 percent, while vegetables' and fruits' share rose to around 44 percent. Moreover, animal fats, meats, and other products were stable before 1994 and increased over time after that table 2-3.

Table 2-1: Saudi Arabian Nominal Gross Domestic Product by Sector and Per Capita Income 1990-1999

Year	Oil GDP (Million Riyals)	Non-oil GDP (Million Riyals)	Total GDP (Million Riyals)	Per capita Income (Riyals)	Agricultural GDP (Million Riyals)	Agriculture's Share of Total GDP	Agriculture's Share of Non-oil GDP
1990	238,533	146,460	384,993	21,721	25,142	6.53	10.54
1991	267,512	167,525	435,037	23,296	26,902	6.18	10.1
1992	265,774	186,524	452,298	23,082	28,785	6.36	10.8
1993	276,201	158,364	434,565	21,904	30,224	6.96	10.94
1994	284,014	157,722	441,736	2,118	31,131	7.1	10.96
1995	295,950	175,201	471,151	20,603	31,598	6.71	10.68
1996	307,746	212,629	520,375	20,298	32,162	6.18	10.45
1997	325,494	213,846	539,340	20,132	33,400	6.19	10.26
1998	330,495	140,696	471,191	19,751	33,901	7.2	10.25
1999	340,010	185,381	525,391	19,195	34,443	6.56	10.13
Average annual growth rates	3.93 %	2.62 %	3.75 %	-1.4 %	3.5 %	NA	NA

Table 2-2: Saudi Arabia Total Agricultural Production and Growth Rate (1000 Metric Tons) 1990-1999

Year	Cereals	Growth Rate %	Oil crops, Vegetable Oils	Growth Rate %	Vegetables &Fruit	Growth Rate %	Animal Fats, Meat & Milk	Growth Rate %	Other Products	Growth Rate %	Total	Growth Rate %
1990	4,137	--	12	--	3,005	--	896	--	284	--	8,334	--
1991	4,574	10.56	10	-16.67	2,661	-11.45	925	3.24	297	4.58	8,467	1.60
1992	4,703	2.82	16	60.00	2,876	8.08	987	6.70	333	12.12	8,915	5.29
1993	5,043	7.23	8	-50.00	2,966	3.13	1022	3.55	410	23.12	9,449	5.99
1994	4,860	-3.63	8	0.00	3,039	2.46	1096	7.24	505	23.17	9,508	0.62
1995	2,669	-45.08	14	75.00	3,370	10.89	1147	4.65	626	23.96	7,826	-17.69
1996	1,932	-27.61	16	14.29	3,373	0.09	1202	4.80	599	-4.31	7,122	-9.00
1997	2,339	21.07	13	-18.75	3,420	1.39	1368	13.81	600	0.17	7,740	8.68
1998	2,202	-5.86	14	7.69	3,331	-2.60	1381	0.95	616	2.67	7,544	-2.53
1999	2,452	11.35	14	0.00	3,013	-9.55	1424	3.11	666	8.12	7,569	0.33
Average annual growth rates		-5.81%		1.71%		0.03 %		5.15%		9.47		-1.1 %

Source: Food and Agricultural Organization of the United Nation, (FAO). FAO Food Balance Sheet.

Table 2-3: Saudi Arabian Agricultural Production Groups and Shares (1000 Metric Tons) 1990-1999

Year	Cereals	% Of Total	Oil crops &Vegetable Oils	% Of Total	Vegetables &Fruit	% Of Total	Animal Fats, Meat, & Milk	% Of Total	Other Products	% Of Total	Total
1990	4,137	49.64	12	0.14	3,005	36.06	896	10.75	284	3.41	8334
1991	4,574	54.02	10	0.12	2,661	31.43	925	10.93	297	3.51	8467
1992	4,703	52.75	16	0.18	2,876	32.26	987	11.1	333	3.74	8915
1993	5,043	53.37	8	0.08	2,966	31.39	1022	10.82	410	4.34	9449
1994	4,860	51.11	8	0.08	3,039	31.96	1096	11.53	505	5.31	9508
1995	2,669	34.10	14	0.18	3,370	43.06	1147	14.66	626	8.0	7826
1996	1,932	27.13	16	0.22	3,373	47.36	1202	16.88	599	8.41	7122
1997	2,339	30.22	13	0.17	3,420	44.19	1368	17.67	600	7.75	7740
1998	2,202	29.19	14	0.19	3,331	44.15	1381	18.31	616	8.17	7544
1999	2,452	32.40	14	0.18	3,013	39.81	1424	18.81	666	8.80	7569

Source: Food and Agricultural Organization of the United Nation, (FAO). FAO Food Balance Sheet.

2.4 Food Consumption

Food consumption in Saudi Arabia has changed significantly over time. During the 1970s, cereals, dates, animal milk and meat were the main sources of food. This composition changed during the 1980s and 1990s. The changing population structure, increasing income levels, increased pilgrims every year, and people becoming more concerned about their diet and health, is factors that are responsible for this structural change.

Over the last decade, there has been an increase in population and gross domestic product (GDP). The population growth rate averaged around 3% during the period 1994-2001, as in table 2-4. Due to significant growth in economic development projects in the country, the demand for guest workers, on average 29% of the total population, increased about 26% during this period. Then it decreased after 1998 due to a policy to reduce illegal workers. On the other hand, because of an increase in oil prices and exports, in addition to development plan projects, gross domestic product increased during this time. Table 2-4 show that the growth rate in non-oil sector nominal GDP during the 1990-1999 period was 27%, while the growth rate in oil sector nominal GDP was 30%.

As a consequence of these and other factors, like change in the standard of living and consumption preferences, food consumption has increased. The average annual food consumption growth rates of cereals, vegetable oils, fruit, and meat during the period 1990-1999 were 2.56%, 2.67%, 2.56%, and 4.43%, respectively, while vegetable consumption growth rate was 2.18% as shown in table 2-5. The per capita annual consumption of cereals increased from 172 kg in 1990 to 182.2 kg in 1994 as seen in figure 2-1. This recent decline in cereal consumption could be related to a change in prices due to a decrease in wheat production as a result of government policy. The figures over the last decade indicated declining per capita consumption for vegetables from 163.2 kg in 1990 to 105.1 in 1999 as shown in figure 2-1. This decline may have happened because of a change in preferences or that population growth exceeded supply growth during this time. Per capita annual consumption of fruit reached a peak of 109.6 kg in 1995 and has been gradually declining since then. More meat was consumed consistently over the last decade, as per capita annual consumption of meat increased from 45 kg in 1990 to 52.6 kg in 1999. The quantity of vegetables oils consumed was fairly stable over the last decade, and an average person consumed about 14.7 kg annually.

Moreover, per capita average annual growth rate of calories consumed for all products was -0.1 percent during the period 1990-1999 as illustrated in table 2-6. The per capita annual growth rate of calories consumed from cereals was 0.15% while it was -1.14%, -1.22%, and 0.23% for vegetables and fruit, animal fats and milk, and other products, respectively, figure 2-2. This change in calories consumed over time might be related to Saudis becoming more concerned about their nutritional and health status in addition to educational efforts to encourage families to use healthful food. The decline in fruit and vegetable consumption may just be related to unique years 1990 and 1999, with the earlier year being unusually high and the later year being low. Alternatively, it may come from lower dates consumption among the large Non-Saudi population.

The consumption of food is usually affected by economic factors, such as food prices and consumers' incomes. These factors have an important influence on a consumer's decision about whether to purchase a particular food, how often, and how much to purchase. For example, if the price of one good goes up while the price of the substitute good remains the same, consumers likely will buy less of the relatively more expensive good and buy more of the relatively less expensive good. At the same time, consumption of complementary goods is also affected. Also, a change in per capita income affects quantities demanded for all foods through expenditure elasticities. Only per capita meat consumption exceeds population growth, suggesting that a significant income effect for meat exists. Moreover, the decline in cereals consumption from the reduction of subsidies in wheat suggests that there is still a significant substitution effect at work in regard to prices. Another source of likely price sensitivity is the large portion of non-Saudi workers and families who live in the country. These are generally workers of modest means, and given that they are nearly a third of the population, there could still be a significant price reaction. Indeed, there is some variability shown in figure 2-1, and estimations shown later in this research confirms the existence of high price elasticities.

Table 2-4: Saudi Arabian Total Population and Population Structure 1994-2001

Year	Total Population	Population Growth %	Saudi National	Growth Rate %	Saudi % of Total	Non-Saudi	Growth Rate %	Non-Saudi % of Total
1994	18.2	-	13.2	--	73%	5	--	27%
1995	19.1	5%	13.6	3	71%	5.5	10	29%
1996	20	5%	14	2.9	70%	6	9.1	30%
1997	21	5%	14.5	3.6	69%	6.5	8.33	31%
1998	21	0%	15	3.5	71%	6	- 7.7	29%
1999	21.4	2%	15.4	2.7	72%	6	0	28%
2000	21.8	2%	15.8	2.6	72%	6	0	28%
2001	22.54	3%	16.24	2.8	72%	6.3	5	28%
Average annual growth rates		3.1 %	2.96%				3.3 %	

Source: The Saudi Economy: Mid-year 2001 update, Saudi American Bank, August 2001.

Table 2-5: Total Food Consumption in Saudi Arabia (1000 Metric Tons) 1990-1999

Year	Cereals	Vegetable Oils	Vegetable	Fruit	Meat
1990	2,649	239	2,513	1,569	693
1991	2,847	238	2,052	1,628	762
1992	2,911	259	2,197	1,632	720
1993	2,956	251	2,248	1,724	661
1994	3,040	241	2,242	1,809	660
1995	3,041	228	2,466	1,872	845
1996	3,081	247	2,449	1,805	811
1997	3,209	262	2,422	1,871	902
1998	3,271	249	2,450	1,969	920
1999	3,334	304	2,065	1,975	1,032
Average annual growth rates	2.56 %	2.67 %	-2.18 %	2.56 %	4.43 %

Source: Food and Agricultural Organization of the United Nation, (FAO). FAO Food Balance Sheet.

Table 2-6: Per Capita Calories/Day from Different Products in Saudi Arabia 1990-1999

Year	Cereals		oilcrop &vegetable oils		Vegetables & fruits		Animal fats & milk		Other products		Total	
	Calories Day	Growth rate	Calories /day	Growth rate	Calories /day	Growth rate	Calories /day	Growth rate	Calories /day	Growth rate	Calories /day	Growth rate
1990	1,421	--	364	--	319	--	212	--	657	--	2,973	--
1991	1,494	5.14	393	7.97	293	-8.15	212	0.00	648	-1.37	3,040	2.25
1992	1,506	0.80	410	4.33	301	2.73	138	-34.91	621	-4.17	2,976	-2.11
1993	1,501	-0.33	385	-6.10	309	2.66	122	-11.59	600	-3.38	2,917	-1.98
1994	1,518	1.13	365	-5.19	310	0.32	127	4.10	605	0.83	2,925	0.27
1995	1,493	-1.65	339	-7.12	321	3.55	177	39.37	676	11.74	3,006	2.77
1996	1,474	-1.27	355	4.72	313	-2.49	207	16.95	657	-2.81	3,006	0.00
1997	1,483	0.61	369	3.94	312	-0.32	178	-14.01	652	-0.76	2,994	-0.40
1998	1,466	-1.15	336	-8.94	306	-1.92	172	-3.37	645	-1.07	2,925	-2.30
1999	1,440	-1.77	364	8.33	288	-5.88	190	10.47	671	4.03	2,953	0.96
Average annual Growth rates		0.15 %				-1.14 %		-1.22 %		0.23 %		-0.1 %

Source: Food and Agricultural Organization of the United Nation, (FAO). FAO Food Balance Sheet.

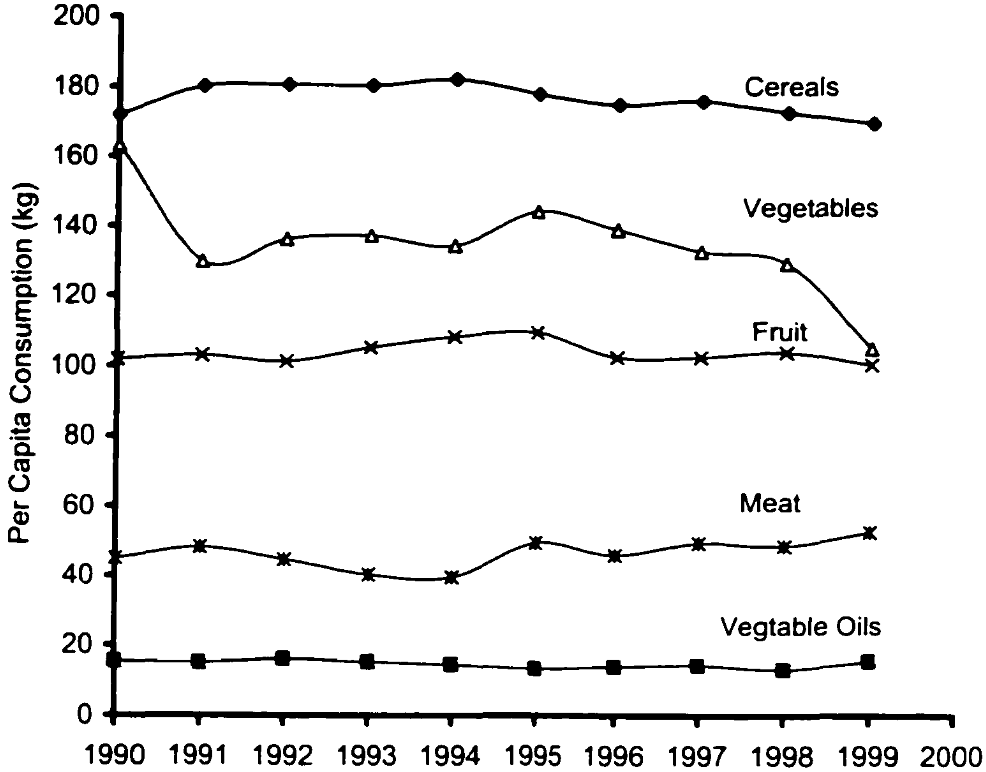


Figure 2-1: Per Capita Consumption of Selected Food Products in Saudi Arabia 1990-1999

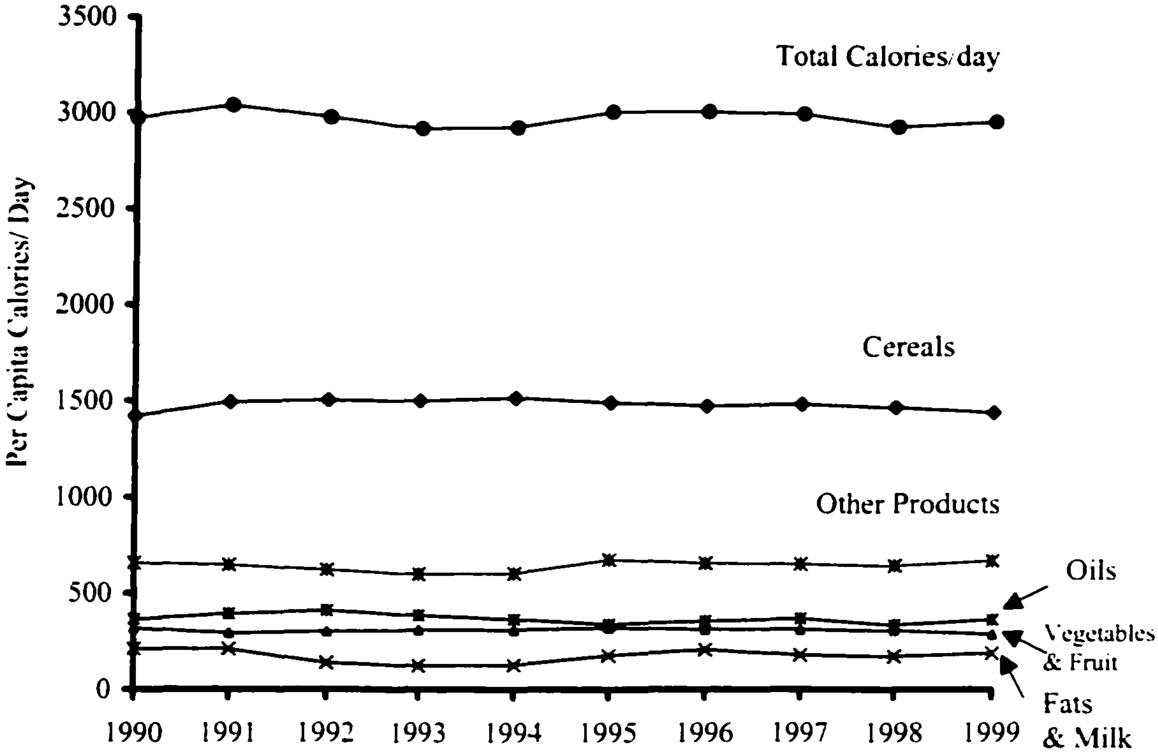


Figure 2-2: Per Capita Calories/Day in Saudi Arabia 1990-1999

2.5 Agricultural Imports

Agricultural imports have varied in quantity and quality during recent years. As in most countries, Saudi Arabia could not reach self-sufficiency in all products due to comparative advantage issues. There are some constraints, such as climate and resource availability, which make the country unable to cover all food demand.

As a result of governmental support for the agricultural sector, the annual rate of agricultural food imports and other products has varied over time. In 1990, agricultural import's share of total import value was about 14%. During the period 1991-1994, this share decreased to 12% due to the effect of Gulf War on national income. The change in agricultural policy at the end of this time as a response to water shortages increased the share of agricultural imports to 17% of total import values during 1995-2000. At the same time, table 2-7 shows that the average annual growth rate of agricultural imports was more than that for total imports.

The import quantity of food products increased during the period 1990-2000 by 2.1 million tons, or 22%, from 9.3 to 11.4 million tons. Cereals' average share of total imports was 58.5% during 1990-1999. The average shares for oil crops and vegetable oils, vegetables and fruit, animal fats, meat, and milk, and other products were 3.6%, 15.1%, 12.75%, and 10.05%, respectively as seen in table 2-8. The reason for high cereal quantity imports is the importation of large quantities of barley, which represents the largest part of feed for traditional and specialized animal production projects.

The cereals, oil crops and vegetable oils, vegetables and fruit, animal fats and milk, and other products growth rates were volatile during the same period with annual growth of 3.35%, 3%, -0.1%, -0.13%, and 2.57%, respectively as shown in table 2-9.

The reasons behind the increasing growth rate of cereals include the effects of policy directed at wheat reduction, combined with the increasing demand for barley as a livestock feed. Oil crops and vegetables oils grew at 3% during this period, due to both added demand and low production. Vegetables and fruit imports have decreased by 0.1% during this period because of increased local production and decline in local demand. The same happened to animal fats, meat, and milk group. Other products' quantity imported has increased by 2.57%, which is largely due to increasing demand for tobacco. In general, the quantities imported of all groups are variable during the period except for vegetables and fruits, which may give insights to the likely effects of income change.

The value of total agricultural imports increased by 16% during the 1990-1998 period. The cereals import value, which represents an average of 26% of total import value, increased by 39%. Meat and dairy, fruit and vegetables, and animal fats and vegetable oils represent on average 20%, 14%, and 10% of total import value, respectively, and have increased by 20%, 26%, and 57% while other products' value, which represent 30% of total import value, has deceased by 15% table 2-10.

Table 2-7: Agricultural Import Share in Total Country Imports 1990-2000 (Million Riyals)

Year	Total Imports	Growth Rate %	Agricultural imports	Growth Rate %	Agricultural imports as % of total imports
1990	90.282		12.760		14.13%
1991	108.934	20.66	14.202	11.30	13.04%
1992	124.606	14.39	13.226	-6.87	10.61%
1993	105.616	-15.24	11.450	-13.43	10.84%
1994	87.449	-17.20	11.316	-1.17	12.94%
1995	105.187	20.28	17.171	51.74	16.32%
1996	103.980	-1.15	17.956	4.57	17.27%
1997	107.643	3.52	18.748	4.41	17.42%
1998	112.397	4.42	17.616	-6.04	15.67%
1999	104.980	-6.60	18.072	2.59	17.21%
2000	113.240	7.87	20.310	12.38	17.94%
Average annual Growth rates		2.27 %		4.65 %	

Source: Central Department of Statistics Ministry of Finance and National Economy, Saudi Arabia.

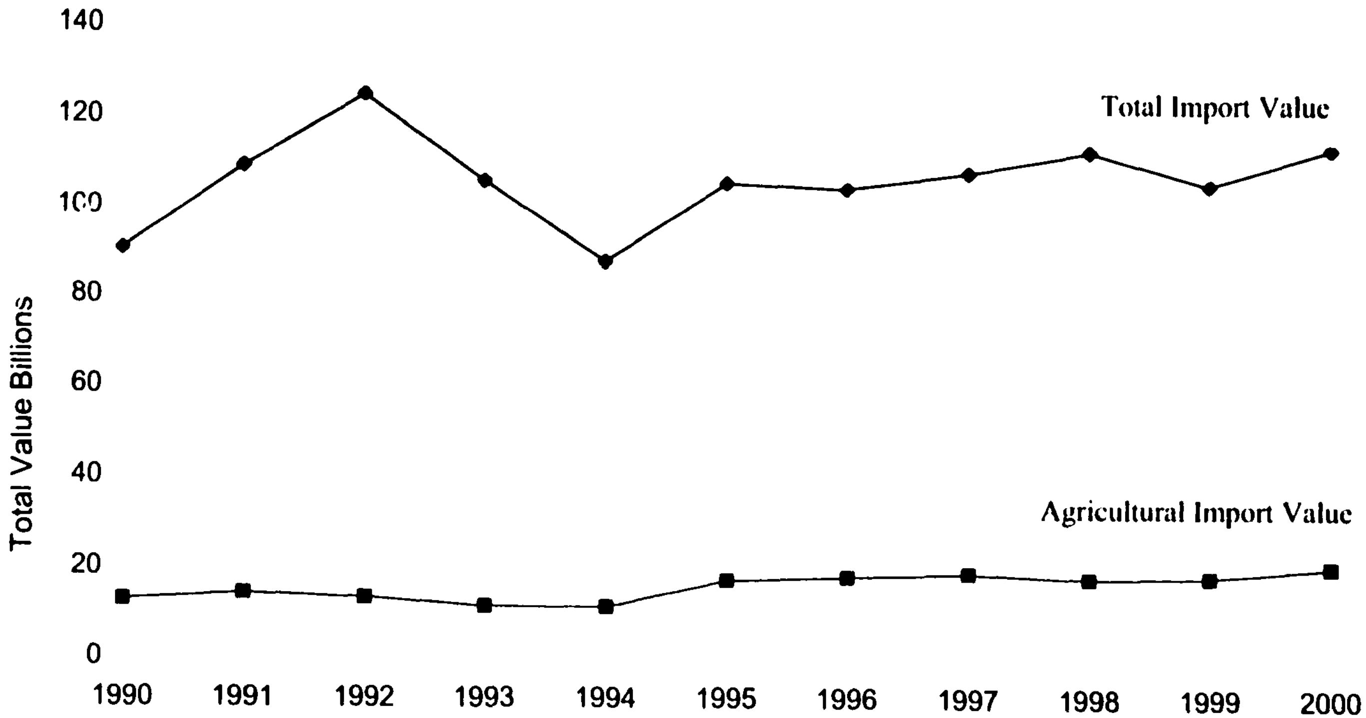


Figure 2-3: Saudi Arabian Total Import Value (Million$) 1990-2000

Table 2-8: Saudi Arabian Agricultural Import Quantity Groups and Share (1000 Tons) 1990-1999

Year	Cereals	% Of Total	Oil Crops Vegetable Oils	% Of Total	Vegetables & Fruit	% Of Total	Animal, Meat Fats, Milk	% Of Total	Other Products	% Of Total	Total
1990	5,001	53.95	320	3.45	1,474	15.90	1,595	17.21	879	9.48	9,269
1991	5,243	54.64	383	3.99	1,449	15.10	1,593	16.65	928	9.67	9,596
1992	6,899	66.08	379	3.63	1,424	13.64	817	7.83	921	8.82	10,440
1993	3,805	53.13	327	4.57	1,472	20.55	677	9.45	881	12.30	7,162
1994	6,290	65.41	289	3.01	1,458	15.16	654	6.80	926	9.63	9,617
1995	5,776	58.23	389	3.92	1,487	14.99	1,305	13.16	962	9.70	9,919
1996	5,987	56.13	342	3.21	1,438	13.48	1,745	16.36	1,154	10.82	10,666
1997	7,135	62.86	389	3.43	1,418	12.49	1,383	12.19	1,025	9.03	11,350
1998	5,429	55.33	349	3.56	1,611	16.42	1,368	13.94	1,055	10.75	9,812
1999	6,759	59.67	419	3.70	1,466	12.94	1,576	13.91	1,108	9.78	11,328

Source: Food and Agricultural Organization of the United Nation, (FAO). FAO Food Balance Sheet.

Table 2-9: Saudi Arabian Total Agricultural Import Quantity (1000 Tons) and Growth Rates 1990-1999

Year	Cereals	Growth Rate %	Oil crops Vegetable Oils	Growth Rate %	Vegetables Fruit	Growth Rate %	Animal, Meat, Fats Milk	Growth Rate %	Other Products	Growth Rate %	Total	Growth Rate %
1990	5,001	--	320	--	1474	--	1595	--	879	--	9,269	--
1991	5,243	4.84	383	19.69	1449	-1.70	1593	-0.13	928	5.58	9,596	3.53
1992	6,899	31.58	379	-1.04	1424	-1.73	817	-48.71	921	-0.75	10,440	8.80
1993	3,805	-44.85	327	-13.72	1472	3.37	677	-17.13	881	-4.34	7,162	-31.40
1994	6,290	65.31	289	-11.62	1458	-0.95	654	-3.40	926	5.12	9,617	34.28
1995	5,776	-8.17	389	34.60	1487	1.99	1305	99.54	962	3.89	9,919	3.14
1996	5,987	3.65	342	-12.08	1438	-3.30	1745	33.72	1154	19.96	10,666	7.53
1997	7,135	19.17	389	13.74	1418	-1.39	1383	-20.75	1025	-11.18	11,350	6.41
1998	5,429	-23.91	349	-10.28	1611	13.61	1368	-1.10	1055	2.93	9,812	-13.55
1999	6,759	24.50	419	20.06	1466	-9.00	1576	15.21	1108	5.02	11,328	15.45
Average annual Growth rates		3.35 %		3.0 %		-0.1%		-0.13%		2.57%		2.23 %

Source: Food and Agricultural Organization of the United Nation, (FAO). FAO Food Balance Sheet.

Table 2-10: Saudi Arabian Agricultural Import Values ($1000) 1990-1999

Year	Total Value	Meat, Dairy	% From Total	Fruit, Vegetables	% From Total	Animal, Fats Vegetable Oil	% From Total	Cereals	% From Total	Other Products	% From Total
1990	3,960,977	874,735	0.22	553,010	0.14	298,481	0.08	872,396	0.22	1,362,355	0.34
1991	4,336,806	1,030,394	0.24	607,701	0.14	384,676	0.09	845,988	0.20	1,468,047	0.34
1992	3,662,597	624,507	0.17	510,835	0.14	409,528	0.11	1,166,123	0.32	951,604	0.26
1993	3,418,775	498,616	0.15	561,129	0.16	329,020	0.10	793,867	0.23	1,236,143	0.36
1994	3,123,408	473,785	0.15	548,715	0.18	347,862	0.11	887,793	0.28	865,253	0.28
1995	4,481,753	991,922	0.22	643,949	0.14	497,259	0.11	1,112,532	0.25	1,236,091	0.28
1996	4,740,872	1,152,349	0.24	628,686	0.13	411,659	0.09	1,385,992	0.29	1,162,186	0.25
1997	4,893,623	986,740	0.20	634,455	0.13	354,908	0.07	1,531,430	0.31	1,386,090	0.28
1998	4,583,051	1,053,347	0.23	698,524	0.15	470,011	0.10	1,208,826	0.26	1,152,343	0.25
Average annual Growth rates	1.62 %	2.1 %	0.2	2.6 %	0.14	5.1 %	0.10	3.62 %	0.26	-1.86 %	0.30

Source: Food and Agricultural Organization of the United Nation, (FAO). FAO trade yearbook.

2.6 WTO and Saudi Agriculture

Saudi Arabia has been going through procedures for accession to the World Trade Organization (WTO). Admission to the body, which will be the dominant force in international commercial and economic relations in the future, is expected to have benefits for other countries as well as for Saudi Arabia itself. Also the WTO negotiations would affect all economies whether they join WTO or not.

In 1993, prior to the launch of the WTO, Saudi Arabia had applied to join GATT and had attended its meetings as an observer. With the establishment of the WTO, Saudi Arabia has focused its efforts on joining this organization. A number of steps have been taken to comply with requirements. These include the introduction of a new code for taxing foreign invested capital, revision of regulations on sponsorship law and a change in the law for ownership of real estate by resident foreigners. Opening the door to investment by foreigners should bring new technologies that will enhance skills by training Saudi labor. This also will lead Saudi Arabia's products to being competitive in domestic, regional and international markets.

The effects of joining WTO on the Saudi agricultural sector will emerge in different ways. Reduced local support as well as lower import customs duties will have an effect. The expected effect of this reduced support on the Saudi agricultural sector will be an increase in input prices, combined with a decrease in local output prices. This will increase the level of competition between producers and encourage the local agricultural sector to produce according to competitive advantage. In the same way, food imports are expected to increase in quantity and value as a result of increases in the domestic prices.

Moreover, in addition to expected internal effects from joining WTO, external effects will emerge as well. Diao, Somwaru, and Roe (2001) show that removing trade barriers, subsidies and other trade distorting forms of support will cause the aggregate world price of agricultural commodities to rise by almost 12 percent. The percent change in world commodity prices will be 22 percent for livestock and products, 18 percent for wheat, 15 percent for other grains, 14 percent for sugar, 11 percent for oil and oilseeds, 10 percent for rice, 8 percent for vegetables and fruits and processed food, and 6 percent for other crops. As Saudi Arabia imports most of these commodities, there will certainly be changes in the agricultural sector in Saudi Arabia.

A study done by the Department of Agricultural Economics, King Saud University, Saudi Arabia, 1995, showed the estimated effects joining WTO would have on the agricultural sector. The study discussed effects on world prices and the volume of world supply, demand and trade, and then evaluated the effect of these changes on Saudi agriculture, including influences on local agricultural production, agricultural external trade, the government budget, and local agricultural resources. In addition, the analyses evaluated the micro effect of WTO on agricultural producers and consumers, along with government revenues and expenses. The total effect on economic structure and social welfare was evaluated using different econometric models.

Producers allocate resources between different products according to prices, which may be affected by government intervention and local support for agricultural production, which was reflected in low input prices and high output prices. The expected change in agricultural input and output prices were assessed in this study, with this support being reduced. The comparison was made assuming input is produced locally or imported from other countries, which reflects its correlation with world market changes. For example, the retail price of wheat was expected to increase from 1080 SR/ton in 1992-1994 to 1174 SR/ton in 2002-2004.

To determine the net effect of the WTO impact on the agricultural sector, the analysis was done as if Saudi Arabia were to join the WTO, which was then compared with a "status quo" scenario in which Saudi remains out of the WTO. These estimations were determined by dividing agricultural goods into groups reflecting the importance of the good in the agricultural sector, the good's value, area or subsidy criteria, the importance of the good in agricultural trade based on import and export values, and the importance of the good in the consumption sector, depending on self-sufficiency criteria. Using these criteria, 21 goods were chosen and divided into seven groups: grains (wheat, barley, rice); vegetables (tomatoes, potatoes, onion); fruit (dates, citrus, bananas, apples, grapes); red meats (sheep and goats, beef, camels); poultry (chicken, eggs); milk (fresh, powder) and sugar, tea and coffee.

In the study, different analytical techniques were utilized. Forecasting techniques like double exponential smoothing and autoregressive integrated moving average (ARIMA) were used to forecast the time series variables. Ordinary least squares in different forms (linear, double logarithm, one side logarithm, exponential) were used to estimate the effect of prices and other related variables on production quantity, consumption, exports, imports and crop areas. Classical welfare analysis was used to estimate the effect of Saudi Arabia joining the WTO on production, consumption and trade of agricultural goods in addition to consumer surplus, producer's surplus, social welfare, government expenditure, government revenues, customs duties, import bill, and subsidy expenses. Comparative statistic analyses were used to compare the possible outcomes in two time periods. The average of 1992-1994 was used as a base period and was then forecasted to 2002-2004 as a comparison period. The study assumed that local prices would respond at the same rate as the world prices, and the study forecasted world prices for major commodities.

The results obtained from this study showed that the production of wheat, barley and eggs were expected to decrease between the base period and the comparison period by 18.12%, 1.36%, and 7.5% respectively. These declines could be variously attributed to support reduction on wheat production, lower import prices for barley and stable egg prices combined with over-production. At the same time, as illustrated in figure 2- 4, the production of tomatoes, potatoes, onion, dates, grapes, sheep and goats meat, beef meat, chicken meat and fresh milk would increase by 49.49%, 32.25%, 32.22%, 25.7%, 17.02%, 18%, 46%, 50.2%, and 25.2%, respectively, due to continued increases in onion, tomatoes, and potatoes prices; an expected increase in date prices and beef meat wholesale prices; changes in world prices for chicken meat combined with unchanged support for inputs; and unchanged support directed to milk production inputs but with an increase in milk prices over time.

Moreover, the imports of rice, tomatoes, potatoes, chicken meat, and powdered milk are expected to decrease by 9.89%, 21.57%, 45.64%, 16.7%, and 61.13% respectively due to an increase in rice import prices, increase local tomato and potato production, slight decrease in per capita consumption of chicken combined with increases in local production; while the imports of onions, citrus, bananas, apples, grapes, sheep and goats meats, beef meat, sugar, tea, coffee, were expected to increase by 11.04%,

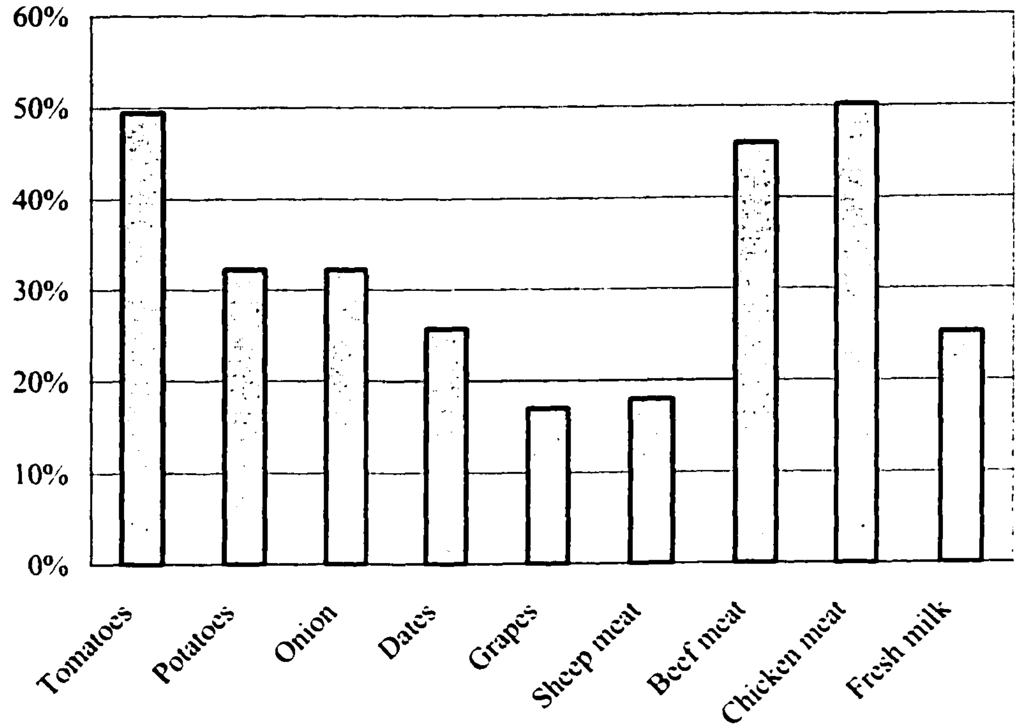


Figure 2-4: Expected Percentage Increase in Saudi Arabia Local Agricultural Production

19.02%, 5.5%, 8.6%, 79.03%, 85%. 30%, 9.58%, 30.59%, and 36.54% respectively because of increased demand and a shortage in local production of onions; citrus, apples, and grapes increase in local prices of sheep and goats meats, no local production (net importer) sugar, tea, and coffee.

With regard to the area planted, the results expected a decrease in the total cropped area by 8.33% between two periods due to the reduction in wheat area and small increases in the other products areas. This reduction would cut water requirements by 1.98%.

The agricultural production value was expected to increase by 37.67%. However, living costs are expected to increase due to an increase in goods prices, compared with an increased import bill by (38.66%), because of increased import demand. The government's revenue from custom's duties should also increase.

While the objectives are close to this study, data and estimation methods used are quite different. In the research reported in this thesis, import demand is estimated by different demand systems using import data. Using the results obtained, local demand is determined, and a model that contains integrated analyses of imports, local demand, and local supply is used to estimate the effects of world price changes simultaneously. Simulations using the model developed are done under different policy scenarios. The King Saud study thus provides a good comparison but with very different methods.

2.7 Water Issues in Saudi Arabia

Saudi Arabia falls in a tropical and sub-tropical region. It has low average annual rainfall, high evaporation, and limited surface and groundwater, as well as high living standards and population growth. The annual rainfall varies between regions. In the north. annual rainfall ranges between 100 and 200 mm. In the south. except near the coast. annual rainfall drops below 100 mm. alternatively the higher elevation in the west and south experience appreciable rainfall. Total precipitation is equal to 59 mm per year over the whole country. This rainfall. which is the source of surface water. has been estimated at 2.2 km^3 per year. Most of it (about 1 km^3) goes to recharge aquifers.

The total groundwater reserves have been estimated at about 500 km^3. of which 340 km^3 can be extracted probably at an acceptable cost in view of the economic conditions of the country.

The country is experiencing an imbalance between increasing water demand and existing limited resources. The challenges imposed by the climate. geography. increased population. economic activity. improvement in standards of living. efforts to establish self-sufficiency in food. and promotion of industrial development have resulted in accelerating pressure on the government to provide water. Due to the lack of natural water resources. the deficit is being met through sea water desalining and mining of groundwater resources. Thus far. 57 desalination plans have been constructed along the Red Sea and the Arabian Gulf Coasts.

The water demand is allocated between domestic. industrial and agricultural uses. Domestic and industrial water requirements are satisfied through desalining and a limited amount of groundwater from both shallow and deep aquifers. while agricultural requirements are met through water from shallow alluvial and deep aquifers. Agricultural water demand had sharply increased as a direct result of government policies encouraging self-sufficiency in food production. These government incentives and subsidies have made it possible for large areas to be cultivated, placing great strain on existing groundwater resources.

Total water demand for agricultural, industrial, and domestic purposes for the country has increased over time. A study done by Mohammed Abdulrazzak in 1997 shows that the water requirements for all sectors was 16.3 km^3 in 1990 and is expected to reach 17.765 km^3 and 24.2 km^3in 2000 and 2025, respectively.

The agricultural sector accounts for the majority of water use, followed by the domestic sector. The percentages of agricultural water demand are estimated to be 89.6%, 84.4%, and 67.4% of total demand during 1990, 2000, and 2025 respectively as a result of the production decline and increase in other uses. Likewise, the industrial percentages of water demand are estimated to be 1.2%, 2.3%, and 6.0% during 1990, 2000, and 2025 respectively while percentages of domestic demand are 9.3%, 13.2% and 26.7%, because of the growth in population.

The government involvement in the agricultural sector, with the support of heavy subsidies, has resulted in a production increase for different products. Despite this success, this policy is a threat to the country's water resources. As a result of this development in agriculture, which is the largest water user, the depletion of leftover ground water takes place at very fast rates and the extensive pumping of groundwater has resulted in a significant drop in the water level, requiring deeper and larger holes to be drilled in addition to a change in water quality. At the 1990 rate of use, it is estimated that usable water resources will last for a maximum of 20 to 25 years, but because of significant growth in demand from population growth and industrial uses, this time span could even be shorter.

These observations have led policy makers and development planners to take steps in the way of water conservation. The subsidies for wheat, which consumes the most water, have been reduced and other changes have been introduced to reduce agricultural water requirements. One way of reducing the use of water requirements would be to raise the price of water via taxation. This expected policy will be investigated in this research through different simulations and the simulated impacts will be presented in Chapter 6.

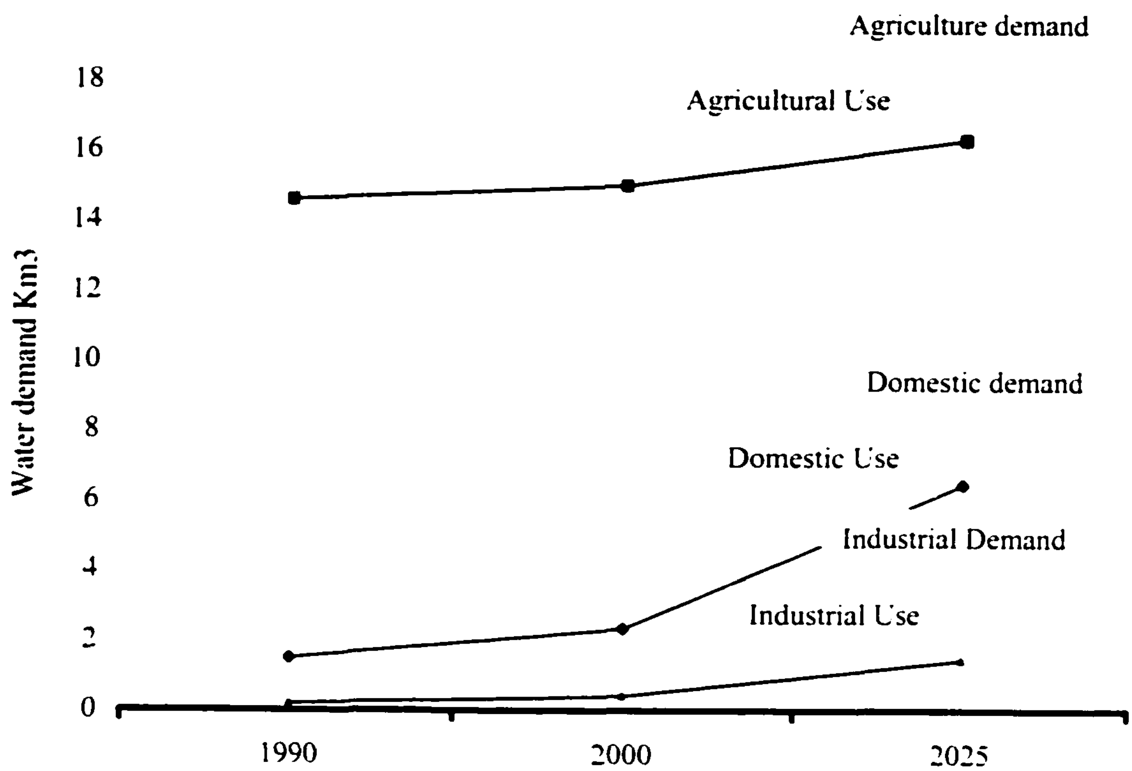


Figure 2-5: Past and Projected Water Demand in Saudi Arabia

2.8 Conclusion

The Saudi Arabian agricultural sector saw several different policy regimes during recent decades. There were policies directed at this sector that led to its development but this development has had side effects on the country's resources. The level of groundwater usage decreased dramatically, and in addition, there was increased environmental pollution. During recent years, the government established rules as a response to these effects. The subsidies have been reduced or eliminated and the production quota programs have been issued for the products that consume high levels of water, such as wheat. Secondly, the demand for food is increasing over time because of high population growth, which will continue to increase substantially, as more than half the country's population is under 25 years of age. Other factors driving demand are high-income levels, urbanization, pilgrims, and the non-Saudi population.

The combination of increasing demand for food and decreasing resources for agriculture will affect the country's capacity to meet its consumption needs. The expected entrance to WTO will add to the challenges that producers face in meeting demand for more and different foods. As a result, food and agricultural imports will increase over time and agricultural production should decline.

These facts show the importance of studying and analyzing food demand, supply and importing. The estimation of price and income elasticities will be helpful tools, which can be used by planners and policymakers to draw up future agricultural policy and evaluate import trends.

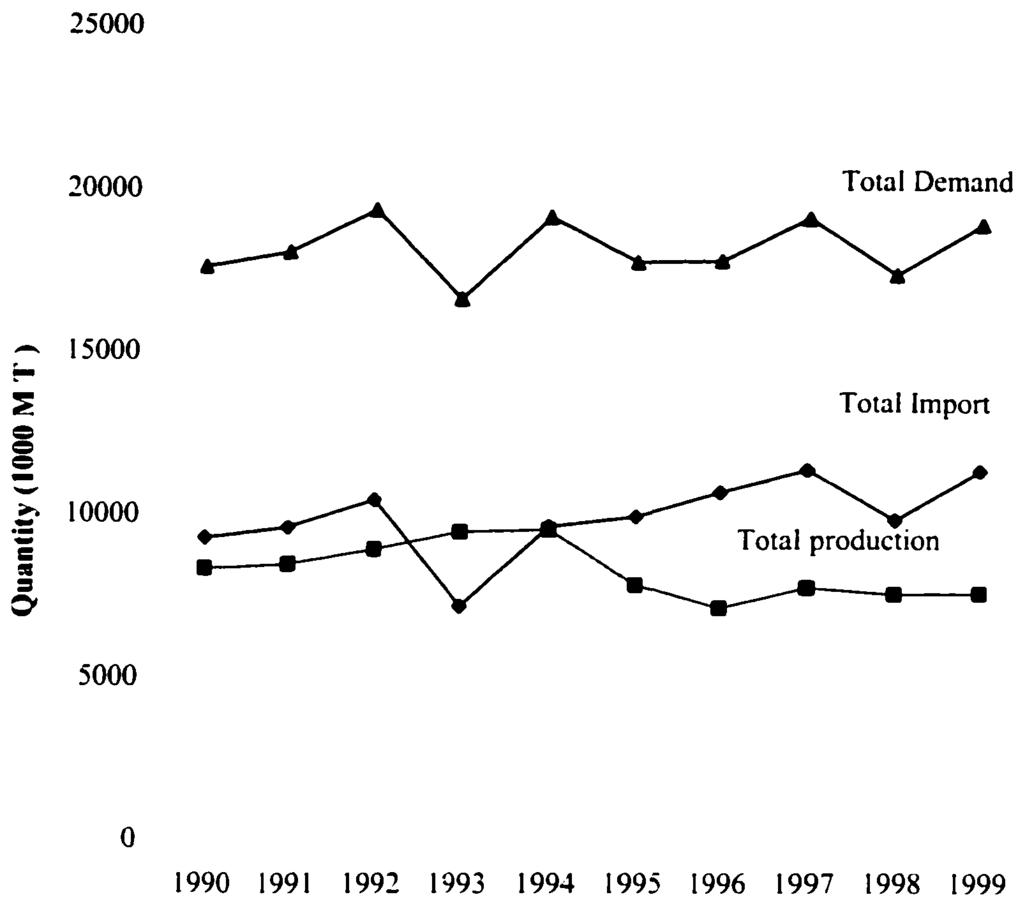


Figure 2-6: Saudi Arabia Total Agricultural Imports and Production Quantities 1990-1999

CHAPTER III

LITERATURE REVIEW

This chapter reviews the previous studies on import demand related to this research. It is divided into four parts. The first part explores Saudi Arabian demand estimations that have been done, while the second part reviews import demand estimation for a number of countries. The third part discusses demand systems specifications and the fourth part summarizes the results from the previous parts.

3.1 Saudi Arabia Demand Estimation

Mohammed (1988) estimated consumption demand for selected food commodities in Saudi Arabia. This study investigated the consumption and income relation, or the Engle curve relationship, for thirteen food commodities in Saudi Arabia. The study separated the commodities into four groups: staple foods, a meat group, fresh fruit, and fresh vegetables, based on the texture characteristics, marketing periods and the taste of the products. Estimations under constant and declining income elasticity models were made within the group using time series data for the 24-year period 1963-1986. The homogeneity and Slutsky restrictions were imposed. The results indicated that food consumption was affected by income level, with varying effects among individual food commodities. The study was used to estimate income and price elasticities and estimate equations for demand projections of major commodities up to 1993.

Kahtani (1989) investigated a complete food commodity demand system for Saudi Arabia with projections and policy applications for wheat. The study estimated three complete demand systems for Saudi Arabia and evaluated government policies in the wheat market. The first system is an 11-sector model based on the social accounting matrix. The second system is for 6 aggregated food commodity groups and one nonfood group. The third system was disaggregated to 26 foods and one nonfood commodity. The demand price and income elasticities were estimated within food groups and across groups. The food projections were made to 1995 under different assumptions. The results showed that the differences in demand parameters and price trends led to different growth rates. The welfare analysis indicated a transfer of income to consumers from producers.

Al-Kheraiji (1994) estimated a demand system analysis for meat consumption in Saudi Arabia. The objective of the study was to estimate relationships among meat and fish groups using annual data for the period 1968 to 1992. The Rotterdam System and the Almost Ideal Demand Systems (AIDS) were used to estimate these patterns. The results showed that the compensated own-price elasticities estimated from the LA/AIDS for meat groups are negative, while expenditure elasticities indicated that chicken and lamb are luxury goods. In addition, demand for chicken and lamb imports were studied using annual data for the period 1971 to 1992. The results indicated the appropriateness of using the LA/AIDS models to study these imports, an elastic demand for chicken and lamb imports, and the existence of complementarity and substitution relationships among chicken and lamb imports. The projection has been done for total meat demand, individual type of meat demand and imported chicken and lamb by import source to the year 2000.

Doroodian, Koshal and Al-Muhanna (1994) examined a traditional aggregate import demand function for Saudi Arabia using annual data for the period 1963-1990.

Traditional formulation of the import demand function was used where total quantity of imports was determined as a function of the real gross domestic product, import prices index and the domestic price level. The log-linear and linear forms were specified for the import demand function. The econometric evidence shows the log-linear formulation is more appropriate than the linear one. The empirical results show that the relative price formulation of the traditional import demand function is inappropriate for estimating elasticities of import demand. The income elasticity in the long run was found to be inelastic. Therefore, imports are treated as necessary goods in Saudi Arabia. In addition, the results indicate a large response of import quantities to changes in the import and import competing prices in the long run. Furthermore, consumers tend to be more responsive to a change in the price of domestic goods than to an equal change in import prices. Finally, the large price elasticities for imports could be a sign that Saudi Arabia has made progress in developing import-substitution industries.

From these previous studies for Saudi Arabian imports, it is seem that the main objectives and results were related to price and expenditure elasticites. In addition, projections were made using these obtained results. None of these studies used differential demand systems as a methodology of estimation nor did they use results to estimate local demand with import data or look at supply issues. Moreover, linkages between import demand, local demand and local production have not studied.

3.2 Import Demand Estimation for Selected Countries

In this section, the literature of import demand estimations that have been done for other countries are reviewed. Yadvan (1975) studied a quarterly model of the Canadian demand for imports. The objective was to estimate the import demand function at a relatively disaggregated level for the period 1956-1972 with attention to the process of lagged adjustment. The study used an ad hoc demand function, where the imported demand for any particular good is a function of the level of real income and the ratio of foreign to domestic prices of the good. The results showed that the use of a relatively simple partial flow adjustment model explained a considerable proportion of the variance in the Canadian volume of imports demanded. The adjustment lags have been found to be statistically significant, which means that less than half of the adjustment between the actual and long run demand for imports occurs in the first quarter. The price and income elasticities were estimated. The assumption of the absence of illusion in the aggregate import demand function was not rejected.

Arize and Afifi (1985) studied a demand system for imports in twenty-seven African countries using a simultaneous equation model to determine whether there is evidence of structural change during the period from 1960 to 1982. The traditional formulation of an aggregate import demand equation relates the real quantity of imports demanded by a country to the ratio of import prices to domestic prices and domestic real income. The relative price and income elasticities were estimated to present empirical evidence of the structural change. The results showed the instability of the import demand functions for all African countries.

Sarmad (1989) analyzed the determinants of import demand in Pakistan. The objective was to specify and estimate import demand functions for the years from 1959-1960 to 1985-86. The functional form of the import equation was determined empirically. The results show that there is strong evidence to support the use of the log-linear form as the appropriate functional form of the import equation, both at the aggregate and disaggregate levels. The income elasticities were greater than one while the relative price elasticities were less than one. The results show that the policy of devaluation or of raising tariffs would not be effective to reduce imports or to affect the balance of trade because of inelastic import demand. The critical dependence on imports has continued with the problem likely being due to domestic structural or supply deficiencies.

Seale, Sparks, and Buxton (1992) discussed the Rotterdam application to international trade in fresh apples. The model was used to fit import data for fresh apples in four importing markets important to U.S. apple exports. The geographic import demand system for fresh imported apples in Canada, Hong Kong, Singapore, and U.K. was estimated. A utility tree approach was chosen by which a country first allocates total income between domestic and imported goods. Nested tests rejected homothecity but could not reject homogeneity, symmetry, or separability among imported apple suppliers. A Monte Carlo test rejected first order autocorrelation. The results indicate that all apple suppliers to these countries should increase apple exports if expenditure for imported fresh apples in these markets increases. The expenditure was more elastic for U.S. apples in Hong Kong, Singapore, and U.K. markets but just unitary elastic in the Canadian market.

Guan, Boey, and Chong (1996) applied a demand system specification to estimate Singapore's import demand function. Use of the homogeneity zero restriction was employed to yield efficient estimators in the presence of simultaneity bias as well as measurement error and omitted variables. The trade data was used to estimate the import demand function via the alternative methodology, which is taking the first difference for the log-linear function and estimating it using OLS. The alternative methodology was found to be significantly better than those obtained using the traditional log-linear methodology.

Pantzios and Fousekis (1999) analyzed Greek meat and dairy import demand. The study attempted a comprehensive demand analysis to empirically analyze meat and dairy imports during the last three decades (1961-1995) in light of recent methodological developments. Seven equation demand systems with total agricultural imports of beef, poultry, mutton and goat, pork and sausage, cheese, butter, and dry and concentrated milk were specified. Statistical procedures have been proposed which allow selection of the correct model among competing demand systems. The Rotterdam, the CBS, the NBR and the AIDS models, which are called differential consumer demand systems, were estimated using maximum likelihood methods with and without imposing standard homogeneity and symmetry restrictions. The results obtained suggest meat and dairy in Greece are not separable in the country's expenditure budget, and that meat imports are elastic with respect to a change in the expenditures allocated to purchasing of imported meat and dairy. However, dairy imports do not show a significant response to change in the expenditure allocated to them. The test for own and cross price changes showed that the change in relative import prices among meat would redistribute imports between beef, mutton and goats, while cheese is the most responsive of dairy imports. The cross relationships indicate that changes in the relative import price between meat and dairy would redistribute imports between beef and dairy (cheese and butter) by only a small amount.

Janda, McCluskey and Rausser (2000) studied food import demand in the Czech Republic. Their objective was to describe food import demand and to create a set of import demand elasticity estimates that could be used in economic analysis and in building structural models of the Czech economy. They tried to obtain estimations that are not dependent on some special structure of a single international trade model of some specified class, so they used demand functions belonging to the class of flexible functional forms. The study utilized the AIDS demand system approach with inclusion of economic theory restrictions of homogeneity, symmetry, and negativity. Their estimation was based on the assumption that the Czech Republic is a small economy, so import prices and agricultural products are exogenous. They estimated the own-price, cross price and group expenditure elasticities. The estimation results were reasonable and all food commodities were found to be normal goods with positive group expenditure elasticities. The maximum likelihood method was used to estimate these relations with bimonthly time series data. The time trend was incorporated as a proxy for demographic and taste changes during the sample period, but the results did not yield a significant trend variable.

Regmi, Seale, and Bernstein (2001) studied international evidence on food consumption patterns. The study examines how changing incomes and prices affect changes in food expenditure for a cross-section of countries, ranging from low to middle and high income. In addition to analyzing the effect on total food demand, the study examines the effect of income and price changes on expenditures of individual food sub-groups. A two-stage demand system was used, in which consumers are first assumed to make budget choices over broad consumption categories and a weak separability among items within a broad group is assumed. The model stages have been estimated by using the maximum likelihood estimation procedure. The results showed that the low-income countries spend a greater portion of their budget on necessities such as food, while richer countries spend a greater proportion of their income on luxuries. Low value staples, such as cereals, account for a larger share of the food budget in poorer countries, while high value food items such as beverages, dairy and meat are a larger share of the food budget in richer countries. The results also indicate that price changes of staple food may result in the greatest responses in middle-income countries.

Schmitz and Seale (2002) analyzed the import demand for disaggregated fresh fruit in Japan using annual data from 1971-1997. The study analyzed the import patterns of Japan's seven most popular fresh fruits by implementing and testing a general differential demand system that nests four alternatives, Rotterdam, AIDS, CBS, and NBR. The test was done using five goods (bananas, grapefruits, oranges, and lemons and aggregating pineapples, berries, and grapes) and six goods (bananas, grapefruits, oranges, lemons, pineapples, and aggregating berries and grapes). In the case of five goods the AIDS and NBR were rejected, while in the case of the six good model, the AIDS, NBR, and CBS were rejected. The elasticities of expenditure, own-price and cross price were estimated. All the expenditure elasticities, in the six good cases, are positive and significant with the exception of the others category. The Slutsky price elasticities were also estimated. The own-price elasticities were all negative and significant and the cross price elasticities were also estimated. The results indicated that if Japanese consumers were to increase their budget, then consumption of grapefruits and pineapples would rise. On the other hand, if Japanese consumers were to decrease their expenditures on fresh fruit imports, they would spend a large portion of their expenditure on bananas, oranges, and lemons.

3.3 Demand Systems Specifications

This section reviews the literature about demand systems and methods of estimation that have been used in the literature. Theil (1965), in his article "The Information Approach to Demand Analysis", demonstrated demand analysis in a probabilistic manner. The paper discussed the usefulness of information theory for demand systems. It stresses that value shares, like probabilities, should be nonnegative and add up to one. On the other hand, under the usual assumption of given prices and income, knowledge of value shares implies and is implied by knowledge of quantities. Therefore, the classical analysis in terms of the quantities is equivalent to an analysis in terms of the shares where the w_i is the share of the i th commodity.

Barten (1969) utilized maximum likelihood estimation for a complete system of demand equations. The objective of the study was to estimate a system of demand equations under various constraints with respect to the coefficients of the system. He considered different versions of a relatively large system (16 equations) and arrived at a first test of the empirical validity of a number of widely used restrictions on demand equations based on utility theory. The data used consisted of time series on expenditure and prices for sixteen groups of commodities for the Netherlands in the periods 1922-1939 and 1949-1962. The maximum likelihood method was chosen for estimation and it was justified.

Lee, Brown and Seale (1992) investigated demand relationships among fresh fruit and juices in Canada using the differential approach for the time period from 1960 through 1987. The Rotterdam model and the CBS model were used with the usual theory restrictions. The models were estimated by the maximum likelihood method and the results indicated that if Canadian consumers were to allocate a larger portion of their budgets to the consumption of fresh fruit and juices, expenditure shares on oranges, apples, orange juices, and apple juice would increase. The own-price elasticities for apple and apple juice are smaller than unity. The study results also indicate that oranges and grapefruit are substitutes for apples, so an increase in the price of fresh apples would increase the consumption of citrus, thus increasing citrus imports.

Alston and Chalfant (1993) discussed and compared the Almost Ideal and Rotterdam models. Agricultural economists have adopted these two systems during the past decade in food demand applications because they are attractive for a variety of reasons. Flexibility, compatibility with demand theory, ease of use, familiarity and plausibility are the main attributes for these models. Tests to distinguish econometrically between both systems have been specified and applied to the demand for meat. In this particular case, the test rejected the linear approximation of the AIDS model but not the Rotterdam; this may yield other conclusions with other data sets. The test can be used to choose between other systems where alternative models involve the same right hand side variables but there exist different dependent variables.

Barten (1993) illustrated choice of functional form for consumer allocation models to satisfy theoretical properties derived from the theory of consumer demand. Four approaches, Almost Ideal Demand System (AIDS), the Dutch Central Bureau of Statistics (CBS), the National Bureau of Research (NBR), and the Rotterdam models, have been formed to meet these conditions. An empirical analyses these models were applied for the Netherlands consumer expenditure and corresponding prices over the period 1921-1981 where the original data for 16 groups and services were aggregated into four major groups, namely food, leisure goods, durables and a remainder set. The systems are nested in a more general model using scalar weights and tested using the likelihood ratio test statistic. The CBS model has been chosen to fit this data due to its superior performance. Another alternative in the testing set-up was a combination of all four systems, which nests combinations of two or three of those systems and choosing among them based on likelihood ratio test.

Neves (1994), in his paper "A Class of Differential Demand Systems", discussed the theoretical performance of differential demand systems (the Rotterdam, Almost Ideal Demand system (AIDS), CBS, and NBR). The restrictions that they impose on the evaluation of demand elasticities over time were illustrated and compared theoretically.

Neves (1993) compared the empirical performance of alternative differential demand systems, the Rotterdam, Almost Ideal Demand system, CBS and NBR. These models constitute alternative parameterizations of the budget differential equation. As far as the evolution of elasticities over time is concerned, the NBR model is the least restrictive parameterization. Portugal's consumer expenditure during the period 1958-1981 was used to illustrate this parameterization. The four systems were estimated by maximum likelihood. An intercept was added as representing factors such as changes in tastes over time. On the other hand, five different variants were estimated, unrestricted estimation, and then various restrictions include homogeneity, symmetry, negativity and homotheticity were added.

Lee, Brown, and Seale (1994) used expenditure data to study how income and prices influenced consumer demand in Taiwan during the previous decade. Alternative demand models, combining the features of the Rotterdam model and the Almost Ideal

Demand System (AIDS), were tested. The choice between these models was accomplished by higher-order comparisons with a general demand system that nested them. Using this general model, the AIDS model was selected over the others (Rotterdam, CBS, NBR). The results suggest that AIDS-type income and price responses better explain Taiwanese expenditure behavior than do other models. They found the using of Rotterdam-type income parameter gave the questionable result that food's income elasticity had increased over time while income increased and food's budget share decreased. The increased number of women working outside the home and the increased likelihood of away-from home food consumption may have brought a small increase in the food income elasticity.

Tiffin and Tiffin (1999) investigated the food demand elasticities for Great Britain using aggregate time series data during the period 1972-1994. These elasticities were estimated using AIDS model and imposing the neo-classical demand theory restrictions. Food imports were divided into four groups: staple foods, meat, vegetables, and fruit. The results conformed to expectations, as the demand for food was found to be both price and expenditure inelastic. The demand for all individual food categories included in the study was inelastic with respect to total household expenditure.

Brown and Lee (2000) utilized a uniform substitutes demand model with varying coefficients to specify demand systems. The synthetic modeling approach has been extended to increase the flexibility of the model. In the Rotterdam model, the marginal propensity to consume (MPC) of a good is treated as a constant, and as a constant plus the budget share for the good in the AIDS model. In this model, the MPC is specified as a linear combination of MPCs for the Rotterdam and AIDS, which allows it to vary over the sample in order to estimate the sensitivity of demand to income and prices. The model has been applied to four orange juice categories using weekly data. The results show that the decreasing sales trend of orange juice may be accompanied by less sensitive income and price responses, just the opposite that would be predicted using a constant MPC specification.

Fousekis and Revell (2000) employed differential demand systems to analyze demand for meat in the United Kingdom during 1989-1999. The study focuses on appropriate model selection in a demand systems context. The seasonality and gradual tastes change was examined by incorporating seasonal dummies and a constant term in the models. The Rotterdam, CBS, AIDS, NBR, and synthetic models (with imposing homogeneity and symmetry restrictions) were estimated using Seemingly Unrelated Regression (SUR) methods. Statistical tests showed that the differential demand models with fixed price effects (the Rotterdam and the CBS models) explain the allocation decision better than models containing variable price effects (NBR and differential AIDS models). The results showed that expenditure elasticities for all meats are close to unity except lamb. The quality change of meat consumption became negative after 1994 due to substitution effects induced by increased prices of poultry and bacon relative to prices of other meats.

3.4 Summary

From this literature review, the results of import demand studies can be summarized as showing the sensitivity of imports to changes in income levels and import prices. The demand price and expenditure elasticities obtained from these studies vary depending on the commodity or group studied, as well as by the country being observed.

Table 3-1 shows a summary of these elasticities for four different groups. Group A, which includes two developed countries, shows that price elasticities for imports range from -0.253 to −1.642, while expenditure elasticities range from 0.01 to 1.947. Group B, which has other developed countries in it, shows that price elasticities for imports range from -0.44 to −1.86 while expenditure elasticities range from 0.01 to 1.54. Group C, which has less developed countries shows that price elasticities for imports range from -0.146 to −1.26 while expenditure elasticities range from 0.326 to 1.573. Finally, Group D, which has other less developed countries, shows that price elasticities for imports range from -0.095 to −1.14 while expenditure elasticities range from 0.32 to 1.28.

Comparing previous elasticities, differences between developed and devolving countries can be noticed. Also, developed countries groups (A, B) experience different response as well as devolving countries does. In general, the reasons behind these differences maybe related to many issues. Availability of substitution products for imports as in developed countries lead to less responsive for price changes. Also, imports proportion in domestic demand effect this response.

Also, in addition to the calculation and evaluation of price and expenditure elasticities for projections, welfare analyses and income effects these studies had various objectives: they analyzed the demand for goods in light of recent methodological developments in the implementation of demand systems; they often examined the factors influencing the demand for imports; and they tested for the existence of structural change in the demand for imports. None of these studies have used the results to form the basis of a comprehensive model capable of evaluating a range of issues as proposed in this thesis. Only the Janda, McCluskey, and Rausser (2000) article even considers the use of import demand functions as inputs into large CGE or partial equilibrium models. However, it does not actually use the results in this manner.

In conclusion, this literature review shows some of what has been done in studying the demand systems for different countries and in Saudi Arabia using different methods and techniques. However, the studies for Saudi Arabia are old and do not investigate the import demand using different differential demand systems. Other literature also falls short in that it does not use the results to their fullest potential.

Table 3-1: Average Price and Expenditure Elasticities for Import Demand from Literature

Good or group	Group A		Group B		Group C		Group D	
	Price Elasticity	Expenditure Elasticity	Price Elasticity	Expenditure Elasticity	Price Elasticity	Expenditure Elasticity	Price Elasticity	Expenditure Elasticity
Food imports	-0.288	0.981			-0.636	0.965		
Beef	-1.642	1.947	-0.77	1.54			-0.095	0.32
Poultry			-0.44	1.42			-0.9	0.82
Mutton & Goat			-1.86	1.53				
Pork & Sausages			-1.26	0.28				
Cheese	-0.336	0.01	-0.65	0.01				
Butter			-0.92	0.05				
Milk	-0.765	0.668					-0.97	1.07
Meat	-0.29	1.594					-1.05	1.03
Carbohydrates							-1.14	1.28
Fruits and Vegetables	-0.253	0.28					-0.45	0.79
Dairy and Sweets							-0.88	1.16
Apples	-0.9	1.38			-1.26			
Oranges	-0.2675	1.367	-1.02	1.41				
Beverages and tobacco					-0.146	1.573		
Oils and Fats					-0.42	0.326		
Total Imports					-0.669	0.631		

Group A: Great Britain, Canada.
Group B: Greece, Japan.
Group C: Pakistan, Taiwan, and Hong-Kong.
Group D: Czech Republic.

CHAPTER IV

CONSUMER DEMAND THEORY

4.1 Introduction

The theory of consumer demand has been a central topic in economics for many years, and the modern formalized economic theory has dealt with consumer demand for a considerable time. This formalization has led the way towards econometric applications.

Consumer behavior generally focuses on preferences, on the axioms of choice, and on utility functions and their applications. This chapter will present the theory underlying empirical work on the demand for food imports.

4.2 Preferences and the Utility Maximization

4.2.1 Preferences

The foundations of neoclassical theory of the consumer are the basic axioms of consumer preference, which is accepted as being true without proof. In principle, we could begin by assuming the existence of a utility function and examining its properties. However, if we would know exactly what is involved in such an assumption, we can find a set of axioms of choice that allows us to maintain a distinction between preferences and utility functions. Consider a consumer facing possible consumption bundles in the consumption set $Q \in R_n^+$, where a consumer is assumed to have preferences concerning these consumption bundles.

Let the consumption of one commodity q_i be

(1) $$q_i = (q_1, \ldots\ldots, q_n) \in Q$$

where:

q_i = the quantity consumed of the i^{th} commodity.

The consumer preferences are assumed to have the following axioms:

Axiom 1: Reflexivity

For any bundle q, $q^1 \geq q^1$ each bundle of commodities is good as itself. This is a trivial assumption but is mathematically necessary.

Axiom 2: Completeness

This assumption just says that any two bundles can be compared. For any two bundles in the choice set, the consumer can rank all bundles of commodities and they can be compared, so $q^1 \geq q^2$, $q^2 \geq q^1$ or $q^1 - q^2$.

Axiom 3: Transitivity

The consumer's preferences are consistent. If consumer's ordering is $q^1 \geq q^2$, and $q^2 \geq q^3$, this implies $q^1 \geq q^3$. This assumption is necessary for any discussion of preference maximization.

Axiom 4: Continuity

For any q^2 the sets $\{q1/(q1 \geq q^2)\}$ and $\{q1/(q2 \geq q^1)\}$ are closed sets. This assumption is necessary to rule out certain discontinuous behavior. That is, as the consumer moves from one bundle to another, there is no jump in the utility level

Axiom 5: Strongly Monotonic

The consumer is assumed to prefer more to less of all goods. For any two goods $q^1 \geq q^2$ and $q^1 \neq q^2$ imply $q^1 \succ q^2$. This assumption says that at least as much of every good, and strictly more of some goods, is strictly better. This is simply assuming that goods are good.

Axiom 6: Local Non-Satiation

Local non-satiation says that one can always do a little bit better, even if one is restricted to only a small change in the consumption bundle.

Axiom 7: Convexity

The consumer prefers averages to extremes. If $q^1 \neq q^2$, $q^1 \geq q^3$, and $q^2 \geq q^3$, then $\lambda q^1 + (1-\lambda) q^2 \succ q^3$ for $0 < \lambda < 1$.

As long as these axioms hold, there exists a continuous utility function U (q) such that $U(q^1) \geq U(q^2)$, where this utility function is assumed to be ordinal, strictly quasi concave, and a twice differentiable function.

4.2.2 Utility Maximization

The consumer is not free to choose because choices are constrained by fixed, known prices in such a way the total value of objects chosen should not exceed some predetermined total, which is represented by a linear budget constraint. Hence, a rational consumer is assumed to allocate his/her total expenditure in a way that maximizes the utility function. That can be shown mathematically as:

(2) $$\text{Max } U = u(q_1, \ldots\ldots, q_n) \ \forall q_i \geq 0$$

where,

q_i is the quantity of the i[th] commodity, and

U is twice differentiable on the interior of set.

This function is subject to:

(3) $$x = \sum_{i=1}^{n} p_i q_i$$

where,

x is the total expenditure.

p_i is the price per unit of the i^th good, and

q_i is the quantity of the i^th good.

By using the Lagrangian equation, we can write the maximization problem as

(4) $$\ell = u(q) - \lambda(x - \sum_{i=1}^{n} p_i q_i).$$

Taking the first derivative of the equation (4) with respect to q_i and λ we will get first order condition (F.O.C.) equations:

(5) $$\frac{\partial u}{\partial q_i} - \lambda p_i = 0 \qquad i= 1,\ldots\ldots,n$$

(6) $$x = \sum_{i=1}^{n} p_i q_i .$$

The second order condition (S.O.C) or Hicksian stability condition

(7) $$U' \equiv \begin{bmatrix} 0 & \frac{\partial u}{\partial q_j} \\ \frac{\partial u}{\partial q_i} & \frac{\partial u}{\partial q_{ij}} \end{bmatrix} \qquad i,j = 1,\ldots,n.$$

is negative definite, and together with the F.O.C, there is a sufficient condition for the existence of a unique maximum.

Solving equations (5) and (6) for the quantity, we obtain the Marshallian (uncompensated) demand functions.

(8) $$q_i = g_i(x, p_1, \ldots, p_n) \text{ For } i = 1 \ldots n$$

4.3 Duality and Consumer Demand

In recent years, duality theory has become popular and used in many branches of economics. This duality approach is a technique or analytical tool that implies a simple and alternative method of analysis. It provides a convenient way of deriving demand functions. In the previous section, we formulated the consumer's problem as maximizing utility for a given budget that is called the primal problem. The solution to this problem will produce some utility level. However, selecting goods to minimize the expenditure necessary to reach a given utility level can reformulate the consumer choice. These two problems are often described as dual problems. This can be presented mathematically as

(9) $$\text{Min } x = \sum_{i=1}^{n} p_i q_i$$

Subject to:

(10) $$U = u(q).$$

Solving this minimization problem, we obtain the Hicks Ian (compensated) demand functions. The solution of the dual problem is identical to the solution of the primal problem.

(11) $$q_i = h_i(u, p_1, \ldots, p_n) \text{ For } i = 1 \ldots n$$

We can use the same utility (u) and budget (x) in both problems since in the dual problem we simply use the u, which is the maximum attainable in the primal problem. Further, since utility maximization and cost minimization must imply the same choice, the budget in the primal problem must be the cost minimum in the dual problem. In the primal problem, the solution is the set of Marshallian (uncompensated) demand g (x, p). In the dual problem, the determining variables are u and p, not x and p, so we get the same solutions but as a function of u and p. These new cost-minimizing demand functions, which we write h (u, p), are known as Hicksian or compensated demand functions. Since the two solution coincide, we have

(12) $$q_i = g_i(x, p) = h_i(u, p).$$

4.4 Restrictions in Consumer Demand

The theoretical properties of the Marshallian (uncompensated) and Hicksian (compensated) demand functions take the form of mathematical restrictions on the derivations of the demand functions and they hold regardless of the form of the utility functions. These properties are adding-up, homogeneity, symmetry, and non-negativity.

Adding-up

In spite of the importance and implications of nonlinear budget constraint, consumer demand analysis is built on the assumption of a simple linear budget constraint. The adding-up restriction follows from the linearity of budget constraint and the monotonicity assumption of preferences. It implies that the total value of both Hicksian and Marshallian demand functions must equal total expenditure in any period. In other words, the budget constraint must hold.

(13) $$x = \sum_{i=1}^{n} p_i h_i(p,u) = \sum_{i=1}^{n} p_i g_i(p,x)$$

where h_i (.) is the Hicksian demand function and g_i (.) is the Marshallian demand function.

Differentiating (12) with respect to (p, x) gives

(14a) $$q_i + \sum_j \left[pi \left(\partial q_i / \partial p_i \right) \right] = 0, \qquad i = 1, \ldots, n,$$

and

(14b) $$\sum_j \left[pi \left(\partial q_i / \partial x_i \right) \right] = 1$$

Equations (14a) and (14b) are the adding-up or aggregation restrictions, which must be satisfied if the budget constraint is always binding. Equation (14a) is called the "Cournot aggregation restriction", while (14b) is called the "Engel aggregation restriction."

Homogeneity

The Marshallian (uncompensated) demand function is homogenous of degree zero in total expenditure and prices, while the Hicksian (compensated) demand function is homogenous of degree zero in prices. If we change all prices and total expenditure in the Marshallian demand by the same proportion t, neither the budget constraint nor the utility function change. This implies that a proportional rise in all prices and expenditure has no effect on demand.

(15) $$h_i(tp, u) = h_i(p, u)$$

and,

(16) $$g_i(tp, tx) = g_i(p, x) \quad t>0$$

This restriction implies that the sum of the own and cross price elasticities and the expenditure elasticity for a particular commodity is zero, as in

(17) $$E_{ii} + E_{ij} + E_{ix} = 0 ,$$

where

E_{ii} = own-price elasticity,

E_{ij} = cross price elasticities, and

E_{ix} = expenditure elasticity.

This condition implies that the substitution effect and the income effect of an own–price change must be consistent with the cross and income elasticities for the commodity.

Symmetry

The symmetry indicates how cross-elasticities are related. The cross-price derivatives of the Hicksian demands are symmetric, that is,

(18) $$\frac{\partial h_i(u, p)}{\partial p_j} = \frac{\partial h_j(u, p)}{\partial p_i}$$

This property shows that the demand functions for compensated price responses are symmetric. This condition is a guarantee of and a test of the consumer's consistency of choice; without it, it suggests inconsistent choices are made.

Negativity

The n-by-n matrix formed by the elements $\partial h_i / \partial p_j$ is negative semi-definite, due to the expenditure being concave in prices. This matrix is also called the substitution or Slutsky matrix. It implies that the diagonal elements of the substitution matrix are non-positive or that $\partial h_i / \partial p_i \leq 0$, which is necessary but not sufficient for negativity.

4.5 Elasticities and Flexibility

Elasticities

Economists frequently make use of percentage relationships, which are independent of the size of units used to measure price and quantity, to study the impact that a given change in price will have on different commodities. The most common of these relationships are the concepts of own-price elasticity, cross price elasticity and expenditure elasticity of demand.

4.6 Separability

According to neoclassical consumer theory, the demand for any good is a function of all prices in the economy and expenditures. However, the empirical analyses of complete demand systems consisting of thousands of equations would require huge amounts of data and a theoretical base for demographic variation, which is impossible to conduct. Even if we get all data, the problem of degrees of freedom will exist. Thus, the way to approach this problem is to assume some sort of structure in the consumer's preferences. Separability is the most common assumption, which implies that goods can be divided into a number of separate groups.

Weak Separability

A utility function

(19) $$u = v(q_1, \ldots\ldots, q_n)$$

is weakly separable if there exists a partition of n goods into m subsets, that can be written as:

(20) $$u = f(v_1(q_1), v_2(q_2), v_m(q_m))$$

where $f(.)$ is any monotonic, increasing function of v_1, v_2 and v_m, which are the sub-utility functions for good 1, 2, and m respectively.

The necessary and sufficient condition for this function is that the marginal rate of substitution between any two goods in the same group is independent of all goods not in that group.

(21) $$\frac{\partial MRS_{ij}^{1}}{\partial q_{n}^{2}} = \frac{\partial}{\partial q_{n}^{k}} \left[\frac{(\partial u\ \partial v_1)\ \partial v_1\ \ \partial q_i^1}{(\partial u\ \partial 2)\ \partial v_1\ \ \partial q_j^1} \right] = 0 \ldots, (i,j) \in G, and..n \in K \ldots \forall ..G \neq K$$

This implies the marginal rate of substitution (MRS) between good j and i within group 1, under weak separability, is independent of the commodities outside this group. In other words, the change in the quantity consumption in group 2 will not affect the MRS between goods in group 1.

Strong Separability

In this assumption, direct utility function is made up of sub-utility for each group, where all sub-utilities are combined additively. In other words, utility function is a function of the summation of all sub-utilities.

Utility can be written as:

$$(22) \qquad u = f\left(v_1(q_1) + v_2(q_2) + \ldots\ldots + v_m(q_n)\right)$$

The necessary and sufficient condition for this function is that the marginal rate of substitution between goods from different subsets depends only on the goods in those subsets, which means it is independent of all goods not in the two groups.

$$(23) \qquad \frac{\partial MRS_{ij}^{12}}{\partial q_n^m} = \frac{\partial}{\partial q_n^m}\left[\frac{(\partial u\ \partial v_1)(\partial v_1\ \partial q_i^1)}{(\partial u\ \partial u_2)(\partial v_2\ \partial q_j^2)}\right] = 0 \ldots i \in G \ldots j \in K.and..n \in M \ldots \forall..G \neq n \neq m$$

In other words, under strong separability, the marginal rate of substitution among commodities within groups 1 and 2 is independent of the commodities outside these two groups.

CHAPTER V

THE ECONOMETRIC MODEL AND POLICY ANALYSIS FRAMEWORKS

5.1 Introduction

In this chapter, the demand systems estimation methodology, the economic model and evaluation methods will be presented and discussed. In the first section, the types of differential demand systems that exist will be presented. Following that, the presentation of the demand equations, the methods of estimation and evaluation of demand systems will be presented and discussed In the last section, a trade elasticities model will be developed based on McCalla and Josling (1985), and a fairly general framework based on Piggott, Piggott and Wright (PPW) will be presented that shows how to use elasticities to examine import and domestic policy change.

5.2 Single Equation versus Equation Systems

Procedures for estimating demand fall into two broad categories. One is the specification and estimation of demand for individual commodities without the imposition of constraints. In this case, the demand for a particular good depends on the prices of all goods in the economy, but many of these prices would be ignored in practice. Demand theory suggests that the quantity demanded of any good is a function of the commodity's own price, the price of substitutes, income and other variables.

The second category of analysis is estimation of a system of market demand equations where the restrictions derived from economic theory are formally imposed on the system. An advantage of this approach is that interdependencies among demands are captured and the theoretical constraints provide a formal structure for the interdependencies.

5.3 Methods of Estimating Demand Functions

Economic theory states that, under certain conditions, the existence of consumer preferences implies the existence of a utility function (and an expenditure function). Specification of demand systems can be obtained directly with certain restrictions that should hold using a utility maximization (expenditure minimization) framework. In the case of the formulation of demand allocation systems, one of the difficulties researchers face is selecting a functional form. Basically, there are four approaches, which satisfy theoretical demand properties that can be used to derive demand equations.

As shown in the previous chapter, the first approach starts from a functionally specified, increasing and strongly quasi-concave utility function=u (q_i), which is maximized subject to a budget constraint $\sum p_i q_i = m$. The set of the Marshallian demand equations can be derived through this maximization. Some examples of this approach are the quadratic-expenditure system (Pollak and Wales 1978) and linear-expenditure system (Stone 1954).

The second approach starts from a functionally specified indirect utility function, $v = v(p, x)$. The indirect utility function shows the maximum attainable utility for given prices and expenditure that is obtainable by substituting optimal quantities demanded into the original utility function. Also, the demand function can be derived directly from this indirect utility function using Roy's Theorem. An example of this approach is the indirect Translog utility function (Christensen et al 1975).

The third approach is based on a specified expenditure function $x = x(x, p_i)$. Hicksian demand equations can be obtained from this function by applying Shephard's lemma. Then, the unobservable utility level can be eliminated by using the expenditure function to express utility in terms of x and p, which gives the Marshallian demand equations. An example of this type of specification is the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980a).

The fourth approach in formulating demand systems is to specify the demand equation directly. The demand for any good i is specified as $q_i = f(p_i, x)$ where p_i is a good's price and x is expenditure. Using this approach, many early empirical demand studies worked with double-logarithmic specifications and constant elasticities. The most popular functional form used in this approach is double-log (Houthaker 1957) but this model is less adequate in reflecting the theoretical restrictions because the adding-up constraint is usually violated. So, differential consumer demand systems have been employed to solve this problem.

5.4 Alternative Specifications of Differential Demand Systems

In the last several decades, consumer demand analysis has moved toward system-wide approaches. There are now numerous algebraic specifications of demand systems, including the Linear and quadratic expenditure systems, the Working model, the Rotterdam model, Translog models, and the Almost Ideal Demand System (AIDS). Two demand systems, which have become popular in agricultural economics, are the

Rotterdam and the AIDS approaches. However, the assumptions used to parameterize these two systems have different implications.

In recent decades, the specification of demand systems in some differential forms has become popular in empirical analyses of consumer demand. Prominent models of this type include the Rotterdam model (Barten, 1964; Theil, 1965), versions of the AIDS model (Deaton and Muellbauer, 1980a), the CBS model (Keller and Van Driel, 1985), and the NBR model (Neves, 1987). The corresponding demand functions can be obtained by applying different parameterizations to the differentials of budget shares. This approach allows derivation of the system through completely general demand equations from a general utility function. Some attractive features of this approach are: (1) the parameterization of the system can be done as the last step prior to estimation, (2) the coefficients of the differential approach need not be constant, and (3) this approach clearly distinguishes between first-order and second-order effects (i.e., substitution effects of price changes are second-order effects).

5.5 Different Parameterizations of the Budget Differential Equation

The Rotterdam model, the AIDS, the CBS and the NBR constitute a class of differential demand systems. The corresponding demand functions can be obtained by applying different parameterizations to the differentials of the budget shares, where the expression 'parameterizations' refers to the assumptions made concerning the constancy of the relevant parameters.

5.5.1 Rotterdam Model (ROT)

The basic equations of the Rotterdam model (Theil, 1965) are expressed as

$$(24) \qquad w_i d\ln q_i = \theta_i d\ln Q + \sum_j \pi_{ij} d\ln p_j \quad i = 1,2,\ldots,n,$$

where:

w_i is the average budget share of commodity i,

p_i is the price of good i,

q_i is the quantity of good i,

θ_i is the marginal budget share of commodity i,

π_{ij} is the compensated price effect,

s_{ij} is the element of the Slutsky substitution matrix, and

n is the number of commodities.

(25) $$d \ln p_i = dp_i / p_i$$

(26) $$d \ln q_i = dq_i / q_i$$

$d \ln Q$: is an index number (Divisia volume index) which equal the summation of all quantities weighted by their shares, as

(27) $$d \ln Q = \sum_i w_i \; d \ln q_i .$$

Demand parameters, $\theta_i and \pi_{ij}$, are given by

(28) $$\theta_i = p_i(\partial q_i / \partial m)$$ where the m is the total outlay, or the budget.

(29) $$\pi_{ij} = (p_i p_j / m) s_{ij}$$

(30) $$s_{ij} = \partial q_i / \partial p_j + q_j \partial q_i / \partial m$$

and the parameters obey the following restrictions:

(31a) $\sum_i \theta_i = 1$ (Engel aggregation)

(31b) $\sum_i \pi_{ij} = 0$ (Cournot aggregation)

(31c) $\sum_j \pi_{ij} = 0$ (Homogeneity)

(31d) $\pi_{ij} = \pi_{ji}$ (Symmetry)

π_{ij} is negative semi-definite of rank n-1 (Negativity)

5.5.2 Almost Ideal Demand System (AIDS)

Deaton and Muellbauer (1980) have derived the AIDS model which is

(32) $$w_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln(m/p),$$

where:

p is a price index defined by

(33) $$\ln p = \alpha + \sum \alpha_k \ln p_k + \frac{1}{2}\sum_k \sum_l \gamma_{kl} \ln p_k \ln p_l \text{. and}$$

(34) $$d \ln m = d \ln p + d \ln Q$$

By taking the total differential for equation (32) we obtain

(35) $$dw_i = \beta_i d \ln Q + \sum_j \gamma_{ij} d \ln p_j .$$

The total differential of budget share is

(36) $$dw_i = w_i (d \ln p_i + d \ln q_i - d \ln m) .$$

From (34) and (36), and based on Deaton and Muellbauer's suggestion of substituting the Divisia Price index $\sum w_i d \ln p_i$ for $d \ln p$, the differential AIDS model can be derived, which is

(37) $$w_i d \ln q_i = (\beta_i + w_i) \; d \ln Q + \sum_j \gamma_{ij} - w_i(\delta_{ij} - w_j) \; d \ln p_j$$

where δ_{ij} is the Kronecker delta equal to unity if $i = j$ and zero otherwise (Barten, 1993).

The constants satisfy the following restrictions:

(38a) $$\sum_i (\beta_i + w_i) = 0$$ (Engel aggregation)

(38b) $$\sum_i \gamma_{ij} - w_i(\delta_{ij} - w_j) = 0 \qquad j = 1,2,..n$$ (Cournot aggregation)

(38c) $$\sum_j \gamma_{ij} - w_i(\delta_{ij} - w_j) = 0 \qquad i = 1,2,.....n \text{, and}$$ (Homogeneity)

(38d) $$\gamma_{ij} - w_i(\delta_{ij} - w_j) = \gamma_{ji} - w_i(\delta_{ij} - w_j).$$

(Symmetry)

This parameterization of the model requires that the difference between the marginal and actual budget shares remains constant over the sample period.

5.5.3 CBS Model

Keller and Van Driel (1985) of the Dutch Central Bureau Central of Statistics (CBS) created a hybrid of the AIDS and Rotterdam systems. Based on the Working model

(39) $$w_i = \alpha_i + \beta_i \ln m,$$

which can be used to derive the quantity coefficients in the Rotterdam model.

To derive the marginal shares implied by the Working model, one multiplies (39) by m and differentiates with respect to m to get:

(40) $$\theta_i = p_i(\partial q_i/\partial m) = \alpha_i + \beta_i(1 + \ln m)$$

(41) $$\theta_i = w_i + \beta_i .$$

Replacing θ_i in the Rotterdam model by (41) we obtain the CBS model

(42) $$w_i d\ln q_i = (\beta_i + w_i)\ d\ln Q + \sum_j \pi_{ij} d\ln p_j$$

with the constants satisfying the following restrictions

(43a) $\sum_i \beta_i = 0$ (Engel aggregation)

(43b) $\sum_i \pi_{ij} = 0$ j =1,2,….,n (Cournot aggregation)

(43c) $\sum_j \pi_{ij} = 0$ i =1,2,….,n (Homogeneity)

(43d) $\pi_{ij} = \pi_{ji}$. (Symmetry)

5.5.4 NBR Model

Neves (1987) of the National Bureau of Research (NBR) created another hybrid of the AIDS and Rotterdam model systems by substituting β_i in the AIDS model with $\theta_i - w_i$, yielding

(44) $$w_i d\ln q_i = \theta_i\ d\ln Q + \sum_j \gamma_{ij} - w_i(\delta_{ij} - w_j)\ d\ln p_j$$

This model has the Rotterdam income coefficients and the AIDS price coefficients as constant, with the constants satisfying the following restrictions

(45a) $$\sum_i \theta_i = 0$$ (Engel aggregation)

(45b) $$\sum_i \gamma_{ij} - w_i(\delta_{ij} - w_j) = 0 \qquad j = 1,2,\ldots,n$$ (Cournot aggregation)

(45c) $$\sum_j \gamma_{ij} - w_i(\delta_{ij} - w_j) = 0 \qquad i = 1,2,n$$ (Homogeneity)

(45d) $$\gamma_{ij} - w_i(\delta_{ij} - w_j) = \gamma ji - w_i(\delta_{ij} - w_j).$$ (Symmetry)

These four models, ROT, AIDS, CBS, and NBR have the same left-hand side variable $w_i d\ln q_i$ and right-hand side variables $d\ln Q$ and $d\ln p_j s$. These models can be considered as four different ways to parameterize a general model. The marginal budget shares are assumed to be constant in the Rotterdam and the NBR models but variable in the AIDS and CBS models. The Slutsky terms are considered to be constants in the Rotterdam and CBS and variable in the AIDS and NBR.

5.5.5 General Demand System

The models considered in the preceding sections are not nested. Barten (1993) showed a general demand system could be developed which nests all four systems. Lee, Brown, and Seale (1994) have derived the following general system:

(46) $$w_i d\ln q_i = d_i d\ln Q + \eta_1 w_i d\ln Q + \sum_j e_{ij} d\ln p_j - \eta_2 \sum_j w_i(\delta_{ij} - w_j) \ d\ln p_j$$

where:

(47) $$d_i = \eta_1 \beta_i + (1-\eta_1)\theta_i$$

(48) $$e_{ij} = \eta_2 \gamma_{ij} + (1-\eta_2)\pi_{ij}$$

are the model parameters and η_i's are called nesting parameters. The value that η_i takes on determines the compatibility of the data with the four nested demand systems. That is, if η_1 and $\eta_2 = 0$ the general model becomes the Rotterdam; it is the CBS when $\eta_1 = 1$ and $\eta_2 = 0$; the AIDS is the correct specification when $\eta_1 = 1$ and $\eta_2 = 1$ and the NBR is best when $\eta_1 = 0$ and $\eta_2 = 1$.

The constants satisfying the following restrictions:

(49a) $$\sum_i d_i = 1 - \eta_1$$ (Engel aggregation)

(49b) $$\sum_i e_{ij} = 0 \qquad j = 1,2,\ldots,n$$ (Cournot aggregation)

(49c) $$\sum_j e_{ij} = 0 \qquad i = 1,2,\ldots,n$$ (Homogeneity)

(49d) $$e_{ij} = e_{ji}.$$ (Symmetry)

5.6 Estimation Issues

To estimate the coefficient of the demand systems, ordinary least squares can be used when the prices are assumed to be exogenous. However, given that these are share equations that are closely related, the method of Seemingly Unrelated regressions (SUR) is appropriate to account for the contemporaneous correlation between the error terms of the different equations. This provides more efficient estimation relative to OLS when contemporaneous correlation exists.

It is assumed that the vector of disturbance terms has a normal distribution with mean zero and covariance matrix $\sum$. Moreover, we assumed the adding-up restriction that led to having n+1 equations and n dependent variables. Consequently, the covariance matrix is singular and the density of disturbances is not defined. Hence, to arrive at a likelihood function, a transformation into nonsingular multivariate normal distribution is required. While the singularity of the distribution of disturbances is due to the fact that the n components of disturbance identically add to zero, one component can be deleted and the resulting vector has a non-singular distribution. So one equation has been dropped during estimation and recovered by deduction from the estimated results.

5.6.1 Autocorrelation

An important assumption about the disturbances is that there is no autocorrelation among them entering into the population regression function. Autocorrelation can arise for several reasons, such as inertia, sluggishness of time series or using incorrect functional form. In the case of system of equations, the Durbin-Watson statistic cannot be used to test for serial correlation. So, a log likelihood test (LRT) can be applied to test the following test:

H_o: Autocorrelation present between disturbances

H_a: No autocorrelation present.

Berndt and Savin (1975) showed that in single equation systems, the adding up property of the shares imposes restrictions on the parameters of autoregressive processes and when these restrictions are not imposed the specification, maximum likelihood estimates, and likelihood ratio test statistics are conditional on the equation deleted. Consequently, the error term in each of the system's equations will be assumed to be correlated to its own past value, but no correlation exists among current or past values of the error terms across equations. Otherwise, the maximum likelihood estimates of the system would vary with the equation deleted and they would be consistent but asymptotically inefficient.

5.6.2 Testing Economic Hypotheses

There are different hypotheses of economic theory that we wish to test for the model to be considered correctly specified. Homogeneity and symmetry are the hypotheses usually tested. A likelihood ratio test (LRT) can be used with OLS and SUR models to test these hypotheses.

The following hypotheses can be set and tested:

H_o: homogeneity, or symmetry, or both, are present.

H_a: No homogeneity, or symmetry present.

The log likelihood ratio test (LRT) can be calculated using log likelihood values for restricted and unrestricted model and compared with a chi-square value with appropriate degrees of freedom (refer to empirical section for details).

5.7 Trade Elasticities Model

The objective of this model is to use the import estimates, which are often based on more reliable trade data, and non-sample domestic supply elasticities to create an analysis framework capable of doing domestic and trade policy analysis. Following McCalla and Josling (1985) and Piggott, Piggott and Wright (PPW) (1995), this model can be established. It will provide a relatively simple but effective method to evaluate many policy alternatives, as well as demand and supply shifters. To demonstrate the range of possible applications of this modeling technique, and examine issues of interest in Saudi Arabian agriculture, a number of simulations will be presented in the results chapter. For example, the prices of imports into Saudi Arabia, which are exogenous because of Saudi Arabia's size, will be altered to account for anticipated WTO trade liberalization impacts. Also, local supply will be affected by changes in inputs prices, water for example, which is expected to rise due to water scarcity. In addition, a reduction in input subsidies will affect these results as well.

Domestic demand for agricultural commodities in Saudi Arabia comes from two sources, domestic supply and imports. It should be clear that the summation of imports and domestic supply equals the total domestic demand in the absence of exports. This identity can be illustrated mathematically as

$$(50) \qquad Q_i^D \equiv Q_i^S + Q_i^M$$

where:

Q_i^D is total quantity demanded of commodity i,

Q_i^S is total quantity supplied of commodity i and,

Q_i^M is total quantity imported of commodity i.

This identity represents the ex ante market clearing equilibrium. The behavioral functions can be added by assuming that import, local supply and domestic prices are the same, and equal to world prices, because the Saudi Arabian economy is small compared to the world market. Substituting out the quantities with the right hand side expressions, the model becomes,

$$(51) \qquad Q^D(P,\ldots\ldots) = Q^S(P,\ldots\ldots) + Q^M(P,\ldots\ldots).$$

The sensitivity of quantities to price change can be established as

$$\frac{dQ^D}{dp} = \frac{dQ^S}{dp} + \frac{dQ^M}{dp}. \tag{52}$$

Rearranging this equation we get,

$$\frac{dQ^M}{dp} = \frac{dQ^D}{dp} - \frac{dQ^S}{dp}. \tag{53}$$

Then, multiplying equation (53) by $P/_{Q^M}$ the equation becomes

$$\frac{dQ^M}{dp}\frac{P}{Q^M} = \frac{dQ^D}{dp}\frac{P}{Q^M} - \frac{dQ^S}{dp}\frac{P}{Q^M}. \tag{54}$$

Multiplying the first component on the right hand side by $\frac{Q^D}{Q^D}$ and second component by $\frac{Q^S}{Q^S}$ the equation (54) becomes

$$\varepsilon_{import} = \varepsilon_{Demand} * \frac{Q^D}{Q^M} - \varepsilon_{Supply} * \frac{Q^S}{Q^M} \tag{55}$$

This identity shows the relation between demand, supply and imports elasticities for linear equations. (This is derived in McCalla and Josling, pp 40).

This relation can be changed to the CBS form by substituting the CBS elasticities, which equal $\frac{\beta_{ij}}{\omega_i}$, so the following identity can be obtained,

$$\frac{\beta_{ij}^m}{w_i^m} = \frac{\beta_{ij}^D}{w_i^D} * \frac{Q^D}{Q^m} - \varepsilon_{Supply} * \frac{Q^s}{Q^m}. \tag{56}$$

Multiplying through by w_i^m, the expression becomes

$$(57) \qquad \beta_{ij}^m = \beta_{ij}^D * \frac{Q^D}{Q^m} * \frac{w_i^m}{w_i^D} - \varepsilon_{Supply} * \frac{Q^s}{Q^m} * w_i^m .$$

where:

β_{ij}^m is the price coefficient of commodity i, when imported.

β_{ij}^D is the price coefficient of commodity i, which demanded domestically.

w_{ij}^D is the share of commodity i demanded.

w_{ij}^M is the share of commodity i imported.

The equation (57) can be rearranged and displayed as

$$(58) \qquad \beta_{ij}^m = \beta_{ij}^D * B^\bullet - A^\bullet$$

where:

$$B^\bullet = \frac{Q^D}{Q^m} \cdot \frac{w_i^m}{w_i^D} = \frac{Q^D}{w_i^D} \cdot \frac{w_i^m}{Q^m}$$

and

$$A^\bullet - \varepsilon_{Supply} * \frac{Q^s}{Q^m} * w_i^m .$$

Substituting equation (58) into the CBS import demand model, we can estimate the domestic demand coefficients using the import data as

$$(59) \qquad w_{it}^{m}(\Delta\ln q_{it} - \Delta\ln Q) = \beta_i \Delta\ln Q + \sum_j (\beta_{ij}^{D} * B^{\bullet} - A^{\bullet})\Delta\ln p_j$$

Rearranging equation (64), the following model can be defined as

$$(60) \qquad w_{it}^{m}(\Delta\ln q_{it} - \Delta\ln Q) + \sum_j A^{\bullet}\Delta\ln p_j = \beta_i \Delta\ln Q + \sum_j \beta_{ij}^{D}(B^{\bullet}\Delta\ln p_j),$$

which shows that the local demand coefficients (β_{ij}^{D}) are estimated using import data. This is a restricted estimation of the CBS that allows for calculation of local demand elasticities given assumed local supply elasticities. (In fact, any functions that are linear in the variables can be combined and analyzed with this structure. For example, a CBS domestic demand function, and a log-log supply function could be accommodated. This is proven in Appendix A.

5.8 A Framework to Analyze Import and Domestic Responses to Policy Change

Following Piggott, Piggott and Wright (1995) (PPW), the import response to a policy change can be established from the market clearing identity. (In this section, the PPW approach is revised to reflect commodities that are imported rather than exported)

$$(61) \qquad Q^{M} = Q^{D} - Q^{S}$$

Assuming a two-commodity case and a supply function in commodity prices, water price, and other inputs, the identity can be redefined using CBS functional forms as:

(62) Demand: $\ln q_i^{D} = \frac{\beta_i}{w_i}\ln Q + \ln Q + \frac{\pi_{i1}}{w_i}\ln p_{i1} + \frac{\pi_{i2}}{w_i}\ln p_{i2}$

(This result was developed by PPW for linear models, while we are able to show that it also works for the CBS model and other functional forms that are linear in their variables. This is another extension of the PPW approach in this research).

(63) Supply: $$\ln q_i^S = \frac{\beta_{i1}}{w_i}\ln p_{i1} + \frac{\beta_{i2}}{w_i}\ln p_{i2} + \frac{\beta_{iw}}{w_i}\ln p_{water} + \frac{\beta_{iw}}{w_i}\ln p_{input}$$

(64) Import: $$\ln q_i^M = \frac{\beta_i}{w_i}\ln Q + \frac{\pi_{i1}}{w_i}\ln p_{i1} + \frac{\pi_{i2}}{w_i}\ln p_{i2}$$

Total differentiation of equations (62) through (64) and conversion to elasticities yields

(65) $$dq_i^D = \varepsilon^{Exp}\cdot\frac{dQ}{Q}\cdot q_i^D + \varepsilon_{i1}^D\cdot\frac{dp_1}{p_1}\cdot q_i^D + \varepsilon_{i2}^D\cdot\frac{dp_2}{p_2}\cdot q_i^D$$

(66) $$dq_i^S = \varepsilon_{i1}^S\cdot\frac{dp_1}{p_1}\cdot q_i^S + \varepsilon_{i2}^S\cdot\frac{dp_2}{p_2}\cdot q_i^S + \varepsilon_i^{Water}\cdot\frac{dpw}{pw}\cdot q_i^S + \varepsilon_i^{input}\cdot\frac{dp_{input}}{p_{input}}\cdot q_i^S$$

(67) $$dq_i^m = \varepsilon^{Exp}\cdot\frac{dQ}{Q}\cdot q_i^m + \varepsilon_{i1}^m\cdot\frac{dp_1}{p_1}\cdot q_i^m + \varepsilon_{i2}^m\cdot\frac{dp_2}{p_2}\cdot q_i^m$$

substituting the equations (65) through (67) in the market clearance condition (identity) yields,

(68) $$\begin{aligned} dq_i^m =\ & \varepsilon^{Exp}\cdot\frac{dQ}{Q}\cdot q_i^D + \varepsilon_{i1}^D\cdot\frac{dp_1}{p_1}\cdot q_i^D + \varepsilon_{i2}^D\cdot\frac{dp_2}{p_2}\cdot q_i^D \\ & -\{\varepsilon_{i1}^S\cdot\frac{dp_1}{p_1}\cdot q_i^S + \varepsilon_{i2}^S\cdot\frac{dp_2}{p_2}\cdot q_i^S + \varepsilon_i^{Water}\cdot\frac{dpw}{pw}\cdot q_i^S + \varepsilon_i^{input}\cdot\frac{dp_{input}}{p_{input}}\cdot q_i^S\}. \end{aligned}$$

Multiplying through by q_i^m yields

(69) $$\begin{aligned} Eq_i^m =\ & \varepsilon^{Exp}\cdot EQ\,\rho_i + \varepsilon_{i1}^D\cdot Ep_1\cdot\rho_i + \varepsilon_{i2}^D\cdot Ep_2\cdot\rho_i \\ & -\{\varepsilon_{i1}^S\cdot Ep_1\cdot(\rho_i+1) + \varepsilon_{i2}^S\cdot Ep_1\cdot(\rho_i+1) + \varepsilon_{iwa}^S Ep_{wa}\cdot(\rho_i+1) + \varepsilon_{iIn}^S Ep_{In}\cdot(\rho_i+1)\}. \end{aligned}$$

where $E(.)$ is the proportional change [defined, for any variable x as $(x_1-x_0)/x_0$ with subscripts 0 and 1 denoting old and new value, respectively]; ρ_i= proportion of commodity i, equals quantity demanded divided by quantity imported.

This equation can be written in matrix form as

$$Eq_i^m = [(\varepsilon_{i1}^D \cdot \rho_i - \varepsilon_{i1}^S \cdot (\rho_i + 1)) \quad (\varepsilon_{i1}^D \cdot \rho_i - \varepsilon_{i1}^S \cdot (\rho_i + 1))] \cdot \begin{bmatrix} Ep_1 \\ Ep_2 \end{bmatrix} + \begin{bmatrix} (\varepsilon^{Exp}) \cdot \rho_i & -\varepsilon_{water}^S \cdot (\rho_i + 1) - \varepsilon_{iln}^S \cdot (\rho_i + 1) \end{bmatrix} \cdot \begin{bmatrix} EQ \\ Ep_w \\ Ep_{ln} \end{bmatrix} \tag{70}$$

which can be illustrated for the Saudi Arabia import model by

$$\begin{pmatrix} Eq_1^m \\ Eq_2^m \\ Eq_3^m \\ Eq_4^m \\ Eq_5^m \\ Eq_6^m \\ Eq_7^m \\ Eq_8^m \end{pmatrix} = \begin{pmatrix} \varepsilon_{i1}^D \cdot \rho_i - \varepsilon_{i1}^S (\rho_i + 1) & \cdots & \varepsilon_{i1}^D \cdot \rho_i - \varepsilon_{i1}^S (\rho_i + 1) \\ \vdots & \cdots & \vdots \\ \vdots & \cdots & \vdots \\ \vdots & \cdots & \vdots \\ \vdots & \cdots & \vdots \\ \vdots & \cdots & \vdots \\ \varepsilon_{i1}^D \cdot \rho_i - \varepsilon_{i1}^S (\rho_i + 1) & \cdots & \varepsilon_{i1}^D \cdot \rho_i - \varepsilon_{i1}^S (\rho_i + 1) \end{pmatrix} \cdot \begin{pmatrix} Ep_1 \\ Ep_2 \\ Ep_3 \\ Ep_4 \\ Ep_5 \\ Ep_6 \\ Ep_7 \\ Ep_8 \end{pmatrix} + \begin{pmatrix} (\varepsilon_1^{Exp}) \cdot \rho_1 & -\varepsilon_{1w}^S \cdot (\rho_1 + 1) & -\varepsilon_{ln}^S \cdot (\rho_1 + 1) \\ (\varepsilon_2^{Exp}) \cdot \rho_2 & -\varepsilon_{1w}^S \cdot (\rho_2 + 1) & -\varepsilon_{ln}^S \cdot (\rho_1 + 1) \\ (\varepsilon_3^{Exp}) \cdot \rho_3 & -\varepsilon_{1w}^S \cdot (\rho_3 + 1) & -\varepsilon_{ln}^S \cdot (\rho_1 + 1) \\ (\varepsilon_4^{Exp}) \cdot \rho_4 & -\varepsilon_{1w}^S \cdot (\rho_4 + 1) & -\varepsilon_{ln}^S \cdot (\rho_1 + 1) \\ (\varepsilon_5^{Exp}) \cdot \rho_5 & -\varepsilon_{1w}^S \cdot (\rho_5 + 1) & -\varepsilon_{ln}^S \cdot (\rho_1 + 1) \\ (\varepsilon_6^{Exp}) \cdot \rho_6 & -\varepsilon_{1w}^S \cdot (\rho_6 + 1) & -\varepsilon_{ln}^S \cdot (\rho_1 + 1) \\ (\varepsilon_7^{Exp}) \cdot \rho_7 & -\varepsilon_{1w}^S \cdot (\rho_7 + 1) & -\varepsilon_{ln}^S \cdot (\rho_1 + 1) \\ (\varepsilon_8^{Exp}) \cdot \rho_8 & -\varepsilon_{1w}^S \cdot (\rho_8 + 1) & -\varepsilon_{ln}^S \cdot (\rho_1 + 1) \end{pmatrix} \cdot \begin{pmatrix} EQ \\ Ep_w \\ Ep_{ln} \end{pmatrix} \tag{71}$$

In contrast to the PPW approach, where prices are endogenous, this system will analyze the effects on quantities imported, produced and demanded due to changing world prices that are assumed to be exogenous. Additionally, the analysis can decompose the changes in imports to determine variations in the domestic supply and demand responses. Thus, these simulations can be used to show the effect of change in local or international policy on quantities imported, demanded domestically and supplied domestically. When prices are exogenous, equations (70) and (71) can be used directly.

In PPW, which assumes endogenous prices, a proportional change in an exogenous shifter leads to price responses in the first equation, and then those price effects cause impacts on quantities in a second equation.

Also, in PPW, there is just one price across all markets, and no policy influences are included. However, producers' prices in supply equations could be constructed as a summation of local prices and subsidies, while consumer prices in demand equations might be a summation of local prices and specific import tariffs. Other tariffs might affect both local supply and demand.

If we assume a linear function, this can be shown as the following:

(72) Import: $$Q_1^m = \beta_1 + \beta_2 p_1^m + \beta_3 p_2^m + \beta_4 z^m$$

(73) Demand: $$Q_1^d = \beta_5 + \beta_6 p_1^d + \beta_7 p_2^d + \beta_8 z^d$$

(74) Supply: $$Q_1^s = \beta_8 + \beta_9 p_1^s + \beta_{10} p_2^s + \beta_{11} z^s$$

These equations show the import, demand and supply functions with the differing prices and appropriate shifters. In the case of the demand function, the prices might include some tariffs and subsidies, so they could be represented as $p_1^d = p^m + TD$, where TD is a shifter, a tariff for example. Supply effects could be shown in the same way, where $p_1^s = p^m + TS$, and TS is a shifter, such as subsidies. Substituting these prices into the previous equations it becomes:

(75) Import: $$Q_1^m = \beta_1 + \beta_2 p_1^m + \beta_3 p_2^m + \beta_4 z^m$$

(76) Demand: $Q_1^d = \beta_5 + \beta_6(p_1^m + TD) + \beta_7 p_2^d + \beta_8 z^d$

(77) Supply: $Q_1^s = \beta_9 + \beta_{10}(p_1^m + TS) + \beta_{11} p_2^s + \beta_{12} z^s$

The effects of tariffs and subsidies appear now in these equations as just other shifters. Because they only affect one equation, they need to be separated, rather than implemented by just shifting the price proportionally, which would induce both a supply and demand response. If an import tariff were to affect all local prices, the change could easily be simulated by making an assumed proportional change on prices (E_P) in equation (71) above. Moreover, if a tariff is assumed to be a percentage of the import price, the local demand price can be written as $p_1^d = p^m(1+T)$, where T is the percentage imposed. This can be written as $p_1^d = p^m + Tp^m$, so the change in the domestic demand price can be simulated through altering the elasticity.

5.9 Summary

This chapter shows the econometric model for demand systems and the framework for policy analysis. The assumptions used to parameterize demand systems have different implications. Allowing model parameters to vary can be important for estimating the sensitivity of demand to income and prices changes. For all previous demand models, each one has a different parameterization. In the Rotterdam model, for example, income and compensated price elasticities for a good are the good's constant marginal expenditure share and Slutsky coefficients, divided by the good's budget share, respectively. So, its income and compensated price elasticities are increasing in absolute value as long as its budget share is decreasing, for example, if a good is experiencing a declining sales trend. Such results may inaccurately show the changing demand situation because income and price elasticities can be decreasing in absolute value with decreasing budget shares. On the other hand, the marginal expenditure share parameter is assumed as a function of budget shares in the AIDS and CBS models, and constant in the NBR model, while the Slutsky term is assumed as a function of budget shares in the AIDS and NBR model, and constant in the CBS model. To choose among these models, researchers rely on statistical tests and inference since economic theory does not provide criteria to make the selection.

Finally, the theoretical development of a trade elasticities model and an associated policy model adapted from Piggott, Piggott and Wright was given for the purpose of setting up a framework to evaluate import and local responses to policy change. This structure, which will be used to examine effects of WTO, changes in water policy, and changes in the subsidies, has been developed. Moreover, an initial framework for the effect of tariff change and local subsidies was discussed for two types of tariffs, lump sum or percentages of import prices.

CHAPTER VI

ECONOMETRIC AND SIMULATION RESULTS

6.1 Introduction

In this chapter, five demand systems models are estimated and discussed. They are the Rotterdam model, AIDS model, CBS model, NBR model and a general encompassing model. Each model consists of a system of eight equations and is estimated using Seemingly Unrelated Regressions techniques. For each model, autocorrelation has been tested for and corrected. In the first section of this chapter, a brief description of data and its sources will be presented.

Given the results obtained from these models, the CBS model was chosen statistically as the best model to fit the Saudi Arabian import setting. Expenditure and price elasticities are reported both with and without imposing restrictions from economic theory. Utilizing the CBS import demand structure, local demand elasticities are estimated as well, using restrictions related to supply elasticities in the manner shown in the previous chapter. With these elasticities, a trade model is constructed and used to simulate different scenarios reflecting various changes in local and international policies.

6.2 Data and Its Sources

The estimations are based on quarterly data from 1990.1-2000.4. This period was chosen due to the availability of data, which covers all agricultural imports into Saudi Arabia. A summary of descriptive statistics for the key variables is given in table 6-1.

The average quantity imported of milk and dairy, which amounted to 43.20 thousand tons, represents the minimum while the average quantity imported of feed grains, which amounted to 1037.61 thousand tons, represents the maximum. Also, the oilseeds, meal, fats and oils represents the smallest average import values, which amounted to 318.75 million SR, while the live and frozen animals represents the largest values, which amounted to 792.41 million SR. Moreover, the feed grains price, which is 0.52 SR/kg, represents the minimum price while milk and dairy, which is 8.74 SR/kg, represents the maximum.

The standard deviation of import quantities ranged from 16.19 for milk and dairy to 887.74 for feed grains while import values ranged from 112.4 for oilseeds, meal, fats and oils to 374.36 for feed grains and prices ranged from 0.2 for feed grains to 1.91 for beverages, tobacco, and other imports, respectively. These are most easily interpreted by looking at the coefficients of variation (CV), which describe the relative variability of each commodity about its mean. The quantity figures show the highest variation, while prices show the lowest range of variability. Thus the greater part of the variation in import values comes from quantity fluctuations rather than unit value changes. Based on these observations, where there are small price variations and large quantity responses, it is likely that there will be high import elasticities.

Feed grains show the highest range (difference between maximum and minimum) of import quantities while milk and dairy show the lowest. Also, feed grains show the largest range of import value while oilseeds, meal, fats and oils show the lowest. Moreover, the range of import prices is notable. Beverages show the highest range of maximum price variation while vegetables and fruit show the lowest. The ranges for price variability are somewhat at odds with the CV results that show relatively low variation. Based on the maximum to minimum ranges for feed grains, the maximum price is five times the minimum. For maize, rice and wheat, the maximum price is three times the minimum, while it is four times for beverages as well as the sugar group. Thus, there were points during the decade when significant outliers appeared to have occurred.

This variation in ranges across groups is linked to behavior in world markets. Feed grains fluctuate the most because they are most sensitive to income variation, which was significant during the decade from the Gulf war and the Asian financial crisis, and probably from local policy change directed at barley in the middle of the period. Maize and wheat are more stable in world markets due to government programs for food grains and a greater prevalence of long term contracts. Beverages and sugar are more consistent as there is more processing done to products in these groups.

Table 6-2 indicates the value and quantity shares of total imports for each group. The Live and frozen animals value holds the largest value share of total imports, which amounted to 19.47%, while oil seeds, meal, fats and oils holds the smallest value share of total imports, which amounted to 7.78% on average over the full period. In contrast, the feed grains category shows the largest share of quantities imported out of total imports, 38.02%, while milk and dairy shows the smallest share, at 2.3%.

Import quantities and values for all agricultural imports were obtained from Foreign Trade Statistics, Ministry of Finance and National Economy, Central Department of Statistics, Kingdom of Saudi Arabia. Quantities are in thousands of metric tons per quarter imported from all sources. Import values are in millions of Saudi Riyals. The prices have been calculated by dividing values by quantities.

Table 6-1: Descriptive Statistics for the Key Variables, 1990.1-2000.4

Variable	*Mean*	Std. Dev.	CV	Min	Max
Import Quantities (1000 tons)					
Live and Frozen Animals	127.59	28.90	22.7	36.06	186.27
Milk and Dairy	43.20	16.19	37.5	14.25	72.49
Fresh and Processed Vegetables and Fruit	387.33	92.24	23.8	265.22	721.49
Feed grains	1037.61	887.74	85.6	5.73	4635.49
Maize, Corn, Rice and Wheat	406.76	205.48	50.5	89.37	905.62
Oilseeds, Meal, Fats and Oils	169.14	79.43	47.0	56.36	373.35
Sugar, Cocoa, Products, Coffee and Tea	136.15	75.79	55.7	36.80	347.22
Beverage, Tobacco, and other Imports	57.45	21.95	38.2	30.95	143.03
All Agricultural Imports	2365.23	1102.68	46.6	897.95	6368.88
Import Values (million SR)					
Live and Frozen Animals	762.41	163.25	21.4	272.62	1060.17
Milk and Dairy	380.22	144.20	37.9	110.58	647.89
Fresh and Processed Vegetables and Fruit	634.83	132.34	20.8	470.27	1021.99
Feed grains	483.27	374.36	77.5	3.65	1991.31
Maize, Corn, Rice and Wheat	534.96	214.53	40.1	178.60	920.65
Oilseeds, Meal, Fats and Oils	318.75	112.40	35.3	138.84	576.26
Sugar, Cocoa, Products, Coffee and Tea	567.84	194.85	34.3	208.78	930.83
Beverage, Tobacco, and other Imports	364.22	134.71	37.0	126.00	674.57
All Agricultural Imports	4046.49	896.23	22.1	2290.17	5459.52

Table 6-1 Continued

Variable	*Mean*	Std. Dev.	CV	Min	Max
Prices (SR / kg)					
Live and Frozen Animals	6.03	0.46	7.6	4.98	7.56
Milk and Dairy	8.74	0.79	9.0	7.48	10.24
Fresh and Processed Vegetables and Fruit	1.66	0.25	15.1	1.18	2.29
Feed grains	0.52	0.20	38.5	0.29	1.61
Maize, Corn, Rice and Wheat	1.43	0.34	23.8	0.82	2.52
Oilseeds, Meal, Fats and Oils	2.01	0.39	19.4	1.28	2.74
Sugar, Cocoa, Products, Coffee and Tea	4.80	1.66	34.6	2.59	9.93
Beverage, Tobacco, and other Imports	6.54	1.91	29.2	2.62	11.80
All Agricultural Imports	1.94	0.69	35.6	0.85	4.02

Table 6-2: Value and Quantity Shares for Each Group Relative to Total Imports

Group	Value % of Total imports	Quantity % of Total imports
Live and Frozen Animals	19.47	6.58
Milk and Dairy	9.4	2.31
Fresh and Processed Vegetables and Fruit	16.1	19.24
Feed grains	11.38	38.02
Maize. Corn. Rice and Wheat	12.97	17.51
Oilseeds. Meal. Fats and Oils	7.78	7.4
Sugar. Cocoa. Products. Coffee and Tea	13.73	6.0
Beverage. Tobacco. and other Imports	9.21	2.95
All Agricultural Imports	100	100

Due to data and computational limitations, it is hard to analyze all individual imported goods simultaneously, so the data was aggregated into a number of relatively large and distinct categories. Based on the importance of a good and its share in total value, agricultural imports were divided into eight groups. These eight groups are: the live and frozen animals group, the milk and dairy group, the fresh and processed vegetables and fruit group, the feed grains group, the maize, corn, rice and wheat group, the oilseeds, meal, fats and oils group, the sugar, cocoa products, coffee and tea group, and the beverage, tobacco, and other imports group. The average share of each group in total quantity and value is given in table 6-2.

As with the coefficients of variation shown earlier, comparing across the value and quantity shares may give some indication of those groups likely to have the highest expenditure and price elasticities. Feed grains, and maize and wheat, have the highest shares in both value and quantity shares (although not the highest ratios between quantity and value shares), and they will be shown to have the highest elasticities overall as well.

Several transformations were needed to prepare this data for the econometrics estimations described in Chapter 5. To calculate the value share (w_{it}) of expenditure for each group, the group expenditures were divided by total expenditures on agricultural imports. Then, the following formula

(78) $$w'_{it} = \frac{w_{it} + w_{i,t-1}}{2}$$

was used to calculate w'_{it}, which is the two-period average value share, an approximation used to get an average value across time with discrete data. The natural logarithm of quantity for each group was then calculated and its growth rate determined using the following formula

(79) $$\Delta \ln q_{it} = \ln q_{it} - \ln q_{i,t-1}.$$

Using the same method, the growth rates of prices are calculated by

(80) $$\Delta \ln p_{it} = \ln p_{it} - \ln p_{i,t-1}.$$

The index number (Divisia Volume Index) for the change in real income is calculated by substituting the results obtained from shares and growth rates of the quantity in the following formula:

(81) $$\Delta \ln Q = \sum_{i} w_i \Delta \ln q_i$$

6.3 Testing for Autocorrelation

Since the data used is time series, autocorrelation is expected to be present in the series. Table 6-3 shows the log-likelihood functions and likelihood ratio tests (LRT) for all demand models (Rotterdam, AIDS, CBS, NBR, and General Model).

The following hypotheses are tested:

H_0: the model does not have autocorrelation.

H_a the model has autocorrelation.

Since each model has one additional parameter compared to the restricted model, the respective LRT statistic is chi-squared distributed with one degree of freedom and its value is two times the logarithmic differences between the likelihood values of the restricted and unrestricted models. Comparing the LRT for all models, which are 16.97, 6.88, 19.49, 5.04, and 21.368 for Rotterdam, AIDS, CBS, NBR and the general model respectively, with the table value of χ^2 at one degree of freedom at 5% level (3.84), the null hypotheses is rejected and we conclude the presence of autocorrelation in all models. This is shown in table 6-3.

6.4 Model Selection

In the previous section, table 6.3 indicated that five demand systems were estimated. The general model was estimated and then restricted to reflect other nested versions, the Rotterdam, AIDS, CBS, and NBR. These different models yield varying results, so one objective is to find the best model to fit Saudi Arabia's agricultural import data. To select the appropriate model, a model selection test has been used and the following null hypotheses have been tested:

H_o: the restricted model (Rotterdam, AIDS, CBS, or NBR) fits the data best.

H_a: the restricted model (Rotterdam, AIDS, CBS, or NBR) does not fit the data.

Table 6-3: Test Results on the Presence of Autocorrelation in All Models

Model	Log Likelihood function without autocorrelation correction	Log Likelihood function with autocorrelation correction	Likelihood ratio test (LRT)
Rotterdam	732.826	741.311	16.97
AIDS	691.1	694.54	6.88
CBS	746.244	754.5	19.49
NBR	675.93	678.45	5.04
General Model	741.7	752.385	21.368

The table value of χ^2 with one degree freedom = 3.84 at α=0.05.

Table 6-4 shows test results for Rotterdam, CBS, AIDS, and NBR as restricted from the general model with first-order autocorrelation imposed. As discussed in chapter 5, all four models are nested within the general model that has two extra parameters (α_1 and α_2) and the model choice depends on the value of these two parameters. If hypothesis tests indicted that these values equal zero, the model will be the Rotterdam; if they equal one, the model will be AIDS. If α_1=1 and α_2=0 the model will be CBS, while the reverse, (α_1=0 and α_2=1) leads to the NBR model. The test results show that the values of these parameters, which equaled 1.42 and 0.06, implied the CBS model was most appropriate. In addition, the general model system rejects the Rotterdam, AIDS, and NBR because the log-likelihood ratio test statistics are greater than the χ^2 with two-degrees of freedom. Only the CBS is not rejected by the general system, implying that the CBS form fits the data better than do the other three.

This result appears to have some logic based on the presentation in Chapter 2. For example, the expenditure elasticity in the CBS model varies with the commodity's share, as it does in the AIDS model, while the Rotterdam and the NBR models have fixed expenditure elasticities. There were at least two significant shifts in shares of food consumed over the decade of the 1990s, which included a rather large decrease in the consumption of fruit and vegetables, and growth in the consumption of meat. Thus, the expenditure elasticities may logically change with the shifting shares as in the CBS model.

The CBS model also has price elasticities that do not change. While this may be harder to assess, real per capita income was relatively stagnant over the decade, the number of non-Saudis did not change as much as a percentage of the population, and thus major shifts that might have led to a declining price sensitivity seem to be absent over the years considered. Thus, the CBS model is adopted as the model of choice for analyzing the import data in this study. Accordingly, the CBS results will be reported and discussed in the following sections.

Table 6-4: Test Results for the Rotterdam, CBS, AIDS, and General Model with First-Order Autocorrelation Imposed.

Model	Log of Likelihood function With autocorrelation correction	Likelihood ratio test (LRT)
General model	752.385	--
Rotterdam	741.311	22.15
AIDS	694.54	115.69
CBS	754.5	4.23
NBR	678.45	147.87

The table value of χ^2 with two degree freedom = 5.99 at α=0.05.

The estimates for α_1 and α_2 are 1.42 and 0.06 with standard error 0.21 and 0.023 respectively.

6.5 CBS Model Estimation

Given that the CBS model is the best model based on statistical tests, the results obtained using the restricted CBS model are the only ones presented in detail. All agricultural imports have been divided into eight groups and estimated. These eight groups are: animals; milk and dairy; vegetables and fruit; feed grains; maize and wheat; oils and fats; sugar and coffee; and beverages and tobacco[1].

6.5.1 Comparing CBS Model Alternatives

Several alternative models using the CBS functional form were computed and evaluated. All of these were corrected for the presence of autocorrelation. An unconstrained model was first estimated and then used to test the validity of demand restrictions, including homogeneity and symmetry. The validity of these restrictions was tested by means of a likelihood ratio test (LRT), with the results being reported in table 6-5. Homogeneity and symmetry restrictions, when imposed individually, could not be rejected at the one percent level, and even more strongly, at the 0.1 percent level, when homogeneity and symmetry were imposed jointly. Thus the results were very compatible with restrictions from economic theory.

6.5.2 CBS Alternative Estimations

In this section, estimation has been done without and with imposing homogeneity and symmetry restrictions on the coefficient matrix. Table 6-6 shows the unrestricted estimation results, while estimations done by imposing restrictions are shown in table 6-7.

[1] Animals group contains live and frozen animals, vegetables and fruit group contains fresh and processed vegetables and fruit, maize and wheat group contains maize, corn, rice and wheat, oils and fats group contains oilseeds, meal, fats and oils, sugar group contains sugar, cocoa, products, coffee and tea, beverages group contains the beverage, tobacco and other imports.

Table 6-5: CBS Model Test Results for the Validity of Demand Properties

Model	Log of Likelihood Function	Likelihood ratio test (LRT)	χ^2
Unrestricted	757.41	--	
Homogeneity Imposed	753.01	8.8134	18.48 (0.01)
Symmetry Imposed	743.43	27.96	38.93 (0.01)
Homogeneity and Symmetry Imposed	731.93	50.97	56.89 (0.001)

***, **, * Significant at 1%, 5%, 10% levels.

Figures in parentheses are standard error of the coefficients.

The equations correspond to the rows of this table. Under each point estimate, the corresponding estimates of standard errors are given. The diagonal elements of the estimated parameter matrix show the right signs, except for milk and dairy and feed grains. The next paragraphs discuss these results. In general, the significance and directions of the various coefficients are highlighted here, and the magnitudes are discussed in the later section on elasticities.

Animals group. The estimated parameter for the aggregated animals group shows a significant expenditure effect at the one percent level. The own-price effect is significant at a five percent probability level as well and has a negative sign, which is compatible with economic theory and implies an inverse relationship between consumption of imported animal products and price. The estimated cross price coefficients show significant substitution relationships with the milk and dairy, sugar and beverage groups.

Imposing restrictions increased the own price parameter and its significance slightly, from –0.189 to –0.206. Also, the substitution relations became significant in the case of vegetables and fruit, feed grains, and oils and fats. Moreover, sugar became more significant, but the milk and dairy coefficient went from a positive and significant value of 0.218 to insignificance. Thus, in the unrestricted case, milk and dairy is a clear and strong substitute in consumption with animal products, but that effect disappears with the use of the restrictions in estimation. In most cases, the cross price effects became smaller with the imposition of restrictions. Also, it appears that imports of animal products are substitutes to products that are higher valued and closely related in consumption, such as vegetables and fruit, oils and fats, sugar and beverages products. The exception is feed grains, which is hypothesized to be a part of an input-output relation with animal products. This relationship is discussed further below.

Milk and Dairy group. The estimated parameter for the aggregated milk and dairy group shows a significant expenditure effect at the one percent probability level. The own-price effect is insignificant and has an incorrect sign, which is incompatible with economic theory. The estimated cross price coefficients show only a few significant substitution relationships with other commodities, specifically the feed grains and beverages groups, at one percent and five percent probability levels respectively, and a ten percent level for vegetables and fruit. While beverages and vegetables and fruit may well be substitutes in consumption, the feed grains result, with a positive value, shows a potential input-output relationship with milk and dairy. Higher feed grain import prices would lead to lower milk production as feed grains are used as inputs in local milk projects. This means more quantities from milk and dairy will be imported.

Imposing restrictions reduces the expenditure coefficient and its significance level, but it is still significant. The own price effect becomes compatible with economic theory and is significant. Also, with the homogeneity and symmetry restrictions, maize and wheat showed a significant substitution effect and feed grains became more significant. The postive link as existed with feed grains shows that some part of this aggregated group is used for inputs into milk and dairy.

Table 6-6: Implied Marginal Shares and Slutsky Coefficients Based on Parameter Estimates of the Autocorrelation-Corrected Unrestricted CBS Model

Imports group	Marginal budget share	Slutsky Coefficient							
		Live and frozen animals	Milk & dairy	Fresh & processed vegetables & fruit	Feed grains	Maize, corn, rice and wheat	Oilseeds, meal, fats and oils	Sugar, cocoa, products, coffee & tea	Beverage, tobacco, and other imports
Live and frozen animals	-0.085 (0.027)***	-0.189 (0.086)**	0.218 (0.111)**	0.067 (0.049)	0.029 (0.022)	0.006 (0.031)	-0.034 (0.035)	0.041 (0.024)*	0.098 (0.022)***
Milk & dairy	-0.030 (0.012)***	0.015 (0.039)	0.034 (0.050)	0.035 (0.022)*	0.021 (0.010)**	0.000 (0.014)	0.004 (0.016)	0.001 (0.011)	0.044 (0.010)***
Fresh & processed vegetables & fruit	-0.068 (0.019)***	0.058 (0.061)	-0.012 (0.079)	-0.124 (0.035)***	0.001 (0.016)	-0.005 (0.022)	0.059 (0.025)**	-0.014 (0.017)	-0.003 (0.016)
Feed grains	0.158 (0.049)***	0.140 (0.154)	-0.430 (0.198)**	-0.120 (0.087)	-0.087 (0.040)**	0.092 (0.056)*	0.100 (0.063)	0.027 (0.043)	-0.112 (0.039)***
Maize, corn, rice & wheat	0.031 (0.018)*	0.015 (0.057)	0.109 (0.074)	0.015 (0.032)	0.043 (0.015)***	-0.131 (0.021)***	-0.044 (0.024)**	0.054 (0.016)***	-0.011 0.015
Oilseeds, meal, fats and oils	0.017 (0.012)*	0.051 (0.039)	0.033 (0.050)	0.025 (0.022)	-0.003 (0.010)	-0.016 (0.014)	-0.081 (0.016)***	0.023 (0.011)**	0.006 0.010
Sugar, cocoa, products, coffee & tea	-0.010 (0.014)	0.052 (0.046)	0.067 (0.059)	0.081 (0.026)***	-0.009 (0.012)	0.017 (0.017)*	0.020 (0.019)	-0.158 (0.013)***	0.033 (0.012)***

***, **, * Significant at 1%, 5%, 10% levels.

Figures in parentheses are standard error of the coefficients.

Table 6-7: Implied Marginal Shares and Slutsky Coefficients Based on Parameter Estimates of the Autocorrelation-Corrected CBS Model with Homogeneity and Symmetry Imposed

Imports group	Marginal budget share	Slutsky Coefficient							
		Live and frozen animals	Milk & dairy	Fresh & processed vegetables & fruit	Feed grains	Maize, corn, rice and wheat	Oilseeds, meal, fats and oils	Sugar, cocoa, products, coffee & tea	Beverage, tobacco, and other imports
Live and frozen animals	-0.051 (0.023)**	-0.206 (0.039)***	-0.025 (0.030)	0.046 (0.024)**	0.044 (0.021)**	0.017 (0.015)	0.028 (0.014)**	0.047 (0.013)***	0.049 (0.012)***
Milk & dairy	-0.018 (0.011)*	-0.011 (0.013)	-0.077 (0.027)***	0.008 (0.017)	0.027 (0.010)***	0.017 (0.011)*	0.014 (0.012)	0.001 (0.008)	0.021 (0.007)***
Fresh & processed vegetables & fruit	-0.044 (0.017)***	0.046 (0.024)**	0.008 (0.017)	-0.155 (0.027)***	0.011 (0.015)	0.039 (0.014)***	0.036 (0.013)***	0.022 (0.011)**	-0.007 (0.010)
Feed grains	0.089 (0.038)***	0.044 (0.021)**	0.027 (0.010)***	0.011 (0.015)	-0.111 (0.037)***	0.049 (0.013)***	-0.003 (0.009)	-0.003 (0.011)	-0.014 (0.010)
Maize, corn, rice & wheat	0.036 (0.015)***	0.017 (0.015)	0.017 (0.011)*	0.039 (0.014)***	0.049 (0.013)***	-0.135 (0.013)***	-0.025 (0.010)***	0.043 (0.009)***	-0.005 (0.008)
Oilseeds, meal, fats and oils	0.017 (0.011)	0.028 (0.015)**	0.014 (0.012)	0.036 (0.013)***	-0.003 (0.009)	-0.025 (0.010)***	-0.071 (0.012)***	0.019 (0.007)***	0.001 (0.007)
Sugar, cocoa, products, coffee & tea	0.001 (0.012)	0.047 (0.013)***	0.001 (0.008)	0.022 (0.011)**	-0.003 (0.011)	0.043 (0.009)***	0.019 (0.007)***	-0.152 (0.010)***	0.013 (0.009)

***, **, * Significant at 1%, 5%, 10% levels.

Figures in parentheses are standard error of the coefficients.

Observing the column related to milk imports, it is seen that there is very little relation to other products beyond those that might be inputs into milk production. The relative lack of links suggests that the milk commodity is relatively independent of the other products, perhaps because it is more of a staple and traditional product, and is fairly unique in consumers' eyes among food products.

Vegetables and fruit group. The estimated parameter for the aggregated vegetables and fruit group shows a significant expenditure effect at the one percent level. The own-price effect is significant at a one percent probability level and has a negative sign, which is compatible with economic theory and implies an inverse relationship between consumption and price. The cross price coefficients show a significant substitution relationship only with the oils and fats group, at a five percent probability level. It is somewhat surprising that only one other commodity acts as a substitute, especially in a country with rising incomes and growing levels of education. Again, it may also indicate that vegetables and fruit are viewed as unique products and there is little comparison made between them and, say, animal products.

Imposing restrictions increases the own price parameter value from –0.124 to –0.155, and it remains significant at the one percent level. Also, maize and wheat show a highly significant substitution effect, as do oils and fats, and sugar. Thus, with the imposition of restrictions, a more reasonable number of substitutes, most probably in consumption, appear.

Feed grains group. The estimated parameter for the aggregated feed grains group shows a significant expenditure effect at the one percent probability level. The own-price effect is significant at a five percent probability level and has a negative sign, which is compatible with economic theory and implies an inverse relationship between consumption and price. The estimated cross price coefficients show a significant substitution relationship with maize and wheat at a ten percent probability level. On the other hand, there is a complementary relationship with milk and dairy and beverages. Imposing restrictions reduces the expenditure coefficient without affecting its significance level. The own price parameter increases and becomes more significant. Significant positive relationships exist with maize and wheat, milk and dairy and animals. The latter positive values suggest that increased prices for livestock leads to a greater import demand for feed grains, showing its input relation to those products. The significance of the maize group suggests some substitution in feeding these products to livestock.

Maize and wheat group. The estimated parameter for the aggregated maize and wheat group shows a significant expenditure effect at the 10 percent probability level. The own-price effect is significant at the one percent level and has a negative sign, which is compatible with economic theory and implies an inverse relationship between consumption and price. The estimated cross price coefficients show a significant substitution relationship with feed grains and sugar, and a complementary relationship with oils and fats. Imposing restrictions yields a more significant expenditure effect, and milk and dairy, and vegetables and fruit, turn into significant substitutes.

The aggregation chosen for this product group may lead to combinations of products that actually have different uses, as the substitution with feed grains and significance in milk and dairy indicates competition for its use as an input to livestock production. In contrast, the significance of cross price coefficients for sugar, oils and fats and vegetables and fruit suggest that some maize and wheat products are substitutes in consumption with these higher valued products, possibly as sweeteners. For instance, maize for feeding and basmati rice, a high valued rice product, may have been aggregated into a single category. Also, the column related to maize and wheat shows more significant relationships than any other column, again suggesting that price increases in maize and wheat have extensive and varying impacts.

Oilseeds and fats group. The estimated parameter for aggregated oils and fats shows a significant expenditure effect at the 10 percent level. The own-price effect is significant at one percent and has a negative sign, which is compatible with economic theory and implies an inverse relationship between consumption and price. The estimated cross price coefficients show a significant substitution relationship with beverages at a five percent probability level. Imposing restrictions shows a significant substitution effect of animals group and vegetables and fruit. Also, maize and wheat shows a significant complementary effect. It is clear from these results that fats and oils primarily interact in a substitution relationship with other high valued products. The maize and wheat result is unusual, but may be related to the aggregation issue raised in the section above.

Sugar group. The estimated parameter for the aggregated sugar group shows the insignificance of an expenditure effect. The own-price effect is significant at a one percent probability level and has a negative sign, which is compatible with economic theory and implies an inverse relationship between consumption and price. The estimated cross price coefficients show significant substitution relationships with vegetables and fruit and beverages. Imposing restrictions corrects the sign of the expenditure effect even though it is still insignificant. Animals, and oils and fats show a significant substitution effect, while the maize and wheat group show a more significant effect. It is clear that the significant substitution effects are with the higher valued products, further confirming that there is a group of five aggregated commodities that appear to operate in close substitution relations, while the others are input supplies to the livestock industry or are relatively independent, as is the case with milk and dairy.

Summary. Overall, these results for the unrestricted model with a correction for autocorrelation show generally significant expenditure effects with the correct signs, and in addition, for most groups there is a significant and negative own price effect. Moreover, numerous significant cross price effects were observed, most of which were substitute relations, but there were also several complements. Imposing homogeneity and symmetry conditions usually improved results, yielding more significant results and better compatibility with economic theory. In general, there appears to be a set of five higher valued products that have significant substitution in consumption relations: animal products, vegetables and fruit, oils and fats, sugar products and the beverage group. Feed grains appear to interact in a distinctly different manner, showing significance usually only with the livestock products that use grain as an input. The milk and dairy group is relatively separated, perhaps due to its traditional standing as an important commodity. Also, the maize and wheat group appears to interact as both an input to livestock and as a final consumption good that substitute with other higher valued products, and perhaps, this group is aggregated incorrectly.

6.5.3 Empirical Elasticities

Using the estimated parameters obtained from the model with homogeneity and symmetry conditions, table 6-8 reports the expenditure elasticities, compensated own-price elasticities, and cross price elasticities computed via the following formulas:

$$\varepsilon_{ij} = \frac{\pi_{ij}}{wi} \text{ and}$$

$$\eta_i = 1 + \beta_i / w_i ,$$

where the ε_{ij} is the price elasticity and η_i is the expenditure elasticity. As significance levels and directions are the same as in the earlier discussion about the coefficient estimates, the discussion is not repeated in great depth. The three categories of elasticities are discussed in the paragraphs below: the own price effects; the cross price effects; and the income effects.

In analyzing demand systems, the consumer is assumed to follow a multi-stage approach in allocating his income (Theil, 1980). In the first stage, the Saudi consumers are assumed to allocate their income to all imported goods. In the second stage, they allocate their expenditure between agricultural import groups. Thus, the price and expenditure elasticities estimated in the study should be interpreted as conditional on the consumer expenditure allocated to agriculture imports as a whole.

Looking first at own-price elasticities on the diagonal, most show unitary elasticities, or nearly so. In the restricted model, all are significant and have the negative signs required by theory for own prices. The ones with unitary elasticities are the animals group, vegetables and fruit, feed grains, maize and wheat, oils and fats, and sugar. In contrast, they are inelastic for milk and dairy, and beverages. Four of the products with unitary elasticities are in the group of higher-valued goods that are expected to be more price sensitive, so elasticities of -1.0 are reasonable. The lowest elasticity is found for milk and dairy, which is consistent with the lower sensitivity to price changes expected due to the lack of substitutes and an insignificant expenditure effect. The feed grains and maize and wheat values seem high, for reasons discussed below.

Table 6-8: Average CBS Elasticity Estimates of Saudi Arabian Agriculture Imports, Based on the Fully Restricted Model, 1990.1-2000.4

Imports group	Income elasticity	Compensated price elasticity							
		Live and frozen animals	Milk & dairy	Fresh & processed vegetables & fruit	Feed grains	Maize, corn, rice and wheat	Oilseeds, meal, fats and oils	Sugar, cocoa, products, coffee & tea	Beverage, tobacco, and other imports
Live and frozen animals	0.745**	**-1.091*****	-0.089	0.224**	0.229**	0.083	0.156**	0.251***	0.237***
Milk & dairy	0.817*	-0.186	**-0.782*****	0.086	0.287***	0.197*	0.140	0.022	0.236***
Fresh & processed vegetables & fruit	0.735***	0.272**	0.050	**-0.968*****	0.068	0.241***	0.228***	0.146**	-0.037
Feed grains	1.784***	0.392**	0.236***	0.096	**-0.975*****	0.434***	-0.027	-0.029	-0.126
Maize, corn, rice & wheat	1.275***	0.124	0.141*	0.297***	0.378***	**-1.029*****	-0.189***	0.331***	-0.052
Oilseeds, meal, fats and oils	1.205	0.389**	0.167	0.468***	-0.040	-0.315***	**-0.915*****	0.232***	0.013
Sugar, cocoa, products, coffee & tea	1.001	0.357***	0.015	0.171**	-0.024	0.315***	0.132***	**-1.096*****	0.130
Beverage, tobacco, and other imports$^{(A)}$	0.652	0.506	0.240	-0.065	-0.156	-0.075	0.011	0.194	**-0.655**

***, **, * Significant at 1%, 5%, 10% levels.

$^{(A)}$ This equation was omitted from the estimation, so there are no significance designations reported.

With respect to cross price effects, a negative cross price elasticity indicates complementary goods, while a positive cross price elasticity indicates substitutes. Of those commodities that are thought to be higher valued products and substitutes with each other, all have their most significant effects and highest values with other products in that general group. That group can be characterized as consumer-ready, or final products, products with higher values and thus more price sensitivity. They include the animals group, vegetables and fruit, oils and fats, sugar and beverages. Maize and wheat appears to also have some features of this group. Thus, for example, the oils and fats row shows that positive and significant cross price elasticities between 0.23 and 0.47 exist for animals, vegetables and fruit, oils and fats, sugar and beverages, just those commodities that are in that group of higher valued products.

Others in this category exhibit similar outcomes. The feed grains have significant and important effects mainly as inputs to livestock production, with elasticities of 0.392 and 0.236 for animals and milk, respectively. Also, maize and wheat is seen as a substitute with feed grains in input usage, as there are positive values of about 0.40 for cross price effects between these two commodities.

The independence of milk and dairy is also seen in this analysis of cross price elasticities, as there are few significant effects except for feed grains. The positive and significant value for beverages is intriguing, indicating that there may be some evolution of substitution between milk and soft drinks, similar to that in the US. Other than that coefficient, beverages are not significant very often, perhaps in part because it is not estimated as a separate equation, which might affect its performance.

Regarding the expenditure effect, a commodity is estimated to be inferior when $\eta_i < 0$, or non-inferior when $\eta_i \geq 0$; in the latter case it can be a normal good when $\eta_i \leq 1$, or a luxury when $\eta_i > 1$ (Barten, 1993). The mean expenditure elasticities for Saudi agricultural imports reported in table 6-8 indicated that animals, milk and dairy, vegetables and fruit, sugar and beverages have expenditure elasticities less than one, but they are all fairly high for food products. Oils and fats, sugar, and beverages have elasticities higher than one but they are not significantly different than zero.

Unexpectedly, the highest expenditure elasticities are for feed grains, and maize and wheat, which were expected to have the lowest income effects. They also exhibited among the highest own price effects. One possible explanation for this is that during 1994-1995, the large government support for wheat production declined and total production dropped considerably. This led to a surge in imports of feed grains, and wheat and maize, which should have been picked up as an exogenous shift due to policy changes. However, attempts to make proxies work were unsuccessful, and thus were not used. A better set of shifters might make these expenditures effects lower. However, the derived demand relationship between the inputs, feed grains, and some of the maize and wheat products, and the outputs of milk and dairy and animals gives an extra demand pull dimension to these products, and may explain the higher expenditure elasticities.

6.6 Estimated Local Demand Elasticities

In order to estimate local demand elasticities, local supply elasticities are assumed to fall within ranges based on literature for Pakistan and other related countries. When goods are not produced in Saudi Arabia, such as oils and fats, sugar, and beverages, there are no supply elasticities to be assumed. To be more precise, three scenarios are created that vary by the assumed supply elasticity matrices. Additionally, these results can vary by whether homogeneity and symmetry restrictions are imposed or not. Thus, there are six alternatives presented here that are used in the simulations in the next section. The assumed supply elasticities in the first scenario are typical of those in the literature, while the second scenario assumes the supply response is lower, and the final scenario uses higher responses for supply.

6.6.1 Local Demand Elasticities Estimated (Scenario 1)

Using a restricted CBS demand system and assumed supply elasticities shown in table 6-9, which appear to be in ranges typical within the literature, local demand elasticities are estimated with and without homogeneity and symmetry restrictions. Table 6-10 shows the resulting local demand elasticities. Own price elasticities are compatible with demand theory except for milk and dairy. They are significant at one percent level for the oils and fats and sugar groups, while it is significant at the 10 percent level for animal and feed grains groups. Income elasticities are significant at the one percent level for animals, milk and dairy, vegetables and fruits, and feed grains. The remaining groups also show positive values and reasonable ranges for expenditure elasticities but they are insignificant.

Table 6-9: First Scenario of Assumed Local Supply Elasticities for Agricultural Products in Saudi Arabia

Imports group	Live and frozen animals	Milk & dairy	Fresh& processed vegetables & fruit	Feed grains	Maize, corn, rice and wheat	Oilseeds, meal, fats and oils	Sugar, cocoa, products, coffee & tea	Beverage, tobacco, and other imports
Live and frozen animals	0.300	0.350	0.000	0.300	0.000	0.000	0.000	0.000
Milk & dairy	0.350	0.250	0.000	0.000	0.000	0.000	0.000	0.000
Fresh& processed vegetables& fruit	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000
Feed grains	0.400	0.000	0.000	0.350	0.000	0.000	0.000	0.000
Maize, corn, rice & wheat	0.000	0.000	0.000	0.000	0.250	0.000	0.000	0.000
Oilseeds, meal, fats and oils	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sugar, cocoa, Products, coffee& tea	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Beverage, tobacco, and other imports	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 6-10: Estimated Local Demand Elasticities Using Local Supply Elasticities (Scenario 1) Without Restrictions Imposed of Saudi Arabia Agriculture Products

		Compensated price elasticity							
Imports group	Income elasticity	Live and frozen animals	Milk & dairy	Fresh& processed vegetables & fruit	Feed grains	Maize, corn, rice and wheat	Oilseeds, meal, fats and oils	Sugar, cocoa, products, coffee & tea	Beverage, tobacco, and other imports
Live and frozen animals	0.537***	**-0.138***	0.291***	0.299	0.021	0.022	-0.189	0.186***	0.513
Milk & dairy	0.683***	0.110	**0.142**	0.374	0.225**	-0.001	0.038	-0.010***	0.463
Fresh& processed vegetables& fruit	0.579***	0.356	-0.073	**-0.055**	0.008	-0.030	0.363**	-0.089	-0.017
Feed grains	2.376***	0.078	-3.763**	-1.060	**-0.167***	0.808*	0.872	0.246	-0.995***
Maize, corn, rice & wheat	0.612	-0.017	0.439	0.622	-0.190	**-0.078**	-0.062	-0.052	0.382*
Oilseeds, meal, fats and oils	1.214	0.653	0.403	0.314	-0.033	-0.211	**-1.034***	0.301**	0.072
Sugar, cocoa, Products, coffee& tea	0.925	0.382	0.483	0.588***	-0.069	0.118	0.145	**-1.147***	0.238***
Beverage, tobacco, and other imports	1.821	-1.648	2.344	-1.647	0.322	-0.884	-0.603	1.003	**-1.265**

***, **, * Significant at 1%, 5%, 10% levels.

Table 6-11: Estimated Local Demand Elasticities Using Local Supply Elasticities (Scenario 1) with Restrictions Imposed of Saudi Arabia Agriculture Products

Imports group	Income elasticity	Compensated price elasticity							
		Live and frozen animals	Milk & dairy	Fresh& processed vegetables & fruit	Feed grains	Maize, corn, rice and wheat	Oilseeds, meal, fats and oils	Sugar, cocoa, products, coffee & tea	Beverage, tobacco, and other imports
Live and frozen animals	0.474***	**0.085**	-0.278***	0.009***	-0.060	-0.046	0.116	0.209**	1.000***
Milk & dairy	0.575***	0.177***	**0.008**	-0.460***	0.057	0.068	-0.097	-0.053	0.301***
Fresh& processed vegetables& fruit	0.800**	-0.338***	-0.267***	**-0.048***	0.065	0.043	0.414***	0.205***	-0.074
Feed grains	1.772**	0.015	0.047	0.092	**-0.112**	0.453***	-0.030	-0.004	-0.461***
Maize, corn, rice & wheat	0.510**	-0.090	0.048	0.053	0.395***	**-0.162*****	-0.104	0.247***	-0.387***
Oilseeds, meal, fats and oils	1.411***	-0.115	-0.116	0.851***	-0.044	-0.173	**-0.674*****	0.229***	0.042
Sugar, cocoa, Products, coffee& tea	1.035	0.165**	-0.036	0.240***	-0.003	0.235***	0.130***	**-1.001*****	0.271***
Beverage, tobacco, and other imports	2.243	0.101	0.594	-0.736	-0.297	-0.417	0.245	0.169	**-0.692**

***, **, * Significant at 1%, 5%, 10% levels.

Table 6-11 shows the resulting local demand elasticities imposing homogeneity and symmetry conditions. Concerning own price effects, imposing restrictions has little impact on the performance of these coefficients. There is still a lack of significance and several effects with incorrect directions. The expenditure effects are similar to the unrestricted case, but there is significance. In both estimations, the expenditure elasticities are lower than those estimated for the import demand models, which seems to be a correct relationship between an import demand model and a domestic demand estimation. In general, these restricted results suggest more reasonable cross price effects. Several large effects become more moderate, such as the milk and dairy impact on feed grains, which goes from a negative and significant -3.763, to a positive and insignificant 0.047. In addition, there are more significant cross price effects and the range appears to be mostly less than 0.40. The overall improvement in performance of the estimation does improve materially by imposing restrictions.

6.6.2 Local Demand Elasticities Estimated (Scenario 2)

In this scenario, different supply elasticities have been assumed, which are lower than those assumed to be typical of the literature. Using a restricted CBS demand system and the assumed supply elasticities that are shown in table 6-12, domestic demand elasticities are estimated with and without homogeneity and symmetry restrictions imposed.

Table 6-13 shows the resulting local demand elasticities without restrictions. Own price elasticities are compatible with demand theory, except for milk and dairy, and they show a negative relationship. These parameters are significant at the one percent level for the vegetables and fruit, oils and fats, and sugar. In addition, it is significant at the five percent level for feed grains and at 10 percent for the animals. The expenditure elasticities estimated are also compatible with theory and significant for the animals, milk and dairy, vegetables and fruit, and feed grains. In addition, the correct signs are obtained, albeit not significant, for the maize and wheat, oils and fats, and the beverages.

Table 6-12: Second Scenario of Assumed Local Supply Elasticities for Agricultural Products in Saudi Arabia

Imports group	Live and frozen animals	Milk & dairy	Fresh& processed vegetables & fruit	Feed grains	Maize, corn, rice and wheat	Oilseeds, meal, fats and oils	Sugar, cocoa, products, coffee & tea	Beverage, tobacco, and other imports
Live and frozen animals	0.250	0.100	0.000	0.130	0.000	0.000	0.000	0.000
Milk & dairy	0.100	0.150	0.000	0.000	0.000	0.000	0.000	0.000
Fresh& processed vegetables& fruit	0.000	0.000	0.200	0.000	0.000	0.000	0.000	0.000
Feed grains	0.130	0.000	0.000	0.180	0.000	0.000	0.000	0.000
Maize, corn, rice & wheat	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.000
Oilseeds, meal, fats and oils	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sugar, cocoa, Products, coffee& tea	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Beverage, tobacco, and other imports	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 6-13: Estimated Local Demand Elasticities Using Local Supply Elasticities (Scenario 2) without Restrictions Imposed of Saudi Arabia Agriculture Products

Imports group	Income elasticity	Compensated price elasticity							
		Live and frozen animals	Milk & dairy	Fresh& processed vegetables & fruit	Feed grains	Maize, corn, rice and wheat	Oilseeds, meal, fats and oils	Sugar, cocoa, products, coffee & tea	Beverage, tobacco, and other imports
Live and frozen animals	0.556***	**-0.148***	0.238**	0.324	0.025	0.026	-0.181	0.199*	0.509***
Milk & dairy	0.683***	0.056	**0.121**	0.374	0.225**	-0.001	0.038	-0.009	0.463***
Fresh& processed vegetables& fruit	0.579***	0.356	-0.073	**-0.100*****	0.008	-0.030	0.363**	-0.089	-0.017
Feed grains	2.377***	0.054	-3.763**	-1.060	**-0.181****	0.808*	0.872	0.246	-0.995***
Maize, corn, rice & wheat	0.612	-0.017	0.438	0.622	-0.190	**-0.089**	-0.062	-0.052	0.382***
Oilseeds, meal, fats and oils	1.214	0.653	0.403	0.314	-0.033	-0.211	**-1.034*****	0.301**	0.072
Sugar, cocoa, Products, coffee& tea	0.925	0.382	0.483***	0.588	-0.069	0.118	0.145	**-1.147*****	0.238***
Beverage, tobacco, and other imports	1.592	-1.335	2.153	-1.064	0.215	-0.622	-0.141	0.552	**-0.652**

***, **, * Significant at 1%, 5%, 10% levels

Table 6-14: Estimated Local Demand Elasticities Using Local Supply Elasticities (scenario 2) with Restrictions Imposed of Saudi Arabia Agriculture Products

Imports group	Income elasticity	Compensated price elasticity							
		Live and frozen animals	Milk & dairy	Fresh& processed vegetables & fruit	Feed grains	Maize, corn, rice and wheat	Oilseeds, meal, fats and oils	Sugar, cocoa, products, coffee & tea	Beverage, tobacco, and other imports
Live and frozen animals	0.499***	**-0.059**	0.048	-0.254	0.015	-0.046	-0.036	0.130*	0.202***
Milk & dairy	0.596***	0.099	**-0.014**	-0.416***	0.067	0.095	-0.095	-0.049	0.313***
Fresh & processed vegetables& fruit	0.793**	-0.309***	-0.242***	**-0.095*****	0.066	0.040	0.408***	0.203***	-0.073
Feed grains	1.766**	0.026	0.055	0.094	**-0.131**	0.446***	-0.030	-0.005	-0.455***
Maize, corn, rice & wheat	0.492**	-0.069	0.068	0.050	0.388***	**-0.177*****	-0.111	0.236***	-0.384***
Oilseeds, meal, fats and oils	1.405***	-0.089	-0.114	0.838***	-0.044	-0.186	**-0.678*****	0.235***	0.038
Sugar, cocoa, Products, coffee& tea	1.028	0.184**	-0.033	0.238***	-0.004	0.224***	0.134***	**-1.008*****	0.265***
Beverage, tobacco, and other imports	2.230	0.216	0.232	-0.454	-0.359	-0.396	0.409	0.257	**0.094**

***, **, * Significant at 1%, 5%, 10% levels

Table 6-14 shows the resulting local demand elasticities created by imposing homogeneity and symmetry conditions. Own local demand price elasticities have a negative sign, so that they are compatible with demand theory. The results show significance at the one percent level for the vegetables and fruit, maize and wheat, oils and fats, and the sugar groups. The rest of groups did not show significance. Expenditure elasticities show the right signs for all groups. Vegetables and fruit, feed grains and maize, and wheat parameters show significance at the five percent level, while animals, milk and dairy, and oils and fats groups are significant at the one percent level. The sugar as well as the beverages group are compatible with theory but are not significant.

In sum, the restricted estimation in this case has all own price elasticities going in the correct directions, most of the cross price effects are moderate in size and there are many significant effects; additionally, the expenditure elasticities are similar to the other estimation and six of the seven estimated values are significant. In the simulations that follow, this restricted version of the second scenario will often be referred to, as its performance is the best of any of the alternative estimations shown in this section. It also suggests that only low supply elasticities are compatible with reasonable local demand matrices.

6.6.3 Local Demand Elasticities Estimated (Scenario 3)

In this scenario, a final set of supply elasticities has been assumed that are higher than those in Scenarios 1 and 2 are. Using a restricted CBS demand system and these assumed supply elasticities, shown in table 6-15, local demand elasticities are estimated with and without homogeneity and symmetry restrictions imposed.

Table 6-16 shows the resulting local demand elasticities without restrictions. Own local demand price elasticities show negative relationships except for the milk and dairy group, which are compatible with demand theory. These parameters are significant at the one percent level for fats and oils group, sugar and beverages. Also, it is significant at the five percent level for vegetables and fruit and at 10 percent for feed grains. The expenditure elasticities estimated are compatible with theory and significant for the feed grains, milk and dairy, live animals and vegetables and fruit. The last four groups have the correct signs but are insignificant.

Table 6-17 shows the resulting local demand elasticities when imposing homogeneity and symmetry conditions. Own price elasticities have the correct negative sign for all groups, except for milk and dairy, and beverages. Also, the results show significance at the one percent level for vegetables and fruit, maize and wheat, fats and oils, and sugar products. The rest of the groups did not show significance. Expenditure elasticities show the right sign and significance at five percent and one percent level for the feed grains and oilseeds, and the fats and oils groups, respectively. Moreover, it indicates the right sign but insignificance for sugar and beverages.

Overall, many of these results are similar to those in Scenario 2 using the restricted matrices except for the incorrect sign on the milk and dairy and beverages own price effects. The main question in both of these estimations is the presence of relatively large complementary relationships between vegetables and fruit and increased price for live animals and milk and dairy. on balance, scenario 2 appears to be the best.

Table 6-15: Third Scenario of Assumed Local Supply Elasticities for Agricultural Products in Saudi Arabia

Imports group	Live and frozen animals	Milk & dairy	Fresh& processed vegetables & fruit	Feed grains	Maize, corn, rice and wheat	Oilseeds, meal, fats and oils	Sugar, cocoa, products, coffee & tea	Beverage, tobacco, and other imports
Live and frozen animals	0.450	0.100	0.000	0.130	0.000	0.000	0.000	0.000
Milk & dairy	0.100	0.400	0.000	0.000	0.000	0.000	0.000	0.000
Fresh& processed vegetables& fruit	0.000	0.000	0.300	0.000	0.000	0.000	0.000	0.000
Feed grains	0.130	0.000	0.000	0.250	0.000	0.000	0.000	0.000
Maize, corn, rice & wheat	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.000
Oilseeds, meal, fats and oils	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sugar, cocoa, Products, coffee& tea	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Beverage, tobacco, and other imports	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 6-16: Estimated Local Demand Elasticities Using Local Supply Elasticities (Scenario 3) without Restrictions Imposed of Saudi Arabia Agriculture Products

Imports group	Income elasticity	Compensated price elasticity							
		Live and frozen animals	Milk & dairy	Fresh& processed vegetables & fruit	Feed grains	Maize, corn, rice and wheat	Oilseeds, meal, fats and oils	Sugar, cocoa, products, coffee & tea	Beverage, tobacco, and other imports
Live and frozen animals	0.556***	**-0.117**	0.238**	0.324	0.025	0.026	-0.181	0.199*	0.509***
Milk & dairy	0.848**	0.056	**0.175**	0.374	0.225**	-0.001	0.038	-0.009	0.463***
Fresh& processed vegetables& fruit	0.653***	0.356	-0.073	**-0.085****	0.008	-0.030	0.363**	-0.089	-0.017
Feed grains	1.803***	0.054	-3.763**	-1.060	**-0.176***	0.808*	0.872	0.246	-0.995***
Maize, corn, rice & wheat	0.740	-0.017	0.438	0.622	-0.190	**-0.099**	-0.062	-0.052	0.382*
Oilseeds, meal, fats and oils	1.086	0.653	0.403	0.314	-0.033	-0.211	**-1.034*****	0.301**	0.072
Sugar, cocoa, Products, coffee& tea	0.947	0.382	0.483	0.588***	-0.069	0.118	0.145	**-1.147*****	0.238***
Beverage, tobacco, and other imports	1.366	-1.366	2.098	-1.079	0.209	-0.612	-0.141	0.552	**-0.652**

***, **, * Significant at 1%, 5%, 10% levels

Table 6-17: Estimated Local Demand Elasticities Using Local Supply Elasticities (Scenario 3) with Restrictions Imposed of Saudi Arabia Agriculture Products

Imports group	Income elasticity	Compensated price elasticity							
		Live and frozen animals	Milk & dairy	Fresh& processed vegetables & fruit	Feed grains	Maize, corn, rice and wheat	Oilseeds, meal, fats and oils	Sugar, cocoa, products, coffee & tea	Beverage, tobacco, and other imports
Live and frozen animals	0.492***	**-0.027**	0.047	-0.267***	0.014	-0.047	-0.042	0.125**	0.197***
Milk & dairy	0.802***	0.099	**0.040**	-0.438***	0.059	0.095	-0.103	-0.057	0.305***
Fresh& processed vegetables& fruit	0.835**	-0.325***	-0.255***	**-0.078*** **	0.065	0.041	0.414***	0.207***	-0.070
Feed grains	1.447**	0.025	0.048	0.092	**-0.121**	0.448***	-0.030	-0.006	-0.457***
Maize, corn, rice & wheat	0.662**	-0.071	0.068	0.051	0.390***	**-0.187*** **	-0.111	0.239***	-0.379***
Oilseeds, meal, fats and oils	1.165***	-0.105	-0.123	0.850***	-0.043	-0.185	**-0.673*** **	0.238***	0.041
Sugar, cocoa, Products, coffee& tea	1.022	0.177**	-0.039	0.242***	-0.005	0.227***	0.136***	**-1.006*** **	0.268***
Beverage, tobacco, and other imports	1.575	0.226	0.212	-0.451	-0.360	-0.392	0.409	0.260	**0.096**

***, **, * Significant at 1%, 5%, 10% levels

6.6.4 Shares of Quantities Imported and Supplied in Local Demand

Table 6-18 shows the average domestic quantities demanded in the second column, which must come from either local supply or imports. Thus, the proportions of these products that supplied and imported as are also expressed as proportions of local demand in columns four and six. Oils, sugar and beverage imports represent total supply because there are no local supplies. Milk and dairy products have the lowest share of imports in domestic demand because that product has the highest production share in local demand, with 91.6 percent of local demand being supplied locally. Feed grains' local production is a small share of local demand, at 10 percent of total demand. The share of a commodity in local demand plays an important role in the following simulation exercises in the next section. Because most of the results are presented as proportional changes in the following simulations, a high import change proportionally, need not lead to a high change in supply or local demand, depending on the portions imported relative to domestic supply.

Table 6-18: Average Local Demand, Local Supply and Import Quantities during 1990-2000 (1000 MT)

Group	Local Demand	Local supply	% Of local demand	Imports	% Of local demand
Live animals	611.411	483.82	79.13	127.59	20.87
Milk and Dairy	514.042	470.84	91.6	43.2	8.4
Vegetable and Fruits	3365.145	2977.815	88.49	387.33	11.51
Feed grains	1151.747	114.137	9.9	1037.61	90.1
Maize, corn and wheat	2544.031	2137.27	84	406.76	16
Oils	169.14	0	0	169.14	100
Sugar	136.15	0	0	136.15	100
Beverages	57.45	0	0	57.45	100

6.7 Simulation Analysis

In this section, simulations looking at three issues for the Saudi Arabian agricultural economy are considered. First, changes are expected to occur in world prices because of WTO trade liberalization, which will affect the pattern of imports, local demand and exports in the economy. Also, input prices, especially water prices, will be rising due to increasing scarcity, which should affect domestic production and imports of different products. Finally, the traditional shifter examined in import demand models has been expenditure change, which will be the third simulation examined. In addition to the three issues to be examined, there will be several different scenarios reviewed for each simulation. As described in the previous section, three variations of simulations will be considered, which differ by the matrices of supply elasticities used to restrict the model to create local demand elasticities.

6.7.1 Changes in World Prices due to WTO Trade Liberalization

The WTO is expected to create changes in relative world prices for agricultural products because of progress made in the Uruguay Round and continued emphasis in the new Doha Round. A study done by Diao, Somwaru, and Roe projected that removing trade barriers, subsidies and other trade-distorting forms of support would increase world prices. This increase was expected to be 18 percent for wheat, 10 percent for rice, 15 percent for other grains, 8 percent for vegetables and fruits, 11 percent for oils and fats, 14 percent for sugar, 6 percent for other crops, 22 percent for livestock and 8 percent for processed food. By inspecting these relative price changes, it would appear that there is an increased incentive for production of grains and livestock, and simultaneously, a disincentive for local demand to expand due to higher prices. Thus, there are some incentives that will create greater pressures on water use in Saudi Arabia, such as better world prices for grain products, but there may be greater incentives to move towards livestock production and away from water-using grain production. The other products being imported into Saudi Arabia, such as oils and sugar, are expected to see smaller increases, so that they may in fact see larger imports from smaller relative price increases and significant substitution elasticities with products having higher increases.

To recognize the effect of these price changes on Saudi agricultural imports, local demand and local production, the expected change in exogenous world prices has been tested under the six scenarios, which are based on three different supply elasticities, and with and without imposing theoretical restrictions. Using the policy simulation framework (equation (71)), the expected changes projected by Diao, Somwaru, and Roe, are put in as proportional changes in prices. In addition, no change in local supply is assumed to occur because there are no policies directed at local production that change in this simulation, nor are there changes in expenditure levels. Thus, any changes in the pattern of local demand and supply come from changes in the exogenous world prices.

6.7.2 Change in Demand, Supply and Imports

The WTO trade liberalization, by changing world prices and thus the prices seen by all participants in the agricultural sector in Saudi Arabia, will have effects on quantities demanded, supplied and imported. As different scenarios were used to estimate local demand elasticities, each scenario has a different effect depending on the assumed supply elasticity and whether demand restrictions are imposed or not. Based on the results obtained in the previous section, scenario 2, which shows better consistency with economic theory as most groups show negative own price elasticities, is chosen as the one that gives the most reasonable estimation of local demand elasticities. Using this scenario, tables 6-14 and 6-15 report the simulation results, and a discussion is given below.

Scenario 2 Simulation Results

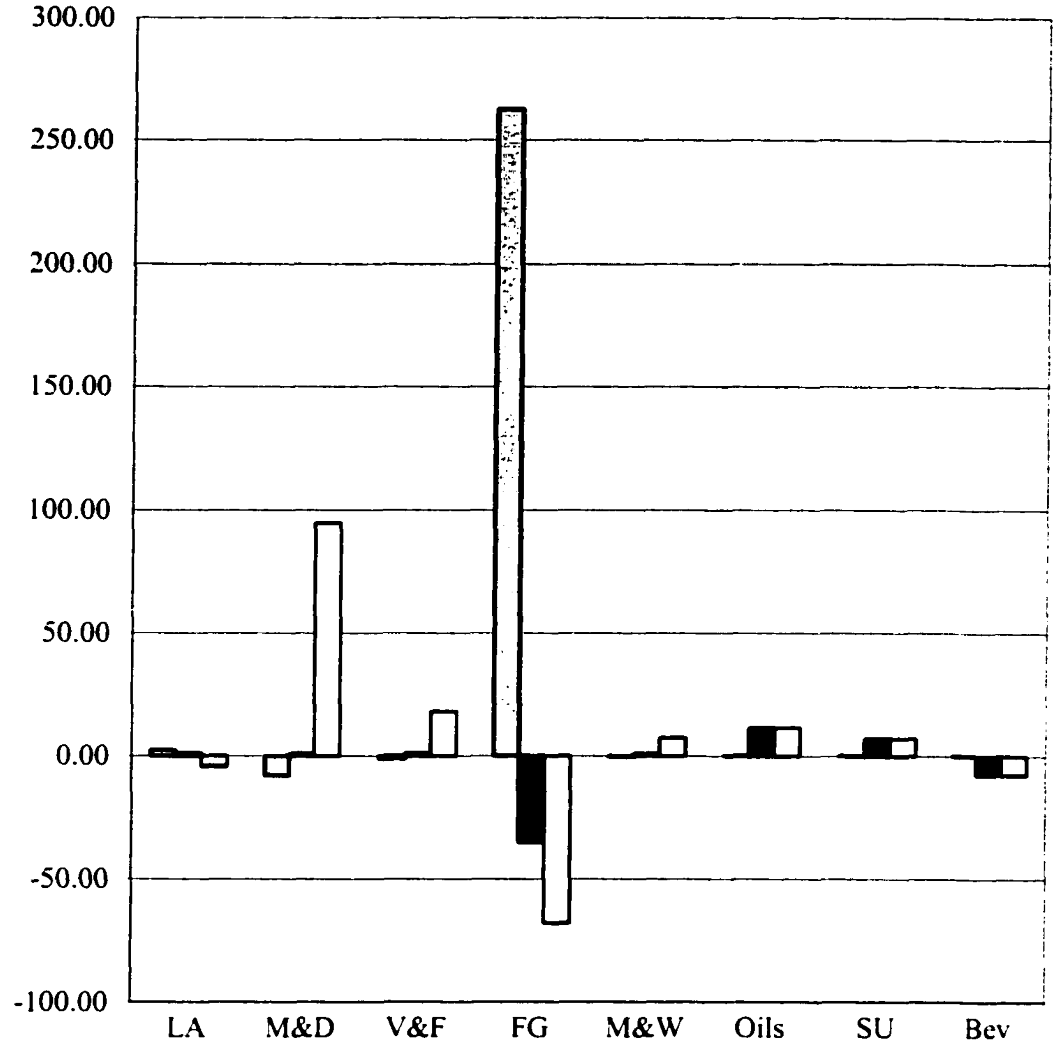
Figures 6-1 and 6-2 show the results obtained from scenario 2 without imposing restrictions on demand and then in the presence of symmetry and homogeneity restrictions. In general, based on economic theory, the quantities imported are expected to decline as a response to price increases because an import demand model was estimated. Thus with most prices rising, reduced imports should be expected. However, there are extensive cross price effects, and also significant changes in the relative prices assumed, so some products may actually see increased imports given the variations assumed in these simulations. In addition, changes in quantities imported will vary among groups depending on the percentage change in groups' prices, local supply elasticities, local demand elasticities and the share of quantities imported in local demand.

For imported groups with some domestic supply (the first five groups), the quantities imported show different responses depending on whether restrictions are imposed or not. The results obtained without imposing restrictions, figure 6-1, show that the quantities imported of milk and dairy, vegetables and fruit, and maize and wheat will increase, which is inconsistent with expectations. These results are related to incorrect local demand own price elasticity for milk and dairy, along with significant and high cross price effects for other two product groups. The quantity imported of live animals and feed grains are consistent with expectations and decline as their world prices increase. These products are expected to experience some of the largest world price increases, so on a relative basis, they see the highest price increases.

When restrictions are imposed, figures 6-2, the quantities imported show completely different and more logical results. The quantities imported show a negative response from import price increases in three groups: animals; milk and dairy; and vegetables and fruit. Vegetables and fruit imply the highest decrease in quantity imported because it has the highest local demand elasticity and several significant cross price coefficients. Feed grains, and maize and wheat, show small increases in quantity imported, mostly due to their use as inputs in livestock production, whose local supply grew significantly as prices increased.

For the groups with no domestic supply and, thus, where domestic demand is supported entirely by imports (the last three groups), the results show similar effects for fats and oils, and sugar regardless of whether restrictions are imposed or not. The changes in quantities imported of these two products and sugar are inconsistent with expectations, as quantities imported increase. The change in these groups' prices is relatively low, as the world prices of other commodities are expected to grow more, and there are significant cross price effects with other groups, so a shift of imports towards fats and oils and sugars occurred. The quantity imported of beverages declines, which is consistent with expectations, and this decline is smaller when restrictions are imposed. The lack of significant cross price effects in beverages may be causing the negative impact in this group.

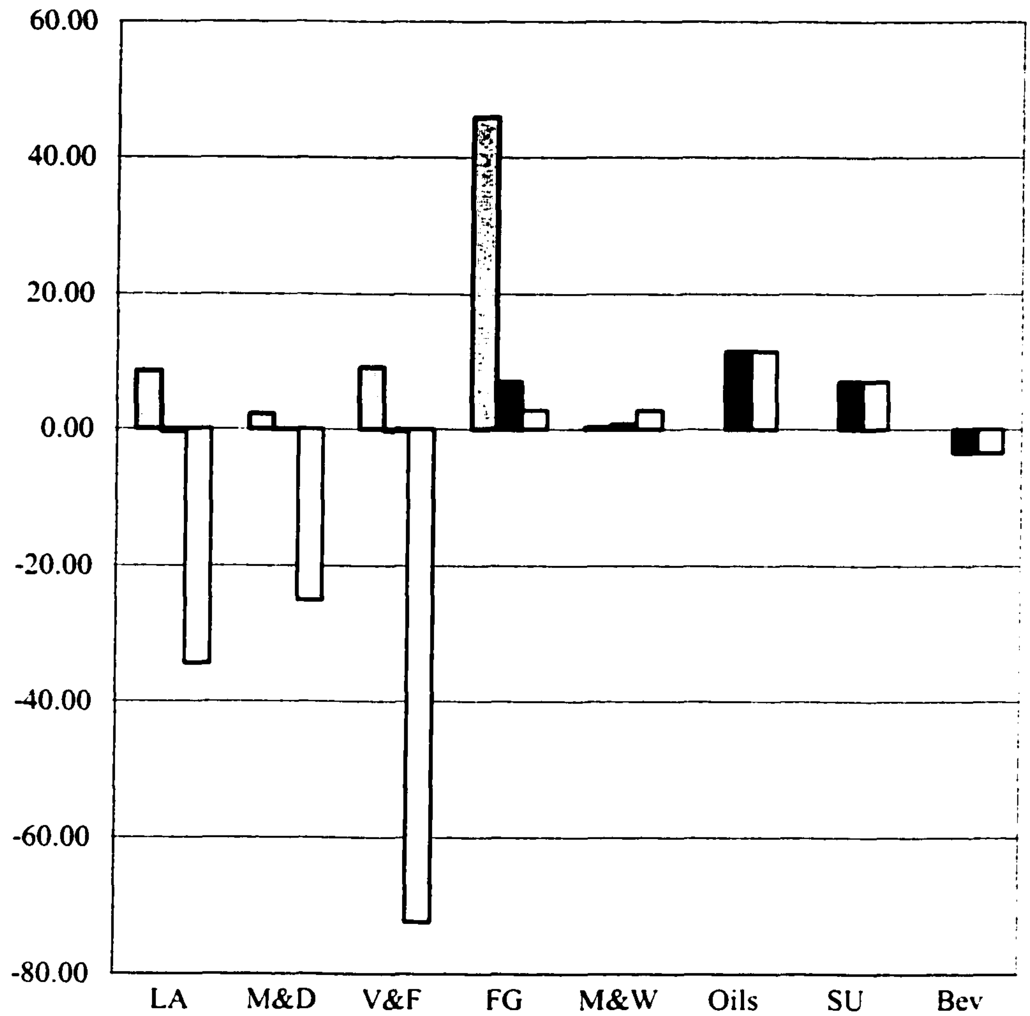
This change in quantity imported implies variations in local demand and local supply. The reactions in percentage terms are related to the proportion of domestic supply versus imports in domestic demand. For example, feed grains show the greatest decrease in domestic quantity demanded because of its high imported share (90 percent), while the quantity demanded locally of milk and dairy shows the lowest response to a change in imports due to its low import share (8 percent) in local demand. In fact, the percentage responses of quantity supplied in the first five groups is correlated directly with their shares in local demand. The quantity supplied of milk and dairy shows the lowest increase because local supply is the greatest proportion of domestic demand, while feed grains show the highest positive response because it holds the lowest share in local demand. For the last three groups, which do not have any domestic supply, the change in quantities imported is identical to the change in quantities demanded locally. That is, domestic quantity demanded is equal to 100 percent of imports, so the percentage change in imports is the same as the percentage change in domestic demand.



	LA	M&D	V&F	FG	M&W	Oils	SU	Bev
□% QS	2.24	-7.80	-1.26	262.73	-0.36	0.00	0.00	0.00
■%QD	0.94	0.82	0.96	-35.05	0.85	11.50	7.00	-7.40
□%QM	-4.00	94.70	18.00	-67.80	7.20	11.50	7.00	-7.40

Figure 6-1: Percent Change in the Proportion of Quantity Imported, Demanded and Supplied Without Imposing Demand Restriction (Scenario 2)

Where: LA= Live and Frozen Animals. M &D= Milk & dairy. V &F= vegetables & fruits. FG= Feed grains. M &W= Maize, corn, rice & wheat. Oils= Oils and fats. Su= Sugar, And Bev = Beverages.



	LA	M&D	V&F	FG	M&W	Oils	SU	Bev
□% QS	8.59	2.26	9.13	45.91	0.36	0.00	0.00	0.00
■%QD	-0.37	-0.03	-0.24	7.04	0.74	11.46	6.96	-3.41
□%QM	-34.36	-25.01	-72.29	2.76	2.72	11.46	6.96	-3.41

Figure 6-2: Percent Change in the Proportion of Quantity Imported, Demanded and Supplied With Imposing Demand Restriction (Scenario 2)

6.7.3 Changes in Input Prices

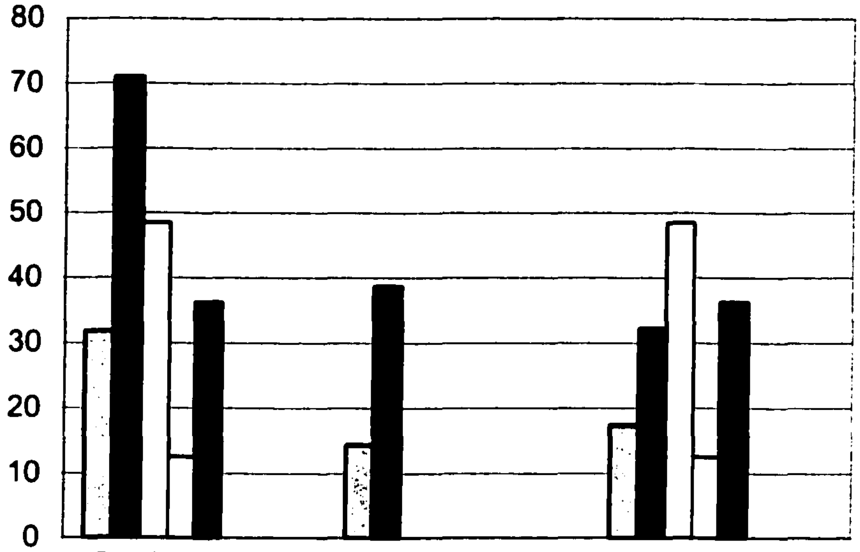
The WTO negotiations are expected to affect the Saudi Arabian agricultural economy in different ways, with a reduction of local support and reduced import subsidies being some of the expected effects. Moreover, the lack of natural water resources, combined with a limited amount of groundwater (where the estimated usable water resource is predicted to last for a maximum of 20 to 25 years) and increased water demand over time, will almost surely lead to changes in local water prices. As a result, these international and domestic issues are expected to lead policymakers to change domestic policy directed at the agricultural sector.

To forecast the expected effect of these changes, different possible scenarios have been tested. The two issues examined here are a change in water price as a result of the domestic concern about water resource availability, and a reduction of an input subsidy paid for imported live animals if Saudi Arabia would join the WTO. These simulations are quite different from those done before, in that they initially affect domestic supply, which then causes effects on import demand. Most analyses based on import demand matrices would not be able to implement this range of simulations.

Using the policy simulation framework (equation (71)) and input supply elasticities, which come from a California study on agricultural water (assuming these elasticities are appropriate for a developing country situation), multiple simulations were conducted. Different scenarios of changes in water prices and live animal prices were done in combination. Also, world prices are assumed not to change because they are exogenous, and there is no change in expenditure either because domestic demand is not affected. To capture and compare possible changes, three simulations were done. First, a change in both local (increased water prices) and international policies (reduced subsidies on imported live animals) is simulated, assuming they work at the same time. Secondly, a change in the import subsidy is made alone to show an international policy effect and a change in water price is made singly to portray the local policy impact.

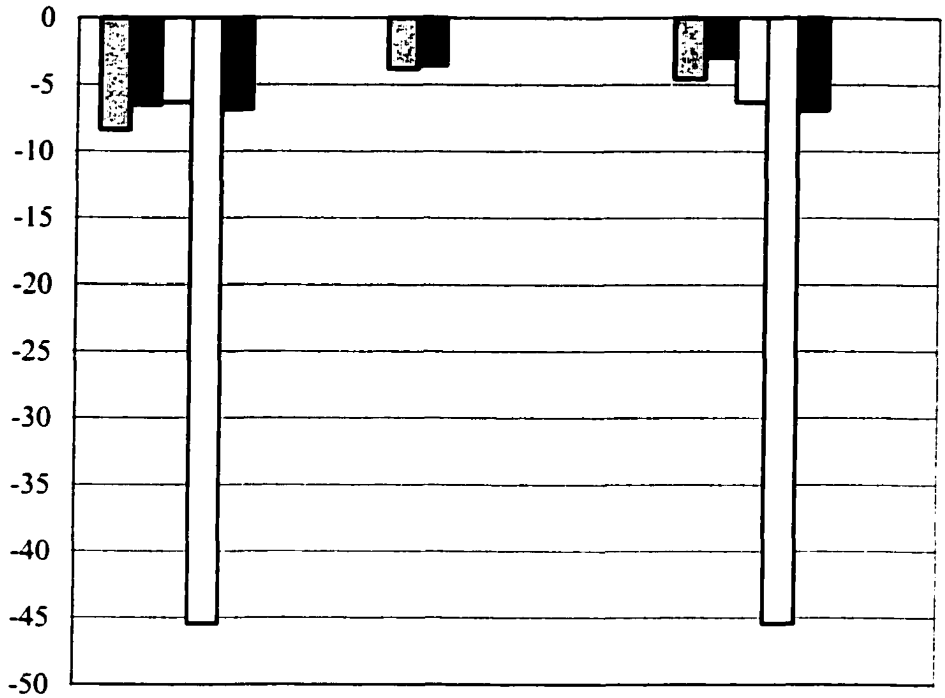
Domestic and International Policy Effect Together. In this case, an increasing water price of 10 percent and a reduction of an input subsidy on imported live animals that increases those prices by 10 percent are simulated together. The first column in figure 6-3 shows the expected effect on quantities imported from each group. The quantities imported from the first two groups, live animals, and milk and dairy, are expected to increase by 32 and 71 percent respectively. Vegetables and fruit, feed grains, and maize and wheat quantities imported are expected to increase by 48, 13, and 36 percentage points, respectively. The last three groups will not affected by these changes, as they are not produced locally and are not affected by input price effects. This change in imports is directly and solely related to the decline in domestic supply, which is displayed in the first column of figure 6-4. The quantity supplied of live animals, and milk and dairy, will decline by 8.4 and 6.5 percent respectively, while quantity supplied of vegetables and fruit, feed grains, and maize and wheat will decline by 6.3, 45.5 and 6.9 percent, respectively.

Because each group has different input price elasticity, assumed to be -0.3 for live animals, -0.25 for milk and dairy, and –0.5 for vegetable and fruits, feed grains, and maize and wheat, these effects vary among groups. Groups with higher input price elasticities should experience more change than other groups.



	AP=+0.1 ;WP=+0.1	AP=+0.1 ;WP=0	AP=0 ;WP=+0.1
□ LA	32	14	17
■ M&D	71	39	32
□ V& F	48	0	48
□ FG	13	0	13
■ M&W	36	0	36
□ Oils	0	0	0
■ Su	0	0	0
□ Bev	0	0	0

Figure 6-3: Percent Increase in the Proportion of Quantity Imported Due to Increase in Water and Live Animal Prices. (AP: Animal Prices, WP: Water Prices)



	AP=+0.1 ;WP=+0.1	AP=+0.1 ;WP=0	AP=0 ;WP=+0.1
LA	-8.4	-3.8	-4.6
M&D	-6.5	-3.6	-3.0
V& F	-6.3	0.0	-6.3
FG	-45.5	0.0	-45.5
M&W	-6.9	0.0	-6.9
Oils	0.0	0.0	0.0
Su	0.0	0.0	0.0
Bev	0.0	0.0	0.0

Figure 6-4: Percent Decrease in the Proportion of Quantity Supplied Due to Increase in Water and Live Animal Prices

As long as the local supply share of domestic local demand is low, the supply response will be higher and import response will be less. For example, the share of local supply in feed grains demand is about 10 percent and the supply response from the price change is a very high 45 percent, in effect replacing the import contribution to local demand. The import response is only 13 percent because the imported proportion is nearly 90 percent, so the high growth in local supply only moderately affects the import position.

International Policy Effect (lower subsidies on imported animals). A reduction of the input subsidy assumes an increase in the imported live animal price by 10 percent. The second column in figure 6-3 shows the expected effect on quantities imported for each group. The quantity imported of live animals and milk and dairy are expected to increase by 14 and 39 percent respectively. Other groups will not be affected because live animals are used as inputs only in the first two groups. This increase in imports comes from a decline in local supply, which is displayed in the second column of figure 6-4. Quantities supplied from live animals, and milk and dairy, are shown to decline by 3.8 and 3.6 percent respectively. This decline is less than the previous one because there is no water policy effect. The live animals experience a smaller decline than milk and dairy as a result of a difference in input price elasticities, which were assumed to be -0.25 for live animals and -0.3 for milk and dairy.

Domestic Policy Effect (rising water prices). Increasing water price by 10 percent is used to show the effect of local policy change on local supply and imports. The third column in figure 6-3 shows the expected effect on quantity imported for each group. The quantities imported of live animals, and milk and dairy, are expected to increase by

17 and 32 percent respectively. Vegetables and fruit, feed grains, and maize and wheat quantities imported are expected to increase by 48, 13, and 36 percentages respectively. The last three groups will not affected by these changes, as they are not produced locally. This increase in imports comes from the decline in local supply, which is displayed in the third column of figure 6-6. Quantities supplied of live animals, and milk and dairy, will decline by 4.6 and 3.0 percent respectively, while the quantities supplied of vegetables and fruit, feed grains, and maize and wheat will decline by 6.3, 45.5 and 6.9 percent, respectively. The difference in response between groups is associated with differences in input price elasticities. Groups with higher price elasticities experience more change than the others. Within each group, the response of imports to changes in local supply depends on import share in local demand. As long as the imported group has a high share the corresponding response will be less and visa versa. Also, it is clear that there is nearly a linear

Several policy implications are implicit in the simulations shown here. There may, in fact, be some positive aspects to the subsidy for live animals. Importing animals and feeding them locally may add value for local producers, especially as the availability of these inputs permits expansion of livestock feeding and processing industries. It is also critical that water be conserved, and agricultural policy should probably facilitate a conversion to animal production, as its water consumption may be lower than for crops. However, this is only a suggestion for research, and it needs a comprehensive study, in which simulations of all agricultural products and livestock processors operations are examined along with their water requirements to draw a conclusive policy. Conversely, water consumption could be reduced through raising water prices to save the local water resource for a longer period. However, given the modest decline in output seen with a ten percent increase in the water price, it may require such a large price effect to control water use in agriculture that outright quotas might be better.

6.7.4 Changes in Expenditure

Expenditures on imports are likely to increase over time. Tastes and preferences are changing because of higher education levels and, in addition, there is increased advertising for foreign goods. The unavailability of different products that are locally produced, due to the lack of a processing sector and adequate products are other factors that may affect expenditure on imports. To understand possible effects of this change, total expenditure on imports is assumed to increase by 10 percent. This expected change has been tested under the six scenarios described earlier, which are based on three different supply elasticities in combination with imposition of theoretical restrictions or not. In addition, this change in import demand is assumed to result from expected changes in expenditures alone, with no change in policy or input prices being assumed. Furthermore, it is assumed that world prices stay constant because Saudi Arabia is a small player in world demand for these products.

Using the policy simulation framework (equation (71)) and assuming no change in world or input prices, different simulations were conducted. The results are presented in figure 6-5. The effect of expenditure changes on quantities imported will be reflected directly in local demand, as local supply and world prices stay unchanged. The rows in figure 6-5 show import groups while columns show the six implied scenarios.

As expected, the effect of increased expenditure is to increase the quantity imported from each group. However, this increase differs among groups depending on their expenditure elasticities, which vary based on the supply elasticity assumed, whether restrictions are imposed or not, and the proportion of quantity imported as a proportion of domestic quantity demanded.

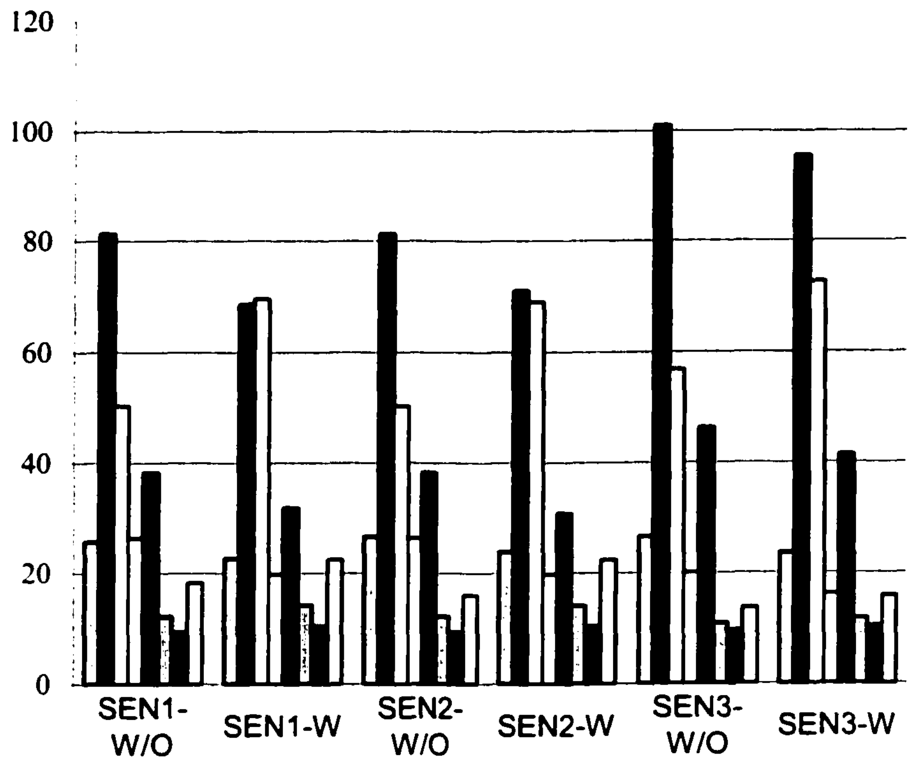
The results obtained show that imposing restrictions on the estimation reduces the proportion of quantities imported for the five groups that are also produced locally, except vegetables and fruits. In contrast, imposing restrictions induces an increase in quantities imported for groups that have no local supply and are thus completely imported. Scenarios 1 and 2 show similar results, while scenario 3 shows a greater fluctuation, presumably based on effects of supply elasticity assumed.

As noted in the earlier simulations, scenario 2 is chosen to evaluate in more detail because the local demand elasticities estimated using this scenario, in tables 6-13 and 6-14, show more consistency with economic theory, as all groups have a negative own price elasticity. Scenario 2 results without restrictions in figure 6-5 show the proportional change in quantities imported as a response to expenditure change. The milk and dairy group shows the highest response, with an increase of 81 percent in imports, while sugar shows the lowest response, with a growth of nine percent in imports. Overall, as expenditure increases, the demand for imported goods will increase for all groups but the percentage increase for groups that are not totally imported, the first five groups, will be higher than for totally imported goods, the last three groups.

These results are simply because the proportion of imports in domestic disappearance varies among the groups. For milk and dairy, with over 90 percent being locally supplied, a seven percent change in domestic demand from the expenditure change leads to the 81 percent increase, in imports, while sugar, which has no domestic supply, sees a 18 percent increase in imports to match the 18 percent increase in domestic demand.

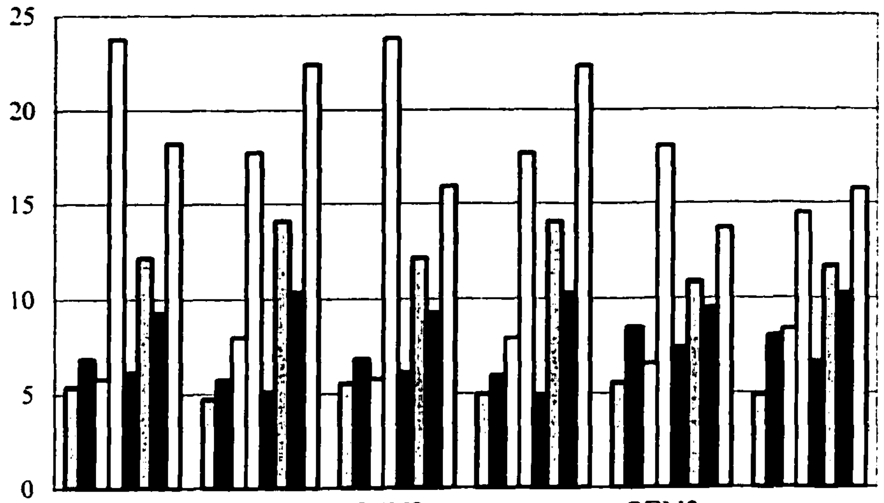
Thus the changes in domestic demand, which are shown in figure 6-6 give a better perceptive on the agricultural system reacts to increased expenditures. These changes are generally modest, with less than 10 percent increases in domestic demand for all but three commodities, regardless of whether they have local supply or not, and regardless of whether restrictions are imported or not. In this table, the differences in domestic demand responses depend only on expenditure elasticities; the high expenditure elasticities in fats and oils, beverages and especially feed grains result in more growth of domestic demand for the other products. Because there is no exogenous price change in the world markets, there is no change in supply, and all variation shown here arises from changes in domestic demand induced by the expenditure shift, which is then translated into changes in imports.

In viewing these results, it must be kept in mind that, to get a ten percent increase in expenditures in these food groups, it would take a thirty percent increase in income because of the two stage budgeting procedure used in this analysis. Assuming an elasticity such as 0.333 for all food, (similar to one value in table 3.1), and assuming it is based on real per capita income changes, then it may well be a long time before these increases arise due to growth in income, as real per capita income has been stagnating for a decade. Thus population growth, for which there will be a direct increase in food consumption for each mouth added, will be a much larger factor in future import and domestic demand for food.



	SEN1-W/O	SEN1-W	SEN2-W/O	SEN2-W	SEN3-W/O	SEN3-W
LA	26	23	27	24	27	24
M&D	81	68	81	71	101	95
V&F	50	69	50	69	57	73
FG	26	20	26	20	20	16
M&Wt	38	32	38	31	46	41
Oils	12	14	12	14	11	12
Su	9	10	9	10	9	10
Bev	18	22	16	22	14	16

Figure 6-5: Percent Change in the Proportion of Quantity Imported for All Groups' Results from the Effect of Expenditure Change Under All Possible Scenarios



	SEN1 - W/O	SEN1 - W	SEN2 - W/O	SEN2 - W	SEN3 - W/O	SEN3 - W
LA	5	5	6	5	6	5
M&D	7	6	7	6	8	8
V&F	6	8	6	8	7	8
FG	24	18	24	18	18	14
M&Wt	6	5	6	5	7	7
Oils	12	14	12	14	11	12
Su	9	10	9	10	9	10
Bev	18	22	16	22	14	16

Figure 6-6: Percent Change in the Proportion of Quantity Demanded for All Groups' Results from the Effect of a Ten Percent Increase in Expenditure

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

Saudi Arabia's food consumption has been growing dramatically over time. Although per capita GDP growth slowed during the 1990s, it was much higher in earlier years. Also, population growth, which is estimated to be three percent, changes in preferences, growth in the number of guest workers and higher education levels have collectively led to this growth in consumption. In order to meet consumption needs, the government adopted a planning system as an instrument to guide development of the agricultural sector, which led to a set of support policies toward farmers and agricultural investors. These policies created a significant effect on agricultural production. The evidence of this effect was seen in increased animal and crop production, and the attainment of self-sufficiency in some products.

However, because of water scarcity, where usable water is estimated to last for a maximum of 20 to 25 years, and the lack of comparative advantage in many agricultural products, these policies have been changed. Support programs directed at the agricultural sector have been reduced, therefore decreasing production. This decline in production, combined with a high rate of consumption growth, has led Saudi Arabia to depend more heavily on food imports to cover the gap between domestic demand and local production. Additional imports are likely from changes in world prices as the WTO has impacts on world agricultural markets. This suggests the need to evaluate effects of domestic and international policy change on imports, local production and local demand.

In general, the objectives of this research were, first, to empirically analyze the demand for food imports in Saudi Arabia in light of recent methodological developments in the implementation of demand systems. Secondly, the estimated demand parameters were used to analyze domestic and international policy issues faced by decision makers in Saudi Arabia. To attain these objectives, several demand systems (specifically the Rotterdam, AIDS, CBS, and NBR models), which are all nested in a general model, were estimated and then expenditure and price elasticities were calculated.

7.1 Econometric Estimation of Import Demand Systems and Key Results

Agricultural imports were divided into eight groups for estimation purpose: live and frozen animals; milk and dairy; fresh and processed vegetables and fruit; feed grains; maize, corn, rice and wheat; oilseeds, meal, fats and oils; sugar, cocoa products, coffee and tea; and beverages, tobacco, and other imports. Estimation results show that the general model system rejects the Rotterdam, AIDS, and NBR specifications, while the CBS is not rejected. This result appears to have some logic based on the presentation in Chapter 2. For example, the expenditure elasticity in the CBS model varies with the commodity's share, as it does in the AIDS model, while the Rotterdam and the NBR models have fixed expenditure elasticities. There were at least two significant shifts in shares of food consumed over the decade of the 1990s: a rather large decrease in the per capita consumption of fruit and vegetables, and growth in the consumption of meat. Thus, the expenditure elasticities may logically change with the changing shares of these products, as in the CBS model.

The CBS model also has price elasticities that do not change. While this may be harder to assess, real per capita income was relatively stagnant over the decade, and the number of non-Saudis did not change much as a percentage of the population, so major shifts that might have caused a declining (or increasing) price sensitivity seem to be absent over the years considered. Thus, the CBS model was adopted as the model of choice for analyzing the import data in this study. In addition, results show the validity of the homogeneity and symmetry restrictions on demand.

The estimated expenditure elasticities imply that if consumer expenditure allocated to agricultural imports were to increase, the demand for all products would grow by varying percentages. Unexpectedly, the highest expenditure elasticities are for feed grains, and maize and wheat, at about 1.784 and 1.275 respectively, which are products that would have been expected to have the lowest income effects. One possible explanation is that during 1994-1995, the government support for wheat production declined, total production dropped considerably, and a surge in imports of feed grains, and wheat and maize, occurred. Attempts to use proxies were unsuccessful, and thus they were not included. Alternatively, the links between feed grains and live animal and milk and dairy production might be causing these results as well. If prices and/or expenditures increase for those livestock products, then local production will also increase and the derived demand for feed grains will rise, which might be reflected in the large expenditure elasticities for these inputs to livestock production.

Most of the import expenditure elasticities are greater than one, although some were not significant. These results need to be interpreted in light of the restrictions imposed on the CBS model, and the fact that this is a conditional demand estimation. Recalling Chapter VI, the expenditure elasticity for the CBS model is

$$\eta_i = 1 + \beta_i / w_i \, .$$

where β_i is the coefficient on expenditures and w_i is the value share of the ith product in the system being estimated. The adding up restriction and relationship between shares within the system implies that $\sum_i \beta_i = 0$ and $\sum_i w_i = 1$. Therefore, the sum of the expenditure elasticities can be seen as

$$\sum_i \eta_i = \sum_i (1 + \beta_i / w_i) = \sum_i 1 + \sum_i (\beta_i / w_i) = i \, .$$

Thus, for the Saudi system considered here, the sum of these elasticities is eight, which leads to very high results in comparison to traditional income elasticity measurements. One way to better interpret these values is to recognize that expenditures on all food imports, taken from a first stage budget allocation, might have an elasticity of 0.333 (based on one example from Chapter III). Then all of the elasticities would have to be multiplied by 0.333 to be made comparable to usual income elasticity values.

In general, the own price and cross price relations suggest that there are five higher-valued products with significant substitution in consumption relations: animal products, vegetables and fruit, oils and fats, sugar products and the beverage group. Feed grains appear to interact in a distinctly different manner, showing significance usually only with livestock products that use grain as an input. The milk and dairy group is relatively separate, perhaps due to its traditional standing as an important commodity and its uniqueness in the Saudi diet. Also, the maize and wheat group appears to be both an input to livestock and a final consumption good that substitutes with other higher valued products. Comparing the estimated price and expenditure elasticities with relevant literature (table 3-1), the Saudi results appear closest to Greek and Japanese responses, showing that although Saudi Arabia still is often seen as a developing country, it has price responsiveness similar to more developed countries.

To evaluate local and international issues, local demand and supply elasticities were needed to set the stage for complete analyses. Hence, reasonable output supply and input elasticities were obtained from the literature for other countries, such as Pakistan, and three different scenarios were created. These supply elasticities were used as restrictions on the import demand model. This estimation method differs from other import demand models developed for many countries, which rarely, if ever, are used to provide the empirical basis for the range of policy and resource issues considered here.

7.2 Simulation Exercises

In order to link domestic and international effects across a wide variety of alternatives, a policy analysis framework was developed. A simulation model, adapting and extending a structure given in an article by Piggott, Piggott and Wright (1995), was constructed. Three different issues in the Saudi Arabian agricultural economy were then considered in this analysis. First, changes are expected to occur in world prices because of WTO trade liberalization, which will affect the pattern of imports, local demand and local supply in the economy. Also, input prices, especially the possibility of rising water prices due to increasing scarcity, should affect domestic production and imports of different products. Finally, the traditional shifter examined with import demand models has been expenditure change, which is the third simulation examined in this analysis.

The first simulation shows the effect of changing world prices due to WTO impacts. A study done by Diao, Somwaru, and Roe projected that removing trade barriers, subsidies and other trade-distorting forms of support would increase world prices, but that relative prices would also change for certain products. It appears that there is an increased incentive for production of grains and livestock because of higher prices, but these same higher prices will reduce local demand. Thus, there are some incentives that will create greater pressures on water use in Saudi Arabia, such as better world prices for grain products, but there may be greater incentives to move towards livestock production and away from water-using grain production. The other products imported into Saudi Arabia, such as oils and sugar, are expected to have smaller price increases; indeed, they may see increased imports, partly from these relatively smaller price increases and partly from the existence of significant substitution elasticities with products having larger price gains.

The last point above shows that are even though all prices are expected to go up, it is possible that some commodities will see greater imports because of cross price effects and lower relative prices after the WTO alters world prices. For example, quantities imported of feed grains, wheat and maize, oils, and sugar increase by 2.8, 2.7, 11.5 and 7 percent, respectively in the first simulation. Also, without imposing theoretical restrictions, several incorrect signs appear, and very large and, perhaps, incorrect cross price effects, represent surprising results. The imposition of the restrictions creates results that are more consistent. For example, milk and dairy, and vegetables and fruit, show increasing quantities imported without imposing restrictions, while their responses are negative with restrictions imposed. Moreover, local production naturally grows with these price increases, and the relative percentage responses depend on the proportion of domestic supply in local demand. For example, if this share is low, as in feed grains (10 percent) the production response will be proportionally high (46 percent).

The second set of simulations was done to look at impacts on domestic supply. To realize the expected total effect of the WTO on the Saudi agricultural sector, assuming Saudi Arabia joins the organization, a reduction of local support and reduced import subsidies are analyzed. Additionally, the increasing domestic concern about water resources suggests that some changes in the agricultural incentives could occur. The two issues examined in these areas were a change in water price and the reduction of an input subsidy paid for imported live animals. These simulations are quite different from those done before, in that they initially affect domestic supply, which then causes effects on import demand.

Multiple simulations were made using varying combinations of changes in water and live animal prices. With a reduction in subsidies on live animal imports, only live animals, and milk and dairy are affected, as the subsidy is directed at these two groups, while all products produced locally are affected by water price changes. Combining the two policy changes in one simulation just gives a sum of the two effects, implying that the effects are additive. This arises mainly because of the assumption that world prices are exogenous, so shifts in supply only change quantities and not prices. Without price changes, there are no spillover effects to other products. With endogenous prices, either of these policies would have impacts on all other products through cross prices effects. This alternative assumption will be used in later research.

Several policy implications are implicit in the second set of simulations. There may in fact be some positive aspects to the subsidy for live animals. Importing animals and feeding them locally may add value to local producers, especially as the availability of these inputs permits expansion of the livestock feeding and processing industries. It is also critical that water be conserved, and agricultural policy should promote a conversion to animal production, as its water consumption is probably lower than for crops. Moreover, there may be some enduring transportation advantages to importing feed grains and feeding livestock locally. However, this is only a suggestion for future research, and suggests need for a comprehensive study. Also, increasing water prices could reduce water consumption. However, given the modest decline in output seen with a ten percent increase in water price, it may require such a large price effect to control water use in agriculture that outright water quotas might be better.

Thirdly, to understand the possible effect of increased expenditures on imported goods from factors affecting demand, such as changes in tastes and preferences or increased advertising for foreign goods, six scenarios were analyzed. The effects differ between groups depending on expenditure elasticities and a group's import share in local demand. Groups with low expenditure elasticities and low import shares in local demand, such as milk and dairy, experience a greater percentage response than those that have higher expenditure elasticities and higher import shares, like feed grains. For those groups that are completely imported, the import response depends directly on the expenditure elasticities. Again, these impacts could be much wider with endogenous prices, as changes in expenditures in any of the products raises prices, which would then affect all other commodities depending on their elasticities.

Comparing the three simulations, some additional perspectives can be seen. In the first simulation, relative price changes from the WTO may in fact save water due to a greater growth in animal agriculture. However, the anticipated reduction in live animal import subsidies (also related to the WTO) may offset some of the incentives for greater production of livestock products. So the movement to livestock activities may be slowed down some due to input price effects from WTO, and some of the water conservation indicated in the first result may not occur. However, the separate analysis of increased water prices might make livestock products more attractive relative to crop production. The second simulation shows some evidence in this direction, as the reduction in feed grains was 46 percent compared with 8 percent for animal products. These trends may be even clearer with endogenous prices.

The WTO simulation is also related to the expenditure simulation in that they show two effects that would influence the cost of imports. It turns out that the products likely to have the greatest increase in world prices from WTO effects, shown in the first simulation, are the same products that will have the greatest expenditure responses from added purchases of food imports. Thus, the cost of agricultural imports could be rising more than expected from the convergence of these two effects. However, higher world prices may well reduce some of the expenditure response in the third simulation, so those products with the highest expenditure elasticities may not be the ones with the greatest import response.

7.3 Limitations and Further Research

Some limitations of this research can be cited here. Consumer theory was written for individuals' consumption behavior, while it has been employed here for studies of aggregate imports. Often, the demand restrictions of homogeneity and symmetry may not be expected to exist in this situation because the supply side may behave differently and is included in an import response, and there may be imperfect competition and non-optimizing institutional behavior that could cause problems in having these restrictions being met. Also, the expected effect of tariffs and subsidies, along with border imperfections, would affect these tests. However, the results in this research show the reverse, and these restrictions were seen to be consistent in this estimation. These results might have worked due to the small effect of the supply side compared with other countries, perhaps less anti-competitive behavior, and the fact that there are relatively low tariffs on food imports.

Another limitation that can be mentioned here is the isolation of the effect of total imports from analysis. There are two stages in allocating budget shares; first, the budget is allocated for all imports, where agricultural imports are just one category of imports. Then, the second stage is the allocation of the budget for agricultural imports between groups within the food industry. Therefore, the analysis in this research is a conditional estimation depending on the assumption that the budget share allocated for agricultural imports remains unchanged during the estimation period. Given the decline in per capita real GDP during the 1990s, some influence of this downward pressure on imports might have been useful to include. This however would require several methodological additions.

Future research can emphasize more varied policy analysis, perhaps including fixed price behavior and quotas, while shifters such as technical change and population could easily be examined. Also, imperfect competition models might be implemented and it would be useful to build in a combination of imports and exports. Questions of what it means theoretically to impose restrictions on import matrices, which imposes limits on both supply and demand matrices, could also be considered.

REFERENCES

Abdulrazzak Mohamed, " The Future of Freshwater Resources in the Arabian Peninsula" In Freshwater Resources In Arid Lands, edited by Juha I. Uitto and Jutta Schneider, pp. 17-43, the United Nations University, 1997.

Ali Mubarik, " Supply Response of Major Crops in Pakistan: A Simultaneous Equation Approach", Special Repoet Series, No.11, Islamabad, December 1988.

Al-Kheraiji, Abdullah Ali., "A Demand System Analysis of Meat Consumption in Saudi Arabia (Rotterdam System, Almost Ideal Demand System).", Ph.D, Dissertation, Kansas State University, Manhattan, Kansas, 1994.

Alston Julian M., and Chalfant James a., "The Silence of the Lambdas: A test of the Almost Ideal and Rotterdam Models" American Journal of Agricultural Economics, 75, May 1993:304-313.

Alston, J. M., and Chalfant, J. " Weak separability and Test for the Specification of Income in Demand Models with an Application to the Demand for Meat in Australia.", the Australian Journal of Agricultural Economics 31(1987): 1-15.

Alston, J. M., K. A. Foster and R.D. Green, " Estimating Elasticities with the linear approximation Almost Ideal Demand System: Some Monte Carlo Results." Review of Economics and Statistics, 76 (1994): 351-356.

Anderson Gordon, and Blundell Richard, " Testing Restrictions in a Flexible Dynamic Demand System: An Application to Consumers' Expenditure in Canada.", Review of Economic Studies 50(1983), 397-410.

Anderson, G., and R. Blundell, " Estimation and Hypothesis Testing in Dynamic Singular Equation Systems." Econometrica 50(1982): 1559-1571.

Arize Augustine, and Afifi Rasoul, " A Simultaneous Equations Model of Demand for Imports in Twenty-Seven African Countries: Evidence of Structural Change.", The Indian Economic Journal, Vol. 33 No.2, 1985: 93-105.

Attfield, C.L.F, " Homogeneity and Endogeneity in Systems of Demand Equations." J. Econ. 27 (1985): 197-209.

Barten, A. P., "Maximum Likelihood Estimation of a Complete System of Demand Equations.", European Econ. Rev. (1969): 7-73.

Barten, Anton P., " Consumer Allocation Models: Choice of Functional Form.", Empirical Economics ,18 (1993): 129-158.

Beach Robert H., and Holt Matthew T., " Incorporating Quadratic Scale Curves in Inverse Demand Systems.", Amer. J. Agr. Econ. 83 (1), (February 2001): 230-245.

Berndt, E. R., and N. E. Savin, " Estimation and Hypothesis Testing in Singular Equation Systems with Autoregressive Distrbances." Econometrica 43 (September-November 1975): 937-56.

Brown, M., and J.Y. Lee., " A Dynamic Differential Demand System: An Application of Translation." South. J. Of Agr. Econ. (1992): 1-10.

Buse, A. " Evaluating the Linearized Almost Ideal Demand System." American Journal of Agricultural Economics, 76 (1994): 781-793.

Buse, A. " Goodness-of-Fit in the Seemingly Unrelated Regressions Model." Journal of Econometrics 45(1977): 23-51.

Byron, R. P., " On the Flexibility of the Rotterdam Model." Eur. Eco. Rev. 24 (1984): 273-283.

Byron, R.P. " A simple Method for Estimating Demand Systems Under separable Utility Assumptions.", Rev. Econ. Stud. 37, (1970): 261-274.

Chesher, A. and Rees, H., " Income Elasticities of Demand for Food in Great Britain.", journal of Agricultural Economics, XXXVIII (1987): 435-448.

Clements, K.W., and E. A. Selvanathan, " The Rotterdam Demand Model and its Application in Marketing." Marketing Science 7 (1988): 60-76.

Davidson, R., and J. Mackinnon. " Several Tests for Model Specification in the Presence of Alternative Hypotheses." Econometrica 49(1981): 781-794.

Deaton, A.S. " Specification and Testing in Applied Demand Analysis." Eco. J.88 (September 1978): 524-36.

Deaton, A.S., and J. Muellbauer., " An Almost Ideal Demand System." Amer. Econ. Rev. 70 (June 1980): 312-26.

Deaton, Angus, and John Muellbauer, " Economics and Consumer Behavior.", Cambridge: Cambridge University Press, 1980b.

Department of Agricultural Economics, " The Effect of Joining WTO on Saudi' Agricultural Sector" King Saud University, Riyadh, Saudi Arabia, 1994 (in Arabic).

Eales S. J. and Unnevehr L.J., " Demand for Beef and Chicken Products: Separability and Structural Change", American Journal of Agricultural Economics, 70(1988): 521-532.

Edgerton, D. L., " On the Estimating of Separable Demand Models." Journal of Agricultural and Resource Economics, 18 (1993b): 141-146.

Edgerton, David L., Assarsson Bengt, Hummelmose Anders, Laurila Ilkka P., Rickertsen, Kyrre, Vale Per Halvor, " The Economitrics of Demand Systems.", Kluwer Academic Publishers, 1996.

Flood, L.R., R. Finke, and H. Theil. " An Evaluation of Alternative Demand Systems by Means of implied Income Elasticities." Econ. Letters 15 (1984): 21-27.

Food and Agricultural Organization of the United Nation (FAO). Production Yearbook, Rome, Various Issues.

Fulponi, L. " The Almost Ideal Demand System: An Application of Food and Meat Groups for France." Journal of Agricultural Economics 40(1989): 82-92.

Green H. A. John, "Consumer Theory" A Subsidiary of Harcourt Brace Jovanovich, Publishers, 1978.

Greene, William H. "Econometric Analysis.", Prentice-Hall Inc., New Jersey, 1997.

Hausman, J. " Specification Test in Econometrics" Econometrica 46 (1978): 1251-71.

Hayes, D. " Meat Demand in South Korea: A Systems Estimate and Policy Projections" Agribusiness 7 (1991): 433-466.

Janda Karel, McCluskey Jill J., and Rausser Gordon C., " Food Import Demand in The Czech Republic.", Journal of Agricultural Economics, Vol. 51, No.1, January 2000: 22-44.

Johnson, Stanley R., Zuhair A. Hassan, and Richared D. Green. Demand Systems Estimation: Methods and Applications, Ames Iowa University Press, 1984.

Kahtani, Safer H., "Complete Food Commodity Demand Systems for Saudi Arabia with Commodity Projections and Policy Applications for Wheat.", Ph.D. Dissertation, Oklahoma State University, Oklahoma, 1989.

Kingdom of Saudi Arabia, Ministry of Agriculture and Water, Department of Economic Studies and Statistics. Bulletin of Agricultural Statistic: Current Sample Survey, various issues, Riyadh, Saudi Arabia.

Kingdom of Saudi Arabia, Ministry of Finance and National Economy, Central Department of Statistics, Statistical Yearbook, various issues, Riyadh, Saudi Arabia.

Kingdom of Saudi Arabia, Ministry of Planning, Central Department of Statistics, Statistical Yearbook, various issues, Riyadh, Saudi Arabia

Kingdom of Saudi Arabia, Ministry planning, Facts and Figures, Riyadh, Saudi Arabia, Various issues.

Kingdom of Saudi Arabia, Saudi Arabian Monetary Agency (SAMA), Annual Report, Research and Statistics Department, various issues, Riyadh, Saudi Arabia.

Lee Jong-Ying, Brown Mark G., and Seal, Jr., James L., "Demand Relationships Among Fresh Fruit And Juices In Canada.", Review of Agricultural Economics., Vol. 14, No. 2, July 1992 : 255-262.

Lee Jong-Ying, Brown Mark G., and Seal, Jr., James L., "Model Choice in Consumer Analysis: Taiwan, 1970-89.", Amer. J. Agr. Econ., 76 (August 1994) : 504-512.

Lewbel Arthur, "Aggregation Without Separability: A Generalized Composite Commodity Theorem.", American Economic Review: Vol. 86, No.3, Sep. 1996: 524-543.

Lewbel, A. " Nesting the AIDS and Translog Demand Systems." International Economic Review, 30 (1989): 349-356.

McCalla Alex F and Josling Timothy E , "Agricultural Policies and World Markets", Macmillan Publishing Company., New York, 1985.

Mohammad, R., " Consumption Demand for Selected Food Commodities in Saudi Arabia With Projections For 1993.", Ph.D Dissertation, Kansas State University, Manhattan, Kansas, 1988.

Neves, Pedro Duarte, " A Class of Differential Demand Systems.", Economics Letters 44 (1994):83-86.

Neves, Pedro Duarte, " Comparing the Empirical Performance of alternative Differential Demand Systems.", Economia (Portuguese Catholic University) v17, n1(January 1993): 65-80.

Pantzios C. J. and Fousekis P., " A Differential Approach in Analyzing Meat Import Demand, v. 9(3), (Sep 1998): 20-25.

Pantzios, Christos J. and Fousekis, Panagiotis, " An Empirical Demand Analysis of the Greek Meat and Dairy Imports by Using Alternative Differential Demand Systems.", RISEC, Vol.46 No.1 (1999) :191-207.

Parks, R. W. " Systems of Demand Equations: An Empirical Comparison of Alternative Functional Forms." Econometrica, 37(1969): 629-650.

Piggott, Roley R., Piggott, Nicholas E and Wright, Vic E " Approximating Farm-Level Returns to Incremental Advertising Expenditure: Methods and an Application to the Austalian Meat industry", Amer. J. Agr. Econ., 77 (August 1995) : 497-511.

Regmi Anita, Seale, Jr.,James, and Bernstein Jason, " International Evidence on Food Consumption Patterns.", paper presented at the January 27-31,2001 SAEA Meeting in Fort Worth, Texas.

Revell Brian J., Fousekis Panos, " Meat Demand in the UK: A Differential Approach.", Journal of Agricultural and Applied Economics, 32, 1(April 2000):11-19.

Roley R. Piggott, Nicholas E. Piggott, and Vic E. Wright, " Approximating Farm-Level Returns to incremental Advertising Expenditure: Methods and an Application to the Australian Meat Industry." Amer. J. Agr. Econ. 77 (August 1995): 497-511.

Seale, Jr., James L., Sparks Amy L., and Buxton Boyd M., "A Rotterdam Application to International Trade in Fresh Apples: A Differential Approach.", Journal of Agricultural and Resource Economics, 17(1), 1992 : 138-149.

Silberberg Eugene, " The Structure of Economics: A Mathematical Analysis", Mc Graw-Hill Publishing Company, Singapore, 1990.

Silberberg Eugene, " The Structure of Economics: A Mathematical Analysis", Mc Graw-Hill Publishing Company, Singapore, 1990.

Stoker, T. M., " Empirical Approaches to the Problem of Aggregation over Individuals." Journal of Economic literature, 31 (1993): 1827-1874.

Stone, Richard, "Linear Expenditure Systems and Demand Analysis: An Application to the Pattern of British Demand." Economic Journal 64 (1954): 511-527.

Theil, Henri, " The System-Wide Approach to Microeconomics", The University of Chicago Press, Chicago, 1980.

Theil, Henri, "Theory and Measurement of Consumer Demand." Volume 2. North-Holland Publishing Company, Amsterdam, New York, Oxford, 1976.

Theil, Henri. "The Information Approach to Demand Analysis." Econometrica. Volume33, Issue1, January 1965:67-87.

Tiffin Abigail and Tiffin Richard, " Estimates of Food Elasticities for Great Britain: 1972-1994.", Journal of Agricultural Economics, Vol. 50, No.1, January 1999: 140-147.

Tomek William G. and Robinson Kenneth L. "Agricultural Product Prices.", Cornele University Press, 1995.

Varian Hal R. " Microeconomic Analysis", W.W.Norton & Company, Inc; New York, 1992.

Working, H. " Statistical Laws of Family Expenditure." J Amer. Statist. Assoc. 38 (March 1943): 43-56.

Yadav Gopal, " A Quarterly Model of the Canadian Demand for Imports 1956-72.", Canadian Journal of Economics, VIII, No.3, 1975.

Yoshihara, K. "Demand Functions: An Application to the Japanese Expenditure Pattern." Econometrica, 37 (1969): 257-274.

APPENDIX A

Comparing Linear and CBS Models

In this appendix the linear, CBS and log-log model will be displayed and improve that they lead to same conclusion. This results show while PPW used linear form and this dissertation used CBS and log-log form all led to the same final equation.

(A) Linear Model:

Assuming we have demand function with only two commodities which take the following form:

$$Q_i = \beta_1 + \beta_2 p_1 + \beta_3 p_2$$

Taking total differential for previous equation we get

$$dQ_i = \beta_2 dp_1 + \beta_3 dp_2$$

Multiplying through by $1/Q_i$

$$\frac{dQ_i}{Q_i} = \beta_2 dp_1 \bullet \frac{1}{Q_i} + \beta_3 dp_2 \bullet \frac{1}{Q_i}$$

Multiplying first component of the right hand side by p_1/p_1 and the second component by p_2/p_2 and rearranging the equation we got:

$$\frac{dQ_i}{Q_i} = \beta_2 \frac{dp_1}{p_1} \bullet \frac{p_1}{Q_i} + \beta_3 \frac{dp_2}{p_2} \bullet \frac{p_2}{Q_i}$$

Defined $Ep_i = \frac{dp_i}{p_i}$ and $EQ_i = \frac{dq_i}{q_i}$, converting to elasticity the equation can be written as:

$$EQ = \eta_1 Ep_1 + \eta_2 Ep_2$$

(B) CBS Model

In the two commodities case the model take the following form:

$$w_i \ln q_i = \beta_1 \ln p_1 + \beta_2 \ln p_2$$

Dividing through by w_i the model becomes:

$$\ln q_i = \frac{\beta_1}{w_i} \ln p_1 + \frac{\beta_2}{w_i} \ln p_2$$

Taking total differential for this equation we get:

$\frac{dq}{q_i} = \frac{\beta_1}{w_i}\frac{dp_1}{p_1} + \frac{\beta_2}{w_i}\frac{dp_2}{p_2}$. Where $\frac{\beta_i}{w_i}$ is the elasticity in CBS model.

Defined $Ep_i = \frac{dp_i}{p_i}$ and $EQ_i = \frac{dq_i}{q_i}$, the equation becomes:

$$EQ = \eta_1 Ep_1 + \eta_2 Ep_2 .$$

(C) Log-Log Model

In the two commodities case the model take the following form:

$$\ln q_i = \beta_1 \ln p_1 + \beta_2 \ln p_2$$

Taking total differential for this equation we get:

$\frac{dq_i}{q_i}{}_i = \beta_1 \frac{dp_1}{p_1} + \beta_2 \frac{dp_2}{p_2}$, Where β_i the elasticity in Log-Log model.

Defined $Ep_i = \frac{dp_i}{p_i}$ and $EQ_i = \frac{dq_i}{q_i}$, the equation becomes:

$$EQ = \eta_1 Ep_1 + \eta_2 Ep_2 .$$

These results show the proportion change of quantity can be defined as a function in elasticity and proportion change in prices whatever the functional form used.