Meat Consumption Pattern in Saudi Arabia

By

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Abstract

Saudi Arabia’s rapid economic development and the affluence of the country’s citizens are served by both imported and domestically produced meat. Adverse climatic conditions in the desert country preclude large-scale livestock production, however, the country still supplies about half of its meat consumption. This research seeks to identify trends in the Saudi diet over a long period of time, during which the nation was transformed from being a desert based country to a modern economy, that is, from 1985 to 2010.

The objective of this thesis is to present a systematic analysis of Saudi Arabia’s meat demand using data for the period between 1985 and 2010 for three types of meat, namely beef, lamb and chicken, as well as fish, under a system-wide framework. To estimate the demand for meat (lamb, beef, and chicken) and fish, economic data were analysed using the Rotterdam econometric models. Also, an import demand model with analysis of future imports has been developed for three types of meat - beef, lamb and chicken.

The results gained from the econometric models applied reveal that in Saudi Arabia, the relative consumption of beef, chicken and fish have a positive growth, while lamb has a negative growth. The average relative price impact on beef, chicken and fish are negative, while that of lamb is positive. The expenditure shares of beef, chicken and fish have increased while that of lamb has fallen. The estimation results of the demand system reveal that there is an autonomous trend away from lamb to beef, chicken and fish. The implied income elasticity indicates that beef, lamb and fish are considered luxuries, while chicken is a necessity. The demand for meat products and fish are price inelastic.

An import demand model was then developed to estimate future trends in domestic meat production and consumption. Imported meat determinants were found to be influenced by elasticity in commodity price, cross-prices between types of meat, and domestic income. Future imports are subject to government incentives to industry, per capita income growth, and ‘healthy’ lifestyle trends evident in other societies where the economy has been matured.

For each type of meat the following findings were important. Consumption and production patterns for beef from 2000 onwards were influenced by government subsidies for domestic production, with production rising until 2010 (+22,000 metric tonnes per
annum), then trending down as projected (-5,000mt pa) until 2022. Due to increases in population, beef imports are predicted to increase over the long term (155,000mt pa to 2025).

For lamb (mutton), domestic production faltered over the period between 1985 and 2010, however, an increase in domestic production has been forecast to 2025. The desired slaughtering process for lamb in the nation restricts imports (about 48,000 metric tonnes per annum) and this restriction is expected to continue in the future.

The Saudi authorities have therefore found that chicken (poultry) is a priority item for domestic production. This emphasis on chicken meat is evident from analysis showing that production went down from 2005 to 2010, but strong growth has been predicted through to 2025, estimated at over 700,000 metric tonnes per annum. This continuing rise is expected as more facilities are being provided for chicken meat production. However, Saudi Arabia remains as the world’s largest importer of chicken meat (about 800,000 metric tonnes per annum), particularly, in the months during Ramadan and the Hajj.

The present thesis is expected to attract major interest among the policy makers and the industry at large in Saudi Arabia.
Doctor of Philosophy Declaration

I, Saad Albalawi, declare that the PhD thesis ‘Meat Consumption Pattern in Saudi Arabia’ has not been previously submitted for a degree or diploma in any university.

To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

This thesis is my own work.

Signed ________________________________

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International Business & Asian Studies, Griffith Business School, Griffith University, Brisbane, Queensland, Australia

April 2015
Publications and Conference Papers Arising from This Thesis


5. Albalawi, Saad; Selvanatham, Saroja; Selvanathan, Selva; Moazzem, Hossain, Meat and Fish Consumption Pattern in Saudi Arabia (submitted and under review).
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List of Abbreviations (acronyms)

AIDS  Almost Ideal Demand System
Agri  Agriculture
DAP  Demand Analysis Package
FAO  Food and Agriculture Organization
GADS  Generalized Addilog Demand System
GCC  Gulf Cooperation Council countries: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates
GFC  Global Financial Crisis
KSA  Kingdom of Saudi Arabia
LA-AIDS  Linear Approximated Almost Ideal Demand System
MOA  Ministry of Agriculture
MOCI  Ministry of Commerce and Industry
MOEP  Ministry of Economy and Planning
OECD  Organization for Economic Cooperation and Development
SAGIA  Saudi Arabian General Investment Authority
SR  Saudi Riyal
UAE  United Arab Emirates
UN  United Nations
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Chapter 1
Introduction

The agricultural sector plays an important role in the Kingdom of Saudi Arabia (KSA), and it effectively contributes to domestic production and strongly supports the national economy. The sector has achieved continuous growth leading to increased domestic production valued from SR 990 million (Saudi Arabian riyal), (US$264 million) in 1970, to SR 38.3 billion (US$10.2 billion) in 2007 (at current prices). The yearly growth between 1990 and 2007, however, was 11%, accordingly placing the sector's share of the gross national product at 5.1% (Ministry of Agriculture (MOA), 2009).

Economists are of the view that Saudi Arabia has a unique experience in agriculture, where its application of ambitious plans has exceeded its objectives to a level where it is exporting many plant and livestock products.

The Saudi government's policies of continuous support and enhancement of the private sector's investment in agriculture have enabled the use of the most up-to-date technologies, particularly after the introduction of such technologies to Saudi local conditions. In fact, such policies have had considerable impact on the current advancement of the Saudi agricultural sector. The crop area has increased from approximately 15,000 hectares in 1975 to approximately 1.1 million hectares in 2007. Accordingly, Saudi Arabia has been able to achieve self-sufficiency in many agricultural food products such as wheat, dates, eggs and fresh dairy products. Moreover, the country's production of other agricultural food products has reached the highest level of self-sufficiency, reaching 85 per cent in vegetables, 65 per cent in fruits, 48 per cent in red meats, 36 per cent in fish, and 55 per cent in poultry (MOA, 2009).

The Saudi livestock sector includes several types of animals, including 7.8 million sheep, 4.4 million goats, 422 thousand camels and 204 thousand cattle. Furthermore, an active domestic fish industry has emerged, which has produced approximately 49,920 tons of fish, with almost half of this amount being exported (MOA, 2009).

Saudi Arabia has achieved great success in poultry farming, including a remarkable increase in the supply of poultry meat and eggs. In this regard, domestic poultry production had exceeded 493 million hens in 2009, with egg production reaching 3,473
million. In addition 476,348 tonnes of chicken meat in specialist projects (approximately 522 million meat chicks, and 21.4 million egg chicks) has been produced.

In 2009, the total number of Saudi domestic animals had increased to 14.2 million: more than 435 thousand cattle, 9.095 million sheep, 3.8 million goats, and 810 thousand camels. According to published reports in 2009, Saudi dairy production was estimated to be more than 1.508 billion litres, and 775 thousand tonnes of meat and fish which included 171 thousand tonnes of red meat, 508 thousand tonnes of poultry meat and 96 thousand tonnes of fish and seafood (MOCI, 2009).

In spite of many obstacles such as low rainfall, limited underground water, shortage of workforce, and scattered agricultural land existing between sand dunes and desert hills, mountains and valleys, Saudi agricultural development has achieved remarkable levels within a short period of time. However, serious efforts have been devoted to enhancing the agricultural sector. Such efforts include allocation of free fallow lands to agricultural investors, provision of long-term interest-free agricultural loans, government's buying of strategic crops, particularly grains, from farmers at high prices and so on. All such efforts, however, have transformed the nation from the stage of importing most of its food products to the stage of self-efficiency and export in several agriculture, livestock and fish products.

In Saudi Arabia, domestic food production policy in recent years has changed towards giving additional focus to attaining food security, due to the adverse climate and scarcity of water on the Arabian Peninsula. Further, high population growth and socioeconomic development are changing peoples’ dietary habits, which were based on traditionally available food such as grains, lamb, fish, goat, camel, fruit and vegetables, and dried or fresh dates. Beef and chicken became available during the last few decades and now constitute a part of the main Arabic diet.

In view of the above, the present study aims to analyse the demand for meat products in Saudi Arabia during the last three decades. The price, income and consumption data that have been used for the analysis are mainly from secondary sources for the period between 1985 and 2010. In this study, the well-known demand system, the Rotterdam model has been used to analyse the meat demand in Saudi Arabia. The income and the price elasticity estimates have been derived based on parameters obtained from the demand systems. Three types of meat, namely, beef, lamb and chicken have been considered. The
purpose of the research is to provide Saudi policy makers in the public and private sectors with relevant consumption information to determine the demand policies for meat and meat products under internal and external economic conditions, including economic shocks.

1.1 Background

This section introduces the context of the study, giving information about the country, its people, agricultural status and food preferences. This is followed by data on meat consumption and imports.

1.1.1 Civil Society

Saudi Arabia is an absolute monarchy, with the King as Prime Minister and Custodian of the Two Holy Mosques, Al Madina and Macca Mokarama. The King is aided by a Crown Prince and 22 Ministers of the administrative arm of government (Royal Embassy of Saudi Arabia, 2014). Further, the Majlis al-Shura is a 150 person consultative body that proposes and amends laws before they are issued as decrees by the King. The Minister of Agriculture is responsible for agriculture policy, and other government agencies involved in food supply include the Saudi Arabian Agricultural Bank for finance and grants, and the Grain Silos and Flourmills Organisation for wheat and stock feed.

The country is divided into 13 provinces that have similar governance structures: a Governor and a deputy appointed by the King. The Governor is advised by a consultative council on the social and economic development of the province. Riyadh is the capital of the Kingdom and the site of a large agricultural district, and Jeddah is the principal city. Makkah and Al-Madinah are the sites of the two holy mosques and host the annual hajj, or pilgrimage (Royal Embassy of Saudi Arabia, 2014).

In 2013, the population of Saudi Arabia was 30 million, of which 20 million were Saudi citizens (Central Department of Statistics and Information, 2014). Ten million foreigners are employed in developing new cities, transport links and high rise buildings, and they also provide agricultural labour supply, some 180,000 of a workforce of 391,000 (46%). Of the total population employed in agribusinesses, about 3,000 are Saudi women (.07%). This reflects the Arabic and Islamic culture, where women form a very low proportion of the labour market (15.5%) and Saudi women have an even lower employment proportion (12.8%) (Central Department of Statistics and Information 2014). This is partially due to
complete gender segregation in public places, enforced by social and religious norms (Ramady, 2013). Ramady explained that the Ministry of Labour was actively enforcing Saudisation, a process by which skilled and professional foreigners are replaced by Saudis, predominantly women. This policy has had mixed success over the years, without noticeable impact on educated women gaining employment. Furthermore, there are reports that full-time Arabs work less than three hours each day (Arabian Business, 2015; Ramady, 2013).

1.1.2 Agriculture Overview

Over the last four decades, agricultural products have changed in the proportion of their contribution to the Saudi economy (Figure 1.1).

**Figure 1.1: Agricultural Products as Share of Saudi GDP, 1972-2012**

![Graph showing agricultural products as share of Saudi GDP, 1972-2012.](image)


The contribution of agriculture to the Saudi gross domestic product reflects the government’s food policies over the decades. Woertz (2011) explained that a largely import oriented food policy changed due to risk of a counter-embargo by grain exporters following an Arab oil export embargo in the 1970s. Saudi growers were assisted to exploit finite water sources to the effect that Saudi was for a short time an exporter of highly subsidised wheat. Elhadj (2006) explained that between 1988 and 2000, the Saudi government spent $US84b on irrigation, producing wheat at five times the global price and using an estimated 300b m$^3$ of mainly non-renewable water, seriously degrading the aquifers. Baig and Straquadine (2014) added that whilst the production of fruit and vegetables increased, and industrial poultry and dairy farms were developed, there
remains a threat of sustainability in Saudi agribusinesses. By 2000, as shown in Figure 1.1, food production began to fall as the aquifers dried up, and in 2008 the King decreed that wheat purchases from Saudi agribusinesses would cease by 2016.

Agriculture is an important economic sector of the economy of Saudi Arabia, even though an unfriendly environment exists for agricultural practices. Domestic production within the agricultural sector provides food security for the Saudi population, which in turn contributes to the national income.

In recent years, Saudi Arabia has been paying greater attention to the agriculture and livestock sectors in recognition of the vital role they play in sustainable economic development and in achieving the goal of food security. As a result, agriculture’s contribution to GDP in 2007 was about SR 40 billion, making its share to the non-oil sector 7% (Table 1.1). In 2005, employment in agriculture was more than 600,000, which is more than 7% of the total labour force. Agriculture’s share to GDP was 4.8% in 2009 (Table 1.1).

Table 1.1: Share of Agricultural Production in Saudi Arabia, from 1996 to 2009

<table>
<thead>
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<th>% Share</th>
<th>% Share</th>
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</table>


1.1.3 Growth of Agriculture over the Last Three Decades
Serious agricultural growth began in the late 1990s (Table 1.2). Large areas of desert land have been turned into agricultural fields. This has been a major achievement in a country that attracts on an average about only 4 inches of rain per year, which is the lowest rate of rainfall in the world. Saudi Arabia exports dates, wheat, eggs, dairy products, fish, vegetables, fruits and flowers. Other government agencies including the Saudi Arabian Agriculture Bank (SAAB), provide subsidies and give interest-free loans. The Grain Silos and Flourmills Organization purchases and stores wheat, constructs flourmills, and also produces animal feed.

The public sector plays a major role in agricultural development in the Kingdom. Government supports have been in terms of providing long-term technical and support services, interest-free loans, incentives by providing fertilizers and free seeds, low-cost water, electricity and fuel, and duty free imports of raw materials and machinery.

Table 1.2: Annual Rate of Growth in Agricultural Sector, 1995 to 2009

<table>
<thead>
<tr>
<th>Year</th>
<th>Agriculture Sector</th>
<th>GDP Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>1996</td>
<td>0.3</td>
<td>3.2</td>
</tr>
<tr>
<td>1997</td>
<td>3</td>
<td>2.6</td>
</tr>
<tr>
<td>1998</td>
<td>1</td>
<td>2.7</td>
</tr>
<tr>
<td>1999</td>
<td>2.3</td>
<td>0.8</td>
</tr>
<tr>
<td>2000</td>
<td>3.9</td>
<td>4.9</td>
</tr>
<tr>
<td>2001</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td>2002</td>
<td>1.3</td>
<td>0.1</td>
</tr>
<tr>
<td>2003</td>
<td>0.8</td>
<td>7.7</td>
</tr>
<tr>
<td>2004</td>
<td>3.1</td>
<td>5.3</td>
</tr>
<tr>
<td>2005</td>
<td>1.2</td>
<td>5.6</td>
</tr>
<tr>
<td>2006</td>
<td>1.1</td>
<td>3.1</td>
</tr>
<tr>
<td>2007</td>
<td>1.9</td>
<td>2</td>
</tr>
<tr>
<td>2008</td>
<td>1.1</td>
<td>4.2</td>
</tr>
<tr>
<td>2009</td>
<td>0.6</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Source: MOA (2010).

Table 1.3, shows the self-sufficiency ratios of domestic food products for Saudi Arabia in 2010. The total of food products available for consumption is the aggregate of local production and net imports. On this basis, the production of eggs is in surplus by 8.7%, similarly fresh milk by 3.4%. On the other hand, red meat is in deficit by 61.7% and poultry meat by 58.8%. In aggregate, the self-sufficiency ratio of domestic food products for 2010 is 41% for animal products, 57.9% for vegetables and 11.5% for cereals. Table
1.4 presents Saudi Arabian and other Arabian agricultural investments in 2009. As can be seen, Table 1.4 shows that the Saudi Arabian government invests in Sudan, Egypt, Tanzania, Indonesia and Ethiopia to the tune of 5,520 thousand hectares in order to produce wheat and rice.

Table 1.3: Self-sufficiency Ratio of Domestic Food Products, Saudi Arabia, 2010

<table>
<thead>
<tr>
<th>ANIMAL PRODUCTS</th>
<th>FRUITS</th>
<th>VEGETABLES</th>
<th>CEREALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>CROP %</td>
<td>CROP %</td>
<td>CROP %</td>
</tr>
<tr>
<td>Eggs</td>
<td>108.7</td>
<td>Dates 108</td>
<td>Cucumber 102.7</td>
</tr>
<tr>
<td>Fresh Milk</td>
<td>103.4</td>
<td>Citrus 18.2</td>
<td>Melons 96.7</td>
</tr>
<tr>
<td>Red Meat</td>
<td>38.3</td>
<td>Grapes 79.1</td>
<td>Water Melons 121.4</td>
</tr>
<tr>
<td>Poultry Meat</td>
<td>41.2</td>
<td>Other Fruits 31.1</td>
<td>Okra 100</td>
</tr>
<tr>
<td>Fish</td>
<td>45.2</td>
<td>-</td>
<td>Others 87.2</td>
</tr>
<tr>
<td>Total</td>
<td>41</td>
<td>Total 57.9</td>
<td>Total 86.9</td>
</tr>
</tbody>
</table>

Source: MOA (2010).

Table 1.4: Saudi Arabian Agricultural Investment, 2009

<table>
<thead>
<tr>
<th>Investor</th>
<th>Country of Investment</th>
<th>Area (hectares)</th>
<th>Type of Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Arabia</td>
<td>Sudan, Egypt, Tanzania, Indonesia, Ethiopia</td>
<td>5,520,000</td>
<td>Wheat, rice</td>
</tr>
<tr>
<td>UAE</td>
<td>Pakistan, Sudan and Ethiopia</td>
<td>707,000</td>
<td>Corn, alfalfa, wheat, potatoes and peas</td>
</tr>
<tr>
<td>Egypt</td>
<td>Sudan</td>
<td>526,000</td>
<td>Wheat, corn and beetroot</td>
</tr>
<tr>
<td>Libya</td>
<td>Ukraine, Liberia</td>
<td>346,000</td>
<td>Rice</td>
</tr>
<tr>
<td>Kuwait</td>
<td>Sudan and Kenya</td>
<td>170,000</td>
<td>Rice</td>
</tr>
<tr>
<td>Qatar</td>
<td>Sudan and Kenya</td>
<td>140,000</td>
<td>Vegetables and fruit</td>
</tr>
</tbody>
</table>

Source: MOA (2009).

1.1.4 The Saudi Diet

The dietary intake of Saudis has changed in the last half a century due to improved socioeconomic conditions and an increasingly urban lifestyle. The traditional food sources, according to Musaiger (2002), were characterised by a low-fat and high fibre diet. This diet comprised dates, milk, fresh vegetables and fruits, whole wheat bread, and fish, and it transformed into a high protein, high fat diet lower in high-fibre food. The contemporary diet varies between Saudis living in urban and rural areas, although they consume similar foods including beans, wheat, dates, rice and chicken. This trend continues, as Musaiger (1993) earlier noted that food subsidy policies of the GCC
countries\(^1\) adversely affected national nutrition practices by encouraging the intake of meat, wheat flour, fat, sugar and rice. ‘Socio-cultural factors such as religion, beliefs, food preferences, gender discrimination, education and women’s employment all have a noticeable influence on food consumption patterns in this region’ (Musaiger, 1993, p. 68). Further, Musaiger noted that the popularity of mass media, especially televised food advertisements, were a factor in the change in food consumption habits. Interestingly, a study of women undergraduates (N = 663) by Khalaf, Westergren, Berggren, Ekblom, and Al-Hazzaa (2014) identified similar phenomena in the body mass index as in other developed countries: a majority were within normal weight limits (57%); however nearly a fifth (19%) were underweight and nearly a quarter were overweight or obese (24%). Whilst there were many factors involved, Khalaf et al. found a significant influence in the number of siblings and the family’s levels of physical activity. Thus the Saudis’ increasingly urban lifestyle is contributing to the effects of body image and consumption prevalent in similar international cohorts.

1.2 Objectives of the Study

The main aim of this study is to analyze the demand for meat in Saudi Arabia, so that Saudi policy makers can make effective policies regarding food security for the Kingdom under the present circumstances of the Saudi meat consumption pattern. The meat demand refers to the demand for beef, lamb and chicken. The major sources for these products are domestic production, imported prepared meat, and imported live animals. The aim of the study is to determine the long-term trends in consumption and the major economic indicators that hold greatest influence over such trends. The determinants are:

a. individual preference and lifestyle (per capita consumption);
b. retail prices of each meat product;
c. per capita income; and,
d. consumer price index (CPI).

Planning for Saudi food security requires economic criteria that underpin long term demand. The Rotterdam demand model was used in this analysis to estimate own-price elasticity, cross price elasticity and income elasticity for each meat product. Other techniques using the meat data include demand homogeneity, proportionate spending on food as income rises (Engel’s law) and Slutsky symmetry.

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\(^1\) Gulf Cooperation Council countries: Saudi Arabia, Bahrain, Kuwait, Oman, United Arab Emirates and Qatar.
1.3 Contribution to Knowledge

This research contributes to the body of knowledge (gap in knowledge) through its use of econometric models to estimate meat product demand in Saudi Arabia during the period from 1980 to 2010. Other researchers such as Al Kahtani and Sofian (1995) and Al-Shuaibi (2011) contributed short term demand modelling, and research was conducted on live sheep imports (Al-Roweas and Al-Dariny, 2007). However, there is no significant research that investigates the long-term effects of economic indicators (per capita consumption, retail price, per capita income, and CPI) on meat demand in Saudi Arabia. The shortfall trend between domestic production and consumption of meat products was also assessed. Further, this research compares estimates results between the models and techniques.

1.4 Significance of the Study

The practical usefulness of this research is that it is a comprehensive study of an important protein component in the Saudi diet. Saudis have traditionally relied on lamb, goat, and camel meat for their sustenance; however, economic development over the last half century has changed food consumption habits towards beef and especially towards chicken. Due to its location and desert weather conditions, Saudi Arabia has no capacity to feed its people from domestic sources and is thus embarked upon a food security program that involves imports and land purchases for developing food chains and partnerships with existing food producers overseas. This research aims at enhancing information for this political and commercial decision making through identifying trends in Saudi meat demand, meat production, and also identifying factors that can be reliably used to assess meat product consumption patterns.

Further it is of use to the private sector in seeking commercial advantage in fulfilling emerging gaps in supply chains. Saudi food security involves imports and investment in sustainable international food resources in partnerships. This study may be the first using long-term data to estimate meat demand in Saudi Arabia.

This study claims to be the first of its kind in the Middle East in general, and in Saudi Arabia in particular, which uses historical data covering the last quarter of a century. The data for the study have been collected from secondary sources based on archaic records of the following government and non-government agencies:

a. The Ministry of Agriculture.

b. The Ministry of Water and Electricity.
c. The Ministry of Commerce and Industry.
d. Saudi Arabia Central Department of Statistics.
e. Saudi Ministry of Trade and Industry.
f. Saudi Ministry of Finance and National Economy.
g. Council of Saudi Chambers.

1.5 Research Questions

By analyzing the Saudi Arabian data this research attempts to find answers to the following research questions:

a) Has any particular pattern emerged with respect to the demand for meat in Saudi Arabia over the last three decades?

b) Is the well-known Engel’s Law (that is the budget share on food falls under increased income) satisfied for meat products in Saudi Arabia?

c) Is the well-known demand theory hypothesis homogeneity and Slutsky Symmetry satisfied for Saudi Arabian meat consumption data?

d) Is the meat consumption pattern in Saudi Arabia similar to that of the world’s meat consumption? And, is there any structural change taking place in the Saudi Arabian meat consumption pattern and what are the consequences for future demand?

e) What are the prospects of meat import demand in Saudi Arabia and how can the government’s food security strategy be met?

1.6 Hypotheses

The following hypotheses (and sub-hypotheses) are derived from the research questions under 1.5 above:

H01 That all meat (and meat product) demand is based on population growth.

H02 That (economic indicator) the demand for chicken meat is greatest for all meat (and meat products).

H03 That all meat (and meat products) demand is greater than domestic production.

H04 That all meat (and meat products) demand is influenced by economic shocks.

1.7 Structure of the Thesis

The thesis presents eight chapters. The introductory chapter presents the thesis, with brief descriptions of the Saudi context, its society, its experiences with agriculture, Saudi food preferences, and meat demand. This is followed by the contribution to knowledge, the
significance of the study, the research questions and hypotheses. The present section concludes the introduction.

Chapter 2 concerns the characteristics of the country, its society and economic development. This is followed by global food structures and food flows, explaining the economic and climatic issues that affect supply. Saudi food preferences and the evolution of Arab food intake are presented. The next chapter, 3, concerns theory, and elements of economic demand models and techniques used are discussed. Chapter 4 presents the literature review which examines the economic studies carried out in the past in several developed and developing nations, including Saudi Arabia. This chapter also includes the current research on meat demand structures and techniques.

In Chapter 5 the preliminary data analysis of the Saudi Arabian meat and fish data using data-analytic techniques introduced by Selvanathan (1987) are presented, before formally estimating demand equations. These are set out in Chapter 6 as the demand for meat (beef, chicken and lamb) using data over the period 1985 to 2010. Chapter 7 analyses the food imports, particularly meat (beef, lamb and chicken) for the country, where its ability to grow food is declining and where it is depending more and more on imports. Chapter 8 concludes the study. Recommendations are made for both the public and private sectors, and future research has been proposed.
Chapter 2
The Saudi Arabian Economy, the Society and Future Plans

The Kingdom of Saudi Arabia is dependent on oil, and despite recent developments in shale oil and gas, the country remained dominant in proven oil reserves in 2012 (United States Energy Information Administration, 2014). Saudi Arabia’s economy developed from the 1960s as the oil industry infrastructure was put in place, and the revenues were directed to socio-economic development. The subsistence lifestyle of the people of the Arabian Peninsula changed dramatically, and as the country urbanised and incomes grew, the country has been opened up to the international market. At the same time, the Saudi diet has changed to incorporate more protein from the traditional goat, mutton and camel meat. The present day protein intake predominantly comprises meat and fish. As all meat consumed in Saudi Arabia is processed according to halal (Accepted process under Islam) certification, this constrains the imports from certain countries and thus food security becomes a major issue.

The present chapter discusses the physical, social, and economic characteristics of the country, followed by global food policies, trade and trends. The discussion then moves to implications of internal policy changes and global influences on food security and food sovereignty and implications for Saudi Arabia.

2.1 Characteristics of Saudi Arabia
This section presents the physical and social background of the country. It begins with geography and climate. This is followed by the religious and historical basis of the foods in the region.

2.1.1 Geography and Climate
Saudi Arabia is a desert country of some 2.15m km$^2$, surrounded by the Red Sea to the west, Jordan and Iraq to the north, the Gulf countries of Kuwait, Bahrain, Qatar, United Arab Emirates and Oman along the Arabian (Persian) Gulf to the east, and Oman and Yemen bordering the Arabian Sea to the south. Saudi Arabia consists of thirteen provinces each containing a number of governorates and cities: Riyadh (which is the capital), Makkah, Al Madinah, Eastern Province, Northern Province, Hail, Al-Jouf, Asir, Al-Baha, Tabuk, Jizan, Najran, and Al-Qassim. The other large cities are Jeddah, Makkah, Dammam, and Al Madinah.
As the average rainfall is just 100mm, almost half the country in uninhabited. The Red Sea is a rift valley and the Hijaz Mountains rise from the coastal plain to the west and slope down across a vast desert plain to the east, the Ar Rub’al Khali, the Empty Quarter. The Hijaz Mountains rise from the north of Jeddah and extend to the south, rising above 2,000m in the southwest in Asir and Jazan, a seasonal food producing area. Summer temperatures rise to the high 40°Cs in the desert climate, milder during the night; whilst coastal cities are hot with high humidity (Royal Embassy of Saudi Arabia, 2014). In the winter season, the climate is temperate, even cool. For example, central Riyadh’s average temperature in July is 42°C and 14°C in January; whilst Jeddah’s coastal location has a summer average of 31°C and 23°C in winter (Al-Hadhrami, 2013). As a result of these conditions, Saudi Arabia has no permanent fresh water, although aquifers form oases and captured runoff is used for agriculture. Some two per cent of Saudi Arabia’s land is used for agriculture, and this is concentrated into a few locations around Tabuk, Riyadh and the south (England, 2009).

2.1.2 History and Society

With the exception of the Yemen tribes to the south and the like ‘the states which previously were formed with a truce with Britain’ Trucial States with Britain to the east,
King Abdulaziz bin al-Saud united the remaining Arabian Peninsula’s tribes in the first decades of the 20th century, forming a series of *hujra* or settlements of the *ikhwan* warriors/protectors (Al-Rasheed, 2012). In 1925, the tribes lost their rights to the *dira* (tribal grazing land) which accelerated the demise of their nomadic lifestyle, with this lifestyle finally ending in 1968 when their remaining land was distributed to individuals, mainly tribal leaders, breaking the traditional community control over land. Using the *ikhwan*, Abdulaziz united the country and declared an Islamic Kingdom in 1932 (United States Library of Congress, 2014).

Early in the 1930s, oil was discovered in Bahrain, Iran and Iraq (Saudi Aramco, 2014). In 1933, the oil concession with the Standard Oil Company of California was signed to search for oil and in 1935 the first well was drilled at Dhahran. Texas Oil bought into the concession in 1936 and although further finds were made and a refinery built, this was shut down over the duration of World War II. With additional owners, the company was named Aramco in 1944. At the end of the 1950s, the company was producing 1 million barrels annually, and Saudis dominated in the oilfields and used offshore corporations to manage production (Al-Rasheed, 2012; Saudi Aramco, 2014). The oil wealth was used to establish a nation with a rapidly rising population. New infrastructure was established for roads, airports, seaports, schools and hospitals, land was allocated and funds distributed to build houses and to provide accommodation (Royal Embassy of Saudi Arabia, 2014).

Government in the Kingdom is based on a constitution, the *Qur’an*, which together with the *Hadith* and *Sunnah* sets out all matters of private, social, commercial and public life in Saudi Arabia, including Shariah laws. Whilst the foundations of government services were established in the first half of the 20th century, progress was slow until the oil revenues began to flow and government ministries could be established in 1953 by Abdulaziz’s successor. During the 1950s and 1960s, 20 government ministries were established, which have now been expanded to 24. The Council of Ministers and the *Shoura* (Consultative Committee, now with female members), form the executive and legislative parts of government. The thirteen provinces are administratively established uniformly with princes, Shoura, ministerial representation and local governments in place (Al-Rasheed, 2012, United States’ Library of Congress, 2014).
2.1.3 Population and Society

The mid-20th century establishment of nationhood and access to international resources through oil production led to the urbanisation of the states of Arabian Peninsula rich with oil wealth\(^2\). Other influences in the conquest of the peninsula were the British, with their colony in Aden (Yemen), protectorates of Bahrain and Qatar, the British-funded non-aggression treaty for the Trucial States, that is, the United Arab Emirates (predominantly Abu Dhabi and Dubai), and the recipient of aid, Muscat (Oman). The Emir of Kuwait was an ally of Abdulaziz (Al-Rasheed 2012, Hollis 2010).

Population growth on the Arabian Peninsula was historically dominated by tribal aggression and food supplies. Once the revenues from oil stabilised and economic plans were implemented (see Section 2.2), population growth accelerated, both from the birth rate with a high survival rate and from the influx of foreign workers who joined in the infrastructure development of the country (Figure 2.2) (United Nations, Department of Economic and Social Affairs, 2014).

**Figure 2.2: Saudi Population Growth from 1950 to 2015**

![Saudi Population Growth from 1950 to 2015](image)

Source: United Nations, Department of Economic and Social Affairs (2014).

Figure 2.2 clearly shows the influence of the expatriate workers, predominantly men. The effects of modernisation are arguably reflected in the female population; although nurses and domestic workers are predominantly foreign women, the trend reflects a high Saudi growth rate, with that (birth) rate slowing from 2010. Very few nonworking expatriates

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\(^2\) Gulf countries party to the Gulf Cooperation Council and oil and gas producers: Saudi Arabia, Kuwait, Bahrain, Qatar, United Arab Emirates and Oman.
can gain residency and fewer still become citizens of Saudi Arabia (Al-Rasheed, 2012; Theodorou, 2014). The Central Department of Statistics and Information (2014) advised that the population reached 30m in 2013, with 20.3m Saudis, with a growth rate of 2.7%. The World Factbook’s (2014) figures are lower, at 27m and growth rate of 1.49%. The difference between the two sources arguably takes into account Saudisation, whereby the Saudi government reduced the number of illegal workers, however, Ghafour (2014) reported that 1.2m expatriates were granted Saudi work permits each year due to the cost effectiveness of imported labour. More than a million Saudis were out of work despite the generous Saudisation/Nitaqat policy for employers (Ghafour 2014).

The conservative Saudi society is arguably caught between its Muslim and Arab foundations and the increasing influence of modernisation. Social commentators like Al-Naqeeb (2012), Ahmed (2014) on illiteracy rates, and Al-Rasheed (2012) on paternalism reflect the changes brought about by rising incomes, urban lifestyles and education. In an urban surrounding, women who formerly worked to support their children in tribal societies were freed to pursue their primary Islamic responsibilities to serve the family as a minor in Saudi Arabia (Al-Fawaz, 2014). The Saudi government recognised this issue and in 2011 embarked on Nitaqat (Saudisation program), an employer compliance policy designed to implement the long-standing policy of Nitaqat (Ramady, 2013). However, as Ghafour (2014) pointed out, Saudis’ refusal to work in the private sector, particularly Saudi women who are averse to mixed gender workplaces, resulted in Saudi women occupying only 15 per cent (1.4m.) of the total jobs available. Ghafour claimed that a million Saudis were out of work; the Central Department of Statistics and Information published the following figures in early 2014 (Table 2.1).

<table>
<thead>
<tr>
<th>Labour force characteristics</th>
<th>Labour force (&gt;15 years of age)</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>National</td>
<td>21.5m</td>
<td>12.5m</td>
<td>9m</td>
</tr>
<tr>
<td>Saudi</td>
<td>13.5m</td>
<td>6.7m</td>
<td>6.8m</td>
</tr>
<tr>
<td>Saudis with jobs</td>
<td>5.5m</td>
<td>4.3m</td>
<td>1.2m</td>
</tr>
</tbody>
</table>

Source: Central Department of Statistics and Information (2014).

The Department reported that 3.15m Saudis (48% women) in the labour force cohorts were in (free) education or training, whilst 3.8m (100% women) were housekeepers. The remaining women were retired, disabled, refused to work, or ‘other’ (Central Department
of Statistics and Information, 2014). The Saudi concept of labour force participation\(^3\) is unclear, with the Central Department appearing to prefer a head count from 15 years and over. Nevertheless, these figures show that women follow Islamic principles of remaining out of the labour market and seeking socialisation with other women (Al-Rasheed, 2012, Ramady, 2013). This voluntary absence from work affects the Saudi economy, family incomes, and food consumption patterns.

Other Central Department statistics (2014) show that there were 395,000 people working in agriculture, animal husbandry and fishing (agribusiness), predominantly in Riyadh, Qassim and Ha’il to the north, Makkah, and Asir and Jazan to the south (Central Department of Statistics and Information, 2014). Of the total agricultural jobs, 99.2 per cent were occupied by men; again out of the total, 54 per cent were Saudi workers (212,662). Of the Saudi agricultural workers, 66.2 per cent (209,709) were over 50 years of age and of the Saudi women agricultural workers (3,132), 76 per cent were aged over 50 years. Consequently, there are very few women in agribusiness, and those who are Saudi are well past the average working age for women (until their early 40s). It may be assumed that young educated Saudis are not interested in agribusiness, which is a challenge for the government’s food policies (Central Department of Statistics and Information, 2014).

2.2 Economic Development

The socio-economic development of the country after nationhood was slowed by the need for oil-based infrastructure: equipment, processors and port facilities at Al-Jubayl, and road and rail to Riyadh, almost 400km distance. By the 1960s, there were strong competing demands from the ministries to fund their diverse projects. This section presents the economic plans developed to rationalise the country’s priorities for funding.

At the initiative of the United Nations Development Fund, Saudi Arabia began a series of national development objectives, including debt control, its five-year development plans (Ministry of Economy and Planning, 2014; United Nations Development Fund, 2009). The first two plans, 1970-1974 and 1975-1979, guided the budgets in paying off debt and building the socio-economic infrastructure, mainly for developing the oil industry. These

\(^3\) The Australian Bureau of Statistics defines the labour force participation rate as the labour force (persons employed or unemployed) expressed as a percentage of the population. Australia meets the International Labour Organisation’s standards ‘almost in their entirety’. Accessed 27 December 2014 from http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/6102.0.55.001Chapter62013
are supported through the domestic development funds. This included technology and education promotion in subsequent plans in 1980-1984 and 1985-1989. They also focused on diversifying oil income to downstream industries, and protection of environment.

The Kingdom’s plans are shown in Table 2.2 (Ministry of Economy and Planning, 2014). Each plan is prefixed by a declaration to maintain the country’s moral values, raise living standards, and provide national security and stability. The economic sections of the plans, listed by priority in the statements, are shown below:

Table 2.2: Aims of Successive 5-year Development Plans

<table>
<thead>
<tr>
<th>Plan</th>
<th>Plan objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st plan 1970-1974</td>
<td>Growth of gross domestic product</td>
</tr>
<tr>
<td>(SR 41,300m)</td>
<td>Develop human resources to improve production and provide</td>
</tr>
<tr>
<td></td>
<td>for the country’s development</td>
</tr>
<tr>
<td></td>
<td>Diversify production to reduce dependence on oil production</td>
</tr>
<tr>
<td>2nd plan 1975-1979</td>
<td>High rate of economic growth</td>
</tr>
<tr>
<td>(SR 498,000m)</td>
<td>Development of human resources</td>
</tr>
<tr>
<td></td>
<td>Social well-being</td>
</tr>
<tr>
<td></td>
<td>Physical infrastructure</td>
</tr>
<tr>
<td></td>
<td>Economic freedom within social welfare</td>
</tr>
<tr>
<td>3rd plan 1980-1984</td>
<td>Structural change in the economy</td>
</tr>
<tr>
<td>(SR 3.1b)</td>
<td>Participation and social welfare in development</td>
</tr>
<tr>
<td></td>
<td>Economic and administrative efficiency</td>
</tr>
<tr>
<td>4th plan 1985-1989</td>
<td>Social and economic reform</td>
</tr>
<tr>
<td>(SR 1,000b)</td>
<td>Raise cultural standards</td>
</tr>
<tr>
<td></td>
<td>Diversify the economy from oil, develop mineral resources</td>
</tr>
<tr>
<td></td>
<td>Improve public sector efficiency</td>
</tr>
<tr>
<td></td>
<td>Integration through the GCC$^d$</td>
</tr>
</tbody>
</table>

(continue …)

<table>
<thead>
<tr>
<th>Plan</th>
<th>Plan objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>5th plan 1990-1994</td>
<td>Productive national workforce</td>
</tr>
<tr>
<td>(SR 753b)$^5$</td>
<td>Develop human resources</td>
</tr>
</tbody>
</table>

$^d$ Gulf Cooperation Council countries: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates

$^5$ Oil shocks reduced expenditure as capital holdings were improved as a future buffer.
<table>
<thead>
<tr>
<th>Plan</th>
<th>Plan objectives</th>
</tr>
</thead>
</table>
| 6th plan 1995-1999 | Raise cultural and information standards  
Diversify the economy from oil, develop mineral resources  
Improve public sector efficiency  
Encourage private sector participation |
| 7th plan 2000-2004 | Productive national workforce, develop human resources  
Balance growth throughout the country  
Encourage private sector participation  
Diversify the economy from oil, develop agriculture, industry and mineral resources  
Improve public sector efficiency |
Long-term economic structural changes and competitiveness  
Long-term development of human resources  
Global energy markets  
Economic stabilisation and diversification of government revenues  
Water resources in the long run  
Science, technology and informatics in future development |

(continue…)
9th plan  
2010-2014  
- Improve economic growth and social welfare.
- Regional development
- Education and training
- Raise standard of living
- Diversify and deepen economic base
- Knowledge-based economy
- Integrate private sector into economy

10th plan  
2015-2019  
- Enhance economic growth with its different dimensions
- Improve mineral resource production
- Diversify oil-based processing both up- and down-stream
- Expand industrial manufacturing
- Develop services sector: financial, tourism, transport, engineering and digital technologies
- Encourage international partnerships in investments
- Develop low-rainfall agriculture, and aquaculture
- Expand industry into rural provinces
- Knowledge-based economy
- Use initiatives to recycle water for agricultural purposes


2.2.1 Early Development Plans

Table 2.2 shows the government’s response to economic threats over decades, although the first plan recognised the long term issues: diversification from oil revenues and accessing skilled labour. King Faisal (1964-1975) opened the country to international markets, introducing television and seeking advice from international organisations such as the United Nations Development Fund, often under threat of retaliation from religious scholars, the ulema. During Faisal’s reign a massive educational program began, with expenditures to 10 per cent of the budget establishing universities, vocational training centres and a large building program for schools. Due to the demand from women, primary schools for girls were established, although these remained under the control of the ulema to convince the many who were opposed to education for women. Health centres were also established and multiplied over the years (United States Library of Congress, 2013).
At the beginning of the 2nd development plan, the Saudi government gradually increased its holding in Aramco to reach 100 per cent by 1980. In 1976, the company was the first to produce 3 billion barrels per year. By the late 1970s, Aramco operated three of the largest global projects, including the Quaryyah seawater treatment plant (Saudi Aramco, 2014). In the 1970s due to the oil price shocks, the Saudi budget was severely impacted upon by successive oil price shocks and embargoes: the Suez Crisis of 1956-57, the OPEC oil embargo of 1973-1974, the Iranian revolution of 1978-1979, the Iran-Iraq War of 1980, and the first Persian Gulf War in 1990-91, and the oil price rise since 2007 due to the GFC (Hamilton 2010). The economic crisis in 2008 contributed to dislocation of the oil price, which continued to rise to reach $US100 per barrel (the Saudi riyal is pegged to the United States dollar, at approximately 27 US cents). The International Monetary Fund (2014) stated that in 2013 the average price of oil was $US104.1. Historical data is presented in Figure 2.3.

Figure 2.3: Historical Oil Prices from 1946 to 2014


For the 3rd development plan, the oil price shocks gave the government the means to establish a modern industrial sector, using gas production to produce chemicals and petrochemicals for export. It continued the construction of energy-intensive industries, and state-of-the-art industrial cities and facilities at Al Jubayl and Yanbu (United States Library of Congress, 2013). This work continued throughout the 1980s and the next
development plans, where the reduced oil prices hampered the rate of new socio-economic development. Security also impeded economic development, and in 1981 Saudi Arabia, Kuwait, the United Arab Emirates, Oman, Qatar and Bahrain formed the Gulf Cooperation Council (BBC News 2012). The BBC report states that the six countries share common social and cultural outlooks, and all are absolute monarchies and control a large part of the world’s oil reserves. Whilst the initiative was security, the Gulf countries later formed a common market (2008), allowing free movement of citizens for work and travel (BBC News 2012). The International Monetary Fund (2013) also reported that on several occasions, Saudi Arabia used its production capacity to fill global demand gaps created by large supply disturbances. The first Gulf War (1990-1991) resulted in a shortfall from Iraq and Kuwait. Production from those countries fell from 4.8 million to 0.4 million barrels per day (mbd), a 6.5 per cent of global oil supply. Saudi Arabia raised its production from 5.4 to 8.2 mbd over the same time, replacing nearly two-thirds of the loss. Nevertheless, global oil supply fell by 3.7 per cent and the oil price doubled by the end of 1991.

In the 1990s, with industry infrastructure largely in place, the government began to seek greater input from the private sector, and the 5th (1990-1994), 6th (1995-1999), and 7th (2000-2004) plans reflected this. Cordesman (2003) explained that, whilst society largely agreed on the need for reform from public sector to private sector dominance, the nature and pace of the changes were difficult issues for building consensus. The reform aims were to strengthen the private sector, privatise public agencies (transport, communications, health and education, but not oil), encourage foreign investment and Saudis to repatriate their wealth and invest in the Kingdom. Whilst each development plan focussed on private sector growth, Cordesman stated that from 1990 to 1997 the government share of the non-oil sector constantly outpaced the private sector. In 1990, the private sector’s share of gross domestic product was 36 per cent, and by 1997 it was 35.3 per cent. Real growth in the non-oil sector was far too low to meet the country’s needs except in construction and government-related areas. From 1993 to 2000, Cordesman states that:

a. real GDP growth over the period was 10.2% (SR62.3b -SR68.6b),
b. the heavily subsidised agriculture, forestry and fishing sector rose erratically by 8.5%,
c. mining and quarrying (non-oil) rose 17%,
d. manufacturing, largely of government-initiated downstream oil products such as plastics, (non-refining) rose by 29%,

e. wholesale and retail trade, restaurants and hotels increased by 8.9%,

f. finance industry rose by 9.8%,

g. construction, generally government-funded, increased by 12.3%,

h. transport, storage and communication, again government funded, increased by 10%,

i. government-controlled petroleum, gas and refining only rose 2.8%, however this reflected up to 40% of GDP, and

j. other government services, health, education, water, electricity grew at 12.3% over the period and this was about half that of the population growth (25.6%).

The published figures did not separate government and private sectors sufficiently to enable analysis. The combined government controlled oil sector and direct government services contributed 51% to gross domestic product in 1993 and 49.1% in 2000. Cordesman therefore believed that the successive development plans aimed at increasing the size of the private sector were unsuccessful. However, the Saudi government claims that the 6th (1995-1999) and 7th (2000-2004) plans were focussed on the private sector, whilst the 8th plan (2005-2009) included foreign as well as national investment:

In the 25 years from 1970 to 1995, the non-oil sector's share of GDP increased from 46 per cent to just over 70 per cent, and that this GDP tripled, to 125.1 billion U.S. dollars, reflecting a growth rate of 8.6 per cent in current prices. By 2002, the GDP had reached 186 billion dollars (Royal Embassy of Saudi Arabia, 2013, p.1).

### 2.2.2 Privatisation Plans

The Saudi Arabian General Investment Authority (SAGIA) was established in 2000, when foreign direct investment was liberalised. Saudi Arabia joined the G-20 group of Finance Ministers at its formation in 1999, and in 2005, Saudi Arabia took membership in the World Trade Organisation (Council for Australian-Arab Relations, 2008). It is not a member of the Organisation for Economic Cooperation and Development (OECD). In 2012, the gross domestic product growth rate at constant prices was 5.13 per cent, and per capita gross domestic product at current prices was SR93,177 (Central Department of Statistics and Information, 2014). By 2012, foreign direct investment was $US13.7b and falling, well down from the 2008, $US39.5b (OECD, 2013).

The effects of population growth were the focus for both the 8th (2005-2009) and 9th (2010-2014) plans. As Cordesman (2003) previously noted, provision of services was
outpaced by population growth in the 1990s, that is, by natural increase and expatriate workers. The large increase in population from the 3rd development plan coincided with the government’s scaling up of infrastructure - accommodation, jobs, schools, medical services and transport. From 2006-2010, the Saudi Arabian General Investment Authority (2014) established the foreign investment protocols for six economic cities, since scaled down to four, to provide lifestyle choices for the young population. These cities are to be located in proximity to Jeddah (King Abdullah Economic City), Ha’il to the north (Prince Abdulaziz Bin Mousaed Economic City), Al Madinah (Knowledge Economic City) in the centre west, and an industrial port to the south of the country (Jazan Economic City). They are expected to contribute $US150 billion to the gross domestic product by 2020 (Saudi Arabian General Investment Authority, 2014). In 2008, foreign direct investment of US$39.5 billion was useful in speeding up development; however, as noted, it was a third of that in 2012 (OECD, 2013). Alshoaiby (2013) reported that King Abdullah Economic City in Rabigh, at an expected 168km2 was dedicated to transport and logistics industries, providing an alternative port to Jeddah. At completion, it will have a population of 2 million, and will create a million jobs. The city will feature a seaport and associated industries, an education zone and residential area and resorts for tourists. The focus of the inland Prince Abdulaziz Bin Mousaed Economic City near Ha’il is again on transport and logistics, as it lies at the crossroads of the Mediterranean and ancient Bedouin routes that cross the country. The new city, on 156km2, also has facilities for bulk commodities of agribusiness, minerals and construction materials. It is intended to accommodate 80,000 people and create 55,000 new jobs in the region. The third city, Knowledge Economic City at Al Madinah, is focussed on Islam, and at 4.8km2 is smaller, intended for a student and faculty population of 200,000 with 20,000 new jobs. The aim is to use Al-Madinah’s Mosque (the Prophet’s Mosque) for religious and academic learning and tourism, using the Prophet’s heritage as inspiration and providing a retail section based on a souq. The last city, according to Alshoaiby (2013), is Jazan Economic City. The 100km2 city already has a heavy industry sector, and as it gains some rainfall, the new city can also contribute to the country through the agribusiness sector, collectively creating up to 500,000 new jobs in the region, whilst accommodating 300,000 citizens (Jazan University, 2014).

A further issue impacting the Kingdom’s economy is the influx of millions of pilgrims to perform the Hajj each year, although 2013 numbers were down due to massive upgrading of the religious sites, from 3.2 million in 2012 to about 2 million in 2013 (Alalam, 2013).
Construction of the Grand Mosque was underway to increase capacity to 2.2 million, and the Haramain very fast rail is being constructed as a 450km link from the King Abdulaziz airport through to Jeddah, Makkah and Al-Madinah (Emirates 24/7, 2014). These transport links are crucial in moving millions of pilgrims from King Abdullah International Airport to the large tent city at Makkah (a distance of about 100km), and through to Al-Madinah, a distance of 450 km.

For the 10th development plan (2015-2019), the reference is again perennial population issues, as the focus is on jobs and housing. Official reports are generally released to the press, and in September 2014, an announcement was made that the Council of Ministers had decided ‘to strengthen the Kingdom’s economy and promote its growth, stability and competitiveness’ (Arab News, 2014, p.1). However, in December 2014, Streifel, Greenwood, and Rouset (2014) reported that crude oil prices continued to fall (shown in Figure 2.3) generally at $US55 per barrel. Streifel et al. attributed the fall to the Kingdom’s determination to maintain a market surplus following the decision of the Organisation of Petroleum Exporting Countries (OPEC), led by Saudi Arabia, to leave its 30 million barrels per day production unchanged. Streifel et al., reporting for the International Monetary Fund, said that the organisation was willing to let oil find a new balance to dampen speculation and achieve longer term oil price stability. It would also remove higher cost oil producers using new production techniques to extract oil from shale deposits that threaten Saudi domination of the sector.

In summary, the economic development of Saudi Arabia in the 20th century was focussed on nation-building; that is, providing the industrial infrastructure of facilities, transport routes and logistics to maximise the country’s income from oil. The successive early development plans mapped out quantitative priorities for the public services; sufficient allocations for accommodation, utility services, health and education to reach and maintain a basic standard of living. As the infrastructure became established through government capital and current resource expenditure, the focus of the plans changed to achieving international standards by raising human resource skills and providing work for citizens. The early attention on financial outlays, a quantitative approach, was set aside as a measure, replaced by human achievements in education, health and lifestyle aspirations. The latter economic plans are therefore becoming generalised and aspirational, as the economy matures and becomes less focussed on oil and diversifies into service sector that must provide jobs for men and suitable jobs for women. Given
legal and religious barriers, this is proving difficult for the government despite the high outlays under Saudisation/Nitaqat.

2.3 International Food Policies and Saudi Arabia

In 1945, forty-four governments established the Food and Agriculture Organisation (FAO) under the United Nations charter to work for human access to food through agriculture. In 1974, the United Nations World Food Conference in Rome recommended the adoption of an international world protocol on food security. The organisation developed databases, standards for food consumption, and moved to protect forests and plants. In 1994, a special program for food security targeting low-income food-deficit countries was launched, together with a trans-boundary animal and plant pests and diseases for the prevention, control and, when possible, eradication of diseases and pests. In May 2012, international conventions were introduced on trade in pesticides; on fishing capacity, sharks and seabirds; plant genetic resources (Food and Agriculture Organisation, 2013, Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security). The Food and Agriculture Organisation typically responds to the plight of impoverished nations, and the effects of wars and the aftermath of natural disasters.

The term food security describes a nation’s ability to feed its population, it does not determine whether this is to meet energy and nutritional requirements or whether to meet economic demand related to self-sufficiency, given that some countries had subsistence farmers who only had access to local production (Pinstrup-Andersen, 2009). The Committee on Food Security of the Food and Agriculture Organisation has broadened this definition into economic terms: ‘Food security exists when all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life’ (Food and Agriculture Organisation, 2013).

2.3.1 Antecedents of Agribusiness

In 18th century England, capitalism was arguably instigated in part for food security to moderate the effects of harvest and famine. As an alternative from feudalism, Adam Smith (1776, 1976) in his dissertation, ‘An inquiry into the nature and causes of the wealth of nations’, introduced the notion of an ideal economy, a self-regulating market system that automatically satisfied all needs of a society. Following Adam Smith, David Ricardo
(1817) focused on the distribution of income from the market among landowners, workers and capitalists, noting inherent conflict between landowners on the one hand, and labour and capital on the other. Based on an agrarian economy, highly dependent on food production, he said that with a fixed supply of land, the growth of population would result in increased rents, and wages and profits would be restrained. However, Thomas Robert Malthus (1798, 1926) disagreed, stating that the market model was insufficient to guarantee supply.

Whilst the modern day economists agree on the problem, they offer multiple recommendations to address Malthus’s notion of land shortfall in food production. Tilman, Balzer, Hill, and Befort (2011) reported that global food demand is increasing rapidly, together with the environmental impact of intensive agriculture. When measured as protein content of all crops combined, global per capita demand for crops has been increasing as a function of per capita real income since 1960; thus a continuing relationship leads to a forecast of doubling global crop demand between 2005 and 2050. Tilman et al. (2011) argued for seeking higher yields on marginal croplands that have been cleared and then abandoned as growers obtain greater productivity through clearance. Tscharntke et al. (2012) added that agriculture practised under smallholder farmer-dominated landscapes (not large-scale farming) is currently the backbone of global food security in the developing world.

2.3.2 Food Production and Climate Change

Climate change and its effects on agriculture production are presently receiving a great deal of attention from environmental and socio-economic researchers. For example, 24 authors from 13 institutes called for carbon abatement for human health and food security using a GAINS model to interpret future scenarios (Shindell et al., 2012). Beddington et al. (2012) produced a report for the Commission on Sustainable Agriculture and Climate Change, including global food production as energy (Figure 2.4).
The Commission (Beddington et al., 2012) found uneven crop production throughout the globe, advocating for improved nutrient and water supplies and other production strategies to improve crop yield. They found that such improvements to crop yields contributed increased yields to 95 per cent of their potential and added 58 per cent to current production. Linking agricultural intensification with biodiversity conservation, the various researchers argued for well-informed regional and targeted solutions based on regional food production to supplant intensive farming. The Commission made the following recommendations:

1. Integrate food security and sustainable agriculture into global and national policies.
2. Significantly raise the level of global investment in sustainable agriculture and food systems in the next decade.
3. Sustainably intensify agricultural production while reducing GHG emissions and other negative environmental impacts of agriculture.
4. Develop specific programmes and policies to assist populations and sectors that are most vulnerable to climate changes and food insecurity.
5. Reshape food access and consumption patterns to ensure basic nutritional needs are met and to foster healthy and sustainable eating patterns worldwide.
6. Reduce loss and waste in food systems, targeting infrastructure, farming practices, processing, distribution and household habits.
7. Create comprehensive, shared, integrated information systems that encompass human and ecological dimensions (Beddington et al., 2012, p.3).

The seven recommendations encompass aspirational targets for global food supply; however, it is problematic whether many governments have the physical resources to accomplish these goals.

Regional food production was supported by Hinrichs (2012) who argued that food security is an urgent social, political and environmental concern. Hinrichs recognised that local food production has issues of capacity and seasonality, and globalisation has another set of issues with security and sustainability. Regionalisation can offer parameters for food security, whereby cooperatives can support production of preferred food types for their respective societies. However, given Saudi Arabia’s desert geography, the chances of providing food for its 30 million people from regional resources seem remote, given the population pressures in African food areas to the south, and long-term security concerns in the north. To counter Malthusian arguments, certain Saudi foodstuffs are produced locally (e.g. chicken, dates, spices) and the remainder are largely imported. Thus food security is largely a global phenomenon, and its characteristics are discussed below.

2.3.3 Global Food Markets

As price fluctuations based on supply and demand are common factors in agricultural product markets, the Food and Agriculture Organisation (2014, November) tracks monthly food prices. The Food and Agriculture Organisation noted that during global financial crisis (GFC) in 2007, a series of dramatic swings (shocks) occurred in commodity prices; food prices soared in 2008, collapsed sixth months later, and then rapidly rose again. At the time (November 2014), the Food and Agriculture Organisation food price index was steady around 192 points, lower than the same month in previous years (Figure 2.5).
Figure 2.5: Food Prices Index

The Food and Agriculture Organisation uses a basket of food commodities for its food price index, dairy, sugar, vegetable oils, cereals, and meat. The right-hand graph in Figure 2.5 shows stable food prices from September to November 2014, some 6.4 per cent under the same period in 2013 (Food and Agriculture Organisation, 2014).

However, the component indices in the left-hand graph in Figure 2.5 show greater volatility. Dairy prices fell substantially over the year, and the Food and Agriculture Organisation (2014) attributed this to exceptionally high prices at the beginning of the year, which were then affected by improved export levels and reduced imports from China and the Russian Federation. Similarly, mid-year high sugar prices were attributed to drought in the main sugar growing areas of Brazil, the main exporter, and price decreases over the last half of the year reflected a return of rainfall and reduced the threat of a prolonged drought (Food and Agriculture Organisation, 2014).

The vegetable oil price index was affected by production slowdowns of palm oil in Malaysia and Indonesia; sunflower oil and soy oil prices were also weak. Cereal prices began to rise in November 2014 as oversupplies began to ease. Wheat prices recovered on prospects of lower growing conditions in 2015 in the northern hemisphere countries, while maize and soy bean prices began to recover. Rice supplies were abundant, thus prices fell on lower import demand. The meat price index was steady at 210 points in November, as prices for most types of meat, in particular bovine meat, were at historic
Food prices, however, reflect different markets and cultural food consumption. Many societies, and individuals, have food preferences and food taboos. These may occur through traditional sources of foods, such as the sheep meat preferences of the people of the Arabian Peninsula, or people from west Europe’s cattle meat focus, related to cultural cuisine (O’Neil, 2010). Food safety changes world dietary preferences, such as the outbreaks of bovine spongiform encephalopathy and bird flu (Kabe and Kanazawa, 2012). The climate plays a role in the local foods available, and cereals vary according to location as well. In religious societies, the religious practices of Islam permit only halal foods, only kosher foods are permitted by Judaism and in Hinduism beef is restricted (Theobald, 2012). Further, there are individual preferences based on food intolerances or food fashions, such as a preference for ‘health’ foods low in types of fat (Stockton and Baker, 2013).

Overriding regional and cultural preferences, Kearney (2010) stated that significant improvements have been made in raising food consumption per person from 2,411 to 2,789 kcals per person per day between 1969 and 2001, given issues in sub-Saharan Africa where rise in consumption did not occur. Between 1963 and 2003, developing countries showed significant increases in energy consumption per head of population: meat (1.19 times), sugar (1.27 times) and vegetable oils (1.99 times). China, as a developing country, showed remarkable changes over the last 40 years: meat (3.49 times), sugar (3.05) times and vegetable oils (6.8 times). Globally, there was a decline in consumption of pulses, and roots and tubers between 1963 and 2003 (Kearney, 2010). As drivers of globalised food consumption, Kearney points to rising per capita incomes, urbanisation, global food corporations (homogeneity of food products), and consumer attitudes and marketing.

In a return to Ricardo’s (1817) restrictions on arable land supply, Kastner, Rivas, Koch and Nonhebel (2012) analysed the Food and Agriculture Organisation’s land-food production data from 1961 to 2007. Kastner et al. (2012) found that diets in most regions became richer while the quantity of land necessary to feed an individual declined. They then studied social drivers of food consumption across the globe: population, agribusiness technology, and diet. The findings were largely supportive of Kearney (2010); that the potential for reduced land for food production was offset by population growth and
change of diet. This effect was greater in emerging economies and Kastner et al. (2012) posited that dietary change is more influential than population growth for land requirements for food.

### 2.3.4 Trade Liberalisation

In the global food markets, trade liberalisation affects food supplies as countries dismantle trade barriers due to global agreements in trade under the World Trade Organisation’s rules (Thow et al., 2010). As well as freeing up food for export, trade liberalisation can remove barriers to foreign investment in food distribution. Thow et al. (2010) observed governments’ use of trade policy to create a healthier food supply to counter the 80 per cent of chronic disease and deaths that occur in low and middle income countries. Food trade also enables foreign investment in other types of food retail; availability of processed food rose in developing countries after foreign direct investment by multinational food companies.

Whilst food security has advanced globally, Blouin, Chopra, and van der Hoeven (2009) found that a country’s trade liberalisation is not sufficient to boost economic growth; trade reforms do not necessarily provide economic expansion due to greater wage inequality and raised economic insecurity. Blouin et al. (2009) noted that trade liberalisation facilitates availability of highly processed, nutrient-poor, calorie-rich food in developing countries. Changes in trade policies facilitate availability and consumption of meat, dairy products and processed foods, thus the global economy affects the health of populations and policy makers need to understand how such risks of trade liberalisation can be mitigated. Thow and Hawkes (2009) stated that trade policies therefore contribute to the ‘nutrition transition’ associated with rising rates of obesity and chronic disease. This is largely supported by Kastner et al. (2012) and Kearney (2010), who find that dietary changes are more important than food production in land usage.

According to the Food and Agriculture Organisation, trade liberalisation may increase the risk of economic shocks that precipitate a food crisis. National policies on trade and the instruments that governments use to implement food policies at the border ‘play an important role in determining the nature of the link between prices in international markets and producer and consumer prices domestically’ (MacLaren and Yabuki, 2012, p.4). The FAO reports that governments may pursue self-sufficiency in staple foodstuffs and use global markets for non-essential supplies or in times of food stress; whereas others may buy predominantly from global markets. MacLaren and Yabuki (2012) noted
that these strategies may be politically inspired rather than implemented through quantitative economic analysis. They state that a nation’s mix of domestic and trade policies render measurement of the effects of one or the other on domestic food security difficult for aligning regional or global trade agreements. As noted, international, regional and national food security and food choices are affected by other than economic influences, such as biological interference, drought, flood and storms. Further, deterioration in the health status could make populations more vulnerable to less extreme shocks (Blouin et al., 2009).

Trade liberalisation is also impacted by the strength of the dominant market suppliers. Ercsey-Ravasz, Toroczkai, Lakner, and Baranyi (2012) pointed out that as the world’s population is in excess of 7 billion, maintaining the sustainability of its production, distribution and trade is vital. Ten exporters form the core of international agricultural and food trade as shown in Table 2.3, whilst the top 10 importers of food and agricultural products included Saudi Arabia in 2013 (Table 2.3) (World Trade Organisation, 2014). These illustrate the interconnectedness of world agricultural trade, a point made clear by Ercsey-Ravasz et al. (2012) who investigated the potential for disease and food impurities in this trade.

<table>
<thead>
<tr>
<th>Country</th>
<th>Exports $US b</th>
<th>Country</th>
<th>Imports $US b</th>
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<tbody>
<tr>
<td>European Union</td>
<td>661</td>
<td>European Union</td>
<td>664</td>
</tr>
<tr>
<td>($175b non-EU exports)</td>
<td></td>
<td>($178b non-EU imports)</td>
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</tr>
<tr>
<td>United States</td>
<td>176</td>
<td>China</td>
<td>165</td>
</tr>
<tr>
<td>Brazil</td>
<td>91</td>
<td>United States</td>
<td>146</td>
</tr>
<tr>
<td>China</td>
<td>70</td>
<td>Japan</td>
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<tr>
<td>Canada</td>
<td>66</td>
<td>Russian Federation</td>
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<tr>
<td>India</td>
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<td>Canada</td>
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<td>Indonesia</td>
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<td>South Korea</td>
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<td>Argentina</td>
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<td>Mexico</td>
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<td>Thailand</td>
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<td>Hong Kong</td>
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<tr>
<td>Australia</td>
<td>38</td>
<td>Saudi Arabia</td>
<td>25</td>
</tr>
</tbody>
</table>

Source: WTO (2014)

The Food and Agriculture Organisation understandably dwells on food security risks, focussing on the poorest sub-Saharan countries and their physical and climatic insecurities. Its main policy instrument is trade liberalisation, where food producers create efficient global food markets that minimise prices so that poorer countries can access food for their population. However, as McLaren and Yabuki (2012), Blouin et al. (2009) and
Thow et al. (2010) pointed out, liberal economic policies alone cannot feed the world and there are long-term impacts on health with the globalisation of food supplies. Further, the advocates of global change point to redistribution of the world’s food-growing areas, whilst food fashion preferences differentiate food supplies away from staples and on to less sustainable food sources. Rather than Malthusian principles, these factors indicate that a renewed focus on flexibility of sources, supply of foodstuff and distribution is necessary.

2.3.5 Food Sovereignty

Food sovereignty may be described as the antithesis of food security, that is, one nation’s right to food security is at the cost of another’s food sovereignty. Pimbert (2009) explained that food sovereignty, as depicted by local agricultural systems, was the basic structure that contributed to a nation’s nutrition, supported its economy, and nurtured and maintained many food producing ecologies around the world. As well, certain food products are often an integral part of religion and culture. In food sovereignty, food is grown, traded, processed, sold and consumed locally. It provides livelihoods for more than 2.5 billion small-scale food producers around the world. Pimbert (2009) argued that this fundamental process is being lost from the combination of two threats. The first threat is the acceleration of control over food sources by global agricultural cartels of nations and corporations that monopolise parts of the food chain. The second threat is the ‘modernist development agenda pursued by organisations such as the World Bank and the Gates Foundation’ (Pimbert, 2009, p.2), which the author argues is encouraging people to leave the land for the urban manufacturing and service sector. To counter this agenda, the food sovereignty movement aims to support people’s right to their traditional food production, distribution and consumption patterns. Thus Pimbert’s principles of food sovereignty are:

a. improving democracy among subsistence farmers, especially women, by encouraging food-producing cooperatives,
b. encouraging research and innovation,
c. equitable access and rights to resource use including land, water, forests, seeds and the means of production, and
d. restructuring food models based on ecology, literacy and local economy models.

One of the pioneering studies on food sovereignty was undertaken by Riches (1999), who argued that food security in Canada encountered barriers including the increasing
paternalism of welfare and the voluntary sector, corporatisation of food, and the neglect by the federal and provincial governments to abide by international law regarding the domestic right to food as expressed in international human rights law. Riches depicted this loss of food security as loss of food sovereignty, that is, the loss of food producing and consumption rights through corporatisation of the food system in Canada. Food sovereignty was associated with, for example, Uzbekistan’s food self-sufficiency and water availability (Wegerich and Bektemirov, 2001), gender (Patel, 2012), and an emerging national policy framework (Windfuhr and Jonsén, 2005). Windfuhr and Jonsén (2005) noted that disparity between identifiers, right to adequate food, food security, and food sovereignty, that is, as complementary ways of describing and searching for solutions to hunger. McMichael (2014) summarised the evolution of food sovereignty, characterising it as a rural/urban activist movement that anticipates ecological constraints and unequal food distributions. McMichael points to public-private ‘governance’ partnerships that threaten food sovereignty activists and predicts that marginalisation of smaller farms in both emerging and older economies could lead to future food scarcities. Whilst generally supporting McMichael’s stance on food security and food sovereignty, Jarosz (2014) pointed to regionalising and the political economy of each situation, arguing that these concepts are dynamic and a situation for both immediate and local matters.

Saudi Arabia has an African food supply presence along the Red Sea and Eastern Littoral (see Section 2.1.1). Ambalam (2013) explored the effects of the GCC countries of ‘land-grabbing’ in Africa, claiming that sub-Saharan Africa’s aquifers have not yet been exploited and international control of agricultural land may end in disaster for the countries’ populations.

The farmers and local communities will seriously be affected not only by the land acquiring process but also the resulting process of land degradation and desertification due to intensive cultivation (Ambalam, 2013, p. 158).

Ambalam (2013) called for sustainable agricultural practices. Pretty, Toulmin, and Williams (2011) stated that agriculture was widely considered to have performed badly in African countries (Figure 2.6).
Figure 2.6: Changes in Africa’s Per Capita Net Agricultural Production (1961-2007)

Note: Scale per capita food production (1961 = 100)

Source: Pretty et al., (2011, p. 6).

Figure 2.6 shows that since the 1960s, African countries lagged world agricultural production per capita of the total African population. In contrast, Asia’s massive population growth over the last half a century saw food production doubled per head of population; whilst South America also improved its per head agricultural production by 63 per cent. This was confirmed by the United Nations Development Program (UNDP) where a report shows that although food production is increasing in sub-Saharan Africa, this is not a steady increase and remains inadequate for appropriate nutrition. In this report, Chauvin, Mulangu, and Porto (2012) stated that food production and consumption trends ‘highlight the importance of pursuing a deep transformation of the agricultural sector in Sub Sahara Africa if incomes are to be risen and food security problems are to be mitigated’ (Chauvin et al., 2012, Abstract). This United Nations’ call for a transformation confirms Africa’s needs, advocating for biological methods to improve crop yields (Pretty et al., 2011; Khan et al., 2014), and to bring changes in agricultural practices and their outcomes (Wollenberg et al., 2012).

Nevertheless, there is evidence of successful interventions in agriculture in Africa, such as the East African Farmer Field Schools (Davis et al., 2012; Waddington, White, and Anderson, 2014), and the British government’s Foresight Food and Farming Futures (Khan et al., 2011). These interventions include ‘crop improvements, agri-forestry and
soil conservation, conservation agriculture, integrated pest management, horticulture, livestock and fodder crops, aquaculture and novel policies and partnerships’ (Pretty et al., 2011, p.1). Benefits accrue to millions of farmers through improved yields, diversification away from production of corn and other staples, and improved sustainability of soils and eco-systems.

In summary, in its 2013 report, the World Trade Organisation (2014) noted that all trade in food and agricultural products maintained a constant 9 per cent share of world trade over the last 13 years. The Food and Agricultural Organisation (2014) reported overall constant food prices, although prices varied; high for meat and low for grain prices during the year. However, as the tenth largest importer of food and agricultural products, Saudi Arabia has increased its food imports by value at an average of 14 per cent per year for the last decade. Arguably, the food security risk for the country could be deemed greater than for other countries which produce more of their own food; against this, the higher incomes of the Saudi population and the willingness of their country to subsidise food costs if necessary reduces such risk. The food security and food sovereignty debates that continue in the literature can be avoided by countries either growing their own food, importing through world trade, or by buying equity into agribusinesses in food-rich economies. The case for Saudi Arabia is presented in the next section.

2.4 Food Consumption in Saudi Arabia

This section describes Arabic food preferences and the influence of Islam on diet. This is followed by the history of agriculture in the Arabian Peninsula.

2.4.1 Food Preferences

Arab food intake from the time of Prophet Mohammad may be described as a plain Bedouin diet of dates, dairy products, and some meat (Daryaee, 2012; Rosenberger, 2013). Where there was access to water, diets were more varied with the consumption of vegetables, fruit and cereals. Along the land and sea trade routes, more exotic produce could be purchased (Daryaee, 2012).

Arabs had a significant effect on global food customs. Civitello (2011) describes the Arab influence on indigenous societies’ food consumption from the early Islamic era, as travellers from the Islamic capital of Baghdad traded, fought and spread the new religion across three continents. In Europe, they planted orchards of stone fruits: cherries, apricots and peaches, and introduced sugar, rice, spinach and spices such as turmeric and saffron.
This was a sophisticated culinary society, as travelling Caliphs had local cooks under the direction of a master chef whose first priority was the health of the Sultan. Civitello noted that the earliest recipes in the 12th century described contemporary recipes such as *tagines*, meat and fruit simmered slowly for hours so that it complied with the Islamic dietary law. Milk from sheep or goats was made into yoghurt or fetta. Vegetables and pulses such as eggplant and chickpeas were prepared as *baba ganoush* and *hummus*. According to Peterson (1980), the Arab influence spread to the extent that from about AD 1300 there was a revolution in the dining habits for the élite in Europe, stimulated by Islamic attention to the preparation and presentation of food. Europe began to associate luxurious dining with the food of the Arabs, and thus began the concept of food influenced by Arabic tastes.

Islam is the national religion of Saudi Arabia, and shapes the daily life of all Saudis (Al-Rasheed, 2012). Islamic rules the individual principles, structure, social and business practices, also including eating habits. Some foods are permitted, *halal*, and others are prohibited, *haram*. Prohibited foods include swine, four-footed predators, birds of prey, incorrectly slaughtered animals, blood or blood products, alcoholic or intoxicating beverages, and drugs (Skanchy, 2009). The main holidays in Islam are feast and fast days, and surprisingly, food consumption raises during the fasting month of Ramadan, as *iftar* and *Seheri*, the meal taken between sunset and sunrise are often a shared banquet of special foods (Zubaida, 2003).

The dietary habits of Saudis changed over the last half-century, as socioeconomic conditions changed and the population drifted into an urban environment from the desert nomad life style seeking a modern urban lifestyle. The traditional food sources of the peninsula, according to Musaiger (2002), were characterised by low-fat and high fibre diet of dates, milk, fresh vegetables and fruits, whole wheat bread, and fish. As Saudis adopted global food consumption practices, in the last half-century dietary energy, protein and fat intake rose from 881 grams per capita per day in the 1960s to 1735 grams by 1990 (Adam, Osama, and Muhammad, 2014). Vegetable consumption fell from 400 grams per capita per day to 250 grams in 2000, whilst meat consumption grew from 26 grams per person per day in 1990 to 139 grams in 2007, and intake of sugar, eggs and milk also rose commensurately (Adam et al., 2014).

The quantities of food people consume are also rising (Food and Agricultural Organisation, 2014). Data show that both the United Kingdom and Saudi Arabia share
similar intakes of ‘average dietary supply adequacy’ at 1.37 times that which the FAO
deems healthy. The Saudi data continue to rise whilst the United Kingdom’s trend is flat.
In comparison, United Arab Emirates’ population consumes 1.3 times an adequate
supply; Australians 1.32 times; and United States’ citizens consume 4.5 times. The world
average is 1.22 times (Food and Agricultural Organisation, 2014).

2.4.2 Health Issues

Food consumption tends to diversify and increase as incomes rise; however, Regmi and
Meade (2013) stated that the proportion of income for food is reduced. In developing
economies food purchases initially increase as incomes rise, and more pre-prepared food
is consumed, both at home and at restaurants or by buying take-away food. Regmi and
Meade further pointed to food preferences changing towards meat and fish, while cereal
consumption declines.

Saudi researchers Darwish, Al-Saif, Albahrani, and Sabra (2014) support the trend
towards greater food intake described by Regmi and Meade (2013). Darwish et al. (2014)
found overweight and obesity in 60.3 per cent of the mothers (n = 300) of Eastern
Province preschool children, finding that one-quarter of the families frequently consumed
pizza, hamburgers, and soft drinks. Snacks, sweet biscuits and chocolate were part of their
diet. Al-Hazzaa, Abahussain, Al-Sobayel, Qahwaji, and Musaiger, (2012) also found that
Saudi boys and adolescents in private schools were more overweight than the average for
their cohorts, as they avoided vegetables and lacked vigorous physical activity. However,
Burger et al. (2014) found healthier eating habits among Saudis from the consumption of
2.2 fish-based meals per week, with an average serve of 68 grams, while expatriates ate
3.1 fish-based meals per week at 128 grams. Fish was consumed both at home and in
restaurants.

2.4.3 Agriculture

Until the mid-1970s, agriculture in the Kingdom was confined to the south west Asia
region, close to Yemen, and representing only three per cent of the land area, where
limited rainfall allowed some cultivation (Nowshirvani, 1987). These were subsistence
farms, together with other farms in the southern Tiahama coastal region, where runoff
from the mountains was diverted for agricultural purposes. In the north and inland of the
country, oases based on shallow groundwater and wells permitted subsistence farming
and some commercial crops. In the central and northern parts of the peninsula, at Jeddah
and Ha’il, similar conditions allowed farming. The richest farms, however, were at Jeddah on the west coast and Dammam on the east, with high water table, natural springs and better soils, although dependant on irrigation for their principal crop, which was dates. The size of these small owner-operated farms was dictated by the water supply. Although water pump technology became available, the farmers did not change traditional production, preferring to work in the cities rather than in intensive agricultural pursuits when competing with heavily subsidised imports. Nowshirvani (1987) concludes that there were regional differences in crop production; in the Riyadh central region, demand from the largest city encouraged commercial production, the size of the farms increased and the concept of tenant farming emerged. However, in the traditional arable land to the south and west, three-quarters of the agricultural population produced 53 per cent of the agricultural output of the country late in the 20th century (Nowshirvani, 1987).

After an Arab oil export embargo in the 1970s, the Saudi government realised that the country was vulnerable to a counter embargo on grain and thus commenced a heavily subsidised irrigation scheme based on pumping water from fossil aquifers, some over a kilometre below the surface (Brown, 2009). Saudi investors were given access to large subsidies to import agricultural equipment and workers to implement a policy of food self-sufficiency. Nowshirvani (1987) explained that a totally new structure emerged. Over the 1980s, traditional farming in the south west slowly commercialised, utilising the new technology and non-renewable groundwater identified in 1960s surveys. However, the major changes were in the large greenhouses established for vegetables and fruit, industrial-sized poultry farms producing white meat and eggs, integrated milk and red meat farms, and vast wheat farms on virgin land (Al-Shayaa, Baig, and Straquadine, 2012).

By 1980, there were 924,000 hectares of land under wheat cultivation in Saudi Arabia, and production in 1992 was 3.7m tonnes. The country became a significant grain exporter. In the early 1990s, however, falling oil revenues and security costs, including the 1991 Gulf War, delayed payments to the famers so that by 1996, 76 per cent of the wheat acreage was abandoned and as a result wheat production dropped significantly by the year 2000, and barley production was also abandoned (Elhadj, 2008). The Ministry of Agriculture and Water estimated that two-thirds of the aquifer water pumped over the years was non-renewable. The Economist Intelligence Unit (2014) reported that between 2003 and 2007, 90 per cent of Saudi water usage was agricultural, with less than 5 per cent of the gross domestic product attributed to the sector.
In light of population growth and urban demand, the Saudi government changed its policy on self-sufficiency in grains, and the King decreed that domestic purchases of domestic wheat were to be reduced by 12.5 per cent annually, with the aim of relying entirely on imports by 2016 (Elhadj, 2008). Production of the 2013 wheat crop was estimated at 700,000 tonnes, some 10 per cent lower than in 2012. The government intends to maintain the guaranteed purchase price for locally grown wheat at $US267 per tonne until 2016 (Global Information and Early Warning System on Food and Agriculture, 2013). Nevertheless, agriculture still claims 88 per cent of the country’s water supplies, although this has been reducing (Food and Agriculture Organisation, 2012). Wheat fields decreased from 450,000 hectares in 2007 to about 83,000 hectares in 2014. Overall, 2014 cereal production is expected to fall by 10 per cent: wheat 500,000t, (down 17%); sorghum 265,000t (steady), maize 80,000t (steady) and other crops 26,000t (down 7%) (Food and Agriculture Organisation, 2014a). Saudi food production is thus moving towards fresh food (Ahmed, Hamrick, Guinn, Abdulsamad, and Gereffi, 2013). As part of the re-focus on food security, the King Abdullah’s Initiative for Saudi Agricultural Investment Abroad identified a number of countries for importing bulk cereals, and bilateral agreements were signed. Further, the Saudi Agricultural Investment and Animal Production Company was established to facilitate trade through these agreements in 2009. Saudi firms such as Janat, Hail Agricultural Development Company, and the National Agricultural Development Company invested in new and existing agribusinesses around the world (Ahmed et al., 2013).

The Food and Agriculture Organisation (2014) uses an international monetary value ($) to estimate a country’s food production, and Figure 6.4 shows the 2011 values for Saudi Arabia. The highest value production is chicken meat, followed by dates and milk products.
The Saudi government’s food security strategy goals include poultry production, through offering rebates on the purchase of poultry equipment, interest-free loans, and subsidies for animal feed, according to the United States based Poultry Site (2014). In 2014, 42 per cent of poultry meat consumption needs, estimated at 1.44 million tonnes, were produced locally. The Poultry Site further reported that Saudi Arabia’s broiler meat production in 2013 was 600,000 tonnes, 13 per cent more than in 2011 due to expansion by its major broiler meat companies. Total production was projected to grow in 2014 by another 7 per cent to 640,000 tonnes, and reach 700,000 metric tonnes by 2015 (Poultry Site, 2014). However, poultry diseases decimate flocks and high poultry feed costs are constraints to greater production (Mansour, Al-Jbouri, and Mansour, 2013). The Poultry Site (2014) also pointed out that the government was taking steps to reduce average chicken mortality rates from 25 per cent to 5 per cent, and was compensating farmers for the financial loses of poultry disease outbreaks. Saudi firms export about 35,000 metric tonnes per annum to other Gulf countries (Beer, 2014).

The Kingdom of Saudi Arabia's agriculture and food sectors are expected to sustain a combined annual growth of 18.5 per cent, driven by a rising population and strong consumer demand and spending. Food sales account for around half of the domestic retail market in the Kingdom (Food and Agricultural Organisation, 2014; World Trade
Organisation, 2014). However, the World Fact book (2014) estimated that domestic agriculture contributed only 2 per cent to the GDP in 2014.

### 2.4.4 Imported Food

The World Trade Organisation (2014) stated that food imports for the country in 2011 were $US19.7b, in 2012 $US21.4b, and in 2013, $US24.1b. Cereal requirements for the 2015 fiscal year were estimated by the FAO (2014a) at 16.1 million tonnes: wheat imports 3.5 million tonnes, barley and maize for animal feedstock at 8.5 million tonnes and 2.7 million tonnes respectively. Imported rice was estimated to remain high at 1.3 million tonnes (Food and Agriculture Organisation, 2014a).

In 2013, Beer (2014) reported that Brazilian chicken meat imports accounted for 79 per cent of the Saudi imports, followed by France with 18 per cent market share. Figure 2.8 shows the top imports and Table 2.4 presents food products imports for Saudi Arabia for 2011.

**Figure 2.8: Food Imports, 2011**

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Value (1000 $)</th>
<th>Unit value ($/tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>200000</td>
<td></td>
</tr>
<tr>
<td>Chicken meat</td>
<td>180000</td>
<td></td>
</tr>
<tr>
<td>Pork</td>
<td>150000</td>
<td></td>
</tr>
<tr>
<td>Eggs</td>
<td>120000</td>
<td></td>
</tr>
<tr>
<td>Grains</td>
<td>100000</td>
<td></td>
</tr>
<tr>
<td>Dairy</td>
<td>80000</td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>60000</td>
<td></td>
</tr>
<tr>
<td>Cereal</td>
<td>50000</td>
<td></td>
</tr>
</tbody>
</table>

Note: International monetary values $1000 on left hand axis, weight (million tonnes) right hand axis

Table 2.4: Saudi Food Imports in 2011

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Quantity (1000 tonnes)</th>
<th>Value (Intl. $1000)</th>
<th>Unit value (Intl. $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>6351.6</td>
<td>1958754</td>
<td>308</td>
</tr>
<tr>
<td>Chicken meat</td>
<td>737.3</td>
<td>1720551</td>
<td>2334</td>
</tr>
<tr>
<td>Food prepared</td>
<td>212.3</td>
<td>1061303</td>
<td>5000</td>
</tr>
<tr>
<td>Cigarettes</td>
<td>35.8</td>
<td>771207</td>
<td>21538</td>
</tr>
<tr>
<td>Wheat</td>
<td>2066.6</td>
<td>659339</td>
<td>319</td>
</tr>
<tr>
<td>Maize</td>
<td>1649.1</td>
<td>611379</td>
<td>371</td>
</tr>
<tr>
<td>Sugar raw centrifugal</td>
<td>847.9</td>
<td>597406</td>
<td>705</td>
</tr>
<tr>
<td>Palm oil</td>
<td>393.3</td>
<td>526473</td>
<td>1338</td>
</tr>
<tr>
<td>Infant food</td>
<td>36.2</td>
<td>442078</td>
<td>12203</td>
</tr>
<tr>
<td>Milk white dried</td>
<td>102.2</td>
<td>441142</td>
<td>4317</td>
</tr>
<tr>
<td>Chocolate</td>
<td>62.5</td>
<td>368166</td>
<td>5893</td>
</tr>
<tr>
<td>Soybeans</td>
<td>613.6</td>
<td>342842</td>
<td>559</td>
</tr>
<tr>
<td>Meat-cattle boneless (beef &amp; veal)</td>
<td>86.4</td>
<td>327657</td>
<td>3790</td>
</tr>
<tr>
<td>Pastry</td>
<td>82.4</td>
<td>318943</td>
<td>3872</td>
</tr>
<tr>
<td>Processed cheese</td>
<td>57.9</td>
<td>305784</td>
<td>5277</td>
</tr>
<tr>
<td>Sugar refined</td>
<td>398.5</td>
<td>276008</td>
<td>693</td>
</tr>
<tr>
<td>Sheep meat</td>
<td>49.1</td>
<td>253464</td>
<td>5159</td>
</tr>
<tr>
<td>Milk skimmed dry</td>
<td>69.1</td>
<td>247549</td>
<td>3583</td>
</tr>
<tr>
<td>Cheese of whole cow milk</td>
<td>64.5</td>
<td>240761</td>
<td>3734</td>
</tr>
<tr>
<td>Cake of soybeans</td>
<td>545.7</td>
<td>232552</td>
<td>426</td>
</tr>
</tbody>
</table>


Saudi Arabia, according to Beer (2014) was the world’s largest importer of broiler meat in 2013 with a total of 875,000 tonnes. This is expected to decline for 2014, given the reduced number of hajj and umrah (pilgrimage) visas offered due to contagious disease mitigation, and reduced demand by food caterers. Brazil dominated the Saudi poultry import market in 2013, with 79 per cent market share, followed by France with 18 per cent, and the United States with 3 per cent (United States Foreign Agriculture Service, 2014). Sheep meat imports place Saudi among the top importers, as shown in Table 2.5 below:
Table 2.5: Origin Countries for Sheep and Goat Meat Imports, 2012

<table>
<thead>
<tr>
<th>Country</th>
<th>Quantity tonnes</th>
<th>Value $US m</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand</td>
<td>23,493</td>
<td>92</td>
</tr>
<tr>
<td>Australia</td>
<td>23,883</td>
<td>91</td>
</tr>
<tr>
<td>Pakistan</td>
<td>7,216</td>
<td>39</td>
</tr>
<tr>
<td>India</td>
<td>5,891</td>
<td>38</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>4,831</td>
<td>26</td>
</tr>
<tr>
<td>Brazil</td>
<td>250</td>
<td>1</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>40</td>
<td>NA</td>
</tr>
<tr>
<td>Argentina</td>
<td>37</td>
<td>NA</td>
</tr>
<tr>
<td>Jordan</td>
<td>27</td>
<td>NA</td>
</tr>
<tr>
<td>Other countries</td>
<td>376</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: APEDA AgriXchange (2014).

Cattle imports are also growing, and have been estimated at 9 million head for 2013, an increase of more than 1 million from 2012 (Al-Abyad, 2013). The Saudi market needs about 7.8 million head of cattle per year, including during the Hajj and Ramadan periods, with meat consumption in the month of Ramadan alone amounting to 3 million head. Cattle are sourced from suppliers in Djibouti, Somalia and Sudan, and cattle are inspected offshore and quarantined upon arrival in Jeddah (Al-Abayad, 2013).

In its annual report on the Gulf countries’ food industry, Alpen Capital (2013) noted that the changing patterns of food consumption for the region derives from increased per capita income and urbanisation. According to this report, per capita consumption would therefore continue to rise as the shift continued from a carbohydrate-based diet to higher protein consumption that includes meat and dairy items. Alpen Capital predicted that increased urbanisation, pace of life, the emergence of large food retail formats, and the growing presence of international food companies would increase consumption of high-value processed foods.

The Economist Intelligence Unit (2014) agreed with Alpen Capital’s assessment, adding that the food price spike of 2008 had an impact on the Gulf countries’ food policies. To avert the added risk of water prices from desalination, using domestic production to meet more of their food needs is not an option; thus imports are rising. The Economist pointed to the need for the Gulf countries, predominantly Saudi Arabia, to protect the lifestyles of their remaining rural communities through maintaining fishing, dairy, and dry-climate cropping, such as production of dates. Agribusinesses can be further encouraged through importing raw materials, such as sugar and cocoa in the production of sweets.
In summary, the characteristics of Saudi food and agricultural supplies can be broadly described as economic, geographic, and political. The complexity of the global food and agricultural markets, with their inherent stresses, were discussed. While the Saudi government balances some meat and vegetable production with imports and price support, the food security goal remains on track. The geographic situation is largely resolved, so the remaining issues that can arise are political, and the policy makers are concerned with the impact of imports on ensuring Saudi food security.

2.4.5 Saudi Agricultural Initiatives

A drive under way in Saudi Arabia to encourage businesses to invest in farming operations abroad could see the Kingdom improve food security and increase investment opportunities. The Oxford Business Group (2013) noted the Kingdom’s food policies for wheat, milk, meat and eggs, although grain production is being phased out as water aquifers are depleted. The Saudi grain agency, the Grain Silos and Flour Mills Organisation, reduced its purchases of Saudi wheat by 12.5 per cent each year from 2008, and will cease buying local grain in 2016, thus imports are expected to rise. Feedstock requirements for cattle, goats and sheep production will also increase over time.

The United Farmers Holding Company, a Saudi consortium comprising Saudi Grains and Fodder Holding, Saudi Agricultural and Livestock Investment Company, and the Dairy Corporation and Almarai Company, commenced purchases for ensuring food security by buying the European Continental Farmers Group, with agricultural land in Ukraine and Poland in March 2013. The Oxford Business Group estimates that the Saudi government and businesses have already invested some $US11bn in agricultural ventures across a number of countries, including Brazil, Canada, Ukraine, Ethiopia and Sudan. Nevertheless, in 2013 the Kingdom has not replaced the Saudi farm land under wheat production in 2008 (450,000 ha).

The Ethiopians-Saudi company Star Agricultural Development Company in 2011 leased in 10,000 ha in Ethiopia from the government for rice production at $US9.42 per ha annually, with an option for another 290,000 ha in the region of Gambela. Ethiopia planned to lease (there is no private land ownership) 3m ha to private investors by 2014, thus inviting criticism from various parties that domestic farmers are being dispossessed, and the country should use the land to grow its own food instead of relying on food aid. Indeed, the Ethiopian government announced plans to relocate 45,000 households, half of whom are semi-nomadic, into villages to improve public-service delivery (Davison,
An attack on the Star Farm in April 2012 was met with reprisals from the Ethiopian army, according to Human Rights Watch (2012). The Ethiopian government denies all allegations, and reported that in July 2013 some 35,000 people were gathered into 100 new or enlarged villages, putting them closer to roads and services. However, displacement of residents covering 45 per cent of the Gambela province is reportedly of concern to the global donors who contribute $US3b to Ethiopia each year (Davison, 2013). The owner of Star Agricultural Company, Al-Amoudi (2014), reported in April that 10,000 tonnes of fruit and vegetables were now exported to Saudi Arabia each month from Ethiopia, and livestock exports were 1,000 tonnes per month and were expected to grow. Al-Amoudi reported that improvements to trade infrastructure was assisting both countries, and there was a $US2.5b rice-growing project under way, using European professionals to skill up Ethiopians. In the Deutsche Bank report, Schaffnit-Chatterjee (2012) reported that from 2006-2012, Saudi companies acquired 177,000 ha from Sudan.

In 2012, the Kingdom’s agricultural investment was corporatized to the Saudi Company for Agricultural Investment and Animal Production from the government agency, King Abdullah Initiative for Saudi Agricultural Investment Abroad, with capital of SR3bn ($US800m), although it is unclear how much of this has thus far been committed. Woertz (2013) stated that many of the planned initiatives did not proceed, or if so, were on a smaller scale than envisaged. Historically, Saudi Arabia sought agricultural land from Sudan, Ethiopia, Tanzania, West Africa, Senegal and Mali. Whilst the Gulf countries source livestock from Sudan, Ethiopia and Djibouti, there is little agricultural export available from the continent. Woertz (2013) notes that, products such as wheat and barley which are in demand in the Gulf countries are not available in the tropics and are sourced on the open market. The Star Agricultural Company is pursuing rice, which is a crop grown in Africa that Saudi can use, however, rice is also sourced now from Pakistan and India. Other Arab investors are piloting rice growing in Senegal and Mali for export to the Gulf countries (Woertz, 2013).

There are political and commercial risks from international food production. Sommerville, Essex, and Le Billon (2014) explained that international attention sharpened on recent ‘global farmland acquisitions, questions of agro-food governance, the securitisation of hunger and obesity, and the environmental impacts of dominant agro-food systems’ (Sommerville et al., 2014, p. 239). The political issues encountered by Star Agriculture in Gambela with its land-lease are viewed as land-grabbing and are condemned by international activists. Woertz (2013) cited an example in Kenya, where
Qatar negotiated for land in the Tana River valley, promising communications and a new port. Due to resistance from local communities, Qatar did not pursue the matter and the Chinese have the port contract. Arab investors have become more sensitive to these issues, so that they seek new models for food production, such as sharing equity, or starting cooperatives. This could also be useful to Saudi interests who could use global expertise in setting up and managing cooperative farms, as they do not have tropical farming expertise. Nevertheless, some Saudi entrepreneurs are taking up the challenge: in 2011, Menafea Holdings invested $US125m in a new Zambian pineapple farm and processing plant (Woertz, 2013).

Further, the Gulf governments are considering using the Food and Agriculture Organisation to act as an honest broker and to establish agricultural partnerships between the GCC and Africa. In this manner, the GCC could achieve its goal of food security, whilst remaining less exposed to issues that may arise (Woertz, 2013). Saudi Arabia needs safe food supplies and is rich. African nations are fertile and need income; as these issues are being resolved, there is likely to be far more trade between the GCC countries, notably Saudi Arabia, and Africa. However, the Economist Intelligence Unit (2014) is less optimistic and stated that for the Gulf countries to succeed in Africa, they will need to be sensitive to political turmoil, the subsistence farmers already on the land, and environmental degradation.

2.5 Summary
This chapter describes the context of the study through a discussion on the physical, social and economic factors impinging on food production and imports for the Kingdom. It discusses the early decades of nation-building, then the change of focus to raise the quality of public services, not least the quality and quantity of foodstuffs as the population’s consumption habits grew aligned to global tastes. The discussion then moved to world trade in agricultural products, notably food, noting the 2008 price shocks and the government’s policy change to address possible future food price volatility. These policies included a move away from large scale crop support towards local fresh foods: animals, fruit and vegetables.

As there is little that can be achieved in self-sufficiency, a series of acquisitions were made offshore by Saudi firms to start agribusinesses on arable lands, however there was resistance from local activists, and this was taken up by global entities in discourses described as food security versus food sovereignty, which remain to be resolved.
Nevertheless, there are some viable partnerships occurring and food is flowing into the country. This study concerns meat demand in Saudi Arabia. This chapter shows a significant change in diet by Saudis towards meat consumption and this will be explored further in subsequent chapters.
Chapter 3
Theory of Consumer Demand

3.1 Basics of Consumer Demand

The basics of consumer demand are presented in this chapter, for example, consumer’s income, budget shares, marginal shares, and income and prices elasticity. The materials follow have been drawn to a large extent from Selvanathan and Clements (1994).

3.1.1 Total Expenditure or income

Let \( q_i \) be the quantity demanded of good \( i \), \( p_i \) be the price of good \( i \). Where \( i = 1, 2, ..., n \) and \( n \) is the number of commodities. Then, income \( M \) (or total expenditure) is given by:

\[
M = \sum_{i=1}^{n} p_i q_i \quad \text{or} \quad p'q = M
\]

(3.1)

where \( p' = (p_1, p_2, ..., p_n) \) and \( q' = (q_1, q_2, ..., q_n) \) are \( n \times 1 \) vectors of prices and quantities, respectively. Equation (3.1) is also called the “budget constraint” of the consumer.

3.1.2 Budget and Marginal Shares

Furthermore, the share of total expenditure allocated to good \( i \), (also known as the budget share) is defined by:

\[
w_i = \frac{p_i q_i}{M}
\]

\( i = 1, ..., n \) (3.2)

The budget shares have the following properties,

\[
w_i > 0 , \quad i = 1, 2, ..., n \quad \text{and} \quad \sum_{i=1}^{n} w_i = 1
\]

(3.3)

When income rises by $1, the additional amount spent on commodity \( i \) can be measured as:

\[
\theta_i = \frac{\partial(p_i q_i)}{\partial M} \quad i = 1, ..., n
\]

(3.4)

which also referred to as the \( i^{th} \) marginal share. The marginal shares satisfy,

\[
\sum_{i=1}^{n} \theta_i = 1
\]

(3.5)
The marginal shares need not always be positive. When $\theta_i$ is negative, then goods $i$ is classified as an inferior good. When income increases, demand of an inferior good will decrease.

### 3.1.3 Income Elasticity

The income elasticity of demand for good $i$ is the ratio of percentage change in demand for good $i$ to the percentage change in income.

More formally, the income elasticity $\eta_i$, for good $i$ is,

$$\eta_i = \frac{\partial q_i}{\partial M / M} = \frac{\partial (\log q_i)}{\partial (\log M)} \quad i = 1, \ldots, n$$

(3.6)

The income elasticity of commodity $i$, $\eta_i$ is the percentage change in consumption of commodity $i$ when income rises by 1 per cent.

From (3.6), it can also be easily seen that:

$$\eta_i = \frac{\theta_i}{w_i}$$

(3.7)

Where, we have also used equations (3.2) and (3.4).

The following points are worth noting in relation to income elasticity:

a. A negative income elasticity of demand is linked with inferior goods; rise in income will lead to a fall in the demand.

b. A positive income elasticity of demand is linked with normal goods; rise in income will lead to increase in demand.

c. If income elasticity of demand of a commodity is less than 1, it is defined as a necessity.

d. If the income elasticity of demand of a commodity is greater than 1, it is classified as a luxury.

e. A zero income elasticity of demand occurs when an increase in income is not linked with a change in the demand of a good.

### 3.1.4 Price Elasticity

Price elasticity of demand is measures on how sensitive the demand for a good in related to a change of its price other goods.
Price elasticity of demand for a good is defined as the percentage change in quantity demand to percentage change in the price. It is:

\[ \eta_i = \frac{\partial (\text{log } q_i)}{\partial (\text{log } p_i)} \quad i = 1, \ldots, n \tag{3.8} \]

The price elasticity is expected to be negative according to the “Law of Demand”. The cross-price of elasticity of demand for good \( i \) with respect to the price of the \( j \)th good is defined by:

\[ \eta_{ij} = \frac{\partial q_i / q_i}{\partial p_j / p_j} = \frac{\partial (\text{log } q_i)}{\partial (\text{log } p_j)} \quad i,j = 1, \ldots, n \quad i \neq j \tag{3.9} \]

The following points are worth noting in relation to price elasticity:

If \( |\eta_i| > 1 \), then the demand for good \( i \) is said to be price elastic. (The demand is sensitive to its own price changes).

If \( |\eta_i| < 1 \), then the demand for good \( i \) is price inelastic. (The demand is not sensitive to its own price changes).

If \( \eta_{ij} > 0 \), then the pair of goods \( i \) and \( j \) are said to be pair-wise substitutes.

If \( \eta_{ij} < 0 \), then the pair of goods \( i \) and \( j \) are said to be pair-wise complements.

### 3.2 Divisia Indices

In this section we define first and second order price and quantity indices in the form of Divisia indices, which can be used to summarize the price and quantity data.

The differential of the budget constraint (3.1) gives:

\[ dM = \sum_{i=1}^{n} p_i dq_i + \sum_{i=1}^{n} q_i dp_i \]

Dividing both sides by \( M \), using the identity \( dx/x = d (\log x) \) and \( w_i = p_i q_i / M \), we obtain,

\[ d (\text{log } M) = \sum_{i=1}^{n} w_i d (\text{log } q_i) + \sum_{i=1}^{n} w_i d (\text{log } p_i) \]

which can be written as

\[ d (\text{log } M) = d (\text{log } Q) + d (\text{log } P) \]

where

\[ d (\text{log } Q) = \sum_{i=1}^{n} w_i d (\text{log } q_i) \tag{3.10} \]

the Divisia volume (or quantity) index.
and
\[ d(\log P) = \sum_{i=1}^{n} w_i d(\log p_i) \] (3.11)
is the Divisia price index.

The volume index defined above is a weighted average of the \( n \) logarithmic quantity changes \( d(\log q_1), d(\log q_2), \ldots, d(\log q_n) \), and the price index is a weighted average of the price log-changes, \( d(\log p_1), d(\log p_2), \ldots, d(\log p_n) \), the weights being the budget shares \( w_1, w_2, \ldots, w_n \).

The Divisia quantity and price indices given by (3.10) and (3.11) can be viewed as a weighted first-order moment of the quantities and price log changes, respectively. The corresponding second-order moments are the Divisia quantity and Divisia price variances
\[ K = \sum_{i=1}^{n} w_i [d(\log q_i) - d(\log Q)]^2 = \sum_{i=1}^{n} w_i \left[ \frac{d(\log q_i)}{Q} \right]^2, \] (3.12)
and
\[ \Pi = \sum_{i=1}^{n} w_i [d(\log p_i) - d(\log P)]^2 = \sum_{i=1}^{n} w_i \left[ \frac{d(\log p_i)}{P} \right]^2, \] (3.13)

These two variances measure the degree to which the quantities and prices of the individual commodities change disproportionately, respectively. The Divisia quantity and price variances will disappear if all quantities and prices change proportionately. Empirical results show that the Divisia quantity variance systematically exceeds the corresponding price variance. (For example, see, Selvanathan, 2003).

The corresponding price quantity correlation is defined as
\[ \rho = \frac{\Gamma}{\sqrt{K\Pi}}. \] (3.14)
where
\[ \Gamma = \sum_{i=1}^{n} w_i \left[ \log \frac{P_i}{\overline{P}} \right] \left[ \log \frac{q_i}{\overline{Q}} \right], \] (3.15)
is the Divisia price-quantity covariance.

The Divisia price quantity covariance and correlation are expected to be negative according to the “Law of Demand”.

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3.3 Simple Demand Equations

In this section we present two popular demand systems, namely, the double demand system and Working model, which were used previously in demand studies to analyse the pattern of consumer demand, without any reference to utility functions.

3.3.1 Double-Log Demand System

The double-log model is a demand system expresses the demand for a good in terms of income and price of that good and prices of all other goods. All variables in a double–log demand system are expressed in logarithmic form. Double-log demand system has been used extensively by Stone (1954) and a number of others.

\[
\log q_i = \alpha_i + \eta_i \log M + \sum_{j=1}^{n} \eta_{ij} \log p_j, \quad i = 1, \ldots, n \tag{3.16}
\]

The attraction of model (3.16) is, by estimating a double-log system one can read the demand elasticities directly as the estimated coefficients of model (3.6).

The income elasticity of demand for good \(i\) is

\[
\eta_i = \frac{\partial (\log q_i)}{\partial (\log M)}.
\]

The cross-price elasticity of good \(i\) with respect to the price of good \(j\) is

\[
\eta_{ij} = \frac{\partial (\log q_i)}{\partial (\log p_j)}.
\]

Since money income \(M\) is on the right-hand side of (3.16), the income effect of the change in the \(j^{th}\) price is included in \(\eta_{ij}\). Therefore, the price elasticity \(\eta_{ij}\) obtained from model (3.16) is called the Cournot price elasticity.

3.3.2 Working’s model

Under the assumption of constant prices, (as it is approximately the case for a household expenditure survey data) and by choosing units such that price for each good is unity, Working (1943) proposed the model.

\[
w_i = \alpha_i + \beta_i \log M, \quad i = 1, \ldots, n \tag{3.17}
\]

Under Working’s model, the budget shares are linear functions of the logarithm of income. As the sum of the budget shares is unity, it follows that

\[
\sum_{i=1}^{54} \alpha_i = 1 \quad and \quad \sum_{i=1}^{54} \beta_i = 0. \tag{3.18}
\]
If \( M = 1 \), for some household, \( \alpha_i \) can be interpreted as the budget share of \( I \) for that household; and \( \beta_i \) represents 100 times the change in the budget share of \( i (\Delta w_i \times 100) \) resulting from a 1 per cent increase in income.

To derive the marginal shares implied by Working’s model (3.17) we multiply both sides by \( M \), to give

\[
p_i q_i = \alpha_i M + \beta_i (M \log M)
\]  
(3.19)

Differentiating (3.19) with respect to \( M \) gives

\[
\frac{\partial (p_i q_i)}{\partial M} = \alpha_i + \beta_i (1 + \log M)
\]

The above equation can be written as

\[
\theta_i = w_i + \beta_i.
\]  
(3.20)

Thus, under Working’s model the \( i \)-th marginal share exceeds the corresponding budget share by \( \beta_i \).

Using (3.7), the income elasticity, based on Working’s model is given by,

\[
\eta_i = 1 + \frac{\beta_i}{w_i}
\]  
(3.21)

Thus, as \( w_i > 0 \),

- A good with positive \( \beta_i \) will have \( \eta_i > 1 \) and will be a luxury good; and
- A good with negative \( \beta_i \) we have \( \eta_i < 1 \) and hence the good will be a necessity.

### 3.4 Deriving Demand Equation from Utility Maximizing

In the last section, demand equations were specified without any references to consumer utility function. In this section we derive demand equations by maximizing consumer’s utility function subject to his/her budget constraint.

The general form of a consumer utility function can be written as

\[
U = u(q_1, q_2, \ldots, q_n)
\]  
(3.22)

where \( q_1, q_2, \ldots, q_n \) are the quantities of consumed goods \( i = 1, 2, \ldots, n \).

Consumer will maximize his/her utility function (3.22) subject to his/her budget constraint: (3.1), which we reproduce as:
\[ \sum_{i=1}^{n} p_i q_i = M \]  

(3.23)

where, \( M \) is consumer’s income, and \( p_i \) is the price, and \( q_i \) is the quantity of good \( i \).

Demand equations can be derived by maximizing the consumer’s utility function subject to his/her budget constraint using a Lagrangian function. This function to show the quantity demanded of each commodity as a function of price and income:

\[ q_i = q_i(M, p_1, \ldots, p_n) \]  

(3.24)

Demand function, based on utility maximization, is the Marshalling or uncompensated demand function. We assume that the utility function is differentiable and there is nonsatiation, so each marginal utility is positive, then

\[ \frac{\partial u}{\partial q_i} > 0, \quad i = 1, \ldots, n. \]  

(3.25)

Further, we assume that there is generalized diminishing marginal utility, so that the Hessian matrix of the utility function is negative definite.

Hessians are symmetric, we have

\[ U = \begin{bmatrix} \frac{\partial^2 u}{\partial q_i \partial q_j} \end{bmatrix} \]  

(3.26)

is a symmetric negative definite \( n \times n \) matrix.

To maximize (3.22) subject to (3.23), we from with the Lagrangian expression

\[ u(q_1, \ldots, q_n) - \lambda \left[ \sum_{i=1}^{n} p_i q_i - M \right], \]  

(3.27)

Where \( \lambda \) is a lagrangian multiplier. The first-order conditions for a maximum of (3.27) are (3.23), which:

\[ \frac{\partial u}{\partial q_i} = \lambda p_i, \quad i = 1, \ldots, n \]  

(3.28)

which states that each marginal utility is proportional to the corresponding prices. As the prices are positive, it follows from (3.25) and (3.28) \( \lambda > 0 \). By dividing both sides by \( p_i \), we obtain \( \partial u / \partial q_i / p_i = \lambda \) or \( \partial u / \partial (p_i q_i) = \lambda. \)
This shows that if $1 rise in income causes utility to increase by $ \lambda$ when this rise is spent on any of the $n$ goods. Accordingly, $\lambda$ is known as the marginal utility of income. The second-order conditions for a maximum are satisfied by (3.26).

The first order conditions (3.23) and (3.28) constitute $(n + 1)$ equations which in principle could be solved for the $(n + 1)$ unknowns $q_1, ..., q_n$ and $\lambda$. We assume that the resulting quantities are positive for relevant values of prices and income. So that the optimal quantities depend on the income and the prices.

We can write

$$q_i = q_i (M, p_1, ..., p_n) \quad i = 1, ..., n.$$  \hspace{1cm} (3.29)

Equations gives by (3.29) are system of $n$ demand equations.

### 3.5 An Example of a Utility Based Demand System

In this section we shall give an example of a specified form of the utility function and derived the resulting demand system based on that utility function. For this purpose, we introduce the well-known Stone–Geary utility function. This utility function has also been previously considered by Klein and Rubin (1948).

#### 3.5.1 The Stone–Geary Utility Function

The Stone–Geary utility function is given by:

$$u(q) = \sum_{i=1}^{n} \beta_i \log(q_i - \gamma_i).$$ \hspace{1cm} (3.30)

where $\beta_i > 0$, $\sum_{i=1}^{n} \beta_i = 1$ and $0 < q_i < \gamma_i$ are constants.

Differentiating (3.30) with respect to $q_i$ and use (3.28), we get

$$\frac{\partial u}{\partial q_i} = \beta_i \cdot \frac{1}{(q_i - \gamma_i)} = \lambda p_i.$$ \hspace{1cm} (3.31)

By rearranging (3.31), we get

$$\lambda p_i (q_i - \gamma_i) = \beta_i \quad i = 1, ..., n.$$ \hspace{1cm} (3.32)

Sum both sides of (3.32) over $i = 1, ..., n$ and noting the fact that $\sum_{i=1}^{n} \beta_i = 1$, we obtain
\[ \lambda = \frac{1}{M - \sum_{j=1}^{n} p_j \gamma_j} \]

Substituting the value of \( \lambda \) into (3.32), we obtain,

\[ p_i q_i = p_i \gamma_i + \beta_i \left[ M - \sum_{j=1}^{n} p_j \gamma_j \right], \quad i = 1, \ldots, n \quad (3.33) \]

Equation (3.33) is the algebraic form of the demand equations (3.29) associated with the Stone-Geary utility function (3.30). As expenditure on good \( i \) is a linear function of the \( n \) prices and income, (3.33) is known as the linear expenditure system. If \( \gamma_i \)'s are positive, then (3.33) has the following interpretation.

The consumer first purchases \( \gamma_i \) units of good \( i \) at a cost of \( p_i \gamma_i \); this can be termed subsistence consumption of that commodity. The total subsistence consumption on all goods is \( \sum_{i=1}^{n} p_i \gamma_i \) which leaves \( M - \sum_{i=1}^{n} p_i \gamma_i \) as supernumerary income. Out of this supernumerary income, a fixed fraction \( \beta_i \) is also spent on commodity \( i \) the marginal share \( \theta_i \) implied by linear expenditure system is equal to the constant coefficient \( \beta_i \).

Consequently, the income elasticity of \( i \) takes the form

\[ \eta_i = \frac{\beta_i}{w_i}. \quad (3.34) \]

An increase in income with prices held constant the budget shares of necessities to fall and those of luxuries to rise. Equation (3.34) dictates that increasing affluence causes the income elasticities of necessities increase whilst those of luxuries fall; and the income elasticities of both types of goods become closer to unity. Take the case of food, a necessity. The LES implies that as the consumer becomes richer, the \( \eta_i \) for food increases causing food to become less of a necessity or more of a luxury. This behaviour of the elasticity is implausible as food should be less of a luxury for a richer consumer. This is in contrast to what we observe under Working’s model; where an increasing income drives the income elasticity towards one, which is plausible.

If we differentiate (3.33) with respect to \( p_j \) and multiply both sides by \( p_j / q_i \), we get the uncompensated price elasticities.
\begin{equation}
\eta_{ij} = \frac{(\gamma_i - q_i)}{q_i} \delta_{ij} - \frac{\beta_i \gamma_j p_j}{p_i q_i}, \quad i, j = 1, \ldots, n
\end{equation}

where \( \delta_{ij} \) reflect the Kronecker delta. Therefore, the own-price elasticity of commodity \( i \) is

\begin{equation}
\eta_{ii} = -1 + (1 - \beta_i) \frac{\gamma_i}{q_i},
\end{equation}

Since \( \beta_i > 0 \) and \( \sum_{i=1}^{n} \beta_i = 1 \), we have \( 0 < \beta_i < 1 \). This together with \( 0 < \gamma_i < q_i \), this will make all own-price elasticities are in the range -1 and 0. In other words, the LES implies that all commodities are price-inelastic.

The uncompensated cross-price elasticities are

\begin{equation}
\eta_{ij} = -\frac{\beta_i \gamma_j p_j}{p_i q_i}, \quad i \neq j.
\end{equation}

If \( \gamma_i > 0 \) and \( \beta_i > 0 \), all cross-price elasticities are negative. Thus, under LES all pairs of commodities are gross complements.

### 3.6 Preference Independence

Preference independence utility function is a special case of general utility function. Under preference independence, the total utility can be written as the sum of \( n \) sub-utility functions, one for each good. It is

\begin{equation}
u(q_1, q_2, \ldots, q_n) = \sum_{i=1}^{n} u_i(q_i)
\end{equation}

and the marginal utility of good \( i \) is independent of the consumption of good \( j, i \neq j \).

Accordingly, (3.38) is known as the preference independence type. If the commodities are fairly broad group, such as food, housing, clothing and the like, then (3.38) presents a reasonable working hypothesis as it conveys the idea that total utility is derived from the utility obtained from the consumption of food and utility from housing and utility from clothing and so on. These broad commodity groups can be interpreted as representing the basic wants of the consumer which could be expected to exhibit scant interaction in the utility function.

The Stone-Geary utility function (3.30) is a special case of (3.38), with
\[ u_i(q_i) = \beta_i \log(q_i - \gamma_i) \]  

(3.39)

### 3.7 Barten’s Fundamental Matrix Equation

In this section we apply the method of comparative statics to acquire information in demand equations. To answer the question of how the values of the endogenous variables \( q_1, \ldots, q_n \) respond to changes in the exogenous variables \( p_1, \ldots, p_n, M \).

First, we differentiate the budget constraint (3.23) with respect to \( p_j \) and \( M \) to yield

\[
\sum_{i=1}^{n} p_i \frac{\partial q_i}{\partial p_j} = -q_j, \quad j = 1, \ldots, n
\]

and

\[
\sum_{i=1}^{n} p_i \frac{\partial q_i}{\partial M} = 1.
\]

The above equations can be expressed in matrix form as

\[
\mathbf{p}' \frac{\partial \mathbf{q}}{\partial \mathbf{p}'} = -\mathbf{q}'
\]

and

\[
\mathbf{p}' \frac{\partial \mathbf{q}}{\partial M} = \mathbf{1}.
\]

(3.40)

where \( \frac{\partial \mathbf{q}}{\partial \mathbf{p}} = [\hat{q}_i / \hat{p}_j] \) is the \( n \times n \) matrix of price derivatives of demand of the demand functions; and \( \frac{\partial \mathbf{q}}{\partial M} = [\hat{q}_i / \hat{M}] \) is the vector of \( n \) income slopes of the demand functions.

Second, differentiate the proportionality conditions (3.28) with respect to \( p_j \) and \( M \) to give

\[
\sum_{k=1}^{n} \frac{\partial^2 u}{\partial q_i \partial q_k} \frac{\hat{q}_k}{\partial p_j} + p_i \frac{\partial \hat{\lambda}}{\partial p_j} = \lambda \delta_{ij}, \quad i, j = 1, \ldots, n,
\]

where \( \delta_{ij} \) is the Kronecker delta (=1 if \( i=j \), 0 otherwise), and

\[
\sum_{k=1}^{n} \frac{\partial^2 u}{\partial q_i \partial q_k} \frac{\partial q_k}{\partial M} = p_i \frac{\partial \hat{\lambda}}{\partial M},
\]

\( i = 1, \ldots, n \)

The above equations be written in matrix form as
\[ U \frac{\partial q}{\partial p} = \lambda I + p \frac{\partial \lambda}{\partial p} \]

and

\[ U \frac{\partial q}{\partial M} = \frac{\partial \lambda}{\partial M} p, \quad (3.41) \]

where

\( U \) is the Hessian matrix defined in (3.26);

\( I \) is the n x n identity matrix; and,

\[ \frac{\partial \lambda}{\partial p'} = \left[ \frac{\partial \lambda}{\partial p_i} \right]. \]

Third, we combine (3.40) and (3.41) to give

\[ \begin{bmatrix} U & p' \\ p' & 0 \end{bmatrix} \begin{bmatrix} \frac{\partial q}{\partial M} \\ \frac{\partial q}{\partial p'} \end{bmatrix} = \begin{bmatrix} 0 & \lambda I \\ -\frac{\partial \lambda}{\partial p'} & 1 - q' \end{bmatrix}. \quad (3.42) \]

This is known as Barten’s fundamental matrix equation in consumption theory, after Barten (1964). The matrix immediately to the left of the equal sign contains the derivatives of all the endogenous variables with respect to all exogenous variables.

### 3.8 Solving the Matrix Equation

The inverse of the matrix on the far left of (3.42) is

\[ \begin{bmatrix} U & p' \\ p' & 0 \end{bmatrix}^{-1} = \frac{1}{p'U^{-1}p} \begin{bmatrix} (p'U^{-1}p)U^{-1} - U^{-1}p(U^{-1}p)' & U^{-1}p \\ (U^{-1}p)' & -1 \end{bmatrix} \quad (3.43) \]

Using this inverse the solution of (3.42) is

\[ \begin{bmatrix} \frac{\partial q}{\partial M} \\ -\frac{\partial \lambda}{\partial p'} \end{bmatrix} = \frac{1}{p'U^{-1}p} \begin{bmatrix} (p'U^{-1}p)U^{-1} - U^{-1}p(U^{-1}p)' & U^{-1}p \\ (U^{-1}p)' & -1 \end{bmatrix} \begin{bmatrix} 0 & \lambda I \\ -\frac{\partial \lambda}{\partial p'} & 1 - q' \end{bmatrix}. \quad (3.44) \]

Carrying out the matrix multiplication block by block, we obtain;

\[ \frac{\partial q}{\partial M} = \frac{1}{p'U^{-1}p} U^{-1} p \quad (3.45) \]

\[ \frac{\partial q}{\partial p'} = \lambda U^{-1} - \frac{\lambda}{p'U^{-1}p} U^{-1} p(U^{-1}p') - \frac{1}{p'U^{-1}p} U^{-1} pq' \quad (3.46) \]

\[ \frac{\partial \lambda}{\partial M} = \frac{1}{p'U^{-1}p} \quad (3.47) \]

\[ \frac{\partial \lambda}{\partial p'} = - \frac{\lambda}{p'U^{-1}p} U^{-1} p - \frac{1}{p'U^{-1}p} q'. \quad (3.48) \]
To simplify these expressions we use (3.47) to substitute $\partial \lambda / \partial M$ for the reciprocal of $p'U^{-1}p$ in (3.45), (3.46). Equation (3.45) then becomes

$$\frac{\partial q}{\partial M} = \frac{\partial \lambda}{\partial M} U^{-1} p.$$  \hspace{1cm} (3.49)

We replace $U^{-1}p$ in (3.46) and (3.48) with $\partial q/\partial M$ divided by $\partial \lambda / \partial M$. This yields

$$\frac{\partial q}{\partial p} = \lambda U^{-1} - \lambda \frac{\partial q}{\partial \lambda} \frac{\partial \lambda}{\partial M} \frac{\partial q}{\partial M} - \frac{\partial q}{\partial M} q'.$$  \hspace{1cm} (3.50)

$$\frac{\partial \lambda}{\partial p} = -\lambda \frac{\partial q}{\partial M} - \frac{\partial \lambda}{\partial M} q.$$  \hspace{1cm} (3.51)

Equations (3.49) and (3.50) give the income and price derivatives of the demand functions. The equation can be written in scalar form as

$$\frac{\partial q_i}{\partial p_j} = \lambda u^i - \lambda \frac{\partial q_j}{\partial \lambda} \frac{\partial \lambda}{\partial M} \frac{\partial q_j}{\partial M} - \frac{\partial q_i}{\partial M} q_j, \hspace{1cm} i,j = 1,\ldots,n$$  \hspace{1cm} (3.52)

where $u^i$ is the $(i,j)$-th element of $U^{-1}$. This equation shows that the effect of a change in $p_j$ on $q_i$, with income and other prices constant, is made up by three terms. The third term which on the right of equation (3.52), $-q_j (\partial q_j / \partial M)$, is the income effect of the price change.

### 3.9 A Differential Demand System

In this section we use the solution to the fundamental matrix equation to derive a general system of differential demand equations.

The total differential of equation (3.29) is

$$dq_i = \frac{\partial q_i}{\partial M} dM + \sum_{j=1}^n \frac{\partial q_i}{\partial p_j} dp_j,$$  \hspace{1cm} i = 1,\ldots,n  \hspace{1cm} (3.53)

By multiplying both sides by $p_i/M$ and using $w_i = p_i q_i / M$, we change that to logarithmic-differential form

$$w_i d(\log q_i) = \frac{\partial (p_i q_i)}{\partial M} d(\log M) + \sum_{j=1}^n \frac{p_i p_j}{M} \frac{\partial q_i}{\partial p_j} d(\log p_j).$$  \hspace{1cm} (3.54)

The second term on the right of the above can be expressed

$$\sum_{j=1}^n \frac{p_i p_j}{M} \frac{\partial q_i}{\partial p_j} d(\log p_j) = \sum_{j=1}^n \frac{p_i p_j}{M} \left[ \lambda u^i - \frac{\lambda}{\partial \lambda / \partial M} \frac{\partial q_j}{\partial M} \frac{\partial q_j}{\partial M} - \frac{\partial q_i}{\partial M} q_j \right] d(\log p_j).$$  \hspace{1cm} (3.55)
By substituting to (3.54) and rearranging gives
\[ w_{ij}d(\log q_j) = \frac{\partial (p_{ij})}{\partial M} \left[ d(\log M) - \sum_{j=1}^{n} \frac{\partial p_{ij} \mu^{\prime i}}{M} \right] + \sum_{j=1}^{n} \left[ \frac{\lambda_p \mu^{\prime i}}{M} - \frac{\lambda / M}{\partial \lambda / \partial M} \frac{\partial (p_{ij})}{\partial M} \right] d(\log p_i) \] (3.56)

In view of (3.10) the term in square bracket on the right side of above equation is the Divisia volume index \(d(\log Q)\), which allow to write
\[ \frac{\partial (p_{ij})}{\partial M} \left[ d(\log M) - \sum_{j=1}^{n} w_{ij}d(\log p_i) \right] = \theta_i d(\log Q), \] (3.57)

To simplify the price substitution term of (3.56), we define
\[ \phi = \frac{\lambda / M}{\partial \lambda / \partial M} = \left[ \frac{\partial \log \lambda}{\partial M} \right]^{-1} < 0 \] (3.58)
as the reciprocal of the income elasticity of the marginal utility of income. To brevity, we shall refer to \( \phi \) as the income flexibility. We also define
\[ v_{ij} = \frac{\lambda_p \mu^{\prime i}}{M} p_j p_{ij}^{\prime i}, \quad i, j = 1, \ldots, n, \] (3.59)

which satisfy
\[ \sum_{j=1}^{n} v_{ij} = \phi \theta_i, \quad i = 1, \ldots, n \] (3.60)

The replacement term of (3.55) can then be expressed as
\[ \sum_{j=1}^{n} \left[ \frac{\lambda_p \mu^{\prime i}}{M} - \frac{\lambda / M}{\partial \lambda / \partial M} \frac{\partial (p_{ij})}{\partial M} \right] d(\log p_i) = \sum_{j=1}^{n} v_{ij} \left[ d(\log p_i) - d(\log P_j) \right] \] (3.61)

where
\[ d(\log P_j) = \sum_{i=1}^{n} \theta_i d(\log p_i) \] (3.62)
is the Frisch (1932) price index. This index differs from the Divisia price index (3.11) which uses budget shares as weights rather than marginal shares.

3.10 Derivations and Extensions

The first objective is to show that \( \phi \) is negative, as stated in equation (3.58). By using (3.59) and (3.60) to write
\[
\sum_{j=1}^{n} \frac{\lambda}{M} p_i p_j u_{ij} = \phi \theta_i, \quad i=1, \ldots, n.
\]

In view of \( \sum_i \theta_i = 1 \) and summing both sides of the above over \( i = 1, \ldots, n \) yields

\[
\phi = \frac{\lambda}{M} \sum_{i=1}^{n} \sum_{j=1}^{n} p_i p_j u_{ij}
\]

(3.63)

The right hand side is proportional to a quadratic form with matrix \( U^{-1} \) and vector \( p \); in view of (3.26) the matrix is negative definite. As the factor of proportionality \( \lambda/M \) on the right of above equation is positive, we conclude that \( \phi < 0 \).

Constraint (3.60) can be verified by multiplying both sides of (3.49) in scalar form by \( p_i \), which yields

\[
\theta_i = \frac{\partial \lambda}{\partial M} \sum_{j=1}^{n} p_i p_j u_{ij}, \quad i=1, \ldots, n,
\]

and using (3.58) to substitute \( \lambda/(\phi M) \) for \( \partial \lambda/\partial M \). To verify (3.61) we use (3.4), (3.58), (3.59) to express the substitution term of (3.62) as

\[
\sum_{j=1}^{n} \left[ \frac{\lambda}{M} p_j u_{ij} - \frac{\lambda}{M} \frac{\partial (p_j q_i)}{\partial \lambda} \frac{\partial (p_j q_i)}{\partial M} \right] d(\log p_j) = \sum_{j=1}^{n} (v_{ij} - \phi \theta_i \theta_j) d(\log p_j),
\]

(3.64)

The right-hand side of (3.64) can be written from view of (3.62) as

\[
\sum_{j=1}^{n} (v_{ij} - \phi \theta_i \theta_j) d(\log p_j) = \left[ \sum_{j=1}^{n} (v_{ij} d(\log p_j) - \phi \theta_j d(\log p_j)) \right].
\]

(3.65)

By substituting \( \sum_i v_{ij} \) for \( \phi \theta_i \) it comes from (3.60), on the right-hand side of (3.65).

Equation (3.65) also shows that the substitution term of (3.62) is the difference between \( \sum_i v_{ij} d(\log p_j) \) and \( \phi \theta_j d(\log p_j) \).

To further interpret the \( v_{ij} \)'s, (3.59) can be use to define the \( n \times n \) matrix

\[
[v_{ij}] = \frac{1}{M} P U^{-1} P,
\]

(3.66)

where \( P \) is the diagonal matrix with \( p_1, \ldots, p_n \) on the diagonal and \( U^{-1} \) is the inverse of the Hessian of the utility function. On the right equation above, because \( \lambda, M > 0 \); so \( P \) is a symmetric positive definite matrix and \( U^{-1} \) is negative. Therefore

\[
[v_{ij}] \text{ is a symmetric negative definite } n \times n \text{ matrix.}
\]

(3.67)

Inverting together of (3.66), we obtain

64
\[ v_{ij} = \frac{M}{\lambda} \frac{\partial^2 u}{\partial (p_i q_i) \partial (p_j q_j)}, \quad i,j = 1, \ldots, n \] (3.68)

where \( v_{ij} \) is the \((i,j)\)-th element of \( [v_{ij}]^{-1} \).

Under preference independence, the demand equation

\[ w_i d (\log q_i) = \theta_i d (\log Q) + \sum_{j=1}^{n} v_{ij} d \left[ \log \frac{p_j}{\bar{p}} \right], \] (3.69)

takes the simple form

\[ w_i d (\log q_i) = \theta_i d (\log Q) + \phi \theta_i d \left[ \log \frac{p_i}{\bar{p}} \right] \] (3.70)

Consequently, preference independence implies that only the own deflated price appears in each demand equation, rather than all \( n \) of such prices.

The substitution term of equation \( w_i d (\log q_i) = \theta_i d (\log Q) + \sum_{j=1}^{n} v_{ij} d \left[ \log \frac{p_j}{\bar{p}} \right], \) is formulated in terms of deflated prices. We use (3.65) to express the substitution term in absolute (or undeflated) prices as

\[ \sum_{j=1}^{n} v_{ij} d \left[ \log \frac{p_j}{\bar{p}} \right] = \sum_{j=1}^{n} \pi_{ij} d (\log p_j). \] (3.71)

where

\[ \pi_{ij} = (v_{ij} - \phi \theta_i \theta_j), \quad \text{and} \quad i,j = 1, \ldots, n \] (3.72)

is the \((i,j)\)-th Slutsky (1915) coefficient. It gives the total substitution effect on the demand for good \( i \) of a change in the \( j \)-th price.

Using (3.71) in (3.69) yields the demand equation for good \( i \) in terms of absolute prices,

\[ w_i d (\log q_i) = \theta_i d (\log Q) + \sum_{j=1}^{n} \pi_{ij} d (\log p_j). \] (3.73)

Dividing both sides of (3.73) by \( w_i \), we find that the income and compensated price elasticities are

\[ \eta_i = \frac{\theta_i}{w_i}, \quad \eta_i^* = \frac{\pi_{ij}}{w_i}, \quad i,j = 1, \ldots, n \] (3.74)

These elasticities satisfy demand homogeneity and Slutsky symmetry.
3.11 Preference Independence and Block Independence

In this section we analyse the case when preferences can be represented by a utility function that is additive in the $n$ goods.

$$u = \sum_{i=1}^{n} u_i(q_i). \quad (3.75)$$

The utility function (3.75) is known as preference independence, as the marginal utility of good $i$ is independent of consumption of good $j$ for $i \neq j$. Under preference independence the Hessian matrix of utility function and its inverse are both diagonal.

As $v_{ij} = 0$ for $i \neq j$ and $v_{ij} = \phi \theta_i$, the demand equation

$$w_i d (\log q_i) = \theta_i d (\log Q) + \sum_{j=1}^{n} \nu_{ij} d \left[ \log \frac{P_j}{P} \right], \quad \text{simplifies to}$$

$$w_i d (\log q_i) = \theta_i d (\log Q) + \phi \theta_i d \left[ \log \frac{P_i}{P'} \right] \quad (3.76)$$

Preference independence implies that each $\theta_i$ is positive, it rules out inferior goods. A weaker version of preference independence is block independence, whereby the additive specification (3.75) is applied to groups of goods. The $n$ goods be divided into $G < n$ groups, written $S_1, ..., S_G$, such good belongs to only one group. Let the consumer’s preferences be such that the utility function is the sum of $G$ group utility functions is the sum of $G$ group utility functions, involving the quantities of only one group,

$$u = \sum_{g=1}^{G} u_g(q_g), \quad (3.77)$$

which $q_g$ is the vector of the $q_i$’s that fall under $S_g$. The above equation is marginal utility of a good depends only on the consumption of goods belonging to the same group. When the goods are numbered, the Hessian inverse become block-diagonal from the utility function.

Equation $w_i d (\log q_i) = \theta_i d (\log Q) + \sum_{j=1}^{n} \nu_{ij} d \left[ \log \frac{P_j}{P'} \right]$, and (3.60) can be written if $i$ belong to $S_g$ as

$$w_i d (\log q_i) = \theta_i d (\log Q) + \sum_{j \in S_g} \nu_{ij} d \left[ \log \frac{P_j}{P'} \right], \quad (3.78)$$
\[
\sum_{j \in S_g} v_{ij} = \phi \theta_i, \quad i \in S_g.
\] (3.79)

### 3.12 The Demand for Groups of Goods under Block Independence

We write

\[
W_g = \sum_{i \in S_g} w_i, \quad \Theta_g = \sum_{i \in S_g} \theta_i
\] (3.80)

The marginal share \( \Theta_g \) is the increase in expenditure on \( S_g \) as a result of $1 increase in income. Both sides of (3.80) over \( i \in S_g \) shows that

\[
\sum_{i \in S_g} \sum_{j \in S_g} v_{ij} = \phi \Theta_g > 0,
\] (3.81)

Where the inequality sign is based on the positive definiteness of the matrix \([v_{ij}]\). Accordingly, block independence means that no group as a whole can be inferior.

We define the group Divisia volume and Frisch price indexes as:

\[
d(\log Q_g) = \sum_{i \in S_g} \frac{w_i}{W_g} d(\log q_i),
\] (3.82)

\[
d(\log P_g) = \sum_{i \in S_g} \frac{\theta_i}{\Theta_g} d(\log p_i),
\] (3.83)

These two above aggregate consistently since a budget-share weighted average of \( d(\log Q_1) \), \ldots, \( d(\log Q_G) \) equals the Divisia volume index of all the \( n \) goods \( d(\log Q) \); and a marginal-share-weighted average of \( d(\log P'_1) \), \ldots, \( d(\log P'_G) \) equals the overall Frisch price index \( d(\log P') \). That is,

\[
\sum_{g=1}^G W_g d(\log Q_g) = d(\log Q),
\]

and

\[
\sum_{g=1}^G \Theta_g d(\log P'_g) = d(\log P').
\]

We obtain the demand equation for the group \( S_g \) as a whole under block independence by simply adding over \( i \in S_g \) both sides of the demand equation for good \( i \) under block independence, equation (3.83). In view of (3.80) and (3.82) this yields
Our objective is to simplify the price substitution of this equation. As $v_{ij}$ is symmetric in $i$ and $j$. From equation (3.68) and (3.79) can be expressed as

$$\sum_{i \in S_g} v_{ij} = \phi \theta_j, \quad j \in S_g,$$

so that

$$\sum_{i \in S_g} \sum_{j \in S_g} v_{ij} d \left[ \log \frac{p_j}{P'} \right] = \phi \sum_{j \in S_g} \theta_j d \left[ \log \frac{p_j}{P'} \right] = \phi \Theta_g d \left[ \log \frac{P'_g}{P'} \right],$$

Accordingly, (3.84) can be expressed as

$$W_g d (\log Q_g) = \Theta_g d (\log Q) + \phi \Theta_g d \left[ \log \frac{P'_g}{P'} \right]. \quad (3.85)$$

This is the compound demand equation for $S_g$ as a group. The equation above shows that under block independence, the demand for a group of goods as a whole depends on real income and the relative price of the group $d \left[ \log \left( \frac{P_g}{P'} \right) \right]$, the relative price is the Frisch-deflated Frisch price index of group. By dividing both sides of this equation by $W_g$, we find that $\Theta_g / W_g$ is the income elasticity of demand for the group $S_g$ and $\phi \Theta_g / W_g$ is the own-price elasticity of the group $S_g$.

### 3.13 Conditional Demand Equations

To find the conditional demand equations, we rearrange (3.85).

$$d (\log Q) = \frac{W_g}{\Theta_g} d (\log Q_g) - \phi d \left[ \log \frac{P'_g}{P'} \right]. \quad (3.86)$$

In the next equation it is shown that the yields for $i \in S_g$

$$w_i d (\log q_i) = \theta_i W_g d (\log Q_g) + \sum v_{ij} d \left[ \log \frac{p_j}{P_g} \right]. \quad (3.87)$$

where

$$\theta'_i = \frac{\theta_i}{\Theta_g}, \quad i \in S_g.$$
is the conditional marginal share of good $i$ within the group $S_g$, with

$$\sum_{i \in S_g} \theta'_i = 1.$$  

The share $\theta'_i$ answers the question, if income rises by $1$, resulting in a certain additional amount spent on the group $S_g$, what is the proportion of this additional amount that is allocated to commodity $i$?

Equation (3.87) is the demand equation for $i \in S_g$, given the demand for the group as a whole $W_g d(\log Q_g)$. It is the conditional demand equation for $i \in S_g$. Equation (3.87) shows that the allocation of expenditure to goods within the $g$-th group depends on the total consumption of the group, as measured by $W_g \, d(\log Q_g)$, and the relative prices of goods within the group. The price coefficients satisfy,

$$v_{ij} = v_{ji}, \quad i, j \in S_g.$$  \hspace{1cm} (3.87)

The $v_{ij}$'s within $S_g$ are also constrained by (3.79) which we repeat here:

$$\sum_{j \in S_g} v_{ij} = \phi \theta_j, \quad i \in S_g.$$  \hspace{1cm} (3.88)

The conditional demand equation (3.87) is to be contrasted with (3.78) which can be described as the corresponding unconditional demand equation.

3.14 The Conditional Version of the Rotterdam Model

Consider equation (3.87) in terms of finite changes:

$$\bar{w}_a Dq_a = \theta_i \bar{w}_g DQ_g + \sum_{j \in S_g} v_{ij} (Dp_{ji} - DP_{ji}),$$  \hspace{1cm} (3.89)

where $\bar{W}_g \, DQ_g = \sum_{a \in S_g} \bar{w}_a Dq_a$; $DP_{ji} = \sum_{a \in S_g} \theta'_a \bar{D}p_{ji}$ is the Frisch price index of the group in term of finite changes; and the other notation is as before.

Equation (3.89) is analogous to the unconditional Rotterdam model. The price coefficients $v_{ij}$ in these two equations are identical, and the constraint on the $v_{ij}$'s within $S_g$,

$$\sum_{j \in S_g} v_{ij} = \phi \theta_j, \quad i \in S_g.$$  \hspace{1cm} (3.90)
which follows from (3.87) and (3.88). Constraint (3.90) also follows from (3.88) and (3.60) as \( v_{ij} = 0 \) for \( i \) and \( j \) belonging to different groups.

The absolute price version of (3.89) is,

\[
\bar{w}_i D_q = \theta \bar{w}_j D_Q + \sum_{j \in S_g} \pi_{ij} D_p, \tag{3.91}
\]

where

\[
\pi_{ij} = v_{ij} - \phi \Theta_{ij}, \quad i, j \in S_g, \tag{3.92}
\]

is the \((i,j)\)-th conditional Slutsky coefficient. This coefficient measures the effect of a change in the price of good \( j \) on the consumption of \( i \) \((i,j \in S_g)\) under the condition that other prices and total consumption of the group remain constant.

The conditional Slutsky coefficients satisfy demand homogeneity,

\[
\sum_{j \in S_g} \pi_{ij} = 0, \quad i \in S_g, \tag{3.93}
\]

which follows from (3.90), (3.92) and \( \sum_{j \in S_g} \theta_j' = 1 \) and are symmetric,

\[
\pi_{ij} = \pi_{ji}, \quad i, j \in S_g, \tag{3.94}
\]

which follow from (3.91) and (3.92). Equation (3.91) is a conditional version of

\[
\bar{w}_i D_q = \theta D_Q + \sum_{j=1}^n \pi_{ij} D_p, \quad \text{and similarly} \ (3.92), (3.93) \text{ and } (3.94) \text{ are the conditional counterparts of equation (3.72), } \sum_{j=1}^n \pi_{ij} = 0, \text{ and } \pi_{ij} = \pi_{ji}.
\]
Chapter 4
Review of Studies of Global Meat Demand

4.1 Global Studies
As a subset of consumer demand, meat demand received early attention from agricultural economists, although there were discrepancies in international research outcomes. This chapter aims to review the literature from studies conducted in both developed and developing nations.

4.2 Western Europe
Two approaches have been used by researchers in the US and Europe to study meat consumption. In the United States, on one hand, researchers have continued using the Rotterdam model. For example, Brester and Schroder (1995) studied the effects of generic and private branding on meat demand, Kinnucan, Xiao, Hsia, and Jackson (1997) researched generic branding and health information using the Rotterdam model. On the other hand, European researchers preferred the Almost Ideal Demand System (AIDS). For example, Fulponi (1989) studied possible changes to meat and food demand in France, and Molina (1994) estimated price elasticity for Spain. Since the early 1990s, there have been several iterations of the AIDS model, including inversion (Eales and Unnevehr, 1994), and a dynamic specification (Karagiannis, Katranidis, and Velentzas 2000). The two models were based on consumer theory, which depends on consumer preferences explaining the relationship among demand, income, and price, as well as other variables. However, economic theory or statistical analysis does not give a clear indication of choice between the two models, so that which model fits the particular dataset is part of the research process and empirical question. This may have been resolved by Barnett and Kanyama (2013), who studied the differences between the Rotterdam model and three versions of the Almost Ideal Demand System with the intention of predicting the time-variable income elasticity of each. They found the Rotterdam model to be superior in tracking the paths of the time-based income elasticity, and this was conducted at very high true values. The Almost Ideal System, on the other hand, was also not efficient when approximating non-linear data. Kabe and Kanazawa (2014), however, proposed a modification, a Bayesian estimation for the Markov switching Almost Ideal Demand System that they validated across the Japanese meat
market through the shifts in meat demand caused by bovine spongiform encephalopathy occurrences, both in Japan and internationally.

The first study was carried out by Beardsworth and Bryman (2004) between 1992 and 2003. They studied the meat avoidance and meat consumption pattern of young people by investigating the behaviour of students in a UK university. The results showed that while at first the demand for meat was reduced (as evidenced by low consumption), towards the end of the study period (2003) however, the level of demand increased (as evidenced by increased consumption levels) (Beardsworth and Bryman, 2004). The authors concluded that meat avoidance continued for a while after which it reached a peak, and later the demand for meat increased (Beardsworth and Bryman, 2004). Another study, by Beardsworth and Bryman (1999), was carried out with data between 1992 and 1997. They investigated the meat avoidance and meat consumption patterns of young people by studying the behaviour of first year students at Loughborough University, and over the five years that the study was ongoing, no change in consumption of meat was observed, which means that the demand for meat remained stable (Beardsworth and Bryman, 1999). The authors concluded that this could have meant that the meat avoidance trend that had been going on for years before the study began could have come to an end (Beardsworth and Bryman, 1999). In another study, Mitchell (1999) analysed empirical data from different surveys and attempted to determine if the nature of British people's main meals (which consists of a considerable amount of meat) had changed over the years. The results showed that consumption of meat remained constant, though the place of traditional forms of meat such as beef and lamb had been taken by poultry (Mitchell, 1999). The authors concluded that the demand for meat in Britain had remained stable over the years (Mitchell, 1999).

The effects of the UK government's announcement in 2000 of a possible link between human health and bovine spongiform encephalopathy (BSE), and its appearance in European herds accelerated research interest in red meat throughout the world. Henson and Mazzocchi (2002), assessed the impact on agribusinesses using three approaches to derive benchmark models against which abnormal returns are estimated: a simple market model, Scholes-Williams approach, and an autoregressive distributed lag model. Over the timeframe of eight days, they found that the autoregressive distributed lag model performed best, indicating significant negative abnormal returns in the beef, pet food, fodder, and dairy sectors, and positive abnormal returns in the other meat sectors of reduced beef consumption. Bansback (1995) studied consumption trends over 40 years in
the United Kingdom and other EU countries, finding that some countries had doubled consumption over the period, while the United Kingdom remained relatively stable. The author called for greater collaboration between economists and ‘consumer behaviourists’ to investigate why such a trend emerged in Western Europe.

4.3 North America

In an influential study, Umberger, Feuz, Calkins, and Killinger-Mann (2002) used an experimental auction technique in the United States to identify the price elasticity of domestic corn-fed beef and Argentinian grass-fed beef. They used three groups based on the two growers, and a third, indifferent group. Umberger et al. found that Americans would pay a significant premium for their domestic product, and that there were just 15 per cent of participants who were indifferent to the beef source.

Daniel, Cross, Koebnick and Sinha (2011) conducted a study recently on the trends in meat consumption in the United States. They used data from 1961 to 2003 available at FAO and USDA. The authors found that red meat consumption in the U.S continues to rise, despite the shift towards poultry consumption. They emphasized that given the evidence of cancer and chronic disease risk brought by red and processed meat consumption, researchers and public health professionals should understand the trends and determinants of meat consumption in order to reduce chronic cardiac and related diseases.


Tonsor, Mintert and Schroeder, (2010) conducted a study into an overall demand for meat in the U.S. They used national, quarterly data in examining the demand for meat using the Rotterdam model. In their findings, they observed a complete understanding of the effects of multiple information factors that consumers face. The authors gave an insight into the issues by describing the effect of the media’s interest in multiple health problems with diet connecting meat demand. Moschini and Meilke (1988) modelled a pattern of structural change in demand for meat in the United States. The data used was from 1970
to 1987, and the analysis was conducted using a gradual switching model. They found that structural change plays a significant role in explaining meat consumption patterns. Rodriguez and Eales (2012) explained the nature of food preferences over a half-century in the United States through a reverse Almost Ideal System and smooth transition regressions. The results showed a structural change to food preferences in America around 1985; however there were more frequent changes based on inflation, where preferences differed between meat types and between meats and substitute foods (Rodriguez and Eales, 2012).

Alston and Chalfant (1991) analysed the demand for beef, pork, poultry and fish in Canada using the Rotterdam and AIDS models for the period 1960 to 1988. The results showed that the income elasticities of demand using the AIDS model are 1.71 for beef, 0.44 for lamb, -0.11 poultry, and 0.14 for pork. The Rotterdam models are 1.63 for beef, 0.56 for lamb, 0.07 for poultry, and 0.21 for pork, indicating that beef is a luxury and lamb, poultry and pork are necessities. The own-price elasticity using the AIDS model are -1.33 for beef, -1.40 for lamb, -0.73 for poultry and -0.95 for pork and the Rotterdam model are -1.30 for beef, -1.59 for lamb, -0.21 for poultry and -0.71 for pork, implying that the demand for poultry and pork is price inelastic and that for beef and lamb is price elastic.

In Canada, Cranfield (2012) explained that in 2003, the discovery of bovine spongiform encephalopathy disease closed the United States’ border and international trade, thus forcing Canada to use its domestic production. After the initial increase in consumption in 2003, beef consumption declined in the long-run, as the country sought to recapture the lost international market share. Accordingly, Cranfield studied the drivers to beef, pork and chicken consumption and the relationship between beef and ancillary aspects such as beef promotion, using data from 1998 to 2010. A quadratic, Almost Ideal Demand System was used. Due to findings that meat demand was weakly separable from other consumption items, a two-stage estimation model was used. The first stage results indicated that meat demand in Canada over the period was inelastic, and the second stage confirmed this view. Thus whilst beef demand was inelastic before the advent of the encephalopathy, long-term change after 2003 was slightly more elastic, however, ‘the change is subtle’ (Cranfield, 2012, p. 17).

Considering the effects on marketing margins of shocks caused by disease, Capps, Colin-Castillo, and Hernandez (2013) studied United States’ monthly meat data from 1986 to
2008. They studied bovine spongiform encephalopathy outbreaks and recalls for lesser disease occurrences and the effects across countries (United States and Canada) and the food industry chain. However there was no evidence of significant change in price margins across countries, although Capps et al. found that in the United States, occurrences of bovine spongiform encephalopathy affected marketing margins for wholesaler to retail. However, subsequent occurrences had lesser effect than the first for the United States meat industry.

Investigating food preferences among young American adults, Chang, Elliott, Sand, Dailey, and Blachford (2014) collected participants’ meat purchases over two periods, 20 days each in May and August, separated by food information delivered through social media. Data were analysed using the Almost Ideal Demand System to examine food purchasing habits and cross-item elasticity. At that time, results were not available; however the authors point to the use of the demand system in non-traditional data analysis models.

4.4 Australia

Cashin (1991) estimated the demand for lamb, beef, chicken and pork in Australia using the LA/AIDS with data for the period 1967-1990. The study reported the income elasticity for beef is 1.65, for lamb is 0.53, for pork is 0.23 and is 0.06 for chicken. The results indicate that lamb, pork and chicken are necessities while beef is a luxury. The own price elasticity are -1.24, -1.33, -0.83 and -0.47, respectively, for beef, lamb, pork and chicken. The finding indicated that the demand for pork and chicken is inelastic while the demand for beef and lamb is elastic.

In another study, Griffith et al. (2001) analyzed data from some studies that had been carried out on the demand elasticity of meat in Australia. The analysis covered studies from the early 1960s to 2000, and observed that over the years the demand for chicken had increased and this has attributed to significant portrayal of poultry meat being healthier than red meat (Griffith et al., 2001). Bhati (1987) also carried out a study in which he found the demand and supply of poultry in Australia between 1971 and 1986 using a conceptual model that was developed at slaughterhouse level. The results showed that demand for poultry meat increased over the study period, and the author attributed this to a drop in the price of poultry meat and also a decline in the costs of poultry feed. In another study, Fisher (1979) investigated the demand for meat between 1962 and 1977. Fisher used the modified trans-log model and the double logarithmic model to obtain
demand estimates, and the results were consistent with both models. He showed that the
demand for chicken meat was fairly inelastic due to the fact that chicken was a special
occasion meal in those days (Fisher, 1979).

Roberts (1990) analysed the meat demand in Australia using the Rotterdam model and
data for the period 1962-1977. The study considered three types of meat namely (beef,
lamb and chicken), and estimated the income and own-price elasticity. The income
elasticity for beef (1.19), for lamb (0.79) and for chicken (0.13), indicating that beef is a
luxury, and lamb and chicken were less than one, indicating that they are necessities. The
absolute value of the own-price elasticity of beef (-0.44), lamb (-1.02) and chicken (-
0.32), implies that the demand for beef and chicken is price inelastic and that for lamb is
price elastic.

Hyde and Perloff (1998) use the AIDS model to determine the demand for pork, beef and
lamb in Australia. The study implemented data for the period 1970 to 1988. The estimated
income elasticity are 1.24 for beef, 0.93 for lamb, and 0.41 for pork, indicating that beef
is a luxury and, that lamb and pork are necessities. The own-price elasticity is -1.41 for
beef, -1.71 for lamb, and -1.04 for pork and all greater than one in absolute value. The
findings indicate that the demand for lamb, pork and beef is price elastic.

Ulubasoglu, Mallick, Wadud, Hone, and Haszler (2010) analysed the demand for (beef,
lamb, chicken and pork) in Australia using data for the period 1999-2004 using the LA-
AIDS model for estimation. The estimated income elasticity are 1.64 (beef), 1.64 (lamb),
1.38 (chicken) and 1.59 (pork), indicating that beef, lamb, chicken and pork are luxuries.
The own-price elasticity for beef, lamb, chicken and pork are, -1.35, -1.42, -1.39 and -
2.20, respectively. This price elasticity reveals that the demand for beef, lamb, chicken
and pork is price elastic.

Using time series data for the period 1978-1988, Piggot, Chalfant, Alston, and Griffith
(1996) analysed the demand response to adverts by the Australian Meat and Livestock
Corporation in Australia, using Double Log (OLS) model estimation. The study
estimated the income elasticity for beef is 1.82, for lamb 0.43, for chicken 0.18 and pork
0.15 indicating that beef is a luxury and lamb, chicken and pork are necessities. The own-
price elasticity are -0.42 for beef, -1.26 for lamb, -0.46 for chicken and -0.87 for pork,
implying that the demand for beef, chicken and pork is inelastic and that for lamb is price
elastic.
Martin and Porter (1985) analysed meat demand in Australia for five types of meat (beef, lamb, chicken, pork and mutton) using data from 1962-1983 using the Double Log (OLS) model for estimation. The estimated income elasticity are 0.68 (beef), -0.13 (lamb), 2.13 (chicken), 0.25 (pork) and -3.59 (mutton), implying that chicken is a luxury while beef, lamb, pork and mutton are necessities. The own-price elasticity are -1.13 for beef, -1.88 for lamb, -0.85 for chicken, -1.09 for pork and 1.39 for mutton, implying that the demand for beef, lamb, mutton and pork is price elastic and that for chicken is price inelastic.

Using annual data from 1965 to 2010, Griffith, Mounter, and Villano (2012) analyzed the domestic demand for meat (beef, lamb, pork and poultry) in Australia. The study estimated three demand systems, the Rotterdam, the Almost Ideal Demand Systems (AIDS) and the LA/AIDS. The estimated income and price elasticity reveal that in Australia. The study estimated income elasticity using the LA/AIDS model are 1.492 for beef, 0.783 for lamb, 0.477 for pork, and 0.092 for chicken. The income elasticity using the LA-AIDS model are 1.49 for beef, 0.78 for lamb, 0.48 for pork, and 0.09 for chicken. Using AIDS model, the income elasticity are 1.49 for beef, 0.72 for lamb, 0.47 for pork, and 0.14 for chicken. The income elasticity using the Rotterdam model are 1.61 for beef, 0.56 for lamb, 0.30 for pork, and 0.06 for chicken. The own price elasticity using the LA/AIDS model are -0.986 for beef, -0.844 for lamb, 0.357 for pork, and -0.268 for chicken. The own price elasticity using the LA-AIDS model are -0.99 for beef, -0.84 for lamb, -0.36 for pork, and -0.27 for chicken. Using the AIDS model, the own-price elasticity is; -2.81 for beef, -1.02 for lamb, -0.81 for pork, and -1.38 for chicken. The own-price elasticity using the Rotterdam model are -1.41 for beef, -0.89 for lamb, -0.25 for pork and -0.30 for chicken. Table 4.1 presents summary of income and own-price elasticity for meat (beef, lamb, pork and chicken) in Australia (Mounter et al., 2012).
Table 4.1: Summary of Income and Own-price Elasticity of Meat in Australia from 1965 to 2010

<table>
<thead>
<tr>
<th>Model</th>
<th>Beef</th>
<th>Lamb</th>
<th>Pigment</th>
<th>Chicken</th>
<th>Beef</th>
<th>Lamb</th>
<th>Pork</th>
<th>Chicken</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA-AIDS</td>
<td>1.49</td>
<td>0.78</td>
<td>0.48</td>
<td>0.09</td>
<td>-0.99</td>
<td>-0.84</td>
<td>-0.36</td>
<td>-0.27</td>
</tr>
<tr>
<td>AIDS</td>
<td>1.49</td>
<td>0.72</td>
<td>0.47</td>
<td>0.14</td>
<td>-2.18</td>
<td>-1.02</td>
<td>-0.81</td>
<td>-1.38</td>
</tr>
<tr>
<td>Rotterdam</td>
<td>1.61</td>
<td>0.56</td>
<td>0.30</td>
<td>0.06</td>
<td>-1.14</td>
<td>-0.89</td>
<td>-0.25</td>
<td>-0.30</td>
</tr>
</tbody>
</table>

Source: Mounter et al. (2012)

4.5 East Asian Region

Studies estimating demand for meat continue to use the almost ideal demand system (AIDS) in Asia and other regions. Following avian virus detection, Honda, Kimura, and Otsuki (2011) studied Japanese demand for poultry meat following changes to food safety regulations with a particular focus on residue limits for pesticides. They found an asymmetric demand response to a change in residue levels and avian influenza bans, with imports from Brazil preferred to those from the United States or China. Also in Japan, Ishida, Ishikawa, and Fukushige (2010), studied the effects of the cattle virus (BSE) and avian virus on meat demand, and found that the BSE had a persistent impact, whereas avian virus did not.

Using a different approach, Coffey, Schroeder, and Marsh (2011) found that some individual meat products have stronger substitutes across species than within species (e.g. beef steak and pork chops are substitutes, but beef roast or minced beef are not substitutes for steak). Jung and Koo (2000) used fish and meat demand in Korea, using a LA/AIDS approach. They found that beef imports would increase as per capita income rises, and local beef would decrease. Chicken and pork could retain a market share, but fish could not. All these suggest the demand models have been considerably used by researchers using a range of variables to study the influence of economic conditions, disease, and diets on demand. Estimating Chinese meat preferences over time, Hovhannisyan and Gould (2014) adapted the Generalized Quadratic Almost Ideal Demand System and used panel data from 2002 to 2010 to study changes in consumption of food groups favored by urban Chinese. Hovhannisyan and Gould found that preferences between meat, fish, vegetables and fruit, and cereals in particular continued to evolve.
4.6 Middle East and North Africa Countries

In the Middle-East there is a mixed bag. In Tunisia, estimation of meat demand is especially relevant, as meat products have the largest share, almost 25 per cent, of the total food expenditure of this nation. Furthermore, meat products, fish, and fruit and vegetables are not subsidized and retail prices are determined by market forces, generating an increased need for demand analyses of these products. Ben Kaabia and Gil (2001) used Johansen and Juselius’s (1992) approach to identify co-integer vectors as demand equations and to test the theoretical restrictions. A structural VAR model was then specified and impulse response functions calculated for long and short-run dynamics of the demand elasticity. The authors concurred with previous studies that meat products, as a group, behave as luxury items in relation to total food expenditure in Tunisia.

For the period 1990–2005, Egyptian meat demand was analysed using the linearized model by Alboghdady and Alashry (2010) to estimate own-price, cross-price, and expenditure elasticity. The authors found that the own-price elasticity was highest for fish, then poultry, beef and duck. They found the highest substitutive meats were poultry and beef.

In an analysis of Jordan’s meat consumption patterns, Jabarin (2005) used a censored regression method for the model equation to allow for zero consumption for some foods. In the first stage of a two-step procedure, an inverse Mill ratio was estimated using a probity regression model. In the second stage, the estimated variable was included in the model to estimate meat demand elasticity. The model was used to obtain estimates of Hicksian, Marshallian and expenditure demand elasticity for meats, finding that the demand for lamb and poultry was elastic, while the demand for beef and fish was inelastic. Further, the cross-price elasticity showed that poultry and beef were substitutes for mutton, thus beef and lamb were luxury goods, while fish and poultry were seen as necessities.

In Turkey, Bilgic and Yen (2014) used a Bayesian censored system to estimate 12 food products from a Turkish household expenditure survey, finding all price elasticity of demand negative and higher for rural households. At higher priced goods such as red meat, they found that rural households were more price sensitive. Thus the characteristics of the region and the season affected households’ choice in foods and their price sensitivity, notably in urban areas.
Testing price sensitivity for ‘organic’ food, that is, food which is expected to be pesticide and fertiliser-free in the United Arab Emirates, Muhammad, Fathelrahman, and Ullah (2015) used a regression model to study the responses of 300 citizens. Muhammad et al. found that demographic indicators of age, education and income were influential in predicting future purchases of labelled organic items. Again in the United Arab Emirates, Basarir (2013) studied food consumption (lamb, goat, fish, chicken, camel and beef) using the Almost Ideal System. The results indicated relationships that associated education and lamb, nationals and beef, household size with camel, and income with goat. Cross price comparisons found complementary pairs; however chicken and camel were substitutes. Lamb and goat were luxuries. Basarir predicted that with increasing income, consumption of lamb, goat, camel and fish would rise, but proportionally, not beef or chicken. Indeed, Azzam and Rettab (2012) reported that food inflation supported economic inequality in the Emirates. Price rises following food shocks for the Arabian Peninsula resulted in food expenditure for the lowest income-producing quintile averaging a quarter of that of households in the highest income quintile. Further, Basarir and Sherif (2012) used an ordered probity model to investigate food labelling in the Emirates (N = 500). They found that consumers were highly aware of food labelling and the important factors for such labelling were expiry (use-by) date, ingredients and country of origin.

4.7 Saudi Arabia

There have been a few studies that have looked into the demand for meat in Saudi Arabia. To determine change in preference in meat in Saudi Arabia, a few studies have attempted estimating elasticity. A review of Saudi literature is provided below:

A study published in 1995 tried to determine the change in structural demand in red meat as compared to fish and other sources of meat such as various types of fish and poultry. A Fortran program was used to determine the random coefficients of the structural change. Significant structural coefficients were found in the case of red meat as compared to poultry or fish, showing that a structural change in demand has been taking place in the red meat category (Becker, 2000).

A study that was published in 2011 used the Almost Ideal Demand System to perform an economic analysis of Saudi demand for red meat (Al-shuaibi, 2011). The main objective of this study was to estimate the demand for various types of red meat and also estimate the various types of elasticity such as price elasticity, income elasticity and cross price elasticity of different types and sources of meat in the Kingdom. The overall result of the
elasticity analysis was that the demand for red meat and fish was elastic, while that of poultry was inelastic. Also, it was revealed that red meat and fish were complementary goods, meaning that an increase in price of red meat increased the consumption of fish. It is also found that an increase in price of red meat increased the consumption of poultry.

Duwais, Ismaiel, Al-Qunaibet, and Al-Omair (1999) earlier studied import demand for poultry meat in the GCC countries using the Almost Ideal Model and panel 20 data from 1979-1992. They found that population growth, real price, and real national income influenced purchases, using their results to predict poultry meat imports to the region after changes to regulations among the countries after membership to the World Trade Organisation was finalised. Duwais et al. (1999) estimated that GCC poultry imports would be in the range of 496,000 tonnes to 534,000 tonnes, depending on projected increases of the real import price.

Al-Shuaibi (2011) used panel data from 1999-2008 to estimate price elasticity for red meat, fish and poultry. The author found that demand for poultry is inelastic, while the demand for red meat and fish is elastic and complementary. An increase in the price of fish influenced purchase of red meat, however, an increase of red meat price increased demand for poultry. An increase in the price of fish influenced purchase of red meat, however, an increase of red meat price increased poultry demand.

In Saudi Arabia, a country which relies on imported food more than locally produced products, Al-Kahtani and Safian (1995) used estimation techniques to establish that there was greater variation in red meat purchases in the country at that time than in poultry or fish. Another Saudi study used the model for import demand for live sheep from Turkey, Syria, and Sudan as suppliers (Al-Rowaes and Al-Dariny, 2007). Panel data for variables included imports, prices and expenditures, and the Non-linear Least Squares method was used to estimate the model. The price and expenditure elasticity were derived to examine Saudi Arabia’s import policy options and forecast imports for 2005-2010. Results showed that imports from Turkey were highly elastic with respect to own price and Syrian import prices. In all, import demand forecasts indicated a general trend towards more imports from Syria and Sudan. Table 4.2 shows elasticity of meat and meat products in Saudi Arabia, Egypt and Jordan.

Table 4.2: Meat Elasticity and Meat Products in Saudi Arabia, Egypt and Jordan
<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Chicken</th>
<th>Lamb</th>
<th>Beef</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Arabia</td>
<td>2011</td>
<td>Inelastic-</td>
<td>Elastic-</td>
<td>Elastic</td>
</tr>
<tr>
<td>Egypt</td>
<td>2010</td>
<td>Elastic-</td>
<td>NA-</td>
<td>Elastic</td>
</tr>
<tr>
<td>Jordan</td>
<td>2005</td>
<td>Elastic-</td>
<td>Elastic-</td>
<td>Inelastic</td>
</tr>
</tbody>
</table>

Source: Adopted from several recent studies.
Chapter 5
Preliminary Data Analysis

5.1 Introduction

This chapter presents a preliminary analysis of the Saudi Arabian meat and fish data using data-analytic techniques introduced in Selvanathan et al., (1987), before formally estimating demand equations, in Chapter 6 of the thesis. The Demand Analysis Package DAP (S. Selvanathan et al., 1989) implements several of these techniques in a convenient way.

The meat and fish data for the period 1985 – 2010 have been drawn from various issues of Ministry of Agriculture, Saudi Ministry of Trade and Industry statistical publications, and publications from the Food and Agriculture Organisation of the United Nations (FAO). We apply data analytic techniques to the Saudi Arabian meat and fish data to gain preliminary estimates for the marginal shares, income and price elasticity and income flexibility.

5.2 The Basic Data

Table 5.1 presents Saudi Arabia annual per capita consumption, $q_{it}$ (in kg) and prices $p_{it}$ (in SR/kg). Consumption and price data of beef, chicken, lamb and fish are covered for the years 1985-2010. As can be seen, over the years from 1985 to 2010, the per capita consumption of beef has fallen from 6.1 kg to 5.2 kg, chicken has increased from 31.7 kg to 39.9 kg, lamb has fallen sharply from 29.3 kg to 12.3 kg, and fish has increased slightly from 5.6 kg to 6.1 kg. The price of beef has doubled, the prices of chicken and fish have almost doubled while the price of lamb has increased more than two and a half times.

Figure 5.1 plots the consumption data given in Table 5.1.

Figure 5.2 plots the prices (in SR/kg) data given in Table 5.1. As can be seen, there is an increasing trend in prices for chicken, beef, lamb and fish. Comparatively, the lamb price has shown a sharp increase between the years 2005 and 2010.
Table 5.1: Per Capita Consumption and Prices of Beef, Chicken, Lamb and Fish, Saudi Arabia, 1985-2010

<table>
<thead>
<tr>
<th>Year (1)</th>
<th>Beef</th>
<th>Chicken</th>
<th>Lamb</th>
<th>Fish</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>6.1</td>
<td>15.0</td>
<td>31.7</td>
<td>6.4</td>
</tr>
<tr>
<td>1986</td>
<td>5.8</td>
<td>15.5</td>
<td>30.3</td>
<td>6.5</td>
</tr>
<tr>
<td>1987</td>
<td>5.6</td>
<td>16.2</td>
<td>31.9</td>
<td>6.4</td>
</tr>
<tr>
<td>1988</td>
<td>5.2</td>
<td>16.8</td>
<td>32.0</td>
<td>6.5</td>
</tr>
<tr>
<td>1989</td>
<td>4.2</td>
<td>17.5</td>
<td>30.0</td>
<td>6.7</td>
</tr>
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<td>1990</td>
<td>4.5</td>
<td>18.2</td>
<td>31.1</td>
<td>6.4</td>
</tr>
<tr>
<td>1991</td>
<td>5.5</td>
<td>18.9</td>
<td>33.2</td>
<td>6.2</td>
</tr>
<tr>
<td>1992</td>
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<td>28.2</td>
<td>6.7</td>
</tr>
<tr>
<td>1993</td>
<td>3.6</td>
<td>20.5</td>
<td>26.3</td>
<td>7.1</td>
</tr>
<tr>
<td>1994</td>
<td>3.7</td>
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<td>24.3</td>
<td>7.2</td>
</tr>
<tr>
<td>1995</td>
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<td>1996</td>
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<td>23.9</td>
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<td>23.7</td>
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<td>7.1</td>
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<td>34.3</td>
<td>8.5</td>
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<td>22.0</td>
<td>39.3</td>
<td>8.4</td>
</tr>
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<td>2001</td>
<td>2.4</td>
<td>21.8</td>
<td>41.0</td>
<td>8.1</td>
</tr>
<tr>
<td>2002</td>
<td>3.8</td>
<td>22.3</td>
<td>37.0</td>
<td>8.1</td>
</tr>
<tr>
<td>2003</td>
<td>3.2</td>
<td>22.4</td>
<td>40.5</td>
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<tr>
<td>2004</td>
<td>4.0</td>
<td>22.3</td>
<td>38.7</td>
<td>8.2</td>
</tr>
<tr>
<td>2005</td>
<td>4.2</td>
<td>22.5</td>
<td>43.2</td>
<td>8.3</td>
</tr>
<tr>
<td>2006</td>
<td>5.2</td>
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<td>2007</td>
<td>5.2</td>
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</tr>
<tr>
<td>2010</td>
<td>5.2</td>
<td>30.1</td>
<td>39.9</td>
<td>10.8</td>
</tr>
</tbody>
</table>

*Notes: Cons = Consumption. Consumption is in kilograms per capita and the prices are in Saudi riyal.
Figure 5.1: Per Capita Consumption of Beef, Chicken, Lamb and Fish, Saudi Arabia, 1985-2010

Figure 5.2: Retail Prices of Beef, Chicken, Lamb and Fish, Saudi Arabia, 1985-2010

Table 5.2 converts the prices in Table 5.1 in index form with the base year 2000 = 100. Figure 5.3 plots the price indices presented in Table 5.2. As can be seen, the prices of all three types of meat and fish have increased steadily over the sample period. The price of lamb has increased at a faster rate than the prices of beef, chicken and fish.
Table 5.3 presents the per capita expenditure in current prices on beef, lamb, chicken, fish and the total on meat and fish group. These expenditures \( E_i \) are obtained by multiplying the per capita consumption \( q_i \) by the corresponding retail prices \( p_i \) presented in Table 5.1. That is, per capita expenditure \( E_i = p_i q_i \). As can be seen, for example in 2010, an average Saudi Arabia consumer spends SR 154.86 on beef, SR 432.60 on chicken, SR 519.58 on lamb, and SR 172.71 on fish, with a total of SR 1279.75 on the meat and fish group. Figure 5.4 plots the per capita expenditures presented in Table 5.3.

Table 5.4 gives per capita expenditure \( p_i q_i \) on each meat type \( i = \text{beef, chicken, lamb and fish} \) presented in columns (2) - (5), expressed as a fraction of total meat and fish expenditure \( M_{gt} \) presented in column (6) in Table 5.3. That is \( w_i = p_i q_i / M_{gt} \), where \( M_{gt} = \sum_{i=1}^{4} p_i q_i \) is the total of meat and fish expenditure. These fractions \( w_i' \) are called the conditional budget shares. As can be seen, the conditional budget share for lamb has fallen; from 55.91 per cent in 1985 to 40.6 per cent in 2010. This fall has been mostly captured by beef, chicken and fish. The budget share for beef has increased from 10.26 per cent in 1985 to 12.1 per cent in 2010. Over the same period, the budget share for chicken has increased from 22.6 per cent to 33.8 per cent and fish has increased from 11.23 per cent in 1985 to 13.5 in 2010. The mean values presented in the last row the table reveal that, on average, out of SR 100 spent on meat and fish, consumers allocate SR 10.42 to beef, SR 30.09 to chicken, SR 49.03 to lamb, and SR 10.46 to fish. The conditional budget shares are plotted in Figure 5.5.
<table>
<thead>
<tr>
<th>Year</th>
<th>Beef</th>
<th>Chicken</th>
<th>Lamb</th>
<th>Fish</th>
<th>Total</th>
</tr>
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<tbody>
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<td>1985</td>
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Table 5.3: Per Capita Expenditure of Beef, Chicken, Lamb and Fish (in SR), Saudi Arabia, 1985-2010

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Figure 5.3: Price indexes for Beef, Chicken, Lamb and Fish: Saudi Arabia (2000 = 100)

Figure 5.4: Per Capita Expenditure of Beef, Chicken, Lamb and Fish (in SR): Saudi Arabia 1985-2010
Table 5.4: Conditional Budget Shares of Beef, Chicken, Lamb and fish, Saudi Arabia, 1985-2010 (in percentages)

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Column 2 of Table 5.5 presents the general consumer price index CPI \(P_t\) for Saudi Arabia and column (3) presents the per capita total consumption expenditure \(M_t\). The next four columns present the unconditional budget shares for beef, chicken, lamb and fish for the years 1985 to 2010. These unconditional budgets shares \(w_{it}\) are calculated as the ratio of each per capita expenditure presented in columns (2) to (5) of Table 5.3 by the per capita total consumption expenditure presented in column (3) of Table 5.5. That is, the unconditional budget share \(w_{it} = p_{it} q_{it} / M_t\). Column 8 of the last table presents the group budget share, which is the sum of the four unconditional budget shares. The last row of the table presents the mean value of each column, averaged over the sample period. As can be seen, for example in 2010, the unconditional budget share of beef,
chicken, lamb and fish is 2.67, 7.46, 8.96 and 2.98 per cent, respectively. The total meat and fish group unconditional budget share in 2010 is 22.08 per cent. These numbers indicate that, of 100 SR income, Saudi consumers allocate SR 2.67 to beef, SR 7.46 to chicken, SR 8.96 to lamb and SR 2.98 to fish and SR 22.08 in total to the meat and fish group. We plot these unconditional budget shares in Figure 5.6.

In Table 5.6 and 5.7 we give the quantity and price log-changes. The log change in consumption and the price from year \( t-1 \) to \( t \) are defined as \( Dq_i = \log q_{it} - \log q_{i,t-1} \) and \( Dp_i = \log p_{it} - \log p_{i,t-1} \), where \( q_i \) and \( p_i \) represent per capita consumption and the price of item \( i \) (\( i = \text{beef, chicken, lamb and fish} \)) in year \( t \). As can be seen from the last row of Table 5.6, the per capita consumption of beef and lamb has fallen at a rate of -0.7% per annum and -3.49% per annum, respectively. The per capita consumption of chicken and fish has grown at a rate of 0.93% per annum, and 0.29% per annum, respectively.

As can be seen from the last row of Table 5.7, on average, the prices have increased at a rate of 2.78 %, 2.1 %, 3.63 % and 1.86 % per annum for beef, chicken, lamb and fish, respectively. We plot the price and quantity log change given in Table 5.6 and 5.7 in Figures 5.7 and 5.8.
Table 5.5: CPI, per Capita Total Consumption Expenditure and Unconditional Budget Shares (in percentages) for Beef, Chicken, Lamb and fish, Saudi Arabia, 1985-2010

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Figure 5.5: Conditional Budget Shares of Beef, Chicken, Lamb and fish, Saudi Arabia, 1985-2010 (in percentages)

Figure 5.6: Unconditional Budget Shares of Beef, Chicken, Lamb and fish, Saudi Arabia, 1985 to 2010
Table 5.6: Per Capita Quantity Log-change (in percentage) for Beef, Chicken, Lamb, and Fish: Saudi Arabia, 1985-2010

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Table 5.7: Price Log-change (in percentage), for Beef, Chicken, Lamb, and Fish, Saudi Arabia, 1985-2010

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</table>
Table 5.8 presents the unconditional budget shares, the budget share for total meat and the conditional budget shares, all in arithmetic average form. Here, \( \overline{W}_{it} = \frac{1}{2} (w_{it} + w_{i,t-1}) \), \( i=1 \) (beef), 2 (chicken), 3 (lamb), 4 (fish), is the arithmetic average of the unconditional budget share of \( i \); \( \overline{W}_{gt} = \sum_{i=1}^{4} \overline{W}_{it} \) is the arithmetic average of the budget share of total meat.
and fish; and \( \bar{w}_i = \frac{1}{2}(w'_i + w'_{i-1}) \) is the arithmetic average of the conditional budge share of \( i=1(\text{beef}), 2(\text{chicken}), 3(\text{lamb}), 4(\text{fish}) \).

**Table 5.8:** Arithmetic Average of Unconditional and Conditional Budget Shares for Meat: Saudi Arabia, 1985-2010 (in percentages)

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<tr>
<th>Year (1)</th>
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<th>Conditional</th>
</tr>
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<td>( \bar{w}_2 )</td>
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<td>1990</td>
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</tr>
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### 5.3 Divisia Indexes

We use the Divisia price and quantity indices introduced in Chapter 3 to summarize the price and quantity data presented in Section 5.2. This section will present within group (or conditional) versions of Divisia indexes.
The within-meat versions of the Divisia volume and price indexes are,

\[ DQ_{gt} = \sum_{i=1}^{4} \bar{w}_i Dq_{it}, \quad DP_{gt} = \sum_{i=1}^{4} \bar{w}_i Dp_{it}, \]

(3.1)

We use the Divisia price and quantity variances to measure the variation in prices and quantities of beef, chicken, lamb and fish and correlation to measure the co-movement of prices and quantities of beef, chicken, lamb and fish, defined as,

\[ K_{gt} = \sum_{i=1}^{4} \bar{w}_i (Dq_{it} - DQ_{gt})^2, \quad \Pi_{gt} = \sum_{i=1}^{4} \bar{w}_i (Dp_{it} - DP_{gt})^2, \]

(3.2)

\[ \Gamma_{gt} = \sum_{i=1}^{4} \bar{w}_i (Dp_{it} - DP_{gt})(Dq_{it} - DQ_{gt}), \quad \rho_{gt} = \frac{\Gamma_{gt}}{\sqrt{\Pi_{gt}K_{gt}}}, \]

(3.3)

where \( Dq_{it} \) and \( Dp_{it} \) are the quantity and price log-changes presented in Tables 5.6 and 5.7 and \( \bar{w}_i \) are the arithmetic average conditional budget shares presented in Table 5.8. Columns (2) and (3) of Table 5.9 presents the Divisia price and volume indices; columns (4) and (5) present the Divisia price and quantity variances and column (8) presents the Divisia price-quantity correlation defined by (3.3).

The Divisia price and quantity indices given in columns 2 and 3 of the table show that meat and fish consumption as a group has fallen at a rate of 1.46 per cent per annum while prices have increased at a rate of 2.88 per cent per annum. Comparing entries in columns 4 with 5, we observe that the quantity variance given in column 5 systematically exceeds the price variance given in column 4, which is an empirical regularity noticed by many other consumption studies (for example, Selvanathan (1987, 1988), Clements (1982, 1983), Meisner (1979). The Divisia price-quantity correlations presented in the last column of the table reveal that most of them are negative with an average of -0.01.
Table 5.9: Divisia moments: Meat and Fish Consumption, Saudi Arabia, 1985-2010

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<th>Quantity variance</th>
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Notes: All entries in columns 2 and 3 are to be divided by 100, columns 4 and 5 are to be divided by 10000.

5.4 Scatter Plots

In this section we use the differential demand equations presented in Chapter 3 to provide the framework for a preliminary analysis of the Kingdom of Saudi Arabia’s meat and fish data. The Rotterdam parameterization of the group demand equation under block independence is,

$$\bar{W}_{gt} DQ_{gt} = \Theta_g DQ_t + \phi \Theta_g (DP_{gt} - DP_t)$$

(4.1)
where $DQ_{gt}$ is the Divisia quantity index of the meat and fish group defined by the equation (3.1); $\Theta_g$ is the marginal share of the group; $DQ_t = (DM_t - DP_t^*)$ is the Divisia index of the change in real income; $\phi$ is the income flexibility; $DP_{gt} = \sum_{j=1}^{n} \theta_j Dp_{jt}$ is the Frisch price index of the meat and fish group $\theta_i = \theta_i / \Theta_g$ is the conditional marginal share of i; $\theta_j$ is the unconditional marginal share of i; and $DP_t = \sum_{j=1}^{n} \theta_j Dp_{jt}$ is the overall Frisch price index. Equation (4.1) shows that under block independence, the demand for a group of goods as a whole depends on the change in real income $DQ_t$ and the change in the relative price of the group, $(DP_{gt}^* - DP_t^*)$. The relative price is the Frisch-deflated Frisch price index of the group and the relative prices of goods outside the group in question play no role in equation (4.1).

If we replace the marginal shares, $\theta_i$ and $\theta_j$, with the corresponding budget shares, $\bar{w}_i$ and $\bar{w}_j$, then the group marginal share $\Theta_g$ becomes the group budget share $\bar{W}_g$ and the composite demand equation (4.1) simplifies to:

$$DQ_{gt} - DQ_t = \phi(DP_{gt} - DP_t), \quad (4.2)$$

Where $DP_{gt}$ is the Divisia price index for the meat and fish group defined by the equation (3.1) and,

$$DP_t = \sum_{j=1}^{n} \bar{w}_j Dp_{jt}, \quad (4.3)$$

is the overall Divisia price index.

Equation (4.2) shows that growth in consumption of meat and fish group relative to the real income, $(DQ_{gt} - DQ_t)$, depends only on the change in the relative price of the group, $(DP_{gt}^* - DP_t^*)$. Using (4.2) if we plot $(DQ_{gt} - DQ_t)$ against $(DP_{gt} - DP_t)$ for $t=1,\ldots, T$, the points should be scattered around a straight line with slope $\phi$. In order to construct this scatter plot, in Table 5.10 we give the values of $DQ_t$ which is approximated by $(DM_t - DP_t^*)$, where $DM_t$ is the log-change in per capita income (or per capita total
expenditure) and \( DP^*_t \) is the CPI log-change: \( DM_t \) and \( DP^*_t \) are also given in that table. We approximate the overall Divisia price index \( DP_t \) in (4.3) with \( DP^*_t \).

Figure 5.9 plots \((DQ_{gt} - DQ_{t})\) against \((DP_{gt} - DP^*_t)\), where data are from Tables 5.9 and 5.10. This figure also gives the least squares regression line.

Under (4.2), the slope of this line is interpreted as an estimate of the income flexibility \( \phi \).

Estimate of \( \phi \) under (4.2) = -0.576, (0.471) (4.4)

The estimate is negative as expected and very close to the previous findings (for example, Selvanathan and Selvanathan 2005; McGuinness, 1980; Clements and Theil, 1978).

We return to (4.1), with \( DP_g \) and \( DP^*_t \), replacing \( DP_g \) and \( DP^* \), as before. We write this as,

\[
\bar{W}_{g} DQ_{gt} = \Theta_g \left[ DQ_t + \phi(DP_{gt} - DP^*_t) \right] \tag{4.5}
\]

The term in square brackets on the right represents the change in real income adjusted for the change in the relative price of meat and fish. Thus, if we specify the value of \( \phi \) and plot \( \bar{W}_{g} DQ_{gt} \) against \( \left[ DQ_t + \phi(DP_{gt} - DP^*_t) \right] \), the observations should be scattered around a line with slope \( \Theta_g \). This scatter is given in Figure 5.10.
Table 5.10: Per Capita Total Consumption Expenditure (DM), CPI and Real Expenditure (DQ) Log-charges: Saudi Arabia, 1985-2010

<table>
<thead>
<tr>
<th>Year (1)</th>
<th>DM (2)</th>
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<th>DQ=DM-DP* (4)</th>
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<td>1987</td>
<td>-9.3242</td>
<td>-1.5549</td>
<td>-7.7694</td>
</tr>
<tr>
<td>1988</td>
<td>-2.1110</td>
<td>0.9061</td>
<td>-3.0171</td>
</tr>
<tr>
<td>1989</td>
<td>-0.9156</td>
<td>1.0224</td>
<td>-1.9379</td>
</tr>
<tr>
<td>1990</td>
<td>5.9641</td>
<td>2.0582</td>
<td>3.9059</td>
</tr>
<tr>
<td>1991</td>
<td>1.3313</td>
<td>4.7461</td>
<td>-3.4148</td>
</tr>
<tr>
<td>1992</td>
<td>-1.7809</td>
<td>-0.0845</td>
<td>-1.6964</td>
</tr>
<tr>
<td>1993</td>
<td>2.8011</td>
<td>1.0512</td>
<td>1.7499</td>
</tr>
<tr>
<td>1994</td>
<td>-1.2846</td>
<td>0.5631</td>
<td>-1.8477</td>
</tr>
<tr>
<td>1995</td>
<td>1.5699</td>
<td>4.7616</td>
<td>-3.1917</td>
</tr>
<tr>
<td>1996</td>
<td>1.1870</td>
<td>1.2121</td>
<td>-0.0252</td>
</tr>
<tr>
<td>1997</td>
<td>-1.6793</td>
<td>0.0588</td>
<td>-1.7381</td>
</tr>
<tr>
<td>1998</td>
<td>-6.4602</td>
<td>-0.3629</td>
<td>-6.0973</td>
</tr>
<tr>
<td>1999</td>
<td>-2.1108</td>
<td>-1.3552</td>
<td>-0.7557</td>
</tr>
<tr>
<td>2000</td>
<td>-0.1100</td>
<td>-1.1318</td>
<td>1.0218</td>
</tr>
<tr>
<td>2001</td>
<td>-1.8735</td>
<td>-1.1142</td>
<td>-0.7593</td>
</tr>
<tr>
<td>2002</td>
<td>-2.0979</td>
<td>0.2238</td>
<td>-2.3217</td>
</tr>
<tr>
<td>2003</td>
<td>1.1876</td>
<td>0.5877</td>
<td>0.5999</td>
</tr>
<tr>
<td>2004</td>
<td>3.3710</td>
<td>0.3328</td>
<td>3.0381</td>
</tr>
<tr>
<td>2005</td>
<td>6.6020</td>
<td>0.6924</td>
<td>5.9096</td>
</tr>
<tr>
<td>2006</td>
<td>8.3906</td>
<td>2.1859</td>
<td>6.2047</td>
</tr>
<tr>
<td>2008</td>
<td>10.9230</td>
<td>9.4140</td>
<td>1.5090</td>
</tr>
<tr>
<td>2009</td>
<td>8.0509</td>
<td>4.9368</td>
<td>3.1141</td>
</tr>
<tr>
<td>2010</td>
<td>6.2009</td>
<td>5.2078</td>
<td>0.9931</td>
</tr>
<tr>
<td>Mean</td>
<td>0.8835</td>
<td>1.4073</td>
<td>-0.5238</td>
</tr>
</tbody>
</table>

All entries are to be divided by 100.

The slope of the least-squares line fitted to the points in Figure 5.10 is 0.092. Under (4.5), this slope is interpreted as an estimate of $\Theta_s$.

Estimate of $\Theta_s$ under (4.5) = 0.092, (0.123) (4.6)

This means that a one-dollar increase in income results in a 9.2 cents increase in spending on meat and fish. Dividing this estimate by the mean of $\bar{W}_g$ of 0.2425 (see Table 5.8), yields an implied income elasticity of $\eta_g = \Theta_g/\bar{W}_g = .092/.2425 = 0.38$. Thus meat as a whole has an income elasticity of less than one. This means that the meat and fish group
can be considered as a necessity in the Saudi Arabian consumer budget. Based on these figures, from (4.1) the own-price elasticity of meat and fish group is

\[ \eta_{gg} = \frac{\phi \Theta_g}{W_g} = -0.576 \times 0.38 = -0.219. \]

Since the absolute value of the own-price elasticity is less than one, we conclude that the demand for meat and fish group is price inelastic.

**Figure 5.9:** Relative Consumption of Meat and Fish group against its Relative Price, Meat and Fish: Saudi Arabia, 1985-2010.

**Figure 5.10:** Meat and Fish Scattergram, Saudi Arabia, 1985-2010.
The $i$-th equation of the relative price version of the conditional Rotterdam demand model is

$$\overline{w}_i Dq_{it} = \theta_i \overline{W}_t DQ_{gt} + \sum_{j=1}^{4} \nu_{ij} (Dp_{jt} - DP_{gt}',) \quad i = 1, 2, 3, 4 \quad (4.7)$$

Where $DP_{gt}'$ is defined below equation (4.1); and $\nu_{ij}$ is the $(i,j)$-th relative price coefficient satisfying $\sum_{j=1}^{4} \nu_{ij} = \phi \Theta_i = \phi \Theta_s \theta_i$, i = 1, 2, 3, 4. Equation (4.7) is the demand equation for product $i$; given the demand for the group as a whole $\overline{W}_t DQ_{gt}$. This equation shows that the allocation of expenditure in each item within the meat and fish group depends on the total consumption of the group as measured by $\overline{W}_t DQ_{gt}$, and the relative prices of item $i$ within the meat and fish group, $(Dp_{jt} - DP_{gt}')$, j = 1, 2, 3, 4.

Under preference independence within meat and fish group, we have

$$\nu_{ij} = 0, \quad i \neq j = 1, 2, 3, 4,$$

which implies that

$$\nu_{ii} = \phi \Theta_s \theta_i', \quad i = 1, 2, 3, 4.$$

Thus (4.7) becomes

$$\overline{w}_i Dq_{it} = \theta_i \overline{W}_t DQ_{gt} + \phi \Theta_s \theta_i (Dp_{it} - DP_{gt}). \quad i = 1, 2, 3, 4 \quad (4.8)$$

To estimate the unknown parameters from (4.8), we replace $\theta_i'$ with $\overline{w}_t$ and $\Theta_s$ with $\overline{W}_t$ (this equivalent is assuming unitary income elasticities) so that the equation becomes

$$Dq_{it} - DQ_{gt} = \phi(Dp_{it} - DP_{gt}). \quad i = 1, 2, 3, 4 \quad (4.9)$$

Equation (4.9) is a lower-case version of the equation (4.2). Using (4.9) for a given $i$, we can plot the growth in consumption of $i$ relative to the group average $(Dq_{it} - DQ_{gt})$ against the change in its relative price $(Dp_{it} - DP_{gt})$ for $t=1,\ldots, T$. The points should be
scattered around a straight line with slope $\phi$. These figures are plotted in Figures 5.11-5.14. Although there is quite a lot of dispersion, most of the observations do fall around a negatively-sloped line for chicken and lamb.

**Figure 5.11:** Consumption of Beef against Adjusted Total Meat Consumption: Saudi Arabia, 1986-2010.

![Graph of Beef consumption](#)

**Figure 5.12:** Consumption of Chicken against Adjusted Total Meat Consumption: Saudi Arabia, 1986-2010.

![Graph of Chicken consumption](#)
Thus, when the price of chicken and lamb increases more than average \( (D_{p_i} > D_{P_{g}}) \), their consumption grows at a rate less than average \( (D_{p_i} < D_{Q_{g}}) \). The slope of the least-squares line for chicken and lamb can be interpreted as an estimate for the income flexibility \( \phi \). Therefore,

\[
\text{Estimate of } \phi \text{ under (4.9)} \quad (4.10)
\]

Chicken \( \phi = -0.505 \), (0.389)

Lamb \( \phi = -0.201 \), (0.527)
Beef $\phi = 0.237$, (0.442)

Fish $\phi = 0.597$, (0.099)

From (4.8) we also have,

$$
\bar{W}_g Dq_{gt} = \theta_i' \left[ \bar{W}_g DQ_{gt} + \phi \Theta_g (Dp_{gt} - DP_{gt}) \right]
$$

(4.11)

Where $DP_{gt}$ has been replaced by $DP_{gt'}$, as before. Now, if we plot $\bar{W}_g Dq_{gt}$ against $\left[ \bar{W}_g DQ_{gt} + \phi \Theta_g (Dp_{gt} - DP_{gt}) \right]$, the observation should be scattered around a straight line with slope $\theta_i'$. Figures 5.15 – 5.18 gives these plots with $\phi = -0.576$ and $\Theta_g = 0.092$ [from (4.6)] for beef, chicken, lamb and fish, respectively. The slope of the least-squares regression line can be interpreted as a conditional marginal share of item $i$.

Estimate of $\theta_1$ under (4.11) = 0.120, (0.046) \hfill (4.12)

Estimate of $\theta_2$ under (4.11) = 0.123, (0.064) \hfill (4.13)

Estimate of $\theta_3$ under (4.11) = 0.657, (0.097) \hfill (4.14)

Estimate of $\theta_4$ under (4.11) = 0.105, (0.027) \hfill (4.15)

Figure 5.15: Consumption of Beef against Adjusted Total Meat and Fish Consumption: Saudi Arabia, 1986-2010.
Figure 5.16: Consumption of Chicken against Adjusted Total Meat and Fish Consumption: Saudi Arabia, 1986-2010.

Figure 5.17: Consumption of Lamb against Adjusted Total Meat and Fish Consumption: Saudi Arabia, 1986-2010.
These figures indicate that when total expenditure on meat and fish increases by one dollar, expenditure on beef, chicken, lamb and fish would increase by 12 cents, 12 cents, 66 cents and 11 cents respectively.

By dividing both sides of \((4.8)\) by \(\bar{w}_{it}\), we get income elasticity of \(i\),

\[
\eta_i = \frac{\theta_i}{\bar{w}_{it}}
\]

\(\text{(4.16)}\)

and, the own price elasticity of \(i\),

\[
\eta_{ii} = \phi \theta_i \frac{\theta_i'}{\bar{w}_{it}} = \eta_{gg} \eta_i
\]

\(\text{(4.17)}\)

We evaluate the income and own-price elasticities by \((4.16)\) and \((4.17)\) using the mean budget shares given in Table 5.8 and the estimates given in \((4.12)\) - \((4.15)\).
Table 5.11: Income and Own Price Elasticities for Beef, Chicken, Lamb, and Fish Group, Saudi Arabia, 1985-2010

<table>
<thead>
<tr>
<th>Type</th>
<th>Income elasticity</th>
<th>Own price elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>1.15</td>
<td>-0.25</td>
</tr>
<tr>
<td>Chicken</td>
<td>0.41</td>
<td>-0.09</td>
</tr>
<tr>
<td>Lamb</td>
<td>1.34</td>
<td>-0.29</td>
</tr>
<tr>
<td>Fish</td>
<td>1.01</td>
<td>-0.22</td>
</tr>
<tr>
<td>Group</td>
<td>0.380</td>
<td>-0.219</td>
</tr>
</tbody>
</table>

The income elasticity of beef, chicken, lamb and fish are 1.15, 0.41, 1.34 and 1.01, respectively. This means that Saudi consumers consider beef, lamb and fish as luxuries and chicken as a necessity. The group income elasticity is 0.38, indicating that meat and fish as a group is a necessity. The own-price elasticity of beef, chicken, lamb and fish are -0.25, -0.09, -0.29 and -0.22, respectively. Absolute values of these numbers are all less than 1, indicating that the demand for beef, chicken, lamb and fish are all price inelastic.

5.5 Further Estimate of Income Flexibility

Now we introduce another procedure to estimate income flexibility \( \phi \). Consider again equation (4.8), the conditional demand equation for meat \( i \) under preference independence. We divide both sides of the equation by \( \bar{w}_{gi} \) and add a disturbance \( (\varepsilon_{it}^{w}) \) to give,

\[
w_{it}Dq_{it} = \theta_i^i(DQ_{it}) + \phi_{it}^{\omega} \theta_i(Dp_{it} - DP_{gi}) + \varepsilon_{it}^{w}.
\]  

(5.1)

Again we eliminate the unknown parameters \( \theta_i \) and \( \Theta_{it} \) by replacing them with \( \bar{w}_{it} \) and \( \bar{W}_{git} \), respectively. Therefore (5.1) becomes,

\[
\bar{w}_{it}(Dq_{it} - DQ_{git}) = \phi_{it}^{\omega}(Dp_{it} - DP_{git}) + \varepsilon_{it}^{w}
\]  

(5.2)

We assume that the disturbance \( \varepsilon_{it}^{w} \) has zero means and,

\[
\text{cov} \left[ \varepsilon_{it}^{w}, \varepsilon_{jt}^{w} \right] = \sigma^2_{\varepsilon_{it}^{w}} \delta_{ij},
\]  

(5.3)

where \( \delta_{ij} \) is the Kronecker delta. Specification (5.3) states that the error variance is larger for those goods having a larger conditional budget share, which is plausible. As
\[ \sum_{i=1}^{4} e_{it} = 0, \] the assumption that \( \text{cov}[e_{it}^*, e_{jt}^*] = 0 \) for \( i \neq j \) cannot be exactly true. However, as our analysis is designed only to obtain a preliminary feel for the data, we shall use this assumption as an approximation. Accordingly, the transformed disturbances \( e_{it}^* \sqrt{w_u} \) are uncorrelated with zero mean and the same variance \( \sigma_t^2 \). This means that if we divide both sides of (5.2) by \( \sqrt{w_u} \) and then regress \( \sqrt{w_u} (Dq_{it} - DQ_{gt}) \) on \( \sqrt{w_u} (DP_{it} - DP_{gt}) \) for \( i=1,2,3,4 \), we obtain for year \( t \) the least-squares estimators of \( \phi \) as,

\[
\hat{\phi}_t = \frac{\sum_{i=1}^{4} \sqrt{w_u} (DP_{it} - DP_{gt})(Dq_{it} - DQ_{gt})}{\sum_{i=1}^{4} \sqrt{w_u} (DP_{it} - DP_{gt})^2}.
\]

Using (3.2) and (3.3) we can write (5.4) as,

\[
\hat{\phi}_t = \frac{\Gamma_{gt}}{\Gamma_{gt}}.
\]

It follows that the sampling variance of this estimator is,

\[
\text{var} \hat{\phi}_t = \frac{\sigma_t^2}{\Pi_{gt}}.
\]

and that \( \sigma_t^2 \) is estimated unbiasedly by,

\[
\hat{\sigma}_t^2 = \frac{1}{n_g - 1} [K_{gt} - \hat{\phi}_t \Gamma_{gt}].
\]

when \( n_g = 4 \) and \( K_{gt} \) is defined in (3.2).

Equation (5.5) provides a one-period estimator of \( \phi \). Thus if we have \( T \) periods we get \( T \) estimates of \( \phi \). If these are independent, an optimal estimator of \( \phi \) for all \( T \) periods is given by a weighted average of \( \hat{\phi}_1, \ldots, \hat{\phi}_T \) which weighs inversely proportional to their variances. This yields,
\[
\hat{\phi} = \sum_{t=1}^{T} \frac{\prod_{g}^{t}}{\prod_{g}} \hat{\phi} = \sum_{t=1}^{T} \frac{\prod_{g}^{t}}{\prod_{g}} \frac{\Gamma_{gt}}{\prod_{g}^{t}} = \sum_{t=1}^{T} \frac{\Gamma_{gt}}{\prod_{g}^{t}} = \frac{\Gamma_{g}}{\prod_{g}}, \quad (5.8)
\]

where \[\bar{\Gamma} = (1/T) \sum_{t=1}^{T} \Gamma_{gt}, \bar{\prod}_{g} = (1/T) \sum_{t=1}^{T} \prod_{g}^{t};\] and where we have also assumed that \[\sigma_{t}^{2} = \sigma^{2},\] a constant. Selvanathan (1994) shows that the sampling variance of \[\hat{\phi}\] is,

\[
\text{var} \hat{\phi} = \frac{\sigma^{2}}{\sum_{t=1}^{T} \prod_{g}^{t}} = \frac{\sigma^{2}}{T \prod_{g}}, \quad (5.9)
\]

and that an unbiased estimator of \[\sigma^{2}\] is given by,

\[
\hat{\sigma}^{2} = \frac{1}{[Tn_{g} - 1]} \sum_{t=1}^{T} (K_{gt} - \hat{\phi} \Gamma_{gt}) = \frac{T}{[Tn_{g} - 1]} (\bar{K}_{g} - \hat{\phi} \bar{\Gamma}_{g}), \quad (5.10)
\]

where \[\bar{K}_{g} = (1/T) \sum_{t=1}^{T} K_{gt}.\] (For a similar approach, see Clements and Theil, 1978).

Using our data to evaluate (5.8) and (5.9) yields,

\[
\hat{\phi} = -0.282 (0.078) \quad (5.11)
\]

### 5.6 Comments on Assumptions

We conclude this chapter with a brief recapitulation of the assumptions under which we obtained preliminary estimates of the income flexibility and the marginal shares. The estimate (4.4) is derived under block-independence with marginal shares replaced by the corresponding budget shares. As the income elasticity is the ratio of the marginal share to budget share, this amounts to assuming unitary income elasticities. The estimate of \[\Theta_{g}\] given in (4.6) is also derived under a similar assumption.

The assumptions underlying the estimate of \[\phi\] given in (4.10) are (i) unitary income elasticities and (ii) that the four types of meat are preference independent in the consumer’s utility function. Some of these assumptions are obviously quite strong. Accordingly, the estimates derived in this chapter are only meant to have a preliminary status.
Chapter 6
Patterns of Meat and Fish Consumption in Saudi Arabia

6.1 Introduction
The agricultural sector plays an important role in Saudi Arabia, and it effectively contributes to the domestic production and strongly supports the national economy. In Saudi Arabia in recent years, domestic food production policy has changed towards giving additional focus to attaining food security, due to the adverse climate and scarcity of water on the Arabian Peninsula. Saudis have traditionally relied on lamb, goat, and camel meat for their sustenance; however, the socio-economic changes over the last 50 years have changed the meat consumption habits, where beef, chicken and fish now constitute the main Arabic diet. The worldwide consumer demand for meat and meat products has been growing unabated due to both economic and social changes over the last decade or two. The dietary habits of Saudis have changed drastically due to improved socioeconomic conditions and an increasingly urban lifestyle.

The Saudi livestock sector includes several types of animals, including 7.8 million sheep, 4.4 million goats, 422 thousand camels, and 204 thousand cattle (MOA, 2009). Furthermore, an active domestic fish industry has emerged, which has produced approximately 49,920 tonnes of fish, and which has exported almost half of this amount to overseas markets. Saudi Arabia has achieved a great success in poultry farming including a remarkable increase in the supply of poultry meat and eggs. In this regard, according to the Saudi Arabian Ministry of Agriculture, the domestic poultry production had exceeded 493 million hens in 2009, with egg production reaching 3,473 million, in addition to the 476,348 tonnes of chicken meat in specialist projects, approximately 522 million meat chicks, and 21.4 million egg chicks (MOA, 2009). Saudis are high consumers of poultry, consuming 41.6 kg per capita of chicken annually against a world average of only 12.5 kg (Global Poultry Trends, 2010). Furthermore, according to the Ministry of Commerce and Industry, the Saudi dairy production was estimated to have produced more than 1.508 billion litres of milk, while meat production of around 760 thousand tonnes was recorded, including 171 thousand tonnes of red meat, 508 thousand tonnes of poultry meat. In addition 96 thousand tonnes of fish and seafood production was reported (MOCI, 2009).
In Chapter 3 we presented the theoretical framework for consumer demand analysis. Chapter 4 presented a review of global demand studies of meat. In Chapter 5 we presented a preliminary data analysis of the Saudi Arabian meat and fish data. This chapter presents an empirical analysis of the demand for three types of meat, namely beef, lamb and chicken, and fish in Saudi Arabia over the period 1985-2010. We employ the well-known system-wide approach (Theil and Clements, 1987; and Selvanathan and Selvanathan, 2003) for our analysis. There are two basic reasons for the selection of a system-wide approach in this study. Firstly, due to consumers’ fixed incomes, the budget constraint needs to be satisfied in terms of purchasing all consumer goods. This means that any increase in expenditure on one good can only arise from a decreased expenditure on at least one other good. This underlying interrelationship between the consumption of the different types of goods necessitates the study of all three meat items and fish simultaneously under a system-wide approach.

Secondly, in developing the demand equations, there are certain cross-equation restrictions arising from consumption theories that necessitate the utilization of a system of demand equations. For example, when the consumer’s real income is held constant, the quantity change in the consumption of a good, arising from a one-dollar increase in the price of another good, will be exactly the same as the change in the consumption of the first good brought about by a one-dollar increase in the price of the latter good. This is termed Slutsky symmetry and to test and impose such restrictions, the demand analysis must be carried out under a system-wide framework, rather than as a number of single commodity equations.

To our knowledge, there are no other published comprehensive econometric studies available that analyze the demand for meat and fish in Saudi Arabia in a system-wide manner using more recent data. We believe that this study would be the first to fill at least part of this gap. The organisation of the chapter is as follows. In Section 6.2, we review a number of research studies that analyse the demand for meat products in countries where the Muslim people are in a majority. We present the demand system for estimation and test various demand theory hypotheses in Section 6.3. In Section 6.4, we present the estimated results and the implied income and price elasticity. The next section presents some policy related applications and analysis and finally, in Section 6.6, we present our concluding comments.
6.2 A Review of Arabic Meat Studies

In this section, we present a review of a number of recent research studies that analyse meat and fish consumption in countries with a majority Muslim population.

Wadud’s (2006) study of meat consumption in Bangladesh using quarterly data from the Household Expenditure Survey for the period 1980(1)–2000(4) considered three meat types, beef, chicken and mutton, and used the Linear Approximated Almost Ideal Demand System (LA-AIDS) for estimation. The estimated own-price elasticity were \(-0.25\) (beef), \(-0.91\) (chicken) and \(-0.94\) (mutton). The study also found substitutability between beef, chicken and mutton. The income elasticity for chicken (1.46) and mutton (3.08) were greater than one, indicating that both are luxuries, and that the income elasticity for beef (1.04) is negative, indicating that it is an inferior good.

Alboghdady and Alashry (2010) analysed the demand for meat in Egypt using the LA-AIDS model and data for the period 1990–2005. The study considered a number of meat types (beef, chicken, mutton, duck and rabbit) and fish and estimated the income and price elasticities. The income elasticity for chicken (1.65) and fish (1.35) were greater than one, indicating that they are luxuries, while that for beef (0.75), duck (0.55) and rabbit (0.66) were less than one indicating that they are necessities. The income elasticity for mutton (0.25) is negative, indicating that it is an inferior good. All the own price elasticities, except for mutton, are negative and are less than one in absolute value indicating that the demand for beef, chicken, duck, rabbit and fish are price inelastic. The own price elasticity for mutton is positive. Most of the estimated cross-price elasticities are negative, indicating a high level of complementarity between the different meat types and fish.

Using time series data for the period 1982-2007, Motallebi and Pendell (2013) analysed the demand for red meat (beef and lamb combined), chicken and fish in Iran. They used both static and dynamic AIDS model for estimation. Both set of estimation results reveal that the income elasticity for red meat, chicken and fish are all larger than one, indicating that they are all luxuries in Iran. The own-price elasticities resulting from both the static and dynamic estimations for red meat and chicken are larger than one, indicating that the demand for red meat and chicken are both price elastic. The own-price elasticity estimate for fish from the static model estimation resulted in a value smaller than one (in absolute value) and larger than one from the dynamic model estimation.
Using household expenditure survey data (collected from 2600 urban households) and an LA-AIDS model, Jabarin (2005) analysed the demand for meat in Jordan. The study analysed three meat types, beef, poultry and mutton, together with fish. Jabarin estimated the income and price elasticities for these four items. The estimated income elasticity of beef (1.64) and mutton (1.01) are greater than one and for poultry (0.97) and fish (0.13) are less than one, indicating that beef and mutton are luxuries, and poultry and fish are necessities. The absolute value of the own price elasticity of poultry (-1.02) and mutton (-3.06) are greater than one in absolute value, and for beef (-0.76) and fish (-0.65) are less than one in absolute value, indicating that the demand for poultry and mutton are price elastic, and the demand for beef and fish are price inelastic. A majority of the cross-price elasticities are positive, indicating that there is a great deal of substitutability between beef, poultry, mutton and fish.

Baharumshah and Mohamed (1993) applied the AIDS model to estimate the demand for beef, mutton, chicken, pork and fish in Malaysia. The study used annual data for the period 1960-1990. The estimated income elasticities were 0.06 for beef, 1.12 for mutton, 1.43 for chicken, 1.15 for pork and 1.02 for fish, indicating that beef is a necessity, while mutton, chicken, pork and fish are all luxuries. The own-price elasticities are -0.55 for beef, -0.42 for mutton, -0.59 for pork and -0.63 for fish, and are all less than one in absolute value. In comparison, the own-price elasticity for chicken was -3.78 which is larger than one in absolute value. The findings indicate that the demand for beef, mutton, pork and fish are price inelastic, while for chicken the demand is price elastic.

A study by Madfri and Brorsen (1993) analysed the meat and fish consumption patterns of Moroccan consumers on the three meat types, namely, beef, mutton, poultry and fish using the LA-AIDS model for the period 1969-1985. The analysis revealed that there is a declining trend in per capita consumption of beef and mutton, and an increasing trend in the consumption of poultry and fish. The prices of beef and mutton have increased at a faster rate compared to the price increases in poultry and fish. The income elasticities are 0.76 (beef), 2.35 (mutton), 0.03 (poultry) and 0.24 (fish), implying that mutton is a luxury and, beef, poultry and fish are necessities. The own-price elasticities for beef, mutton, poultry and fish are, -1.81, -0.78, -1.26 and -0.18, respectively. These price elasticities reveal that the demand for beef and poultry are price elastic and the demand for mutton and fish is price inelastic.
Ezedinma, Kormawa and Chianu (2006) analysed the demand for meat in Nigeria using 1999/2000 household expenditure data (960 households) and using the LA-AIDS model. The study estimated the income and price elasticity for beef, mutton, chicken and fish separately for high-income and low-income households. The results show that beef and fish are necessities and chicken is a luxury for both types of consumers. However, mutton is considered as a luxury by high income households while it is a necessity for low-income households. The study also found that the demand for all items is price elastic, while the demand for beef of high-income households is price inelastic.

Using annual data for the period 1999-2008, Al-Shuaibi (2011) analysed the demand for red meat, poultry and fish for Saudi Arabia using the LA/AIDS model for estimation. The estimated income elasticity for red meat is 1.10, for fish 0.90 and poultry 0.84, indicating that red meat is a luxury and poultry and fish are necessities. Moreover, the own-price elasticity is -0.98 for red meat, -1.78 for fish, and -1.29 for poultry, implying that the demand for red meat is price inelastic, and that for fish and poultry, the demand is price elastic.

Dhehibi and Gil (1999) analysed the demand for meat (beef, mutton and poultry) and fish in Tunisia using the Generalized Addilog Demand System (GADS), also with the data from 1973 to 1994. The study reported that the income elasticity for beef as 1.24, mutton 0.78, poultry -0.08 and fish 1.39. These estimates indicate that beef and fish are luxuries and mutton is a necessity, while poultry is an inferior good. The own price elasticity are -0.60, -0.51, -0.60 and -0.55, respectively, for beef, mutton, poultry and fish implying that demand for beef, mutton, poultry and fish is price inelastic.

A more recent study by Dhraief, Oueslati and Dhehibi (2013), using household survey data from 504 households distributed equally among seven regions of Tunisia, analysed the impact of income, education and age on meat and fish consumption. The study estimated four demand systems, Rotterdam, CBS, AIDS and NBR for four meat types (beef, mutton, chicken, turkey) and fish. The estimated income and price elasticity reveal that in Tunisia, beef and mutton are considered as luxuries and chicken, turkey and fish are necessities overall and for different age groups (less than 40 years, 40-50 years, and over 50 years). Overall, the demand for all four items across all age groups is price inelastic, except for beef and mutton which are price elastic for the 40-50 years age group.
Basarir (2013) estimates the demand for five different meat products (beef, lamb, goat, chicken and camel) and fish in the United Arab Emirates (UAE) using a LA/AIDS and data based on a face to face survey conducted with 500 randomly selected households from the UAE. The results reveal that highly educated UAE nationals demand more beef and lamb meat compared to less educated non-UAE nationals. The demand for camel and goat meat increases as household size and household income increases. However, demand for beef decreases as household income increases. The estimated income elasticity reveals that lamb, goat and camel are luxuries while beef, chicken and fish are necessities. All the estimated own-price elasticity are less than one in absolute value, indicating that the demand for all meat types and fish is price inelastic.

Table 6.1 presents a summary of the results from the above meat studies in relation to a number of Muslim countries, namely, Bangladesh, Egypt, Iran, Jordan, Malaysia, Morocco, Nigeria, Saudi Arabia, Tunisia, and the United Arab Emirates (UAE). As can be seen, on average, in a majority of the countries, beef and fish are considered as necessities (income elasticity less than 1) while chicken and mutton are considered as luxuries (income elasticity greater than 1). The demand for beef and fish is price inelastic (the absolute values of own-price elasticity is less than 1) and demand for mutton and chicken is price elastic (the absolute vale of the own-price elasticity is greater than 1).
Table 6.1: Summary of Income and Own-price Elasticity of Meat Groups from Previous Studies: Muslim Countries

<table>
<thead>
<tr>
<th>Author</th>
<th>Country</th>
<th>Percentage of Muslim population</th>
<th>Data period</th>
<th>Model / Estimation</th>
<th>Income Elasticity</th>
<th>Own-price Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Beef</td>
<td>Mutton</td>
</tr>
<tr>
<td>Abdul Wadud (2006)</td>
<td>Bangladesh</td>
<td>89</td>
<td>1980(1)-2000(4)</td>
<td>LA/AIDS</td>
<td>-1.04</td>
<td>3.08</td>
</tr>
<tr>
<td>Albohgday &amp; Alashry (2010)</td>
<td>Egypt</td>
<td>90</td>
<td>1990-2005</td>
<td>LA/AIDS</td>
<td>0.75</td>
<td>-0.25</td>
</tr>
<tr>
<td>Baharumshah &amp; Mohamed (1993)</td>
<td>Malaysia</td>
<td>60</td>
<td>1960-1990</td>
<td>LA/AIDS</td>
<td>0.06</td>
<td>1.12</td>
</tr>
<tr>
<td>Basarir (2013)</td>
<td>UAE</td>
<td>76</td>
<td>HES data</td>
<td>LA/AIDS</td>
<td>0.80</td>
<td>1.18</td>
</tr>
<tr>
<td>Dhehibi &amp; Gil (1999)</td>
<td>Tunisia</td>
<td>98</td>
<td>1973-1994</td>
<td>GADS</td>
<td>1.24</td>
<td>0.78</td>
</tr>
<tr>
<td>Dhraief, Queslati &amp; Dhehibi (2013)</td>
<td>Tunisia</td>
<td>98</td>
<td>HES, 2008</td>
<td>Differential Demand System</td>
<td>1.06</td>
<td>1.35</td>
</tr>
<tr>
<td>Ezedinma, Kormawa &amp; Chianu (2006)</td>
<td>Nigeria</td>
<td>50</td>
<td>HES data (Hi)³</td>
<td>LA/AIDS</td>
<td>0.62</td>
<td>1.37</td>
</tr>
<tr>
<td>Ezedinma, Kormawa &amp; Chianu (2006)</td>
<td>Nigeria</td>
<td>50</td>
<td>HES data (Li)³</td>
<td>LA/AIDS</td>
<td>0.79</td>
<td>0.71</td>
</tr>
<tr>
<td>Jabarin (2005)</td>
<td>Jordan</td>
<td>95</td>
<td>HES data</td>
<td>LA/AIDS</td>
<td>1.64</td>
<td>1.01</td>
</tr>
<tr>
<td>Mdaifi &amp; Brorsen (1993)</td>
<td>Morocco</td>
<td>99</td>
<td>1969-1985</td>
<td>LA/AIDS</td>
<td>0.76</td>
<td>2.35</td>
</tr>
<tr>
<td>Motallebi &amp; Pendell (2013)</td>
<td>Iran</td>
<td>98</td>
<td>1982-2007</td>
<td>Static AIDS</td>
<td>1.71²</td>
<td>1.48</td>
</tr>
<tr>
<td>Motallebi &amp; Pendell (2013)</td>
<td>Iran</td>
<td>98</td>
<td>1982-2008</td>
<td>Dynamic AIDS</td>
<td>1.36²</td>
<td>1.40</td>
</tr>
<tr>
<td>Shuaibi (2011)</td>
<td>Saudi Arabia</td>
<td>100</td>
<td>1999-2008</td>
<td>AIDS</td>
<td>1.10</td>
<td>0.84</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.71</td>
<td>1.27</td>
</tr>
</tbody>
</table>

¹Countries where Muslims are the majority population; ²Red meat; ³Hi=High Income; and Li=Low Income. HES=Household Expenditure Survey.
6.3 The Demand Model

In terms of differential demand systems, under the system-wide approach, one of the most popularly utilised demand systems in applied demand analysis has been the Rotterdam demand system (Barten, 1964; Theil, 1965). In this study, we use the Rotterdam demand system to analyse the consumption patterns for beef, chicken, lamb and fish in Saudi Arabia. This demand system has been previously used by many studies for narrowly defined commodities such as the meat group (for example, see Clements and Johnson, 1983; Duffy, 1987, 2001, 2003; Selvanathan, 2006; and Selvanathan and Selvanathan, 2005, 2006). We first introduce the Rotterdam demand system to be used for estimation and then test the demand theory hypotheses, homogeneity, symmetry, and preference independence. In the following sections, we present the estimation results and implied income and price elasticity for beef, chicken, lamb and fish, and present some applications in relation to policy issues.

Rotterdam Demand System

The basic specification of the Rotterdam model for good \( i \), in differentials, take from Chapter 3 the form (see, for example, Theil, 1980; Selvanathan and Selvanathan, 1993; Selvanathan and Clements, 1995)

\[
\bar{w}_{it} Dq_{it} = \alpha_i + \theta_i DQ_{gt} + \sum_{j=1}^{4} \pi_{ij} Dp_{jt} + \epsilon_{it}, \quad i = 1(\text{beef}), 2(\text{chicken}), 3(\text{lamb}) \text{ and } 4(\text{fish}) \quad (3.1)
\]

where \( Dp_{it} = \ln(p_{it}) - \ln(p_{i,t-1}) \) and \( Dq_{it} = \ln(q_{it}) - \ln(q_{i,t-1}) \) are the price and quantity log-changes; \( \bar{w}_{it} = \frac{1}{2}(w_{it} + w_{it-1}) \) is the arithmetic average of the conditional budget shares in periods \( t \) and \( t-1 \); \( DP_{gt} = \sum_{i=1}^{4} \bar{w}_{it} Dp_{it} \) and \( DQ_{gt} = \sum_{i=1}^{4} \bar{w}_{it} Dq_{it} \) are the Divisia price and quantity indices of the meat and fish group; and \( \alpha_i \) is the constant term of the \( i^{th} \) demand equation satisfying \( \sum_{i=1}^{4} \alpha_i = 0 \). The use of the constant terms in the demand equations is to take into account any trend-like changes in tastes, etc. The marginal share, \( \theta_i \), answers the question, ‘if the expenditure on the meat and fish group (beef, chicken, lamb and fish) increases by one dollar, how much of this increase will be allocated to item \( i \) of the group?’ The marginal share also satisfies \( \sum_{i=1}^{4} \theta_i = 1 \). If \( \theta_i < \bar{w}_{it} \) (or equivalently, income elasticity < 1), then item \( i \) will be classified as a necessity; otherwise it will be...
classified as a luxury. The coefficient $\pi_{ij}$ is the $(i,j)^{th}$ Slutsky price coefficient which satisfies the adding-up restrictions,

$$\sum_{i=1}^{4} \pi_{ij} = 0, \quad j=1,2,3,4 \tag{3.2}$$

and demand homogeneity,

$$\sum_{j=1}^{4} \pi_{ij} = 0, \quad i=1,2,3,4 \tag{3.3}$$

Constraint (3.3) reflects the demand homogeneity property of the demand system that postulates that an equiproportionate change in all prices has no effect on the demand for any good under the condition that total meat and fish group consumption is held constant.

The Slutsky coefficients are symmetric in $i$ and $j$, that is,

$$\pi_{ij} = \pi_{ji}, \quad i,j=1,2,3,4 \tag{3.4}$$

which is known as Slutsky symmetry. In other words, when total meat and fish group consumption is held constant, the effect of an increase in the price of item $j$ on the demand for item $i$ is equal to the effect of a price increase of $i$ on the demand for $j$. In other words, as the item subscripts can be interchanged, the substitution effects are symmetric in $i$ and $j$. In general, the Slutsky matrix, $[\pi_{ij}]$, is symmetric negative semi-definite with rank $(n_g - 1)$, where $n_g = 4$ is the number of items in the meat and fish group $S_g = \{\text{beef, chicken, lamb, fish}\}$.

The term $\epsilon_t$ is the disturbance term of the $i^{th}$ equation. It is assumed that the disturbance terms, $\epsilon_{it}, \; i=1,\ldots,n_g$, are serially independent and normally distributed with zero means with a contemporaneous covariance matrix. Equation (3.1) for $i=1,\ldots,n_g$, is a fairly general demand system in the sense that it can be considered as a first-order approximation of the true demand equations. If we sum both sides of (3.1) over $i=1,\ldots,n_g$, we obtain $\sum_{i=1}^{n_g} \epsilon_{it} = 0, \; \text{for } t=1,\ldots,T$, where $T$=sample size. Therefore, the $\epsilon_t$ values are linearly dependent and one of the equations becomes redundant and can be deleted (Barten, 1969). We delete the $n_g^{th}$ equation. It can be shown that the best linear unbiased estimators of the parameters for the system of equations (3.1) for $i=1,\ldots,n_g$ will be the
same as those obtained by estimating each equation separately by least squares (LS), see Theil (1971) for details.

The income and price elasticity implied by demand system (3.1) are given by,

\[
\eta_{it} = \frac{\theta_i}{w_{it}} \quad \text{and} \quad \eta_{ij} = \frac{\pi_{ij}}{\bar{w}_{it}}
\]  

(3.5)

If the income elasticity of good i is less (greater) than 1, then good i is classified as a necessity (luxury).

**Stationarity of the time series variables in the models**

As the variables we use to estimate the demand system are time series variables, before estimation it is desirable to investigate whether the variables to be used in the demand system estimation are stationary. We use the Augmented Dicky-Fuller unit root test (Dickey and Fuller, 1979, 1981) for this purpose. The test results are presented in Table 6.2. As can be seen, as all \( p \)-values (except for the price of beef) are less than 10 per cent, we safely assume that all the variables to be used in the demand system are stationary.
Table 6.2: Testing for the Stationary of the Demand System Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>τ-statistic</th>
<th>p-value</th>
<th>Stationarity (5% level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{w}_1 Dq_1$</td>
<td>-5.39213</td>
<td>0.0002</td>
<td>Yes</td>
</tr>
<tr>
<td>$\bar{w}_2 Dq_2$</td>
<td>-6.94766</td>
<td>0.0000</td>
<td>Yes</td>
</tr>
<tr>
<td>$\bar{w}_3 Dq_3$</td>
<td>-6.97494</td>
<td>0.0000</td>
<td>Yes</td>
</tr>
<tr>
<td>$\bar{w}_4 Dq_4$</td>
<td>-6.53595</td>
<td>0.0000</td>
<td>Yes</td>
</tr>
<tr>
<td>$Dp_1$</td>
<td>-2.61144</td>
<td>0.1080</td>
<td>Yes*</td>
</tr>
<tr>
<td>$Dp_2$</td>
<td>-2.91295</td>
<td>0.0586</td>
<td>Yes*</td>
</tr>
<tr>
<td>$Dp_3$</td>
<td>-5.08473</td>
<td>0.0005</td>
<td>Yes</td>
</tr>
<tr>
<td>$Dp_4$</td>
<td>-4.96388</td>
<td>0.0006</td>
<td>Yes</td>
</tr>
<tr>
<td>$DQ_g$</td>
<td>-7.16951</td>
<td>0.0000</td>
<td>Yes</td>
</tr>
<tr>
<td>$Dp_1 - DP_g^*$</td>
<td>-4.14383</td>
<td>0.0039</td>
<td>Yes</td>
</tr>
<tr>
<td>$Dp_2 - DP_g^*$</td>
<td>-2.60293</td>
<td>0.0117</td>
<td>Yes</td>
</tr>
<tr>
<td>$Dp_3 - DP_g^*$</td>
<td>-4.99775</td>
<td>0.0006</td>
<td>Yes</td>
</tr>
<tr>
<td>$Dp_4 - DP_g^*$</td>
<td>-5.03355</td>
<td>0.0000</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* At the 11% level.

Testing Demand Theory Hypotheses

We use the Demand Analysis Package, DAP2000 (Yang et al., 2000) and DEMMOD-3 (Barten et al., 1989) program to estimate the demand system given by (3.1).

Testing Demand Homogeneity

We now test the demand homogeneity hypothesis based on the estimation results of the demand systems using the Saudi Arabian meat and fish data. For testing homogeneity, there are two tests available. The Wald test which is an asymptotic $\chi^2$ test with $n_g - 1$ degrees of freedom and the other is a finite-sample test introduced by Laitinen (1978) based on Hotelling’s $T^2$ distribution which is also a constant $[(n_g-1)(T-n_g-2)/(T-2n_g)]$ multiple of the $F$ distribution with $n_g - 1$ and $T-2n_g$ degrees of freedom. From the estimation results, the Wald test statistic has a value of 1.12 with a critical value of $\chi^2(3,0.05) = 7.82$, indicating that homogeneity is acceptable by the data. Furthermore, Laitinen’s finite sample test statistic takes the value of 0.33, which is less than the critical value of $F(3,17) = 3.20$, leading to the acceptance of the homogeneity hypothesis. Therefore, both the asymptotic and finite-sample tests support demand homogeneity.

Testing Slutsky Symmetry
For testing symmetry, we use asymptotic $\chi^2$ test with $q = \frac{1}{2}(n_g - 1)(n_g - 2)$ degrees of freedom (see Theil, 1971, for details). The value of the test statistic for testing symmetry is 4.48 with a critical value of $\chi^2(3,0.05) = 7.82$, indicating that the symmetry is acceptable at the 5 per cent level of significance. Therefore, we conclude that the homogeneity and symmetry hypotheses are both generally acceptable and in the remaining sections of the paper, we consider models with homogeneity and symmetry imposed.

**Testing Preference Independence**

Now we test for the preference independent utility structure among the meat group. Preference independence means that the marginal utility of commodity $i$ is independent of commodity $j$ for $i \neq j$. Under preference independence, the Slutsky coefficients take the form $\pi_{ij} = \phi \eta_g \delta_{ij}(\delta_{ij} - \delta_j)$, where $\phi$ is the reciprocal of the income elasticity of the marginal utility; $\eta_g$ is the income elasticity of the group; and $\delta_{ij}$ is the Kronecker delta. With the substitution of $\pi_{ij}$, the Rotterdam demand model in equation (3.1) takes the form,

$$
\bar{w}_{it} Dq_{it} = \alpha_i + \hat{\theta}_i DQ_{gt} + \phi \eta_g \hat{\theta}_i (Dp_{it} - DP_{gt}) + \epsilon_{it}, \quad i=1, \ldots, n_g.
$$

(3.6)

where $DP_{gt} = \sum_{i=1}^{n_g} \hat{\theta}_i Dp_{it}$. is the Frisch price index of the group. We test for preference independence using a likelihood ratio (LR) test as well as the Monte Carlo simulation method described in Selvanathan (1987). For the LR test, the test statistic has an asymptotic $\chi^2$ distribution with degree of freedom, $[\frac{1}{2}n_g(n_g-1)-1]$. The data-based value of the test statistic for the LR test is 1.31 with a critical value of of $\chi^2(5,0.05) = 11.07$, indicating that the preference independence hypothesis is also supported by the data. If we use the Monte Carlo simulation method in order to check the validity of the asymptotic test using 999 simulations, if the rank of the test statistic is 995, 996, 997, 998 or 999, we reject the null hypothesis. The rank of the data-based value of the test statistic is found to be 33. This means that at the 5 per cent level of significance, we are unable to reject the preference independent structure of the meat group.

Therefore, we conclude that the homogeneity, symmetry and preference independence hypotheses are all acceptable for the Saudi Arabian meat data. In the next section, we estimate the Rotterdam demand model (3.6) and use the estimation results to obtain the implied demand elasticity from the Rotterdam demand system under preference independence.
6.4 Estimation Results and Implied Elasticity

Table 6.3 presents the estimation results from the Rotterdam demand system under preference independence. As can be seen, the signs of the constant terms indicate that there is an autonomous trend away from lamb to beef, chicken and fish. All the marginal shares are positive as they should be, and all are statistically significant. The marginal shares are 0.11 for beef, 0.15 for chicken, 0.62 for lamb and 0.12 for fish. These numbers indicate that if a consumer spends an additional dollar on meat, in that extra dollar, 11 cents will be allocated to beef, 15 cents to chicken, 62 cents to lamb and the remaining 12 cents to purchase fish.

<table>
<thead>
<tr>
<th>Item, $i$</th>
<th>Constant ($a_i \times 100$)</th>
<th>Income coefficient ($\theta_i$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>0.089</td>
<td>0.111*</td>
</tr>
<tr>
<td></td>
<td>(0.358)</td>
<td>(0.046)</td>
</tr>
<tr>
<td>Chicken</td>
<td>0.497</td>
<td>0.145*</td>
</tr>
<tr>
<td></td>
<td>(0.466)</td>
<td>(0.059)</td>
</tr>
<tr>
<td>Lamb</td>
<td>-0.787</td>
<td>0.621*</td>
</tr>
<tr>
<td></td>
<td>(0.680)</td>
<td>(0.086)</td>
</tr>
<tr>
<td>Fish</td>
<td>0.200</td>
<td>0.123*</td>
</tr>
<tr>
<td></td>
<td>(0.208)</td>
<td>(0.029)</td>
</tr>
</tbody>
</table>

Table 6.3: Estimation Results for Saudi Arabian Meat Data from 1985 to 2010 (Standard errors are in parentheses)

Table 6.4 presents the implied income and price elasticity given by (3.5) calculated from the demand model (3.6) estimates given in Table 6.4. As can be seen, the estimated income elasticity are 1.07 for beef, 0.48 for chicken, 1.27 for lamb and 1.19 for fish, respectively, indicating that chicken is a necessity and beef, lamb and fish are luxuries. All the own-price elasticity are less than one in absolute value, indicating that the demand for beef, chicken, lamb and fish is price inelastic.
### Table 6.4: Implied Income and Price Elasticity

<table>
<thead>
<tr>
<th>Item, i</th>
<th>Income elasticity</th>
<th>Price elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>Beef (2)</td>
</tr>
<tr>
<td>Beef</td>
<td>1.07</td>
<td>-0.204</td>
</tr>
<tr>
<td>Chicken</td>
<td>0.48</td>
<td>0.011</td>
</tr>
<tr>
<td>Lamb</td>
<td>1.27</td>
<td>0.030</td>
</tr>
<tr>
<td>Fish</td>
<td>1.19</td>
<td>0.028</td>
</tr>
</tbody>
</table>

#### 6.5 Policy-Related Issues

In Chapter 5, we noted that per capita chicken consumption has increased from 31.7 kg in 1985 to 39.9 kg in 2010, and per capita consumption of lamb has fallen from 29.3 kg in 1985 to 12.3 kg in 2010. During the same period we also found that the conditional budget share of chicken has increased from 22.6 per cent in 1985 to 33.8 per cent in 2010 while, during the same period, the share of lamb has declined from 56 per cent to 41 per cent. The above statistics clearly indicate that chicken sales have improved at the expense of declining lamb sales.

In this section we use the estimated results presented in 6.4 to analyse and explain the changes in the consumption patterns of beef, chicken, lamb and fish in Saudi Arabia, and to show how these estimation results can be used in policy related issues. Below, we present three such policy-related applications. The first application shows how to decompose the growth in beef, chicken, lamb and fish consumption in terms of autonomous trend, income, own-prices and cross-prices. The second application demonstrates how the change in budget shares of beef, chicken, lamb and fish can be decomposed in terms of autonomous trend, income, own-prices, cross prices and direct own relative prices. The third application shows how the consumption of beef, chicken, lamb and fish can be simulated under various economic policy scenarios. For these applications, we use the coefficient estimates presented in Tables 6.3 and 6.4, together with the consumption and price data.

**Growth in the meat and fish consumption and its components**

Now we divide both sides of demand system (3.1) by the budget share $\hat{w}_{it}$ to give,

$$Dq_{iti} = \alpha_{it}^* + \eta_{it}^*DQ_{igt} + \eta_{it}^*Dp_{it} + \sum_{j(i)=1}^{4} \eta_{ij}^*Dp_{jt} + e_{it}^*, \quad i=1,2,3,4; \quad t=1,...,T. \quad (5.1)$$
where $\alpha_{it}^* = \alpha_i / \bar{w}_{it}$ is the autonomous trend in consumption of item $i$ and $\eta_i$ and $\eta_{ij}$ are income and price elasticity defined in (3.5). Therefore, growth in consumption of item $i$ in each year can be decomposed into the following components,

Total growth in consumption of item $i$ ($Dq_{it}$) =

- autonomous trend component ($\alpha_{it}^*$)
- + income component ($\eta_i DQ_{gt}$)
- + own-price component ($\eta_{ii}^* Dp_{it}$)
- + cross-price component ($\sum_{j(t)}^{4} \eta_{ij}^* Dp_{jt}$)
- + residual component ($\varepsilon_{it}^*$).

Table 6.5 presents the decomposition of $Dq_{it}$ as per the above equation at sample means for beef, chicken, lamb and fish. Row 1 of the table reveals that on average, the total growth in beef consumption has declined at a rate of 0.7% per annum. This total growth is made up of the following: (1) autonomous trend, 0.86%; (2) income component, -1.56%; (3) own-price component -0.57%; (4) cross-price component, 0.64%; and the (5) residual component, -0.07%. The two components involving the own- and cross-prices almost cancel out, with a strong negative income component and a strong but less positive autonomous trend component as the two dominant components, resulting in a negative overall growth in beef consumption. For chicken, income (less negative) and autonomous trend (more positive) are the dominant components, which has resulted in a positive overall growth in chicken consumption. For lamb, the two negative dominant components are autonomous trend and income, resulting in a negative overall growth in lamb consumption. For fish, income (less negative) and autonomous trend (more positive) are the dominant components, resulting in a positive overall growth in fish consumption.
Table 6.5: Decomposition of Change in Consumption of Beef, Chicken, Lamb, and Fish, in Saudi Arabia from 1985 to 2010 (at sample means)

<table>
<thead>
<tr>
<th>Item, i</th>
<th>Total growth ((Dq_i))</th>
<th>Autonomous trend</th>
<th>Income</th>
<th>Own-price</th>
<th>Cross-price</th>
<th>Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>-0.700</td>
<td>0.857</td>
<td>-1.562</td>
<td>-0.567</td>
<td>0.640</td>
<td>-0.068</td>
</tr>
<tr>
<td>Chicken</td>
<td>0.930</td>
<td>1.648</td>
<td>-0.702</td>
<td>-0.185</td>
<td>0.287</td>
<td>-0.118</td>
</tr>
<tr>
<td>Lamb</td>
<td>-3.490</td>
<td>-1.604</td>
<td>-1.847</td>
<td>-0.374</td>
<td>0.227</td>
<td>0.108</td>
</tr>
<tr>
<td>Fish</td>
<td>0.290</td>
<td>1.927</td>
<td>-1.730</td>
<td>-0.415</td>
<td>0.729</td>
<td>-0.221</td>
</tr>
</tbody>
</table>

Decomposition in the change in the budget shares

In finite changes, the budget share, \(w_{it} = \frac{p_{it}q_{it}}{M_{gt}}\), can be expressed as (see Clements and Johnson, 1983)

\[
\Delta w_{it} = \Delta w_{it}^I Dq_{it} + \Delta w_{it}^D (Dp_{it} - DP_{gt}) - \Delta w_{it}^Q DQ_{gt} + \alpha_3, \quad i=1,2,3,4; t=1,…,T. \tag{5.2}
\]

where \(\Delta w_{it} = (w_{it} - w_{i,t-1})\); \(DQ_{gt} + DP_{gt} = DM_{gt}\) and \(\alpha_3\) is a remainder term of the third degree (see Theil, 1975/76, pp 37-40 and 215). If we substitute for \(\Delta w_{it} Dq_{it}\) from equation (3.1), equation (6.8) becomes,

\[
\Delta w_{it} = \alpha_i + (\theta_i - \pi_i)DQ_{gt} + \sum_{j=1}^{4} \pi_{ij} Dp_{jt} + \Delta w_{it}^D (Dp_{it} - DP_{gt}) + \alpha_3 + \epsilon_{it}, \quad i=1,2,3,4; t=1,…,T. \tag{5.3}
\]

Equation (5.3) shows that the change in budget share of item \(i\) can be decomposed into the following components, namely, (1) autonomous trend component, \(\alpha_i\); (2) income component, \((\theta_i - \pi_i)DQ_{gt}\); (3) own price components, \(\pi_{ij} Dp_{jt}\); (4) cross price component, \(\sum_{j(x \neq i)} \pi_{ij} Dp_{jt}\); and (5) direct relative price component, \(\Delta w_{it}^D (Dp_{it} - DP_{gt})\); and the residual component.

The estimated values of these components at sample means are presented in Table 8. Looking at the first row of the table, on average, the budget share of beef has increased by 0.074 percentage points per annum. The major contributors for this increase are the shift in consumer preferences towards beef (0.089%) and an increase in the price of lamb (0.041%); its own price increase had a negative effect (-0.059%), income (0.01%), prices of chicken (0.01%) and fish (0.01%), and direct relative price (-0.01%). On average, the
budget share of chicken has increased by 0.448 percentage points per annum. The major contributors for this increase are the shift in consumer preferences (0.497%), income (0.229%) and increase in the price of lamb (0.041%); its own price (-0.056%) and direct relative price (-0.235%) worked against the increase in the budget share. On average, the budget share of lamb has fallen by 0.612 percentage points per annum. The major contributors to this fall are the shift in consumer preferences (-0.787%), income (-0.190%) and an increase in its own price (-0.183%); increase in the price of beef (0.053%), chicken (0.069%) and fish (0.059%) and the direct relative price (0.368%). For fish, on average, the budget share has increased by 0.091 percentage points per annum. While the shift in consumer preferences (0.200%) contributed positively to the growth, its own price (-0.043%) and the direct relative price (-0.106%) worked against the growth in the budget share of fish.

Table 6.6: Decomposition of Changes in Budget Shares of Beef, Chicken, Lamb and Fish in Saudi Arabia from 1985 to 2010 (at sample means)

<table>
<thead>
<tr>
<th>Item, i</th>
<th>Change in the budget share of item i, ( \Delta w_i \times 100 )</th>
<th>Trend</th>
<th>Income</th>
<th>Price substitution</th>
<th>Direct relative</th>
<th>Residuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>0.074</td>
<td>0.089</td>
<td>-0.010</td>
<td>-0.059</td>
<td>0.010</td>
<td>0.008</td>
</tr>
<tr>
<td>Chicken</td>
<td>0.448</td>
<td>0.497</td>
<td>0.229</td>
<td>0.007</td>
<td>-0.056</td>
<td>0.041</td>
</tr>
<tr>
<td>Lamb</td>
<td>-0.612</td>
<td>-0.787</td>
<td>-0.190</td>
<td>0.053</td>
<td>-0.183</td>
<td>0.059</td>
</tr>
<tr>
<td>Fish</td>
<td>0.091</td>
<td>0.200</td>
<td>-0.028</td>
<td>0.005</td>
<td>0.007</td>
<td>0.031</td>
</tr>
</tbody>
</table>

**Why has chicken consumption grown while lamb consumption declined?**

Now we simulate beef, chicken, lamb and fish consumption under different scenarios to isolate the key factors that are responsible for the growth in chicken consumption and decline in lamb consumption. It is an interesting policy issue to investigate what happens to the consumption of beef, chicken, lamb and fish. For example, (a) if consumer preferences didn’t change (that is, each constant term, \( \alpha_{ij}^* \), in demand equation (5.1) is equal to 0); (b) if total consumption of the meat and fish group does not grow; (that is, \( DQ_{gt}^s = 0 \) for any period t); and (c) if total consumption of the meat and fish group grew at a fixed rate of -1% instead of the actual average growth rate of -1.5% shown in chapter 5 (that is, \( DQ_{gt}^s = -0.01 \) for any period t).

**What if consumer preferences did not change?**

Considering the demand equation (5.1), which we reproduce here,
\[ D_{it} = \alpha_{it}^* + \eta_t DQ_{gt} + \sum_{j=1}^{4} \eta_{ij}^t Dp_{jt} + \varepsilon_{it}^* \quad i=1,2,3,4; \quad t=1,\ldots,T. \] 

(5.4)

If the simulated consumption log-change corresponding to scenario (a) that there is no change in consumer preference is \( Dq_{it}^s \), then,

\[ Dq_{it}^s = 0 + \eta_t DQ_{gt} + \sum_{j=1}^{4} \eta_{ij}^t Dp_{jt} + \varepsilon_{it}^* \quad i=1,2,3,4; \quad t=1,\ldots,T. \] 

(5.5)

Therefore, from equations (5.4) and (5.5), we get,

\[ Dq_{it}^s = Dq_{it} - \alpha_{it}^* \quad i=1,2,3,4; \quad t=1,\ldots,T. \] 

(5.6)

Next, using (5.6), we calculate the simulated consumption by converting changes to levels,

\[ q_{it}^s = q_{i,t-1}^s \exp(Dq_{it}^s) \text{ with } q_{i,1985}^s = q_{i,1985} \quad i=1,2,3,4; \quad t=1,\ldots,T. \] 

(5.7)

The simulated consumptions for beef, chicken, lamb and fish, using equations (5.6) and (5.7) together with the estimates of the \( \alpha_i \)'s from Table 6.5 are presented in columns (6)-(9) of Table 9. For comparison, the actual consumption is also presented in columns (2)-(5) of the same table. Looking at columns (6)-(9) of the table, it can be seen that the simulated per capita consumption of beef, chicken, lamb and fish for the year 2010 are 4.14 kg, 26.01 kg, 18.48 kg and 3.70 kg, respectively. Accordingly, the shift in consumer preferences causes beef consumption to be about \((4.14-5.15)/4.14 = 24.4\) per cent higher than otherwise, chicken to be \((26.01-39.94)/26.01 = 53.6\) per cent higher than otherwise, lamb to be \((18.48-12.26)/18.48 = 33.7\) per cent lower than otherwise and fish to be \((3.70 - 6.06)/3.70 = 63.7\) per cent higher than otherwise.

What if total meat and fish consumption does not grow?
If the simulated consumption log-change corresponding to the scenario (b) that no change in total meat and fish consumption shown in Chapter 5 (that is, \( DQ_{gt} = 0 \)) is \( Dq_{it}^s \) then,

\[
Dq_{it}^s = \alpha_{it}^* + 0 + \sum_{j=1}^{4} \eta_{ij} Dp_{jt} + \varepsilon_{it}^*, \quad i=1,2,3,4; \ t=1,\ldots,T.
\]  

(5.8)

Therefore from (10) and (14) we get,

\[
Dq_{it}^s = Dq_{it} - \eta_{t} DQ_{gt} \quad i=1,2,3,4; \ t=1,\ldots,T.
\]  

(5.9)

We evaluate the simulated consumption as before, using equations (5.7) and (5.9). Columns (10)-(13) of Table 6.7 present the simulated consumption. As can be seen, the simulated per capita consumption of beef, chicken, lamb and fish for the year 2010 are 7.62 kg, 47.63 kg, 19.48 kg and 9.35 kg, respectively. Accordingly, zero growth in total meat and fish consumption would have caused beef consumption to be about \((7.62-5.15)/7.62 = 32.4\) per cent higher than otherwise, chicken to be \((47.63-39.94)/47.63 = 16.1\) per cent higher than otherwise, lamb to be \((19.48-12.26)/19.48 = 37\) per cent higher than otherwise and fish to be \((9.35 - 6.06)/9.35 = 35.2\) per cent higher than otherwise.
## Table 6.7: Actual and Simulated Consumption of Beef, Chicken, Lamb and Fish in Saudi Arabia from 1985 to 2010

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual consumption</th>
<th>Simulated consumption with no preference</th>
<th>Simulated consumption with total meat and fish group growth rate = 0%</th>
<th>Simulated consumption with total meat and fish group growth rate = -1%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beef (2) Chicken (3) Lamb (4) Fish (5)</td>
<td>Beef (6) Chicken (7) Lamb (8) Fish (9)</td>
<td>Beef (10) Chicken (11) Lamb (12) Fish (13)</td>
<td>Beef (14) Chicken (15) Lamb (16) Fish (17)</td>
</tr>
<tr>
<td>1985</td>
<td>6.14 31.69 29.34 5.63</td>
<td>6.14 31.69 29.34 5.63</td>
<td>6.14 31.69 29.34 5.63</td>
<td>6.14 31.69 29.34 5.63</td>
</tr>
<tr>
<td>1986</td>
<td>5.84 30.26 29.78 5.20</td>
<td>5.79 29.58 30.19 5.10</td>
<td>5.94 30.48 30.35 5.29</td>
<td>5.88 30.33 29.97 5.23</td>
</tr>
<tr>
<td>1987</td>
<td>5.56 31.86 30.64 5.18</td>
<td>5.47 30.44 31.49 4.98</td>
<td>5.52 31.75 30.35 5.13</td>
<td>5.40 31.44 29.59 5.01</td>
</tr>
<tr>
<td>1988</td>
<td>5.15 32.02 26.06 5.37</td>
<td>5.02 29.91 27.15 5.07</td>
<td>5.67 33.42 29.17 5.97</td>
<td>5.49 32.94 28.08 5.76</td>
</tr>
<tr>
<td>1989</td>
<td>4.22 30.01 22.40 3.80</td>
<td>4.06 27.46 23.66 3.51</td>
<td>5.46 33.71 30.42 5.06</td>
<td>5.23 33.07 28.92 4.83</td>
</tr>
<tr>
<td>1990</td>
<td>4.54 31.08 21.00 3.56</td>
<td>4.34 27.88 22.49 3.20</td>
<td>6.05 35.35 29.48 4.89</td>
<td>5.74 34.51 27.67 4.61</td>
</tr>
<tr>
<td>1991</td>
<td>5.51 33.24 19.66 4.32</td>
<td>5.22 29.23 21.35 3.80</td>
<td>7.19 37.47 26.94 5.80</td>
<td>6.75 36.41 24.97 5.41</td>
</tr>
<tr>
<td>1992</td>
<td>5.37 28.20 16.88 4.13</td>
<td>5.05 24.31 18.60 3.55</td>
<td>8.05 33.83 27.22 6.46</td>
<td>7.47 32.71 24.92 5.95</td>
</tr>
<tr>
<td>1993</td>
<td>3.65 26.28 20.43 4.23</td>
<td>3.41 22.18 22.84 3.56</td>
<td>5.19 30.81 31.04 6.26</td>
<td>4.77 29.64 28.05 5.69</td>
</tr>
<tr>
<td>1994</td>
<td>3.67 24.29 17.97 3.05</td>
<td>3.40 20.06 20.35 2.51</td>
<td>5.94 30.16 31.75 5.20</td>
<td>5.40 28.89 28.33 4.67</td>
</tr>
<tr>
<td>1995</td>
<td>4.91 31.54 18.69 4.91</td>
<td>4.51 25.54 21.48 3.94</td>
<td>6.69 36.25 26.96 6.92</td>
<td>6.01 34.55 23.76 6.15</td>
</tr>
<tr>
<td>1997</td>
<td>2.94 33.36 15.65 4.89</td>
<td>2.65 26.07 18.54 3.77</td>
<td>4.59 40.76 26.52 8.01</td>
<td>4.04 38.47 22.78 6.95</td>
</tr>
<tr>
<td>1998</td>
<td>3.79 36.35 14.00 4.92</td>
<td>3.39 27.96 16.86 3.72</td>
<td>5.93 44.42 23.72 8.06</td>
<td>5.16 41.73 20.12 6.91</td>
</tr>
<tr>
<td>1999</td>
<td>3.70 34.28 14.76 4.45</td>
<td>3.28 25.98 18.09 3.30</td>
<td>5.84 42.06 25.28 7.37</td>
<td>5.02 39.32 21.18 6.24</td>
</tr>
<tr>
<td>2000</td>
<td>3.42 39.27 15.19 4.54</td>
<td>3.00 29.35 18.94 3.30</td>
<td>5.07 46.90 24.22 7.03</td>
<td>4.32 43.63 20.04 5.88</td>
</tr>
<tr>
<td>2001</td>
<td>2.43 41.00 13.06 4.34</td>
<td>2.11 30.26 16.59 3.09</td>
<td>3.92 50.85 23.01 7.37</td>
<td>3.31 47.08 18.79 6.10</td>
</tr>
<tr>
<td>2002</td>
<td>3.82 37.04 17.59 4.33</td>
<td>3.27 26.97 22.72 3.02</td>
<td>5.33 43.03 26.09 6.27</td>
<td>4.44 39.65 21.05 5.12</td>
</tr>
<tr>
<td>2003</td>
<td>3.22 40.51 15.12 4.54</td>
<td>2.74 29.07 19.86 3.10</td>
<td>4.75 48.23 23.92 6.98</td>
<td>3.92 44.23 19.05 5.64</td>
</tr>
<tr>
<td>2004</td>
<td>3.95 38.66 14.96 5.24</td>
<td>3.32 27.37 20.00 3.52</td>
<td>5.74 45.75 23.29 7.93</td>
<td>4.69 41.75 18.31 6.33</td>
</tr>
<tr>
<td>2005</td>
<td>4.20 43.21 16.87 5.58</td>
<td>3.49 30.16 22.97 3.69</td>
<td>5.45 48.63 23.01 7.46</td>
<td>4.40 44.17 17.87 5.89</td>
</tr>
<tr>
<td>2006</td>
<td>5.18 40.38 14.72 5.68</td>
<td>4.28 27.79 20.42 3.69</td>
<td>7.15 46.67 21.53 8.11</td>
<td>5.71 42.18 16.51 6.32</td>
</tr>
<tr>
<td>2008</td>
<td>5.47 40.56 12.72 5.58</td>
<td>4.45 27.16 18.38 3.52</td>
<td>7.95 48.01 19.81 8.45</td>
<td>6.22 42.98 14.81 6.43</td>
</tr>
<tr>
<td>2009</td>
<td>5.59 39.87 12.12 5.66</td>
<td>4.52 26.34 17.89 3.51</td>
<td>8.30 47.63 19.33 8.77</td>
<td>6.42 42.44 14.27 6.60</td>
</tr>
<tr>
<td>2010</td>
<td>5.15 39.94 12.26 6.06</td>
<td>4.14 26.01 18.48 3.70</td>
<td>7.62 47.63 19.48 9.35</td>
<td>5.83 42.24 14.20 6.95</td>
</tr>
<tr>
<td>Mean</td>
<td><strong>4.46</strong> 34.88 18.28 4.82</td>
<td><strong>4.02</strong> 27.35 21.59 3.73</td>
<td><strong>6.06</strong> 40.35 25.86 6.87</td>
<td><strong>5.30</strong> 37.81 22.45 5.87</td>
</tr>
</tbody>
</table>
What if total meat and fish consumption grew at a rate of -1%?

If the simulated consumption log-change corresponding to scenario (c) that the rate of growth in total consumption of the meat and fish group is a fixed -1% per annum instead of the observed average of -1.5% shown in Chapter 5 (that is, \(DQ_{gt} = -0.01\)) is \(Dq_{it}^s\), then,

\[Dq_{it}^s = \alpha_i^s + \eta_i (-0.01) + \sum_{j=1}^{4} \eta_{ij} Dp_{jt} + \epsilon_{it}^s, \quad i=1,2,3,4; \quad t=1,\ldots,T. \tag{5.10}\]

Therefore, from (10) and (16), we get,

\[Dq_{it}^s = Dq_{it} - \eta_i^s (0.01 + DQ_{gt}) \quad \quad i=1,2,3,4; \quad t=1,\ldots,T. \tag{5.11}\]

We evaluate the simulated consumption as before using equations (13) and (17). Columns (14)-(17) of Table 6.7 present the simulated consumption. As can be seen, the simulated per capita consumption of beef, chicken, lamb and fish for the year 2010 is 5.83 kg, 42.24 kg, 14.20 kg and 6.95 kg, respectively. Accordingly, if growth in the total meat and fish consumption fixed at a rate of -1% per annum, that would have caused beef consumption to be about \((5.83-5.15)/5.83 = 11.6\) per cent higher than otherwise, chicken to be \((42.24-39.94)/42.24 = 5.7\) per cent higher than otherwise, lamb to be \((14.20-12.26)/14.20 = 15.7\) per cent higher than otherwise and fish to be \((6.95-6.06)/6.95 = 14.7\) per cent higher than otherwise.

### 6.6 Conclusions

In this chapter, we analysed the demand for beef, chicken, lamb and fish in Saudi Arabia using data for the period 1985 to 2010 under a system-wide approach. We reviewed a number of previous studies on meat and fish demand in a number of countries, where a majority of the population are Muslims. The results revealed that in these countries, generally, beef and fish are considered as necessities and mutton and chicken are luxuries. The demand for beef and fish is price inelastic while that of mutton and chicken is price elastic.

We tested the homogeneity, symmetry and preference independence hypotheses and found all three hypotheses were supported by the Saudi meat and fish data. Estimated results revealed that there was an autonomous trend away from lamb to beef, chicken and fish. If Saudi consumers have the opportunity to spend another SR on meat and fish they
would allocate 11.1 cents on beef, 14.5 cents on chicken, 62.1 cents on lamb and the remaining 12.3 cents on fish.

We also found the income elasticity of beef (1.07), chicken (0.48), lamb (1.27) and fish (1.19), indicating that chicken is a necessity and beef, lamb and fish are considered as luxuries by Saudi consumers. All the own-price elasticity estimates are less than one in absolute value, indicating that the demand for beef, chicken, lamb and fish are price inelastic. These income and price elasticity estimates are useful to Saudi officials to set various tax policies on these products. Using the income and price elasticity estimates, we simulated per capita consumption of beef, chicken, lamb and fish under various policy scenarios. Simulation results show that change in consumer taste had played a significant role in Saudi Arabians’ meat and fish consumption, where consumers shifted their preferences mostly from lamb to chicken during the last two decades.
Chapter 7
Food Security and Import Demand for Meat

7.1 Introduction

It is clear from the preceding chapters that the Saudi meat industry will make major contribution to the food security of this nation in the future. Food security is one of the critical services that a government must deliver, not only for the present, but also for the future under all conditions, those induced by nature or by humans. Food security generally comprises quantity, content, quality of food standards and customer preferences. Food can be grown nationally, internationally, purchased or contracted. Furthermore, food can be fresh, prepared, dried, frozen or manufactured.

This chapter analyses the food issues for three types of meat (beef, lamb and chicken) when geographic conditions largely prevent the nations of the Arabian Peninsula, predominantly Saudi Arabia, from growing sufficient food to feed its people. Table 7.1 presents the major foods imported by Saudi Arabia. Among the food imports, chicken is ranked 3rd and beef and veal are ranked 12th.
Table 7.1: Saudi Arabia’s Food Imports by Commodity, 2011

<table>
<thead>
<tr>
<th>Rank</th>
<th>Commodity</th>
<th>Quantity (tonnes)</th>
<th>Value ($'000)</th>
<th>Unit value ($/tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rice</td>
<td>1258730</td>
<td>1302670</td>
<td>1035</td>
</tr>
<tr>
<td>2</td>
<td>Barley</td>
<td>5960240</td>
<td>1258650</td>
<td>211</td>
</tr>
<tr>
<td>3</td>
<td>Chicken meat</td>
<td>554709</td>
<td>1008940</td>
<td>1819</td>
</tr>
<tr>
<td>4</td>
<td>Cigarettes</td>
<td>28101</td>
<td>513490</td>
<td>18273</td>
</tr>
<tr>
<td>5</td>
<td>Maize</td>
<td>1544640</td>
<td>377929</td>
<td>245</td>
</tr>
<tr>
<td>6</td>
<td>Food Prepared</td>
<td>55752</td>
<td>375041</td>
<td>6727</td>
</tr>
<tr>
<td>7</td>
<td>Wheat</td>
<td>1300920</td>
<td>373141</td>
<td>287</td>
</tr>
<tr>
<td>8</td>
<td>Sugar raw</td>
<td>848214</td>
<td>367401</td>
<td>433</td>
</tr>
<tr>
<td>9</td>
<td>Palm oil</td>
<td>316570</td>
<td>297849</td>
<td>941</td>
</tr>
<tr>
<td>10</td>
<td>Infant food</td>
<td>22805</td>
<td>288465</td>
<td>12649</td>
</tr>
<tr>
<td>11</td>
<td>Processed cheese</td>
<td>49203</td>
<td>257427</td>
<td>5232</td>
</tr>
<tr>
<td>12</td>
<td>Meat-Cattle boneless (beef &amp; veal)</td>
<td>76138</td>
<td>207362</td>
<td>2724</td>
</tr>
<tr>
<td>13</td>
<td>Cake of soybeans</td>
<td>448964</td>
<td>186384</td>
<td>415</td>
</tr>
<tr>
<td>14</td>
<td>Milk white dried</td>
<td>47095</td>
<td>169602</td>
<td>3601</td>
</tr>
<tr>
<td>15</td>
<td>Oranges</td>
<td>303642</td>
<td>167859</td>
<td>553</td>
</tr>
<tr>
<td>16</td>
<td>Chocolate Prunes</td>
<td>25480</td>
<td>162986</td>
<td>6397</td>
</tr>
<tr>
<td>17</td>
<td>Sheep meat</td>
<td>47687</td>
<td>159289</td>
<td>3340</td>
</tr>
<tr>
<td>18</td>
<td>Tea</td>
<td>20331</td>
<td>153783</td>
<td>7564</td>
</tr>
<tr>
<td>19</td>
<td>Sugar refined</td>
<td>292333</td>
<td>145739</td>
<td>499</td>
</tr>
<tr>
<td>20</td>
<td>Bananas</td>
<td>252375</td>
<td>135396</td>
<td>536</td>
</tr>
</tbody>
</table>

Note 5: International monetary value

Source: Food and Agricultural Organisation, 2012

7.2 Prospects for Meat Consumption

Rising food imports by Saudi Arabia in recent years are of major concern. Saudi Arabia’s poultry consumption had grown by about 5 per cent annually by 2011. In total, poultry meat consumption was estimated at about 1.3m tonnes, with per-capita consumption reaching about 47 kg per year (The Poultry Site, 2012). Saudi requirements for the import of chicken are that birds are fed with vegetable-origin feed and are hormone-free. This very much restricts supplies. In 2011, The Poultry Site, (2012) reported that Saudi poultry was sourced mainly from Brazil (623,000 tonnes) and France (149,000 tonnes). Domestic production has not maintained pace with demand. In 2007, the total poultry production was estimated at 490,400 tonnes, about half of the demand, and in 2011, Saudi poultry production declined to 420,000 tonnes, or one-third of the market’s needs, while 780,000 tonnes were imported. Whilst the Saudi government’s policy objective is to encourage an increase in self-sufficiency in poultry production, price competition from imported supplies necessitates government subsidies for poultry feed ingredients, plant and equipment, and packaging and cold storage facilities. Saudi Arabia does not yet have adequate infrastructure to support additional food production (The Poultry Site, 2012).
Sheep meat imports in Saudi Arabia are shown in Table 7.2 below:

<table>
<thead>
<tr>
<th>Country</th>
<th>Quantity Tonnes</th>
<th>Value $US ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>22,092</td>
<td>95</td>
</tr>
<tr>
<td>New Zealand</td>
<td>18,693</td>
<td>86</td>
</tr>
<tr>
<td>India</td>
<td>8,331</td>
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<tr>
<td>Pakistan</td>
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<td>34</td>
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<tr>
<td>Ethiopia</td>
<td>5,010</td>
<td>24</td>
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<tr>
<td>Other areas</td>
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<td>6</td>
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</table>

Source: APEDA AgriXchange (2012).

Cattle imports are also growing, with an estimate of 9 million head for 2013, an increase of more than 1 million from 2012 (Al-Abyad, 2013). The Saudi market needs about 7.8 million head of cattle per year, including during the Hajj and Ramadan periods, with meat consumption in the month of Ramadan alone amounting to 3 million head. Cattle are sourced from suppliers in Djibouti, Somalia and Sudan, and cattle are inspected offshore and quarantined upon arrival in Jeddah.

### 7.3 Future Meat Production, Imports and Consumption Trends

Beef, lamb and chicken were the meat sources selected for this analysis. Each of these meat items are discussed below.

#### 7.3.1 Beef

Production

The early 1994 increase in beef production (30,000 tonnes) was partly due to priority given to domestic production, which declined by 9,000 tonnes in 1999; and then rose again to 44,000 tonnes in 2010. This was due to investments by the private sector and government support. The projection for beef production shows that production will again fall by 3,000 tonnes by the year 2025 (Table 7.3).

Imports

Saudi Arabian beef imports remained roughly constant at 55,000 tonnes up to 1987, dropped to 41,000 tonnes in 1990 and then increased to 63,000 tonnes by 1992. The imports dropped to 35,000 tonnes in the next two years, then returned to 63,000 tonnes by 1995. Beef imports decreased from 63,000 tonnes in 1995, to 49,000 tonnes in 2003.
and then grew to 101,000 tonnes in 2006. Since then imports decreased to 98,000 tonnes until 2010, and the projection further shows imports gradually increasing to 114,000 tonnes in 2025. The unstable trend of beef imports over the years may be reflected in changes in the oil price. The increasing population and demand for beef would contribute to an increase in beef imports in the next two decades (Table 7.3).

Consumption

The consumption of beef has decreased from 73,000 tonnes in 1985 to 69,000 tonnes in 1990. Beef consumption dropped to 63,000 tonnes in 1993, and then increased to 89,000 tonnes in 1995. Since then it has dropped to 51,000 tonnes up to 2001, increased next year (2002) to 82,000 tonnes, and then again dropped up to 71,000 tonnes in 2003. Consumption grew between 2004 and 2009 to 149,000 tonnes, and then decreased substantially in 2010 to 142,000 tonnes. The unstable trend of beef consumption over the years may be reflecting several factors, including the Gulf War, urbanization, an increase in population and a shift in consumption patterns to meat and meat products. From 2011, projections show the consumption of beef is expected to increase gradually until 2025, when it will reach 155,000 tonnes (Table 7.3).

Figure 7.1: Beef Production, Imports and Consumption in Saudi Arabia, 1985-2010
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<th>Beef Import</th>
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7.3.2 Lamb

Production
As can be seen, in Table 7.4, the domestic production of lamb increased gradually to the tune of 16,000 tonnes from 1985 to 1989, then dropped to 6,000 tonnes in 1991. Production increased by an annual average of 10,000 tonnes by 1994 and dropped by an annual average of 1,000 tonnes by 1996. The production of lamb rose by 3,000 tonnes the following year and dropped again by an annual average of 2,000 tonnes in 1998. Lamb production then grew again by 10,000 tonnes by 2011 and dropped by 5,000 tonnes in 2006. The unstable trend of lamb production may be related to the fact that Saudi Arabia is primarily a desert land with high humidity and temperatures throughout the country. These conditions are not suitable for grazing lamb. The expected lamb production in the next two decades will be increased to 27,000 tonnes by 2025, and this is due to the growth of the population in the future (Table 7.4).

Imports
Saudi Arabian lamb import increased from 280,000 tonnes to 323,000 tonnes to 1987 and then gradually dropped in most years. The projections show that a drop in imports will continue to 2025. This is due to a dispute on slaughtering processes adopted by the trading partners. This may possibly cause the termination of contracts or business relationships with other countries, and therefore, decrease imports of lamb to Saudi Arabia (Table 7.4).

Consumption
The consumption of lamb increased from 349,000 tonnes to 402,000 tonnes by the year 1987. Consumption is expected to drop to 329,000 tonnes by the year 2025. The reduction in lamb consumption may be due to the fact that the Saudi market has recently responded more favourably towards white meats such as poultry (Table 7.4).
Table 7.4: Lamb Production, Imports and Consumption, 1985-2010 ('000 tonnes)

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<th>Consumption</th>
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7.3.3 Chicken

Production

As can be seen in Table 7.5, the production of chicken increased gradually to a total of 239,000 tonnes from 1985 to 1998, then dropped by 65,000 tonnes in 1999. Production increased by 178,000 tonnes in 2006 and then dropped by 112,000 tonnes in 2010. Saudi Arabian poultry production is growing strongly, but a clear decline in chicken production may be due to financial losses from poultry disease outbreaks. It is expected that production of chicken will increase by 304,000 tonnes by 2025.

Imports

Saudi Arabian chicken imports increased from 181,000 tonnes to 213,000 tonnes to 1992, then dropped to 154,000 tonnes in 1994. The reduction in Saudi chicken imports may be due to a decreased demand from food caterers because of an anticipated reduced number of pilgrims and higher domestic production. Imports are expected to grow to 829,000 tonnes by 2025, which may be due to an increase in the number of pilgrims expected due to the relaxation of visa requirements in the future (Table 7.5).
Consumption

The consumption of chicken has increased by between 377,000 tonnes and 531,000 tonnes per year up to 1991. Consumption then dropped to 430,000 tonnes by the year 1994. Consumption is expected to grow further to the tune of 1,558,000 tonnes by the year 2025. An increase in chicken consumption may be due to affordable prices and the perception that chicken meat is healthier compared to red meat, annual population growth and an increase in the number of pilgrims (Table 7.5).

Figure 7.3: Chicken Production, Imports and Consumption in Saudi Arabia, 1985-2010
Table 7.5: Chicken Production, Imports and Consumption, 1985-2010 ('000 tonnes)

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<td>793</td>
<td>1495</td>
</tr>
<tr>
<td></td>
<td>2024</td>
<td>717</td>
<td>811</td>
<td>1526</td>
</tr>
<tr>
<td></td>
<td>2025</td>
<td>730</td>
<td>829</td>
<td>1558</td>
</tr>
</tbody>
</table>
7.4 Import Demand for Meat

7.4.1 Introduction

This section presents the import demand analysis for meat, namely beef, lamb and chicken in Saudi Arabia. The aim is to investigate factors determining the short run demand and supply of meat, focusing on the relationship between domestic supply and imports. An analysis of the impact of government assistance on import demand and domestic production is also attempted in this section.

Generally, the import demand works as a function of income, prices and relevant supply and demand shifters (Hossain and Morris, 1988). In the meat sector, the demand shifters in Saudi Arabia are largely influenced by the government, which plays an important role in increasing the domestic market share of meat through local production. It also takes into account tariffs and non-tariff barriers which may lead to a negative impact on the import demand of meat in the short run.

7.4.2 Theoretical Framework

The theoretical approach adopted in this part of the thesis is based on the ‘excess demand’ theory as used by Mitchell (1985) and Hossain and Morris (1988). To illustrate the ‘excess demand’ Mitchell (1985) makes a number of assumptions:

The importing country is sufficiently small so that its decisions do not affect world price.

a. Imports and domestic goods are effectively perfect substitutes.

b. There are no trade barriers.

c. The supply of imports is perfectly elastic at a given price, and the demand for imports can be taken as an excess demand schedule.

One of the implications of the above assumptions is that, in order for domestic producers to survive, domestic prices must equal world prices (ignoring transport and other such costs). Assumption 2 is required because if the imported good is not a substitute for the domestically produced good, no amount of change in domestic production will affect the demand for imports; whereas if the imported and domestic good are identical, they are perfect (product) substitutes and a unit of imported good will exactly offset a unit of domestically produced good (Mitchell 1985).
The domestic demand and supply schedules in the absence of policy intervention (assumption 3), are shown in Figure 7.4A as D and S respectively. The difference between D and S at any price below the domestic equilibrium price $P_1$ is the excess demand schedule. $D_E$ in Figure 7.4B – is the demand for imports. Thus, at a world price $P_W$ below $P_1$, domestic demand exceeds domestic supply, and as a result imports are needed to satisfy domestic demand (Mitchell, 1985).

The above framework needs to be modified for the specific market conditions faced by Saudi meat producers, because of deviations from the assumption outlined above. So, assumption 1 holds. Assumption 2 does not hold; imported products are not perfect substitutes for domestic products, with the result that domestic prices, $P_D$, deviate from world prices $P_W$ (Figure 7.5). The demand curve, $D_D$, for domestically produced goods interacts with the domestic supply curve, S, to determine domestic prices, $P_D$. Import demand becomes exogenous because imports can be differentiated from domestic products; thus, the import demand curve, M, cannot be derived from $D_D$ and S. Import supply is still assumed to be perfectly elastic. The quantity imported will depend on the interaction of $S_W$ and M.

Although not perfect substitutes, the imported and domestic products are still to some extent substitutable, so that, for example, an increase in the world price, $P_W$, will lead to increased demand for domestically produced goods if other exogenous factors are constant. This can be represented by an upward shift in the demand for domestic production curve, to $D_{D1}$, so that $Q_0Q_1$ replaces the import shown by $M_0M_1$. (However, as the imported and domestic products are imperfect substitutes, it is unlikely that $M_0M_1$ will equal $Q_0Q_1$). Where the curve interacts with the domestic supply curve, a new equilibrium domestic price, $P_{D1}$, will be established at a higher level.

The above basically outlines the partial equilibrium situation, not allowing for wider effects such as the effects of tariffs on import prices. A tariff can be included in the model by replacing $P_W$ with the import price if paid by Saudi Arabia, thus, $P_W + T = P_m$. (where $T$ is tariff and $P_m$ is price of meat).

An import demand model is required to be developed in order to analyse and examine import demand for meat. Imports of various types of red meat in Saudi Arabia are largely focused on price elasticity, income elasticity and cross price elasticity. The aggregate nature of data studied in Saudi Arabia revealed that an increase in price of one commodity
will increase the consumption of another commodity. A good example of Saudi market share is that an increase in red meat and fish prices will increase demand for poultry (Al-Shabi, 2011).

**Figure 7.4: Imports as an Excess Schedule (With Perfectly Competitive Markets)**

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Figure 7.4: Imports as an Excess Schedule (With Perfectly Competitive Markets)
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![Figure 7.4: Imports as an Excess Schedule (With Perfectly Competitive Markets)](image)

**Figure 7.5: Partial Equilibrium Situation (Imperfectly Competitive Markets)**

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Figure 7.5: Partial Equilibrium Situation (Imperfectly Competitive Markets)
```

![Figure 7.5: Partial Equilibrium Situation (Imperfectly Competitive Markets)](image)

Given this situation it is possible to derive a set of equations as follows. Though the graphical representation suggests linear relationships, the equations are presented in nonlinear form to better represent the market.

First, in the absence of a tariff domestic supply is,
\[ S_t = e^{a_0 + a_1 P_{Dt} + a_2 C_t}, \quad (7.1) \]

demand for domestic products is,

\[ D_t = e^{b_0 + b_1 P_{Dt} + b_2 P_{Wt}}, \quad (7.2) \]

the domestic equilibrium condition is,

\[ D_t = S_t = Q_t; \quad (7.3) \]

and import demand is,

\[ M_t = e^{d_1 + d_2 P_{Dt} + d_3 P_{Wt} + d_4 M_{t-1}}, \quad (7.4) \]

Where,

- \( S_t \) is domestic supply at time \( t \) (endogenous), time being expressed in quarters,
- \( P_{Dt} \) is real domestic price at time \( t \) (endogenous),
- \( C_t \) is costs at time \( t \),
- \( D_t \) is demand for domestic product at time \( t \) (endogenous),
- \( P_{Wt} \) is real world price at time \( t \),
- \( Q_t \) is equilibrium quantity of domestic product at time \( t \),
- \( M_t \) is imports at time \( t \) (endogenous), and
- \( a, b, c, d \) and \( e \) are appropriate parameters.

Equation (7.1) expresses domestic supply as a function of domestic price and domestic costs of production. Equation (7.2) expresses demand for domestic production as a function of domestic price and world price. Equation (7.3) is the domestic equilibrium definition that domestic supply equals demand for domestic production. Finally, equation (7.4) specifies the demand for imports as a function of domestic price, world price and lagged import demand.

### 7.5 Model Specification

In the short run, cost factors are found to be of greater importance to domestic supply than price factors. Therefore, supply was assumed to be perfectly inelastic in the short run with respect to domestic price and was going to be estimated as a function only of
real costs, as shown in equation (7.5). The demand for the domestic product (equation 7.6), has been specified as a function of domestic price and lagged import price (typically one year). Using the equilibrium condition (equation 7.7), a reduced form equation (7.8) was going to be estimated by a two-stage least square approach, with price as an endogenous variable – namely as a function of the exogenous demand variables and the fitted supply function S. This is necessary because there is likely to be a correlation between actual supply and the residual in the price equation. This system allows a parameter in the domestic demand equation to be uniquely identified.

Import demand was specified (in equation 7.9) as a function of domestic price, lagged import price, and lagged import demand,

**domestic supply,**

\[
\log S_t = a_0 + a_1 \log C_{t-1} + a_2 \log S_t \quad (7.5)
\]

**domestic demand,**

\[
\log D_t = b_0 + b_1 \log P_{Dt} + b_2 \log P_{Mt-1} \quad (7.6)
\]

where \( P_M \) is the import price (world price plus tariff, if any).

**Domestic equilibrium,**

\[
S_t = D_t = Q_t \quad (7.7)
\]

**domestic price,**

\[
\log P_{Dt} = \frac{-b_0}{b_1} + \frac{1}{b_1} \log S_t - \frac{b_2}{b_1} \log P_{Mt-1} \quad (7.8)
\]

**import demand,**

\[
\log M_t = d_1 + d_2 \log P_{Dt} + d_3 \log P_{Mt-1} + d_4 \log M_{t-1} \quad (7.9)
\]

where, \( M_t \) = import demand and \( P_{Dt} \) = domestic price and \( d_2, d_3 \), and \( d_4 \) are parameters.
7.6 Results

The equations were estimated using yearly data for the period between 1985 and 2010. Tables 7.6, 7.7 and 7.8 summarises the results estimated for beef, lamb and chicken respectively.

7.6.1 Beef

Table 7.6: Import Demand for Beef in the Short Run
(a) Coefficient derived from price and supply equations

<table>
<thead>
<tr>
<th>Depnd. variable</th>
<th>Intercept</th>
<th>Cost</th>
<th>Import price (lagged)</th>
<th>Domestic price</th>
<th>Import quantity</th>
<th>R²</th>
<th>DW or h</th>
<th>Estimation period and procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply</td>
<td>1.24 (0.76)</td>
<td>0.17 (0.17)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.55</td>
<td>2.15</td>
<td>1985-2010</td>
</tr>
<tr>
<td>Price</td>
<td>-0.08 (0.15)</td>
<td>-</td>
<td>0.90 (0.05)</td>
<td>-</td>
<td>-</td>
<td>0.96</td>
<td>2.06</td>
<td></td>
</tr>
<tr>
<td>(a) Demand</td>
<td>0.86</td>
<td>-</td>
<td>-9.45</td>
<td>10.53</td>
<td>-</td>
<td>0.41</td>
<td>2.07</td>
<td></td>
</tr>
<tr>
<td>Import demand</td>
<td>0.09 (1.04)</td>
<td>-</td>
<td>-0.98 (1.54)</td>
<td>1.64 (1.62)</td>
<td>47 (0.20)</td>
<td>0.41</td>
<td>2.07</td>
<td></td>
</tr>
</tbody>
</table>

In the import demand equation for beef, only import quantity is significant, while the import price is significant in the price equation. The supply equation shows that the no variables are found to be significant, dependent on the cost of beef over time. The corrected coefficients of determination ($R^2$) for all equations show satisfactory fit of the estimated equations to the actual data.

The results indicate that a tariff increase of, say, 10 per cent will have an impact on import demand in two ways. First, the direct effect is drop in import demand by 9.8 per cent. The second effect occurs via a 9 per cent increase in domestic prices, which may result increase in domestic production. Overall, the short run effect on imports is dropped by 9.8 per cent. Note that this table provides a short run partial consideration of the import demand for beef.

The insignificance of supply response to price fluctuations in the short run has three major implications: one, an increased tariff will be born totally by consumers through an increase in domestic and import price; two, producers will benefit from substitution for import demand due to the increase in import price, and three, to reduce the dependence on imported beef products, domestic beef production should be increased.
7.6.2 Lamb

Table 7.7: Import Demand for Lamb in the Short Run
(a) Coefficient derived from price and supply equations

<table>
<thead>
<tr>
<th>Depdt. variable</th>
<th>Intercep t</th>
<th>Cost</th>
<th>Import price (lagged)</th>
<th>Domesti c price</th>
<th>Import quantit y</th>
<th>R²</th>
<th>DW or h</th>
<th>Estimatio n period and procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply</td>
<td>3.67 (1.14)</td>
<td>0.04 (0.08)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.07</td>
<td>2.13</td>
<td>1985-2010</td>
</tr>
<tr>
<td>Price</td>
<td>-1.67 (1.53)</td>
<td>-</td>
<td>1.06 (0.06)</td>
<td>-</td>
<td>-</td>
<td>0.93</td>
<td>1.71</td>
<td></td>
</tr>
<tr>
<td>Demand (a)</td>
<td>6.35</td>
<td>-</td>
<td>-4.07</td>
<td>3.85</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Import demand</td>
<td>4.62 (1.45)</td>
<td>-</td>
<td>-0.72 (0.63)</td>
<td>0.47 (0.57)</td>
<td>0.30 (0.20)</td>
<td>0.16</td>
<td>2.04</td>
<td></td>
</tr>
</tbody>
</table>

In the import demand equation for lamb, all variables are not significant except for the import price. The supply equation shows that supply is not significantly dependent on the production cost of lamb. The corrected coefficients of determination (R²) for the domestic price equation show satisfactory fit of the estimated equations to the actual data. In contrast, the corrected coefficients of determination (R²) for the domestic supply and the import demand equations are not satisfactory and are not appropriate for model fit.

The results indicate that a tariff increase of, say, 10 per cent will have an impact on import demand in two ways. First, the direct effect is a drop in import demand by 7.2 per cent. The second effect occurs via a 10.6 per cent increase in domestic prices, which may result in an increase in domestic production. Overall, the short run effect on imports is dropped by 7.2 per cent. Note that this table provides a short run partial consideration of the import demand for lamb.

The insignificance of supply response to price fluctuations in the short run has three major implications: one, increased tariffs will be born totally by consumers through an increase in domestic and import price; for suppliers, an increase in domestic price will encourage domestic production, and three, increased lamb prices will encourage domestic production.
7.6.3 Chicken

Table 7.8: Import Demand for Chicken in the Short Run
(a) Coefficient derived from price and supply equations

<table>
<thead>
<tr>
<th>Depd. variable</th>
<th>Intercept</th>
<th>Cost</th>
<th>Import price (lagged)</th>
<th>Domestic price</th>
<th>Import quantity</th>
<th>R²</th>
<th>DW or h</th>
<th>Estimation period and procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply</td>
<td>0.05 (0.39)</td>
<td>-0.10 (0.09)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.94</td>
<td>2.56</td>
<td>1985-2010</td>
</tr>
<tr>
<td>Price</td>
<td>-0.40 (0.24)</td>
<td>-</td>
<td>0.71 (0.17)</td>
<td>-</td>
<td>-</td>
<td>0.89</td>
<td>1.74</td>
<td></td>
</tr>
<tr>
<td>Demand (a)</td>
<td>2.51</td>
<td>-</td>
<td>-4.55</td>
<td>6.45</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Import demand</td>
<td>0.22 (0.48)</td>
<td>-</td>
<td>0.62 (0.63)</td>
<td>0.60 (0.63)</td>
<td>0.53 (0.20)</td>
<td>0.85</td>
<td>2.46</td>
<td></td>
</tr>
</tbody>
</table>

In the import demand equation, only import quantity is significant, while the import price is significant in the price equation. The supply equation shows that only supply is found to be significantly dependent on the cost of chicken over time.

The corrected coefficients of determination ($R^2$) for the all equations show satisfactory fit of the estimated equations to the actual data.

The results indicate that a tariff increase of, say, 10 per cent will have an impact on import demand in two ways. First, the direct effect is a drop in import demand by 6.2 per cent. The second effect occurs via a 7.1 per cent increase in domestic prices, which may result in an increase in domestic production. Overall, the short run effect on imports is dropped by 39 per cent. Note that this table provides a short run partial consideration of the import demand for chicken. The significance of a supply response to price fluctuations in the short run has four major implications

Increased tariff levels will be born totally by consumers through an increase in domestic and import price. Producers will benefit from substitution for import demand due to the increase in import price. Domestic price is affected by domestic supply and import price, and therefore, this will lead to an increase in domestic chicken production in a larger number to meet domestic consumption.

7.7 Conclusions

Overall, the results presented above for beef, lamb and chicken have given some insights into the behaviour of import demands for meat in Saudi Arabia in the short run. The results indicate that a 1 per cent increase in the price of beef imports will decrease imports by almost 1 per cent and increase domestic price by 0.90 per cent. A 1 per cent increase
in the price of lamb will decrease imports by 0.72 per cent and increase the domestic price by 1.06 per cent. In the case of chicken, a 1 per cent rise in price will decrease imports by 3.9 per cent and increase the domestic price by 0.71 per cent. The short run domestic supply response to domestic price was not found to be significant for beef, but for lamb and chicken they were significant. This is reasonable for beef in view of the large scale of plants and short run flexibility of capital structure.
Chapter 8
Conclusions

This research addressed food consumption trends in Saudi Arabia, primarily concerning beef, lamb and chicken, and fish. The study analysed demand over the period from 1985 to 2010 to assist Saudi decision-makers in both the government and business sectors to plan for the Kingdom’s food security. The study sought to understand the long term effects of economic indicators (per capita consumption, retail price, per capita income, and inflation (CPI)) on Saudi meat demand. The shortfall trend between domestic production and consumption of the meat products was also assessed.

Saudis traditionally have relied on lamb, goat, and camel for their sustenance; however, economic development over the last half a century have changed food consumption habits towards beef and especially chicken. Due to its location and desert weather conditions, Saudi Arabia has no capacity to feed its people from domestic sources and is thus embarked upon a food security program that involves importing and land purchases for developing food chains and partnerships with existing food producers overseas. This research aimed at enhancing information for this political and commercial decision making through identifying trends in Saudi meat demand, meat production, and also identifying factors that can be reliably used to assess meat product consumption patterns. Further, it is of use to the private sector in seeking commercial advantage in fulfilling emerging gaps in supply chains. Saudi food security involves imports and investment in sustainable international food resources in partnerships.

This chapter comprises a review of the findings of the thesis, including a chapter summary. This is followed by conclusions and recommendations, the benefits and limitations of the thesis and concludes with suggestions for further research.

8.1 Summary of the Thesis

The introductory chapter set the environment for the thesis. It showed the nature of Saudi society and its historical challenges in accessing water and food for the population. The rapid population increases of the late 20th century, combined with food security concerns associated with oil price shocks and grain shortfalls prompted the government to seek sustainability. Developing agricultural industries for food security in the 1980s from ancient aquifers, policymakers soon learned that the water supply was ancient and not
renewable. Thus food supply policies turned to short term food supplies such as poultry and vegetable farms. All other foods were imported through a variety of business arrangements. The thesis structure and its intent were also presented in this chapter.

Chapter 2 presented the characteristics of Saudi Arabia, its harsh terrain where heat and dust storms precluded large scale agricultural pursuits for much of the year, and the explanations of changing food policies as local and international events occurred. Saudi Arabia is the site of the Two Holy Mosques at Al Madinah and Makkah, and the annual visit, the hajj, of two to three million pilgrims places a heavy burden on the host country to provide a healthy and safe experience for the religious tourists. Many stay longer to study or enjoy a holiday along the Red Sea coastline, thus tourism standards, including expectations of fine food and accommodation, set another challenge for the Kingdom. This has been met by a series of five-year rolling economic development plans that set priorities for the government and allowed the rapid development of facilities and services that typifies the modern country. The chapter then moved to international food security through the work of the Food and Agricultural Organisation, and the relationships between the Organisation and the Kingdom that seek the improvement of food security in less developed countries through long-term investment.

The next chapter (3) explored the theories of consumer demand and the concepts relating to demand. Examples of utility-based demand systems were discussed together with the selection of model relevant to this research, that is, the Rotterdam estimation. Chapter 4 presents a review of literature for various parts of the globe including the Middle East. Following this is a chapter on demand systems used in other countries. Using time series data, Chapter 5 introduced the preliminary results from the data analysis, illustrating various iterations from the analyses that would best answer the research questions.

Chapter 6 reviewed the methodology and produced estimation results from the studies selected. Consumption and price data of beef, chicken, lamb and fish for the years 1985-2010 showed that the per capita consumption of beef fell from 6.1 kg to 5.2 kg, chicken consumption increased from 31.7 kg to 39.9 kg, demand for lamb collapsed from 29.3 kg to 12.3 kg per capita, and fish increased slightly from 5.6 kg to 6.1 kg. Over these years, significant changes in prices occurred. Fish prices increased by 1.5 times, beef prices doubled, chicken and fish prices almost doubled, whilst lamb prices increased over 2.5 times. The data analysis showed positive growth for the relative consumption of beef, chicken and fish, while the demand for lamb fell. The average relative price growth rates
of beef, chicken and fish are negative, while that of lamb is positive. The expenditure shares of beef, chicken and fish have increased, while that of lamb has fallen. The estimation results of the demand system revealed an autonomous trend from lamb to beef, chicken and fish. The implied income elasticity indicated that beef, lamb and fish are considered luxuries, while chicken is a necessity. The demand for all meat products and fish were found to be price inelastic. These elasticities are key inputs for policy analysts in terms of devising policies in relation to meat production, meat imports, taxation and food security issues in Saudi Arabia. The relevance of these elasticities was demonstrated by simulating the consumption of beef, chicken, lamb and fish under various policy scenarios.

An import demand estimate in the short run in chapter 7 indicates that a 1 per cent increase in the price of beef imports will decrease imports by almost 1 per cent and increase domestic price by 0.90 per cent. A 1 per cent increase in the price of lamb will decrease imports by 0.72 per cent and increase the domestic price by 1.06 per cent. In the case of chicken, a 1 per cent rise in price will decrease imports by 3.9 per cent and increase the domestic price by 0.71 per cent. The short run domestic supply response to domestic price was not found to be significant for beef, but for lamb and chicken they were significant.

Whilst beef consumption is slowly declining, the per capita lamb consumption is falling at a faster rate, and has more than halved in the period to 2010. On the other hand, chicken consumption increased rapidly, more so than fish. The following hypotheses were supported:

H01 That all meat and fish (and meat products) demand is based on population growth (chapter 5)
H02 That for (economic indicators) the meat and fish demand is greatest for all meat and meat products (chapter 5).
H03 That all meat and fish (and meat products) demand is greater than domestic production (chapter 5).
H04 That all meat and fish (and meat products) demand is influenced by economic shocks (chapter 6).

8.2 Conclusions
This study concerns the establishment of a stable economy in the Kingdom from the period of 1985. By this time, the structural elements were in place for the economy to
grow. Estimated results revealed that since 1985, there has been an autonomous trend from lamb consumption to beef, chicken and fish consumption, and this was arguably due to greater choice and declining sources of supply due to international concerns over slaughtering practices. There is also the factor of ‘healthy living’, where lean meat is increasingly preferred by some sections of the population.

The income elasticity of beef (1.07), chicken (0.48), lamb (1.27) and fish (1.19) indicated that chicken is considered to be a necessity and beef, lamb and fish are considered luxuries by Saudi consumers. All the own-price elasticity estimates are less than one in absolute value, indicating that the demand for beef, chicken, lamb and fish are price inelastic. Given a further Saudi riyal to spend, a Saudi consumer would allocate 11.1 cents to beef, 14.5 cents to chicken, 62.1 cents to lamb and the remaining 12.3 cents to fish. Using income and price elasticity estimates, simulation results showed that changes in consumer tastes have shifted from lamb to chicken during the last two decades.

8.3 Contributions and Limitations

The contribution of this research is that it explores the economic structure of a range of high protein foods that form a large part of the Saudi diet. The detection of a trend to chicken, and arguably to fish, from lamb and beef supports that of developed countries where societies expect health benefits from consuming less protein and fats and more carbohydrates in the form of vegetables, fruit and cereals. This supports, or perhaps explains, the Saudi government’s food policies of using scarce water resources on fast growing foods such as chicken and fresh vegetables, and using imports for water-consuming agribusinesses such as beef and lamb. Further, policymakers are promoting crustacean aquaculture along the Red Sea.

Limitations include the application of only one model in quantitative analysis, the Rotterdam model. Other models may have produced different results. The period selected was determined by availability of data and this may change if further years were included, given changes in social expectations and health scares emanating from viruses such as bird flu or the Middle East respiratory syndrome. Data were unavailable concerning other meat sources such as camel meat, although anecdotal evidence suggests that there is high demand for this type of meat. Therefore, this might be one possible avenue for further research to be undertaken by future researchers who are keen to investigate this phenomenon, subject to the availability of reliable data. Another possible avenue for further research is to make comparisons by provinces, since the Kingdom of Saudi Arabia
has thirteen provinces. This will enable policy makers to make optimum decisions for each province and help make comparisons between them.

8.4 Recommendations

The findings of this research indicated that there is an evolution in food preferences within the Saudi population and this is brought about by changing lifestyles. Over the decades of this study, there has been a relatively steady increase in income growth despite a large increase in population from the 1980s. Women will presumably become more used to employment and thus people will increase consumption of food outside the home. As income grows, food habits may follow the trends of developed countries elsewhere, and the percentage of fat consumed would fall as people move to ‘healthier’ foods such as cereals, fresh fruit and vegetables and ‘leaner’ meats and fish.

Saudi Arabia has by necessity always imported food, and the current food security policy is to secure external sources of food through owning land and growing food, leasing land for food, entering into partnerships for food, or purchasing food from suppliers or on the open market. If there is a critical demand for some foods that are without obvious substitutes such as wheat, rice, and sugar, then policies should be in place for contracts with many stages of redundancy; that is multiple sources of potential supply. Vegetables and fruit are generally seasonal, so the population is used to a range of options and substitutes should be readily available.

With meat forming a large part of the current Saudi diet, particularly during Ramadan and the hajj season, the decision-makers in both the public and private sectors should consider a range of potential sources to ensure food security of all four meat types: chicken, sheep/goat, beef and fish. Given the real and potential difficulties of a fresh water supply, fish farming in clean seawater is a potential new source of food from small crustaceans such as shrimp or prawns. Red meat sources should continue from the traditional suppliers on each continent.

8.5 Further Research

Suggestions for further research in this vital area include updating and finding data for a larger time period including recent years. There may be value in reusing these data with other models, or with recent variations on both models. Non-econometric studies could include the effects on food consumption caused by the rapid changes in Saudi society, where the social stigma of paid employment in the private sector is dissipating as the
government releases more jobs for women and continues its pursuit of Saudisation, employment of nationals. In all, the Saudi food environment is of great interest to researchers, given the challenges of its recent economic development, the tourism potential, and the gender trend towards economic self-sufficiency. More money available to families may yet bring the greatest change to Saudi food consumption practices. Furthermore, a study based on primary survey of households on taste, household size, family income etc in order to perform a cross-sectional quantitative and qualitative study may be relevant.
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