ECONOMETRIC MODELING OF THE

EUROPEAN UNION COTTON DEMAND

by

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A THESIS

IN

AGRICULTURAL AND APPLIED ECONOMICS

Submitted to the Graduate Faculty
of Texas Tech University in
Partial Fulfillment of
the Requirements for
the Degree of

MASTER OF SCIENCE

Approved

Chairperson of the Committee

Accepted

Dean of the Graduate School

May, 2004

ACKNOWLEDGMENTS

I would like to express my deep appreciation and gratitude to my committee chair, Dr. Jaime Malaga, for his constant guidance and encouragement throughout the development of this thesis. His patience, motivation and positive attitude gave me the strength needed to bring this thesis to a conclusion. His wisdom and knowledge of demand systems were truly insightful.

I would also like to thank my other committee members, Dr. Octavio Ramirez and Dr. Samarendu Mohanty. Dr. Ramirez's advice and guidance motivated me to continuously work with dedication and enthusiasm over the past two years. His assistance in econometrics was very helpful. Dr. Mohanty's suggestions and ideas were really beneficial.

Although not on my committee, Dr. David Willis was always willing to answer any type of question as well as to provide references and relevant material. I am grateful to Dr. Mohamadou Fadiga for his useful comments in the AIDS model. I would also like to express my appreciation to Dr. Suwen Pan for his assistance with data collection. Mr. James M. Welch's editorial comments and Mr. Jim Curtis's office support were particularly helpful. My gratitude is extended to other faculty, staff, and fellow students in the Agricultural and Applied Economic Department who helped make my experience in the U.S. a valuable one.

I thankful for having my family and friends stand by me throughout my graduate career. My girlfriend's, Priscilla, love, support, and enthusiasm have been an inspiration

for me. She has provided me the affection and energy needed to go through this journey. Finally and most important of all, I want to thank God for giving me strength, courage, and wisdom and providing me with valuable opportunities in life.

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CHAPTER I

INTRODUCTION

Background

The European Union (EU) was formally established on November 1st, 1993 (European Union, 2003). However, it informally originated in 1951 when France, West Germany, Italy, Belgium, the Netherlands, and Luxembourg established the European Coal and Steel Community (ECSC). It became the European Economic Community (EEC) in 1957 and then became the European Community (EC) in 1967. On January 1st, 1973, the United Kingdom, Denmark, and Ireland joined the European Community. Greece was admitted to the EC in 1981, followed by Spain and Portugal in 1986. In 1995, Austria, Finland, and Sweden became part of the European Union bringing the total number of nations to 15.[1]

The European Union contributes significantly to the world cotton trade. Among major cotton-consuming countries, the European Union ranks sixth in world cotton consumption and first in world cotton imports (U.S. Department of Agriculture, 2003b) over the last five years. For crop years 1998/1999-2002/2003, the six largest cotton-consuming countries were China, India, the United States, Pakistan, Turkey, and the European Union. However, the European Union ranked fifth in cotton consumption over the last twenty years and fourth over the last forty years (i.e., Table 1.2, Table 1.3, and Table 1.4). Again, for crop years 1998/1999-2002/2003, the five largest cotton-importing

[1] For a more complete description of events in the European Union history, see Table 1.1 at the end of the chapter.

countries were the European Union, Indonesia, Turkey, Mexico and Thailand (i.e., Table 1.5).

Since 1960, the European Union's and the United States' market shares of world cotton mill consumption have been decreasing at average annual rates of 3% and 2% respectively, while China's, India's, Pakistan's, and Turkey's market shares have been increasing at average rates of 3%, 1%, 4%, and 5%, respectively (U.S. Department of Agriculture, 2003b). Together, these six countries account for 70% of world cotton consumption. Similarly, the share of EU cotton imports has been declining at an average rate of 2% since 1960/1961. However, the EU is the world's largest importer of cotton based on average imports over the last 5, 20, and 40 years (i.e., Table 1.5, Table 1.6, and Table 1.7).

Within the European Union itself, the five largest cotton consuming countries for 1998/1999 to 2002/2003 are Italy, Greece, Portugal, Germany, and Spain. For the same period, the five largest cotton importing countries are Italy, Portugal, Germany, France and Belgium-Luxembourg. This is not the case for 20 and 40 year averages (i.e., Table 1.8 to Table 1.13). Further, it can be misleading to think that all EU countries cotton mill consumption and imports have been decreasing through time. It can be argued that cotton mill consumption in Italy, Greece, Portugal and Austria has been increasing, while similar consumption in France, Germany, Belgium-Luxembourg, Netherlands, United Kingdom, Denmark, Ireland, Spain, Finland, and Sweden has been decreasing (i.e., Figure 1.1 to Figure 1.14).

When considering cotton available for home use, which includes the fiber equivalent of textile imports and exports, the above scenario changes. The cotton mill consumption trend in most cases differs from the trend of cotton available for home use. This is also the case for manmade fiber and wool (e.g., Figure 1.15 to Figure 1.28). For example, in the cotton case, it can be argued that the trends are different in France, Belgium-Luxembourg, Netherlands, United Kingdom, Denmark, Ireland, Greece, Austria, Finland, and Sweden; while they are similar in Germany, Italy, Spain, and Portugal. In the wool case, they are different in Belgium-Luxembourg, Denmark, Austria and Sweden, while they are similar in all other countries. Finally, in the manmade fiber case, they are different in Belgium-Luxembourg, Denmark, and Greece, while they are similar in all others.

While per capita cotton mill consumption and available for home use are different variables and have different trends in some EU countries, previous studies have only used mill consumption to estimate the consumer demand for cotton. Furthermore, although the cotton demand has been increasing in some countries and decreasing in others, most previous studies have used aggregated European cotton demand, which offsets the increasing trends in some countries with the decreasing trends in others. Therefore, previous methodological choices might not appropriately allow the estimation of the European cotton demand parameters.

General Problem

Despite efforts of some countries to impose import quotas and negotiate voluntary export restraints, the value of international world trade (exports plus imports) rose from \$643 billion in 1970 to more than \$114 trillion in 1999. When members of GATT signed a major new agreement and established the World Trade Organization (WTO) in 1994, the outlook for commerce was improved, as many barriers to free trade were struck down. Furthermore, regional treaties such as the North American Free Trade Agreement (NAFTA) took place.

Textiles have played an important role in international commerce. The world market for textile fibers is extensive. They have a place in almost every integral part of our everyday life—tires for our automobiles, clothing for our bodies, parachutes and body armor for military forces, and towels and spreadsheets for homes. Cotton is an important agricultural commodity and/or manufacturing raw material in many industrial countries (e.g., Australia, the United States) and provides a significant contribution to farm income and export earnings. Moreover, cotton fiber is produced commercially as an annual cash crop on farms in at least 80 countries located in tropical and temperate climatic zones.

However, the global financial crisis that began in 1997 caused world economic growth to decelerate from 4% in 1997 to 2.5% in 1998 and 3% in 1999. The crisis interrupted a four-year period of rapid expansion of world end-use consumption of textiles (Valderrama, 2000). In addition, while the textile market expanded by 8 million tons between 1990 and 1999, cotton consumption merely gained 500,000 tons during the same period. This difference in performance can be explained by the 95% increase in noncellulosic fibers consumption, essentially polyester; a decline in the promotion of cotton in chemical fiber markets; and the reversal of a declining trend of the price of cotton relative to the prices of other fibers (Valderrama, 2000). However, world end-use cotton consumption is expected to increase from 19.2 million tons in 1999 to 20.5 million tons in 2005 (Valderrama, 2000).

Despite trade liberalization efforts of the WTO, the sector of Textiles and Clothing is still an exception to free trade. Quotas and tariffs in this sector constitute barriers for a globalized world economy. However, thanks to the Agreement on Textiles and Clothing (ATC) passed at the end of the Uruguay Round in 1994, quotas on textiles and clothing will disappear by January 1, 2005.

The ATC elimination of quotas was scheduled in four stages: first stage (1995-1997), second stage (1998-2001), third stage (2002-2004), and fourth stage (1 January 2005). In the fourth stage there will be no quotas and tariffs might gradually be reduced.

Since ATC implementation began, only a few quotas have been eliminated by major importing countries. According to the United Nations (1999), the USA has only eliminated 13 out of 750 quotas by integration in stages one and two and by early elimination under Article 2.15. In the same way, the EU has only eliminated 14 out of 219 quotas and Canada 29 out of 295 quotas. These failures of quota liberalization have created what is known as "end-loading." In other words, importing countries have been delaying the integration of the most important products to WTO rules until the end of the transitional period. This elimination at the end of the transitional period by the three major importers of textile and clothing (Canada, the European Union, and the United States) is expected to induce drastic changes in the world trade of cotton, textiles and clothing. Two main impacts of this process on these countries would be:

1. More accessible markets for textile and clothing exporting countries, which will change textile and clothing trade and therefore cotton trade patterns;
2. Better market position for some competitive textile and clothing exporting countries.

According to the U.S. Department of Agriculture (2003b), the EU imports of cotton constitute about 14% of world total imports for the last five years (i.e., Table 1.5). In 2000, world total imports of cotton were 5,802,201 MT of which EU imports were 1,112,582 MT (U.S. Department of Agriculture, 2003b). All countries involved in textile, clothing, and cotton trade with the EU are going to be affected by 2005 ATC quota elimination. The European Union imports textiles and cotton from about 100 countries (European Commission, 2003). In 2001, according to the European Commission, the European Union imported $64.73 billion in textiles and $3.7 billion in cotton. Of all textiles imported to the EU in 2001, eighteen countries accounted for two-thirds of all textile imports, worth approximately $45 billion. In order of major exports to the EU, those countries are China, Turkey, India, Bangladesh, Tunisia, Hong Kong, Romania, Morocco, Indonesia, Poland, Pakistan, USA, South Korea, Switzerland, Czech Republic, Thailand, Hungary, and Taiwan. On the export side, the EU exported $38.96 billion in textiles. Of all textiles exported by the EU in 2001, twelve countries accounted for 56% of all textile exports, worth approximately $22 billion.

With the elimination of quotas on January 1, 2005, the EU market for textiles may undergo radical changes. The EU may reduce its textile and cotton imports from the USA, Latin American and Caribbean countries and become more reliant on countries in Europe (currently outside the EU), Asia, and Africa.

Researchable Problem

The US as well as all other countries in the WTO faces an incognita with respect to what may happen after January 1, 2005 with the elimination of MFA quotas. It is possible that the market structure will change significantly with few countries dominating the cotton market, and many others might become noncompetitive and be forced to exit the market.

The EU is the world largest importer of cotton (i.e., Table 1.5 to Table 1.7) and ranks among the six world largest cotton-consuming countries (Table 1.2 to Table 1.4). All countries involved in cotton trade with the EU will benefit from a better knowledge of the long-run changes and tendencies of the EU after the 2005 quota liberalization. There is a need to determine the magnitude of the EU cotton demand parameters in order to identify the EU reaction to changes in cotton price and quota eliminations. In order to provide a more accurate and appropriate estimation of the European Union cotton demand parameters, the cotton demands of the 15 European Union members at both mill consumption and home consumption levels need to be explored.

Objectives

The primary objective of this study is to accurately and appropriately estimate the European Union cotton demand parameters using country-disaggregated consumption levels and a demand system approach. The specific objectives are to:

- Determine the factors affecting the cotton demand of EU countries;
- Estimate parameters of the cotton demand of EU countries;
- Calculate the respective Marshallian and Hickisian price and expenditure elasticities;
- Compare the estimated elasticities at four levels: aggregated mill consumption, country-disaggregated mill consumption, aggregated home consumption, and country-disaggregated home consumption.

Table 1.1 Major events in the History of the European Union.

Year	Event
1951	The European Coal and Steel Community (ECSC) is established and includes France, West Germany, Italy, Belgium, The Netherlands, and Luxembourg.
1957	The European Economic Community (EEC) and the European Atomic Energy Community (Euratom) are established by the members of the ECSC.
1960	In response to the ECSC, Denmark, Sweden, Norway, Austria, Portugal, Switzerland, and the United Kingdom establish the European Free Trade Association (EFTA).
1965	Treaty is signed merging the ECSC, EEC, and Euratom into the European Community (EC).
1968	The European Community customs union is completed, removing all customs duties between members of the EC and establishing a common external tariff.
1972	Norwegian electorate rejects membership in the European Community in a referendum.
1973	The United Kingdom, Denmark, and Ireland join the European Community.
1979	The European Monetary System (EMS) is established to increase monetary stability within the EC and to promote eventual monetary union within the community (March).
1979	First direct elections are held for the European Parliament, the legislative body of the European Community (June).
1981	Greece joins the European Community.
1986	Spain and Portugal join the European Community.
1987	The Single European Act (SEA) enters force; it comprises amendments to existing European Community treaties to increase cooperation and integration within the EC.
1989	EC member states agree to establish Economic and Monetary Union (EMU), which includes the adoption of a single European currency for EC members.
1990	Following the reunification of Germany, the territory of the former East Germany becomes part of the European Community.
1991	The European Council meets at Maastricht, The Netherlands, and agrees to the Treaty on European Union which establishes the European Union (EU).

Table 1.1 Continued.

Year	Event
1992	The European Union and the remaining countries of the European Free Trade Association (EFTA)—Iceland, Norway, and Liechtenstein—agree to form the European Economic Area (EEA), an association establishing a single market and removing trade barriers among member countries.
1993	After ratification by member states, the Treaty on European Union goes into effect.
1995	Austria, Finland, and Sweden join the European Union.
1997	The member governments of the European Union issue the Amsterdam Treaty, which revises the Treaty on European Union to provide for such things as cooperation in job creation throughout the EU and relaxing border controls between member states.
1998	The European Union opens discussions regarding membership with Cyprus, Poland, Slovenia, Estonia, Hungary, and the Czech Republic (March).
1998	As part of the plan for Economic and Monetary Union (EMU), 11 of the 15 EU member states agree to adopt the euro as a common currency.
1998	The European Central Bank (ECB) is created to oversee the inauguration of the euro and to take control of EU monetary policy (July).
1999	The euro is adopted for electronic transactions and for accounting purposes; Greece officially adopts the euro for such purposes in 2001, becoming the 12th country to do so.
2002	The euro becomes the official currency of the 12 participating countries; euro coins and bills are issued and the currencies of the 12 states cease to be legal tender.

Source: "European Union," Microsoft® Encarta® Online Encyclopedia 2003. http://encarta.msn.com

Table 1.2 The Ten Largest Cotton Consuming-Countries, Average1998/1999 to 2002/2003.

	Average 98-02 Use Domestic Consumption (MT)	**Average 98-02 Share of World Use Domestic Consumption**
China; Peoples Republic of	5,155,765	0.26
India	2,886,444	0.14
United States	1,934,239	0.10
Pakistan	1,761,408	0.09
Turkey	1,211,300	0.06
EU(15)	999,104	0.05
Brazil	847,392	0.04
Indonesia	489,885	0.02
Mexico	483,353	0.02
Thailand	365,737	0.02

Source: USDA-ERS-PSD Database.

Table 1.3 The Ten Largest Cotton Consuming-Countries, Average 1983/1984 to 2002/2003.

	Average 83-02 Use Domestic Consumption (MT)	**Average 83-02 Share of World Use Domestic Consumption**
China; Peoples Republic of	4,494,420	0.24
India	2,235,812	0.12
United States	1,928,611	0.10
Pakistan	1,262,564	0.07
EU(15) [a]	1,214,501	0.07
Turkey	794,931	0.04
Brazil	777,948	0.04
Japan	492,802	0.03
Russian Federation	477,768	0.03
Union of Soviet Socialist Rep	397,351	0.02

a_/ Includes all 15 current European countries.

Source: USDA-ERS-PSD Database.

Table 1.4 The Ten Largest Cotton Consuming-Countries, Average 1960/1961 to 2002/2003.

	Average 60-02 Use Domestic Consumption (MT)	**Average 60-02 Share of World Use Domestic Consumption**
China; Peoples Republic of	3,327,166	0.22
United States	1,788,193	0.12
India	1,662,722	0.11
EU(15) [a]	1,301,078	0.09
Union of Soviet Socialist Rep	1,091,630	0.07
Pakistan	794,824	0.05
Japan	614,470	0.04
Brazil	565,725	0.04
Turkey	480,548	0.03
Germany [b]	269,323	0.02

a_/ Includes all 15 current European countries.
b_/ Adds Germany Democratic Republic and Germany Federal Republic for the period 1960/1961 to 1990/1991.

Source: USDA-ERS-PSD Database.

Table 1.5 The Ten Largest Cotton Importing-Countries, Average 1998/1999 to 2002/2003.

	Average 98-02 Imports (MT)	**Share of World Imports**
EU(15)	818,216	0.14
Indonesia	507,521	0.08
Turkey	446,644	0.07
Mexico	412,156	0.07
Thailand	370,484	0.06
Russian Federation	333,122	0.05
Korea; Republic of	327,635	0.05
India	305,906	0.05
Italy	288,531	0.05
Taiwan	286,702	0.05

Source: USDA-ERS-PSD Database.

Table 1.6 The Ten Largest Cotton Importing-Countries, Average 1983/1984 to 2002/2003.

	Average 83-02 Imports (MT)	**Share of World Imports**
EU(15) [a]	1,075,885	0.17
Russian Federation	490,690	0.08
Japan	488,491	0.08
Korea; Republic of	369,471	0.06
Indonesia	364,376	0.06
Union of Soviet Socialist Rep	335,495	0.05
Italy	307,582	0.05
Taiwan	305,862	0.05
Thailand	294,356	0.05
China; Peoples Republic of	281,989	0.04

a_/ Includes all 15 current European countries.

Source: USDA-ERS-PSD Database.

Table 1.7 The Ten Largest Cotton Importing-Countries, Average 1960/1961 to 2002/2003.

	Average 60-02 Imports (MT)	**Share of World Imports**
EU(15) [a]	1,182,422	0.21
Union of Soviet Socialist Rep	664,724	0.12
Japan	615,969	0.11
Germany [b]	284,199	0.05
China; Peoples Republic of	264,371	0.05
Korea; Republic of	259,322	0.05
Italy	255,383	0.05
Russian Federation	228,228	0.04
Taiwan	218,496	0.04
Indonesia	195,706	0.04

a_/ Includes all 15 current European countries.
b_/ Adds Germany Democratic Republic and Germany Federal Republic for the period 1960/1961 to 190/1991.

Source: USDA-PSD-ERS Database.

Table 1.8 Cotton Mill Consumption of the Fifteen European Union Countries, Average 1998/1999 to 2002/2003.

	Average 98-02 Use Domestic Consumption (MT)	**Share of EU(15) Use Domestic Consumption**
Italy	282,609	0.2829
Greece	151,886	0.1520
Portugal	136,297	0.1364
Germany	120,403	0.1205
Spain	106,773	0.1069
France	94,493	0.0946
Belgium-Luxembourg	37,884	0.0379
Austria	35,272	0.0353
United Kingdom	20,684	0.0207
Netherlands	4,442	0.0044
Sweden	4,355	0.0044
Ireland	2,613	0.0026
Denmark	1,394	0.0014
Finland	-	-

Source: USDA-ERS-PSD Database.

Table 1.9 Cotton Mill Consumption of the Fifteen European Union Countries, Average 1983/1984 to 2002/2003.

	Average 83-02 Use Domestic Consumption (MT)	**Share of EU(15) Use Domestic Consumption**
Italy	303,620	0.2500
Germany	209,290	0.1723
Portugal	159,202	0.1311
Greece	153,965	0.1268
Spain	126,477	0.1041
France	119,848	0.0987
Belgium-Luxembourg	39,692	0.0327
United Kingdom	32,561	0.0268
Austria	31,451	0.0259
Ireland	16,112	0.0133
Netherlands	7,903	0.0065
Finland	6,510	0.0054
Sweden	5,040	0.0042
Denmark	2,831	0.0023

Source: USDA-ERS-PSD Database.

Table 1.10 Cotton Mill Consumption of the Fifteen European Union Countries, Average 1960/1961 to 2002/2003.

	Average 60-02 Use Domestic Consumption (MT)	**Share of EU(15) Use Domestic Consumption**
Germany	269,323	0.2070
Italy	255,064	0.1961
France	176,581	0.1357
Portugal	126,570	0.0973
Spain	121,719	0.0936
Greece	114,367	0.0879
United Kingdom	95,217	0.0732
Belgium-Luxembourg	50,077	0.0385
Netherlands	30,036	0.0231
Austria	26,993	0.0207
Ireland	11,438	0.0088
Finland	10,501	0.0081
Sweden	9,160	0.0070
Denmark	3,823	0.0029

Source: USDA-ERS-PSD Database.

Table 1.11 Cotton Imports of the Fifteen European Union Countries, Average 1998/1999 to 2002/2003.

	Average 98-02 Imports (MT)	**Share of EU Imports**
Italy	288,531	0.3526
Portugal	133,815	0.1635
Germany	133,771	0.1635
France	98,587	0.1205
Belgium-Luxembourg	55,564	0.0679
Austria	35,881	0.0439
Spain	34,226	0.0418
United Kingdom	20,423	0.0250
Greece	5,531	0.0068
Netherlands	4,485	0.0055
Sweden	4,093	0.0050
Ireland	2,046	0.0025
Denmark	1,263	0.0015
Finland	-	-

Source: USDA-ERS-PSD Database.

Table 1.12 Cotton Imports of the Fifteen European Union Countries, Average 1983/1984 to 2002/2003.

	Average 83-02 Imports (MT)	**Share of EU Imports**
Italy	307,582	0.2859
Germany	226,544	0.2106
Portugal	160,486	0.1492
France	129,754	0.1206
Spain	77,837	0.0723
Belgium-Luxembourg	47,410	0.0441
Austria	34,129	0.0317
United Kingdom	32,975	0.0306
Greece	21,218	0.0197
Ireland	15,720	0.0146
Netherlands	8,121	0.0075
Finland	6,292	0.0058
Sweden	5,008	0.0047
Denmark	2,809	0.0026

Source: USDA-ERS-PSD Database.

Table 1.13 Cotton Imports of the Fifteen European Union Countries, Average 1960/1961 to 2002/2003.

	Average 60-02 Imports (MT)	**Share of EU Imports**
Germany	284,199	0.2404
Italy	255,383	0.2160
France	186,333	0.1576
Portugal	127,456	0.1078
United Kingdom	94,964	0.0803
Spain	66,953	0.0566
Belgium-Luxembourg	53,257	0.0450
Netherlands	31,327	0.0265
Austria	28,254	0.0239
Greece	19,844	0.0168
Ireland	11,408	0.0096
Finland	10,344	0.0087
Sweden	8,932	0.0076
Denmark	3,767	0.0032

Source: USDA-ERS-PSD Database.

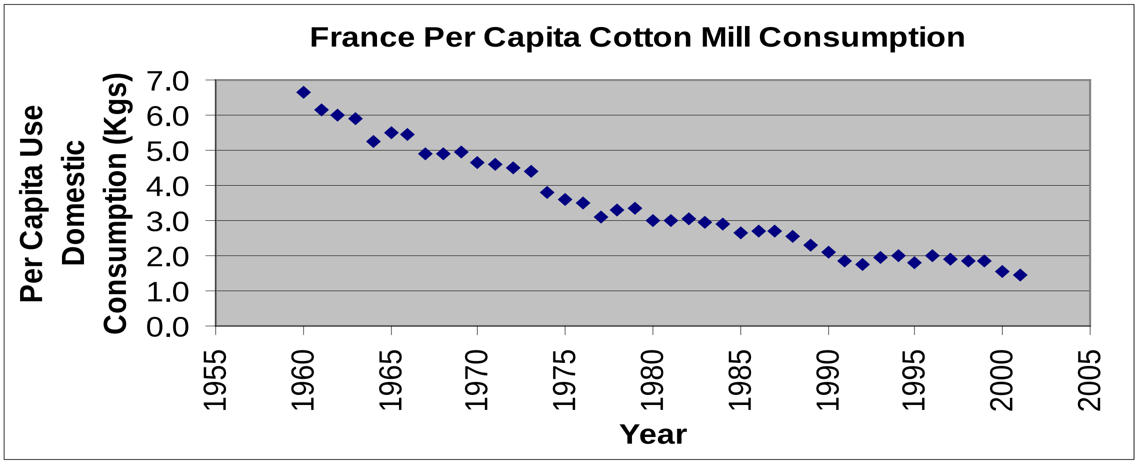
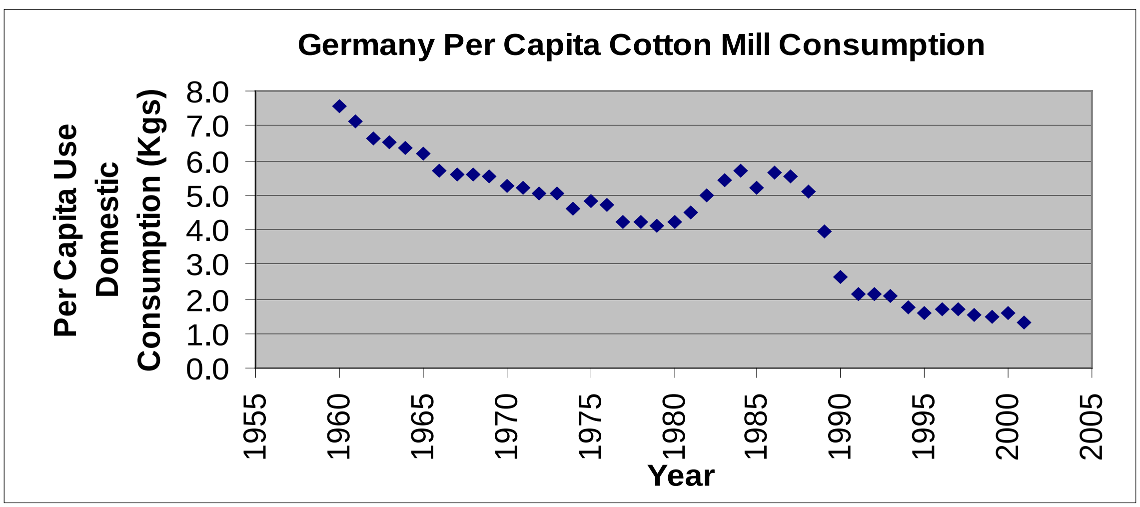


Figure 1.1 France Per Capita Mill Consumption for the Period 1960/1961-2001/2002.

Source: Mill Consumption from USDA-ERS-PSD Database. Population from IMF.



a_/ It adds Germany Democratic Republic and Germany Federal Republic for the period 1960/1961 to 1990/1991.

Figure 1.2 Germany Per Capita Mill Consumption for the Period 1960/1961-2001/2002.

Source: Mill Consumption from USDA-ERS-PSD Database. Population from IMF.

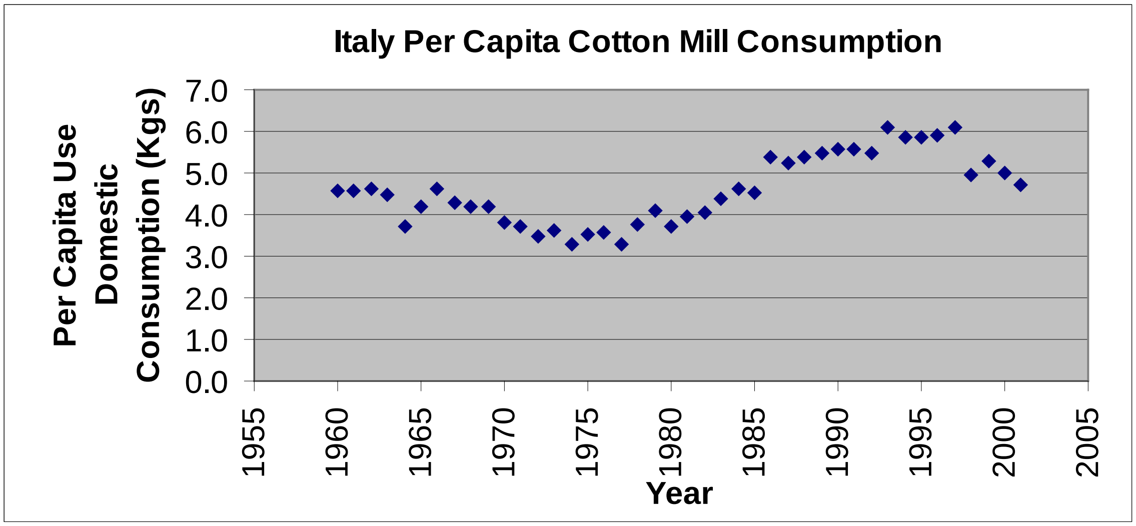


Figure 1.3 Italy Per Capita Mill Consumption for the Period 1960/1961-2001/2002.

Source: Mill Consumption from USDA-ERS-PSD Database. Population from IMF.

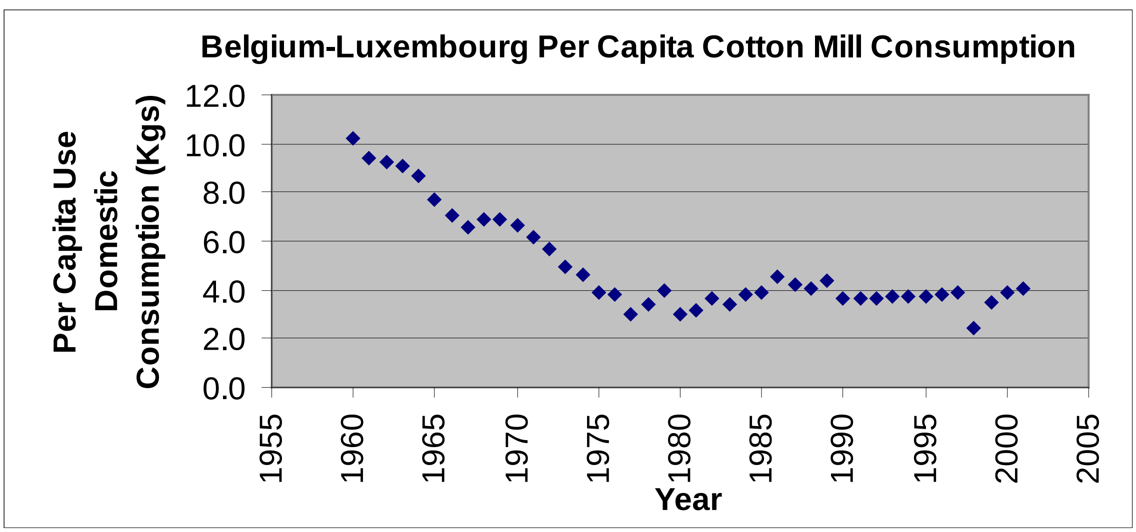


Figure 1.4 Belgium-Luxembourg Per Capita Mill Consumption for the Period 1960/1961-2001/2002.

Source: Mill Consumption from USDA-ERS-PSD Database. Population from IMF.

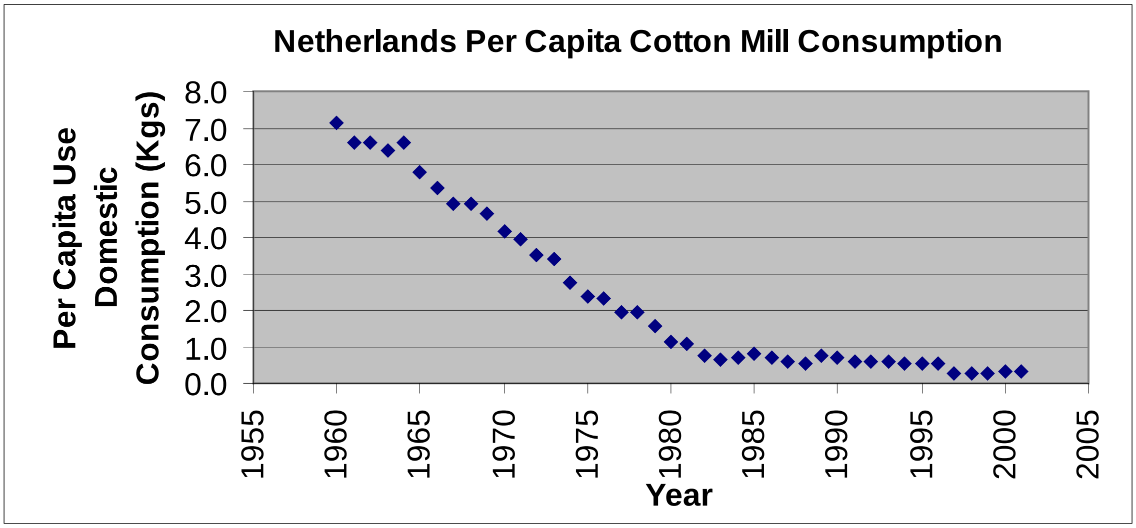


Figure 1.5 Netherlands Per Capita Mill Consumption for the Period 1960/1961-2001/2002.

Source: Mill Consumption from USDA-ERS-PSD Database. Population from IMF.

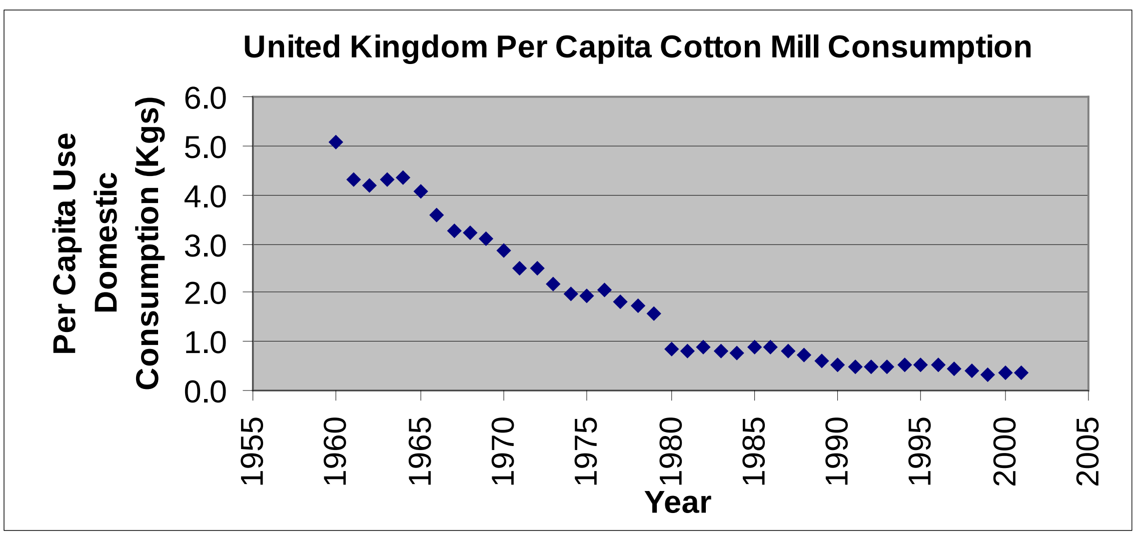


Figure 1.6 United Kingdom Per Capita Mill Consumption for the Period 1960/1961-2001/2002.

Source: Mill Consumption from USDA-ERS-PSD Database. Population from IMF.

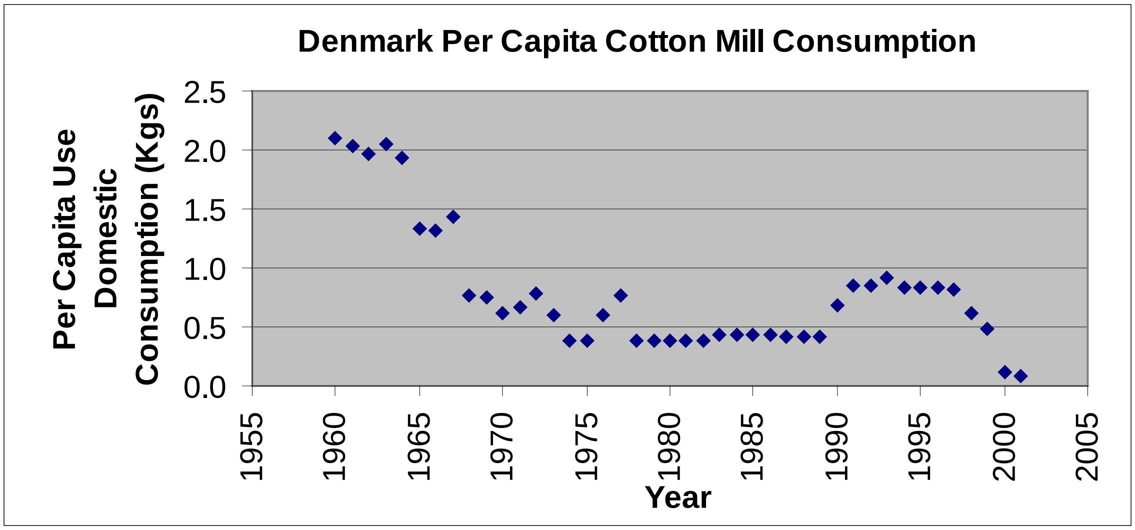


Figure 1.7 Denmark Per Capita Mill Consumption for the Period 1960/1961-2001/2002.

Source: Mill Consumption from USDA-ERS-PSD Database. Population from IMF.

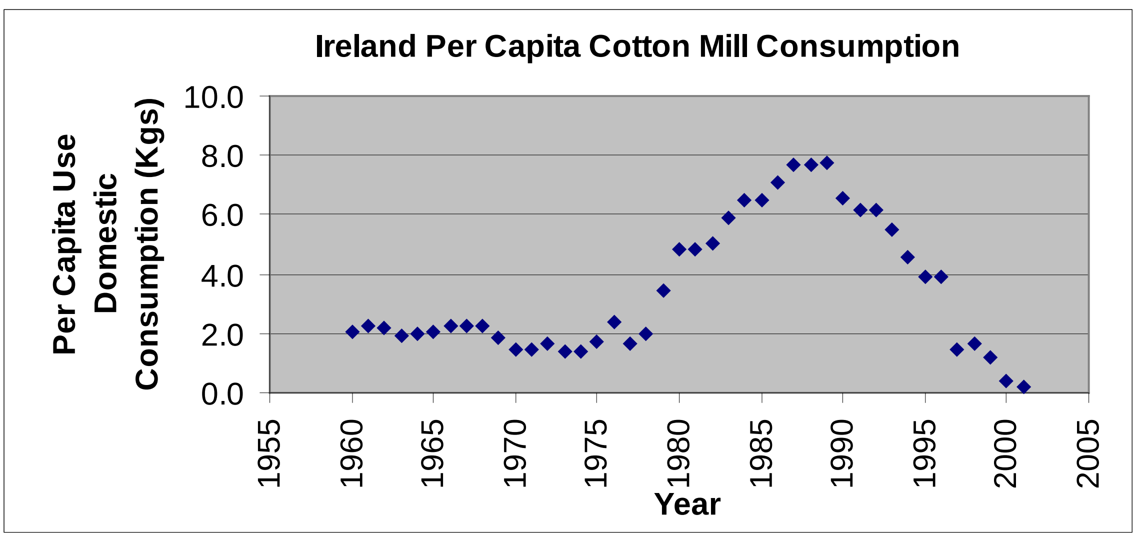


Figure 1.8 Ireland Per Capita Mill Consumption for the Period 1960/1961-2001/2002.

Source: Mill Consumption from USDA-ERS-PSD Database. Population from IMF.

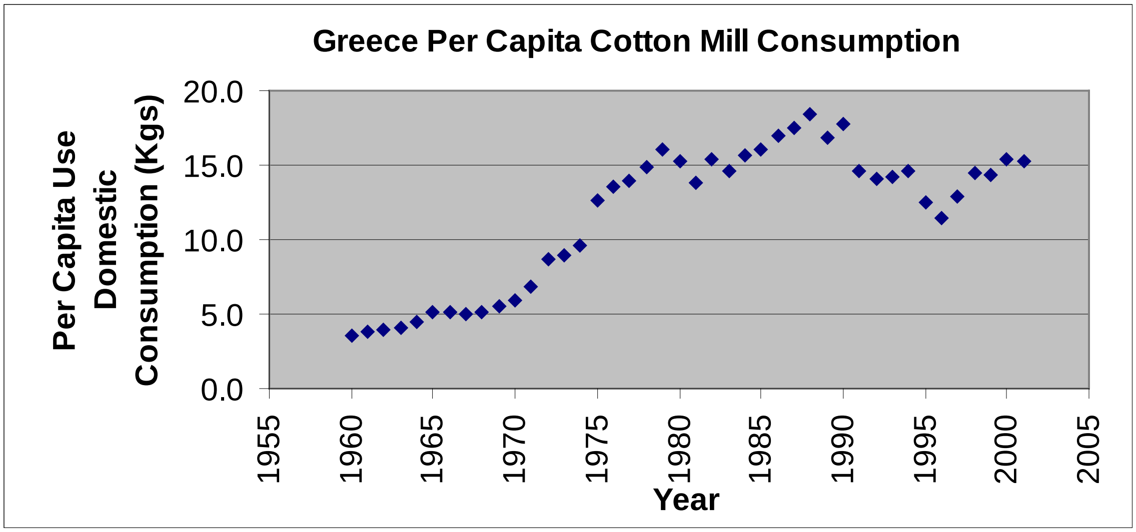


Figure 1.9 Greece Per Capita Mill Consumption for the Period 1960/1961-2001/2002.

Source: Mill Consumption from USDA-ERS-PSD Database. Population from IMF.

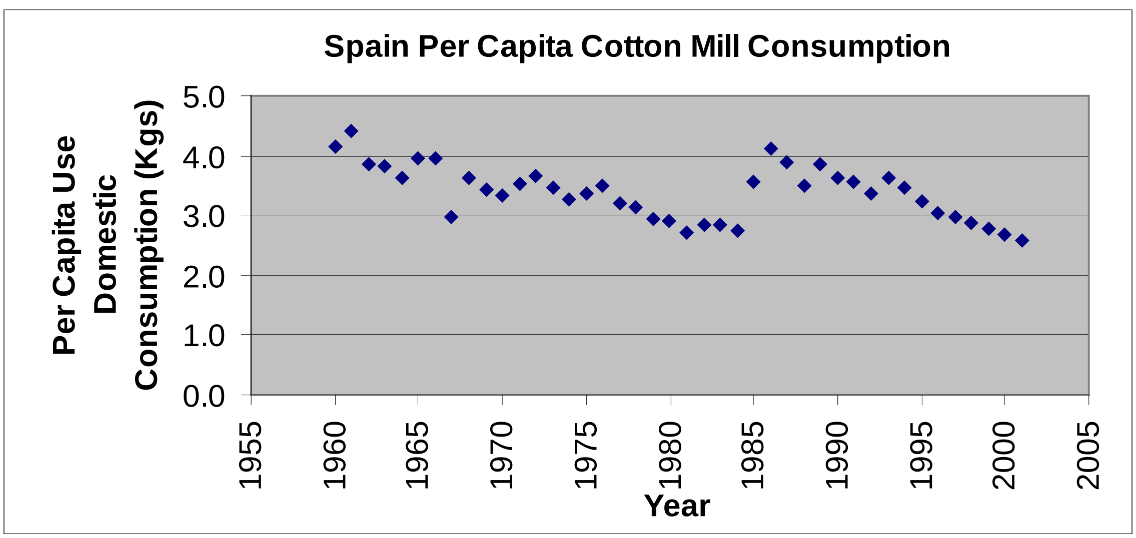


Figure 1.10 Spain Per Capita Mill Consumption for the Period 1960/1961-2001/2002.

Source: Mill Consumption from USDA-ERS-PSD Database. Population from IMF.

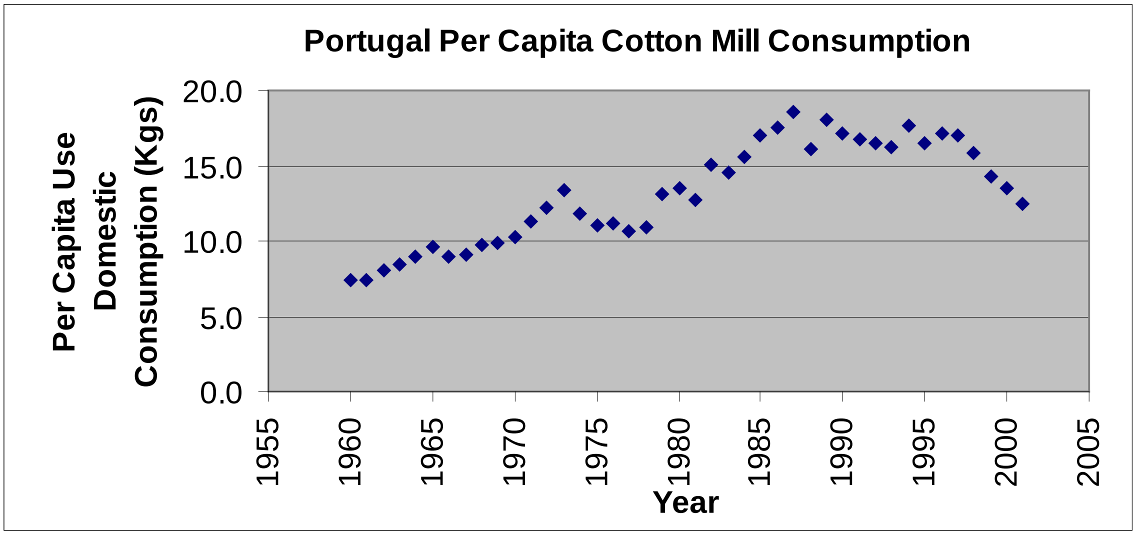


Figure 1.11 Portugal Per Capita Mill Consumption for the Period 1960/1961-2001/2002.

Source: Mill Consumption from USDA-ERS-PSD Database. Population from IMF.

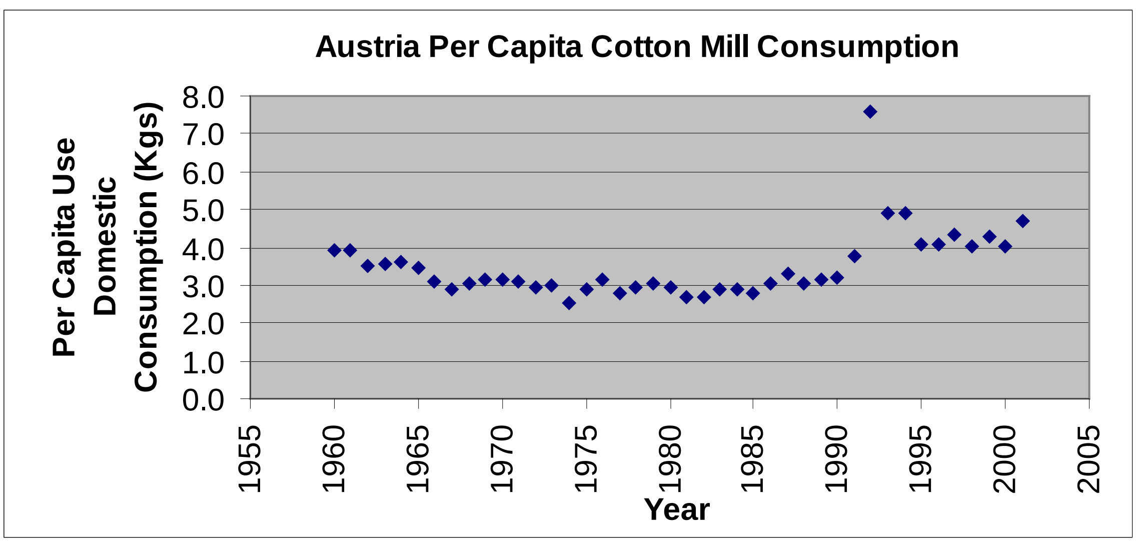


Figure 1.12 Austria Per Capita Mill Consumption for the Period 1960/1961-2001/2002.

Source: Mill Consumption from USDA-ERS-PSD Database. Population from IMF.

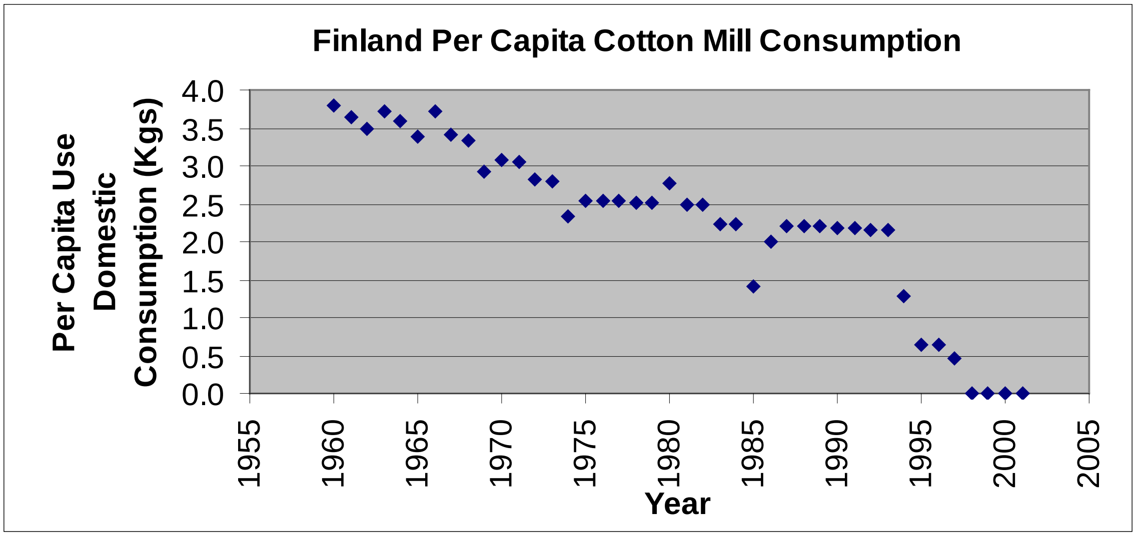


Figure 1.13 Finland Per Capita Mill Consumption for the Period 1960/1961-2001/2002.

Source: Mill Consumption from USDA-ERS-PSD Database. Population from IMF.

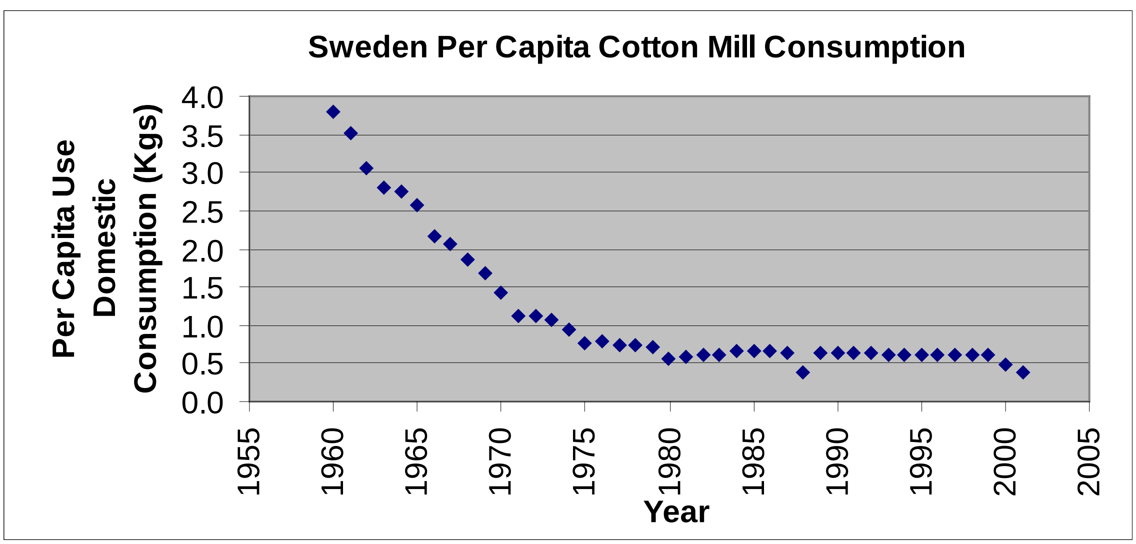


Figure 1.14 Sweden Per Capita Mill Consumption for the Period 1960/1961-2001/2002.

Source: Mill Consumption from USDA-ERS-PSD Database. Population from IMF.

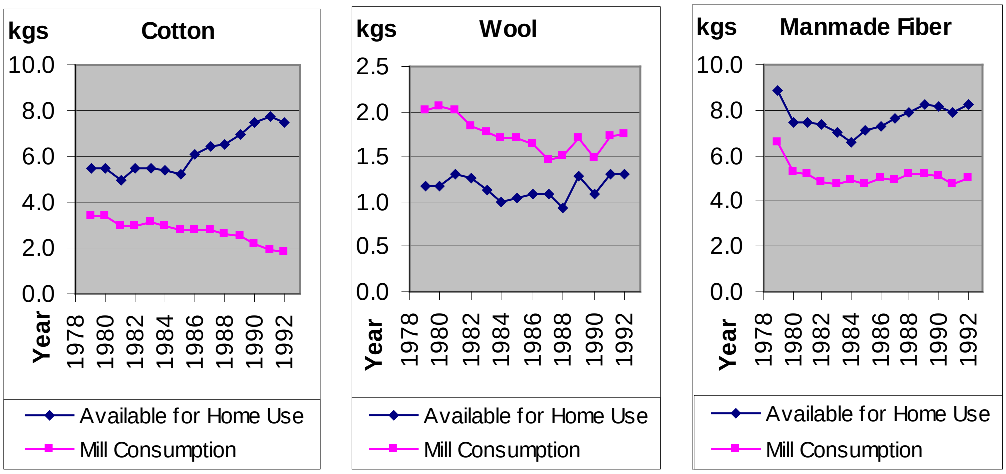


Figure 1.15 France Per Capita Cotton, Wool and Manmade Fiber Mill Consumption and Available for Home Use for the Period 1979 to 1992.

Source: World Apparel Consumption Survey, FAO.

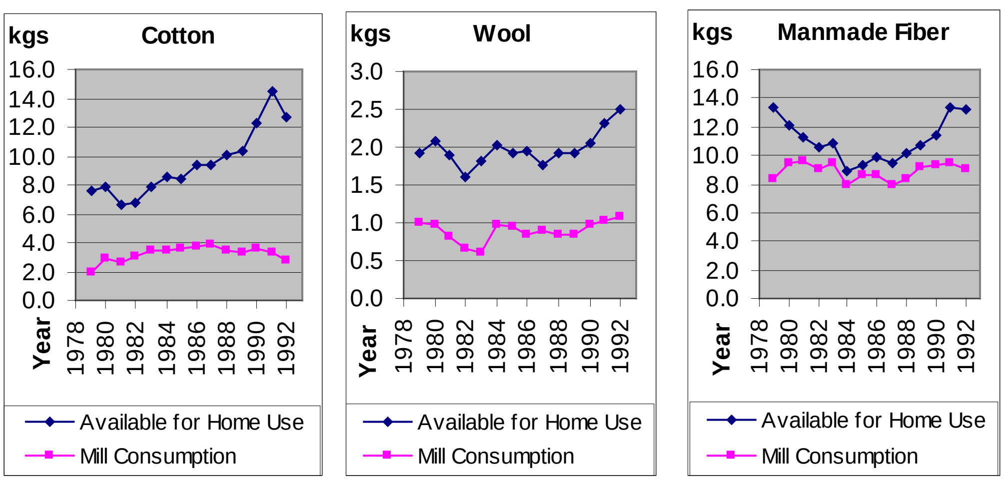


Figure 1.16 Germany Per Capita Cotton, Wool and Manmade Fiber Mill Consumption and Available for Home Use for the Period 1979 to 1992.

Source: World Apparel Consumption Survey, FAO.

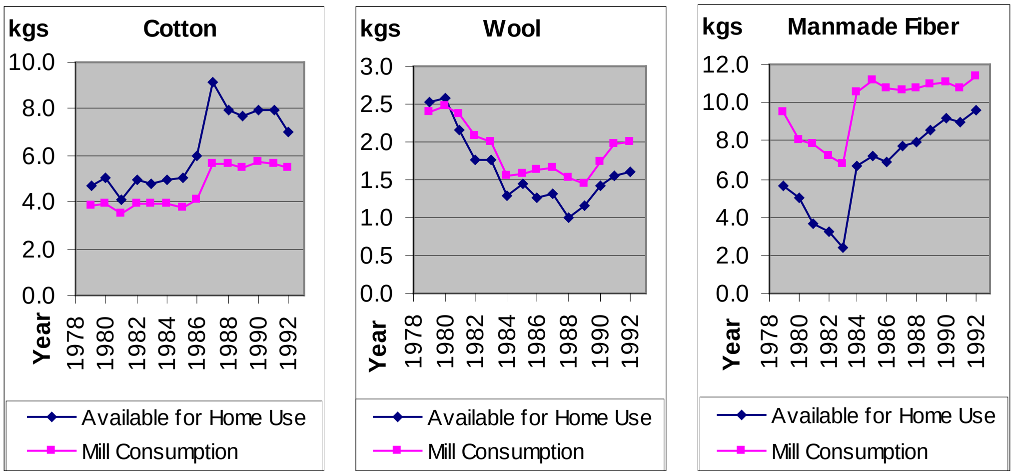


Figure 1.17 Italy Per Capita Cotton, Wool and Manmade Fiber Mill Consumption and Available for Home Use for the Period 1979 to 1992.

Source: World Apparel Consumption Survey, FAO.

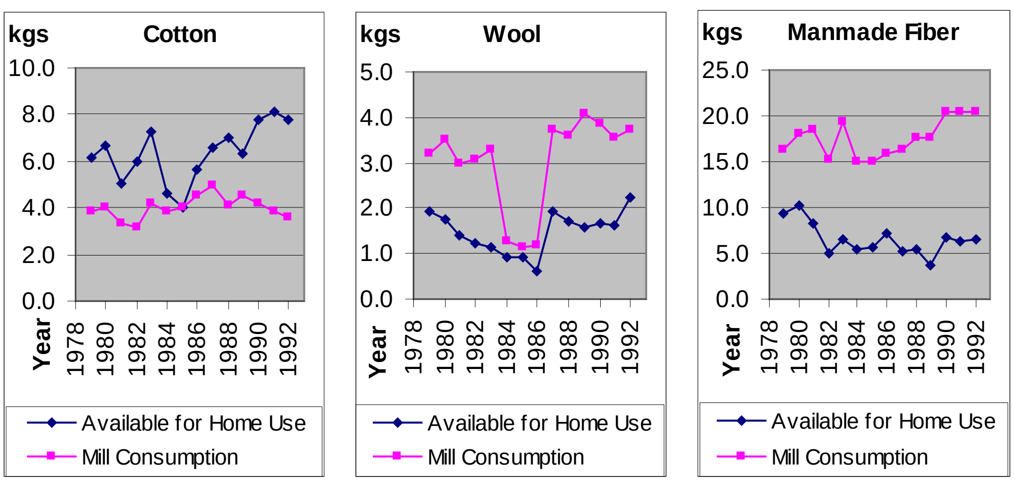
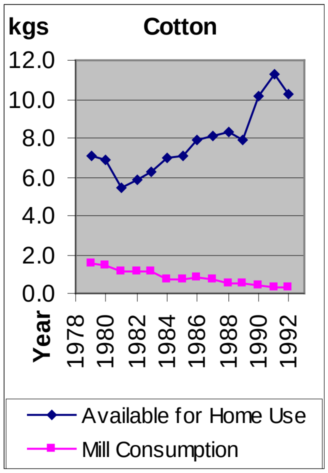
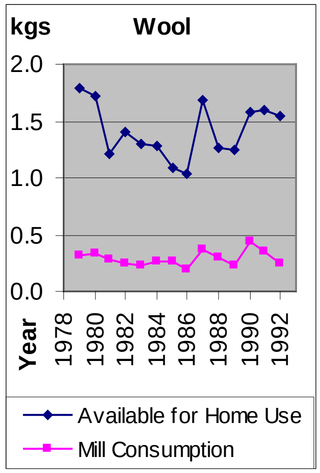


Figure 1.18 Belgium-Luxembourg Per Capita Cotton, Wool and Manmade Fiber Mill Consumption and Available for Home Use for the Period 1979 to 1992.

Source: World Apparel Consumption Survey, FAO.





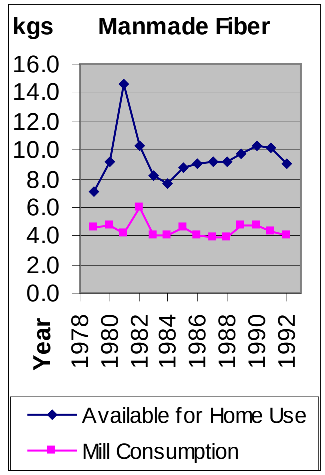
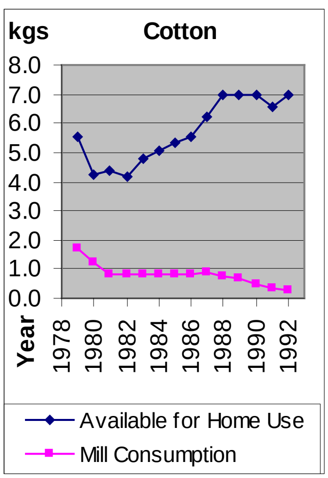
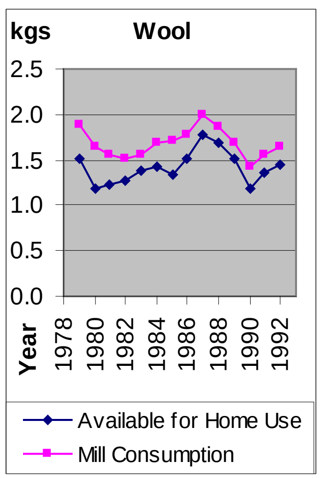


Figure 1.19 Netherlands Per Capita Cotton, Wool and Manmade Fiber Mill Consumption and Available for Home Use for the Period 1979 to 1992.

Source: World Apparel Consumption Survey, FAO.





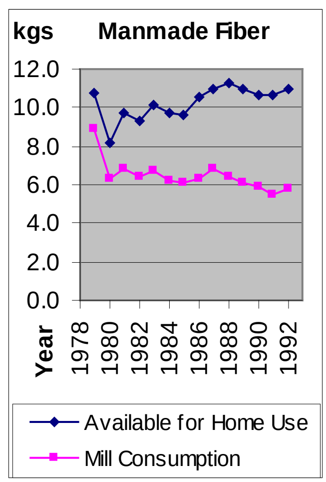


Figure 1.20 United Kingdom Per Capita Cotton, Wool and Manmade Fiber Mill Consumption and Available for Home Use for the Period 1979 to 1992.

Source: World Apparel Consumption Survey, FAO.

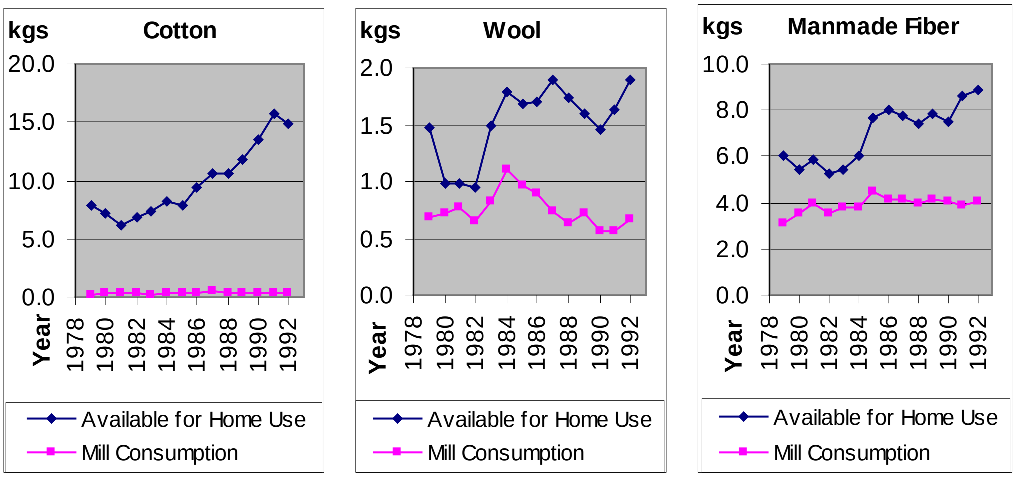


Figure 1.21 Denmark Per Capita Cotton, Wool and Manmade Fiber Mill Consumption and Available for Home Use for the Period 1979 to 1992.

Source: World Apparel Consumption Survey, FAO.

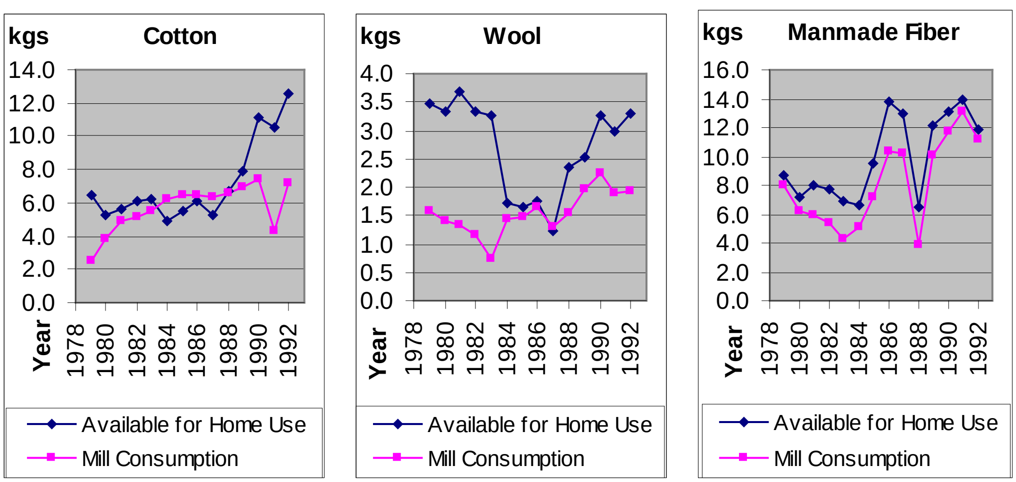


Figure 1.22 Ireland Per Capita Cotton, Wool and Manmade Fiber Mill Consumption and Available for Home Use for the Period 1979 to 1992.

Source: World Apparel Consumption Survey, FAO.

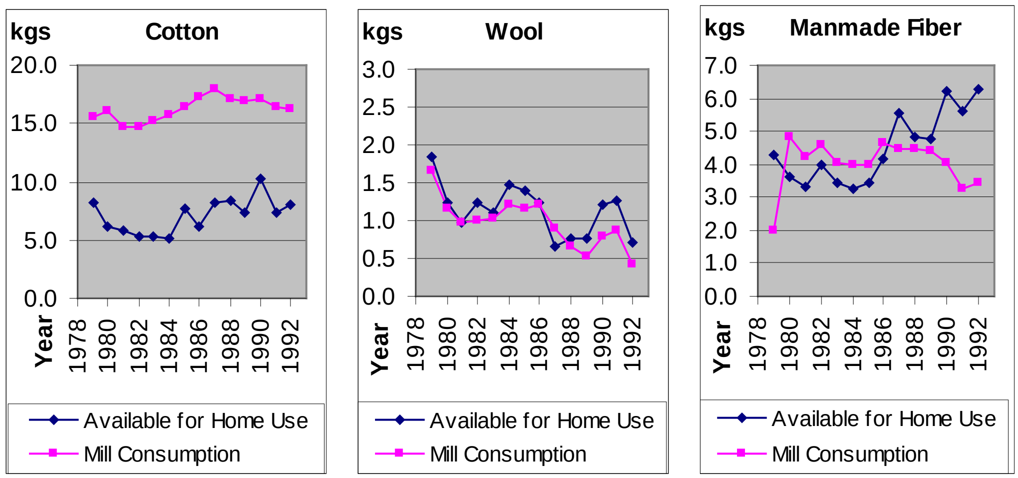


Figure 1.23 Greece Per Capita Cotton, Wool and Manmade Fiber Mill Consumption and Available for Home Use for the Period 1979 to 1992.

Source: World Apparel Consumption Survey, FAO.

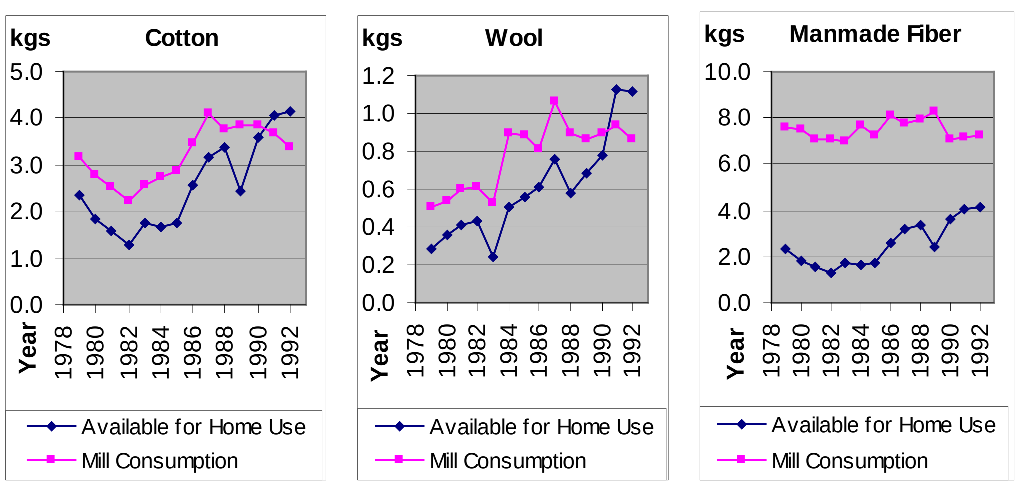


Figure 1.24 Spain Per Capita Cotton, Wool and Manmade Fiber Mill Consumption and Available for Home Use for the Period 1979 to 1992.

Source: World Apparel Consumption Survey, FAO.

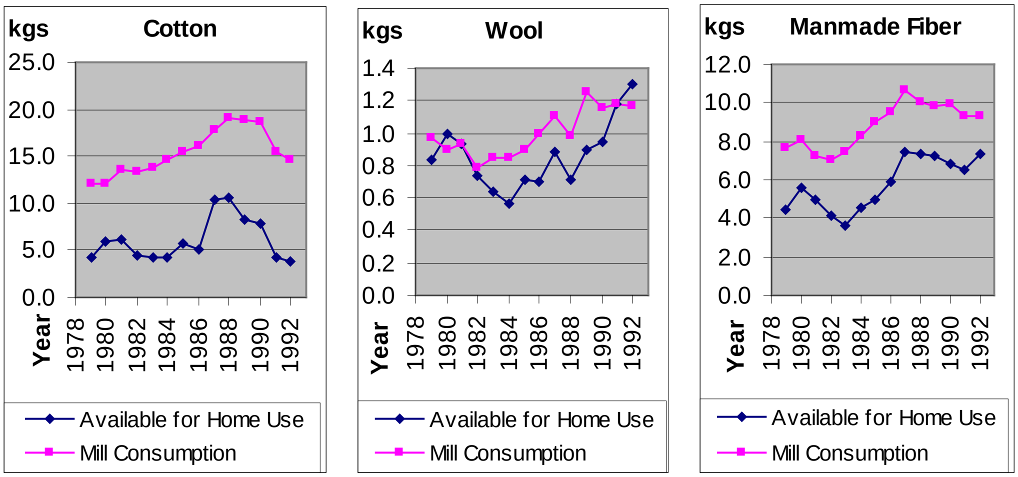


Figure 1.25 Portugal Per Capita Cotton, Wool and Manmade Fiber Mill Consumption and Available for Home Use for the Period 1979 to 1992.

Source: World Apparel Consumption Survey, FAO.

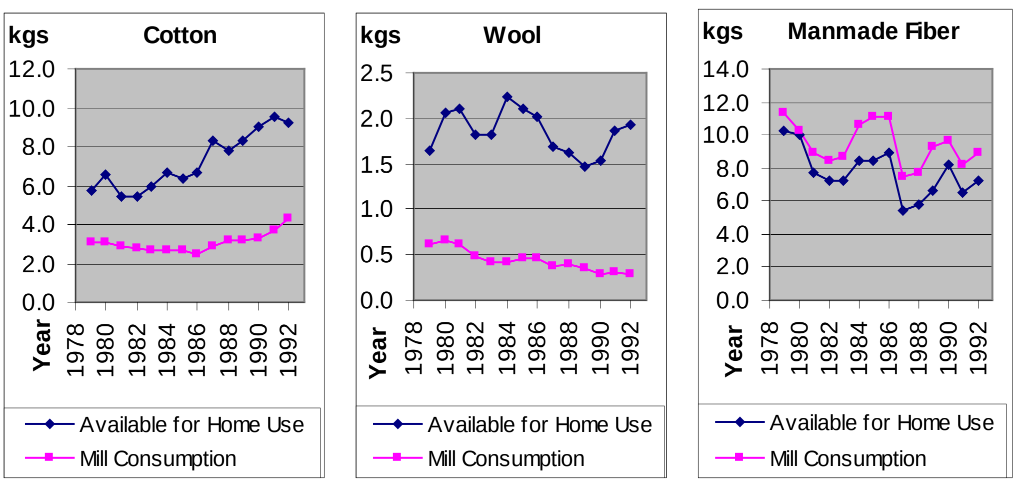


Figure 1.26 Austria Per Capita Cotton, Wool and Manmade Fiber Mill Consumption and Available for Home Use for the Period 1979 to 1992.

Source: World Apparel Consumption Survey, FAO.

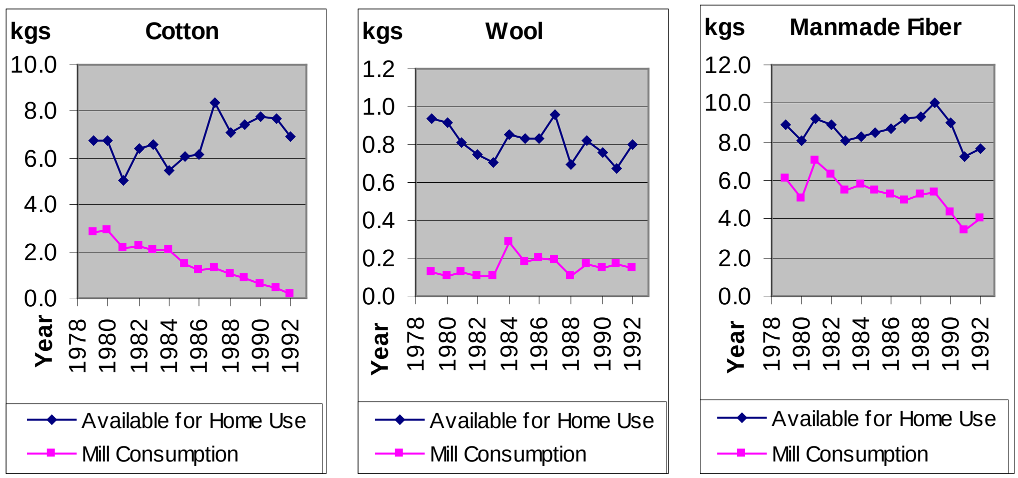


Figure 1.27 Finland Per Capita Cotton, Wool and Manmade Fiber Mill Consumption and Available for Home Use for the Period 1979 to 1992.

Source: World Apparel Consumption Survey, FAO.

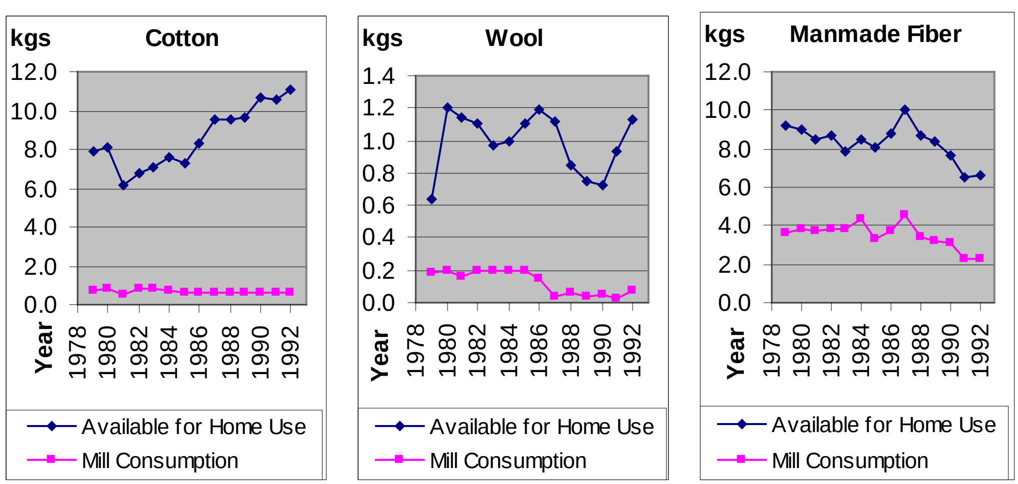


Figure 1.28 Sweden Per Capita Cotton, Wool and Manmade Fiber Mill Consumption and Available for Home Use for the Period 1979 to 1992.

Source: World Apparel Consumption Survey, FAO.

CHAPTER II

LITERATURE REVIEW

There are few economic studies that examine the cotton demand of the European Union. Most of the analyses done on this region have been performed within world models frameworks. In fact, this author is unaware of any recent studies primarily focused on the European Union. Furthermore, previous studies have mainly emphasized the conventional way of estimating cotton demand by a variety of functional forms, except for Clements and Lan (2001) who used a demand system approach.

In general, the objective of the literature review is to learn as much as possible from other research's efforts. Its purpose is to provide an understanding of the weaknesses and strengths of prior research. This review begins with an analysis of world fiber and cotton models, continues with an analysis of U.S. fiber and cotton models, and concludes by reviewing non-price factors that affect fiber demand. A summary of the literature reviewed is then provided.

2.1 World Fiber and Cotton Models

In their recent work, Clements and Lan (2001) used a system-wide approach to jointly model the demand for cotton, wool and chemical fibers. In doing so, they made use of cross-country data to estimate demand equations and avoid exchange-rate conversion problem of converting data into a common currency unit. Clements and Lan used cross-sectional data over 91 countries for two snapshots in time: 1974 and 1992.

By means of the separability theory and the assumption that the three fibers form a group which is distinct from all other goods, Clements and Lan (2001) used three demand models: the Rotterdam model, Working's model, and Selvanathan's model. To experiment with different specifications, two more models were specified. These two were a combination of Working's and Selvanathan's models but one was with income coefficients suppressed and the other with intercepts only. All five models for cotton, wool, and chemical fibers were estimated using maximum likelihood. Using a "stress test" of the models and adopting a simple iterative scheme, Clements and Lan analyzed the quality of the predictions. As a result, three models were dropped out because they predicted negative shares for wool. In this sense, only the Rotterdam and Working's and Selvanathan's models with intercepts passed the stress test.

Clements and Lan (2001) analyzed the decomposition of information inaccuracy using the Strobel measure for the Rotterdam and various special cases of the Working's and Selvanathan's with intercepts only (unitary income elasticities, no price effects, unitary income eslaticities and no price effects, and no-change extrapolation). Finally, creating a composite model from the two sets of competing forecasts, the Rotterdam and no-change extrapolation of the quantity shares gave rise to improvements in the quality of the predictions.

The estimated conditional income elasticity of world demand for cotton was 0.8, making it a conditional necessity; for wool it was 0.5, making it more of a necessity; and for chemical fibers was 1.3, making it a luxury. Each of the fiber demands was price inelastic. The estimated conditional own-price elasticities were -0.14, -0.02, and -0.16 for cotton, wool, and chemical fibers, respectively.

Clements and Lan (2001) showed that demand systems can be created in a theoretically satisfactory way to capture the interrelationships between fibers. Their methodology will be very useful in formulating the EU cotton demand model. However, they made use of the strong assumption that countries share the same tastes, preferences and technology, and thus the same demand function. Furthermore, their model only used mill consumption data for two snapshots in time. Better results might have been obtained if the data were pooled over time. Additionally, mill consumption data might not appropriately reflect the consumer choices as it is needed in demand system models. Finally, even though Clements and Lan made use of European countries in their model, their corresponding elasticities were not found. The present study will calculate Marshallian and Hicksian price and expenditure elasticities by considering the use of time series data pooled over time, any change in parameter specification that might have resulted through time, and tastes, preferences and technology of the E.U. alone.

Clements and Lan (2001) used a similar approach to Coleman and Thigpen (1991) and Coleman (1991) in modeling world demand for cotton and noncellulosic fibers. Coleman and Thigpen calculated an econometric model for the demand and supply of cotton and non-cellulosic fiber markets. The model was used to simulate and forecast world price, production, and consumption in the cotton and non-cellulosic fiber sectors. It was also used to assess the impact of future changes in China, the former Soviet Union (USSR), and U.S. cotton policy on world prices and supply and demand conditions in other countries. It additionally assessed the effect of the Multi-Fiber Agreement (MFA) on cotton demand and prices.

Coleman and Thigpen (1991) used a two-step approach, which was consistent with the two-stage budgeting model, to calculate cotton for home use. The first step calculated per capita total fibers for home use, which measured the consumption of all fiber types in the form of apparel and textile clothing. The second step calculated cotton share of total fibers for home use. To complete the demand equation, cotton use was computed by multiplying cotton share times per capita total fiber use times population.

In the first step, per capita total fiber use was estimated as a function of per capita deflated gross domestic product. The price of textiles was not included in per capita total fiber use equations because the use of indexes of prices was econometrically unsuccessful and because of a lack of data on textile prices. Fourteen per capita total fiber use equations were estimated. Different variables were used according to each country. These variables were per capita deflated gross domestic product, lagged per capita deflated gross domestic product, logarithm of per capita deflated gross domestic product, lagged per capita total fiber use, lagged logarithm of per capita total fiber use, trend variables, logarithms of trend variables, zero-one dummy variables, and the unemployment rate. Lagged per capita total fiber use was used for strong trends in per capita total fiber use. The trend variable was included to provide more reliable estimates of the elasticity of total fiber use with respect to income. The unemployment variable accounted for declining textiles sales during periods of recession. Logarithms were used when found that they provided a better fit to the data than their linear transformation.

Per capita total fiber use in the European Union (EEC-12) was estimated as a function of the logarithm of per capita deflated gross domestic product, the unemployment rate, and three zero-one dummy variables for the Multi-fiber Agreements (MFA) (1974 to 1977, 1978 to 1981, and 1982 to 1985). Together these variables explained 93% of the total variation in per capita total fiber use for the period 1964-87. The unemployment rate variable was not significant but was kept in the equation because it was signed correctly. The three dummy variables captured the decline in consumption resulting from restrictions on imports of textile products to the EU (EEC-12) from developing countries. Coleman and Thigpen (1991) also estimated the model with an index of prices of textile and apparel products variable but the variable was dropped from the equation because it had a very low t-value (i.e., less than unity). Consequently, the income elasticity of demand for the EU was 1.08.

In the second step, cotton share captured the manufacturers' behavior of the consumption of cotton, wool, and synthetics as dependent on their relative prices. Cotton share was derived from the price of cotton and the price of polyester staple. Coleman and Thigpen (1991) also included an income variable, but since it was not statistically significant, it was pursued no further.

The two-stage least squares estimator (2SLS) was used to avoid the inconsistency of OLS due to the fact that the cotton share equation contained endogenous variables on the right-hand side. The variables used were lagged cotton share, lagged logarithm of cotton share, deflated cotton price, logarithm of deflated cotton price, deflated polyester price, logarithm of deflated polyester price, the ratio of deflated cotton price to deflated polyester price, logarithm of the ratio of deflated cotton price to deflated polyester price, and zero-one dummy variables. The ratio of cotton price to polyester price was used to improve the goodness of fit.

Cotton share in the EU was estimated as a function of the logarithm of the ratio of deflated cotton price to deflated polyester price and a zero-one dummy variable for year 1983. Together, these variables explained 70% of the total variation in cotton share for the period 1964-87. The estimated own- and cross-price elasticities were -0.14 and 0.14 respectively.

However, there are some disadvantages of using Coleman and Thigpen's model. First, no restriction was imposed to require that the sum of the fiber shares equals one. This will imply that the sum of the per capita individual fiber demand would not equal per capita total fiber use. Second, theoretically, the equation of the cotton share (second step) does not distinguish between the consumer side and the producer side. It captured the manufacturers' behavior for the consumption of cotton, wool and synthetics as dependent on their relative prices, but input costs and output prices were not taken into account (producer side). Third, with per capita total fibers use being determined only by income, all fiber's income elasticities are equal. Fourth, wool was not considered in their model. Fifth, when price ratios are used in equations, it may be due to an effort to try to get both prices to enter the equations with the expected sign in the parameter estimate. Finally, Coleman and Thigpen's model did not incorporate the theoretical classical restrictions of demand in the estimation process.

Although Coleman and Thigpen (1991) did not experiment with demand systems such as Rotterdam, Working's, AIDS, etc., they used a method that was consistent with the two-stage budgeting approach that provides a good background for the development of the conceptual framework. Coleman and Thigpen also illustrated how to approach the cotton demand of the EU. The variables used in their model plus any new parameter change will be considered in the present study.

Similar to Coleman and Thigpen (1991) and Coleman (1991), Meyer (2002) was concerned with a world model that could be simulated. Meyer developed a model for textile fiber supply and inter-fiber competition. The model was structured to answer questions concerning competition of fibers, the impact of textile demand on fiber prices, and effects of the adoption of GATT rules on U.S. fiber consumers and cotton producers, and Asian fiber consumers. The model worked with countries in Africa, Asia, Australia, North America, Latin America, and Europe. However, emphasis was on Asia and the United States.

The model covered world cotton production and consumption. However, synthetic and cellulosic production and consumption was only determined for the US and three Asian countries. Further, Meyer (2002) determined from the model demand, trade and production equations for finished textile goods in the U.S. market. Finally, behavioral results from sustained shocks to exogenous variables were also simulated. Two scenarios were considered, a 10% positive world wide income shock and a 10% increase in the ATC quota growth index.

In general, Meyer's (2002) model can be thought of as several sub-models linked together to form a world fiber and textile model. The cotton model was linked through trade and the world price with the cotton A-index being solved simultaneously with the supply and demand equations of each country. The A-index price entered into each country or region adjusted for exchange rates. Then, equilibrium was obtained by balancing global net exports and imports. Model equations were estimated using ordinary least squares (OLS).

The variables explaining per-capita cotton consumption in the EU were the cotton A-index price, a cotton processing loss, the Euro-$US-exchange rate, the U.S. polyester price (U.S. 1.5 denier polyester price), a synthetic processing loss, five dummy variables, E.U. real GDP, and E.U. population. The A-index price variable was included in all countries and it was determined simultaneously. Finally, the EU per capita cotton mill consumption was restricted to an equilibrium condition. All variables except real GDP were significant at p-value less than 0.005. Those variables explained 86.37% of the total variation of per-capita cotton consumption in EU. The elasticities for A-index price, synthetic price and per-capita GDP were -0.546, 0.531, and 0.199 respectively.

In terms of meeting his objectives and providing simulations, the model was successful. However, in several countries and in the case of the EU, Meyer (2002) did not justify the logic of the functional form used. For instance, explanation of the use of the dummy variables was not provided. In addition, wool was left out of the cotton consumption equation without explaining why. Being wool an important commodity and being closely related to cotton and manmade fiber, it will be better if it were present in the model. Similarly, the equation for the EU per-capita cotton consumption did not incorporate the theoretical classical demand restrictions nor captured interrelationship among cotton, wool, and manmade fiber.

Magleby and Missaien's models (1971) provided a good start for considering the use of single equation functional forms for cotton share in the EU. Magleby and Missaien estimated world fiber and cotton demand using time series data pooled over a large number of countries to examine questions on prospects for export earnings and on resource allocation to cotton production. Areas of particular concern were the expansion in future cotton consumption, import needs of major cotton deficit regions, and the sources and ways to meet these needs.

In their study, per capita income was the only regressor for world fiber demand and a variety of functional forms were tested, included linear, semi-log, and log-log equations. A time trend, a difference (polyester or nylon price minus cotton price), a ratio (cotton price to polyester or nylon price), income, and cotton price were the regressors for world cotton demand, depending on the country and on the functional form tested, including linear and semi-log forms. Log-log projections based on medium elasticity and medium income growth assumptions were accepted as the most appropriate for per capita fiber use. Total world fiber use was calculated by multiplying the accepted per capita fiber use projections by the projected population.

Cotton's share projections were made by time trends and different price levels. The accepted projections were arrived at by selecting from the alternative projections that which seemed most reasonable under a particular price assumption. Projections of per capita cotton use were obtained by multiplying projected per capita total fiber use by cotton's projected shares. Finally, projections of total domestic cotton use were made by multiplying projected per capita cotton use at alternative prices by projected population.

The results of the time series analysis of cotton's share for the period 1953-64 for the EU (France, Germany, Italy, Belgium, Netherlands, and Luxembourg only) depended on the model specification. Seven different functional forms were tested. The first was specified only by time, and it explained 87% of the total variation in cotton share. The second was specified by the logarithm of the time trend, and it explained 86% of the total variation in cotton share. The third was examined by the difference combined with the time trend or income; however, the wrong sign was obtained on the difference. The fourth was specified by the ratio combined with the time trend or income, and it explained 87% of the total variation in cotton share. The fifth was specified by cotton price combined with the time trend or income. However, no analysis was made for cotton share because of inadequate data, data with clearly too much variation to provide results, or because share of synthetic fibers was under 10%. The sixth was specified only by the difference, and it explained 80% of the total variation in cotton share. Finally, the seventh was specified only by the ratio, and the wrong sign was obtained.

The results of cotton's share for the period 1955-66 for the United Kingdom, which was not part of the EU at that time, also depended on the model specification. The same seven different functional forms mentioned above were tested. In the first, 95% of the total variation in cotton share was explained only by time. In the second, 95% of the total variation in cotton share was explained by logarithm of time trend. In the third, 96%

of the total variation in cotton share was explained by the difference when combined with time trend or income. In the fourth, 95% of the total variation in cotton share was explained by the ratio when combined with time trend or income. In the fifth, no analysis was made for cotton price combined with time trend or income. In the sixth, 87% of the total variation in cotton share was explained only by the difference. Finally in the seventh, 31% of the total variation in cotton was explained when only the ratio was used.

Although Magleby and Missaien (1971) provided seven different functional forms for cotton share, not all of them are useful. Econometrically, variables that are known to affect cotton share should be kept in the model. Consequently, only the functional form that incorporated own price, substitute prices, and time or income are acceptable. In this case, only the third and fourth specification will be accepted. Nonetheless, like Coleman and Thigpen (1991) and Meyer (2000), their model specifications didn't take into account wool. Furthermore, "ad-hoc" linear single demand equations do not incorporate the theoretical classical demand restrictions nor capture the interrelationship among cotton, wool, cellulose and synthetic.

Again, like Coleman and Thigpen (1991), Magleby and Missaien (1971) did not use demand systems. However, the variety of functional forms and variables used for the EU cotton demand will be of great use when considering the correct specification for the present study. Further, parameter changes due to technological factors and change of tastes will be accounted for in this recent work.

2.2 U.S. Fiber and Cotton Models

Viator (2000) quantitatively examined the demand for cotton in twelve selected end-uses from 1973 to 1997. Changes in fashion and governmental policy were also assessed during this time period. Viator also analyzed the direction of consumer demand in the textile industry. Her study helped the cotton industry, especially textile mills, to identify what end-use markets to target based on consumer end-use history.

Based on economic theory and her prior research in this field, Viator (2000) used five independent variables for the full model of cotton consumption. These variables were disposable personal income, the consumer price index for apparel and upkeep, lagged cotton and polyester prices, and a population variable based on the age and gender of consumers using the specific end-uses. The consumer price index for apparel and upkeep reflected the relative expensiveness of apparel items and their upkeep. The price of cotton used was the raw-fiber equivalent for middling, 1-1/16" fiber length at Group B mill points. Raw-fiber equivalent polyester prices were used as indicator of competition between cotton and synthetic fibers. A sixth variable was considered, a trade-weighted exchange rate index, to reflect the fluctuations in the value of the U.S. dollar against a group of currencies; but it showed no significance and was henceforth removed (after correcting for stationarity in this variable).

Ordinary Least Squares (OLS) was used to calculate the parameters of the five variables under a linear specification and a logarithmic specification. After performing an analysis using Directed Graphs for both the linear and the logarithmic data, OLS was run a second time to calculate the demand for cotton in twelve selected end-uses as indicated by the directed graph analysis. Overall, the linear model had more significance than the logarithmic model. The linear full model (using all variables) explained from 63% to 96% of the total variation in cotton demand in the selected end-use. The linear directed graph model explained from 31% to 96% of the total variation in cotton demand in the selected end-use.

Although Viator's (2000) general model is focused on cotton consumption in the varying end-uses, her approach can be easily modified to calculate aggregate cotton demand. The variables Viator used will also be considered as variables affecting cotton demand for the purpose of our study. However, as emphasized throughout the literature review, the disadvantage of working with linear models is that the theoretical classical restrictions of demand are not incorporated. Further, the strong interrelationship between competing commodities is better captured in a demand system.

In 1974, in an attempt to improve Donald, Lowenstein, and Simon's (1962) model for aggregate fiber demand analysis (used for deriving price elasticities for fiber and projecting domestic use), Dudley ran a regression to help explain U.S. fiber demand past trends and indicate what may lie ahead for fibers. Dudley's study helped economists, industry planners, consumers, and farmers make rational decisions. His study for the U.S. market discussed methods of estimating total fiber demand, presented demand for each major fiber, measured price elasticities for fibers in major end uses, and identified where price changes have the greatest effect on demand. As Viator, Dudley also considered the estimation of cotton demand at end–uses.

The factors Dudley (1974) recognized affecting the aggregate fiber demand were income, price of fiber products, price of non-fiber products, tastes and preferences, consumer stocks of fiber products, and technology. Unfortunately, not all these factors could be measurable. After identifying some measurable long-run factors affecting aggregate fiber demand, such as industrial activity, consumer income, and population, and some non-measurable factors such as climate, fashion changes, new products and increasing leisure time, Dudley developed a method to project future demand.

To achieve the best possible estimate of aggregate fiber consumption, he selected a real price approach. He computed a price index that used the price of polyester staple as representative of noncellulosic staple fiber rather than nylon and deflated it. Then he deflated this price index again by an index of personal disposable income. Dudley (1974) also included in his model changes in the deflated level of personal disposable income, aggregate fiber consumption lagged one year and a time trend variable. A log-linear model was estimated to better fit the data. The resulting equation explained 97% of the variation in total fiber use during 1953-70. All coefficients except the lagged dependent variable were significant at the 5% probability level with the expected signs. The equation indicated that a 10% increase in the real price of fibers resulted in a 3.8% decrease in fiber use in the U.S.

When trying to proportion the aggregate level among the various fibers by considering competitive factors such as prices, utility, and wearability, regression analysis were unsatisfactory. Thus, to calculate domestic consumption for each fiber, Dudley (1974) used a nonparametric device, the Compertz curve.

Finally, to calculate each fiber use in end uses for men's apparel, women's apparel, household furnishings, other consumer products, and industrial uses markets; Dudley used econometric models. For the equation of fiber use in each market, the variables included were a ratio of the price of the fiber with the price of noncellulosic fiber, the total demand for each fiber, and a time trend; except for the noncellulosic fiber where he used, instead of the ratio, a weighted average price for noncellulosic fibers deflated by the Wholesale Price Index. The models worked better for the cotton and noncellulosic fibers than for the wool and cellulosic fibers.

Note that Viator (2000) estimated cotton demand at end-uses and her approach was totally different. Dudley calculated total cotton demand first and then he calculated cotton demand in end-uses. On the contrary, Viator formulated equations to calculate cotton demand in end-uses without having to calculate total cotton demand.

Although Dudley (1974) did not calculate the aggregate demand level for different fibers, his model for aggregate fiber demand identified key variables such as own price, other fiber prices, income, lagged fiber demand, and trend, that are known to determine aggregate fiber demand. Some of these variables have appeared in Coleman and Thigpen (1991), and Magleby and Missaien (1971), but under different functional form specifications. Basically, economists have concentrated on looking for the functional forms that better illustrate their case rather than adding more variables. Dudley's identification of key variables explaining aggregate fiber demand will be an input in this study.

Lewis (1971) performed an econometric analysis of the demand for textile fibers. Lewis specified, estimated, and simulated dynamic demand equations for natural fibers (cotton, apparel wool, and carpet wool) and the man-made fibers (rayon-acetate staple and filament yarn and synthetic staple and filament yarn) in the United States using annual data to calculate elasticities and forecast mill consumption.

The steady-state demand level was specified as a function of a series of fiber prices and the level and the rate of change of real per capita income. Then, a stock-adjustment mechanism was introduced to describe the actual time pattern of demand. The demand equations were estimated at the mill level using the poundage of each fiber processed annually as the dependent variable. Cross-prices were lagged one period assuming information delay. In some occasions, the synthetic price was inverted. Dummy variables were used for depression periods and war years. The demand equation for cotton, wool and rayon was linear but for synthetics, a log-linear specification better fitted the data. After assuming that fiber prices were exogenous, the demand equations were estimated using OLS and GLS. To estimate the demand of cotton, Lewis (1971) used OLS and introduced in the equation a lagged dependent variable, income level, own price, synthetic staple price inverted, the change in the income level, a war dummy variable and a depression dummy variable.

For the U.S., this cotton equation specification explained 92% of the total variation in cotton demand at the mill level for the period 1922-1966. Even though the DW statistic was greater than two, only scattered evidence was found of significant negative autocorrelation. Lewis' (1971) model predicted fairly well consumption levels in the very near future (in few cases as far ahead as three years), but it generally deteriorated thereafter. In general, Lewis found evidence of significant substitutability between fibers and a price inelastic fiber demand, which helped to explain the observed instability in fiber prices. However, Lewis stressed the importance of non-price factors in inter-fiber competition such as quality improvement, successful promotional campaigns, stable supplies, and technical assistance in handling synthetic fibers.

Once again, key variables were identified and found to determine cotton demand. These key variables were the same variables shown by other studies to affect fiber demand. These variables will be considered and tested for the EU.

2.3 Non-Price Factors Affecting Fiber Demands

Shui, Beghin, and Wohlgenant (1993) developed a complete system of input cost shares in U.S. textile production to evaluate the impact of technical change, scale effects, and forward ordering on fiber demands. The system of input cost shares used a linear logit specification with time-series data for the period 1950-87. Shui, Beghin and Wohlgenant decomposed fiber use into two categories: natural fiber (cotton and wool) and manmade fiber (rayon and polyester).

Two measures were used to capture the technical change effect on fiber demands: a traditional time trend and the rate of shuttleless weaving. This rate was computed by dividing shuttleless looms by total weaving looms. This share captured the changing nature of physical capital in textile production (type of looms used in weaving). This was found to represent an increasingly important technical break-through in textile production after the 1960s. It indicated that technical change had adversely affected the demand for natural fibers (cotton and wool) in favor of manmade fibers. Technical change has also being studied by Field (1987), Batavia (1979) and Ward and King (1973).

Scale effects were found to be important determinants of fiber demand. Scale effect did not account for economies of scope. However, scale effects consisted of two measures of textile output: the index of industrial production of textile mill products and real shipment values for the U.S. textile industry. The output index reflected some of the change in product mix of the textile industry.

Forward ordering referred to the fact that there existed some lags between orders and deliveries. In the U.S., distributors and retailers, often, contracted for cotton fiber and other materials twelve months or more prior to delivery. Forward ordering effects were taken into account by allowing both cost of adjustment and lagged natural fiber prices to take place in the system of input cost shares. Forward ordering in the U.S. has also been studied by Stennis, Piar, and Allen (1983).

Shui, Beghin and Wohlgenant (1993) performed a decomposition analysis to estimate the relative importance of different factors contributing to the decline of natural fiber use relative to manmade fiber use. They found that factors such as technical change and scale effects have contributed significantly to this decline. Further, nonprice factors contributed to about 70% of the predicted decline of the natural fiber share.

Due to the importance of nonprice factors on fiber demands, this study will attempt to incorporate them. This will help the model in this study to better fit the data. However, it should be mentioned that due to data limitations and the nature of the model’s functional form used, some nonprice effects will not be able to be incorporated. However, Shui, Beghin and Wohlgenant (1993) have provided variables to account for factors other than prices and quantities.

2.4 Demand System Models

Medina (2000) used a demand system approach to estimate household demand for meats in the United States. She empirically measured the demand for different meats and meat cuts building on previous research and applying new techniques and data. In her dissertation, she put emphasis in incorporating and measuring the impact of demographic variables, prices, promotional effects, and health concerns on consumer preferences for meat. Demand curve, expenditure, and demographic simulations were performed after ranking the impact of all demand drivers.

Medina (2000) used an Almost Ideal Demand System (AIDS) model and estimated Marshallian and Hicksian price and expenditure elasticities under two scenarios. Scenario one calculated the parameters of the demand for beef, poultry, pork, and fish; while scenario two considered nine products (roast, steak, other beef, ground beef, chicken, turkey, other poultry, pork, and fish). Medina did not use Stone’s (1954) price index but approximated it in a nonlinear manner, including it into the AIDS model and using maximum likelihood. Her AIDS model incorporated demographic variables by using demographic translating. Each demographic variable was binary and was usually represented by dummy variables. However, the dummy variables were coded as differences from the excluded dummy variable. This step was performed to compare each demographic variable to an average household.

The demographic effects included household size, age of female, female employment level, female education level, census region, and market size. Income was not included as another demographic variable because the income effect was claimed to be embedded in the total expenditure variable. Consequently, the models were separated into income groups before actually being estimated.

Medina's (2000) study pooled cross sectional and time series data. Panel data in the model did not present a problem because household differences were captured trough demographics and seasonality. Therefore, all parameters were estimated focusing on the right specification of the systematic component and imposing the theoretical classical restrictions of the AIDS model.

Overall, Medina's (2000) work is a good example of how a demand system approach can be used in combination with panel data. Her model incorporated the theoretical classical demand restrictions and captured the interrelationship among products. Medina's model development will provide insight in determining the appropriate AIDS model specification for this study.

2.5 Summary

This chapter reviewed relevant studies of cotton demand for both the world and the U.S. that will be useful for EU model considerations. There are numerous economic studies that examine cotton demand, but only world models include the EU. Only four world models were found to work with the EU: Meyer (2002), Clements and Lan (2001), Coleman and Thigpen (1991), and Magleby and Missaien (1971). Of these four studies, only Meyer (2002), Coleman and Thigpen (1991), and Magleby and Missaien (1971) provided some elasticity results. These elasticities are summarized in Table 2.1. In some cases the cotton demand elasticity values differ substantially. For example, the income elasticity of cotton ranges from 0.20 (a necessity) to 1.08 (a luxury).

Furthermore, most previous studies have used country-aggregated data of European cotton consumption or have used mill consumption instead of fiber equivalent home consumption. Those methodological choices might not appropriately allow the estimation of the cotton European demand parameters. Similarly, most previous studies have excluded wool as a cotton competitive commodity without explaining the reason. Finally, most of the cotton demand estimation models use the conventional functional approach and few use a demand systems approach. The demand system approach makes a formal attempt to incorporate theoretical restrictions into the model to insure consumer behavior is consistent with theory. Further, it has proven to better capture the strong interrelationship between commodities.

Consequently, as the literature review revealed, the demand of the largest world cotton importer has not received appropriate emphasis. Therefore, a recent study to accurately and appropriately estimate the European Union cotton demand parameters is needed. This research will explore the cotton demand elasticities of the 15 European Union members at both mill consumption and home consumption levels using country-disaggregated data and a demand system approach.

Table 2.1 Summary of Empirical Cotton Demand Elasticities for the European Union

Reference	Period	Income Elasticity	Own-Price Elasticity	Cotton-Manmade Price Elasticity	Note
Meyer, 2002	1986-1998	0.20	-0.55	0.53	World Simulation Model
Coleman and Thigpen, 1991	1964-1987	1.08	-0.14	0.14	Two-Stage Approach
Magleby and Missaien, 1971	1953-1964	0.63	-	-	Single Demand Equation Approach

CHAPTER III

CONCEPTUAL FRAMEWORK

Through time, consumption of cotton fiber has varied widely. Demand fluctuations and long-term trends have been dependant upon among other factors, changes in fiber price relationships, changes in tastes and preferences, and the introduction of new and improved products made possible by fiber research, particularly in the noncellulosic fiber industry.

Since the primary objective of this study is to determine the cotton demand of the EU, this section presents alternative approaches for estimating demand. Two well-known approaches are the conventional demand analysis and the "demand systems" analysis; although a combination of the two is sometimes used (a method consistent with the two-stage budgeting approach).

3.1 Conventional Demand Analysis

According to Neoclassical Demand Theory, consumer preferences are complete, reflexive, transitive, and continuous. Utility is maximized subject to a budget constraint,

$$(3.1) \quad y \geq \sum_{i=1}^{k} (p_i * q_i)$$

where y = income or budget constraint,

p_i = price of commodity "i,"

q_i = quantity demanded for commodity "i."

By using a Lagrangian multiplier, an expression for quantity demanded as a function of all prices and income can be derived. In economics this is called the generalized demand function. Then, from the generalized demand function, the ordinary demand function, the Engel curve, and the cross-price demand functions can derived by simply allowing each price or income to vary in turn. The generalized demand function will look as follows:

(3.2) $q_i = q_i(y, p_1, p_2, p_3, \ldots, p_k)$.

Based on this approach, conventional demand estimations have been used in the analysis of cotton demand. Viator (2000), Dudley (1974), Lewis (1971), and Magleby and Missaien (1971) have estimated a simple cotton demand equation by using variables such as income, own-price and price of substitutes. These variables are always included in the equation because the demand curve is mathematically obtained from the Lagrangian multiplier.

The drawback of this single commodity model is that it fails to recognize explicitly the interrelationships among commodities that are closely related and generally makes no formal attempt to incorporate theoretical restrictions to the process of demand estimation.

3.2 Demand Systems Analysis

Modern demand theory developments suggest models that are able to capture close interrelationships among commodities. Credit for the first empirical application of the complete demand systems approach goes to Stone (1954). He is the first to form a bridge between the old methodology and the new.

Complete “demand systems” are sets of demand equations derived from well-behaved utility functions which describe the allocation of expenditures among alternative commodities. This demand systems approach provides information on the degree and nature of the interrelatedness of the demand functions, makes assumptions regarding the interaction of commodities and the nature of utility functions, and makes a formal attempt to incorporate theoretical restrictions into the model to insure consumer behavior is consistent with theory.

For instance, given a strong correlation in the demand of three competitive fibers (e.g., cotton, wool and manmade fiber), demand systems can be used to capture interrelationships and jointly estimate their demand parameters. Basically, if the price of one of the commodities changes it will increase/decrease the quantity demanded of all commodities. The system approach recognizes that the change in consumption of that commodity will be balanced by changes in the consumption of the other two fibers. In other words, changes in prices in one commodity simultaneously affect the quantity demanded of the other two commodities and the allocation of total expenditure.

The theoretical restrictions incorporated into the model consist of Marshallian demand equations obtained by maximizing the utility function subject to a budget constraint, and Hicksian demands derived from the cost minimization principle and must satisfy four properties: (a) adding-up, (b) homogeneity, (c) symmetry, and (d) negativity.

The property or restriction of adding-up implies that the sum of expenditures on alternative commodities within a demand system must be equal to the total expenditure on commodities in that system, in both Marshallian and Hicksian demands. That is, the following equation must hold:

(3.3) $$\sum_{i=1}^{k} p_i * h_i(u, p) = \sum_{i=1}^{k} p_i * q_i(y, p) = y,$$

Where p_i = price of commodity "i", h_i = Hicksian demand of commodity "i", q_i = Marshallian demand of commodity "i", u = utility, y = total expenditure. The Engel aggregation condition is derived from the adding-up property.

The property of homogeneity of degree zero in prices and total expenditure for Marshallian demands implies that, for any positive constant $\Theta > 0$, changing prices and expenditures by Θ will not affect the quantities demanded. The property of homogeneity of degree 0 in prices for Hicksian demands implies that for any positive constant $\Theta >0$, changing all the prices by Θ will not affect the quantities demanded. Expressed in equation form:

(3.4) $$h_i(u, \Theta p) = h_i(u, p) = q_i(\Theta y, \Theta p) = q_i(y, p).$$

The symmetry property of the cross-price derivatives of the Hicksian demands is implied by Young's theorem. This means that, in a Hicksian constant utility demand system, the effect of the price of commodity j on the demand for commodity i is equal to the effect of the price of commodity i on the demand for commodity j, or:

(3.5) $$\partial h_i(u, p)/ \partial p_j = \partial h_j(u, p)/ \partial p_i, \text{ for every } i \neq j.$$

The negativity condition of Hicksian demands implies that the own-price derivatives will be negative because the Slutzky matrix of elements $\partial h_i / \partial p_j = s_{ij}$ is negative semidefinite, a condition derived from the concavity of well-behaved cost functions.

A demand system approach usually incorporates the first three restrictions into one model to ensure that it is consistent with consumer behavior theory.

Some advantages of the demand systems approach are:

- ❖ Imposing the neoclassical restrictions allows economies of parameterization, always important when dealing with time series data,
- ❖ These restrictions, when appropriately imposed, are useful in econometric sense, permitting gains in efficiency of the estimation and likely alleviating to a large degree the problem of multicollinearity among prices, income, and other exogenous factors,
- ❖ Capture change in any socioeconomic and demographic characteristics that may lead to reallocation of expenditure among the consumption categories,
- ❖ Balance changes in consumption in other commodities,
- ❖ Obtain a realistic description of consumer behavior under varying conditions.

Unfortunately, even when the demand system approach is selected, the following drawbacks still exits:

- ❖ Requires a relatively large sample size,

- Works with a large number of coefficients,
- Does not provide information about the "true" form of the demand functions.

However, several approaches have developed specifications that approximate the true form. The most used approaches in demand systems are the Rotterdam model and Almost Ideal Demand Systems (AIDS). Economists Clements and Lan (2001) based their cotton demand estimation on a Rotterdam model.

3.3 Two-Stage Budgeting Approach

Several economists have combined modern theory with the conventional approach to estimate demand equations. For instance, the two-stage budgeting approach discussed by Deaton and Muellbauer (1980) has provided theoretical structure for modeling the demand for agricultural commodities.

This approach is based on the assumptions of separability of preferences. If separability of preferences holds, agricultural commodities can be partitioned into groups so that preferences within groups can be described independently of the quantities in other groups. Subsequently, subutility functions can be obtained for each group and the values of these subutilities can be combined to get total utility.

The utility function can be written as:

(3.6) $u = v(q_1, q_2, q_3, \ldots, q_n) = f\,[v_1(q_{11}, q_{12}, q_{13}, \ldots, q_{1k}), v_2(q_{21}, q_{22}, q_{23}, \ldots, q_{2k}), \ldots, v_m(q_{m1}, q_{m2}, q_{m3}, \ldots, q_{mk})]$

where $f(\ldots)$ = some increasing function,

$v_1, v_2, \ldots, v_m$ = subutilities functions associated with their respective commodity or commodities in their subgroup,

n = the number of commodities,

k = number of commodities in a subgroup,

m = partition of all consumption goods into groups or subgroups,

$n > k$.

Note that some group may only contain one good. Additionally, each V_i for $i = 1, \ldots, m$ can be regarded as a utility function for brad commodity groupings such as food, apparel or entertainment, while q_{ai} for $a = 1 \ldots m$ ("a" representing the subgroup) and $i = 1, \ldots, k$ are the quantities of individual goods consumed within the group.

Therefore, the commodities are partitioned into m groups so that preferences within any subutility function can be described indepently of the quantities of goods consumed in other subutility functions. This is known as weak separability. Modifying Deaton and Muellbauer's example, the following utility tree is provided for illustration:

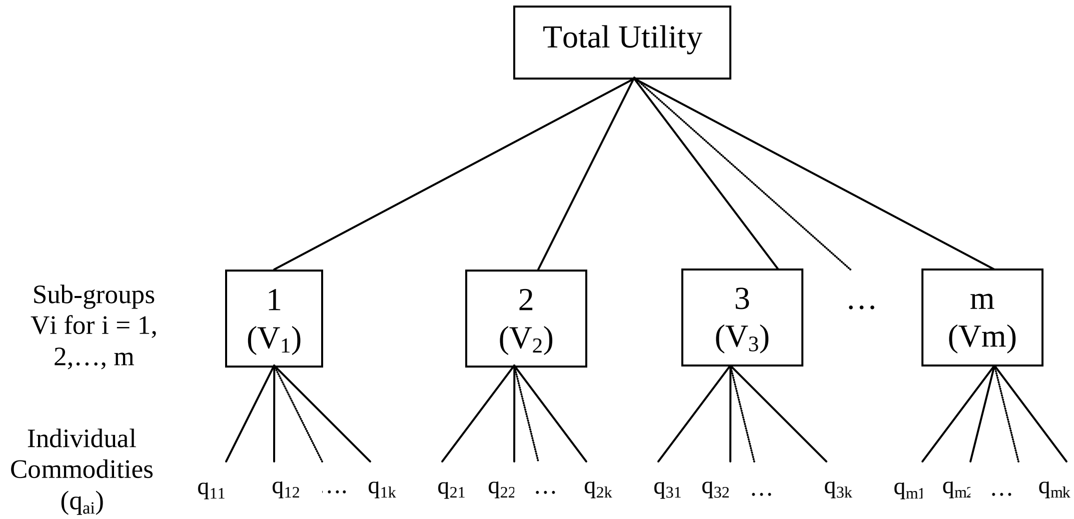


Figure 3.1 Utility Tree.

The example provided by Deaton and Muellbauer (1980) is as follows:

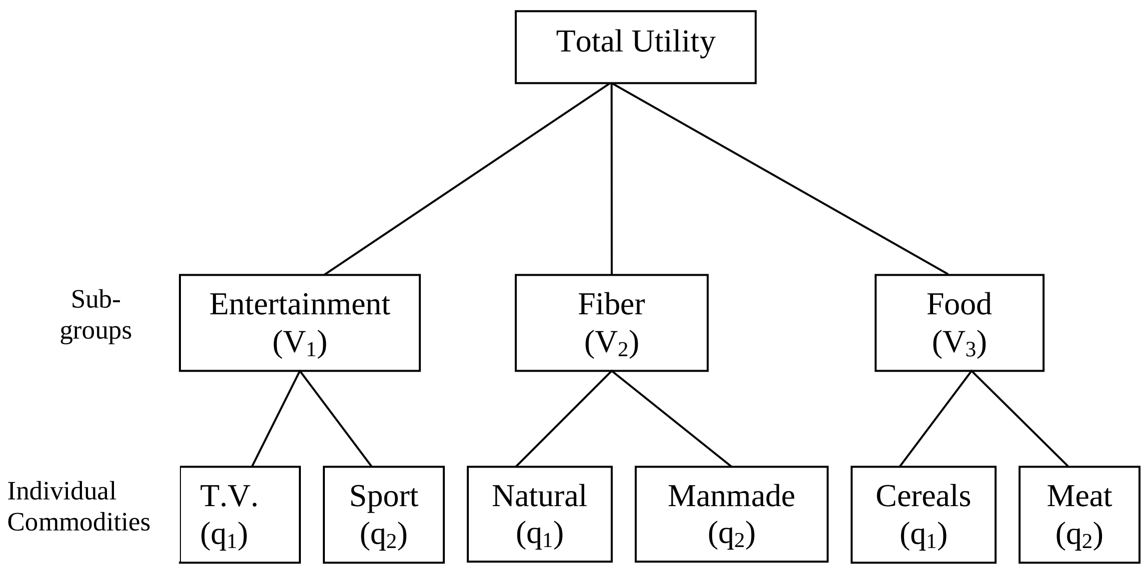


Figure 3.2 Deaton and Muellbauer's Utility Tree.

Source: Deaton and Muellbauer (1980).

The way consumers allocate total expenditures in two stages leads to the idea of two-stage budgeting. In the first stage, or higher stage of the tree, expenditure is allocated to broad commodity groups. Given knowledge of total expenditures and appropriately defined group prices, allocation must be possible. This is achieved by maximizing total utility subject to total expenditure. That is,

(3.7) Max. u = Max $[v_1(q_{11}, q_{12}, q_{13}, \ldots, q_{1k}), v_2(q_{21}, q_{22}, q_{23}, \ldots, q_{2k}), \ldots, v_m(q_{m1}, q_{m2}, q_{m3}, \ldots, q_{mk})]$

subject to $\sum_{a=1}^{m} \sum_{i=1}^{k} (p_{ai} * q_{ai}) = y$

where p_{ai} = price of commodity “i” in subgroup “a,”

q_{ai} = quantity demanded of commodity “i” in subgroup “a,”

y = total expenditure.

In the second stage or lower stage of the tree, consumers maximize the subutility function for each group and group expenditures are allocated to the individual commodities. Individual expenditures must be functions of group expenditures and prices within the group only. That is,

(3.8) Max. $V_a (q_{ai})$

subject to $\sum_{i=1}^{k} (p_{ai} * q_{ai}) = y_a$

i = 1, 2, …, k, represents a commodity in a subgroup “a,”

a = 1, 2, …, m, represents a subgroup,

y_a = expenditure in subgroup “a.”

Expenditures on commodity “i” that belong to subgroup “a,” are maximized subject to total expenditure on subgroup “a.” Therefore, the Marshallian demand for commodity “i” within group “a” can be derived as:

(3.9) $q_i = g_{ai} (y_a, p_{a1}, p_{a2}, \ldots, p_{ak})$ for $i = 1, 2, \ldots, k$.

That is, the Marshallian demand for commodity “i” within group “a” is a function of expenditure in subgroup “a” and prices of all other commodities in the same subgroup “a.” There is no impact of individual commodities prices and quantities from all other subgroups. Therefore, the advantage of using this approach is that it avoids working with prices and quantities of commodities in other subgroups. Furthermore, the above demand functions possess all the usual properties of demand functions since they derive from a standard utility maximizing problem. Economists Coleman and Thigpen (1991) based their cotton demand estimate on this approach.

3.4 Summary

Three approaches to perform demand analysis are discussed in this chapter: the conventional “ad-hoc” single demand analysis, demand systems, and the two-stage budgeting approach. The conventional demand analysis has been the most widely used to estimate cotton demand due to its simplicity and ease of handling. However, it fails to recognize explicitly the interrelationships among commodities that are closely related and generally makes no formal attempt to incorporate theoretical restrictions in the process of demand estimation.

On the other hand, complete demand systems are appropriate to deal with interdependent relationships among demands and make a formal attempt to integrate the boundaries of modern consumer behavior. The theoretical restriction on demand of adding-up, homogeneity, and symmetry are incorporated. Unfortunately, theory does not provide much information about the “true” form of the demand functions and it requires relatively large data.

Due to drawbacks in conventional demand analysis and demand systems, some economists have analyzed demand through an intermediate approach, methods that are consistent with the two-stage budgeting approach. This approach avoids working with prices and quantities of commodities in other subgroups and possesses all the usual properties of demand functions. Nonetheless, demand systems are proving to provide better estimates.

Regardless of the approach used to estimate cotton demand, the model requires incorporating the fact that the demand for cotton fiber is a derived demand. That is, the consumer demands cotton through the textile industry and not directly from farmers. However, unlike other derived demand cases (e.g., steel), it could still be argued that the properties of cotton are carried on into cotton-made products in a way that the consumer can still base their preferences on the perceived characteristics of cotton products when compared with other fibers.

CHAPTER IV

METHODS AND PROCEDURES

The general objective of this research is to appropriately estimate the EU cotton demand parameters using the analytical framework of the demand system approach. As discussed in Chapter III, the demand system approach is the most appropriate methodology when strong interrelation exists among demands of competitive products. This seems to be the case for the demand for fibers. Furthermore, the demand system methodology incorporates the classical restriction of demand theory in the estimation process, providing parameter estimates in accordance with the modern consumer theory, which is not the case of estimation using single equation ad-hoc demand specifications.

A method that is consistent with the two-stage budgeting approach as the one used by Coleman and Thigpen (1991) for the World Bank combines modern theory with the conventional approach to estimate demand equations. This method will also be used in order to compare and contrast results with those of the demand systems. Additionally, this method is very flexible and can be combined with demand systems to model cotton demand.

The accomplishment of the general objective requires establising the factors affecting EU cotton demand and estimating parameters of EU cotton demand. Following the estimation of EU cotton demand parameters, Marshallian and Hicksian price elasticities will be calculated and compared at four levels: aggregated mill consumption, country-disaggregated mill consumption, aggregated home consumption, and country-disaggregated home consumption. Important demographic variables as well as updated and more appropriate parameter estimates could be incorporated into world cotton models used to simulate future scenarios for the industry.

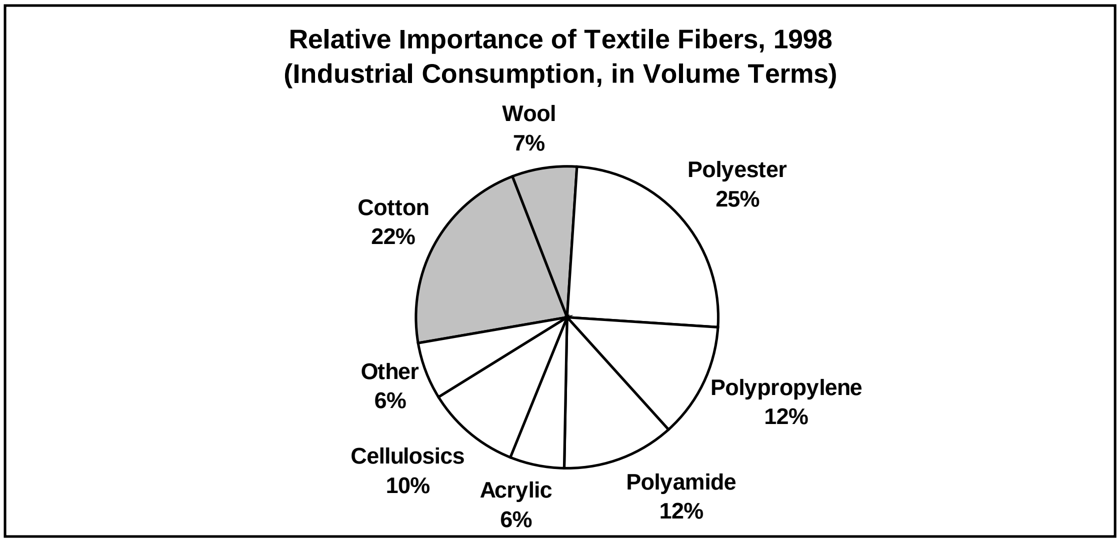
In estimating a cotton demand system, it should be kept in mind that there are a number of features of cotton demand that make the estimation task different from modeling the demand for many other agricultural products. First, cotton is a derived demand, which means that raw cotton is demanded by the processors in response to final consumer demand for apparel items and other manufactured textile products. Second, manufactured textile items are often a mixture of fibers (e.g., cotton, wool, cellulose, synthetics) and the consumer seems to be indifferent to the fiber composition and the textile mixture. Third, the price of fibers accounts for a very small proportion of the price of the final good and thus the consumer is insensitive to fiber prices. Consequently, consumer demand for fibers can be expected to be highly inelastic and this has been supported empirically in a number of studies (Meyer, 2002; Clements and Lan, 2001; Coleman and Thigpen, 1991; Dudley, 1974; Magleby and Missaien, 1971; Thigpen 1978). Similar to Shui, Beghin and Wohlgenant (1993), this study will also work with textile mill fiber demand and will exclude end-uses such as apparel because mill demand for fibers represents the bulk of the derived demand. However, unlike previous studies, this paper reports research in which demands of the fifteen European Union members are not aggregated.

The Rotterdam and Almost Ideal Demand System (AIDS) are the two most used demand system models. Of these two, only the Rotterdam model has been employed in previous studies to estimate EU cotton demand. This research attempts to use both demand system models.

4.1 Model Specification

4.1.1 Fibers

Fibers are classified according to their origin, chemical structure, or both. Textile fibers refers to fibers that can be spun into yarn or made into fabric by such operations as weaving, knitting, braiding, and felting. Textile fibers are divided into animal fibers (wool, silk, etc.), vegetable fibers (cotton), and manmade fibers which can be subdivided into cellulose (rayon) and non-cellulose, or synthetic (nylon or polyamide, polyester, acrylic, polypropylene, etc.). Because cotton, wool, and manmade fiber are the most representative of each textile fiber division used in textile production and have been considered in other studies (Clements and Lan, 2001; Shui, Beghin and Wohlgenant, 1993; Lewis, 1972), our model will only examine these. In this study, manmade fiber consumption is obtained by adding cellulosic and synthetic fiber consumption. An approximation of the relative importance of individual fibers in Europe's textile and clothing sector is provided in Figure 4.1.



Note: The gray areas represent natural fibers, the white ones relate to manmade fibers. Source for statistics: CIRFS (Comité International de la Rayonne et des Fibres Synthétiques) and Euratex. Figures relate to EU and EFTA. No comparable information is available for 'flax' and 'silk', which together are estimated to represent about 5% of total fiber consumption.

Figure 4.1 Relative Importance of Textile Fibers.

Source: Stengg, 2001.

4.1.2 Almost Ideal Demand System

The Almost Ideal Demand System (AIDS) was developed by Deaton and Muelbauer in 1980 as an arbitrary first order approximation of any demand system. It satisfies the axioms of choice exactly and aggregates perfectly over consumers up to a market demand function without invoking parallel linear Engel curves. The functional form is consistent with household-budget data, can be used to test the properties of homogeneity and symmetry through linear restrictions on fixed parameters, and is not difficult to estimate. In the AIDS model, the Marshallian demand function for commodity "i" in share form is specified as:

(4.1) $$w_{it} = \alpha_i + \sum_{j} \gamma_{ij}\, log(p_{jt}) + \beta_i\, log[Y_t/P_t] + \varepsilon_{it}$$

where w_{it} = budget share of commodity i in period t,

p_{jt} = price of commodity j in period t,

Y_t = total expenditure on set of commodities,

α_i, β_i and γ_{ij} are parameters,

ε_i = disturbance term, and

P_t = a price index.

In a nonlinear approximation, the price index P_t is defined as:

(4.2) $$Log\,(P_t) = \alpha_0 + \sum_{k} \alpha_k\, log\,(p_{kt}) + \frac{1}{2} \sum_{k} \sum_{j} \gamma_{kj}\, log(p_{kt})\, log(p_{jt})$$

Estimation can be done by substituting (4.2) into (4.1) to obtain:

(4.3) $$w_{it} = (\alpha_i - \beta_i\, \alpha_0) + \sum_{j} \gamma_{ij}\, log(p_{jt}) + \beta_i\, [log(Y_t) - \sum_{k} \alpha_k\, log\,(p_{kt}) - \frac{1}{2} \sum_{k} \sum_{j} \gamma_{kj}$$

$$log(p_{kt})\, log(p_{jt})] + \varepsilon_{it}$$

In the linear approximation of the AIDS model (LA/AIDS) suggested by Stone (1954), (4.2) is estimated by:

(4.4) $$log\,(P^{*}) = \sum_{k} w_{kt}\, log\,(p_{kt}).$$

The theoretical classical properties of demand can be imposed on the system by restricting the model parameters as follows:

(4.5) Adding-up: $\sum_i \alpha_i = 1$, $\sum_j \gamma_{ij} = 0$, and $\sum_i \beta_i = 0$;

(4.6) Homogeneity: $\sum_i \gamma_{ij} = 0$;

(4.7) Symmetry: $\gamma_{ij} = \gamma_{ji}$

When the LA/AIDS model is used, the Marshallian (uncompensated) and the Hicksian (compensated) price elasticities as well as the expenditure elasticities can be computed from the estimated coefficients:

(4.8) Marshallian Price Elasticity: $-\delta_{ij} + \gamma_{ij}/w_i - \beta_i\, w_j/w_i$

(4.9) Hicksian Price Elasticity: $-\delta_{ij} + w_j + \gamma_{ij}/w_i$

(4.10) Expenditure Elasticity: $1 + \beta_i\, /w_i$

where δ is the Kronecker delta equal to one if $i = j$ and equal to zero otherwise.

In this research, three commodities will be considered: cotton, manmade fiber, and wool. One equation will be omitted in the estimation of this system, but the parameters of that equation will be recovered by making use of the theoretical classical properties. Usually the equation excluded is the one holding the smallest budget share.

In this study, demographic (population and income) and geographic variables (climate) will be incorporated into the AIDS model. The introduction of demographic variables in demand systems has been discussed by Barten (1964), Muellbauer (1977) and Pollak and Wales (1978, 1980, 1981). Pollak and Wales (1981) discuss five general procedures for incorporating demographic variables into classes of demand systems: demographic translating, demographic scaling, the “Gorman procedure,” the “reverse Gorman procedure,” and the “modified Paris-Houthakker procedure.” The procedures are general, can be used in conjunction with any complete demand system, and do not assume a particular functional form for the original demand system. In these cases the demand systems describe the allocation of expenditure among an exhaustive number of consumption categories. All procedures replace the original demand system with a similar specification, which uses parameters that depend on the demographic variables. As Medina's (2000) Ph.D. dissertation, this study uses demographic translating as part of the AIDS model specification. According to Pollak and Wales (1981), translating can sometimes be understood as allowing necessary or subsistence parameters of a demand system to depend on the demographic variables.

According to Medina (2000), when demographic variables are introduced into the AIDS model;

$$(4.11)\quad w_{ict} = \alpha_i + \sum_r \Theta_{irct} + \sum_j \gamma_{ij}\, log(p_{jct}) + \beta_i\, log[Y_{ct}/P_{ct}] + \varepsilon_{it}$$

then, the price index, P_t, is given by:

$$(4.12)\quad Log\,(P_{ct}) = \alpha_0 + \sum_r \Theta_{irct}\, log\,(p_{kct}) + \sum_k \alpha_k\, log\,(p_{kct}) + \frac{1}{2} \sum_k \sum_j \gamma_{kj}\, log(p_{kct})\, log(p_{jct})$$

where Θ_{irct} includes the demographic and geographical variables, and i = cotton, manmade, or wool; r = demographic or geographic, and c = country (i.e., France, Germany, Italy, Belgium-Luxembourg, Netherlands, United Kingdom, Denmark, Ireland, Greece, Spain, Portugal, Austria, Finland or Sweden), and t = time period (i.e., 1979, 1980, 1981, etc.). Notice that the subscript "c" is implicit when working with only one country.

4.1.2.1 Demand Elasticities

A demand function can be described in terms of its elasticity values. In the LA/AIDS or AIDS, the elasticities measure the percentage response of the quantity demanded to a one percent change in price or total expenditure. The own price elasticity of demand measures the percent decrease (increase) in the quantity demanded of a commodity from a one percent increase (decrease) in the price of that commodity. If the own price elasticity is less than 1, the demand of that commodity is inelastic, while if it is greater than 1, the demand of that commodity is elastic. The cross price elasticity of demand measures the percent increase or decrease in the quantity demanded of a commodity from a one percent increase or decrease in the price of another commodity. If the cross price elasticity of demand is positive, the commodities are substitutes, while if it is negative the commodities are complements. Similarly, the expenditure elasticity of demand measures the percent increase or decrease in the quantity demanded of a commodity from a one percent increase or decrease in total expenditure. If the expenditure elasticity is positive, the commodity is normal; however, if it is negative the commodity is inferior. Compensated demand elasticities take into account the change in real expenditure when the price of a commodity increases or decreases.

4.1.2.1.1 Marshallian (Uncompensated) Own Price Elasticity of Demand

In the AIDS model, the expression for the Marshallian own price elasticity of demand can be obtained by taking the partial derivative of (4.11) with respect to p_i after (4.12) has been replaced into (4.11).

$$(4.13) \quad \frac{\partial w_i}{\partial p_i} = \frac{\gamma_{ii}}{p_i} - \frac{\beta_i \phi_i}{p_i} = \frac{\gamma_{ii} - \beta_i \phi_i}{p_i}$$

where

$$(4.14) \quad \phi_i = \alpha_i + \sum_r \Theta_{ir} + \sum_{j=1}^{3} \gamma_{ij} \ln(p_i)$$

Considering the definitions of expenditure shares, $w_i = \frac{p_i q_i}{y}$, and own price elasticity, $\varepsilon_{ii} = \frac{\partial q_i}{\partial p_i} . \frac{p_i}{q_i}$, then:

$$(4.15) \quad \frac{\partial \left(\frac{p_i q_i}{y} \right)}{\partial p_i} = \frac{q_i}{y} + \frac{p_i}{y} \frac{\partial q_i}{\partial p_i} = \frac{1}{y} \left(q_i + p_i \frac{\partial q_i}{\partial p_i} \frac{q_i}{q_i} \right)$$

$$= \frac{1}{y} \left(q_i + q_i \varepsilon_{ii} \right) = \frac{q_i}{y} \left(1 + \varepsilon_{ii} \right)$$

Expressions (4.13) and (4.15) are equal. Therefore,

$$(4.16) \quad \frac{q_i}{y} \left(\varepsilon_{ii} + 1 \right) = \frac{\gamma_{ii} - \beta_i \phi_i}{p_i}$$

Multiplying both sides of (4.16) by $\frac{p_i}{w_i}$ then gives:

(4.17) $\frac{w_i}{w_i}(\varepsilon_{ii}+1)=\frac{(\gamma_{ii}-\beta_i\phi_i)}{w_i}$

Solving for w_i gives,

(4.18) $\varepsilon_{ii}=\frac{(\gamma_{ii}-\beta_i\phi_i)}{w_i}-1$

where ϕ_i is given in (4.14). However, in the LA/AIDS model, $\phi_i = w_i$.

4.1.2.1.2 Marshallian (Uncompensated) Cross Price Elasticity of Demand

Similar to the Marshallian own price elasticity, the Marshillian cross price elasticity of demand can be calculated by taking the partial derivative of (4.11) with respect to p_j after (4.12) has been replaced into (4.11).

(4.19) $\frac{\partial w_i}{\partial p_j}=\frac{\gamma_{ij}-\beta_i\phi_i}{p_j}$

Where ϕ_i is given in (1.14). Considering now the definition of expenditure share, and the definition of cross price elasticity, $\varepsilon_{ij}=\frac{\partial q_i}{\partial p_j}\frac{p_j}{q_i}$, then (4.19) becomes:

(4.20) $\frac{\partial\left(\frac{p_i q_i}{y}\right)}{\partial p_j}=\frac{p_i}{y}\frac{\partial q_i}{\partial p_j}=\frac{1}{y}\left(\frac{\partial q_i}{\partial p_j}p_i\right)$

$$=\frac{1}{y}\left(\frac{\partial q_i}{\partial p_j}p_i\frac{q_i}{q_i}\frac{p_j}{p_j}\right)=\frac{1}{y}\left(\varepsilon_{ij}\frac{p_i q_i}{p_j}\right)$$

Expressions (4.20) and (4.19) are equal.

(4.21) $$\frac{1}{y}\left(\varepsilon_{ij}\frac{p_i q_i}{p_j}\right)=\frac{\gamma_{ij}-\beta_i\phi_i}{p_j}$$

Multiplying both sides of (4.21) by $\frac{p_i}{w_i}$:

(4.22) $$\frac{p_i}{w_i}\frac{1}{y}\left(\varepsilon_{ij}\frac{p_i q_i}{p_j}\right)=\frac{\gamma_{ij}-\beta_i\phi_i}{p_j}\frac{p_i}{w_i}$$

Solving for ε_{ij}:

(4.23) $$\varepsilon_{ij}=\frac{\gamma_{ij}-\beta_i\phi_i}{w_i}$$

where ϕ_i is given in (4.14). Notice that in the LA/AIDS model, $\phi_i = w_j$.

4.1.2.1.3 Hicksian (Compensated) Elasticity of Demand

The Hicksian own price elasticity of demand can be obtained from the Marshallian own price elasticity of demand:

(4.24) $h_i(p_1, p_2, \ldots, p_n, u) = q_i(p_1, p_2, p_3, \ldots, p_n, y(p, u))$

Totally differentiating (4.24) with respect to p_i:

(4.25) $$\frac{\partial h_i(p,u)}{\partial p_i}=\frac{\partial q_i(p,y)}{\partial y}\frac{\partial y(p,u)}{\partial p_i}+\frac{\partial q_i(p,y)}{\partial p_i}$$

By Shephards's Lema, $\frac{\partial y(p,u)}{\partial p_i}=h_i$, by duality, $h_i = q_i$, and by multiplying both sides of (4.25) by $\frac{p_i}{q_i}$ and the first term in the right hand side by $\frac{y}{y}$ gives:

(4.26) $$\frac{\partial h_i(p,u)}{\partial p_i}\frac{p_i}{q_i} = \frac{\partial q_i(p,y)}{\partial y}\frac{y}{q_i}\frac{p_i q_i}{y} + \frac{\partial q_i(p,y)}{\partial p_i}\frac{p_i}{q_i}$$

(4.27) $$\varepsilon_{ii}^{*} = \eta_i w_i + \varepsilon_{ii}$$

Similarly, the Hicksian cross price elasticity of demand can be obtained from the Marshallian cross price elasticity of demand.

Totally differentiating (4.24) with respect to p_j:

(4.28) $$\frac{\partial h_i(p,u)}{\partial p_j} = \frac{\partial q_i(p,y)}{\partial y}\frac{\partial y(p,u)}{\partial p_j} + \frac{\partial q_i(p,y)}{\partial p_j}$$

By Shephards's Lema, $\frac{\partial y(p,u)}{\partial p_j} = h_j$, by duality, $h_j = q_j$, and by multiplying both sides of (4.29) by $\frac{p_j}{q_i}$ and the first term in the right hand side by $\frac{y}{y}$ gives:

(4.30) $$\frac{\partial h_i(p,u)}{\partial p_j}\frac{p_j}{q_i} = \frac{\partial q_i(p,y)}{\partial y}\frac{y}{q_i}\frac{p_j q_j}{y} + \frac{\partial q_i(p,y)}{\partial p_j}\frac{p_j}{q_i}$$

(4.31) $$\varepsilon_{ij}^{*} = \eta_i w_j + \varepsilon_{ij}$$

4.1.2.1.4 Expenditure Elasticity of Demand

The expenditure elasticity of demand can be obtained in the same way the own and cross price elasticities were calculated. That is, by taking the partial derivative of (4.11) with respect to total expenditure after (4.12) has been replaced into (4.11).

(4.32) $$\frac{\partial w_i}{\partial y} = \frac{\beta_i}{y}$$

By substituting $w_i = \frac{p_i q_i}{y}$ into the above equation:

$$(4.33)\quad \frac{\partial\left(\frac{p_i q_i}{y}\right)}{\partial y} = \frac{\frac{\partial(p_i q_i)}{\partial y} y - p_i q_i \frac{\partial y}{\partial y}}{y^2} = \frac{y\left(\frac{\partial p_i}{\partial y} q_i + \frac{\partial q_i}{\partial y} p_i\right) - p_i q_i}{y^2}$$

Being $\frac{\partial p_i}{\partial y} = 0$, the expression (4.33) becomes:

$$(4.34)\quad \frac{\frac{\partial q_i}{\partial y} p_i \frac{q_i}{q_i} y - p_i q_i}{y^2} = \frac{p_i q_i\left(\frac{\partial q_i}{\partial y}\frac{y}{q_i} - 1\right)}{y^2} = \frac{p_i q_i(\eta_i - 1)}{y^2}$$

Expressions (4.34) and (4.32) are equal.

$$(4.35)\quad \frac{w_i(\eta_i - 1)}{y} = \frac{\beta_i}{y}$$

The expenditure elasticity is then given by:

$$(4.36)\quad \eta_i = 1 + \frac{\beta_i}{w_i}$$

<u>4.1.2.2 Estimation Considerations with the LA/AIDS and AIDS Models</u>

When pooling cross sectional and time series data in this study, the error term will be capturing country differences in fiber consumption. However, these country differences in fiber consumption can be separated from the error term by introducing dummy variables into the model. As to Medina's (2000) Ph.D. dissertation, pooling cross sectional and time series data in the AIDS model should not present a problem given that country differences are captured with demographic and geographic variables.

In this study, the demographic effects include population and GDP, and the geographic effect includes climate. The Academic American Encyclopedia (1998) defines three dominant types of climate in Europe: maritime in the west, continental in the east and north, and Mediterranean in the south. The maritime climate has moderate temperatures in both summer and winter. The continental climate is characterized by extreme differences between winter and summer temperatures. Finally, the regions on the Mediterranean coast have dry, hot summers and cool to mild, rainy winters. Climatic differences are expected to influence consumers' decisions on clothing since consumers will adapt to the environment by increasing or decreasing purchases.

In the European Union, France, Germany, Belgium, Luxembourg, Netherlands, United Kingdom, Denmark, Ireland, and Austria have a maritime climate. Sweden and Finland have a continental climate, and Greece, Italy, Spain, and Portugal have a Mediterranean climate. On the other hand, population and GDP can be accounted by per capita GDP levels. Consumers with higher per capita GDP have higher purchasing power; therefore, they can consume more cotton, wool, or manmade fiber. Dummy variables will be used to include the demographic and geographic effect.

The following five models are different ways to introduce geographic and demographic variables in the LA/AIDS and the AIDS model. Models 1 and 4 aggregate the European Union, while models 2, 3, and 5, disaggregate the European Union into two groups, five groups, and fourteen countries respectively.

4.1.2.2.1 Model 1

Two dummy variables are created for per capita real GDP (GDP_1 = 1 if per capita GDP $\leq$ \$20,000, 0 otherwise; and GDP_2 = 1 if per capita GDP > \$20,000, 0 otherwise) and three dummy variables will be created for climate (CL_1 = 1 if Maritime climate as in the West, 0 otherwise; CL_2 = 1 if Continental climate as in the East and North, 0 otherwise; and CL_3 = 1 if Mediterranean climate as in the South, 0 otherwise). The countries with per capita GDP less than or equal \$20,000 are Italy, United Kingdom, Ireland, Greece, Spain, and Portugal. Two additional variables are created to account for fiber consumption expansion due to Multi-Fiber Agreements II and III (MFA_2 = 1 if 1974-1977, 0 otherwise; and MFA_3 = 1 if 1982-1985, 0 otherwise).

The demographic effect is expressed as:

(4.37) $\Theta_{i1ct} = D_{i1}\ GDP_1$

where D_{i1} is the corresponding parameter of the dummy variable GDP_1.

The geographic effect is expressed as:

(4.38) $\Theta_{i2ct} = D_{i2}\ CL_1 + D_{i3}\ CL_2$

where D_{i2}, and D_{i3} are parameters.

Therefore,

(4.39) $\sum_r \Theta_{irct} = D_{i1}\ GDP_1 + D_{i2}\ CL_1 + D_{i3}\ CL_2 + D_{i4}\ MFA_2 + D_{i5}\ MFA_3$

where D_{i4} and D_{i5} are parameters.

Equation (4.39) is then introduced in (4.11) and (4.12) to run the AIDS model. Equation (4.4) is used instead of (4.12) to run the LA/AIDS model.

4.1.2.2.2 Model 2

Model 2 is a modification of model 1. Model 2 introduces a real expenditure shifter for the real expenditure variable, $log[Y_{ct}/P_{ct}]$, in (4.11). In the LA/AIDS and AIDS models, the modification is:

$$(4.40)\quad w_{ict} = \alpha_i + \sum_r \Theta_{irct} + \sum_j \gamma_{ij}\, log(p_{jct}) + (\beta_i + \beta_{i1}\, GDP_1)\, log[Y_{ct}/P_{ct}] + \varepsilon_{it}$$

Equations (4.40) and (4.12) are used after (4.39) has been introduced in (4.40) and (4.12) if the AIDS model is used. After (4.39) has been introduced into (4.40), (4.40) and (4.4) are used if the LA/AIDS model is desirable.

The real expenditure shifter states that the effect of real expenditure on “i” consumption in European Union countries with per capita real GDP less or equal than \$20,000 is different from European Union countries with per capita real GDP greater than \$20,000. Countries with higher per capita real expenditure will be expected to consume more cotton, manmade fiber or wool.

4.1.2.2.3 Model 3

Unlike Model 1, model 3 separates the European Union countries into five per capita real GDP categories and uses those categories as real expenditure shifters as well. The five dummy variables for per capita real GDP are: $GDP_1 = 1$ if $\$5,000 \leq$ per capita real GDP $< \$10,000$, 0 otherwise; $GDP_2 = 1$ if $\$10,000 \leq$ per capita real GDP $<$ \$15,000, 0 otherwise; $GDP_3 = 1$ if $\$15,000 \leq$ per capita real GDP $< \$20,000$, 0 otherwise; $GDP_4 = 1$ if $\$20{,}000 \leq$ per capita real GDP < \$25,000, 0 otherwise; $GDP_5 =$ 1 if $\$25{,}000 \leq$ per capita real GDP < \$30,000, 0 otherwise. GDP_1 includes Portugal, GDP_2 includes Ireland, Greece, and Spain, GDP_3 includes Italy and United Kingdom, GDP_4 includes France, Belgium, Luxembourg, Netherlands, Austria, and Finland, and GDP_5 includes Germany, Denmark, and Sweden. Climate and the multi-fiber agreement variables are the same as in Model 1.

The LA/AIDS and AIDS models are modified as follows:

(4.41) $$w_{ict} = \alpha_i + \sum_r \Theta_{irct} + \sum_j \gamma_{ij}\, log(p_{jct}) + (\beta_i + \beta_{i1}\, GDP_1 + \beta_{i2}\, GDP_2 + \beta_{i3}\, GDP_3 + \beta_{i4}\, GDP_4)\, log[Y_{ct}/P_{ct}] + \varepsilon_{it}.$$

The demographic and geographic effects are now expressed as:

(4.42) $$\Theta_{i1ct} = D_{i1}\, GDP_1 + D_{i2}\, GDP_2 + D_{i3}\, GDP_3 + D_{i4}\, GDP_4$$

(4.43) $$\Theta_{i2ct} = D_{i5}\, CL_1 + D_{i6}\, CL_2.$$

Therefore,

(4.43) $$\sum_r \Theta_{irct} = D_{i1}\, GDP_1 + D_{i2}\, GDP_2 + D_{i3}\, GDP_3 + D_{i4}\, GDP_4 + D_{i5}\, CL_1 + D_{i6}\, CL_2 + D_{i7}\, MFA_2 + D_{i8}\, MFA_3.$$

The AIDS model makes use of equations (4.41) and (4.12) after (4.43) has been introduced in (4.41) and (4.12). Similarly, after (4.43) has been replaced in (4.41), the LA/AIDS model makes use of equations (4.41) and (4.4).

4.1.2.2.4 Model 4

Model 4 makes use of dummy variables per country. In literature model 4 is also known as the least-squares dummy variable (LSDV) model (Gujarati, 2003).

Differences in demographic and geographic characteristics among European Union countries are now taken into account in:

(4.44) $\sum_{r} \Theta_{irct} = D_{i1}\, D_{France} + D_{i2}\, D_{Germany} + D_{i3}\, D_{Italy} + D_{i4}\, D_{Belgium\text{-}Luxembourg} + D_{i5}$

$D_{Netherlands} + D_{i6}\, D_{United\ Kingdom} + D_{i7}\, D_{Denmark} + D_{i8}\, D_{Ireland} + D_{i9}\, D_{Greece} + D_{i10}\, D_{Spain}$

$+ D_{i11}\, D_{Portugal} + D_{i12}\, D_{Austria} + D_{i13}\, D_{Finland}$.

Where D_{France} = 1 if France, 0 otherwise,

$D_{Germany}$ =1 if Germany, 0 otherwise,

D_{Italy} = 1 if Italy, 0 otherwise,

$D_{Belgium\text{-}Luxembourg}$ = 1 if Belgium-Luxembourg, 0 otherwise,

$D_{Netherlands}$ = 1 if Netherlands, 0 otherwise,

$D_{United\ Kingdom}$ = 1 if United Kingdom, 0 otherwise,

$D_{Denmark}$ = 1 if Denmark, 0 otherwise,

$D_{Ireland}$ = 1 if Ireland, 0 otherwise,

D_{Greece} = 1 if Greece, 0 otherwise,

D_{Spain} = 1 if Spain, 0 otherwise,

$D_{Portugal}$ = 1 if Portugal, 0 otherwise,

$D_{Austria}$ = 1 if Austria, 0 otherwise,

$D_{Finland}$ = 1 if Finland, 0 otherwise,

D_{i1}, D_{i2}, D_{i3}, D_{i4}, D_{i5}, D_{i6}, D_{i7}, D_{i8}, D_{i9}, D_{i10}, D_{i11}, D_{i12}, D_{i13} = parameters. Notice that the excluded dummy variable is D_{Sweden} (1 if Sweden, 0 otherwise).

After (4.44) has been replaced in equations (4.11) and (4.12), they are used to estimate the AIDS model. To estimate the LA/AIDS model, equation (4.44) and (4.4) are replaced in (4.11).

4.1.2.2.5 Model 5

Model 5 uses the same dummy variables introduced in model 4 as real expenditure shifters. This model specification states that per capita real expenditure affects differently the consumption on the "i" fiber in each European Union country. Consumers with higher per capita real expenditure are expected to consume more.

Model 5 looks as follows:

$$(4.45)\quad w_{ict} = \alpha_i + \sum_r \Theta_{irct} + \sum_j \gamma_{ij}\, log(p_{jct}) + (\beta_i + \beta_{i1} D_{France} + \beta_{i2} D_{Germany} + \beta_{i3} D_{Italy} + \beta_{i4} D_{Belgium\text{-}Luxembourg} + \beta_{i5} D_{Netherlands} + \beta_{i6} D_{United\ Kingdom} + \beta_{i7} D_{Denmark} + \beta_{i8} D_{Ireland} + \beta_{i9} D_{Greece} + \beta_{i10} D_{Spain} + \beta_{i11} D_{Portugal} + \beta_{i12} D_{Austria} + \beta_{i13} D_{Finland})\, log[Y_{ct}/P_{ct}] + \varepsilon_{it}.$$

Equation (4.44) is replaced in (4.45) and (4.12) to run the AIDS model. To run the LA/AIDS model, equations (4.44) and (4.4) are replaced in (4.45).

4.1.3 Rotterdam Model

This directly specified system, developed by Barten and Theil (1964) does not assume a particular utility function, but it does allow testing or imposing the classical theoretical demand restrictions and works in differentials. The original price version of the Rotterdam model may be written as:

$$\text{(4.46)} \quad w_i \, d\mathit{log}\,(q_i) = b_i \, d\mathit{log}\,(Q) + \sum_j c_{ij} \, d\mathit{log}\,(p_j) + \varepsilon_i$$

where $d\mathit{log}\,(Q) = d\mathit{log}\,(y) - \sum_k w_k \, d\mathit{log}\,(p_k) = \sum_k w_k \, d\mathit{log}\,(q_k)$ is the Divisa Volume Index, and

q_i = per capita consumption of commodity i,

y = total expenditure,

p_j = price of commodity j,

w_i = budget share of commodity i,

b_i and c_{ij} = parameters, and

ε_i = disturbance term.

The Divisa Volume Index is a weighted average of the "n" logarithmic quantity changes $d\mathit{log}(q_1)$, $d\mathit{log}(q_2)$, …, $d\mathit{log}(q_n)$, where the weights are the budget shares.

For the estimation purposes of this study, the original price version of the Rotterdam model will be approximated using first-order differentials as:

$$\text{(4.47)} \quad \hat{w}_{it} \, Dq_{it} = b_i \, [Dy_t - \sum_k \hat{w}_{kt} \, Dp_{kt}] + \sum_j c_{ij} \, Dp_{jt}$$

D = approximate log differentials,

$Dq_{it} = \log(q_{it} / q_{it-1})$

$Dp_{jt} = \log(p_{jt} / p_{jt-1})$

$Dy_t = \log(y_t / y_{t-1})$

$\hat{w}_{it} = (w_{it} + w_{it-1})/2$

w_{it} = budget share of product i in period t,

b_i, c_{ij} = the parameters to be estimated,

i = cotton, wool, cellulose, and synthetic fibers, and

j = any of the four fibers.

The theoretical classical properties can then be incorporated into the model by imposing restrictions on the model parameters as follows:

(4.48) Adding-up: $\sum_i b_i = 1, \sum_j c_{ij} = 0$;

(4.49) Homogeneity: $\sum_i c_{ji} = 0$;

(4.50) Slutsky Symmetry: $c_{ij} = c_{ji}$.

The set of Marshallian (non-compensated) and Hicksian (compensated) price elasticities and the expenditure elasticity can be calculated from the estimated coefficient as follows:

(4.51) Marshallian Price Elasticity: $(1/\hat{w}_i)(c_{ij} - \hat{w}_j b_j)$;

(4.52) Hicksian Price Elasticity: $c_{ij} / \hat{w}_i$;

(4.53) Expenditure Elasticity: $b_j / \hat{w}_i$.

When estimating any demand system models, one equation needs to be omitted to avoid the singularity of the variance-covariance matrix of disturbances. By making use of the neoclassical restrictions, the parameters associated with the omitted demand can be recovered.

The following set of equations illustrates how the system of demands will be estimated simultaneously by using Seemingly Unrelated Regression (SUR) and imposing the theoretical classical restrictions.

$$(4.54) \quad \hat{w}_{cotton\ t}\, Dq_{cotton\ t} = b_{cotton}\,[Dy_t - \hat{w}_{cotton\ t}\, Dp_{cotton\ t} - \hat{w}_{manmade\ t}\, Dp_{manmade\ t} - \hat{w}_{wool\ t}\, Dp_{wool\ t}] + c_{cotton\ cotton}\, Dp_{cotton\ t} + c_{cotton\ manmade}\, Dp_{manmade\ t} + c_{cotton\ wool}\, Dp_{wool\ t}$$

$$(4.55) \quad \hat{w}_{manmade\ t}\, Dq_{manmade\ t} = b_{manmade}\,[Dy_t - \hat{w}_{cotton\ t}\, Dp_{cotton\ t} - \hat{w}_{manmade\ t}\, Dp_{manmade\ t} - \hat{w}_{wool\ t}\, Dp_{wool\ t}] + c_{manmade\ cotton}\, Dp_{cotton\ t} + c_{manmade\ manmade}\, Dp_{manmade\ t} + c_{manmade\ wool}\, Dp_{wool\ t} .$$

Note that we have excluded the equation for wool in order to avoid the singularity of the variance-covariance matrix of disturbances. However, again, by making use of the neoclassical restrictions, the parameters associated with the omitted demand equation can be recovered.

Furthermore, non-price effects of technological change and forward ordering will be incorporated in the model. These non-price variables can take place at the end of the above equations as dummy variables. Shui, Beghin, and Wohlgemant (1993) used a time trend to include technical change effects and lagged prices of cotton and wool to account for forward ordering effects. The importance of non-price aspects of fiber competition has been stressed by Shui, Beghin, and Wohlgemant (1993), Field (1987), Batavia (1979),Ward and King (1973), and Lewis (1972), and in earlier literature in the 1960s by Barlowe and Donald (1968); Ward (1968) and Yale (1964).

4.1.4 Two-Stage Budgeting Approach

Even though it is not possible to apply the two stage budgeting approach in its purest form, the fact that cotton demand is a derived demand allows calculating demand in two stages. Similar to Coleman and Thigpen's study (1991) for the World Bank, EU cotton demand will be calculated in two steps using a method that is consistent with the two stage budgeting approach. In the first step, per capita total fiber demand will be calculated. In the second step, cotton's share of total fiber will be calculated. EU cotton demand will be obtained by multiplying cotton's share of total fiber by per capita demand of total fiber. From a manufacturer's point of view, consumption of cotton, wool, and manmade fiber will depend on their relative prices. How the prices of one commodity affect the others will be captured in the second step as follows:

(4.56) $D_{cotton} = D_{fiber} * \hat{w}_{cotton} * POP$

(4.57) First Step $D_{fiber} = f(P_{cotton}, P_{wool}, P_{manmade}, GDP)$

(4.58) Second Step $\hat{w}_{cotton} = f(P_{cotton}, P_{wool}, P_{manmade})$

D_{cotton} = Per capita demand of cotton,

D_{fiber} = Per capita demand of total fiber,

$\hat{w}_{cotton}$ = Cotton share,

POP = Population,

P_{cotton} = Price of cotton,

P_{wool} = Price of wool,

$P_{manmade}$ = Price of manmade fiber, and

GDP = Per capita deflated real gross domestic product.

Dummy variables will be considered for the estimation of D_{fiber} and $\hat{w}_{cotton}$. Three dummy variables will be representative of the effect of the three Multi-Fiber Agreements (MFA) (1974 to 1977, 1978 to 1981, and 1982 to 1985), and two dummy variables will be representative of Agreement on Textile and Clothing (ATC) quota elimination (first stage 1995-1997 and second stage 1998-2001). These variables will be correctly specified after testing for different specifications.

The unemployment rate is not included in the equation for per capita total fiber use because per capita GDP will change during periods of recession. Coleman and Thigpen (1991) used an unemployment variable to account for declining textiles sales during periods of recession. Another important thing to notice is that cotton share in this model can be taken from the cotton share of the Rotterdam model. In other words, the Rotterdam model can be combined with this method to determine and make predictions of cotton demand.

4.2 Data

Availability of recent data on wool and manmade fiber consumption and price by countries has been a major problem in studying EU cotton demand. Furthermore, the availability of data quickly diminishes when moving from mill consumption to home consumption of fibers. Additionally, consumption of cotton, wool and manmade fiber may not be reported in the same publication.

Data on cotton mill use is the most frequently found. The *Production, Supply and Distribution Database* from the Economic Research Service of the United States Department of Agriculture (USDA-ERS-PSD) carries worldwide information on cotton area harvested, beginning stocks, production, imports, total supply, exports, domestic consumption, loss domestic consumption, total domestic consumption, ending stocks and total distribution in metric units.

The *World Apparel Consumption Survey* from the Food and Agriculture Organization of the United Nations (FAO) published in five editions (1983, 1985, 1989, 1992, 1994) contains worldwide information on cotton, wool, flax, cellulosic fiber and synthetic fiber mill consumption, foreign trade, and home consumption for the years 1974-1975 and 1979-1992. Foreign trade included cotton imports and exports of yarn, fabrics, clothing and other manufactures. Home consumption included mill consumption plus imports minus exports of cotton fiber equivalent.

Fiber Organon from the Fiber Economic Bureau publishes information on cotton, wool, and manmade fiber. In the case of the European Union fiber consumption, *Fiber Organon* has aggregated information on cotton, wool, cellulosic fiber, and synthetic fiber mill consumption for the European Economic Community (ECC) for 1986-1993, aggregated row cotton consumption for Western Europe and Eastern Europe since 1950, aggregated total mill fiber consumption for Western Europe since 1994, and aggregated cotton, wool, cellulosic fiber and synthetic fiber mill consumption for Eastern Europe since 1994.

Cellulose and synthetic fiber data is more difficult to obtain and update because it is primarily from private sources and industry groups. However, *CIRFS Statistical Yearbook 2001* from Comité International de la Rayonne et des Fibres Synthétiques (CIRFS) has aggregated data on Western European synthetic fiber, cellulosic fiber, wool and cotton mill consumption from 1987 to 2000. It also provides information on total polyamine, polyester, acrylic, polypropylene, synthetic fiber, and cellulosic fiber mill consumption of Western Europe from 1969 to 2000.

Cotton: World Statistics from the International Cotton Advisory Committee (ICAC) publishes information on consumption of cotton lint per country. It used to offer data on wool, rayon and acetate (cellulosic fiber), and synthetic fiber mill consumption by country. Data on wool can be found from 1953 to 1988, and data on rayon and acetate, and synthetic fiber from 1953 to1987. *Cotton: World Statistics* is the only source found to provide recent cotton prices in Greece and Spain, and polyester prices in Germany and Italy. Greece cotton prices are reported per crop year since 1959/1960 (International Cotton Advisory Committee, 1963a, 1963b, 1966, 1969, 2002). Spain cotton prices are available from 1986/1987 to 1992/1993 and from 1996/1997 to present. Germany and Italy polyester prices are available since 1989/1990.

Old polyester prices for the United Kingdom for 1952-1967 can be found in Magleby and Missaien (1977) who sourced USDA/FAS compilations. Old polyester prices for the European Community (EC) (a simple average of prices in France, Italy and West Germany) for 1956-1966 can also be found in Magleby and Missaien (1977). No European country polyester price for the period 1967-1988 was found.

The United States Department of Agriculture (USDA), in the Economic Research Service's (ERS) *Cotton and Wool Situation and Outlook Yearbook*, provides the United States actual and raw-fiber equivalent cotton prices as well as the actual and raw-fiber equivalent polyester prices since 1965. It also provides information on the cotton A-index, the Memphis price, farm price, and the adjusted world price. The US cotton price for the period 1952-1968 can be found in Magleby and Missaien (1977), who sourced USDA/FAS and Interntional Cotton Advisory Committee. Similarly, the US polyester price for the period 1952-1967 can be found in Magleby and Missaien (1977), who sourced table 220 of the U.S. Department of Agriculture (1968) and table 11 of the U.S. Department of Agriculture (1969).

The International Monetary Fund's (IMF) *International Financial Statistics* on CD-ROM, provides United Kingdom's wool price. This price also serves as the world price for clean wool and has been used in some studies as representative of the world wool price. The 64's and 48's United Kingdom wool price are available since 1948 and 1950 respectively. The IMF also offers worldwide data on gross domestic product (GDP), GDP deflator, unemployment rate, exchange rate, and population.

After gathering the data provided by all of the above sources, mill consumption of cotton, wool and manmade fiber by country was available up to 1992. Unfortunately, there is no information available for wool mill consumption for the period 1976-1979 for Netherlands and Denmark, for the period 1963-1968 for Greece, and for the period 1976-1978 for Belgium-Luxembourg and Ireland. Similarly, data is missing for manmade fiber mill consumption for the years 1973 and 1976-1978 for Netherlands, 1976-1978 for Denmark, and 1976-1978 for Belgium-Luxembourg. However, missing periods were imputed using previous years trends; therefore, there would be data available on cotton, wool and manmade fiber mill consumption for the period 1960-1992 for France, Germany, Italy, Netherlands, United Kingdom, Denmark, Greece, Spain, Portugal, Sweden and Switzerland; and for the period 1974-1992 for Belgium-Luxembourg, Ireland, Finland, and Norway, and for Austria from 1970 to 1992.

Data on the aggregated European Union cotton, wool, and manmade fiber mill consumption is available from 1960 to 2000. Data on home equivalent consumption is only provided by FAO. Cotton, wool and manmade fiber home equivalent consumption is available for 1974-1975 and 1979-1992.

4.3 Procedures

The aggregated EU cotton demand parameters and the cotton demand parameters of the fifteen EU members will be obtained by using a demand system approach. Moreover, unlike available estimations, this study will not only use mill consumption data but also cotton equivalent consumption at home. In the latter case, due to the unavailability of data, the AIDS model and panel data will be used. However, the AIDS model as well as the Rotterdam model can be used to calculate and estimate the EU cotton demand parameters when using mill consumption data at both aggregated and country-disaggregated levels. Therefore, this study will allow comparisons of the expenditures elasticities, cross price and own price Hicksian and Marshallian elasticities at four levels: aggregated mill consumption, country-disaggregated mill consumption, aggregated home consumption, and country-disaggregated home consumption.

4.4 Model Validation

Each equation of the demand system will be validated using standard t-tests and the R-square. Basic significant tests, t-tests, are used to test whether any given model parameter is statistically different from zero; which implies that the corresponding independent variable likely affects the dependent variable. The coefficient of determination, R^2, is the most common measure of model's goodness of fit and the interpretation of its value is independent of the unit of measurement of the data being analyzed. However, one concern with the R-square is that its value increases if another independent variable is added into the model, at worst its value will stay the same. Higher R-square values are preferred because a higher proportion of the total variation in the dependent variable will be explained by the model, i.e. the independent variables.

For the t-tests to be strictly valid, the following conditions are assumed:

- The error term follows a normal distribution with a zero mean and a constant variance for all n observations, i.e.:

- A zero mean occurs if no relevant independent variables are left out of the model.
- The dependent variable follows a normal distribution with a constant variance across observations.

- The values taken by the dependent variable in different observations are not correlated to each other.

When the error term is not normally distributed, the t-statistics are roughly valid if the sample is large enough (more than 250 observations).

To asses whether the value taken by the dependent variable in any particular observation is not related to the previous value(s) taken by the dependent variable, the basic Durbin-Watson statistic will be implemented. The Durbin Watson (D.W.) statistic is calculated as:

$$(4.59) \quad DW = \frac{\sum_{t=2}^{T}\left(\hat{\varepsilon}_t - \hat{\varepsilon}_{t-1}\right)^2}{\sum_{t=1}^{T}\hat{\varepsilon}_t^{\,2}}$$

where $\hat{\varepsilon}_t$ = residual value at time t

$\hat{\varepsilon}_{t-1}$ = residual value at time t-1

T = number of time periods

If there is no first order autocorrelation the value of *DW* will be close to two.

CHAPTER V

RESULTS AND DISCUSSION

The results and analysis of the AIDS, LA/AIDS, and Rotterdam models, and the Two-Stage Budgeting Approach are presented and discussed in this chapter. However, this study concentrates on pooled AIDS and LA/AIDS models estimated over time series using country disaggregated annual data. Five different types of model specifications are tested for the AIDS and LA/AIDS models using both available for home use data and mill consumption data. In all of these models one equation is dropped in the estimation to avoid the singularity of the variance-covariance matrix of disturbances. All parameters under different models are estimated using the imposed theoretical neoclassical restrictions as explained in Chapter IV for the AIDS and LA/AIDS models. By making use of these restrictions, the parameters associated with the omitted demand equation can be recovered. For convenience, t-values instead of standard errors are reported. Correction for autocorrelation is performed in the determination of the different parameters and supporting statistics. The estimation algorithm uses numeric derivatives. The explanation of this procedure can be found in Shazam (2001).

Different elasticities of demand, including own price, cross price Hicksian and Marshallian, and expenditure elasticities will be useful for showing the meaning of the different econometric estimates. Elasticities are calculated at mean values and evaluated at four levels: aggregated mill consumption, country-disaggregated mill consumption, aggregated home consumption, and country-disaggregated home consumption.

Comparisons of the elasticities will provide insight in determining whether the European Union cotton demand should be aggregated or disaggregated.

5.1 Available for Home Use Data

Data on fiber home consumption for the European Union countries for the period 1979 to 1992 are taken from *World Apparel Consumption Survey* (United Nations, 1983, 1985, 1989, 1992, 1994). Data on country level consumption is originally reported in thousand tons but it is transformed in per capita consumption in kilograms by using the population provided by the same source. Fiber consumption of Belgium and Luxembourg are reported together; therefore, Belgium-Luxembourg in this study is considered as one country. Data on Gross Domestic Product by country are taken from the International Monetary Fund. It is originally reported in each country's currency; however, it is converted into U.S. dollars by using the corresponding country's exchange rate provided by the same source. It is then converted into real GDP in 1995 U.S. dollars by using the U.S. GDP deflator (1995=100). Finally, real GDP in 1995 U.S. dollars is converted to per capita real GDP in 1995 U.S. dollars by using the population provided by the same source. Dummy variables are then created.

Greece's cotton price, the United States actual polyester price, and the United Kingdom wool price are representative of the cotton price, manmade fiber price, and wool price in each European Union country. The cotton price in Greece is reported in *Cotton: World Statistics* (International Cotton Advisory Committee, 2002) in SM 1-1/16 inches prior to 1981, and Middling 1-3/32 inches since. The United States polyester price is reported in *Cotton and Wool Situation and Outlook Yearbook* (U.S. Department of Agriculture, 2003a) at f.o.b. producing plants. The United Kingdom wool price is provided by the *International Monetary Fund.* This study uses the 64s c.i.f. EQ wool price. The Greece cotton price and the United States polyester price are originally reported in U.S. cents/pound, but they are converted to U.S. cents/kilogram. However, the United Kingdom wool price is reported in U.S. cents/kilogram. All three prices are converted to real prices by using the U.S. GDP deflator (1995=100). Consequently, all real fiber prices are in 1995 U.S. cents/kg.

5.1.1 Almost Ideal Demand System: AIDS and LA/AIDS

As explained in the previous chapter, five different models are tested (see Chapter IV, section 4.1.2.2). Estimation of the nonlinear system of equations by maximum likelihood is performed using Shazam econometric software. When using available for home use data, the AIDS full model provides better results than the LA/AIDS model using stone price index. When models 1, 2, 3, and 4 are estimated using the LA/AIDS model, Hicksian cotton-cotton and manmade-manmade price elaticicities appear with the wrong sign (positive sign). When model 5 is estimated using the LA/AIDS model, Marshallian wool-wool and Hicksian wool-wool appear with the wrong sing (positive sign) and unreasonable elasticity values. Estimation of model 1, 2, and 3 using the AIDS full model provide similar results. However, model 4 and 5 of the full AIDS model provide acceptable results. Their corresponding parameter estimates and elasticity values are provided in Table 5.1 to Table 5.4.

In Table 5.1, parameters α_i, γ_{i1}, γ_{i2}, and β_i are significantly different from zero, with less than 0.01% probability of error (Table t at 0.01% = 2.576). Most of the dummy variable parameters for the cotton equation are negative suggesting that most of the country intercepts are smaller than the excluded dummy (Sweden). However, in the manmade fiber equation, the dummy variable parameters have positive and negative signs. Each equation explains about 80% of the total variation in cotton or manmade fiber share. Both Durbin-Watson statistics are close to 2, indicating autocorrelation is successfully corrected.

Table 5.2 provides the European Union elasticity results based on model 4. Unlike most previous studies, the elasticity results provided in Table 5.2 are based on available for home use data. Home equivalent consumption includes fiber equivalent consumption of imports and exports of textiles; therefore, it more appropriately represents the consumer consumption of fiber than mill consumption. Marshallian cotton own price elasticity is -0.4787, which is close to Meyer's (2002) elasticity result. Cotton expenditure elasticity is 1.06 and it is close to Coleman and Thigpen's (1991) elasticity of 1.08. However, the Marshallian cotton-manmade cross price elasticity is -0.4831 but the Hicksian cotton-manmade cross price elasticity is 0.0421. Marshallian elasticities sometimes give the wrong sign because they do not take into account the change in real expenditure. A positive Hicksian cross price elasticity suggests cotton and manmade fibers are substitutes rather than complementary commodities. An increase in the price of manmade fiber will increase the demand of cotton. The consumer will substitute the more expensive commodity for the cheaper commodity.

Previous studies have reported the cotton-manmade cross price elasticity in the European Union to be 0.531 (Meyer, 2002) or 0.14 (Coleman and Thigpen, 1991). However, Meyer's and Coleman and Thigpen's Durbin Watson test for autocorrelation remained inconclusive. Furthermore, Meyer had only 13 observations for the European Union and made use of 5 variables. Therefore, Meyer had a degrees of freedom problem.

The Marshallian cotton-wool cross price elasticity is -0.6842. A negative cross price elasticity reflects the consumption of wool mainly through textiles composed of a mixture of fibers. Furthermore, considering that most of textiles are mixture of fibers, it makes sense that an increase in the price of one fiber will decrease the consumption of another fiber. Additionally, consumers might prefer mixture of fibers because mixtures are stronger and easier to maintain; therefore, they last longer.

Relatively high Marshallian and Hicksian wool-cotton and wool-manmade elasticities are expected due to the fact that the average wool expenditure share only accounts for 7%. Cotton and manmade fiber expenditure shares account for 43% and 50% respectively. The small wool expenditure share makes the elasticity estimate relatively high.

The full AIDS model parameter estimates for model 5 are reported in Table 5.3. Model 5 allows for the estimation of the European Union country-disaggregated elasticities. In the cotton equation, most of the dummy variables are positive and significant at a 90% statistical certainty level. Similarly, in the cotton equation, most of the real expenditure shifter variables are negative and significant at a 90% statistical certainty level. Parameters α_i, γ_{i1}, and γ_{i2} are significantly different from zero in both equations with less than 0.01% probability of error (Table t at 0.01% = 2.576).

Uncompensated (Marshallian) and compensated (Hicksian) price elasticities and expenditure elasticities for each European Union country are presented in Table 5.4. As defined in Chapter IV, Hicksian elasticities are net of income effects, thus providing a more accurate interpretation of the coefficient estimates determined in Table 5.3. All own price elasticities are negative, except for the Hicksian cotton own price elasticity in Denmark. The increasing available for home use cotton consumption in Denmark from 1979 to 1992 (i.e., Figure 1.21) combined with a small consumption variability during this period influences the Hicksian cotton own price elasticity estimate.

The Marshallian cotton own price elasticity ranges from -0.63354 in Germany to -0.31590 in Austria while the Hicksian cotton own price elasticity ranges from -0.04441 in Italy to 0.13320 in Denmark. Similarly, the Hicksian cotton-manmade cross price elasticity ranges from -0.29927 in France to 0.42875 in Austria. Therefore, cotton and manmade fiber are complements in some countries (Sweden, France, Germany, Spain, and Finland) while they are substitutes in others (Italy, Belgium-Luxembourg, Netherlands, United Kingdom, Denmark, Ireland, Greece, Portugal, and Austria). This is not the case when aggregating the EU cotton-manmade cross price elasticity values into one elasticity value. Consequently, more accurate cotton-manmade cross price elasticity values are obtained when disaggregating EU countries. Compared to the Marshallian and Hicksian cotton own price elasticities, more variability is found in the Hicksian cotton-manmade cross price elasticity.

The negative Hicksian cotton-manmade cross price elasticity in Sweden, France, Germany, Spain, and Finland reflects the consumption of cotton mainly through textiles composed of a mixture of fibers as explained before. For example, an increase in the price of manmade fiber will increase the price of cotton-manmade textiles; therefore, decrease the consumption of cotton. This is also the case for most of the European Union countries' Hicksian cotton-wool cross price elasticity.

The negative Hicksian cotton-manmade cross price elasticities are also explained by the textile and clothing companies' strategies in Europe to improve competitiveness. A focus on innovation and products with high quality and/or fashion content is increasing the use of mixture of textiles. For example, the industrial sector is becoming more reliant on the so-called technical (or industrial) textiles, which include products which are as diverse as filters, conveyer belts, optical fibers, packing textiles, ribbons and tapes, air bags, insulation and roofing materials, etc. (Stengg, 2001). These products will likely combine fibers rather than using only one fiber. Consequently, this trend will influence fibers to be complementary commodities.

The expenditure elasticities measure the change in the demand of cotton, manmade fiber, or wool, as the allocation of expenditures among these commodities changes. Expenditure elasticities for each European Union country are provided at the bottom of Table 5.4. In general, wool presents the lowest expenditure elasticity, while manmade fiber has the highest values. Consequently, manmade fiber has the largest relative gain (loss) if total expenditure increases (decreases). Negative expenditure elasticities mean that the commodity is inferior. For instance, if total expenditure increases, consumption of a particular commodity decreases. This is the case of wool in Sweden, Italy, Denmark, Ireland, and Austria.

Cotton is a normal luxury commodity in Sweden, France, Germany, United Kingdom, Denmark, Greece, Spain, Portugal, and Finland while it is a normal necessary commodity in Italy, Belgium-Luxembourg, Netherlands, Ireland, and Austria. Similarly, manmade fiber is a normal luxury commodity in some European Union countries while it is a normal necessary commodity in others. However, depending on the European Union country, wool is a normal luxury commodity, normal necessary commodity, or even an inferior commodity. These differences in expenditure elasticities are not captured when they are aggregated in one expenditure elasticity value (i.e. Table 5.2).

5.1.2 The Rotterdam Model

One disadvantage of using the Rotterdam Model is that it can not be applied when employing panel data. Equation (4.47) approximates the original price version of the Rotterdam model by using first-order differentials. First-order differentials present a problem when moving from one country to another because the last observation of a country cannot be differentiated with the first observation of another country. Consequently, the Rotterdam model parameters are not estimated with available for home use panel data.

5.1.3 The Two-Stage Budgeting Approach

The two-stage budgeting approach can be employed when using panel data. However, similar to the Rotterdam model, when working with available for home use data, the two-stage budgeting approach provides unsatisfactory results. Different functional forms in the second step, equation (4.58), present highly insignificant parameters. Consequently, parameter estimates when using available for home use data and the two-stage budgeting approach are not reported.

5.2 Mill Consumption Data

Data on mill consumption for the European Union countries for the period 1979 to 1992 are taken from *World Apparel Consumption Survey* (United Nations, 1983, 1985, 1989, 1992, 1994). Data on Gross Domestic Product by country are taken from the International Monetary Fund. The Greece cotton price, the United States actual polyester price, and the United Kingdom wool price are also representative of the cotton price, manmade fiber price, and wool price in each European Union country when working with mill consumption data. All changes in the unit of measurements are performed as explained in section 5.1 and the same dummy variables are then created.

When mill consumption data is used, it is assumed that mill demand for fibers represents the bulk of the derived demand. That is, the consumer demands cotton through the textile industry and not directly from farmers. Economists Clements and Lan (2001), Meyer (2002), and Magleby and Missaien (1971) used mill consumption data to estimate the aggregated European Union cotton demand.

5.2.1 Almost Ideal Demand System: AIDS and LA/AIDS

The same five different models (see Chapter IV, section 4.1.2.2) that are run with available for home use data are run with mill consumption data. Maximum likelihood procedures are used to estimate the AIDS and LA/AIDS models and resulting parameters and supporting statistics are reported. The LA/AIDS model performs more satisfactory in models 1, 2, and 3 while the AIDS full model performs superior in model 5. When model 4 is estimated using either AIDS or LA/AIDS model, the Marshallian and Hicksian wool own price elasticity appear with the wrong sign (positive sign) and unreasonable elasticity value. Nonetheless, the models that show most statistical significant parameters are LA/AIDS model 1 and AIDS model 5. Parameters and elasticity values are reported in Table 5.5 to Table 5.8.

In Table 5.5, cotton equation parameters α_i, γ_{i1}, γ_{i2}, and β_i, and manmade fiber equation parameters α_i, γ_{i1}, and γ_{i2} are significantly different from zero with less than 0.01% probability of error (Table t at 0.01% = 2.576). Most of the dummy variable parameters in both equations are also statistically significant. Each equation explains about 88% of the total variation in cotton or manmade fiber share. Autocorrelation was successfully corrected as indicated by the Durbin-Watson statistics.

The parameter estimates in Table 5.5 yield the elasticity results reported in Table 5.6. Like previous studies, these elasticities are based on mill consumption data. The Marshallian cotton own price elasticity and the cotton expenditure elasticity are close to Meyer's (2002) and Coleman and Thigpen's (1991) elasticity results respectively. The

Hicksian cotton own price elasticity is 0.1118 and it is close to Coleman and Thigpen's (1991) Marshallian cotton own price elasticity. Unlike the Hicksian elasticity, the Marshallian cotton-manmade cross price elasticity in Table 5.6 is negative. However, Hicksian elasticities are net of income effects, thus providing a more accurate interpretation.

Positive Hicksian cross price elasticity values suggest that the two commodities are substitutes while negative Hicksian cross price elasticity values suggest that the two commodities are complements. Negative Hicksian cross price elasticity values illustrates the consumption of the two commodities in textiles composed of mixture of fibers. Relative high wool-manmade cross price elasticity values and wool own price elasticity values are expected because of a low wool expenditure share.

Table 5.7 reports the full AIDS model parameter estimates for model 5. Unlike parameter estimates in Table 5.5, parameter estimates in Table 5.7 allow the approximation of the European Union country-disaggregated elasticities. Most of the parameter estimates in Table 5.7 are statistically significant. In the cotton equation, all real expenditure shifters except one are positive while in the manmade fiber equation they are negative. Their changing magnitude indicates that real expenditure affects differently each European Union country. Therefore, different elasticity values are expected in each country. Overall, each equation explained more than 94% of the total variation in cotton or manmade fiber share. The Durbin-Watson statistics shows that autocorrelation has been successfully corrected.

The corresponding elasticity values based on the parameter estimates on Table 5.7 are reported on Table 5.8. All Hicksian and Marshallian own price elasticity values are negative. The Marshallian cotton own price elasticity values range from -0.6828 in France to -0.29147 in Belgium-Luxembourg while the Hicksian cotton own price elasticity values range from -0.21672 in Sweden to -0.01057 in Greece. However, the Hicksian cotton own-price elasticity values have more variability across countries. Variability in elasticities across countries is lost when aggregating the EU elasticities. Consequently, country-disaggregated elasticities better reflect the consumer choices in each European Union country.

Most countries have a positive Hicksian cotton-manmade cross price elasticity value, except for France, United Kingdom, Greece, and Portugal. A positive Hicksian cross price elasticity value indicates substitute commodities while a negative Hicksian cross price elasticity value indicates complementary commodities. In European Union countries with positive Hicksian cotton-manmade cross price elasticity, an increase in the price of manmade fiber will increase the demand of cotton. However, in countries with negative Hicksian cotton-manmade cross price elasticity, an increase in the price of manmade fiber will decrease the demand of cotton.

Negative Hicksian cotton-manmade cross price elasticity values are explained by consumer preferences of textiles composed of mixture of fibers such as cotton and manmade fiber. This trend is emerging as the European Union textile and clothing companies strive to remain competitive by means of higher productivity, and through competitive strengths such as innovation, quality, creativity, design, and fashion. For example, carpets, which are usually made of a mixture of fibers, belong to the technical textile sub-sector, which accounts for 21% of the textile industry (Table 5.9).

Expenditure elasticities for each European Union country, when mill consumption data is used, are provided at the bottom of Table 5.8. All expenditure elasticity values are positive except the wool expenditure elasticity in Italy. A positive expenditure elasticity value measures the percent increase in the demand of cotton, given a 1% increase in total expenditure. Cotton expenditure elasticity values range from 0.37881 in Belgium-Luxembourg to 1.91065 in France. Similarly, manmade fiber expenditure elasticity values range from 0.65010 in France to 1.2396 in Sweden. The variability in the cotton expenditure elasticity is significant since a 1% increase in total expenditure will only lead to a 0.3788% increase in the demand of cotton in Belgium-Luxembourg, while the same 1% increase in total expenditure will lead to a 1.91065% increase in the demand of cotton in France.

Cotton is a normal luxury commodity in France, Germany, Italy, Netherlands, United Kingdom, Ireland, Greece, Spain, Portugal, and Austria while it is a normal necessary commodity in Sweden, Belgium-Luxembourg, Denmark, and Finland. Similarly, manmade fiber is a normal luxury commodity in some European Union countries while it is a normal necessary commodity in others. However, depending on the European Union country, wool is a normal luxury commodity, normal necessary commodity, or even an inferior commodity. Similar to the available for home use expenditure elasticities analysis, differences in expenditure elasticities are not captured when they are aggregated (i.e. Table 5.6).

5.2.2 The Rotterdam Model

As explained in section 5.1.2, one disadvantage of using the Rotterdam Model is that it can not be applied when employing panel data. Consequently, the Rotterdam model parameters are not estimated with mill consumption panel data for the period 1979 to 1992. However, the Rotterdam model is employed when using observations on individual European Union countries. Different periods and data sources, according to each country, result in statistically insignificant parameters. Furthermore, the parameter $c_{cotton\ cotton}$, in equation (4.54) is consistently positive, providing a positive Hicksian cotton own price elasticity. Positive Hicksian own price elasticity values are caused by incorrect data or incorrect functional form. Consequently, the Rotterdam model's parameter and elasticity estimates are not reported in this research.

5.2.3 The Two-Stage Budgeting Approach

The two-stage budgeting approach is employed when using mill consumption panel data. However, in general, parameter estimates in the second step, equation (4.58), are highly insignificant. The linear specification, the semi-log specification, and the double-log specification were tested. Consequently, the results provided by the two-stage budgeting approach are not reported in this study.

5.3 Comparison of Elasticity Results from Available for Home Use Data and Mill Consumption Data

Since a comparison of all Marshallian and Hicksian Price elasticities and Expenditure elasticities will be very extensive, this section is limited to a comparison of the most relevant cotton elasticities: Marshallian cotton own price elasticity, Hicksian cotton own price elasticity, Hicksian cotton-manmade cross price elasticity, and cotton expenditure elasticity. Most previous studies have only used mill consumption data instead of fiber equivalent home consumption. Mill consumption data might not appropriately reflect the consumer choices. Consequently, previous methodological choices might not appropriately allow the estimation of the European Union cotton demand.

The variability in the elasticity estimates on Table 5.6 and Table 5.8 reveal that better approximation of the European Union elasticities can be obtained by calculating individual country elasticities. Further, variability of the elasticities in each country depends on the commodity being analyzed. For instance the Marshallian cotton own price elasticity does not show as much variability across countries as the Marshallian manmade or wool price elasticity does. Figure 5.1 to Figure 5.4 compare some cotton elasticity results obtained from AIDS model 5 when using mill consumption data and available for home use data.

In Figure 5.1, the Marshallian cotton own price elasticity under mill consumption data and available for home use data maintains about a 0.10 difference in Germany, Italy, Belgium-Luxembourg, Netherlands, and Denmark. However, this difference is greater than 0.10 in Sweden, United Kingdom, Austria, and Finland. Finally, there is a very small difference in Ireland, Greece, Spain, and Portugal. The aggregated Marshallian cotton own price elasticity is -0.4787 when using available for home use data and -0.4386 when using mill consumption data. In both cases, these aggregated elasticity values will only approximate the elasticity values of five or six European countries.

Similarly, the difference between Hicksian cotton own price elasticity under mill consumption data and available for home use data across countries is around 0.05 and 0.15 (i.e., Figure 5.2). When using available for home use data, the aggregated Hicksian cotton own price elasticity of -0.024 might closely approximate the Hicksian cotton own price elasticities of the European Union countries because there is a small variability. However, when using mill consumption data, the aggregated Hicksian cotton own price elasticity of -0.0979 is not a good approximation of the European Union country elasticities.

The Hicksian cotton-manmade cross price elasticity under mill consumption and available for home use data significantly changes across countries (i.e., Figure 5.3). When a country's cotton home consumption and cotton mill consumption trends are not the same, the cotton-manmade cross price elasticity under available for home use and mill consumption data are expected to be different. Sweden's, Germany's, and Finland's Hicksian cotton-manmade cross price elasticity (i.e., Figure 5.3) considerably differ in magnitude and in sign because their cotton available for home use trends significantly differ from their cotton mill consumption trends (i.e., Figure 1.16, Figure 1.27, and

Figure 1.28). A similar argument can also be made for United Kingdom, Greece, Spain, and Portugal.

Additionally, due to the great variability in the Hicksian cotton-manmade cross price elasticity estimates, the aggregated elasticity under mill consumption data (0.1118) and available for home use data (0.0422) are not a good approximation of each individual country elasticity. Furthermore, both aggregated elasticities reveal that cotton and manmade fiber are only complementary commodities while the disaggregated elasticities reveal that cotton and manmade fiber are complementary as well as substitute commodities, depending on the country.

There is a similar case in Figure 5.4. The cotton expenditure elasticity estimates are not only different when using mill consumption and available for home use data but also they are not well approximated by aggregated elasticities. For example, depending on the type of data used and the country analyzed cotton is a normal necessary commodity or a normal luxury commodity. On the other hand, the aggregated scenarios reveal that cotton is only a normal luxury commodity.

Overall, mill consumption elasticities are different from available for home use elasticities and they are also different across countries. Since available for home use data is a better approximation of the consumer demand of fibers, previous methodological choices that use mill consumption data might not appropriately represent the European Union cotton demand. Therefore, a greater effort should be done to keep collecting available for home use data and incorporate these data into studies. Additionally, given the large variability in fiber demand elasticities among European Union countries, it will be more appropriate to use country disaggregated elasticities rather than aggregated elasticities.

Table 5.1 Parameter Estimates for AIDS Model 4, Available for Home Use Data.

	Cotton		Manmade Fiber	
	Coefficient Estimates	Coefficients t-values	Coefficient Estimates	Coefficients t-values
α_i	3.634200	3.47840	4.041500	3.46200
D_{i1}	-0.034860	-0.54242	0.011747	0.15916
D_{i2}	-0.097744	-1.62230	0.045957	0.69420
D_{i3}	-0.068340	-1.23000	-0.014353	-0.22111
D_{i4}	-0.050767	-0.91543	-0.019884	-0.30471
D_{i5}	-0.069265	-1.20260	0.031790	0.48158
D_{i6}	-0.245010	-3.47150	0.222670	2.94330
D_{i7}	0.092126	1.62710	-0.141450	-1.95590
D_{i8}	-0.184500	-2.97130	0.057581	0.86834
D_{i9}	0.126230	2.15850	-0.180390	-2.42120
D_{i10}	-0.300990	-4.01070	0.358380	3.88480
D_{i11}	-0.011285	-0.20201	0.017515	0.26856
D_{i12}	-0.036284	-0.64390	-0.032265	-0.48996
D_{i13}	-0.090151	-1.68320	0.101690	1.67100
γ_{i1}	0.316360	6.77050	-0.114990	-3.37100
γ_{i2}	-0.114990	-3.37100	0.351460	6.04910
β_i	0.025211	3.79570	0.028476	4.00410

R-Sq (cotton equation) = 0.8043
DW (cotton equation) = 1.9626
Rho (cotton equation) = 0.01588

R-Sq (manmade equation) = 0.7976
DW (manmade equation) = 2.0165
Rho (manmade equation) = -0.01223

Period = 1979-1992
Number of Observations = 196
Log likelihood = 862.3725

Table t at 10% = 1.645 (two-tailed)
Table t at 20% = 1.282 (two-tailed)

Model 4:

$$w_{ict} = \alpha_i + \sum_r \Theta_{irct} + \sum_j \gamma_{ij}\, log(p_{jct}) + \beta_i\, log[Y_{ct}/P_{ct}] + \varepsilon_{it}$$

$$Log\,(P_{ct}) = \alpha_0 + \sum_r \Theta_{irct}\, log\,(p_{kct}) + \sum_k \alpha_k\, log\,(p_{kct}) + \frac{1}{2} \sum_k \sum_j \gamma_{kj}\, log(p_{kct})\, log(p_{jct})$$

$$\sum_r \Theta_{irct} = D_{i1} D_{France} + D_{i2} D_{Germany} + D_{i3} D_{Italy} + D_{i4} D_{Belgium\text{-}Luxembourg} + D_{i5} D_{Netherlands} + D_{i6} D_{United\ Kingdom} + D_{i7} D_{Denmark} + D_{i8} D_{Ireland} + D_{i9} D_{Greece} + D_{i10} D_{Spain} + D_{i11} D_{Portugal} + D_{i12} D_{Austria} + D_{i13} D_{Finland}$$

Table 5.2 Aggregated European Union Elasticity Estimates for AIDS Model 4, Available for Home Use Data.

Marshallian Price Elasticity	
Cotton-Cotton	-0.4786952
Cotton-Manmade	-0.4831041
Cotton-Wool	-0.684242
Manmade-Cotton	-0.4651607
Manmade-Manmade	-0.5262918
Manmade-Wool	-0.7096752
Wool-Cotton	-5.8235969
Wool-Manmade	-8.1041854
Wool-Wool	-1.7620277

Hicksian Price Elasticity	
Cotton-Cotton	-0.0240276
Cotton-Manmade	0.0421931
Cotton-Wool	-0.6642068
Manmade-Cotton	-0.0104931
Manmade-Manmade	-0.0009946
Manmade-Wool	-0.6896400
Wool-Cotton	-5.7068851
Wool-Manmade	-7.9691662
Wool-Wool	-1.7419925

Expenditure Elasticity	
Cotton	1.0587044
Manmade	1.0573164
Wool	0.2717661

Table 5.3 Parameter Estimates for AIDS Model 5, Available for Home Use Data.

	Cotton		Manmade Fiber	
	Coefficient Estimates	Coefficients t-values	Coefficient Estimates	Coefficients t-values
α_i	0.346060	6.46170	0.484510	6.38460
D_{i1}	0.026470	0.48506	0.036362	0.82609
D_{i2}	0.079657	1.41190	0.050925	0.97850
D_{i3}	0.063746	1.65150	0.083224	2.14350
D_{i4}	0.075946	1.71940	0.306770	1.77060
D_{i5}	0.070016	1.79990	0.093180	1.78640
D_{i6}	-0.068774	-0.45720	0.114950	1.25020
D_{i7}	-0.940920	-3.58310	0.659830	2.39240
D_{i8}	0.032103	0.619790	0.107860	1.67270
D_{i9}	0.220230	2.27560	-0.427150	-2.24880
D_{i10}	-0.168450	-1.22470	0.113410	1.57750
D_{i11}	0.126100	1.84790	-0.149650	-0.68529
D_{i12}	0.071370	1.86470	0.094274	2.09840
D_{i13}	-0.099054	-0.57821	0.051814	0.99327
γ_{i1}	0.227250	15.39800	-0.198030	-12.99200
γ_{i2}	-0.198030	-12.99200	0.235180	12.69700
β_i	0.132630	1.87200	-0.017465	-0.20053
β_{i1}	0.047966	0.27293	-0.158130	-0.80175
β_{i2}	0.029047	0.22934	-0.077401	-0.52865
β_{i3}	-0.230920	-2.51740	0.242540	2.22010
β_{i4}	-0.177650	-2.00670	0.104340	1.02400
β_{i5}	-0.254590	-1.73890	0.205890	1.19520
β_{i6}	-0.113550	-1.37040	0.013979	0.15784
β_{i7}	-0.058967	-0.86223	0.100650	1.11740
β_{i8}	-0.160240	-1.92520	0.165240	1.79960
β_{i9}	-0.123570	-1.75640	0.061422	0.74000
β_{i10}	-0.100370	-1.56110	-0.028072	-0.33197
β_{i11}	-0.123410	-1.71020	0.062499	0.78803

Table 5.3 Continued

	Cotton		Manmade Fiber	
	Coefficient Estimates	Coefficients t-values	Coefficient Estimates	Coefficients t-values
β_{i12}	-0.289610	-2.25870	0.255560	1.60330
β_{i13}	-0.062339	-1.10960	-0.069990	-0.63022

R-Sq (equation 1) = 0.8159
DW (equation 1) = 1.9159
Rho (equation 1) = 0.03922

R-Sq (equation 2) = 0.8163
DW (equation 2) = 1.9864
Rho (equation 2) = 0.00291

Period = 1979-1992
Number of Observations = 196
Log likelihood = 883.5252

Table t at 10% = 1.645 (two-tailed)
Table t at 20% = 1.282 (two-tailed)

Model 5:

$$w_{ict} = \alpha_i + \sum_r \Theta_{irct} + \sum_j \gamma_{ij}\, log(p_{jct}) + (\beta_i + \beta_{i1} D_{France} + \beta_{i2} D_{Germany} + \beta_{i3} D_{Italy} + \beta_{i4} D_{Belgium\text{-}Luxembourg} + \beta_{i5} D_{Netherlands} + \beta_{i6} D_{United\ Kingdom} + \beta_{i7} D_{i7} D_{Denmark} + \beta_{i8} D_{Ireland} + \beta_{i9} D_{i9} D_{Greece} + \beta_{i10} D_{i10} D_{Spain} + \beta_{i11} D_{Portugal} + \beta_{i12} D_{Austria} + \beta_{i13} D_{Finland})\, log[Y_{ct}/P_{ct}] + \varepsilon_{it}$$

$$Log\,(P_{ct}) = \alpha_0 + \sum_r \Theta_{irct}\, log\,(p_{kct}) + \sum_k \alpha_k\, log\,(p_{kct}) + \frac{1}{2}\sum_k \sum_j \gamma_{kj}\, log(p_{kct})\, log(p_{jct})$$

$$\sum_r \Theta_{irct} = D_{i1} D_{France} + D_{i2} D_{Germany} + D_{i3} D_{Italy} + D_{i4} D_{Belgium\text{-}Luxembourg} + D_{i5} D_{Netherlands} + D_{i6} D_{United\ Kingdom} + D_{i7} D_{Denmark} + D_{i8} D_{Ireland} + D_{i9} D_{Greece} + D_{i10} D_{Spain} + D_{i11} D_{Portugal} + D_{i12} D_{Austria} + D_{i13} D_{Finland}$$

Table 5.4 Disaggregated European Union Countries Elasticity Estimates for AIDS Model 5, Available for Home Use Data.

Marshallian Price Elasticity	**Sweden**	**France**	**Germany**	**Italy**	**Bel-Lux**	**Netherlands**	**U Kingdom**
Cotton-Cotton	-0.57971	-0.63022	-0.63354	-0.37557	-0.42593	-0.35085	-0.48345
Cotton-Manmade	-0.56999	-0.62049	-0.62382	-0.36585	-0.41620	-0.34112	-0.47372
Cotton-Wool	-0.17691	-0.22741	-0.23074	0.02723	-0.02312	0.05196	-0.08065
Manmade-Cotton	-0.38142	-0.22588	-0.30528	-0.61998	-0.48404	-0.58393	-0.39517
Manmade-Manmade	-0.50945	-0.35392	-0.43332	-0.74801	-0.61208	-0.71197	-0.52320
Manmade-Wool	-0.05760	0.09794	0.01853	-0.29616	-0.16023	-0.26011	-0.07135
Wool-Cotton	1.13668	0.87649	1.02248	1.16412	0.96353	1.02166	0.90151
Wool-Manmade	-0.23192	-0.49211	-0.34612	-0.20447	-0.40506	-0.34694	-0.46709
Wool-Wool	-1.08876	-1.34895	-1.20296	-1.06131	-1.26190	-1.20378	-1.32393
Hicksian Price Elasticity							
Cotton-Cotton	-0.01763	-0.02016	-0.04241	-0.04441	-0.04149	-0.04335	-0.03491
Cotton-Manmade	-0.09063	-0.29927	-0.22186	0.35605	0.16749	0.34412	0.01961
Cotton-Wool	-0.21835	-0.15869	-0.22383	-0.02583	0.00874	0.05921	-0.02252
Manmade-Cotton	0.18067	0.38417	0.28585	-0.28881	-0.09961	-0.27643	0.05337
Manmade-Manmade	-0.03010	-0.03269	-0.03137	-0.02612	-0.02838	-0.02672	-0.02987
Manmade-Wool	-0.09904	0.16666	0.02545	-0.34922	-0.12836	-0.25285	-0.01322
Wool-Cotton	0.89526	1.27681	1.06274	0.85502	1.14917	1.06393	1.24013
Wool-Manmade	-0.51120	-0.02899	-0.29955	-0.56207	-0.19031	-0.29803	-0.07536
Wool-Wool	-1.13020	-1.28023	-1.19605	-1.11438	-1.23004	-1.19652	-1.26580
Expenditure Elasticity							
Cotton	1.30883	1.42052	1.37647	0.77113	0.89517	0.71601	1.04443
Manmade	0.96485	0.64656	0.80905	1.45303	1.17486	1.37926	0.99298
Wool	-0.56215	0.93216	0.09375	-0.71977	0.43226	0.09844	0.78848

Table 5.4 Continued.

Marshallian Price Elasticity	**Denmark**	**Ireland**	**Greece**	**Spain**	**Portugal**	**Austria**	**Finland**
Cotton-Cotton	-0.36992	-0.44612	-0.48293	-0.48467	-0.48112	-0.31590	-0.51233
Cotton-Manmade	-0.36019	-0.43639	-0.47320	-0.47494	-0.47139	-0.30617	-0.50260
Cotton-Wool	0.03289	-0.04331	-0.08012	-0.08187	-0.07831	0.08691	-0.10953
Manmade-Cotton	-0.48041	-0.54395	-0.44183	-0.35380	-0.44289	-0.63278	-0.31257
Manmade-Manmade	-0.60845	-0.67198	-0.56987	-0.48184	-0.57093	-0.76082	-0.44061
Manmade-Wool	-0.15660	-0.22013	-0.11801	-0.02999	-0.11907	-0.30897	0.01125
Wool-Cotton	1.23513	1.14849	0.98990	0.83332	0.99282	1.05626	0.82414
Wool-Manmade	-0.13347	-0.22011	-0.37870	-0.53528	-0.37578	-0.31234	-0.54446
Wool-Wool	-0.99031	-1.07695	-1.23554	-1.39212	-1.23262	-1.16918	-1.40130
Hicksian Price Elasticity							
Cotton-Cotton	0.13320	-0.04427	-0.04441	-0.02295	-0.04244	-0.04342	-0.01258
Cotton-Manmade	0.21981	0.20821	0.06758	-0.02366	0.07046	0.42875	-0.09324
Cotton-Wool	-0.05024	-0.08975	-0.05942	0.00513	-0.05885	0.07951	-0.01864
Manmade-Cotton	0.02270	-0.14210	-0.00331	0.10791	-0.00421	-0.36031	0.18717
Manmade-Manmade	-0.02844	-0.02739	-0.02909	-0.03056	-0.02907	-0.02590	-0.03124
Manmade-Wool	-0.23972	-0.26657	-0.09731	0.05701	-0.09960	-0.31636	0.10213
Wool-Cotton	0.75089	0.87794	1.11051	1.34012	1.10623	1.01319	1.35358
Wool-Manmade	-0.69366	-0.53309	-0.23917	0.05102	-0.24458	-0.36216	0.06803
Wool-Wool	-1.07344	-1.12339	-1.21484	-1.30512	-1.21315	-1.17657	-1.31041
Expenditure Elasticity							
Cotton	1.17153	0.93571	1.02110	1.07512	1.02147	0.63447	1.16367
Manmade	1.16743	1.29744	1.08848	0.90834	1.09064	1.47924	0.82397
Wool	-1.12755	-0.62997	0.28085	1.18010	0.26408	-0.10028	1.23282

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Table 5.5 Parameter Estimates for LA/AIDS Model 1, Mill Consumption Data.

	Cotton		Manmade Fiber	
	Coefficient Estimates	Coefficients t-values	Coefficient Estimates	Coefficients t-values
α_i	0.3401400	3.38180	0.5818700	6.04340
D_{i1}	0.0464090	1.30350	-0.0913050	-2.66240
D_{i2}	-0.2092400	-4.08710	0.1778900	3.58750
D_{i3}	-0.2264500	-2.99080	0.2504400	3.42110
D_{i4}	-0.0065721	-0.38953	0.0066801	0.40229
D_{i5}	0.0018132	0.11277	-0.0031553	-0.20154
γ_{i1}	0.1818700	8.71170	-0.1544900	-7.84100
γ_{i2}	-0.1544900	-7.84100	0.2078600	9.90290
β_i	0.0364540	1.26620	-0.0261730	-0.95580

R-Sq (cotton equation) = 0.8813
DW (cotton equation) = 1.9984
Rho (cotton equation) = 0.00051

R-Sq (manmade equation) = 0.8739
DW (manmade equation) = 2.0941
Rho (manmade equation) = -0.04742

Period = 1979-1992
Number of Observations = 196
Log likelihood = 729.2011

Table t at 10% = 1.645 (two-tailed)
Table t at 20% = 1.282 (two-tailed)

Model 1:

$$w_{ict} = \alpha_i + \sum_r \Theta_{irct} + \sum_j \gamma_{ij}\, log(p_{jct}) + \beta_i\, log[Y_{ct}/P_{ct}] + \varepsilon_{it}$$

$$log\,(P^*) = \sum_k w_{kt}\, log\,(p_{kt})$$

$$\sum_r \Theta_{irct} = D_{i1}\, GDP_1 + D_{i2}\, CL_1 + D_{i3}\, CL_2 + D_{i4}\, MFA_2 + D_{i5}\, MFA_3$$

Table 5.6 Aggregated European Union Elasticity Estimates for LA/AIDS Model 1, Mill Consumption Data.

Marshallian Price Elasticity	
Cotton-Cotton	-0.4385722
Cotton-Manmade	-0.5821383
Cotton-Wool	-0.0991288
Manmade-Cotton	-0.2364460
Manmade-Manmade	-0.6384131
Manmade-Wool	-0.0829068
Wool-Cotton	-0.3187044
Wool-Manmade	3.3747651
Wool-Wool	-3.9209577

Hicksian Price Elasticity	
Cotton-Cotton	-0.0979277
Cotton-Manmade	0.1118395
Cotton-Wool	-0.0139118
Manmade-Cotton	0.0548973
Manmade-Manmade	-0.0448742
Manmade-Wool	-0.0100231
Wool-Cotton	-0.0556109
Wool-Manmade	3.9107521
Wool-Wool	-3.8551412

Expenditure Elasticity	
Cotton	1.1198393
Manmade	0.9577659
Wool	0.8648970

Table 5.7 Parameter Estimates for AIDS Model 5, Mill Consumption Data.

	Cotton		Manmade Fiber	
	Coefficient Estimates	Coefficients t-values	Coefficient Estimates	Coefficients t-values
α_i	0.175930	4.062600	0.7815700	17.516000
D_{i1}	0.048560	1.750300	-0.0055032	-0.087609
D_{i2}	-0.127030	-0.999790	-0.0578170	-0.762740
D_{i3}	0.064587	0.763580	-0.1537800	-1.487800
D_{i4}	0.088844	9.524300	0.4985000	3.606100
D_{i5}	-0.101340	-0.765920	-0.0063005	-0.164280
D_{i6}	0.148600	2.551900	0.0236110	0.734650
D_{i7}	-0.067539	-0.908130	0.1850100	1.402900
D_{i8}	0.302500	2.298700	-0.5092100	-3.257400
D_{i9}	-0.148210	-2.140100	-0.0583960	-2.026000
D_{i10}	-0.043733	-0.404620	-0.0280820	-0.406660
D_{i11}	-0.094061	-1.220500	-0.0411160	-1.031500
D_{i12}	0.011100	0.098631	0.0099336	0.423320
D_{i13}	0.063845	6.034000	-0.4259300	-3.113100
γ_{i1}	0.162730	10.071000	-0.1348500	-8.365400
γ_{i2}	-0.134850	-8.365400	0.1829900	9.991500
β_i	-0.149580	-1.932300	0.1484800	1.784500
β_{i1}	0.426590	1.237100	-0.3653200	-1.150200
β_{i2}	0.224050	2.919500	-0.1890600	-1.984000
β_{i3}	0.246840	2.815400	-0.1580400	-1.853100
β_{i4}	-0.039381	-0.430800	-0.0537340	-0.613650
β_{i5}	0.192660	2.508100	-0.1551300	-1.798800
β_{i6}	0.313290	2.961300	-0.2980700	-2.467400
β_{i7}	0.143630	1.513900	-0.0719290	-0.782930
β_{i8}	0.180480	2.305300	-0.1223300	-1.469800
β_{i9}	0.324160	3.805400	-0.3445400	-3.629900
β_{i10}	0.220350	2.781400	-0.2047200	-1.781400
β_{i11}	0.300310	3.626100	-0.2980700	-3.165800

Table 5.7 Continued

	Cotton		Manmade Fiber	
	Coefficients Estimates	Coefficients t-values	Coefficient Estimates	Coefficient t-values
β_{i12}	0.2233900000	2.712400000	-0.2379500	-2.612400
β_{i13}	0.0000037944	0.000041530	-0.1041000	-1.273500

R-Sq (cotton equation) = 0.9613
DW (cotton equation) = 1.8822
Rho (cotton equation) = 0.05876

R-Sq (manmade equation) = 0.9484
DW (manmade equation) = 2.0249
Rho (manmade equation) = -0.01327

Period = 1979-1992
Number of Observations = 196
Log likelihood = 913.1792

Table t at 10% = 1.645 (two-tailed)
Table t at 20% = 1.282 (two-tailed)

Model 5:

$$w_{ict} = \alpha_i + \sum_r \Theta_{irct} + \sum_j \gamma_{ij}\, log(p_{jct}) + (\beta_i + \beta_{i1} D_{France} + \beta_{i2} D_{Germany} + \beta_{i3} D_{Italy} + \beta_{i4} D_{Belgium\text{-}Luxembourg} + \beta_{i5} D_{Netherlands} + \beta_{i6} D_{United\ Kingdom} + \beta_{i7} D_{i7} D_{Denmark} + \beta_{i8} D_{Ireland} + \beta_{i9} D_{i9} D_{Greece} + \beta_{i10} D_{i10} D_{Spain} + \beta_{i11} D_{Portugal} + \beta_{i12} D_{Austria} + \beta_{i13} D_{Finland})\, log[Y_{ct}/P_{ct}] + \varepsilon_{it}$$

$$Log\,(P_{ct}) = \alpha_0 + \sum_r \Theta_{irct}\, log\,(p_{kct}) + \sum_k \alpha_k\, log\,(p_{kct}) + \frac{1}{2} \sum_k \sum_j \gamma_{kj}\, log(p_{kct})\, log(p_{jct})$$

$$\sum_r \Theta_{irct} = D_{i1} D_{France} + D_{i2} D_{Germany} + D_{i3} D_{Italy} + D_{i4} D_{Belgium\text{-}Luxembourg} + D_{i5} D_{Netherlands} + D_{i6} D_{United\ Kingdom} + D_{i7} D_{Denmark} + D_{i8} D_{Ireland} + D_{i9} D_{Greece} + D_{i10} D_{Spain} + D_{i11} D_{Portugal} + D_{i12} D_{Austria} + D_{i13} D_{Finland}$$

Table 5.8 Disaggregated European Union Countries Elasticity Estimates for AIDS Model 5, Mill Consumption Data.

Marshallian Price Elasticity	**Sweden**	**France**	**Germany**	**Italy**	**Bel-Lux**	**Netherlands**	**U Kingdom**
Cotton-Cotton	-0.37133	-0.68280	-0.48059	-0.54662	-0.29147	-0.47767	-0.64394
Cotton-Manmade	-0.34960	-0.66107	-0.45886	-0.52489	-0.26974	-0.45594	-0.62221
Cotton-Wool	0.00205	-0.30941	-0.10721	-0.17323	0.08191	-0.10429	-0.27056
Manmade-Cotton	-0.40386	0.05441	-0.16670	-0.20561	-0.33645	-0.20926	-0.02995
Manmade-Manmade	-0.89327	-0.43500	-0.65610	-0.69502	-0.82586	-0.69867	-0.51936
Manmade-Wool	-0.26165	0.19662	-0.02449	-0.06340	-0.19424	-0.06705	0.11226
Wool-Cotton	0.84803	0.88755	0.87060	0.90530	0.78797	0.87224	0.85785
Wool-Manmade	-0.61466	-0.57514	-0.59209	-0.55739	-0.67471	-0.59045	-0.60484
Wool-Wool	-1.23550	-1.19598	-1.21293	-1.17823	-1.29556	-1.21129	-1.22568
Hicksian Price Elasticity							
Cotton-Cotton	-0.21672	-0.10160	-0.10193	-0.14517	-0.17625	-0.13040	-0.17604
Cotton-Manmade	0.41859	-0.25819	0.12027	0.08526	0.44471	0.15712	-0.15209
Cotton-Wool	0.07925	-0.29348	-0.06500	-0.18484	0.25222	-0.06462	-0.20858
Manmade-Cotton	-0.24925	0.63561	0.21196	0.19584	-0.22122	0.13801	0.43795
Manmade-Manmade	-0.12507	-0.03213	-0.07697	-0.08486	-0.11140	-0.08561	-0.04924
Manmade-Wool	-0.18445	0.21255	0.01772	-0.07500	-0.02393	-0.02738	0.17424
Wool-Cotton	1.15662	0.95122	1.03932	0.85892	1.46878	1.03080	1.10559
Wool-Manmade	0.01401	-0.44543	-0.24837	-0.65187	0.71225	-0.26741	-0.10012
Wool-Wool	-1.15830	-1.18006	-1.17073	-1.18983	-1.12524	-1.17163	-1.16371
Expenditure Elasticity							
Cotton	0.50827	1.91065	1.24481	1.31973	0.37881	1.14162	1.53818
Manmade	1.23960	0.65010	0.93452	0.98457	1.15289	0.98927	0.75861
Wool	1.01446	0.20930	0.55465	-0.15247	2.23808	0.52127	0.81445

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Table 5.8 Continued.

Marshallian Price Elasticity	**Denmark**	**Ireland**	**Greece**	**Spain**	**Portugal**	**Austria**	**Finland**
Cotton-Cotton	-0.46263	-0.51513	-0.48935	-0.49920	-0.51286	-0.51397	-0.33994
Cotton-Manmade	-0.44090	-0.49339	-0.46761	-0.47747	-0.49112	-0.49224	-0.31821
Cotton-Wool	-0.08925	-0.14174	-0.11596	-0.12581	-0.13947	-0.14058	0.03344
Manmade-Cotton	-0.31363	-0.25040	0.02834	-0.14705	-0.02995	-0.10537	-0.27327
Manmade-Manmade	-0.80304	-0.73981	-0.46107	-0.63646	-0.51936	-0.59478	-0.76268
Manmade-Wool	-0.17142	-0.10819	0.17055	-0.00484	0.11226	0.03684	-0.13106
Wool-Cotton	0.89427	0.88553	0.83489	0.85811	0.84948	0.83864	0.78089
Wool-Manmade	-0.56841	-0.57715	-0.62780	-0.60458	-0.61321	-0.62405	-0.68180
Wool-Wool	-1.18926	-1.19800	-1.24864	-1.22542	-1.23406	-1.24489	-1.30264
Hicksian Price Elasticity							
Cotton-Cotton	-0.16439	-0.18003	-0.01057	-0.12424	-0.05794	-0.13597	-0.18533
Cotton-Manmade	0.25536	0.15247	-0.04396	0.08600	-0.02100	0.03800	0.34588
Cotton-Wool	-0.08375	-0.12269	-0.01838	-0.06425	-0.06451	-0.04883	0.21474
Manmade-Cotton	-0.01539	0.08469	0.50711	0.22791	0.42497	0.27263	-0.11866
Manmade-Manmade	-0.10677	-0.09395	-0.03742	-0.07299	-0.04924	-0.06453	-0.09859
Manmade-Wool	-0.16592	-0.08915	0.26813	0.05673	0.18722	0.12860	0.05023
Wool-Cotton	0.91625	0.96168	1.22494	1.10422	1.14911	1.20543	1.50559
Wool-Manmade	-0.52365	-0.42204	0.16683	-0.10319	-0.00279	0.12319	0.79460
Wool-Wool	-1.18376	-1.17895	-1.15107	-1.16385	-1.15910	-1.15313	-1.12134
Expenditure Elasticity							
Cotton	0.98044	1.10158	1.57392	1.23265	1.49551	1.24264	0.50828
Manmade	1.12353	1.04220	0.68363	0.90925	0.75861	0.85563	1.07161
Wool	0.07223	0.25030	1.28227	0.80906	0.98502	1.20579	2.38239

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Table 5.9 Relative Importance of Sub-Sectors of the Textile Industry.

Sub-sector	**Share (%)**
Woven fabrics	22
Technical/industrial textiles (including carpets)	21
Knitted fabrics and articles	18
Yarn and thread	16
Textile finishing	12
Home textiles	11
TOTAL TEXTILES	100

Source: Stengg, 2001.

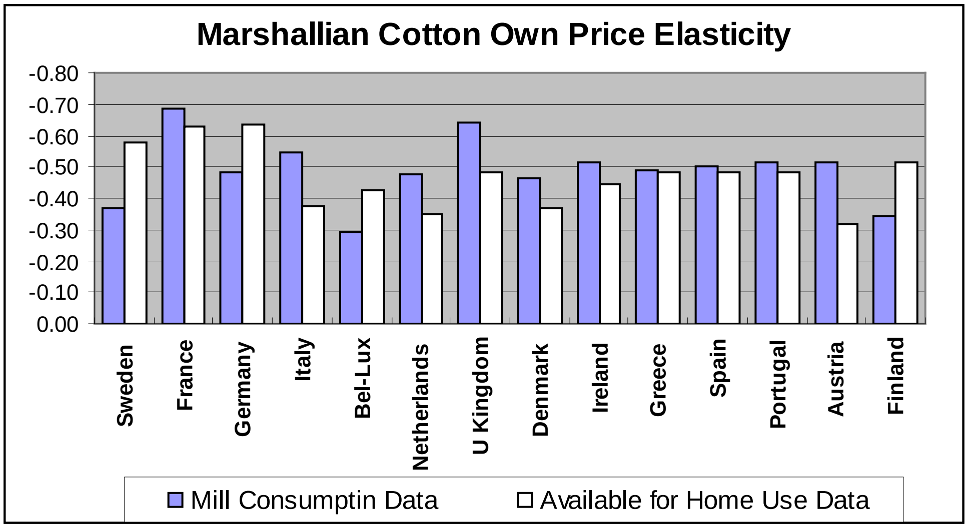

Figure 5.1 Comparison of European Union Countries Marshallian Cotton Own Price Elasticity Results Under Available for Home Use Data and Mill Consumption Data.

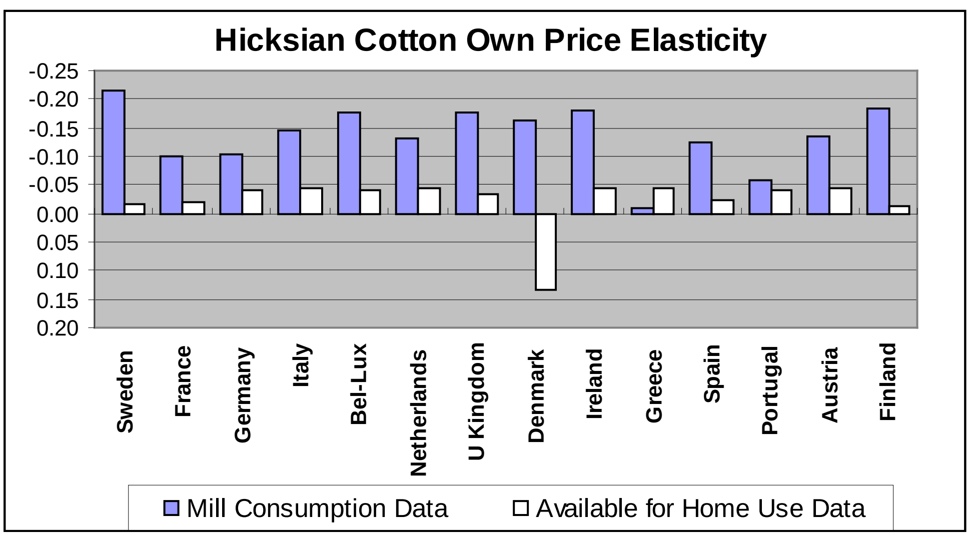

Figure 5.2 Comparison of European Union Countries Hicksian Cotton Own Price Elasticity Results Under Available for Home Use Data and Mill Consumption Data.

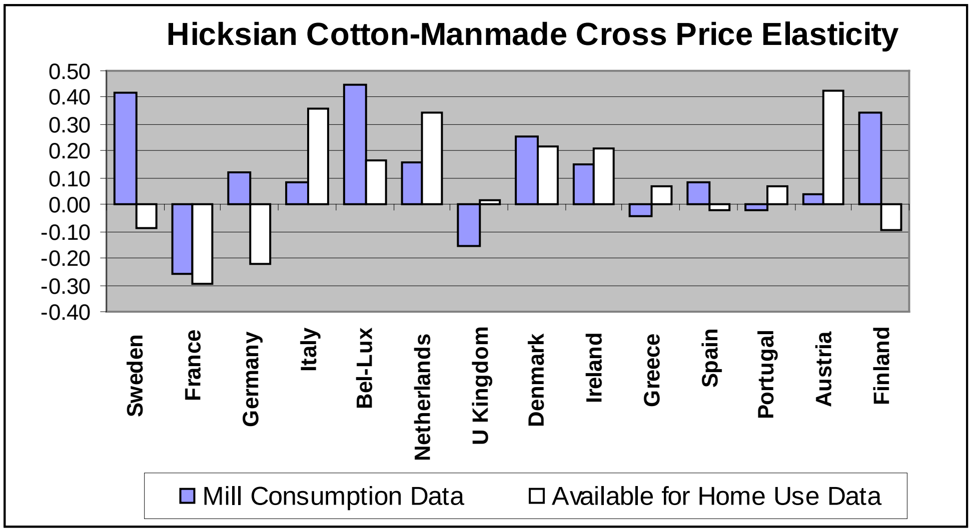

Figure 5.3 Comparison of European Union Countries Hicksian Cotton-Manmade Cross Price Elasticity Results Under Available for Home Use Data and Mill Consumption Data.

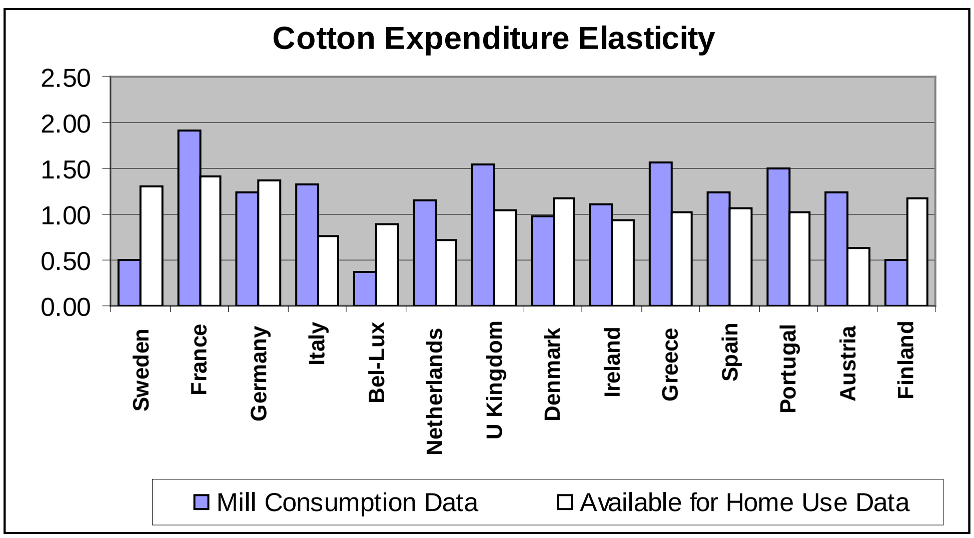

Figure 5.4 Comparison of European Union Countries Cotton Expenditure Elasticity Results Under Available for Home Use Data and Mill Consumption Data.

CHAPTER VI

CONCLUSION AND IMPLICATIONS

This chapter presents a review of the major issues addressed in the preceding chapters. Several implications of the empirical results are presented, together with concluding remarks and findings associated with the objectives of the study. Having a precise empirical measure of the European Union cotton demand is fundamental to identify how the EU might react to changes in the price of cotton and the elimination of quotas. World cotton demand analysts can use the results provided in this study and connect them into a world model to simulate different scenarios for the EU after the 2005 quota liberalization.

The EU is the world's largest importer of cotton and it contributes significantly to the world cotton trade. This study explores the cotton demands of the 15 European Union members at both mill consumption and home consumption levels. Unlike previous studies, this research uses available for home use data and a demand system approach, and it includes wool as competitive commodity of cotton. One of the advantages of a demand system approach is that it has proven to better capture the strong interrelationship between commodities, providing more accurate parameter estimates.

Even though the Rotterdam model and a method consistent with the two-stage budgeting approach are considered and tested in the European Union countries, this study concentrates on pooled AIDS and LA/AIDS models estimated over time series using country disaggregated annual data. Five different types of model specifications are tested for the AIDS and LA/AIDS models using both available for home use data and mill consumption data. Country differences in fiber consumption are separated from the error term by introducing dummy variables into the model. These dummy variables capture country differences in demographic and geographic characteristics. In this study, the demographic effects include population and GDP, and the geographic effect includes climate. Dummy variables are incorporated into the AIDS and LA/AIDS models by using translating techniques.

Most of the time the AIDS full model performs superior to the LA/AIDS model, providing more statistically significant parameters, higher R-squares, and more elasticity values with the correct signs. When working with available for home use data, model 4 and 5 of the full AIDS model provide the best results while when working with mill consumption data, model 1 of the LA/AIDS model and model 5 of the full AIDS model provide the best results. Estimation of the nonlinear system of equations by maximum likelihood was performed in all five models using Shazam econometric software. After successfully correcting for autocorrelation, the estimated parameters are used to calculate elasticities at four levels: aggregated mill consumption, country-disaggregated mill consumption, aggregated home consumption, and country-disaggregated home consumption. In this study, due to the nature of the data, the AIDS model successfully provides parameter estimates that are theoretically acceptable while the Rotterdam model does not. Barten (1993) explains that the right functional form in consumer allocation models sometimes depends on the data being used.

Overall, most of the parameter estimates in the reported models are statistically significant with at least 80% statistical certainty level. The coefficient of determination in these models is at least 0.7976 and sometimes above 0.90. Additionally, Durbin-Watson statistics shows a successful correction of autocorrelation.

When using available for home use data, all own-price elasticities of cotton, wool and manmade fiber are negative except for one Hicksian cotton own price elasticity in Denmark. The most responsive Marshallian cotton own price elasticity is -0.63354 in Germany and the least responsive is -0.3159 in Austria. The most responsive Hicksian cotton-manmade cross price elasticity is 0.42875 in Austria while the least responsive is 0.01961 in United Kingdom. Similarly, the cotton expenditure elasticity ranges from 1.42052 in France to 0.63447 in Austria. On the other hand, when using mill consumption data, the most responsive Marshallian cotton own price elasticity is -0.68280 in France and the least responsive is -0.29147 in Greece. The most responsive Hicksian cotton-manmade cross price elasticity is 0.44471 in Belgium-Luxembourg and the least responsive is -0.021 in Portugal. Finally, the cotton expenditure elasticity ranges from 1.57392 in Greece to 0.50827 in Sweden.

Wool elasticities are anticipated to be higher than cotton or manmade fiber elasticities because of a small wool expenditure share. However, all cotton and manmade fiber price elasticities are less than one or greater than minus one. Low cotton and manmade fiber price elasticities are expected because the price of fibers accounts for a very small proportion of the price of the final good and thus the consumer is insensitive to fiber prices. Consequently, consumer demand for fibers can be expected to be highly inelastic and this has been supported empirically in a number of studies (Meyer, 2002; Clements and Lan, 2001; Coleman and Thigpen, 1991; Dudley, 1974; Magleby and Missaien, 1971; Thigpen, 1978).

Unlike most of the positive Hicksian cotton-manmade cross price elasticities, the Marshallian cotton-manmade cross price elasticities are negative. However, Hicksian elasticities are net of income effects, thus they provide a more accurate interpretation. Positive Hicksian cross price elasticity values suggest that the two commodities are substitutes while negative Hicksian cross price elasticity values suggest that the two commodities are complements. When using home consumption data, cotton and manmade fiber are complements in Sweden, France, Germany, Spain, and Finland, while they are substitutes in Italy, Belgium-Luxembourg, Netherlands, United Kingdom, Denmark, Ireland, Greece, Portugal, and Austria. Negative Hicksian cross price elasticity values illustrates the consumption of the two commodities in textiles composed of mixture of fibers.

Pressure in the European Textile and Clothing Industry for innovation, quality, creativity, design, and fashion influences fiber composition in textiles and clothing. Furthermore, the presence of the textile and clothing industry is different in each EU country. For example, some southern countries such as Spain, Portugal, and Greece have higher concentration on clothing, while countries such as the Netherlands, Sweden, Belgium, and Austria have focused their activities on the textile sector (Stengg, 2001). Additionally, labor productivity, value added per hourly wage cost, textile employment, and clothing employment vary from country to country in the European Union (Stengg, 2001).

The cotton expenditure elasticity estimates under available for home use data reveal that cotton is a normal luxury commodity in Sweden, France, Germany, United Kingdom, Denmark, Greece, Spain, Portugal, and Finland while it is a normal necessary commodity in Italy, Belgium-Luxembourg, Netherlands, Ireland, and Austria. However, the aggregated expenditure elasticity estimate calculated in this study only shows that cotton is a normal luxury commodity. These differences in expenditure elasticities are not captured when all European Union country expenditure elasticities are aggregated in one expenditure elasticity value.

Given the large variability in the fiber demand elasticities among the EU counties, a more accurate description of the European Union cotton demand can be obtained by calculating individual country elasticities. Further, variability of the elasticities in each country depends on the commodity being analyzed. Variability in elasticity values across countries reflects that consumers' choices and preferences on cotton, wool, and manmade fiber are different in the European Union countries.

Unlike mill consumption, home equivalent consumption includes fiber equivalent consumption of imports and exports of textiles; therefore, it more appropriately represents the consumer consumption of fiber. Mill consumption elasticities are different from available for home use elasticities. Since available for home use data is a better approximation of the consumer demand of fibers, previous methodological choices that use mill consumption data might not appropriately represent the European Union cotton demand. Further, given that available for home use data is more consistent with demand theory, this approach should be used when estimating the EU fiber demand elasticities. Therefore, a greater effort should be done to keep collecting available for home use data and incorporate these data into studies.

6.1 Considerations for Further Research

This research describes the European Union demand for cotton in terms of its country elasticity values. One limitation of this study is that it assumes that the Food and Agriculture Organization of the United Nations appropriately and correctly calculated available for home use data. Changes in the methodology employed might alter the demand elasticities reported in this study. This research also uses the Greece cotton price, the United States actual polyester price, and the United Kingdom wool price as representative of the cotton price, manmade fiber price, and wool price in each European Union country. Results can be improved by collecting and using data on each EU country's cotton, manmade fiber, and wool prices.

Additionally, sophisticated tests can be implemented on the parameters or the disaggregated elasticity estimates to asses if they are significantly different from each other. This could be approached by consolidating the real expenditure shifters in model 5 by applying F-tests or log of the likelihood ratio tests. These sophisticated tests are not applied in this research due to time constraints.

This study could also benefit by increasing the sample size. Data on available for home use wool and manmade fiber consumption by country is currently available only from 1979 to 1992. Similarly, wool and manmade fiber mill consumption by country is available up to 1992. By increasing the sample size not only more recent estimates will be obtained but also different tests can be performed.

First, a test for endogeneity of prices or endogeneity of total expenditure might help to provide better estimates of the European Union cotton demand parameters. To test for endogeneity of total expenditure an extra equation needs to be included in the AIDS or LA/AIDS model. Economists Capps et al. (1994) corrected for endogeneity of total expenditure in the Rotterdam model by including an extra equation in the system. They regressed the total expenditure variable on a set of exogenous variables. The set of exogenous factors includes the log differences of prices as well as the log differences of real income. This technique was developed by Attfield (1985) and by Hausman.

In the LA/AIDS model, the following equation will have to be included in the system:

(6.1) $\mathit{log}[Y/P] = \Gamma_0 + \Gamma_1 \mathit{log}(p_{cotton}) + \Gamma_2 \mathit{log}(p_{manmade}) + \Gamma_3 \mathit{log}(p_{wool}) + \Gamma_4 \mathit{log}(GDP) + u_i$

Alternatively, in the full AIDS model, the additional equation can be:

(6.2) $\mathit{log}(Y) = \Gamma_0 + \Gamma_1 \mathit{log}(p_{cotton}) + \Gamma_2 \mathit{log}(p_{manmade}) + \Gamma_3 \mathit{log}(p_{wool}) + \Gamma_4 \mathit{log}(GDP) + u_i$

Where p_{cotton} = price of cotton

p_{manmde} = price of manmade

p_{wool} = price of wool

GDP = per capita real gross domestic product

$\Gamma_0, \Gamma_1, \Gamma_2, \Gamma_3, \Gamma_4$ = parameters

If the test of the hypothesis that the parameters Γ_0, Γ_1, Γ_2, Γ_3, and Γ_4 are jointly equal to zero, is rejected, then parameter estimates of both the price and expenditure coefficients in the demand system would be unbiased and consistent because the correlation of total expenditure and the disturbance terms is corrected by the extra equation. If this hypothesis cannot be rejected, then there exists no simultaneity or endogeneity of total expenditure, and the extra equation is not needed. However, this test is not performed in this study to avoid problems of degrees of freedom.

Second, previous studies on the European Union cotton demand have only included cotton and manmade fiber as competitive commodities, excluding wool. A likelihood ratio test can be performed to determine if separability between wool and other commodities (cotton and manmade fiber) is supported by the data. This study did not employ this test because the restricted model would have consisted of only two equations. Considering that one equation needs to be excluded to avoid the singularity of the variance-covariance matrix of disturbances, estimation of European Union cotton parameters by only one equation would have not appropriately captured the interrelationship among cotton and manmade fiber. However, if the cellulosic price is obtained, manmade fiber can be separated into cellulosic and synthetic fibers and a separability test for wool can be easily implemented.

Third, when pooling data, this study focuses on the use of the fixed effects model (FEM), or least squares dummy variable (LSDV) model. The estimation of the European Union cotton demand parameters can also be approached by the error components model (ECM), or random effects model (REM). This approach decomposes the error term in two (or more) components. One advantage of ECM over FEM is that it is economical in degrees of freedom. To determine which model is better, a Hausman (1978) test can be performed.

Finally, world cotton demand analysts can use the results provided in this study and connect them into a world model to simulate different scenarios for the EU after the 2005 quota liberalization.

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APPENDIX A

SHAZAM PROGRAM FOR LA/AIDS MODEL 1

```
READ (C:\antonio\ttu\Thesis\DATA\Panel1.TXT) OBS YEAR CT W MM PCT PW &
PM GDP1 GDP2 CL1 CL2 CL3 MFA2 MFA3/SKIPLINES=4
SAMPLE 1 196

GENR Y=CT*PCT+W*PW+MM*PM

***GENERATING BUDGET SHARES
GENR WCT=CT*PCT/Y
GENR WW=W*PW/Y
GENR WM=MM*PM/Y

***GENERATING LOG PRICES
GENR LNPCT=LOG(PCT)
GENR LNPW=LOG(PW)
GENR LNPM=LOG(PM)

***GENERATING STONE'S APPROXIMATION FOR PRICE INDEX
GENR LNP=(WCT*LNPCT+WW*LNPW+WM*LNPM)
GENR LNY=LOG(Y)
GENR LNYP=LNY-LNP

***RUNING NL RESTRICTD CORRECTED FOR AUTOCORRELATION
NL 2/NCOEF=17 AUTO PCOV CONV=0.0001 ITER=300 RSTAT PITER=50
EQ WCT=A1+D11*GDP1+D12*CL1+D13*CL2+D14*MFA2+D15*MFA3 &
+G11*LNPCT+G12*LNPM-(G11+G12)*LNPW+B1*LNYP
EQ WM=A2+D21*GDP1+D22*CL1+D23*CL2+D24*MFA2+D25*MFA3 &
+G12*LNPCT+G22*LNPM-(G12+G22)*LNPW+B2*LNYP

COEF A1 0.083 D11 -0.11 D12 0.008 D13 0.01 D14 -0.005 D15 0.002 G11 -0.21 &
G12 -0.20 B1 0.13 A2 0.76 D21 0.08 D22 0.012 D23 0.037 D24 0.006 D25 -0.00091 &
G22 0.23 B2 -0.11

END
```

APPENDIX B

SHAZAM PROGRAM FOR AIDS MODEL 1

```
READ (C:\antonio\ttu\Thesis\DATA\Panel1.TXT) OBS YEAR CT W MM PCT PW &
PM GDP1 GDP2 CL1 CL2 CL3 MFA2 MFA3/SKIPLINES=4
SAMPLE 1 196

GENR Y=CT*PCT+W*PW+MM*PM

***GENERATING BUDGET SHARES
GENR WCT=CT*PCT/Y
GENR WW=W*PW/Y
GENR WM=MM*PM/Y

***GENERATING LOG PRICES
GENR LNPCT=LOG(PCT)
GENR LNPW=LOG(PW)
GENR LNPM=LOG(PM)

GENR LNY=LOG(Y)

GENR GDP1LNPC=GDP1*LNPCT
GENR CL1LNPCT=CL1*LNPCT
GENR CL2LNPCT=CL2*LNPCT
GENR MFA2LNPC=MFA2*LNPCT
GENR MFA3LNPC=MFA3*LNPCT
GENR GDP1LNPM=GDP1*LNPM
GENR CL1LNPM=CL1*LNPM
GENR CL2LNPM=CL2*LNPM
GENR MFA2LNPM=MFA2*LNPM
GENR MFA3LNPM=MFA3*LNPM
GENR GDP1LNPW=GDP1*LNPW
GENR CL1LNPW=CL1*LNPW
GENR CL2LNPW=CL2*LNPW
GENR MFA2LNPW=MFA2*LNPW
GENR MFA3LNPW=MFA3*LNPW
GENR LNPCLNPC=LNPCT*LNPCT
GENR LNPCLNPM=LNPCT*LNPM
GENR LNPCLNPW=LNPCT*LNPW
GENR LNPMLNPM=LNPM*LNPM
GENR LNPMLNPW=LNPM*LNPW
```

```
GENR LNPWLNPW=LNPW*LNPW

***RUNING NL SYSTEM WITH ALL RESTRICTIONS CORRECTED FOR
***AUTOCORRELATION
NL 2/NCOEF=18 AUTO PCOV CONV=0.0001 ITER=1000 RSTAT PITER=200
EQ WCT=A1+D11*GDP1+D12*CL1+D13*CL2+D14*MFA2+D15*MFA3 &
+G11*LNPCT+G12*LNPM+(-G11-G12)*LNPW+B1*LNY &
-B1*(A0+A1*LNPCT+A2*LNPM+(1-A1-A2)*LNPW &
+D11*GDP1LNPC+D12*CL1LNPCT+D13*CL2LNPCT+D14*MFA2LNPC &
+D15*MFA3LNPC &
+D11*GDP1LNPM+D12*CL1LNPM +D13*CL2LNPM +D14*MFA2LNPM &
+D15*MFA3LNPM &
+D11*GDP1LNPW+D12*CL1LNPW +D13*CL2LNPW +D14*MFA2LNPW &
+D15*MFA3LNPW &
+0.5*G11*LNPCLNPC+G12*LNPCLNPM+(-G11-G12)*LNPCLNPW &
+0.5*G22*LNPMLNPM+(-G12-G22)*LNPMLNPW &
+0.5*(G11+2*G12+G22)*LNPWLNPW)

EQ WM=A2+D21*GDP1+D22*CL1+D23*CL2+D24*MFA2+D25*MFA3 &
+G12*LNPCT+G22*LNPM+(-G12-G22)*LNPW+B2*LNY &
-B2*(A0+A1*LNPCT+A2*LNPM+(1-A1-A2)*LNPW &
+D21*GDP1LNPCT+D22*CL1LNPCT+D23*CL2LNPCT+D24*MFA2LNPC &
+D25*MFA3LNPC &
+D21*GDP1LNPM +D22*CL1LNPM +D23*CL2LNPM +D24*MFA2LNPM &
+D25*MFA3LNPM &
+D21*GDP1LNPW +D22*CL1LNPW +D23*CL2LNPW +D24*MFA2LNPW &
+D25*MFA3LNPW &
+0.5*G11*LNPCLNPC+G12*LNPCLNPM+(-G11-G12)*LNPCLNPW &
+0.5*G22*LNPMLNPM+(-G12-G22)*LNPMLNPW &
+0.5*(G11+2*G12+G22)*LNPWLNPW)

COEF A1 0.33 D11 -0.16545 D12 0.0005 D13 0.038 D14 0.018 D15 0.0015 &
G11 0.24 G12 -0.21 B1 0.045 A0 0.3 A2 0.39 G22 0.026 D21 0.14 D22 0.022 &
D23 0.086 D24 0.005 D25 -0.0058 B2 -0.15
END
```

APPENDIX C

SHAZAM PROGRAM FOR LA/AIDS MODEL 2

```
READ (C:\antonio\ttu\Thesis\DATA\Panel2.TXT) OBS YEAR CT W MM PCT PW &
PM GDP1 GDP2 CL1 CL2 CL3 MFA2 MFA3 /SKIPLINES=4
SAMPLE 1 196

GENR Y=CT*PCT+W*PW+MM*PM

***GENERATING BUDGET SHARES
GENR WCT=CT*PCT/Y
GENR WW=W*PW/Y
GENR WM=MM*PM/Y

***GENERATING LOG PRICES
GENR LNPCT=LOG(PCT)
GENR LNPW=LOG(PW)
GENR LNPM=LOG(PM)

***GENERATING STONE'S APPROXIMATION FOR PRICE INDEX
GENR LNP=(WCT*LNPCT+WW*LNPW+WM*LNPM)
GENR LNY=LOG(Y)
GENR LNYP=LNY-LNP

***RUNING NL RESTRICTD CORRECTED FOR AUTOCORRELATION
NL 2/NCOEF=19 AUTO PCOV CONV=0.0001 ITER=300 RSTAT PITER=50 EVAL
EQ WCT=A1+D11*GDP1+D12*CL1+D13*CL2+D14*MFA2+D15*MFA3 &
+G11*LNPCT+G12*LNPM-(G11+G12)*LNPW+B1*LNYP+B11*GDP1*LNYP
EQ WM=A2+D21*GDP1+D22*CL1+D23*CL2+D24*MFA2+D25*MFA3 &
+G12*LNPCT+G22*LNPM-(G12+G22)*LNPW+B2*LNYP+B21*GDP1*LNYP

COEF A1 0.083 D11 -0.11 D12 0.008 D13 0.01 D14 -0.005 D15 0.002 &
G11 -0.21 G12 -0.20 B1 0.13 B11 0.10 A2 0.76 D21 0.08 D22 0.012 D23 0.037 &
D24 0.006 D25 -0.00091 G22 0.23 B2 -0.11 B21 -0.11933
END
```

APPENDIX D

SHAZAM PROGRAM FOR AIDS MODEL 2

```
READ (C:\antonio\ttu\Thesis\DATA\Panel2.TXT) OBS YEAR CT W MM PCT PW &
PM GDP1 GDP2 CL1 CL2 CL3 MFA2 MFA3/SKIPLINES=4
SAMPLE 1 196

GENR Y=CT*PCT+W*PW+MM*PM

***GENERATING BUDGET SHARES
GENR WCT=CT*PCT/Y
GENR WW=W*PW/Y
GENR WM=MM*PM/Y

***GENERATING LOG PRICES
GENR LNPCT=LOG(PCT)
GENR LNPW=LOG(PW)
GENR LNPM=LOG(PM)

GENR LNY=LOG(Y)

GENR GDP1LNPC=GDP1*LNPCT
GENR CL1LNPCT=CL1*LNPCT
GENR CL2LNPCT=CL2*LNPCT
GENR MFA2LNPC=MFA2*LNPCT
GENR MFA3LNPC=MFA3*LNPCT
GENR GDP1LNPM=GDP1*LNPM
GENR CL1LNPM=CL1*LNPM
GENR CL2LNPM=CL2*LNPM
GENR MFA2LNPM=MFA2*LNPM
GENR MFA3LNPM=MFA3*LNPM
GENR GDP1LNPW=GDP1*LNPW
GENR CL1LNPW=CL1*LNPW
GENR CL2LNPW=CL2*LNPW
GENR MFA2LNPW=MFA2*LNPW
GENR MFA3LNPW=MFA3*LNPW
GENR LNPCLNPC=LNPCT*LNPCT
GENR LNPCLNPM=LNPCT*LNPM
GENR LNPCLNPW=LNPCT*LNPW
GENR LNPMLNPM=LNPM*LNPM
GENR LNPMLNPW=LNPM*LNPW
```

```
GENR LNPWLNPW=LNPW*LNPW


***RUNING NL SYSTEM WITH ALL RESTRICTIONS CORRECTED FOR
***AUTOCORRELATION
NL 2/NCOEF=20 AUTO PCOV CONV=0.0001 ITER=1000 RSTAT &
PITER=200 EVAL
EQ WCT=A1+D11*GDP1+D12*CL1+D13*CL2+D14*MFA2+D15*MFA3 &
+G11*LNPCT+G12*LNPM+(-G11-G12)*LNPW+B1*LNY+B11*GDP1*LNY&
-(B1+B11*GDP1)*(A0+A1*LNPCT+A2*LNPM+(1-A1-A2)*LNPW &
+D11*GDP1LNPC+D12*CL1LNPCT+D13*CL2LNPCT+D14*MFA2LNPC &
+D15*MFA3LNPC &
+D11*GDP1LNPM+D12*CL1LNPM +D13*CL2LNPM +D14*MFA2LNPM &
+D15*MFA3LNPM &
+D11*GDP1LNPW+D12*CL1LNPW +D13*CL2LNPW
+D14*MFA2LNPW+D15*MFA3LNPW &
+0.5*G11*LNPCLNPC+G12*LNPCLNPM+(-G11-G12)*LNPCLNPW &
+0.5*G22*LNPMLNPM+(-G12-G22)*LNPMLNPW &
+0.5*(G11+2*G12+G22)*LNPWLNPW)

EQ WM=A2+D21*GDP1+D22*CL1+D23*CL2+D24*MFA2+D25*MFA3 &
+G12*LNPCT+G22*LNPM+(-G12-G22)*LNPW+B2*LNY+B21*GDP1*LNY &
-(B2+B21*GDP1)*(A0+A1*LNPCT+A2*LNPM+(1-A1-A2)*LNPW &
+D21*GDP1LNPC+D22*CL1LNPCT+D23*CL2LNPCT+D24*MFA2LNPC &
+D25*MFA3LNPC &
+D21*GDP1LNPM+D22*CL1LNPM +D23*CL2LNPM +D24*MFA2LNPM &
+D25*MFA3LNPM &
+D21*GDP1LNPW+D22*CL1LNPW +D23*CL2LNPW +D24*MFA2LNPW &
+D25*MFA3LNPW &
+0.5*G11*LNPCLNPC+G12*LNPCLNPM+(-G11-G12)*LNPCLNPW &
+0.5*G22*LNPMLNPM+(-G12-G22)*LNPMLNPW &
+0.5*(G11+2*G12+G22)*LNPWLNPW)

COEF A1 0.33 D11 -0.16545 D12 0.0005 D13 0.038 D14 0.018 D15 0.0015 G11 0.24 &
G12 -0.21 B1 0.045 B11 -0.11 A0 0.3 A2 0.39 G22 0.026 D21 0.14 D22 0.022 D23 &
0.086 D24 0.005 D25 -0.0058 B2 -0.15 B21 0.046
END
```

APPENDIX E

SHAZAM PROGRAM FOR LA/AIDS MODEL 3

```
READ (C:\antonio\ttu\Thesis\DATA\Panel3.TXT) OBS YEAR CT W MM PCT &
PW PM GDP1 GDP2 GDP3 GDP4 GDP5 CL1 CL2 CL3 MFA2 MFA3 /SKIPLINES=4
SAMPLE 1 196

GENR Y=CT*PCT+W*PW+MM*PM

***GENERATING BUDGET SHARES
GENR WCT=CT*PCT/Y
GENR WW=W*PW/Y
GENR WM=MM*PM/Y

***GENERATING LOG PRICES
GENR LNPCT=LOG(PCT)
GENR LNPW=LOG(PW)
GENR LNPM=LOG(PM)

***GENERATING STONE'S APPROXIMATION FOR PRICE INDEX
GENR LNP=(WCT*LNPCT+WW*LNPW+WM*LNPM)
GENR LNY=LOG(Y)
GENR LNYP=LNY-LNP

GENR GDP1LNYP=GDP1*LNYP
GENR GDP2LNYP=GDP2*LNYP
GENR GDP3LNYP=GDP3*LNYP
GENR GDP4LNYP=GDP4*LNYP

***RUNING NL RESTRICTD CORRECTED FOR AUTOCORRELATION
NL 2/NCOEF=31 AUTO PCOV CONV=0.0001 ITER=300 RSTAT PITER=50
EQ WCT=A1+D11*GDP1+D12*GDP2+D13*GDP3+D14*GDP4
&+D15*CL1+D16*CL2 +D17*MFA2+D18*MFA3 &
+G11*LNPCT+G12*LNPM-(G11+G12)*LNPW+B1*LNYP &
+B11*GDP1LNYP+B12*GDP2LNYP+B13*GDP3LNYP+B14*GDP4LNYP
EQ WM=A2+D21*GDP1+D22*GDP2+D23*GDP3+D24*GDP4 &
+D25*CL1+D26*CL2+D27*MFA2+D28*MFA3 &
+G12*LNPCT+G22*LNPM-(G12+G22)*LNPW+B2*LNYP &
+B21*GDP1LNYP+B22*GDP2LNYP+B23*GDP3LNYP+B24*GDP4LNYP

COEF A1 0.083 D11 -0.47 D12 -0.93 D13 -0.24 D14 -0.17 D15 -0.14 D16 -0.15 &
```

D17 -0.06 D18 -0.03 G11 0.25 G12 -0.23 B1 -0.067 B11 0.11 B12 0.28 B13 0.023 &
B14 0.04 A2 0.094 D21 0.36 D22 0.99 D23 -0.17 D24 0.07 D25 0.12 D26 0.16 D27 &
0.048 D28 0.023 G22 -0.23 B2 0.07 B21 -0.08 B22 -0.32 B23 0.12 B24 -0.004
END

APPENDIX F

SHAZAM PROGRAM FOR AIDS MODEL 3

```
READ (C:\antonio\ttu\Thesis\DATA\Panel3.TXT) OBS YEAR CT W MM PCT &
PW PM GDP1 GDP2 GDP3 GDP4 GDP5 CL1 CL2 CL3 MFA2 MFA3/SKIPLINES=4
SAMPLE 1 196

GENR Y=CT*PCT+W*PW+MM*PM

***GENERATING BUDGET SHARES
GENR WCT=CT*PCT/Y
GENR WW=W*PW/Y
GENR WM=MM*PM/Y

***GENERATING LOG PRICES
GENR LNPCT=LOG(PCT)
GENR LNPW=LOG(PW)
GENR LNPM=LOG(PM)

GENR LNY=LOG(Y)

GENR GDP1LNYP=GDP1*LNYP
GENR GDP2LNYP=GDP2*LNYP
GENR GDP3LNYP=GDP3*LNYP
GENR GDP4LNYP=GDP4*LNYP

GENR GDP1LNY=GDP1*LNY
GENR GDP2LNY=GDP2*LNY
GENR GDP3LNY=GDP3*LNY
GENR GDP4LNY=GDP4*LNY

GENR GDP1LNPC=GDP1*LNPCT
GENR GDP2LNPC=GDP2*LNPCT
GENR GDP3LNPC=GDP3*LNPCT
GENR GDP4LNPC=GDP4*LNPCT

GENR CL1LNPCT=CL1*LNPCT
GENR CL2LNPCT=CL2*LNPCT

GENR MFA2LNPC=MFA2*LNPCT
GENR MFA3LNPC=MFA3*LNPCT
```

```
GENR GDP1LNPM=GDP1*LNPM
GENR GDP2LNPM=GDP2*LNPM
GENR GDP3LNPM=GDP3*LNPM
GENR GDP4LNPM=GDP4*LNPM

GENR CL1LNPM=CL1*LNPM
GENR CL2LNPM=CL2*LNPM

GENR MFA2LNPM=MFA2*LNPM
GENR MFA3LNPM=MFA3*LNPM

GENR GDP1LNPW=GDP1*LNPW
GENR GDP2LNPW=GDP2*LNPW
GENR GDP3LNPW=GDP3*LNPW
GENR GDP4LNPW=GDP4*LNPW

GENR CL1LNPW=CL1*LNPW
GENR CL2LNPW=CL2*LNPW

GENR MFA2LNPW=MFA2*LNPW
GENR MFA3LNPW=MFA3*LNPW

GENR LNPCLNPC=LNPCT*LNPCT
GENR LNPCLNPM=LNPCT*LNPM
GENR LNPCLNPW=LNPCT*LNPW
GENR LNPMLNPM=LNPM*LNPM
GENR LNPMLNPW=LNPM*LNPW
GENR LNPWLNPW=LNPW*LNPW

***RUNING NL SYSTEM WITH ALL RESTRICTIONS
NL 2/NCOEF=32 AUTO PCOV CONV=0.0001 ITER=1000 RSTAT PITER=200
EQ WCT=A1+D11*GDP1+D12*GDP2+D13*GDP3+D14*GDP4+D15*CL1 &
+D16*CL2 +D17*MFA2+D18*MFA3 &
+G11*LNPCT+G12*LNPM+(-G11-G12)*LNPW &
+B1*LNY+B11*GDP1LNY+B12*GDP2LNY+B13*GDP3LNY+B14*GDP4LNY &
-(B1+B11*GDP1+B12*GDP2+B13*GDP3+B14*GDP4)*(A0+A1*LNPCT &
+A2*LNPM+(1-A1-A2)*LNPW &
+D11*GDP1LNPC+D12*GDP2LNPC+D13*GDP3LNPC+D14*GDP4LNPC &
+D15*CL1LNPCT+D16*CL2LNPCT+D17*MFA2LNPC+D18*MFA3LNPC &
+D11*GDP1LNPM+D12*GDP2LNPM+D13*GDP3LNPM+D14*GDP4LNPM &
+D15*CL1LNPM +D16*CL2LNPM +D17*MFA2LNPM+D18*MFA3LNPM &
+D11*GDP1LNPW+D12*GDP2LNPW+D13*GDP3LNPW+D14*GDP4LNPW &
+D15*CL1LNPW +D16*CL2LNPW +D17*MFA2LNPW+D18*MFA3LNPW &
```

```
+0.5*G11*LNPCLNPC+G12*LNPCLNPM+(-G11-G12)*LNPCLNPW &
+0.5*G22*LNPMLNPM+(-G12-G22)*LNPMLNPW &
+0.5*(G11+2*G12+G22)*LNPWLNPW)

EQ WM=A2+D21*GDP1+D22*GDP2+D23*GDP3+D24*GDP4+D25*CL1 &
+D26*CL2+D27*MFA2+D28*MFA3 &
+G12*LNPCT+G22*LNPM+(-G12-G22)*LNPW &
+B2*LNY+B21*GDP1LNY+B22*GDP2LNY+B23*GDP3LNY+B24*GDP4LNY &
-(B2+B21*GDP1+B22*GDP2+B23*GDP3+B24*GDP4)*(A0+A1*LNPCT &
+A2*LNPM+(1-A1-A2)*LNPW &
+D21*GDP1LNPC+D22*GDP2LNPC+D23*GDP3LNPC+D24*GDP4LNPC &
+D25*CL1LNPCT+D26*CL2LNPCT+D27*MFA2LNPC+D28*MFA3LNPC &
+D21*GDP1LNPM+D22*GDP2LNPM+D23*GDP3LNPM+D24*GDP4LNPM &
+D25*CL1LNPM +D26*CL2LNPM +D27*MFA2LNPM+D28*MFA3LNPM &
+D21*GDP1LNPW+D22*GDP2LNPW+D23*GDP3LNPW+D25*GDP4LNPW &
+D25*CL1LNPW +D26*CL2LNPW +D27*MFA2LNPW+D28*MFA3LNPW &
+0.5*G11*LNPCLNPC+G12*LNPCLNPM+(-G11-G12)*LNPCLNPW &
+0.5*G22*LNPMLNPM+(-G12-G22)*LNPMLNPW &
+0.5*(G11+2*G12+G22)*LNPWLNPW)

COEF A1 0.33 D11 -0.16545 D12 1 D13 1 D14 1 D15 0.0005 D16 0.038 D17 0.018 &
D18 0.0015 G11 0.24 G12 -0.21 B1 0.045 B11 0.11 B12 1 B13 1 B14 1 A0 0.3 &
A2 0.39 G22 0.026 D21 0.14 D22 1 D23 1 D24 1 D25 0.022 D26 0.086 D27 0.005 &
D28 -0.0058 B2 -0.15 B21 -0.12 B22 1 B23 1 B24 1
END
```

APPENDIX G

SHAZAM PROGRAM FOR LA/AIDS MODEL 4

```
READ (C:\antonio\ttu\Thesis\DATA\Panel4.TXT) OBS YEAR CT W MM PCT PW &
PM DFRANCE DGERMANY DITALY DBELLUX DNETHER DUKING &
DDENMARK DIRELAND DGREECE DSPAIN DPORTUGA DAUSTRIA &
DFINLAND DSWEDEN/SKIPLINES=4
SAMPLE 1 196

GENR Y=CT*PCT+W*PW+MM*PM

***GENERATING BUDGET SHARES
GENR WCT=CT*PCT/Y
GENR WW=W*PW/Y
GENR WM=MM*PM/Y

***GENERATING LOG PRICES
GENR LNPCT=LOG(PCT)
GENR LNPW=LOG(PW)
GENR LNPM=LOG(PM)

***GENERATING STONE'S APPROXIMATION FOR PRICE INDEX
GENR LNP=(WCT*LNPCT+WW*LNPW+WM*LNPM)
GENR LNY=LOG(Y)
GENR LNYP=LNY-LNP

***RUNING NL RESTRICTD CORRECTED FOR AUTOCORRELATION
NL 2/NCOEF=33 AUTO PCOV CONV=0.0001 ITER=300 RSTAT PITER=50 EVAL
EQ WCT=A1+D11*DFRANCE+D12*DGERMANY+D13*DITALY &
+D14*DBELLUX +D15*DNETHER+D16*DUKING+D17*DDENMARK &
+D18*DIRELAND +D19*DGREECE +D110*DSPAIN+D111*DPORTUGA &
+D112*DAUSTRIA+D113*DFINLAND+G11*LNPCT+G12*LNPM &
-(G11+G12)*LNPW+B1*LNYP

EQ WM=A2+D21*DFRANCE+D22*DGERMANY+D23*DITALY &
+D24*DBELLUX+D25*DNETHER+D26*DUKING+D27*DDENMARK &
+D28*DIRELAND+D29*DGREECE +D210*DSPAIN+D211*DPORTUGA &
+D212*DAUSTRIA+D213*DFINLAND+G12*LNPCT+G22*LNPM &
-(G12+G22)*LNPW+B2*LNYP

COEF A1 0.31 D11 -0.055 D12 -0.073 D13 -0.026 D14 -0.018 D15 -0.062 &
```

```
D16 -0.15 D17 0.054 D18 -0.12 D19 0.011 D110 -0.18 D111 0.016 D112 -0.042 &
D113 -0.056 G11 0.19 G12 -0.18 B1  0.047 A2 0.47 D21 0.047 D22 0.0311 &
D23 -0.016 D24 -0.014 D25 0.041 D26 0.13 D27 -0.08 D28 0.04 D29 -0.11 &
D210 0.21 D211 -0.007 D212 -0.0024 D213 0.07 G22 0.23 B2 -0.02
END
```

APPENDIX H

SHAZAM PROGRAM FOR AIDS MODEL 4

```
READ (C:\antonio\ttu\Thesis\DATA\Panel4.TXT) OBS YEAR CT W MM PCT &
PW PM DFRANCE DGERMANY DITALY DBELLUX DNETHER DUKING &
DDENMARK DIRELAND DGREECE DSPAIN DPORTUGA DAUSTRIA &
DFINLAND DSWEDEN/SKIPLINES=4
SAMPLE 1 196

GENR Y=CT*PCT+W*PW+MM*PM

***GENERATING BUDGET SHARES
GENR WCT=CT*PCT/Y
GENR WW=W*PW/Y
GENR WM=MM*PM/Y

***GENERATING LOG PRICES
GENR LNPCT=LOG(PCT)
GENR LNPW=LOG(PW)
GENR LNPM=LOG(PM)

GENR LNY=LOG(Y)

GENR DFRLNPCT=DFRANCE*LNPCT
GENR DGELNPCT=DGERMANY*LNPCT
GENR DITLNPCT=DITALY*LNPCT
GENR DBLLNPCT=DBELLUX*LNPCT
GENR DNELNPCT=DNETHER*LNPCT
GENR DUKLNPCT=DUKING*LNPCT
GENR DDELNPCT=DDENMARK*LNPCT
GENR DIRLNPCT=DIRELAND*LNPCT
GENR DGRLNPCT=DGREECE*LNPCT
GENR DSPLNPCT=DSPAIN*LNPCT
GENR DPOLNPCT=DPORTUGA*LNPCT
GENR DAULNPCT=DAUSTRIA*LNPCT
GENR DFILNPCT=DFINLAND*LNPCT
GENR DSWLNPCT=DSWEDEN*LNPCT

GENR DFRLNPM=DFRANCE*LNPM
GENR DGELNPM=DGERMANY*LNPM
GENR DITLNPM=DITALY*LNPM
```

```
GENR DBLLNPM=DBELLUX*LNPM
GENR DNELNPM=DNETHER*LNPM
GENR DUKLNPM=DUKING*LNPM
GENR DDELNPM=DDENMARK*LNPM
GENR DIRLNPM=DIRELAND*LNPM
GENR DGRLNPM=DGREECE*LNPM
GENR DSPLNPM=DSPAIN*LNPM
GENR DPOLNPM=DPORTUGA*LNPM
GENR DAULNPM=DAUSTRIA*LNPM
GENR DFILNPM=DFINLAND*LNPM
GENR DSWLNPM=DSWEDEN*LNPM

GENR DFRLNPW=DFRANCE*LNPW
GENR DGELNPW=DGERMANY*LNPW
GENR DITLNPW=DITALY*LNPW
GENR DBLLNPW=DBELLUX*LNPW
GENR DNELNPW=DNETHER*LNPW
GENR DUKLNPW=DUKING*LNPW
GENR DDELNPW=DDENMARK*LNPW
GENR DIRLNPW=DIRELAND*LNPW
GENR DGRLNPW=DGREECE*LNPW
GENR DSPLNPW=DSPAIN*LNPW
GENR DPOLNPW=DPORTUGA*LNPW
GENR DAULNPW=DAUSTRIA*LNPW
GENR DFILNPW=DFINLAND*LNPW
GENR DSWLNPW=DSWEDEN*LNPW

GENR LNPCLNPC=LNPCT*LNPCT
GENR LNPCLNPM=LNPCT*LNPM
GENR LNPCLNPW=LNPCT*LNPW
GENR LNPMLNPM=LNPM*LNPM
GENR LNPMLNPW=LNPM*LNPW
GENR LNPWLNPW=LNPW*LNPW

***RUNING NL SYSTEM WITH ALL RESTRICTIONS CORRECTED FOR
***AUTOCORRELATION
NL 2/NCOEF=34 AUTO PCOV CONV=0.0001 ITER=1000 RSTAT PITER=200
EQ WCT=A1+D11*DFRANCE+D12*DGERMANY+D13*DITALY &
+D14*DBELLUX +D15*DNETHER+D16*DUKING+D17*DDENMARK &
+D18*DIRELAND+D19*DGREECE +D110*DSPAIN +D111*DPORTUGA &
+D112*DAUSTRIA+D113*DFINLAND+G11*LNPCT+G12*LNPM &
+(-G11-G12)*LNPW+B1*LNY -B1*(A0+A1*LNPCT+A2*LNPM &
+(1-A1-A2)*LNPW +D11*DFRLNPCT+D12*DGELNPCT+D13*DITLNPCT &
+D14*DBLLNPCT+D15*DNELNPCT+D16*DUKLNPCT+D17*DDELNPCT &
```

```
+D18*DIRLNPCT+D19*DGRLNPCT +D110*DSPLNPCT+D111*DPOLNPCT &
+D112*DAULNPCT+D113*DFILNPCT +D11*DFRLNPM +D12*DGELNPM &
+D13*DITLNPM +D14*DBLLNPM +D15*DNELNPM +D16*DUKLNPM &
+D17*DDELNPM +D18*DIRLNPM +D19*DGRLNPM +D110*DSPLNPM &
+D111*DPOLNPM +D112*DAULNPM +D113*DFILNPM &
+D11*DFRLNPW +D12*DGELNPW +D13*DITLNPW +D14*DBLLNPW &
+D15*DNELNPW +D16*DUKLNPW +D17*DDELNPW +D18*DIRLNPW &
+D19*DGRLNPW +D110*DSPLNPW +D111*DPOLNPW +D112*DAULNPW &
+D113*DFILNPW +0.5*G11*LNPCLNPC+G12*LNPCLNPM &
+(-G11-G12)*LNPCLNPW +0.5*G22*LNPMLNPM+(-G12-G22)*LNPMLNPW &
+0.5*(G11+2*G12+G22)*LNPWLNPW)

EQ WM=A2+D21*DFRANCE+D22*DGERMANY+D23*DITALY &
+D24*DBELLUX+D25*DNETHER+D26*DUKING+D27*DDENMARK &
+D28*DIRELAND+D29*DGREECE +D210*DSPAIN+D211*DPORTUGA &
+D212*DAUSTRIA+D213*DFINLAND+G12*LNPCT+G22*LNPM &
+(-G12-G22)*LNPW+B2*LNY -B2*(A0+A1*LNPCT+A2*LNPM &
+(1-A1-A2)*LNPW +D21*DFRLNPCT+D22*DGELNPCT+D23*DITLNPCT &
+D24*DBLLNPCT +D25*DNELNPCT+D26*DUKLNPCT+D27*DDELNPCT &
+D28*DIRLNPCT +D29*DGRLNPCT +D210*DSPLNPCT+D211*DPOLNPCT &
+D212*DAULNPCT +D213*DFILNPCT +D21*DFRLNPM +D22*DGELNPM &
+D23*DITLNPM +D24*DBLLNPM +D25*DNELNPM +D26*DUKLNPM &
+D27*DDELNPM +D28*DIRLNPM +D29*DGRLNPM +D210*DSPLNPM &
+D211*DPOLNPM +D212*DAULNPM +D213*DFILNPM &
+D21*DFRLNPW +D22*DGELNPW +D23*DITLNPW +D24*DBLLNPW &
+D25*DNELNPW +D26*DUKLNPW +D27*DDELNPW +D28*DIRLNPW &
+D29*DGRLNPW +D210*DSPLNPW +D211*DPOLNPW +D212*DAULNPW &
+D213*DFILNPW +0.5*G11*LNPCLNPC +G12*LNPCLNPM &
+(-G11-G12)*LNPCLNPW +0.5*G22*LNPMLNPM +(-G12-G22)*LNPMLNPW &
+0.5*(G11+2*G12+G22)*LNPWLNPW)

COEF A1 0.31 D11 -0.055 D12 -0.073 D13 -0.026 D14 -0.018 D15 -0.062 D16 -0.15 &
D17 0.054 D18 -0.12 D19 0.011 D110 -0.18 D111 0.016 D112 -0.042 D113 -0.056 &
G11 0.19 G12 -0.18 B1 0.047 A0 0.3 A2 0.47 D21 0.047 D22 0.0311 D23 -0.016 &
D24 -0.014 D25 0.041 D26 0.13 D27 -0.08 D28 0.04 D29 -0.11 D210 0.21 &
D211 -0.007 D212 -0.0024 D213 0.07 G22 0.23 B2 -0.02
END
```

APPENDIX I

SHAZAM PROGRAM FOR LA/AIDS MODEL 5

```
READ (C:\antonio\ttu\Thesis\DATA\Panel5.TXT) OBS YEAR CT W MM PCT &
PW PM DFRANCE DGERMANY DITALY DBELLUX DNETHER DUKING &
DDENMARK DIRELAND DGREECE DSPAIN DPORTUGA DAUSTRIA &
DFINLAND DSWEDEN/SKIPLINES=4
SAMPLE 1 196

GENR Y=CT*PCT+W*PW+MM*PM

***GENERATING BUDGET SHARES
GENR WCT=CT*PCT/Y
GENR WW=W*PW/Y
GENR WM=MM*PM/Y

***GENERATING LOG PRICES
GENR LNPCT=LOG(PCT)
GENR LNPW=LOG(PW)
GENR LNPM=LOG(PM)

***GENERATING STONE'S APPROXIMATION FOR PRICE INDEX
GENR LNP=(WCT*LNPCT+WW*LNPW+WM*LNPM)
GENR LNY=LOG(Y)
GENR LNYP=LNY-LNP

GENR DFRLNYP=DFRANCE*LNYP
GENR DGELNYP=DGERMANY*LNYP
GENR DITLNYP=DITALY*LNYP
GENR DBLLNYP=DBELLUX*LNYP
GENR DNELNYP=DNETHER*LNYP
GENR DUKLNYP=DUKING*LNYP
GENR DDELNYP=DDENMARK*LNYP
GENR DIRLNYP=DIRELAND*LNYP
GENR DGRLNYP=DGREECE*LNYP
GENR DSPLNYP=DSPAIN*LNYP
GENR DPOLNYP=DPORTUGA*LNYP
GENR DAULNYP=DAUSTRIA*LNYP
GENR DFILNYP=DFINLAND*LNYP

***RUNING NL RESTRICTD CORRECTED FOR AUTOCORRELATION
```

```
NL 2/NCOEF=59 AUTO PCOV CONV=0.0001 ITER=300 RSTAT PITER=50 EVAL
EQ WCT=A1+D11*DFRANCE+D12*DGERMANY+D13*DITALY &
+D14*DBELLUX +D15*DNETHER+D16*DUKING+D17*DDENMARK &
+D18*DIRELAND+D19*DGREECE +D110*DSPAIN+D111*DPORTUGA &
+D112*DAUSTRIA+D113*DFINLAND+G11*LNPCT+G12*LNPM &
-(G11+G12)*LNPW+B1*LNYP+B11*DFRLNYP+B12*DGELNYP &
+B13*DITLNYP+B14*DBLLNYP+B15*DNELNYP+B16*DUKLNYP &
+B17*DDELNYP+B18*DIRLNYP+B19*DGRLNYP+B110*DSPLNYP &
+B111*DPOLNYP+B112*DAULNYP +B113*DFILNYP

EQ WM=A2+D21*DFRANCE+D22*DGERMANY+D23*DITALY &
+D24*DBELLUX+D25*DNETHER+D26*DUKING+D27*DDENMARK &
+D28*DIRELAND+D29*DGREECE +D210*DSPAIN+D211*DPORTUGA &
+D212*DAUSTRIA+D213*DFINLAND+G12*LNPCT+G22*LNPM &
-(G12+G22)*LNPW+B2*LNYP+B21*DFRLNYP+B22*DGELNYP &
+B23*DITLNYP+B24*DBLLNYP+B25*DNELNYP+B26*DUKLNYP &
+B27*DDELNYP+B28*DIRLNYP+B29*DGRLNYP+B210*DSPLNYP &
+B211*DPOLNYP+B212*DAULNYP +B213*DFILNYP

COEF A1 -0.77 D11 0.74 D12 0.72 D13 1.43 D14 1.38 D15 1.13 D16 0.60 D17 1.01 &
D18 1.01 D19 1.29 D110 0.66 D111 1.02 D112 1.17 D113 0.61 G11 0.19 G12 -0.18 &
B1 0.43 B11 -0.27 B12 -0.28 B13 -0.52 B14 -0.50 B15 -0.41 B16 -0.26 B17 -0.33 &
B18 -0.39 B19 -0.41 B110 -0.27 B111 -0.35 B112 -0.42 B113 -0.23 A2 1.33 &
D21 -0.54 D22 -0.46 D23 -1.52 D24 -1.04 D25 -0.94 D26 -0.29 D27 -0.68 &
D28 -0.97 D29 -1.18 D210 -0.24 D211 -0.79 D212 -1.10 D213 -0.57 G22 0.23 &
B2 -0.30 B21 0.20 B22 0.18 B23 0.54 B24 0.36 B25 0.34 B26 0.15 B27 0.21 &
B28 0.35 B29 0.38 B210 0.11 B211 0.27 B212 0.38 B213 0.22
END
```

APPENDIX J

SHAZAM PROGRAM FOR AIDS MODEL 5

```
READ (C:\antonio\ttu\Thesis\DATA\Panel5.TXT) OBS YEAR CT W MM PCT &
PW PM DFRANCE DGERMANY DITALY DBELLUX DNETHER DUKING &
DDENMARK DIRELAND DGREECE DSPAIN DPORTUGA DAUSTRIA &
DFINLAND DSWEDEN/SKIPLINES=4
SAMPLE 1 196

GENR Y=CT*PCT+W*PW+MM*PM

***GENERATING BUDGET SHARES
GENR WCT=CT*PCT/Y
GENR WW=W*PW/Y
GENR WM=MM*PM/Y

***GENERATING LOG PRICES
GENR LNPCT=LOG(PCT)
GENR LNPW=LOG(PW)
GENR LNPM=LOG(PM)

GENR LNY=LOG(Y)

GENR DFRLNPCT=DFRANCE*LNPCT
GENR DGELNPCT=DGERMANY*LNPCT
GENR DITLNPCT=DITALY*LNPCT
GENR DBLLNPCT=DBELLUX*LNPCT
GENR DNELNPCT=DNETHER*LNPCT
GENR DUKLNPCT=DUKING*LNPCT
GENR DDELNPCT=DDENMARK*LNPCT
GENR DIRLNPCT=DIRELAND*LNPCT
GENR DGRLNPCT=DGREECE*LNPCT
GENR DSPLNPCT=DSPAIN*LNPCT
GENR DPOLNPCT=DPORTUGA*LNPCT
GENR DAULNPCT=DAUSTRIA*LNPCT
GENR DFILNPCT=DFINLAND*LNPCT
GENR DSWLNPCT=DSWEDEN*LNPCT

GENR DFRLNPM=DFRANCE*LNPM
GENR DGELNPM=DGERMANY*LNPM
GENR DITLNPM=DITALY*LNPM
```

```
GENR DBLLNPM=DBELLUX*LNPM
GENR DNELNPM=DNETHER*LNPM
GENR DUKLNPM=DUKING*LNPM
GENR DDELNPM=DDENMARK*LNPM
GENR DIRLNPM=DIRELAND*LNPM
GENR DGRLNPM=DGREECE*LNPM
GENR DSPLNPM=DSPAIN*LNPM
GENR DPOLNPM=DPORTUGA*LNPM
GENR DAULNPM=DAUSTRIA*LNPM
GENR DFILNPM=DFINLAND*LNPM
GENR DSWLNPM=DSWEDEN*LNPM

GENR DFRLNPW=DFRANCE*LNPW
GENR DGELNPW=DGERMANY*LNPW
GENR DITLNPW=DITALY*LNPW
GENR DBLLNPW=DBELLUX*LNPW
GENR DNELNPW=DNETHER*LNPW
GENR DUKLNPW=DUKING*LNPW
GENR DDELNPW=DDENMARK*LNPW
GENR DIRLNPW=DIRELAND*LNPW
GENR DGRLNPW=DGREECE*LNPW
GENR DSPLNPW=DSPAIN*LNPW
GENR DPOLNPW=DPORTUGA*LNPW
GENR DAULNPW=DAUSTRIA*LNPW
GENR DFILNPW=DFINLAND*LNPW
GENR DSWLNPW=DSWEDEN*LNPW

GENR LNPCLNPC=LNPCT*LNPCT
GENR LNPCLNPM=LNPCT*LNPM
GENR LNPCLNPW=LNPCT*LNPW
GENR LNPMLNPM=LNPM*LNPM
GENR LNPMLNPW=LNPM*LNPW
GENR LNPWLNPW=LNPW*LNPW

***RUNING NL SYSTEM WITH ALL RESTRICTIONS CORRECTED FOR
***AUTOCORRELATION
NL 2/NCOEF=60 AUTO PCOV CONV=0.0001 ITER=1000 RSTAT PITER=200
EQ WCT=A1+D11*DFRANCE+D12*DGERMANY+D13*DITALY &
+D14*DBELLUX +D15*DNETHER+D16*DUKING+D17*DDENMARK &
+D18*DIRELAND+D19*DGREECE +D110*DSPAIN+D111*DPORTUGA &
+D112*DAUSTRIA+D113*DFINLAND+G11*LNPCT+G12*LNPM &
+(-G11-G12)*LNPW +B1*LNY+B11*DFRANCE*LNY+B12*DGERMANY*LNY &
+B13*DITALY*LNY+B14*DBELLUX*LNY+B15*DNETHER*LNY &
+B16*DUKING*LNY+B17*DDENMARK*LNY +B18*DIRELAND*LNY &
```

```
+B19*DGREECE*LNY+B110*DSPAIN*LNY +B111*DPORTUGA*LNY &
+B112*DAUSTRIA*LNY+B113*DFINLAND*LNY -(B1 &
+B11*DFRANCE+B12*DGERMANY+B13*DITALY+B14*DBELLUX &
+B15*DNETHER+B16*DUKING+B17*DDENMARK+B18*DIRELAND &
+B19*DGREECE +B110*DSPAIN+B111*DPORTUGA+B112*DAUSTRIA &
+B113*DFINLAND)*(A0+A1*LNPCT+A2*LNPM+(1-A1-A2)*LNPW &
+D11*DFRLNPCT+D12*DGELNPCT+D13*DITLNPCT+D14*DBLLNPCT &
+D15*DNELNPCT+D16*DUKLNPCT+D17*DDELNPCT+D18*DIRLNPCT &
+D19*DGRLNPCT +D110*DSPLNPCT+D111*DPOLNPCT+D112*DAULNPCT &
+D113*DFILNPCT +D11*DFRLNPM +D12*DGELNPM +D13*DITLNPM &
+D14*DBLLNPM +D15*DNELNPM +D16*DUKLNPM +D17*DDELNPM &
+D18*DIRLNPM +D19*DGRLNPM +D110*DSPLNPM +D111*DPOLNPM &
+D112*DAULNPM +D113*DFILNPM +D11*DFRLNPW +D12*DGELNPW &
+D13*DITLNPW +D14*DBLLNPW +D15*DNELNPW +D16*DUKLNPW &
+D17*DDELNPW +D18*DIRLNPW +D19*DGRLNPW +D110*DSPLNPW &
+D111*DPOLNPW +D112*DAULNPW +D113*DFILNPW &
+0.5*G11*LNPCLNPC +G12*LNPCLNPM+(-G11-G12)*LNPCLNPW &
+0.5*G22*LNPMLNPM +(-G12-G22)*LNPMLNPW &
+0.5*(G11+2*G12+G22)*LNPWLNPW)

EQ WM=A2+D21*DFRANCE+D22*DGERMANY+D23*DITALY &
+D24*DBELLUX+D25*DNETHER+D26*DUKING+D27*DDENMARK &
+D28*DIRELAND+D29*DGREECE +D210*DSPAIN+D211*DPORTUGA &
+D212*DAUSTRIA+D213*DFINLAND+G12*LNPCT+G22*LNPM &
+(-G12-G22)*LNPW +B2*LNY+B21*DFRANCE*LNY+B22*DGERMANY*LNY &
+B23*DITALY*LNY+B24*DBELLUX*LNY+B25*DNETHER*LNY &
+B26*DUKING*LNY+B27*DDENMARK*LNY +B28*DIRELAND*LNY &
+B29*DGREECE*LNY+B210*DSPAIN*LNY+B211*DPORTUGA*LNY &
+B212*DAUSTRIA*LNY+B213*DFINLAND*LNY -(B2 &
+B21*DFRANCE+B22*DGERMANY+B23*DITALY+B24*DBELLUX &
+B25*DNETHER+B26*DUKING+B27*DDENMARK+B28*DIRELAND &
+B29*DGREECE +B210*DSPAIN+B211*DPORTUGA+B212*DAUSTRIA &
+B213*DFINLAND)*(A0+A1*LNPCT+A2*LNPM+(1-A1-A2)*LNPW &
+D21*DFRLNPCT+D22*DGELNPCT+D23*DITLNPCT+D24*DBLLNPCT &
+D25*DNELNPCT+D26*DUKLNPCT+D27*DDELNPCT+D28*DIRLNPCT &
+D29*DGRLNPCT +D210*DSPLNPCT+D211*DPOLNPCT+D212*DAULNPCT &
+D213*DFILNPCT +D21*DFRLNPM +D22*DGELNPM +D23*DITLNPM &
+D24*DBLLNPM +D25*DNELNPM +D26*DUKLNPM +D27*DDELNPM &
+D28*DIRLNPM +D29*DGRLNPM +D210*DSPLNPM +D211*DPOLNPM &
+D212*DAULNPM +D213*DFILNPM +D21*DFRLNPW +D22*DGELNPW &
+D23*DITLNPW +D24*DBLLNPW +D25*DNELNPW +D26*DUKLNPW &
+D27*DDELNPW +D28*DIRLNPW +D29*DGRLNPW +D210*DSPLNPW &
+D211*DPOLNPW +D212*DAULNPW +D213*DFILNPW &
+0.5*G11*LNPCLNPC+G12*LNPCLNPM+(-G11-G12)*LNPCLNPW &
```

```
+0.5*G22*LNPMLNPM+(-G12-G22)*LNPMLNPW &
+0.5*(G11+2*G12+G22)*LNPWLNPW)

COEF A1 0.38 D11 -0.56 D12 -2.42 D13 0.061 D14 0.37 D15 -0.44 D16 -0.50 &
D17 -0.52 D18 0.64 D19 0.51 D110 -0.46 D111 0.46 D112 -0.30 D113 0.23 &
G11 0.15 G12 -0.14 B1 -0.16 B11 0.37 B12 1.05 B13 0.11 B14 -0.024 B15 0.28 &
B16 0.26 B17 0.31 B18 -0.06 B19 0.12 B110 0.31 B111 0.09 B112 0.23 B113 0.0055 &
A0 0.3 A2 0.64 D21 0.34 D22 2.04 D23 -0.71 D24 0.053 D25 0.28 D26 0.20 D27 0.15 &
D28 -0.83 D29 -0.83 D210 0.56 D211 -0.56 D212 0.29 D213 -0.34 G22 -0.18 B2 0.12 &
B21 -0.32 B22 -0.90 B23 0.11 B24 -0.12 B25 -0.20 B26 -0.17 B27 -0.14 B28 0.12 &
B29 0.0007 B210 -0.35 B211 -0.045 B212 -0.21 B213 0.065
END
```

APPENDIX K

SHAZAM PROGRAM FOR ROTTERDAM MODEL

```
READ (C:\antonio\ttu\Thesis\DATA\EU15.TXT) YEAR QCT QW QM PCT PW &
PM/SKIPLINES=5
SAMPLE 1 31

GENR Y=QCT*PCT+QW*PW+QM*PM

GENR WCT=QCT*PCT/Y
GENR WW=QW*PW/Y
GENR WM=QM*PM/Y

GENR LWCT=LAG(WCT)
GENR LWW=LAG(WW)
GENR LWM=LAG(WM)

GENR LAGQCT=LAG(QCT)
GENR LAGQW=LAG(QW)
GENR LAGQM=LAG(QM)

***********************GENERATING LAG PRICES***********************
GENR LAGPCT=LAG(PCT)
GENR LAGPW=LAG(PW)
GENR LAGPM=LAG(PM)

SAMPLE 2 31
GENR DQCT=LOG(QCT/LAGQCT)
GENR DQW=LOG(QW/LAGQW)
GENR DQM=LOG(QM/LAGQM)

SAMPLE 2 31
GENR DPCT=LOG(PCT/LAGPCT)
GENR DPW=LOG(PW/LAGPW)
GENR DPM=LOG(PM/LAGPM)

SAMPLE 1 31
GENR LAGY=LAG(Y)

SAMPLE 2 31
GENR DY=LOG(Y/LAGY)
```

```
GENR AWCT= 0.5*(WCT+LWCT)
GENR AWW= 0.5*(WW+LWW)
GENR AWM= 0.5*(WM+LWM)

**********************GENERATING DEPENDENT VARIABLE**************
GENR WDCT=AWCT*DQCT
GENR WDW=AWW*DQW
GENR WDM=AWM*DQM

**************************GENERATING AY*****************************
GENR AY=DY-((AWCT*DPCT)+(AWW*DPW)+(AWM*DPM))

**************************RUNING SYSTEM*****************************
SYSTEM 2 /RESTRICT RSTAT NOCONSTAT

OLS WDCT AY DPCT DPM DPW
OLS WDM AY DPCT DPM DPW

RESTRICT DPM:1-DPCT:2=0

RESTRICT DPCT:1+DPW:1+DPM:1=0
RESTRICT DPCT:2+DPW:2+DPM:2=0

END

***********************NONLINEAR AUTO CORRECTION******************
SAMPLE 2 31

NL 2/NCOEF=5 AUTO PCOV CONV=0.0001 ITER=300 RSTAT PITER=50

EQ WDCT=C11*DPCT + C12*DPM - (C11+C12)*DPW + B1*AY
EQ WDM=C12*DPCT + C22*DPM - (C12+C22)*DPW + B2*AY

COEF B1 0.16 B2 0.77 C11 0.019 C12 -0.027 C22 0.012
END
```