ECONOMETRIC ESTIMATION OF ARMINGTON ELASTICITIES FOR SELECTED AGRICULTURAL PRODUCTS IN SOUTH AFRICA

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ABSTRACT

The economic evaluation of, for example, trade liberalisation requires complex models that can take different forms and which are based on economic theory. Of particular importance in partial and general equilibrium models is the behavioural function that governs the interactions between different variables. For example, in these models changes in trade regimes and tariffs alter the domestic price of imported goods relative to that of domestically produced goods, and such changes in relative prices affect the fraction of the demand supplied by imports. If such behaviour is not modelled correctly, trade impacts can be either under- or overestimated. Estimates of the elasticity of substitution between goods differentiated by their place of origin are therefore required.

A review of the literature revealed that estimates of Armington elasticities are not available for agricultural products in the majority of countries, including South Africa, in spite of the importance of including Armington elasticities when evaluating the impact of trade policies. The focus of this study was on the estimation of Armington elasticities for selected agricultural products in South Africa.

In this study, non-nested CES Armington elasticities were estimated using the econometric approach for the following agricultural products: Meat of bovine animals (fresh or chilled); meat of bovine animals (frozen); meat of swine (fresh, chilled or frozen); maize or corn; wheat and meslin; soybeans (broken or not broken); and sunflower seeds (broken or not broken). Three econometric models, namely geometric lag, single-equation error correction, and ordinary least square, were estimated based on the time series properties of the data.

All the products considered in this study have significant Armington elasticities at 10 percent level of significance. All the products except soybeans have short and long-run elasticities. The estimates of Armington elasticities range between 0.60 and 3.31 for the short-run elasticities, and between 0.73 and 3.21 for the long-run elasticities. These values suggest that imported and domestic agricultural products are not perfect substitutes. The long-run elasticity estimates show that meat of bovine animals (frozen) is the most import sensitive product followed by maize, meat of bovine animals (fresh or chilled) and sunflower seeds, while wheat and meat of swine (fresh, chilled or frozen) are the least import-sensitive products. The short-run elasticities show that soybeans is the most import-sensitive product followed by meat of bovine animals (fresh or chilled), while meat of swine (fresh, chilled or frozen) is the least import-sensitive product. The dummy variables representing seasonality were found to be statistically not significant for livestock products, with the exception of the fourth quarter for meat of swine (fresh, chilled or frozen). However, dummy variables for the grain products were statistically significant. The results show that seasonality is an important factor in determining import demand for grain products. Dummy variables included to control for outliers were not significant, nor was the dummy variable included for trade liberalisation.

The value of this study is that the estimated Armington elasticities will allow researchers to evaluate more precisely the economic impacts of trade liberalisation and changes in tariffs, as well as other trade policies, in partial and general equilibrium models that include South African agriculture.

Keywords: Armington elasticity, Import substitution, Trade liberalisation, Trade policy models, Behavioural parameters.

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UITTREKSEL

Die ekonomiese evaluering van byvoorbeeld, handelsliberalisering, vereis komplekse modelle, gegrond op ekonomiese teorie, wat verskillende vorms kan aanneem. Wat veral belangrik is in gedeeltelike, sowel as algemene ewewigsmodelle, is die parameters wat die interaksie tussen verskillende veranderlikes beheer. In hierdie modelle byvoorbeeld, het veranderings in handelstelsels en –tariewe ‘n impak op die binnelandse prys van ingevoerde goedere relatief tot die pryse van goedere wat plaaslik geproduseer is. Sodanige veranderings in relatiewe pryse beïnvloed daardié gedeelte van die plaaslike vraag wat ingevoer word. Indien sodanige gedrag nie korrek gemodelleer word nie, kan handelsimpakte oor- of onderskat word. Die elastisiteit van substitusie tussen goedere wat volgens hulle oorsprong bepaal word, moet dus beraam word.

Ten spyte daarvan dat dit uiters belangrik is om die Armington elastisiteit in berekening te bring wanneer die impak van handelsbeleid geëvalueer word, het ‘n oorsig van die literatuur aan die lig gebring dat beramings van die Armington elastisiteit in die meeste lande, insluitend Suid-Afrika, nie geredelik ten opsigte van landbouprodukte beskikbaar is nie. In hierdie studie is daar gefokus op die beraming van die Armington se elastisiteit vir geselekteerde landbouprodukte in Suid-Afrika.

In die studie is daar ‘n beraming gedoen van die “non-nested CES” Armington elastisiteit deur gebruik te maak van die ekonometriese berekenings ten opsigte van die volgende landbouprodukte: beesvleis (vars of verkoel), beesvleis (gevries), varkvleis (vars, verkoel of gevries), mielies of graan, koring en meslin, sojabone (gebreek of ongebreek) en sonneblomsaad (gebreek of ongebreek). Drie ekonometriese modelle, naamlik “geometric lag”, “single-equation error correction”, en die “ordinary least square”, is beraam op grond van die tydreekseienskappe van die data.

Al die produkte wat in hierdie studie oorweeg is, beskik oor betekenisvolle Armington elastisiteite op ‘n 10 persent vlak van betekenisvolheid. Behalwe vir sojabone, beskik al die produkte oor kort- en langtermyn elastisiteite. Die beraming van die Armington elastisiteite wissel tussen 0.60 en 3.31 vir die korttermyn elastisiteite en tussen 0.73 en 3.21 vir die langtermyn elastisiteite. Sodanige waardes dui daarop dat ingevoerde en plaaslike landbouprodukte nie perfekte plaasvervangers is nie. Die langtermyn elastisiteit-beramings toon dat beesvleis (gevries) baie invoer-sensitief is, gevolg deur mielies, beesvleis (vars of verkoel) en sonneblomsaad, terwyl koring en varkvleis (vars, verkoel of gevries) die minste sensitiwiteit vir invoere toon. Die korttermyn elastisiteite dui daarop dat sojabone die meeste sensitiwiteit teenoor invoere toon, gevolg deur beesvleis (vars of verkoel), terwyl varkvleis (vars, verkoel of gevries) die minste invoer-sensitief is. Daar is bevind dat, met die uitsondering van die vierde kwartaal vir varkvleis (vars, verkoel of gevries), die veranderlikes wat seisoensgebondenheid verteenwoordig, geen statistiese betekenis inhou vir lewendehawe produkte nie. Seisoensgebondenheid veranderlikes vir graanprodukte was egter statisties betekenisvol. Die resultate toon dat seisoensgebondenheid ’n belangrike faktor is in die bepaling van invoer-aanvraag vir graanprodukte. Veranderlikes wat ingesluit is om uitskieters in die data te verteenwoordig was nie betekenisvol nie en ook nie veranderlikes vir handelsliberalisering nie.

Die waarde van hierdie studie lê daarin dat die geraamde Armington elastisiteite navorsers in staat sal stel om meer akkuraat te bepaal wat die ekonomiese impak sal wees van handelsliberalisering en veranderings in tariewe, sowel as ander handelsbeleidsrigtings in gedeeltelike en algemene ewewigsmodelle wat landbou in Suid-Afrika insluit.

Sleutelwoorde: Armington elastisiteit, invoersubstitusie, handelsliberalisering, handelsbeleidmodelle, gedragsparameters.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
AIDS	Almost Ideal Demand System
AoA	Agreement on Agriculture
CDE	Constant Difference of Elasticity
CES	Constant Elasticity of Substitution
CGE	Computable General Equilibrium
DF	Dickey-Fuller
DTI	Department of Trade and Industry
ECM	Error Correction Model
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GLS	Generalised Least Square
H-O	Heckscher-Ohlin
HS	Harmonised System
IDC	Industrial Development Corporation
IDCGEM	Industrial Development Corporation General Equilibrium Model
IIT	Intra-Industrial Trade
MA	Moving Average
mm	Millimetres
NAFTA	North American Free Trade Agreement
DOA	National Department of Agriculture
NTB	Non-Tariff Barrier
OLS	Ordinary Least Square
PAM	Partial Adjustment Model
SA	South Africa
SADC	Southern African Development Community
SAGIS	South African Grain Information Service
SAPPO	South African Pork Producers' Organisation
SIC	Standardised Industrial Classification
SLS	Stage Least Square
TIPS	Trade and Industrial Policy Strategies

USA	United States of America
VECM	Vector Error Correction Model
WTO	World Trade Organisation

CHAPTER 1

INTRODUCTION

1.1 Background

Trade policies form the main economic "buffer" between one national economy and another, i.e. the general and specific elements of each nation's trade policy interact directly or indirectly with those of other nations in all economic transactions across international borders. A nation's trade policy involves specific actions to encourage and promote or discourage foreign trade through the legal, financial and institutional environment within which foreign transactions occur. Moreover, the trade policy of a nation reflects its overall attitude towards the importance and value of foreign trade within a complex environment where there are distinct differences in consumption and production patterns, culture and tradition, as well as local socio-economic conditions (Bahta, 2004).

Trade plays a major role in the South Africa agricultural economy, as well as in the Southern African Customs Union (SACU) and the Southern African Development Community (SADC)[1]. Agriculture in South Africa is a net earner of foreign exchange. The value of agricultural exports as a percentage of the total exports has remained fairly constant at approximately 7 to 9 percent (DOA, 2007a). The total value of agricultural exports increased from R22 656 million in 2004 to R26 141 million in 2005 while that of imports increased from R16 415 in 2004 to R16 286 in 2005 (DOA, 2007a). South Africa contributes 67 percent of the GDP and 62 percent of the total value of SADC countries' external trade (Vink *et al.,* 2006). South Africa agriculture generates 24 percent of the contribution of agriculture to GDP in the SADC region, while it provides half of the agricultural exports originating from SADC countries (Vink *et al*., 2006).

[1] Note that trade data referred to in this study is mainly for SACU, but that South Africa contributes to the majority of trade between SACU and the rest of the world.

At a sub-sector level the livestock industry, with products like beef, mutton and pork remains a major contributor to gross farm income. In 2006 livestock products accounted for about 40 – 42% of the gross farming income, which was 9.5 percent higher than the previous year (DOA, 2006a). The grain industry is one of the largest of South Africa's agriculture industries, producing between 25 percent and 33 percent of the value of agricultural production, with a gross value of about R12 billon per annum (GSA, 2005).

The South Africa economy underwent a gradual process of trade reform in the 1990s. On the multilateral front, the country embarked on a programme of comprehensive trade policy reform that was rooted in its World Trade Organization (WTO) obligations agreed to during the Uruguay Round of the General Agreement on Tariffs and Trade (GATT). The endorsement by the South Africa government of the Uruguay Round of the GATT in 1994 has manifested itself in, amongst others, the phasing out of subsidies and replacement of qualitative barriers with tariffs and reduced tariffs (Swanepoel *et al.*, 1997). South Africa also unilaterally reduced tariffs to well below the Agreement on Agriculture (AoA) bound tariffs. At the bilateral level, the country has since established free trade agreements (FTAs) with the European Union and SADC. It has also maintained bilateral trade agreements with, among others, Zimbabwe and Malawi and benefits from the United States of America's African Growth and Opportunity Act (AGOA) initiative (Mabugu, 2005). Trade as a share of output has risen, with both imports and exports contributing to this increase (Mabugu, 2005).

Trade reform, along with other incentives, critically influences the way in which resources are reallocated from one sector of the economy to another (Cassim, 2003). The decision to further liberalise trade and reduce tariffs will be very important for both policymakers and interest groups that have an interest in agriculture.

The potential impact of trade reforms globally and in South Africa has been investigated by many researchers using a variety of different trade models. Central to the question on how trade reforms will impact on a particular country's economy is the extent to which the domestic economy will substitute local goods and services for foreign goods and services. In this regard the so–called Armington elasticity is of vital importance in the models being used to model trade. Moreover, the absence of or incorrect Armington elasticities can result in either underestimation or over-estimation of the effect of trade liberalization. The focus of this study is on the estimation of Armington elasticities for selected agricultural products in South Africa.

1.2 Motivation and problem statement

The Armington assumption that home and foreign products are different is very important in trade modelling. It has routinely been used in both econometric and simulation models to model import demand and to assess the effects of various trade policy options like liberalisation and tariff reduction (Blonigen & Wilson, 1999).

Theoretically, it may seem that agricultural products are homogeneous, but in practice differences in production practices, country of origin, sanitary and phyto-sanitary measures and other food safety regulations make their attributes, as perceived by the consumers, different. These differences and other aspects of heterogeneity make agricultural products differentiated and substitutable. The degree of substitution lies in the potential of a country to exchange one good for another. From the given background, for example livestock products and grain products produced in South Africa and the rest of the world may fall within the same product category, but they are not necessarily perfectly substitutable for each other. It is therefore important to subject this to an empirical analysis to ascertain the degree of substitutability between foreign and domestically produced products.

Trade liberalisation reduces the relative price of imported to domestic goods. When modelling such trade policy changes it may lead to substitution in favour of imported products, the extent of which is dependent on the estimated elasticity. The level of robustness in analysing the magnitude of policy changes on a country's trade balance, level of income and employment, depends to a large degree on the estimated elasticities of substitution (McDaniel & Balistreri, 2001).

The economic evaluation of, for example, trade liberalisation requires complex models that can take different forms and are based on economic theory. Of particular importance in computable partial and general equilibrium models are the behavioural functions that govern the interactions between different variables. For example, in these models changes in trade regimes and tariffs alter the domestic price of imported goods relative to that of domestically produced goods, and such changes in relative price affects the fraction of the demand supplied by imports (Tourinho *et al.*, 2003). If such behaviour is not modelled correctly, trade impacts can be either under- or overestimated. One therefore needs estimates of the elasticity of substitution between goods differentiated by their place of origin. This elasticity is formally known as the Armington elasticity.

Moreover, according to Gallaway *et al* (2003), when economic models are used to evaluate changes in trade policy, conversion of policy changes to price effects is very important. Trade policy models use these price shifts to determine how the policy under review will affect output, employment, trade flows, economic welfare and other variables of interest. Trade model parameters are commonly expressed in the form of elasticities, which represent the percentage change of one variable in response to a one percent change in another variable, all other things being equal. Elasticities are rooted in micro-economic theory and reflect the sensitivity of consumers and firms to changes in relative prices and income (Hertel, 1997).

Estimates of Armington elasticities are not available for agricultural products in the majority of countries, South Africa included, in spite of the importance of including Armington elasticities when evaluating the impact of trade policies. One frequently encounters studies in this area where researchers use Armington elasticity estimates for other countries as proxies to substitute for the required Armington elasticities of their own country, in many cases completely disregarding the important differences that may exist in the structure of production and consumption between foreign countries and their home country.

A review of the literature revealed that Armington elasticities are non-existent for the major agricultural products in South Africa. Therefore, to properly understand import substitution relationships, it is necessary to estimate Armington elasticities for these products. The estimated Armington elasticities can then be used in future trade-related research focussing on South Africa that makes use of partial or general equilibrium models to better represent the substitution effects (imports vs. domestic production) of the selected products.

1.3 Objective of the study

The primary objective of this study is to estimate short-run and long-run Armington elasticities for selected agricultural products (see section 1.4) as specified under the Harmonised System. The secondary objectives are:

- To provide an overview of the livestock and grain sector with specific emphasis on trade.
- To conduct a proper literature review on how the Armington elasticity is estimated and interpreted.
- To develop econometric models to estimate Armington elasticities for the selected products.

1.4 Data and methodology

Using time series quarterly data from 1995 to 2006, this study analyses short-run and long-run Armington elasticities for selected products in the livestock and grain sectors in South Africa. The series required are: real imports, domestic sales of domestically produced goods, and the prices of these two groups of goods. The agricultural products included in this study are: meat of bovine animals (fresh or chilled), meat of bovine animals (frozen); meat of swine (fresh, chilled or frozen); maize or corn; wheat and meslin; soybeans (broken or not broken); and sunflower seeds (broken or not broken). These products were selected based on their sensitivity, relative importance in terms of their contributions to the gross value of agricultural production, their tradability and their use of natural resources. In addition, recent trade policy questions e.g tariffs policy, centres around these products. Data was not available separately for white and yellow maize, therefore maize (corn) was used. Three econometric models, namely ordinary least square, single equation error correction model and geometric lag models are used in the study. This methodology can be used to calculate Armington elasticities for other agricultural products that are not included in this study.

1.5 Outline of the study

Chapter 2 is the literature review that provides a general overview of different trade theories and the modern perception of trade. Selected studies relevant to the methodology involved in estimating the Armington elasticity are also discussed. Chapter 3 provides an industry overview as well as information on trade trends in the South Africa livestock and grain sectors. In chapter 4 the empirical method used in this study is discussed, while chapter 5 presents the results of the study. Chapter 6 provides a summary, conclusions and recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Nations trade for many reasons, and many economic theorists have attempted to isolate those factors that matter most in determining the direction and magnitude of trade. Consumers around the world benefit from trade, and it also brings about specialisation and improves welfare. Trade between countries becomes possible whenever price differences between countries is bigger than the transaction cost (Carbaugh, 2006). Moreover, prices are determined by supply and demand factors, which explain why trade must of necessity entail an investigation of supply and demand functions (Sodersten & Reed, 1994).

Older theories traced the emergence of trade between countries to differences in relative costs of production (Du Plessis *et al.*, 1998). This difference in cost may be the result of a country having an abundance of factors of production relative to its trading partner or the fact that the quality of one of its factors is higher. According to Gandolfo (1998), recent theories gave priority to production technologies and consumer preferences, arguing that differences in cost of production may be a sufficient reason for trade. The principle of returns to scale was used to support this argument. If consumers prefer a variety of products and the firms have increasing returns to scale technologies, then trade between two countries that have identical costs can still occur and be beneficial as long as they produce differentiated products.

This chapter provides a review of the theoretical literature on trade theories and how they are related to the Armington model. In addition, selected studies relevant to the methodology involved in estimating the Armington elasticity are reviewed.

2.2 Trade theories

2.2.1 Classical trade theory

Classical economists played an important role, within the context of the evolution of thought on economic theories, in explaining the importance of two-way trade (both export and import) in the creation of wealth. Notable classical economists are Adam Smith (1723-1790), David Ricardo (1772-1823), Robert Torrens (1780-1864) and John Stuart Mill (1806-1873).

In their writings on the subject of international trade, the main concern of the classical economists was to shed light on popular misconceptions about trade that had arisen, largely due to the writings of a group of scholars known as the Mercantilists. Mercantilism was premised on the erroneous notions that exports are *per se* “good” because they earn a country gold, while imports are *per se* “bad” because they result in an outflow of gold (Grimwade, 2000). The theory was that a country should strive to reduce its dependence on imports by producing as much as it can itself. Such a policy is often referred to as one of autarky or self-sufficiency.

In practical terms, it suggests that government policy should seek to reduce imports by imposing duties and restricting the amount of foreign goods that are allowed into the country. At the same time, every effort should be made to boost exports by whatever means. An obvious objection to such a policy is that it can only work for one country at a time, because one country’s export surplus is another country’s import deficit (Grimwade, 2000).

However, this type of view can be questioned, because the accumulation of a large hoarding of gold by running an export surplus does not make a country materially better off, although it may impart a feeling of economic strength. A country may be able to ensure a large export surplus by denying its citizens goods that could satisfy their wants, i.e. by deliberately under-consuming (Grimwade, 2000). Thus, trade is not a “zero-sum game” in which one country’s gain is another country’s loss, as was implied by the Mercantilists. Trade is able to benefit all countries by enabling them to enjoy more goods at a lower cost than could be secured in the absence of trade.

Adam Smith (1776), argued that trade is beneficial because of differences between countries in the costs of producing different goods. He used the labour theory of value to explain his view. He argued that the cost of producing specific goods was determined by the labour time required to produce the goods in question. Therefore, differences in the cost of producing certain goods in different countries reflected differences in labour efficiencies in each country. Smith argued that rather than each country striving to produce all the products they could, each should concentrate on those products in which they enjoy a cost advantage over other countries.

According to Adam Smith (1776), for two nations to trade with each other voluntarily, both nations must gain. If one nation gains nothing or suffers a loss, it would simply refuse to trade. Therefore, according to the theory, *when one nation is more efficient than (or has an absolute advantage) over another in the production of one commodity but is less efficient than (or has an absolute disadvantage with respect to) the other nation in producing a second commodity, then both nations can gain by each specializing in the production of the commodity of its absolute advantage and exchanging part of its output with the other nation for the commodity of its absolute disadvantage* (Sodersten & Reed, 1994).

By this process, resources are utilised in the most efficient way possible and the output of both commodities will rise. This increase in the output of both commodities measures the gains from specialisation in the production available to be divided between the two nations through trade. It should be borne in mind that how much each country consumes and produces of each of the two goods after trade will depend on the preference of each country's consumers for the two goods (Winters, 1985).

In 1817 David Ricardo published a book, *Principles of Political and Economy and Taxation*, in which he presented the law of comparative advantage. This is one of the famous trade theories and it has been widely used to analyse trade patterns. The concept of comparative advantage extends Adam Smith's concept of absolute advantage in that it states that, *even if a country has an absolute disadvantage relative to a potential trading partner country in the production of two commodities, there is still a basis for mutually beneficial trade* (Sodersten & Reed, 1994). The premise for exchange in such a situation is the difference in "comparative cost of production" (Gandolfo, 1998), which results from technological differences.

Ricardo (1817) assumed in his theoretical proof of gains from trade that labour and capital did not flow between countries. He implicitly assumed that cost remained constant as output increases, otherwise specialisation would not be carried to its fullest extent. Labour hours were used to measure costs – an approach consistent with the labour theory of value. While the theory of comparative advantage is straightforward in a world of two commodities and two countries, indeterminate results arise when more commodities are added or when the number of trading partners increases (Du Plessis *et al*., 1998).

The major contribution of this theory is to introduce analytical methods into trade theory and not to endure as a generalisation for explaining trade (Bhagwati, 1964; Chipman, 1965). It also provides a useful tool for explaining the reasons why trade takes place and how trade enhances the welfare of the trading partners.

Ricardo's trade theory was, however, criticised due to its inability to consider demand conditions. The supply-oriented analysis led to classical economists identifying pre-trade price ratios as the basis for trade. In addition, classical economists failed to explain the reason for the differences in price ratios. Cho and Moon (2002) also stated that the Ricardian model predicts an extreme degree of specialisation, but in practice countries produce not only one but many products, including import-competing products.

Brue (2000) mentioned that Ricardo made several lasting contributions to economic analysis, including the use of abstract reasoning, his theory of comparative advantage, the employment of marginal analysis, and his presentation of the law of diminishing returns in agriculture, as well as a widening of the scope of economic analysis to incorporate the distribution of income.

John Stuart Mill (1806-1873) shared the same view as Ricardo with his law of comparative costs. Mill made his own contribution to the law by adding to it the law of reciprocal demand while trying to answer the question; what determines the terms of trade? Reciprocal demand refers to a country's demand for a product with which another enjoys a comparative advantage in exchange for the product with which the former enjoys a comparative advantage. The law states that *the terms of trade will depend on the relative strength of each country's reciprocal demand for the product which the other country supplies* (Mill, 1848).

Mill (1848) showed that the actual barter terms of trade depend on the pattern of demand in addition to the domestic costs. Terms of trade depend on the strength and elasticity of demand for each product in the foreign country. The products that a nation has available to sell abroad constitute the means of purchasing goods from other nations.

The classical school made a useful contribution to the understanding of how production and trade operate in the world economy. Some of its critics have already been identified, but the school made it clear that a nation can achieve consumption levels beyond what it could produce by itself. It proposes one of the fundamental principles underlying the argument for all countries to strive to expand and "free" world trade.

2.2.2 Neoclassical trade theory

According to the neoclassical theory, commodity trade can substitute for lack of trade in factors of production (Winters, 1985). Efficiency in trade describes a situation where the commodities that are traded are those that are produced at the lowest cost by each country. One of the greatest contributions of the neoclassical model is the identification of the sources of comparative advantage and specialisation (Winters, 1985). The model also provides reasons why one industry can profitably expand while others cannot and also provides additional explanations of why opportunity costs differ. Notable neoclassical economists are Eli Heckscher (1879-1952), Bertil Ohlin (1899-1952), Paul Samuelson, Wolfgang Stolper, and T.N. Rybczynski.

Eli Heckscher (1879-1952) and Bertil Ohlin (1899-1952) developed the Heckscher-Ohlin (H-O) theory, which provided answers to questions not addressed by Smith, Ricardo and Mill. The H-O theory extends the trade theory by explaining the basis for comparative advantage and the effect of trade on factor earnings. The foundation of this theory is that countries are differently endowed with productive resources, and different goods use different combinations of resources in production. The H-O theory states that the assumption of relative factor immobility must be relaxed due to the fact that international exchange has an influence on the prices of factors of production, which in turn affects factor mobility. Heckscher and Ohlin showed that relative factor abundance is the basis for international exchange and that factor price convergence could result from trade among trading partners (Carbaugh, 2006).

Heckscher and Ohlin also postulated that the free mobility of factors of production can be partially substituted by the free mobility of commodities under the condition of international exchange. They argued that this situation would lead to partial equalisation of relative and absolute factor prices. The H-O model defines comparative advantage in terms of intensive use of the abundant factor, whilst trade raises the price of the good that uses the abundant factor, thereby raising the price of the abundant factor. It further explains that opening up trade leads to output price changes that alter real factor rewards, thus creating incentives for owners of the abundant factors to support unrestricted trade and for owners of the scarce factor to resist moves towards unrestricted trade.

If one assumes perfect mobility of factors of production among countries, then factor prices would be the same in all countries. However, even in a world where factors of production cannot move between countries, if goods can move freely, trade in goods can be viewed as a substitution for factor mobility. In the absence of any trade barriers, commodity prices will be the same in every country after opening up to trade. This model was further explained by the Stolper-Samuelson theorem, the factor price equalisation theorem, and the Rybczynski theorem (Sodersten & Reed, 1994).

The Stolper-Samuelson theorem is another basic theorem in trade theory. It describes a relationship between the relative prices of output goods and relative factor rewards, specifically real wages and real returns to capital. The theorem states that: under some economic assumptions (constant returns, perfect competition) — *a rise in the relative price of a good will lead to a rise in the return to that factor which is used most intensively in the production of the good, and conversely, to a fall in the return to the other factor* (Sodersten & Reed, 1994). It was derived in 1941 from within the framework of the Hecksher-Ohlin model by Paul Samuelson and Wolfgang Stolper.

The Stolper-Samuelson theorem is closely linked to the factor price equalisation theorem. Simply stated, when the prices of the output goods are equalised between countries as they move to free trade, then the prices of the factors (capital and labour) will also be equalised between countries. The factor price equalisation theorem proves that free trade leads to a complete equalisation of factor rewards or to a partial equalisation combined with complete specialisation of production in at least one country (Samuelson, 1948).

A number of conditions have to be satisfied for factor price equalisation to take place. Amongst which are zero transportation cost, no trade barriers, and identical technology (Samuelson, 1948). One interesting implication of factor price equalisation is that foreign investment may not be necessary if there is free trade. This can be understood as an international transfer of production factors such as technology, capital and labour (Cho & Moon, 2002). This is an important strategy when prices of these factors are not equal between countries.

One of the important aspects of the theorem is its explanation of the manner in which trade liberalisation affects the income gap between countries (Esterhuizen, 2006). Furthermore, the theorem predicts that income gaps will be reduced by lowering trade barriers. Two important conclusions can be derived from this: Firstly, with the formation of trading blocs, the country of low income will benefit more than the country of high income. Secondly, a less-developed country should actively pursue an open-door policy to increase income levels (Esterhuizen, 2006).

Using the assumption of “two goods, two factors”, Rybczynski (1955) suggests that, when the coefficients of production are given and factor supplies are fully employed, an expansion in the endowment of one factor of production raises the output of the commodity that uses the expanded factor intensively and reduces, in terms of both commodities, the real reward of the other factor. The implication is that the relative price of the commodity using the factor in which supply has risen will fall (Oyewumi, 2005).

Because the classical and neoclassical trade models are simplifications, many of their features are often violated in the real world. Goods do not move without transport costs, production technologies across countries are not necessarily identical, and qualities of inputs differ significantly. Finally, the trading environment is rarely characterised by perfect competition. In recent trade models, some of these real-world observations are taken into account.

2.3 Advances in applying trade theories

Brander and Spencer (1984), Eaton and Grossman (1986), Ethier (1982), Grossman and Helpman (1991), Grossman and Horn (1988) and Krugman (1984, 1986) all criticised international free trade from the perspective of increasing returns to scale and the network effect and came up with more advanced theories. Overall, these models attempt to address the shortcomings of standard trade theory by dealing with some of the realities of trade in a more complex and sophisticated manner by incorporating a fuller range of factors.

The main difference between the more advanced theories and the traditional theories lies in their assumptions about market institutions and production technologies. The advanced theories assume that the market has many firms with the ability to influence price, unlike firms in a perfect competitive market. These firms are able to set the price of a unit of their output above what it cost them to produce it, because their product is slightly different from their closest competitors. As for technology, the firms are assumed to enjoy increasing returns (Grimwade, 2000).

One of the advancements made was the relaxation of the two assumptions of the Heckscher-Ohlin model. While the H-O theory assumes constant returns to scale, international trade can also be based on increasing returns to scale. About half of the trade in manufactured goods among industrialised nations is based on product differentiation and economies of scale, which are not easily reconciled with the H-O factor-endowment model. The advancement leads to proper explanation of intra-industry trade. The gains from trade due to scale economies can be understood fairly intuitively (Carbaugh, 2006).

The older trade models have been able to substantiate the importance and reasons for trade. Modellers have been basing their parameters on these models. The older models failed to properly predict which products will be imported and which will be exported by a country. Armington (1969) developed a theoretical basis that can account for these behavioural parameters. The accuracy of the results taken from any trade model depends to a large degree on the appropriateness of these parameters. In addition to this, trade policy models used to evaluate the magnitude and direction of shocks introduced into an economy are very sensitive to these elasticity parameters. For instance, trade policy can affect the price of traded goods relative to domestically produced goods. The magnitude of these impacts will largely depend on the magnitude of the elasticity parameters.

2.4 Elasticity parameters

Trade model parameters are commonly expressed in the form of elasticities. It represents the percentage change of one variable in response to a one percent change in another variable, all other things being equal. Elasticities are rooted in micro-economic theory and reflect the sensitivity of consumers and firms to changes in relative prices and income (Hertel, 1990).

Trefler (1995) used the Armington assumption to account for home bias and found that the Armington assumption helps to explain why trade across countries is so much lower than that predicted by traditional trade theory. The assumption helps to explain what Trefler calls "*the case of missing trade*" and opens up a number of questions concerning the determinants of consumer preferences that lead to lower trade volumes (Blonigen & Wilson, 1999).

Gallaway *et al.* (2003) also highlighted the role played by Armington elasticities in international trade literature. Firstly, the magnitude of the trade substitution elasticity is important in the debate pertaining to the "border effect". International borders are apparently reducing trade flows among countries, but the extent depends on the degree of substitutability between domestic and imported goods. Secondly, the Armington elasticity is a key variable in testing Grossman and Helpman's "protection for sale" model. Finally, the Armington elasticity plays a key role in applied modelling that is often used to assess *ex ante* economy-wide impact of policy changes, such as tariffs and taxes. Also, Armington elasticities are important when measuring the trade diversion or trade creation effects of trade policy.

Elasticity values are not normally known with precision (Tomek & Robinson, 1990). Elasticity of demand for a given product may differ according to the econometric method employed, the quality of data, as well as the number of variables included or held constant in the basic economic framework used in the estimation (WTO, 2005). The term “trade elasticity” in the literature usually refers to expressions that are price or income elasticity of imports or exports, or elasticities of substitution between home and foreign goods. Trade elasticities are key parameters in trade policy modelling. They are the nexus between trade policies on the import side and the domestic economy (Francois & Reinert, 1997). The most prominent types are the Armington elasticity of substitution and import demand elasticity, price elasticity of demand, and income elasticity.

2.4.1 Elasticity of substitution (σ)

The elasticity of substitution is closely related to the concept of cross-price elasticity. It has its origins in the theory of the firm, characterising firms’ demand for combinations of production factors (inputs) to obtain a given output, subject to the technology used and the cost structure of the firm (WTO, 2005). It measures how the ratio of two inputs responds to a change in the relative price of those inputs (Varian, 1984).

The more positive the response, the more important substitution becomes. If the response is negative, the two goods are said to be complements. Elasticity of substitution often reflects the substitution effects within a branch, holding branch output constant (Keller, 1980). Two commodities for which the substitution elasticity is estimated must be considered alike in all economic respects, except that they are not perfect substitutes (Stern, Francis & Schumacher, 1976). The Armington elasticity has the form of a substitution elasticity, which is the percentage change in relative quantities of two products of different origins divided by the percentage change in relative prices.

2.4.2 Own-price and cross-price elasticity (E_{dp})

An extremely useful measure of the relationship between price and quantity demanded is 'price elasticity of demand'. Price elasticity of demand is a measure of the percentage change in the quantity of a good demanded divided by the percentage change in its price (Case & Fair, 1999).

The own-price elasticity of a product specifies the responsiveness (in percentage) of the quantity demanded for that good to an increase in its price by one per cent. In most cases the quantity demanded is inversely related to price, therefore the parameter/elasticity (E_{dp}) will be negative (Liebenberg & Groenewald, 1997). Demand is said to be unitary elastic when E_{dp} equals one, meaning that a one percent change in price would lead to a one percent change in the quantity demanded. When E_{dp} is less than one, demand is considered to be inelastic, and elastic when it is greater than one. Price elasticity varies at different prices along the demand function. Since price elasticity is defined for a point on the demand curve, it will for most curves be higher at higher prices (Tomek & Robinson, 1990).

The cross-price elasticity expresses by how much (in percentage) the demand for a product changes in response to a one percent price increase in another product. It is positive if two products are substitutes, and negative if they are complements. It is important to take the income effect of a price change into account in dealing with cross-price elasticities. The income effect occurs where a rise in the price of one good causes consumers to reduce their purchase of other goods, by reducing the real income of consumers (Ritson, 1977).

2.4.3 Income elasticity (E_{di})

This concept describes the percentage change in demand for one good in response to a one percent increase in income. For most products, an increase in income leads to an increase in the demand for a product and the income elasticity is therefore positive (greater than zero). Where the change in demand is larger than the percentage increase in income (greater than unity), the product's demand is said to be income elastic (Liebenberg & Groenewald, 1997). Where the elasticity is less than one, but greater than zero, the demand is income inelastic. An inferior good is characterised by negative income elasticity.

2.4.4 Armington elasticity defined

Armington elasticities specify the degree of substitution in demand between similar products produced in different countries. They are critical parameters which, along with model structure, data and other parameters, determine the results of policy experiments

(Whalley, 1985). The effect of trade policy measures and relative prices of similarly traded and domestically produced goods leads to a substitution of domestic for imported goods and vice versa, or to a substitution between imports from different sources (WTO, 2005).

Prior to the development of this theory, goods of a given kind supplied by sellers in one country were assumed to be perfect substitutes for goods of the same kind supplied by any other country. This implies that the elasticity of substitution between these supplies is infinite, and that the corresponding price ratios are constant. This was argued by Armington (1969) to be unrealistic, paving the way for his response whereby at the outset, products of the same kind but differing in origin are assumed to be imperfect, rather than perfect, substitutes in demand (Gibson, 2003).

Moreover, Gibson (2003) stated that Armington started with the basic Hicksian model, with increasingly more restrictive assumptions being applied, leading to the specification of product demand functions, which on simplification retain the qualitatively significant relationships between demand, income and prices. The fundamental adjustment to the general Hicksian model is to assume independence, implying that buyers' preferences for different products of any given kind are independent of their purchases of any other kind. Also, one country's demand for another country's product can be expressed as a function of the size of the corresponding market, e.g. a country's demand for a product and the relative prices of the competing market.

In addition to the assumption of independence, each country's market share is unaffected by changes in the size of the market, so long as the relative prices pertaining to that market remain unchanged (Armington, 1969). Thus the size of the market is a function of both money income and of the prices of various goods. The price function combined with the product demand function yields a function of the demand for a product to be dependent on money income, the price of each good, and the price of that product relative to prices of other products in the same market.

Armington (1969) made two other additional assumptions to simplify the product demand function. Firstly, it is assumed that the elasticity of substitution between products competing in any market is constant, implying that they do not depend on market shares. Secondly, it is assumed that the elasticity of substitution between any two products competing in a market is the same as that between any other pair of products competing in the same market. These assumptions made by Armington (1969) yield a specific form of the relationship between product demand, the size of the corresponding market, and relative prices, whereby the only unknown parameter is the elasticity of substitution in the market.

2.5 Armington model

The Armington model is a prudence model that shares some elements of both neoclassical and advanced trade models. The main theoretical background of this model is that goods imported by a country from the rest of the world are considered imperfect substitutes for goods made in that country (Armington, 1969). The model distinguishes commodities by country of origin, with import demand determined in a separable two-step procedure (Alston *et al.*,1990).

The introduction of Armington substitution in the demand for commodities is a departure from the assumption of perfect substitution that underlies traditional trade models (Lloyd & Zhang, 2006). This departure changes fundamentally the properties of a trade model and the well-known theoretical results that are based on variants of the Hekscher-Ohlin model (Lloyd & Zhang, 2006).

The Armington assumption of product differentiation and imperfect substitution makes existing trade statistics immediately usable for global trade models. The Armington structure also overcomes the problem that arises in a Heckscher-Ohlin-type model with more goods than factors whereby countries tend to specialise in only a few of the goods. It overcomes this problem by considering specialisation in country-specific goods in each country. Complete specialisation is impossible in this model, simply because the preferences do not permit an extreme degree of specialisation to occur at equilibrium (Petersen, 1997). This was a problem encountered in some of the early numerical models of trade, with countries ending up specialising in one product (Whalley, 1985).

2.5.1 Armington model setup

Armington (1969) attempted to distinguish products from different suppliers in a market. By means of a two-stage method he supposed that at the first stage, a buyer (or importing country) decides on the total quantity to buy to maximise utility, and at the second stage allocates shares of the total quantity to individual suppliers (or exporting countries) in order to minimise the costs. For the first-stage equation, he specified the total demand for both foreign and domestic products as the dependent variable.

Armington made two major assumptions in the second-stage equation. Firstly, the elasticity of substitution is constant without considering the share of a product, and secondly there is a single elasticity of substitution between any pair of products in the group. These assumptions are together considered as the Constant Elasticity of Substitution (CES) function, which allows for a decrease in the number of coefficients to be estimated and facilitates the estimation process.

The Armington model assumes imperfect substitution among goods from different geographical areas (Armington, 1969). The model uses a CES aggregation function, which implies that the substitution of imports between any two pairs of importing partners is identical. According to the choice of the CES functional form, *two* different specifications can be considered.

2.5.2 Nested constant elasticity of substitution

The first specification is what Shiells and Reinert (1993) called nested constant elasticity of substitution. This specification assumes that imports from different sources are differentiated products. Under the nested approach, the composite good C_i is assumed to be a function of the domestic good and a composite of imports sourced from the other regions in the model: $C_i = g[D_{i,} h(M_{ir,} M_{is}, ...)]$ where both the function *g* (the "top-level" nest) and the function *h* (the "bottom-level" nest) are CES functions.

This formulation places two main restrictions on the structure of international trade (Hertel *et al.*, 1997). Firstly, imports are made separable from the domestic good: i.e. relative price changes among imports do not affect the quantity demanded of the domestic good, and a change in the price of the domestic good does not affect the relative quantities demanded of the various imported goods. Secondly, the particular assumption of *g* and *h* as CES functions implies not only that the elasticities of substitution at these two levels are constant, but that the elasticity of substitution at the lower level is equal for each of the imports.

A special case of the nested CES Armington structure is that in which the elasticity of substitution among imports (the lower nest) is equal to that between imports and the domestic good (the upper nest). By restricting the elasticity of substitution to be equal among a pair of goods entering the aggregation, the Armington structure can be represented in a single stage function, $C_i = g(D_{i,}(M_{ir,} M_{is}, ...)$, where *g* is the CES function. The implication is that if the elasticity of substitution in the lower nest becomes smaller than that in the upper nest, then the gross complementarity among imports becomes a possibility (Hertel *et al.*, 1997). In other words, a reduction in the price of one import could lead to an increase in the demand for all imports. Under the non-nested specification, the substitution elasticities are implicitly identical at both levels.

2.5.3 Non-nested elasticity of substitution

The second specification can be called the *non-nested* specification (Shiells & Reinert, 1993), which assumes that imports from regions or countries, as well as competing domestic production, all enter into the sub-utility function for a sector *i*. The utility function of a South African consumer can be expressed as a CES function of an aggregate import *M* and aggregate domestic good *D*. In this respect, imported goods from different parts of the world are aggregated into a single good for each sector (as are domestic goods). The utility function is $Q_i = \alpha_i \left[\beta_i M_i^{\left(\frac{\sigma_i - 1}{\sigma_i}\right)} + (1-\beta_i) D_i^{\left(\frac{\sigma_i - 1}{\sigma_i}\right)} \right]^{\left(\frac{\sigma_i}{\sigma_i - 1}\right)}$

Q_i is the utility derived from the consumption of goods in sector *i*, while α_i and β_i are parameters and σ_i is the elasticity of substitution between imports and domestic goods in that sector. Suppose that the prices of the aggregate import and domestic goods in the sector are $P_{i,m}$ and $P_{i,\mathrm{d}}$ respectively. The standard procedure where a consumer maximises utility subject to a budget constraint yields import demand per unit of domestic demand as a function of relative prices, i.e. $\frac{M_i}{D_i} = \left[\left(\frac{\beta_i}{1-\beta_i} \right) \frac{P_{i,d}}{P_{i,m}} \right]^{\sigma_i}$

The elasticities of substitution are industry specific and have been estimated econometrically. The non-nested specification has been applied to the North American Free Trade Agreement (NAFTA) by Cox and Hanis (1992), Roland-Holst *et al.(*1992) and Sobarzo (1992). In particular, the Roland-Holst *et al.* (1992) study utilises the full set of non-nested elasticities estimated by Reinert and Shiells (1991) in the form of weighted averages for Canada and the United States. Shiells and Reinert (1993) used both nested and non-nested Armington specifications to determine the terms-of-trade effects for North America. Results from the non-nested specification seem to be more appropriate than those from the nested specification. They concluded that the nested specification should be abandoned. Non-nested specification will therefore be used in this research, because it makes use of quantity and price ratios, which suit the data available for South Africa. In addition, it relates South Africa to the rest of the world.

2.6 Armington elasticity estimation approaches

There have been two common approaches to empirically obtain Armington elasticities in the literature, namely validation and econometric estimation[2].

Many computable general equilibrium (CGE) models source their elasticity parameters from econometric estimates. Such estimates give the impression of being more rigorously tested to a certain level of statistical accuracy. Using the econometric approach, a variety of functional forms for import demands have been used to model expenditure on domestic output and imports from different sources (Shiells & Reinert, 1993). Three important demand specifications widely used in the literature are log linear specification, the almost ideal demand system (AIDS), and the constant elasticity of substitution (Armington) specification.

[2] Econometric estimation refers to the use of various econometric functional forms to estimate Armington elasticities

In the log linear specification, logarithms of relative import ratios are regressed on the logarithms of income and relative prices. This functional form has been widely criticised, because it is not derivable from an underlying model of optimisation behaviour (Mohanty & Peterson, 1999).

The almost ideal demand system (AIDS) developed by Deaton and Muellbauer (1980) is derived from an indirect expenditure function and can approximate the conditions that are implied by static economic theory, while being sufficiently flexible to frame some of the implied properties as restrictions on a more general model. It has been widely applied to the estimation of food-demand functions (Tiffin & Balcombe, 2005).

The AIDS is commonly estimated under the assumption that the right-hand-side variables in the model are predetermined. This assumption has been criticised and it has been argued that the errors in the AIDS are likely to be correlated with the regressors for two reasons. Firstly, Eales and Unnevehr (1993) argue that many applications of the AIDS have involved the use of aggregate data and that in such cases it is reasonable to assume that prices and quantities are jointly determined. Secondly, Buse (1994) argues that the construction of the Stone’s price index, which is commonly used to linearise the AIDS, leads to a violation of the assumption of predetermined right-hand-side variables (Tiffin & Balcombe, 2005).

Armington (1969) and most CGE modellers have used the CES form for the representative consumer’s sub-utility function for an industry group. For general simulations, the advantages of using the CES form are that it obeys regularity conditions such as global concavity and that it requires only one estimated parameter (Shiells & Reinert, 1993). The CES form is also identical to the general equilibrium model specification. The main advantage of the Armington approach is its parsimony with respect to parameters to be estimated while retaining compatibility with demand theory (Alston *et al.*, 1990).

The econometrics approach has been criticised for the following reasons: Firstly, given the large number of parameters to be estimated, long-time-series data for numerous variables is required to provide sufficient degrees of freedom for estimation. Secondly, the economy is likely to have undergone structural changes over time, which may or may not be appropriately reflected in the estimation procedure. Thirdly, the values of estimates usually seem to vary widely, depending on the time-series data used, the estimating functional forms, and the methodology adopted. It is difficult to verify which estimates represent the true values implied in the model's database for which the estimation is being undertaken (Arndt *et al*., 2002).

As an alternative to the econometric approach, some CGE researchers employ a simple "validation" procedure whereby they run a model forward over a historical period and compare results for some variables. The results can provide a basis for revising estimates of some important parameters, recalibrating the model in a kind of informal Bayesian estimation procedure. However calibration, according to Dawkins *et al.* (2001), means the setting of specified parameters to replicate benchmark data set as a model solution. Examples of this approach can be found in the work of Dixon *et al.* (1997), Gehlhar (1994) and Kehoe *et al.* (1995). Unlike econometric approaches, this approach makes limited use of the historical record and provides no statistical basis for judging the robustness of estimated parameters.

Combining the two methods described above, Arndt *et al*. (2002) adopted an entropy-based approach to estimating elasticity parameters for CGE models. By minimising the entropy (or uncertainty) distance of predicted values from historical targets, they argue that it is possible to endogenously estimate the values of behavioural parameters that permit the model to best track the historical record. Compared with other approaches, this has the advantage of endogenously determining the 'general equilibrium' values of the model's behavioural parameters, including substitution elasticities, which are also consistent with historical observations.

However, there are also limitations to this approach. The results are dependent on an '*entropy ratio*' statistic, which is known to have weak predictive power. As the results are dependent on selected historical targets, like other back-casting-type approaches, this approach also requires a relatively large amount of historical data from external sources, which creates the possibility of data inconsistency (Zhang, 2006).

Despite criticism of the econometric method of estimation, this study makes use of the approach. Justification for this is (i) quarterly data are used in this estimation, which adequately takes care of the problem of number of observations (more information is given about this in chapter four of this study). (ii) dummy variables are used in this research work in order to address the structural changes that might have occurred in the economy and (iii) the estimation of the Armington elasticity is based on the time series properties of the data. The aforementioned, therefore, largely overcome the criticisms described.

2.6.1 Computable general equilibrium models and Armington elasticity

Armington elasticities are widely used in computable general equilibrium (CGE) models. CGE models are a class of economic models that use actual economic data to estimate how an economy might react to changes in policy, technology or other external factors. CGE models have become a useful tool in analysing a number of varied trade policy issues (De Melo, 1988; Shoven & Whalley, 1984; Srinivasen & Whalley, 1986). These models have been used to study the economic effects of trade policies, such as tariffs and non-tariff barriers (NTBs), as well the effect of trade liberalisation on an economy, in a variety of settings (Blonigen *et al.*, 1997). CGE models are useful to model the economies of countries for which time series data are scarce or not relevant, which may be due to disturbances such as regime changes.

In the early works that used CGE models for development policy work, much time was spent on finding ways to model the various distortions in the foreign trade sectors (Khan, 2004). Thus modelling exports, imports, balance of trade and balance of payments became important items on the modelling agenda during the 1980s. After trying various approaches, general consensus was reached that imperfect substitutability between imported goods and their domestic counterparts must be accurately modelled to obtain better results from trade models. The Armington assumption is therefore used by almost all modellers (Khan, 2004). The most common approach now is to specify sectoral CES import demand functions, export transformation functions that assume constant elasticity of transformation (CET), and aggregation functions based on these.

Moreover, the Armington structure was introduced in CGE models to overcome problems that arose in the early CGE modelling efforts and has been accepted as the most appropriate way to model trade flows in a computable general equilibrium (CGE) model (Alston *et al.*, 1990) and has been extensively used in CGE models of international trade in agricultural products. It accommodates cross-hauling, which occurs when a country exports as well as imports the products of an industry (Zhang, 2006). This is an ever-present feature of international trade statistics, and is due to aggregation. Zhang (2006) gives two consequences of introducing the Armington assumption: Firstly, every country in a CGE has market power in every market in which it buys and sells. This means that when one country reduces its tariff rates, the model results tend to display largely negative terms of trade effects.

Secondly, comparative advantage in production does not exist, which means that any resource reallocation across industries is small relative to what might occur in a non-Armington model. Both factors reduce the gains from trade liberalisation in simulations that use a CGE model. As a consequence, any benefits from the reduction of tariffs tend to be small and occasionally negative, especially when the initial tariffs are small. Brown (1987) showed that the relationship between the magnitude of Armington elasticity and that of the terms of trade effects is complex.

Moreover, according to Nganou (2004), one of the most debated issues in the CGE literature concerns the validity of the key behavioural parameters used in the calibration process. CGE modellers seldom estimate those parameters, preferring to borrow from the handful of estimates available in the literature. The lack of data is often cited as a reason for this type of compromise. Estimating key parameters is crucial since CGE results have been shown to be quite sensitive to the value of parameters. Partial and general equilibrium models that rely on the Armington elasticities are usually sensitive to these parameters (McDaniel & Balistreri, 2001). Thus, it is important to use the true Armington parameters for the countries of study.

2.7 Empirical applications

The Armington assumption that home and foreign goods are differentiated purely because of their origin of production has been a workhorse of empirical studies in trade (Sarker & Surry, 2005). It has routinely been used in both econometric and simulation models to model import demands and to assess the effects of various trade policy options (Blonigen & Wilson, 1999). Knowledge of this elasticity is important for trade policy modelling because the degree to which a policy change will affect a country's trade balance, level of income and employment depends on the magnitude of the elasticity used in the model (Gallaway *et al.*, 2003).

2.7.1 Use of the Armington model in international studies

Stern *et al.* (1976) estimated import demand elasticities for the United States of America (USA) at the three-digit ISCI level. Of the 28 industries investigated, various different industries from wearing apparel, rubber products, transport equipment and metal products excluding machinery were found to be extremely import-sensitive industries. Moderately import-sensitive industries are food, beverages, tobacco, textiles, iron and steel, and metal including electrical machinery, while wood and paper industries were found to be import inelastic. According to McDaniel and Balistreri (2001), this study offers "best estimates" for USA import demand.

Using a simple stock adjustment model and annual time series data from 1962 to 1978, Shiells *et al.* (1986) estimated Armington elasticities for 163 USA industries at the three-digit level. Statistically significant estimates were obtained for 122 sectors of the 163 investigated. The estimates of these authors are in conformity with those of Stern *et al.* (1976).

Shiells and Reinert (1993) estimated elasticities of substitution for the USA by disaggregating USA imports into those from the North America Free Trade Agreement (NAFTA) members and those from the rest of the world. Three different estimation methods – namely (i) Generalised least square (GLS) based on the Cobb-Douglas price aggregator, (ii) Maximum likelihood estimation using the CEC price aggregator, and (iii) a simultaneous equation estimator using a Cobb-Douglas price aggregator and employing a distributed lag model – were used on quarterly data from 1980 to 1988 to obtain estimates from 128 mining and manufacturing sectors. The elasticity estimates were found to be insensitive across the three alternatives methods.

Song (2006) estimated import demand elasticities for agricultural products in Korea using data classified according to the harmonised system (HS) from five aggregated agricultural sectors to 27 disaggregated agricultural sub-sectors. Quarterly data from 1991 to 2004 were used and two estimation methods were employed; i.e. ordinary least square with autoregressive correction and two-stage least square (2SLS) with first-order autoregressive correction (AR (1)). Estimation results show that all five aggregated sectors have inelastic import demand while among the 27 disaggregated sectors, 16 sectors have highly elastic import demand.

Kapuscinski and Warr (1999) estimated Armington elasticities for tradable commodities in the Philippines. The data cover a time period from the mid 1970s through to the late 1980s. Estimates were obtained from three model specifications: OLS, the partial adjustment model (PAM), and the error correction model (ECM). Estimated elasticities range from 0.2 for metal products to 4 for sugar milling and refining, with a majority of these estimated elasticities being greater than unity. They found that the ECM specification provides an adequate characterisation of the process of substitution between imports and domestic production.

Gallaway *et al.* (2003) estimated Armington elasticities for 312 industries at a 4-digit SIC in the USA, over the period 1989 to 1995. The methodology they used allowed for extraction of both short-run and long-run elasticities depending on the time series characteristics of the data. Three different specifications were applied: (i) Geometric lag model, (ii) Single equation error correction model, and (iii) the variables were first differenced for stationarity and then estimated by ordinary least square (OLS). They found that, on average, long-run estimates were twice as large as short-run estimates. Statistically significant differences were shown to exist within most 3-digit SIC industries, stressing the importance of estimating at a disaggregated level, as policy focuses on narrow product definitions (Gallaway *et al.,* 2003).

Surry *et al.* (2002) investigated trade in processed food products based on French data. They used a differentiated product model, which captures non-homothetic consumer preferences but also allows for a testable restrictive structure such as homogeneity, homogenous weak separability, and the Armington specification. The model framework adopted was based on the constant difference of elasticity (CDE) function. Econometric results suggest that French consumers distinguish not only between home-produced and imported food products, but also between supplies originating from elsewhere in the European Union and imports from the rest of the world.

Tourinho *et al.* (2003) estimated Armington elasticities for 28 industrial sectors in Brazil using data from 1986 to 2002. Depending on the order of integration of the series of relative prices and quantities, they used one of four approaches namely: simple regression in levels, equations in first differences, mixed equations, or a vector error correction (VEC) model of the type proposed by Johansen. The possibility of uncertainty in prices affecting the demand for imports was also taken into consideration. Significant estimates were obtained for 24 sectors, with the point estimates varying between 0.16 and 5.3, reflecting a broad spectrum of degrees of substitution of the imported products for domestically produced goods.

McDaniel and Balistreri (2001) reviewed studies employing econometric methods for estimating the Armington elasticity and arrived at three major findings. Firstly, the level of trade response to short-run and long-run estimates differs. Secondly, the level of aggregation matters, and that the level of aggregation is directly proportional to the size of the Armington elasticity. Lastly, the methodological approach is of importance due to observed differences between results recorded by cross-sectional studies and those recorded by time-series studies. Substitution rates are higher for the studies that apply cross-sectional data than for those using time-series data.

2.7.2 Use of the Armington model in studies focussing on South Africa

The focus of estimating Armington elasticities for South Africa has been on the manufacturing sector. This is due to lack of suitable time series data to allow similar estimates for the mining and agriculture (Naude *et al.,* 1999).

Dirda (1995) estimated Armington elasticities of substitution between domestically produced and imported intermediate inputs for 27 manufacturing sectors in South Africa. Subsequent to Dirda's study the Industrial Development Corporation (IDC) estimated new Armington elasticities for 25 manufacturing sectors using data from 1973 to 1993 (The estimated elasticities were used in the IDC CGE model).

Time series properties of the data were investigated by carrying out stationarity and cointegration tests. However, data was used in its original form when it remained non-stationary after several first difference transformations and when cointegration relationship could not be established. Since there could not have been a long-run relationship, the long-run elasticities recorded might be due to the use of annual data rather than monthly or quarterly data (Van Heerden and Van Der Merwe, 1997).

Naude *et al*. (1999) estimated Armington elasticities for the South African manufacturing sector using OLS. Due to data limitations elasticities for only 25 sectors were estimated. Most elasticities were found to be of a similar magnitude to those estimated by econometric methods elsewhere, i.e. it was compared with the findings of Alaouze *et al.* (1977) and Comber (1995) that the elasticity of substitution between imported and domestically produced goods clustered around 2.

Gibson (2003) estimated Armington elasticities for industrial products in South Africa, following the procedure used by Gallaway *et al.* (2003) to determine the most suitable method of estimating both the short-run and long-run elasticities. A total of thirty-two out of forty-two industries exhibited positive and significant short-run Armington elasticities, ranging from 0.42 to 2.77. Three industries exhibited significant and positive long-run estimaties, with long-run elasticity ranging from 0.676 to 2.688. The results from this study are consistent with the findings of Gallaway *et al*. (2003) that long-run estimates are on average twice as large as those estimated for the short run and can be up to five times as large (Gibson, 2003).

2.8 Summary and conclusion

This chapter provided an overview of the different trade theories and their relation to the Armington model. The Armington elasticity is a trade substitution elasticity that measures the percentage change in relative quantities of two products of different origins divided by the percentage changes in relative prices. The Armington elasticity is very important in trade models that aim to evaluate the impact of trade policies. The Non-nested Armington specification is preferred because it relates a particular country to the rest of the world. The CES functional form is preferred because it obeys the regularity conditions and requires only one estimated parameter.

The review of literature reveals that extensive work has been done in the field of estimating Armington elasticities for industrial products, but less has been done on agricultural products both locally and internationally. From the international literature reviewed, studies by Reinert and Roland-Holst (1992), Shiells and Reinert (1993), Shiells *et al.* (1986) and Stern *et al.* (1976) provided valuable trade substitution elasticities. These studies did however not carefully consider the time series properties of the data used and did not explicitly consider the long-run aspect of the Armington elasticity that is applicable to applied partial and general equilibrium modelling.

Gallaway *et al.* (2003), Kapuscinski and Warr (1995) and Tourinho *et al.* (2003) employed techniques that took care of the time series properties of the data and they successfully estimated long-run Armington elasticities. The study of Gallaway *et al.* (2003) is unique compared to the other two studies mentioned in that it employed techniques to distinguish between short-run and long-run elasticities.

From the domestic literature reviewed, data availability has been a major problem hindering the estimation of Armington elasticities. Most of the studies ignored stationarity of the time series data, and if the data series employed are non stationary, the estimates generated may be misleading and unreliable for use in applied modelling work.

In South Africa, Burrows (1999), IDC (1997) and Naude *et al.* (1999) applied specifications that do not allow extraction of both short-run and long-run elasticities. However, Gibson (2003) overcame all these problems by applying the specification of Gallaway *et al.* (2003) to successfully estimate Armington short-run and long-run industrial estimates. This study offers the most recent and appropriate set of Armington elasticities for the South Africa industrial sector to date.

CHAPTER 3

INDUSTRY OVERVIEW AND TRENDS IN LIVESTOCK AND GRAIN TRADE OF SOUTH AFRICA

3.1 Introduction

South Africa is divided into a number of farming regions according to climate, natural vegetation, soil type, and farming practices. Agricultural activities range from intensive crop production and mixed farming in winter rainfall and high summer rainfall areas, to cattle ranching in the natural veld, and sheep farming in more arid regions. South Africa covers an area of about 1,220,088 square kilometres. Approximately 84 per cent of the total area is used for agriculture and forestry, of which approximately 80 per cent consists of natural veld, which varies from semi-desert vegetation to the highly productive grasslands of the high-rainfall areas (Bahta, 2004).

The red meat sub–sector is the largest agricultural sub-sector in South Africa, for example it, on average, contributed 14 percent to the gross value of agricultural production between 2001/02 to 2005/06 (DOA, 2007b). Despite this, the red meat industry was a highly regulated sub-sector controlled by various policies, such as the distinction between controlled and uncontrolled areas, restrictions on the creation of abattoirs, the compulsory auctioning of carcasses according to grade and mass in controlled areas, supply control via permits and quotas, the setting of floor prices, the floor price removal scheme and so forth, prior to the commencement of deregulation in the 1990s (Jooste, 2001). However, the industry became totally deregulated in 1997.

The grain industry is also significant in that it contributed, on average, 11.4 percent to the gross value of agricultural production between 2002/2003 to 2006/2007 (DOA, 2007b).

According to Vink and Kirsten (2000), the maize industry experienced a period of state intervention between the 1930's and 1997. Maize marketing and pricing in South Africa was largely directed by government. However, starting in the mid-1980s, internal pressures within the maize industry led to a series of reforms designed to reduce government's role in pricing and distribution and rely increasingly on market forces and the private sector. The Marketing of Agricultural Products Act of 1996 ordered the demise of the control boards and major reforms were implemented in South Africa's maize marketing system in 1997. Price setting at each stage of the system was deregulated and based entirely on negotiation between market actors and the Maize Board was abolished

Livestock in South Africa, as in other developing countries, could be one of the most important sources of livelihoods for the poor (Ngqangweni & Delgado, 2003), and is estimated to contribute to the livelihoods of at least 70 percent of the world's poor (Livestock in Development, 1999). For households affected by poverty, the livestock market remains one of the few rapidly growing markets or has the potential to grow within the agricultural sector. It has also been shown elsewhere that the poor earn a higher income from livestock than the wealthy (Delgado *et al.,* 1999). The grain industry also plays an important role in South Africa's food security programme and provides employment for many households.

This chapter specifically focuses on selected products in the livestock and grain industries, providing insights into issues of common interest. It focuses mainly on trade in the selected products, with specific emphasis on imports.

3.2 South African trade in selected agricultural products in the livestock and grain industries

3.2.1 Imports of red meat products by South Africa

Imports of red meat increased from 58,649 tons in 2004/05 to 74,959 tons in 2005/06. This is 27.8 percent higher than the average of approximately 55,787 tons for the five years up to 2005/06 (DOA, 2006b). Imports of beef amounted to 24,445 tons, which is 63 percent higher than the five-year average of 15,000 tons. Imports of pork amounted to 23,787 tons, which is 22.8 percent more than the five-year average of 19,364 tons, and imports of mutton amounted to 26,727 tons, which is 24.8 percent higher than the average of 21,421 tons for the five years up to 2005/06 (DOA, 2006b). Table 3.1 shows the imports of selected red-meat products from foreign countries between 2001 and 2005.

Table 3.1: Imports of red-meat products from foreign countries

HS rev.	Product	Value 2005 in US$ thousand	Quantity 2005 (tons)	Annual growth in value from 2001-2005, %	Annual growth in quantity from 2001-2005, %
0201	Meat of bovine animals, fresh or chilled	1,713	800	23	17
0202	Meat of bovine animals, frozen	29,459	19,665	74	52
0203	Meat of swine, fresh, chilled or frozen	47,394	26,921	46	39

Source: ITC calculations based on COMTRADE statistics, 2005

Note: The COMTRADE database represents SACU data, but since Namibia and Botswana are net exporters it can safely be assumed that the import data reported represents South African imports

Table 3.1 shows that from 2001 to 2005 South Africa experienced positive growth in the imports of meat of bovine animals (fresh or chilled) as well as meat of bovine animals (frozen) in terms of value and quantity. Positive growth was also experienced in the meat of swine (fresh, chilled or frozen).

3.2.2 Imports of grain products by South Africa

South Africa is in most production years a net exporter of maize, with the export of maize and maize products being an important earner of foreign exchange for the country. South Africa is a net importer of wheat, which is mostly imported for human consumption. It is also a net importer of sunflower seed and soybeans, although trade in these products has been low.

Table 3.2 shows the imports of various grain products from foreign countries. South Africa experienced negative growth in the imports of maize in terms of value and quantity between 2001 and 2005. Positive growth was experienced in wheat and meslin, as well as sunflower seed imports, while soybeans imports experienced negative growth in quantity between 2001 and 2005.

Table 3.2: Imports of grain products from foreign countries

HS rev.	Product	Value 2005 in US$ thousand	Quantity 2005 (tons)	Annual growth in value from 2001-2005, %	Annual growth in quantity from 2001-2005, %
1005	Maize (corn)	7,755	81,168	-16	-11
1001	Wheat and meslin	181,380	1,270,923	54	39
1201	Soybeans, broken or not broken	3,116	14,660	0	-5
1206	Sunflower seeds, broken or not broken	680	877	37	35

Source: ITC calculations based on COMTRADE statistics, 2005

3.2.3 Distribution of trade

The Lorenz curve and GINI coefficients are used in this section to determine skewness/concentration of trade for the industries of interest. The Lorenz curve is based on the share of total trade that accrues to different regions/countries starting with the smallest and working up to the largest. Earlier uses of the curve compared income distribution to the cumulative function of income. Similarly, the distribution of market shares among importers or exporters of a particular agricultural product from a particular country can be represented by a Lorenz curve. In this case the cumulative number of importing or exporting countries is drawn on the horizontal axis and is a function of the share of trade on the vertical axis.

The Lorenz curve can also be used to define a common measure of concentration, generally known as the GINI coefficient. A GINI coefficient equal to zero denotes that trade is equally distributed amongst regions/countries; however, if it is equal to one, trade is restricted to only one country. A higher GINI coefficient denotes that a country has concentrated its imports/exports on a few regions, while a low GINI coefficient indicates a high level of diversification of the importing/exporting countries or regions (Grote & Satorius von Bach, 1994; Sartorius von Bach, 1993; Satorius von Bach & Van Rooyen, 1995). The GINI coefficient is determined as the ratio of the area between the Lorenz curve and the 45-degree line, i.e. at 45 degrees from the origin. Hanson and Simmons (1995) showed that the GINI coefficient can be expressed as a percentage, thus:

$$G_i = 1 - \sum_{i=0}^{N} (\sigma Y_{i-1} + \sigma Y_i)(\sigma X_{i-1} - \sigma X_i)$$

Where σX and σY are cumulative percentages of Xs and Ys (in fractions) and N is the number of elements (observations).

3.2.3.1 Imports of bovine meat into South Africa

The GINI coefficient for bovine-meat imports was calculated at 0.822, which indicates a relatively high degree of import concentration. Figure 3.1 shows the relative skewness of South Africa's imports of bovine meat in 2005. The concentration curve shows a high level of convexity to the 45-degree Lorenz curve, meaning that imports of bovine meat in 2005 were concentrated from a few countries (that is Argentina and Brazil), with 78.4 percent of the total imports (Argentina 33.2% and Brazil 48.2%) of this product into South Africa coming from these two countries.

Other countries from which South Africa imports this product are Paraguay, Uruguay, Australia, New Zealand, France, India, Dominica, Denmark and Canada.

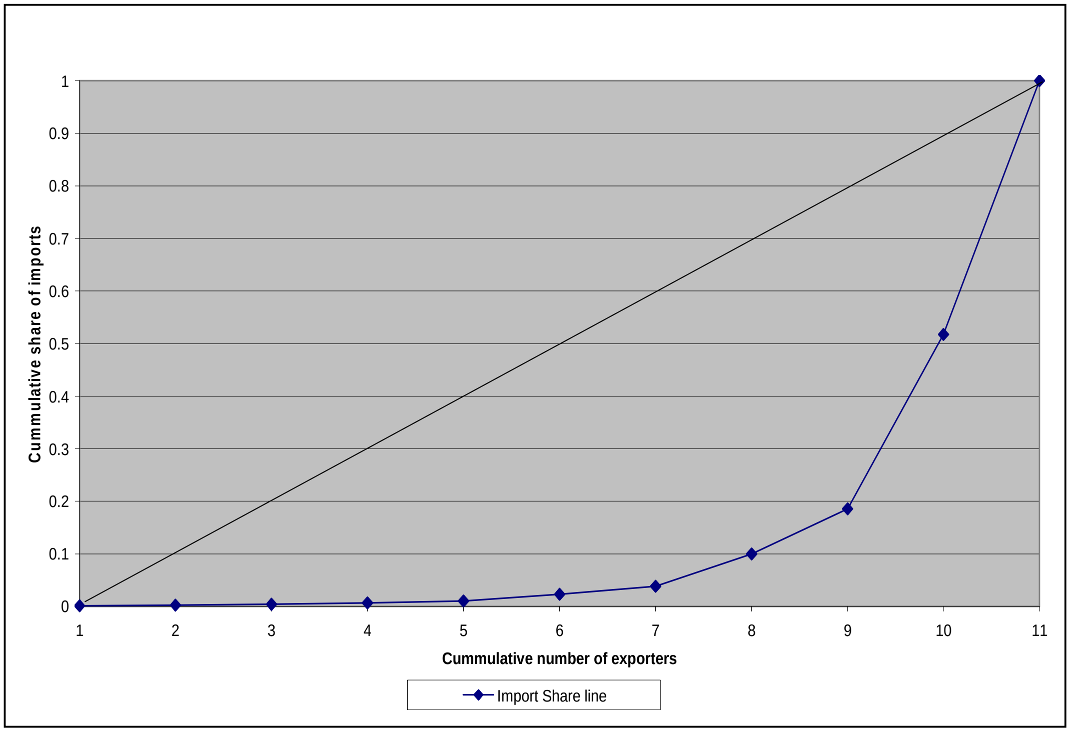

Figure 3.1: Lorenz trade inequality curve: South Africa's imports of bovine meat in 2005

3.2.3.2 Imports of pork into South Africa

The GINI coefficient for pork was calculated at 0.841, which also indicates a very high degree of import concentration. Figure 3.2 shows the relative skewness of South Africa's imports of pork in 2005. Imports of pork were concentrated from a few countries namely Brazil, France and Belgium.

About 86 percent of the total imports of pork by South Africa in 2005 came from Belgium, Brazil and France. These countries were ranked seventh, eighth, and ninth largest exporters of this product in the world respectively in 2005 (ITC, 2005). South African imports of pork from France were affected by the outbreak of classical swine fever in France in 2002. This development required the South African Department of Agriculture (DOA) to place a ban on the importation of pork from France. Despite this, a large percentage of South Africa's pork imports in 2005 still came from France. Brazil is currently the largest exporter of pork to South Africa.

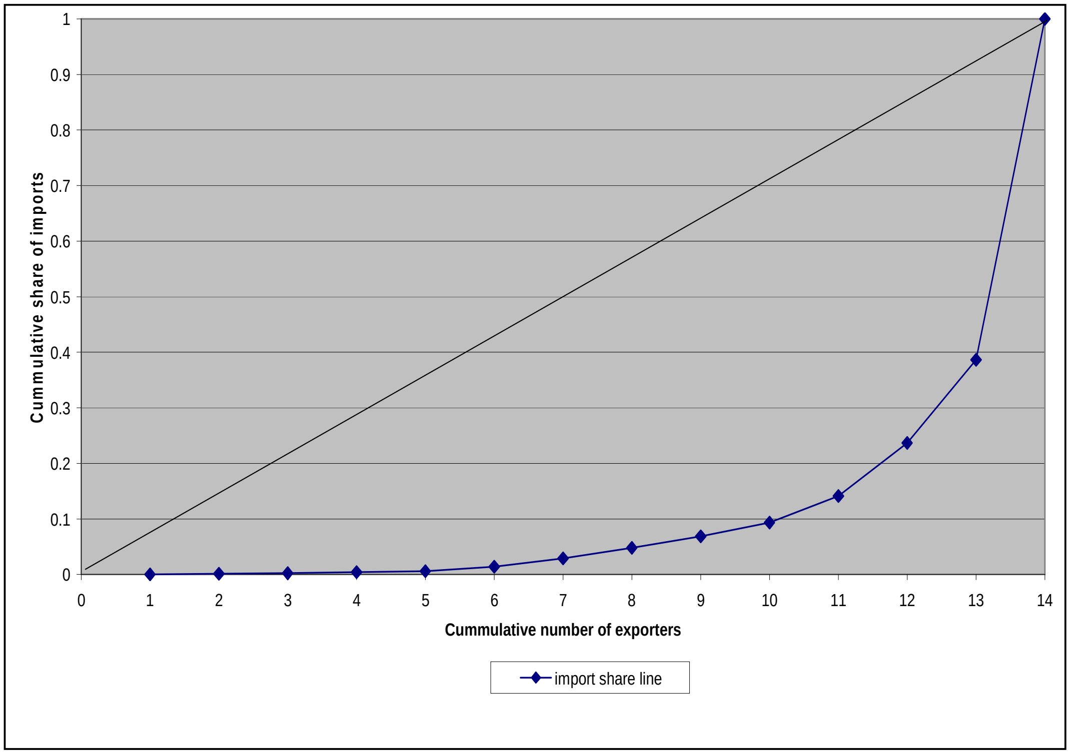

Figure 3.2: Lorenz trade inequality curve: South Africa's imports of swine meat in 2005

3.2.3.3 Imports of maize into South Africa

The GINI coefficient for maize was calculated at 0.982, which indicates a very high degree of import concentration. Figure 3.3 shows the relative skewness of South Africa's imports of maize in 2005. Imports of maize in 2005 were concentrated from only two countries, namely Argentina and the USA. Over 98 percent of the total imports of this product into South Africa came from these two countries.

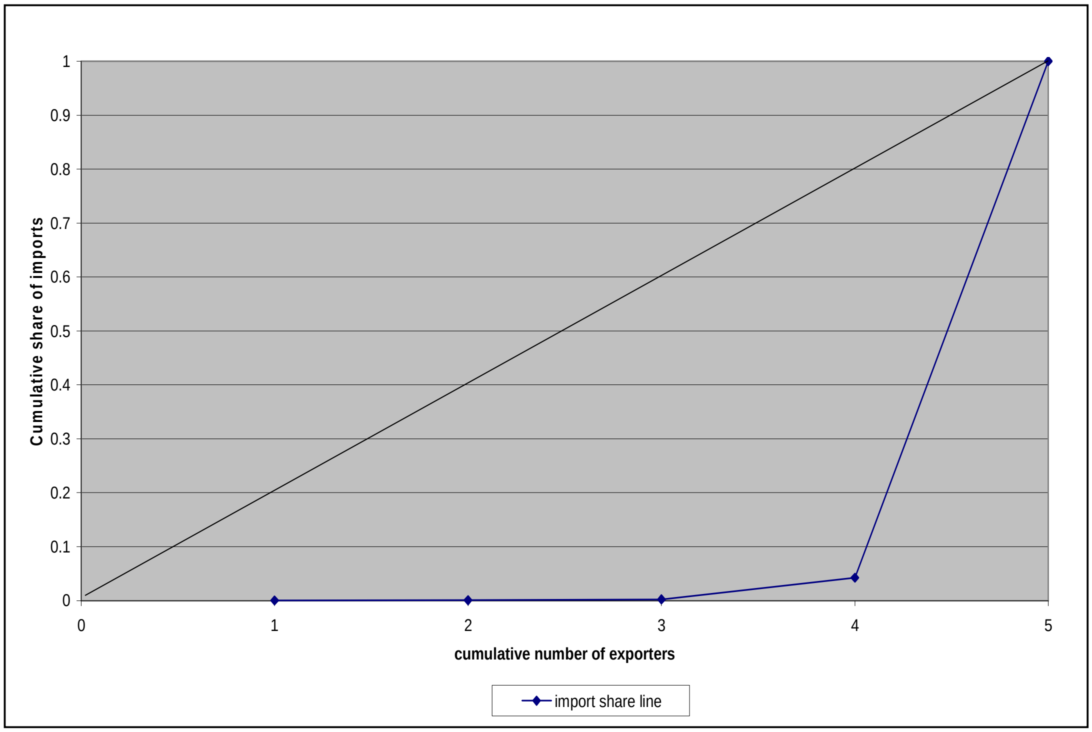

Figure 3.3: Lorenz trade inequality curve: South Africa's imports of maize in 2005

3.2.3.4 Imports of wheat into South Africa

The GINI coefficient for wheat was calculated at 0.678, which indicates a relatively lower degree of import concentration. Figure 3.4 shows the relative skewness of South Africa's imports of maize in 2005. Imports of wheat in 2005 were concentrated in a few countries, namely Argentina, the USA, Germany and Australia. About 94 percent of the imports came from these four countries in 2005 (ITC, 2005).

The USA, Australia, Argentina and Germany were respectively ranked first, third, fifth and seventh highest exporters of the product in 2005 (ITC, 2005).

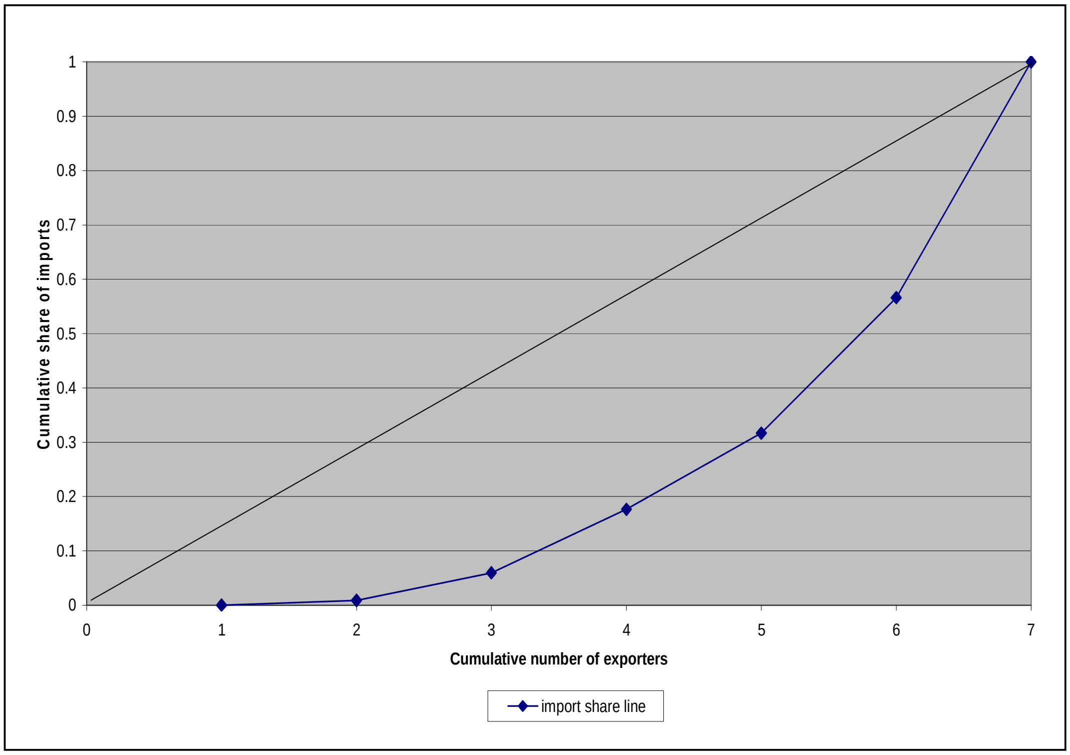

Figure 3.4: Lorenz trade inequality curve: South Africa's imports of wheat in 2005

3.2.3.5 Imports of soybeans into South Africa

The GINI coefficient for soybeans was calculated at 0.999, which indicates a very high degree of import concentration. Figure 3.5 shows the relative skewness of South Africa's imports of soybeans in 2005. Imports of soybeans in 2005 were mainly from Argentina. In fact, as the declining part of the graph shows, over 99 percent of the total imports of this product into South Africa came from this country. Argentina was ranked third largest exporter of this product in 2005. South Africa also imported a minimal amount of soybeans from Taiwan.

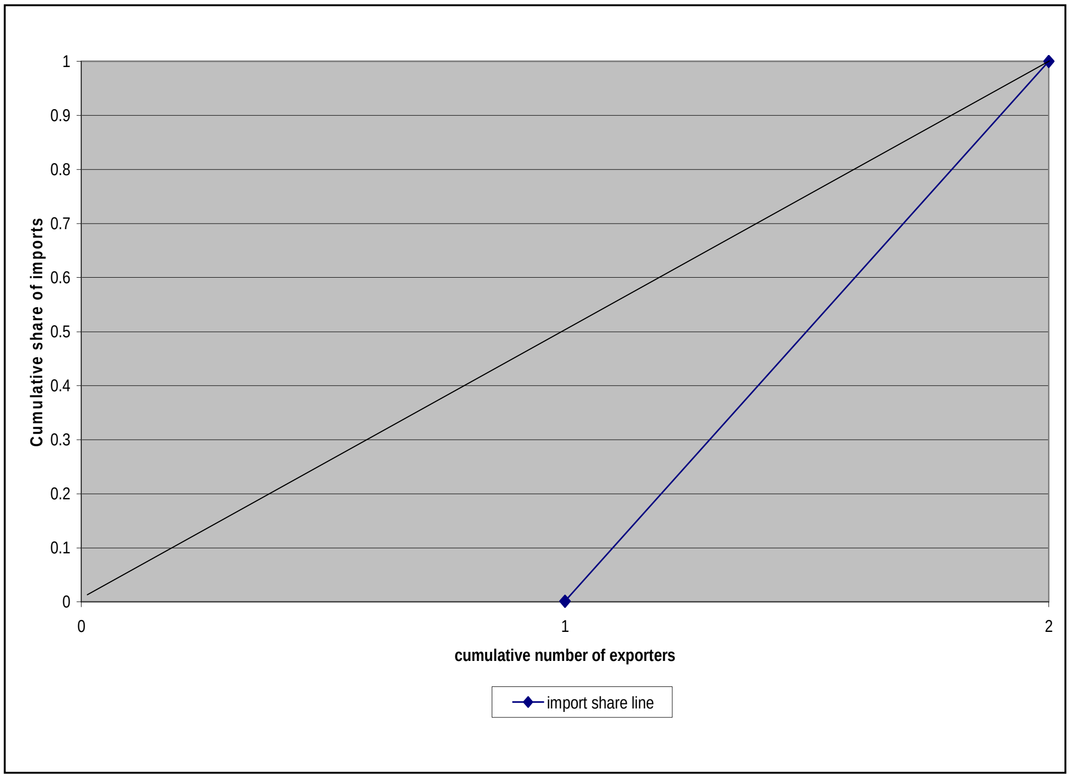

Figure 3.5: Lorenz trade inequality curve: South Africa's imports of soybeans in 2005

3.2.3.6 Imports of sunflower into South Africa

The GINI coefficient for sunflower imports was calculated at 0.642, which also indicates a moderate degree of import concentration. Figure 3.6 shows the relative skewness of South Africa's imports of sunflower in 2005. This reflects the concentration of the share of imports of sunflower between the two large exporters to South Africa. The results show that China and Malawi were the two largest exporters to South Africa in 2005. Fifty per cent of South Africa's sunflower imports came from China alone and 45 percent from Malawi.

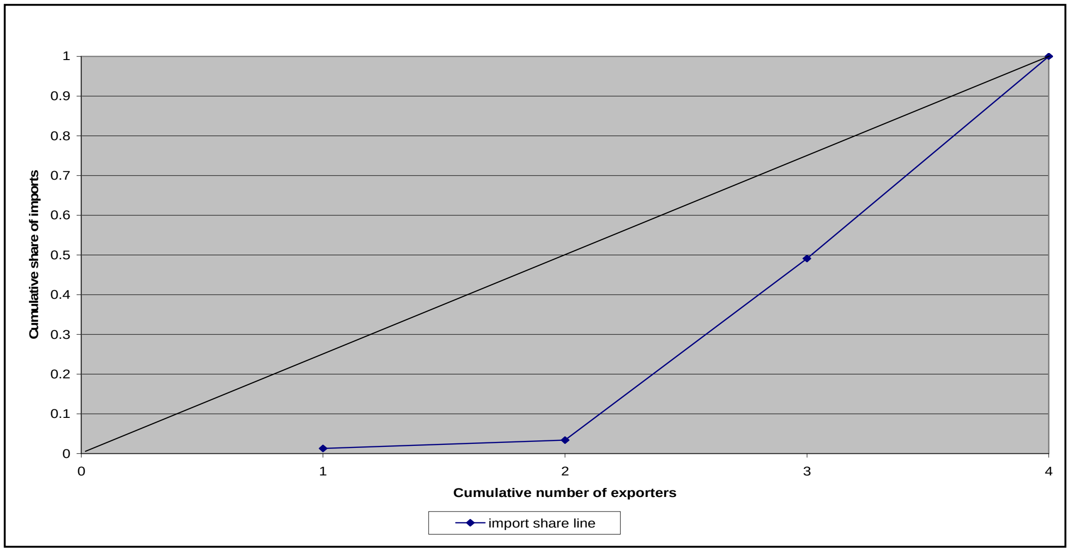

Figure 3.6: Lorenz trade inequality curve: South Africa's imports of sunflower in 2005

3.2.4 Competitiveness of suppliers of selected products to South Africa in 2005

In this section bubble graphs generated from the Trademap database of the ITC are used to analyse the competitiveness of suppliers to the South African market. The bubbles in the respective figures represent the country from where South Africa imported the product with the size of the bubble representing the relative value of overall exports of the country. The diagonal line represents the line of constant world market share, which divides the chart into two parts, viz. growing world market share and growing share in South Africa to the right, and growing world market share and declining share in South Africa to the left. The horizontal axis indicates the annual growth of South Africa's imports from the partner countries between 2001 and 2005. The vertical axis indicates the annual growth in partner countries' exports to the world between 2001 and 2005.

3.2.4.1 Meat of bovine animals (frozen)

Figure 3.7 depicts that Argentina is a dynamic and competitive supplier of this product to South Africa. The reason for this classification is that Argentina experienced a much higher growth in its value of exports than the world average, but at the same time the value of imports from Argentina grew faster than the average growth in the value of imports by South Africa between 2001 and 2005.

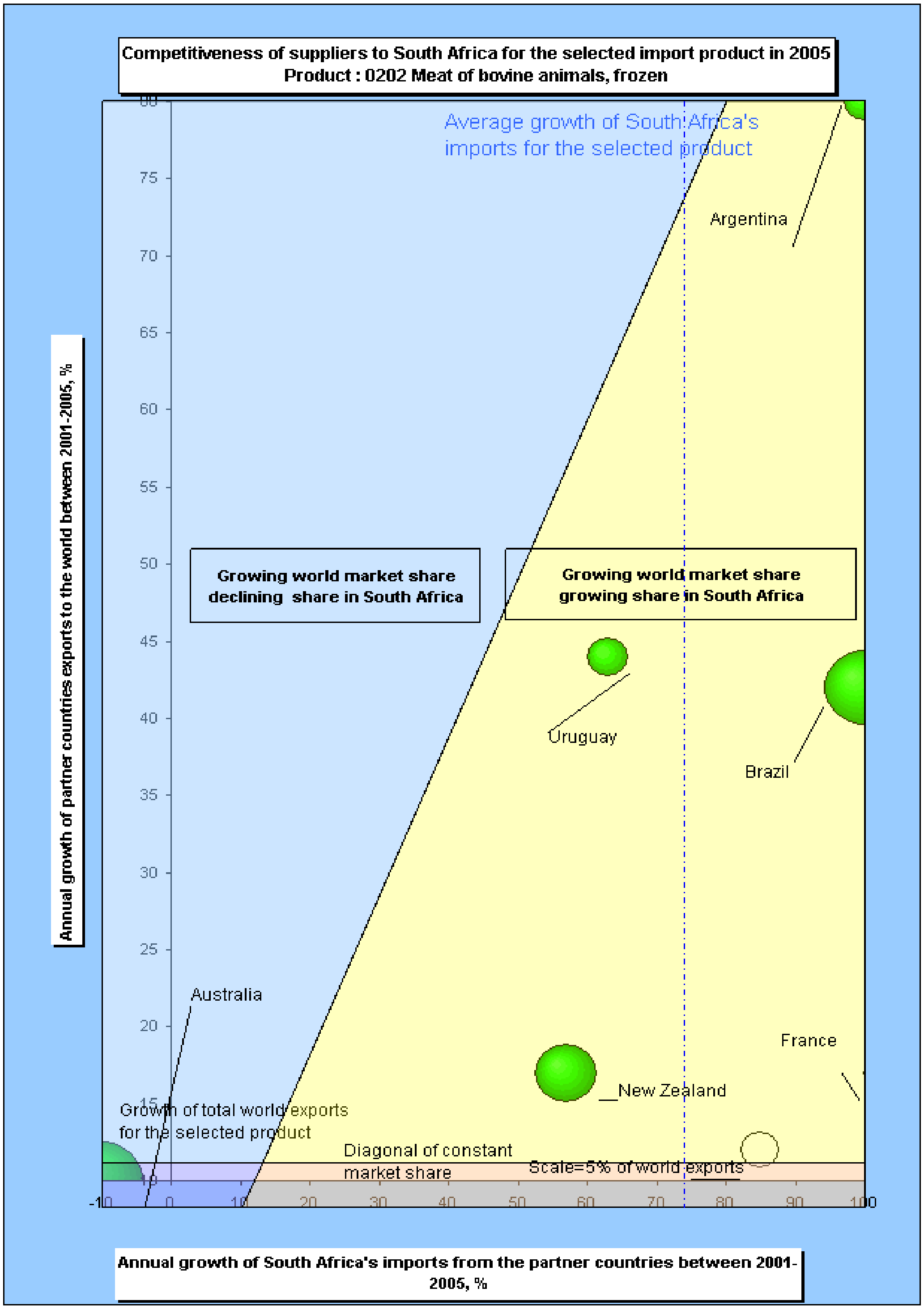

Figure 3.7: Competitiveness of suppliers of the selected import product to South Africa in 2005 (Product: 0202 Meat of bovine animals, frozen)

Source: ITC calculations based on COMTRADE statistics, 2005

Note: Australia is experiencing declining world market share and declining share in South Africa. However, it was not drawn to scale in the diagram.

Argentina experienced 80 percent growth in the value of export of this product to the world market and 100 percent growth in the value of exports to South Africa. Brazil and France also experienced 100 percent growth in the value of exports to the South African market. Both countries also experienced higher growth rates in the value of their exports than the world average. Uruguay and New Zealand also experienced higher growth than the world growth rates and made considerable in roads on the South African market.

3.2.4.2 Meat of swine (fresh, chilled or frozen)

Figure 3.8 shows the most important origins with respect to swine meat. Brazil is regarded as a dynamic and competitive supplier of this product to South Africa. This is due to growth in the value of exports of this product to both the world market and South Africa. It was the largest exporter of this product to South Africa in 2005, experiencing a 100 percent growth in the value of exports to the South African market and a 32 percent growth in the value of exports to the rest of the world. Spain was another dynamic supplier of this product in 2005. The country experienced 100 percent growth in the value of exports to South Africa and 21 percent growth in the value of exports to the rest of the world. The growth in the value of exports by the USA was lower than the world average, while the value of exports to South Africa declined. Denmark, which was ranked number one in the world in 2005, was unable to occupy the same dynamic positions as Brazil and Spain, although it experienced a 96 percent growth in the value of exports to the South African market but a declining growth rate in the value of exports to world market. Therefore, Brazil and Spain were the most dynamic and competitive suppliers of this product to South Africa. Both countries also experienced higher growth rates in the value of their exports than the world average.

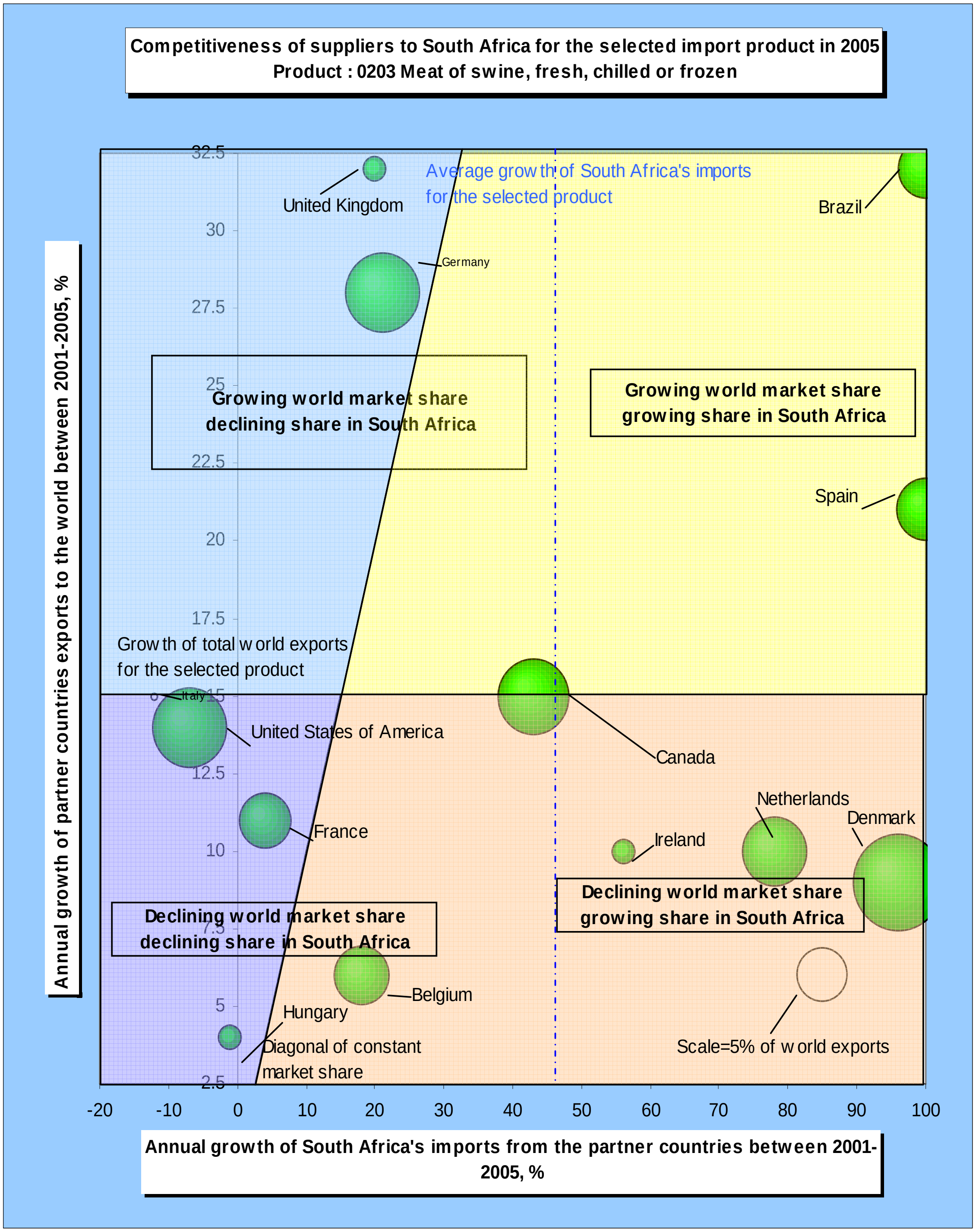

Figure 3.8: Competitiveness of suppliers of the selected import product to South Africa in 2005 (Product: 0203 Meat of swine, fresh, chilled or frozen)

Source: ITC calculations based on COMTRADE statistics, 2005

3.6.4.3 Maize (corn)

Figure 3.9 shows that Argentina was the most dynamic and competitive supplier of this product to South Africa in 2005. Argentina experienced a much higher growth rate in its value of exports than the world average, but at the same time imports from Argentina grew faster than the growth in the value of imports by South Africa between 2001 and 2005. The country experienced 27 percent growth in the value of exports to South Africa and 9 percent growth in the value of exports of this product to the world market. The USA, which was ranked the number-one exporter of this product to the world in 2005, was unable to occupy a dynamic position in South Africa. The growth in the value of exports by the USA was lower than the world average, while the value of exports to South Africa declined. Malawi, which was ranked 79th in the world, experienced 100 percent growth in the value of exports to the South African market but it's growth in the value of exports was lower than the world average.

3.2.4.4 Wheat or meslin

The import trends of all products available are above the world average trend, and therefore it is not possible to produce a bubble graph. Nevertheless, the USA was a dynamic supplier of this product to South Africa in 2005 due to a much higher growth rate in its value of exports than the world average, but at the same time imports from USA grew faster than the growth in the value of imports by South Africa between 2001 and 2005. The country was ranked the number-one exporter of this product in 2005 and it experienced 100 percent growth in the value of exports to the South African market and 9 percent growth in the value of exports of this product to the world market. Australia and Argentina ranked third and fifth respectively, also experienced higher growth than the world growth rates and made considerable in roads on the South Africa market.

3.2.4.5 Soybeans (broken or not broken)

Argentina was a dynamic and competitive supplier of this product to South Africa in 2005 due to a much higher growth rate in its value of exports than the world average, but at the same time imports from Argentina grew faster than the growth in the value of imports by South Africa between 2001 and 2005. The country experienced 100 percent growth in the value of exports to South African and 18 percent growth in the value of exports to the world market. The USA, which was ranked the number-one in the value of exports of this product, has not been able to find its way into South Africa's market.

3.2.4.6 Sunflower

China was a dynamic and competitive supplier of this product to South Africa in 2005 due to a much higher growth rate in its value of exports than the world average, but at the same time imports from China grew faster than the growth in the value of imports by South Africa between 2001 and 2005. The country experienced 100 percent growth in the value of its export to the South African market and 63 percent growth in the value of exports to the world market. Malawi was another dynamic supplier of this product in 2005. It also experienced higher growth than the world growth rates and made considerable in-roads on the South Africa market. France, Hungary and Bulgaria ranked first, second and third respectively in terms of the value of world exports of this product, but have not been able to optimally access the South African market. However, Australia and India experienced higher growth than the world growth rate but a decline in the value of exports to the South Africa market. This situation may change as these countries become more price-competitive.

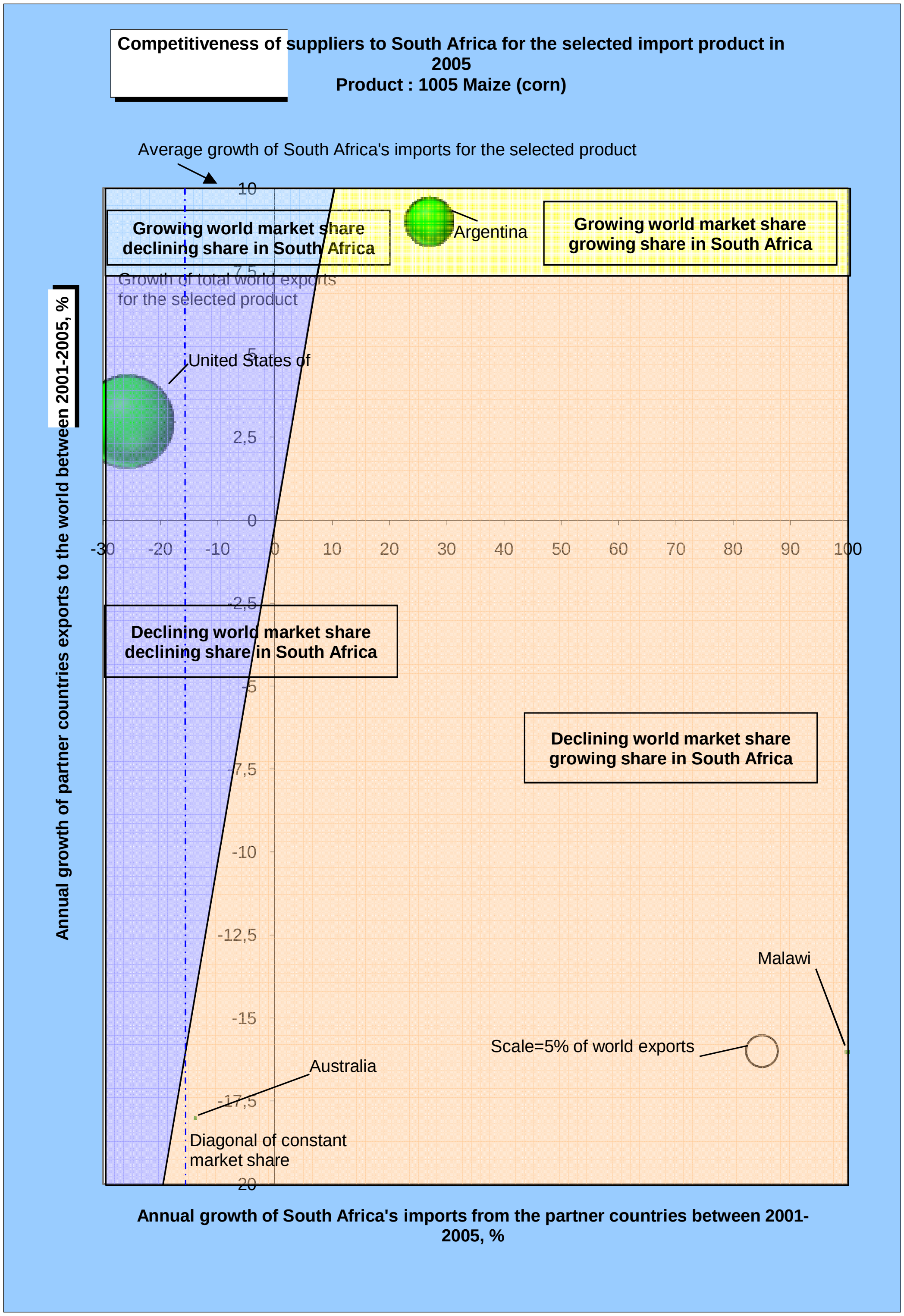

Figure 3.9: Competitiveness of suppliers of the selected import product to South Africa in 2005 (Product: 1005 maize or corn)

Source: ITC calculations based on COMTRADE statistics, 2005

3.3 Conclusion

This chapter provided an overview of the latest trends in trade in the livestock and grain industries of South Africa. South Africa's imports of the products under investigation are highly concentrated. In the beef sector the most dynamic countries from where South Africa imported over the past five years were Argentina, Brazil, France, Uruguay and New Zealand. In the pork industry Brazil and Spain were the most dynamic suppliers to the South African market. In the maize sector the most dynamic countries from where South Africa imported over the past five years were Argentina and Malawi. In the wheat sector, the USA, Argentina and Australia were the most dynamic suppliers to the South African market. Argentina was the most dynamic supplier of soyabeans to South Africa while China and Malawi were the most dynamic suppliers of sunflower to South Africa over the past five years.

CHAPTER 4

METHODOLOGY

4.1 Introduction

The approach proposed by Armington (1969), initially in a partial equilibrium context, has been widely used to evaluate the impacts of changes in trade policy, in partial equilibrium models as well as in general equilibrium models. As mentioned, many CGE trade models adopt an Armington (1969) structure to define demand for domestically produced and imported goods. This structure treats two types of goods as differentiated and, therefore, as imperfect substitutes. In this chapter the modelling framework to estimate Armington elasticities for selected agricultural products in South Africa is discussed.

The mathematical derivation of the Armington equation is discussed in section 4.2. The procedure followed in preparing the data is discussed in section 4.3. In section 4.4 the procedure followed to detect and control outliers is discussed. Statistical properties of the data are discussed in section 4.5. Modelling techniques to estimate Armington elasticities is discussed in section 4.6, while section 4.7 is the summary of the chapter.

4.2 Mathematical derivation of the Armington equation

In modelling trade policy, a standard assumption is that within a product group a representative agent differentiates between domestic and imported goods. The Armington model assumes that products are differentiated solely by origin of the good.

Thus, following Armington (1969) and much of the ensuing literature, it is assumed that consumer utility for goods in a country is separable from consumption of other products and a simple CES sub-utility function is postulated to model demand for domestically produced and imported goods in that country:

$$U = [\beta M^{(\sigma-1)/\sigma} + (1-\beta)D^{(\sigma-1)/\sigma}]^{\sigma/(\sigma-1)} \quad (4.1)$$

Where,

U = sub-utility over the domestic and foreign goods

M = quantity of imported goods

D = quantity of domestic goods

σ = constant elasticity of substitution between domestic and imported goods

β = calibrated parameter in the demand function

Assuming that "ρ" equals price, prices of imports and domestically produced goods are denoted as ρ_M and $\rho_{D.}$ In order to maximise expenditure, prices are made equal to the marginal utility derived from purchasing the associated products so that $\delta U / \delta M = \rho_M$ and $\delta U / \delta D = \rho_D$.

Thus, differentiating equation (4.1) with respect to M and D yields the following:

$$\delta U / \delta M = \sigma /(\sigma - 1)[\beta M^{(\sigma-1)/\sigma} + (1-\beta)D^{(\sigma-1)/\sigma}]^{1/(\sigma-1)}(\sigma - 1/\sigma)\beta M^{(-1)/\sigma}$$

$$= \beta M^{(-1)/\sigma}[\beta M^{(\sigma-1)/\sigma} + (1-\beta)D^{(\sigma-1)/\sigma}]^{1/(\sigma-1)}, \quad (4.2)$$

Also,

$$\delta U / \delta D = \sigma /(\sigma - 1)[\beta M^{(\sigma-1)/\sigma} + (1-\beta)D^{(\sigma-1)/\sigma}]^{1/(\sigma-1)}(\sigma - 1/\sigma)(1-\beta)D^{(-1)/\sigma}$$

$$= (1-\beta)D^{(-1)/\sigma}[\beta M^{(\sigma-1)/\sigma} + (1-\beta)D^{(\sigma-1)/\sigma}]^{1/(\sigma-1)},$$

Given that,

$\delta U / \delta M = \rho_M$ and $\delta U / \delta D = \rho_D$, then ρ_D / ρ_M can be rewritten as:

$$\rho_D / \rho_M = (\delta U / \delta D)/(\delta U / \delta M)$$

$$= (1-\beta)D^{(-1)/\sigma}[\beta M^{(\sigma-1)/\sigma} + (1-\beta)D^{(\sigma-1)/\sigma}]^{1/(\sigma-1)} /[\beta M^{(-1)/\sigma}[\beta M^{(\sigma-1)/\sigma} + (1-\beta)D^{(\sigma-1)/\sigma}]^{1/\sigma-1}]$$

$$= [(1-\beta)D^{(-1)/\sigma}]/[\beta M^{(-1)/\sigma}]$$

$$= [(1-\beta)/\beta][M^{1/\sigma} / D^{1/\sigma}]^{\sigma} \quad (4.3)$$

Rearranging 4.3 gives

$$\begin{aligned} M/D &= (\rho_D/\rho_M)^{\sigma}/[(1-\beta)/\beta]^{\sigma} \\ &= [(\rho_D/\rho_M)^{\sigma}][\beta(1-\beta)]^{\sigma} \\ &= [(\beta/(1-\beta))(\rho_D/\rho_M)]^{\sigma} \end{aligned} \tag{4.4}$$

The first-order condition equates that the rates of substitution and relative prices, as well as the Armington elasticities, can be estimated for disaggregated commodity categories. The first-order condition can be rewritten as:

$$y = a_0 + a_1 x \tag{4.5}$$

Where $y = \ln(M/D)$, $a_0 = \sigma \ln[\beta/(1-\beta)]$, a_1 is the elasticity of substitution between imports and domestic sales, and x represents $\ln(\rho_D/\rho_M)$.

According to Reinert and Roland-Holst (1992) the parameter σ can be interpreted as the compensated price import elasticity of import demand.

4.3 Data used

Data availability was identified as one of the factors hindering the estimation of Armington elasticities for agricultural products in South Africa. Four data series are required to apply equation 4.5. These are real imports, domestic sales of domestically produced goods and the prices of those two groups of goods. These series are not available off-the-shelf in South Africa, but are constructed. Data used for the construction of these series were sourced from the Trade and Industrial Policy Strategies (TIPS), the South African Standardised Industry Indicator Database and the South African Department of Agriculture database. Data on import and export quantities and values was sourced from TIPS, while data on domestic production in real and current terms was sourced from the Department of Agriculture and was already clean of imports. The data is quarterly and of HS 4 classification, from the first quarter of 1995 to the third quarter of 2006.

The series ‘domestic sales of domestically produced goods’ is constructed by subtracting ‘exports’ from total production both in real and current terms. The former is used as the domestic sales series of domestically produced goods. The ratio of constant to current domestically consumed output of domestically produced goods generates a suitable domestic sales price index for each of the products.

In order to deflate import and export series, the Laspeyres index number was computed. A Laspeyres index number is a form of index number where prices, quantities or other units of measure over time are weighted according to their values in a specified base period. This index was used to calculate the real import series using 2000 as the base year as follows:

Let m_{xt} represent the monthly import quantity of the 4-digit HS product *x* in time period *t* with v_i representing the average monthly unit value of product *p* in the year 2000. The real import series is calculated as:

$$M_t = \sum_x v_x \times m_{pt} \tag{4.6}$$

The price series was calculated using the formula:

$$Pm_{xt} = (\sum_x CV_x) / M_{xt} \tag{4.7}$$

Where *CV* represents import value.

The final step in calculating the real import series used in the estimation was to normalise the import quantity series so that the average quarterly 2000 value of M_t equals 1. To get values in constant 2000 terms, this series was then multiplied by the 2000 fourth-quarter value of import to obtain a series of the same magnitude in 2000 as the value of imports for the HS category. Real quarterly exports were constructed using the same procedure as that used for imports.

4.4 Control of outliers

Before estimation, the quantity and price time series are converted to logarithms. Recursive estimates of log-level data were conducted to detect any outliers that may distort the value of the coefficient estimates. Any sizable outliers are controlled for in estimation by including a dummy variable for the year(s) concerned. Thus, the added explanatory variable is given as ‘1’ for the problem year and as ‘0’ otherwise.

This treatment of outliers is preferred over simply dropping the outlier(s), as it retains the full data series for estimation. This process tends to generate equations that are superior over equations that simply omit the distorting years.

4.5 Statistical properties of the data

A time series is stationary if the mean, variance and covariance do not vary systematically over time. Non-stationary series have varying means or time-varying variance. A non-stationary process exhibits random walk and has unit root.

According to Uchezuba (2005), statistical testing of unit root is crucial in the evaluation of the non-stationarity exhibited by most series. This is useful in determining whether the trend component is stochastic through the presence of unit root, or deterministic through the presence of a polynomial trend. An economic series variable is said to contain a deterministic trend if it increases by some fixed rate throughout. On the contrary, the rate of increase or decrease in a stochastic trend is not fixed (Gujarati, 2003), but has the tendency to vary from the average by random amounts (Blake, 1991; Nelson & Plosser, 1982; Stock & Watson, 1988).

Alemu *et al.* (2004) suggest ways of removing trend in economics data. According to them, if a trends is a polynomial function of time, least square is an appropriate technique to de-trend it. If it is stochastic, differencing is the appropriate technique. A series with a deterministic time trend is made stationary by regressing it over time, and the residuals from this regression will then be stationary (Gujarati, 2003). Before the analysis, it is important to first check the statistical properties of the time series to determine the nature of data transformation necessary to perform further statistical analysis.

4.5.1 Unit root test

Dickey and Fuller (1981) developed the Dickey-Fuller (DF) test for unit root. The DF test was constructed on the assumption of independently and normally distributed error terms (Uchezuba, 2005). To allow for the three possibilities, i.e. a random walk process may have no drift, or it may have drift, or it may have both deterministic and stochastic trends, the DF test is estimated in three different forms, i.e. under three different null hypotheses (Gujarati, 2003). Y_t is a random walk, Y_t is a random work with drift, and Y_t is a random walk with drift around a stochastic trend, where t is the time or trend variable. In each case, the null hypothesis is that δ=0; that is, there is a unit root (the time series is not stationary). The alternative hypothesis is that δ is less than zero; that is, the time series is stationary. If the null hypothesis is rejected, it means that Y_t is a stationary time series with zero mean.

The DF test has been criticised on the grounds of its assumption that the error term U_t was uncorrelated. Dickey and Fuller developed another test known as the augmented Dickey-Fuller (ADF) test for a correlated error term. This is conducted by augmenting the DF equations and adding lagged values of the dependent variable ΔY_t (Dickey & Fuller, 1979, 1981; Gujarati, 2003).

Phillips and Perron (1988) used nonparametric statistical methods to take care of the serial correlation in the error terms without adding lagged difference terms, as done by Dickey and Fuller (1981). The Phillips-Perron (PP) test accommodates models with a time trend so that they may be used to discriminate between unit root being non-stationary and stationary about a deterministic trend. However, Gujarati (2003) stated that the asymptotic distribution of the PP and ADF tests are equivalent, but may differ substantially in finite samples due to the different ways in which they correct for serial correlation in the test regression.

The unit root test methods discussed thus far, i.e. DF, ADF and PP, have been criticised on the grounds of the size distortion and power property of the tests (Gujarati, 2003). Gujarati (2003) and Maddala and Kim (1998) observed that the tests suffer from size distortion if the underlying distribution contains a moving average (MA) component. The ADF test displays size distortion in the presence of negative MA or error structure

(Uchezuba, 2005). Researchers usually assume the order of integration to be I(1); if the series is integrated of order I(2) the traditional unit root test will perform poorly. Gujarati (2003) stated, however, that no uniformity power test for a unit root hypothesis exists in the literature.

Despite this criticism, Bamba and Reed (2004) still prefer using the ADF test, because the PP test has less-restrictive assumptions. Engle and Granger (1987) also recommended the ADF test as being the test that exhibits better performance. The ADF test is used in this study, as it is more generally accepted than any other method and it takes into account that serial correlation is prevalent in most time series.

The standard augmented Dickey-Fuller test used to check the statistical properties of the series is expressed as:

$$\Delta\gamma_t = \beta_1 + \beta_2 t + \delta\gamma_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta\gamma_{t-i} + \mu_t \tag{4.8}$$

where μ_t is a white-noise error term and where

$\Delta\gamma_{t-1} = (\gamma_{t-1} - \gamma_{t-2}), \Delta\gamma_{t-2} = (\gamma_{t-2} - \gamma_{t-3}).$

In the ADF tests for unit root in γ_t, namely the quantity ratio and the price ratio, at time *t*, *t* denotes the deterministic time trend and $\Delta\gamma_{t-1}$ are the lagged first differences to accommodate serial correlation in the error term μ_t.

4.5.2 Test for long-run relationships amongst variables

The concept of co-integration was introduced by Granger (1981) and analysed by Engle and Granger (1987). It is a concept for modelling equilibrium or long-run relations of economic variables. Two variables will be co-integrated if they have a long-run relationship (Gujarati, 2003). Co-integration analysis ensures that deviations from equilibrium conditions between two economic variables that are individually stationary in the short run should be stationary in the long run. If two or more series are themselves non-stationary, but a linear combination of them is stationary, then the series are said to be co-integrated. Co-integration techniques offers a means of identifying and hence avoiding spurious regression associated with non-stationary time series.

Therefore, estimating the co-integration relationship is necessary to reveal the existence of long-run relationships and to avoid spurious regression analysis (Gujarati, 2003).

The Johansen multivariate test of co-integration is used to establish long-run relationships among variables. The Johansen test takes into account the number of co-integrating relationships among co-integrating variables. The test is based on the notion that economic variables are much more likely to be endogenously interdependent. Determining the number of co-integrating vectors will provide insight into the number of estimation equations to be fitted. Even though more than one co-integrating relationship might exist, the presence of at least one co-integration relationship is necessary for the analysis of long-run relationships of the quantity and price ratios.

The Johansen test utilises two test statistics for statistics formulations, namely eigenvalues and trace statistics. This is a maximum likelihood ratio test involving a reduced rank regression between two variables, say I(1) and I(0), providing *n* eigenvalues $\hat{\delta}_1 > \hat{\delta}_2 > \ldots \hat{\delta}_n$ and corresponding eigenvector $\hat{\nu} = (\hat{\nu}_1, \ldots, \hat{\nu}_n)$, where the r elements of $\hat{\nu}$ are the co-integration vectors. The magnitude of δ_i is a measure of the strength of correlation between the co-integrating relations for $i = 1 \ldots r$. The test of the null hypothesis that there are *r* co-integrating vectors present can be stated as:

$H_0 : \delta_i = 0 \quad i = r + 1 \ldots\ldots\ldots, n$

The maximal eigenvalue (δ – max) statistics are given by:

$$\delta_{max} = -T\log(1 - \hat{\delta}_{r+1}) \qquad r = 0, 1, 2, \ldots, n-1 \tag{4.9}$$

where T is the sample size, and $(1 - \hat{\delta}_{r+1})$ is the max-eigenvalue estimate.

The trace statistics are computed as:

$$\delta_{trace} = -T \sum_{i=r+1}^{n} \log(1 - \hat{\delta}_i) \qquad r = 0, 1, 2, \ldots, n-1. \tag{4.10}$$

Testing the null hypothesis of *r* co-integrating against the alternative of *r + 1*.

Other methods include Box-Tiao, the principal component method, and the Engle and Granger two-step method. The Engle and Granger method has two main disadvantages.

Firstly, the estimation of the long-run relation independently from the short-run influences introduces the possibility of misspecification, and short-run influences are not dealt with when estimating the long-run relation. Secondly, Engle and Granger's method requires that one of the variables is selected as the endogenous variable (De Jong, 1997). Masih and Masih (2000) noted that the Engle-Granger approach assumes *a priori* the existence of at most a single co-integrating vector rather than testing for the number of co-integrating relationships.

4.6 Modelling techniques to estimate Armington elasticities

Gallaway *et al.,* (2003) specified three different equations that can be used to estimate Armington elasticities based on the time series properties of the data series employed per product. The three models are: geometric lag model, single equation error correction model and ordinary least square model. Each of these models is subsequently discussed.

4.6.1 Geometric lag model

Firstly, for products having stationary log-level data, a parsimonious geometric lag model will be estimated, because it can be used to easily extract both short-run and long-run elasticity estimates. The model is specified as:

$$y_t = \alpha + \beta_0 x_t + \lambda y_{t-1} + b_2 D_2 + b_3 D_3 + b_4 D_4 + v_t \quad (4.11)$$

Where y and x are the goods and price ratios, respectively, and v_t represents an independently and identically distributed (*iid*) error term. Furthermore, in order to reflect the seasonality characteristics of agricultural products, dummies are included in the specification of the Armington equation, and where time variable is found to be important it is also included. There are four quarters in a year, and to avoid the dummy trap three dummy variables (D_2, D_3 and D_4) are added. A dummy variable takes a value of '1' for the particular quarter and '0' otherwise. Where these dummies are found not to be significant they are removed from the regression analysis. D_2, D_3 and D_4 are dummy variables representing the second, third and fourth quarters of the year. Long-run elasticity estimates can be estimated as $\beta_0/(1-\lambda)$ if $0 < \lambda < 1$; otherwise the reported elasticities are β_0.

4.6.2 Error correction model

When the series are both I(1) and co-integrated, a single equation error correction model of the following form is estimated to extract the long-run elasticity estimates:

$$\Delta y_t = \alpha + \beta_0 \Delta x_t + \beta_1 y_{t-1} + \beta_2 x_{t-1} + b_2 D_2 + b_3 D_3 + b_4 D_4 + v_t \qquad (4.12)$$

Where $\Delta y_t = y_t - y_{t-1}$ and v_t represents an (iid) error term. D_2, D_3 and D_4 are dummy variables and were specified earlier. This model allows the short- and long-run responses of demand with respect to price to be determined. Short-run elasticity estimates are β_0 and long-run elasticity estimates are ($\frac{-\beta_2}{\beta_1}$).

4.6.3 Ordinary least square

When only one of the series was stationary, the variables were first differenced for stationarity and an ordinary least square regression was estimated:

$$\Delta y_t = \alpha + \beta_0 \Delta x_t + b_2 D_2 + b_3 D_3 + b_4 D_4 + v_t \qquad (4.13)$$

where β_0 is the short-run Armington elasticity and D_2, D_3 and D_4 are dummy variables as specified earlier. This equation does not yield long-run values, because there is no long-run relationship between the goods and the price ratio series.

4.7 Conclusion

This chapter discussed the derivation of the Armington equation, data sources and the methods for investigating the time series properties of the time series data, as well as the long-run relationship of time series data. Based on the time series properties of the data, three different models can be estimated. For an industry having stationary log-level data, a parsimonious geometric lag model is estimated because it can be used to extract both the short-run and long-run elasticity estimates. When the data are both I(1) and co-integrated, a single error correction model is estimated to extract both the short-run and long-run elasticities. Finally, when only one series is stationary, the variables are first differenced for stationarity and ordinary least square regression is estimated. Empirical results of the analysis are presented in chapter five.

CHAPTER 5

APPLICATION OF THE ARMINGTON MODEL TO SELECTED AGRICULTURAL PRODUCTS IN SOUTH AFRICA

5.1 Introduction

This chapter describes the application of Armington's (1969) specification to extract both short-run and long-run Armington elasticities for selected agricultural products in South Africa. The chapter is structured as follows: Section 5.2 presents the products considered and their HS classification. Section 5.2.1 discusses the results of the ADF test for unit roots, followed by section 5.2.2, which discusses the Johansen co-integration test. Control of outliers and structural breaks is discussed in section 5.2.3. Estimated elasticities are presented in section 5.3, while section 5.4 concludes the chapter.

5.2 Products and statistical properties of the variables

A review of the literature revealed that Armington elasticities do not exist for the major agricultural products in South Africa. Table 5.1 presents the selected agricultural products considered in this study and their HS classification.

Table 5.1: Selected agricultural products and their HS classification

HS classification	Description
0201	Meat of bovine animals, fresh or chilled
0202	Meat of bovine animals, frozen
0203	Meat of swine, fresh, chilled or frozen
1005	Maize (corn)
1001	Wheat and meslin
1201	Soybeans, broken or not broken
1206	Sunflower seeds, broken or not broken

5.2.1 Unit root test

According Gujarati (2003), the data and its characteristics fulfil a central role in econometric analysis. Models that contain non-stationary variables will often result in spurious regression, i.e. indicating the existence of statistically significant relationships where there are none. The test applied in this study is known as the augmented Dickey - Fuller (ADF) test.

Table 5.2 reports the ADF test statistics for the variables to be employed in the analysis. Ordinary least square regression of the variables was first done to ascertain the importance of time trend in the variables and is included where important. Variables that are stationary in the level are said to be of order I(0), while those that are stationary at first difference are of order I(1).

The following hypothesis can be tested for each variable:

H_0: There is unit root

$H_{1:}$ There is no unit root

If the test statistics are smaller than the critical value, H_0 is accepted and the series is said to be non-stationary. On the other hand, if the test statistics are greater that the critical value, H_0 is rejected and it can be accepted that the series is stationary. From Table 5.1 the ADF test confirmed non-stationarity in all the price variables except product 1005 (maize or corn), while two of the quantity series (1005 and 1201) are stationary on levels. All the other variables not stationary in levels are stationary on first difference. So it can be concluded that the majority of the variables are of order I (1), i.e. stationary at first difference.

Table 5.2: Test statistic for unit roots in variables

HS Code	Series	Levels	95% critical value	1st difference	95% critical value
0201					
	LNY	-2.3737	-2.9287	-3.1074*	-2.9339
	LNX	-1.6645	-2.9287	-3.1212*	-2.9358
0202					
	LNY	-1.7012	-2.9339	-4.2229*	-2.9320
	LNX	-1.9461	-2.9339	-2.9523*	-2.9339
0203					
	LNY	-2.5548	-3.5126	-8.1903*	-3.5162
	LNX	-2.3950	-2.9320	-3.1063*	-2.9320
1005					
	LNY	-3.5322*	-2.9303	-3.7357*	-2.9339
	LNX	-3.4421*	-2.9339	-3.5010*	-2.9339
1001					
	LNY	-1.9835	-2.9303	-13.9963*	-2.9303
	LNX	-2.6625	-2.9339	-6.2698*	-2.9303
1201					
	LNY	-4.1276*	-3.5136		
	LNX	-1.7345	-3.5217	-5.2571*	-3.5162
1206					
	LNY	-1.6201	-2.9303	-4.7803*	-2.9303
	LNX	-2.4206	-2.9320	-6.9531*	-2.9303

Asterisk indicates statistical significance at 5%
Note: Y represents quantity variable and X price variable.

5.2.2 Co-integration analysis

Since most of the variables are tested to be I(1), ordinary least square (OLS) is no longer a valid method of estimation, as it can generate spurious regression estimates. Co-integrating relations in the quantity and price series were analysed using the Johansen co-integration test procedure. The test was to confirm the existence of single or multiple co-integrating relations. The test is a maximum likelihood ratio test based on a maximum eigen value and trace of the stochastic matrix in the vector autoregression.

Using eigen value, the hypothesis that $r = 0$ was tested against the alternative where $r = 1$. In the trace, the hypothesis of $r = 0$ against the alternative of $(r + 1)$ co-integrating vector was tested. A combined test of the null hypothesis of $r = 1$ against the alternative of $r > 1$ using eigen value and trace statistics was also considered. Table 5.3 shows that there is co-integration in all the I(1) variables. Co-integration in quantity I(1) and price I(1) series was the only relation tested for.

Table 5.3: Results of co-integration test

Product	Test	Test statistics	95% critical value	90% critical value
0201 LNY - LNX	Max eigen value test r = 0	15.5109*	14.8800	12.9800
	Trace r = 0	21.4239*	17.8600	15.7500
	Max eigen value and trace test: r=1	5.9129	8.0700	6.5000
0202 LNY - LNX	Max eigen value test r = 0	20.2249*	14.8800	12.9800
	Trace r = 0	23.8193*	17.8600	15.7500
	Max eigen value and trace test: r=1	3.5944	8.0700	6.5000
0203 LNY - LNX	Max eigen value test r = 0	24.4991*	19.2200	17.1800
	Trace r = 0	29.7079*	25.7700	23.0800
	Max eigen value and trace test: r=1	5.2088	12.3900	10.5500
1001 LNY - LNX	Max eigen value test r = 0	45.8349*	14.8800	12.9800
	Trace r = 0	58.6832*	17.8600	15.7500
	Max eigen value and trace test: r=1	12.8483*	8.0700	6.5000
1206 LNY - LNX	Max eigen value test r = 0	76.4674*	14.8800	12.9800
	Trace r = 0	87.1588*	17.8600	15.7500
	Max eigen value and trace test: r=1	10.6913*	8.0700	6.5000

Asterisk indicates statistical significance at 5%

5.2.3 Control of outliers

A recursive estimate of OLS regression of log-level data was performed to detect outliers in the series. Taljaard (2003) used the same method to detect breaks in the demand for meat in South Africa. This method has been widely used to serve two purposes, namely to correct for possible outliers in regression analysis and to account for structural breaks that might have occurred in an economy. When points identified do not correspond to any important date for products they are regarded as outliers, dummy variables are used to represent these years instead of removing them totally. Deregulation of the agricultural sector took place in South Africa in 1997. To account for this important year, a dummy variable is also introduced in the regression equation. In addition when residuals leave the second standard error band in a specific quarter, dummy variables are introduced into the equation for the specific quarter. Appendix A shows all the recursive estimates of residuals for the different products considered.

5.3 Estimation results

The estimated short-run and long-run Armington elasticities for the selected agricultural products are presented in Table 5.4. Also reported in Table 5.4 are some important diagnostic tests conducted to ensure consistency of parameter estimates. The Langrange multiplier test for serial correlation confirms that the null hypothesis of no serial residual autocorrelation cannot be rejected for meat of swine (fresh, chilled or frozen) or soybeans (broken or not broken). The Cochrane-Orcutt iterative procedure was applied to correct for the first-order autocorrelation. The method converged after 5 iterations for meat of swine (fresh, chilled or frozen) and 3 iterations for soybeans (broken or not broken). The heteroscedasticity test based on the regression of squared residuals on square fitted values was also conducted. The null hypothesis of no heteroscedasticity was accepted for all the equations estimated.

The price series in the Armington equation is inverted, thus the elasticity estimates are positive. All products considered in this study have a significant Armington elasticity at the 10 percent level of significance. All the products except soybeans have short-run and long-run elasticities (note that soybean is the only product for which equation 4.13 was used).

Equation 4.11 was estimated for maize, while equation 4.12 was estimated for the other products. Short-run Armington elasticities range from 0.60 to 3.31, while long-run elasticities range from 0.73 to 3.21.

According to Kapuscinski and Warr (1999), the higher the value of this parameter, the closer the degree of substitution In other words, a high value of this parameter means that imports and domestic supplies are considered by purchasers to be virtually identical; they would be exactly identical if the parameter was infinite. On the other hand, a low value of the parameter means that the two products are dissimilar or, equivalently, that they are weak substitutes. This means that South African products with high Armington elasticities are virtually identical to what is available in the rest of the world, while those with low values are dissimilar.

Table 5.4: Short and long-run Armington elasticity estimates for agricultural products in South Africa

HS	Eq	Estimate		R^2	Adj R^2	DW Stat	Quarterly Dummies			Serial Correlation	Heterosce-dasticity
		Short-run	Long-run				D_2	D_3	D_4		
0201	4.12	3.07 (0.000)	2.24 (0.000)	0.78	0.77	1.96	-	-	-	0.1573 (0.959)	0.2155 (0.645)
0202	4.12	1.21 (0.033)	3.21 (0.000)	0.36	0.31	1.94	-	-	-	0.9664 (0.437)	1.2749 (0.265)
0203	4.12	0.60 (0.058)	0.73 (0.000)	0.61	0.56	2.01	-	-	0.5834 (0.000)	2.2197 (0.086)	0.1292 (0.721)
1005	4.11	2.03 (0.000)	2.75 (0.000)	0.78	0.76	1.87	-2.6452 (0.000)	-1.5245 (0.22)	-	1.5420 (0.210)	0.3216 (0.574)
1001	4.12	1.10 (0.000)	0.81 (0.000)	0.94	0.92	1.86	2.2333 (0.000)	2.1054 (0.016)	-2.3384 (0.012)	0.5480 (0.702)	1.1025 (0.299)
1201	4.13	3.31 (0.000)	-	0.83	0.81	1.93	-6.3065 (0.000)	3.6016 (0.002)	-	5.3066 (0.002)	1.4221 (0.239)
1206	4.12	1.84 (0.000)	2.24 (0.000)	0.92	0.90	1.95	-1.6335 (0.038)	3.0823 (0.002)	4.1396 (0.000)	0.0853 (0.978)	0.9902 (0.325)

Note: p- values are in brackets

The estimated Armington elasticities for meat of bovine animals (fresh or chilled) are 3.07 and 2.24 for the short and long run respectively. This means that all things being equal, if the world price of meat of bovine animals (fresh or chilled) increases by 1 percent then the quantity of this product imported by South Africa from its trading partners will drop by 3.07 percent in the short run and by 2.24 percent in the long run. In the same vein, if the world price is reduced by 1 percent, the quantity of the product imported will increase by 3.07 percent in the short run and by 2.24 percent in the long run. This product is considered to be a very sensitive product based on its Armington elasticity value. The other Armington elasticities can be interpreted in the same way.

Considering the long-run elasticity result, meat of bovine animals (frozen) is the most import-sensitive product followed by maize, meat of bovine animals (fresh or chilled) and sunflower seed, while wheat and the meat of swine (fresh, chilled or frozen) are the least import-sensitive products.

With regard to short-run elasticity, soybean is the most import-sensitive product followed by meat of bovine animals (fresh or chilled), while the meat of swine (fresh, chilled or frozen) is the least import sensitive. Economic intuition predicts that if the number of product varieties in an economy is high, which may be due to a liberal trade regime or developed industrial structure, the (absolute value of) import demand elasticity will be high as well (Thomakos & Ulubasoglu, 2002). This is due to the fact that when consumers are faced with high import prices for a certain product they can easily switch to other commodity types, whether imported or domestic.

More specifically, following Tourinho *et al.* (2003), the estimated Armington elasticity can be classified as very high, high, average, low, null and wrong sign. The elasticity and classification is presented in Table 5.5. Based on this classification, it can be concluded that the long run Armington elasticities for meat of bovine animals (frozen) is very high. Meat of bovine animals (fresh or chilled), maize (corn) and sunflower seeds (broken or not broken) have high Armington elasticities. Wheat and meslin and meat of swine (fresh, chilled or frozen) have average Armington elasticities. All the estimated elasticities are significant and with the correct signs.

Table 5.5: Classification of Armington elasticities (Long run elasticities)

Elasticity	**Qualification**	**Product**
Larger than 3	Very high	0202(Meat of bovine animals, frozen)
Between 1.5 and 3	High	0201(Meat of bovine animals, fresh or chilled), 1005(Maize (corn), 1206(Sunflower seeds, broken or not broken)
Between 0.5 and 1.5	Average	1001(Wheat and meslin), 0203(Meat of swine, fresh, chilled or frozen)
Less than 0.5	Low	None
Non-significant	Null	None
Negative	Wrong sign	None

Also reported in Table 5.4 are the dummy variables representing seasonality. Dummy variables for livestock products are found to be statistically not significant, with the exception of quarter four for meat of swine (fresh, chilled or frozen). However, the dummy variables for the grain products are statistically significant. This suggests that seasonality is an important factor in determining import demand for grain products. The dummy variables included to control for outliers were not significant, nor were the dummy variables included for trade liberalisation, and therefore they were not included in the final result.

5.4 Conclusion

In this chapter the model discussed in chapter four was applied to estimate short-run and long-run Armington elasticities for selected agricultural products in South Africa. Different econometric models were used for the different agricultural products included in the study. The most appropriate model was determined according to the statistical characteristics of the time series.

All the products considered in this study have a significant Armington elasticity at 10 percent level of significance. All the products except soybeans have short-run and long-run elasticities. Short-run Armington elasticities range from 0.60 to 3.31, while long-run elasticities range from 0.73 to 3.21. Long run Armington elasticities for meat of bovine animals (frozen) is very high. Meat of bovine animals (fresh or chilled), maize (corn) and sunflower seeds (broken or not broken) have high Armington elasticities. Wheat and meslin and meat of swine (fresh, chilled or frozen) have average Armington elasticities. All the estimated elasticities are significant and with the correct signs.

CHAPTER 6

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The primary objective of this study was to estimate Armington elasticities for selected agricultural products in South Africa. The products considered in the study, as specified under the harmonised system, were meat of bovine animals (fresh or chilled), meat of bovine animals (frozen), meat of swine (fresh, chilled or frozen), maize or corn, wheat and meslin, soybeans (broken or not broken), and sunflower seeds (broken or not broken).

Estimates of Armington elasticities are not available for agricultural products in the majority of countries, South Africa included, despite the importance of including Armington elasticities when evaluating the impact of trade policies when using partial or general equilibrium models. One frequently encounters studies in this area where researchers use Armington elasticity estimates for other countries as proxies to substitute for the required Armington elasticities of their own country, in many cases completely disregarding the important differences that may exist in the structure of production and consumption between foreign countries and their home country.

Armington elasticities can be estimated using validation and econometric approaches. The combination of the two approaches leads to another approach called the *'entropy-based'* approach. The validation approach has been criticised on the grounds of the fact that the approach makes very limited use of historical data and provides no statistical basis for judging the robustness of estimated parameters. The entropy-based approach has been criticised because the results are dependent on an *'entropy ratio'* statistic, which is known to have weak predictive power.

The validation approach has been criticised on the grounds of the fact that the approach makes very limited use of historical data and provides no statistical basis for judging the robustness of estimated parameters. The entropy-based approach has been criticised because the results are dependent on an *'entropy ratio'* statistic, which is known to have weak predictive power. The econometric approach is preferred, because most CGE models source their elasticity parameters from econometric estimates. Such estimates give the impression of being more rigorously tested to a certain level of statistical accuracy.

Under the econometric approach, several functional forms can be used. Three important functional forms that are widely used in the literature are the log linear specification, the almost ideal demand system, and the constant elasticity of substitution (Armington) specification. According to the choice of the CES functional form, there are two different specifications, namely nested constant elasticity of substitution and non-nested elasticity of substitution. The non-nested Armington elasticity is preferred, because it relates a country to the rest of the world. For general simulations, the advantages of using CES forms are that it obeys regularity conditions such as global concavity and that it requires only one estimated parameter. The CES form is also identical to the general equilibrium model specification. The main advantage of the Armington approach is its parsimony with respect to parameters to be estimated while retaining compatibility with demand theory. As a result of this the econometric, non-nested Armington specification and the CES functional form were used in the study.

Based on the time series properties of the data, three different econometric models were estimated, namely the geometric lag model, the single error correction model, and the log linear model. For products having stationary log-level data, a parsimonious geometric lag model was estimated to easily extract both short-run and long-run elasticities. When both series are I (1) and co-integrated, a single equation error correction model is estimated to extract both short-run and long-run elasticities. When only a single series was stationary, the variable was first differenced for stationarity and ordinary least square regression was estimated. Dummy variables were included to take care of seasonality of agricultural products and structural breaks.

6.2 Summary of the findings of the study

6.2.1 South Africa's red meat trade

Between 2001 and 2005 South Africa was a net importer of the red meat products considered in this study. South Africa experienced positive growth in imports of meat of bovine animals (fresh or chilled), as well as meat of bovine animals (frozen) in terms of value and quantity. Positive growth was also experienced for the imports of meat of swine (fresh, chilled or frozen), for both quantity imported and value of imports.

The study also employed Lorenz curves and GINI coefficients to measure the concentration in meat imports by South Africa. The imports of beef and pork products by South Africa are highly concentrated. Over 78 percent of South African imports of beef in 2005 originated from Brazil and Argentina, with a GINI coefficient of 0.822. In the case of pork, over 86 percent of South African imports came from Belgium, Brazil and France, with the GINI coefficient in 2005 at 0.841.

The competitiveness of suppliers was analysed using bubble graphs. The results show that between 2001 and 2005 Argentina, Brazil, France, Uruguay and New Zealand were the dynamic and competitive suppliers of meat of bovine animals (frozen) to South Africa. For swine meat, Brazil and Spain were regarded as the dynamic and competitive suppliers to South Africa.

6.2.2 South Africa's grain trade

South Africa experienced negative growth in maize imports in terms of value and quantity between 2001 and 2005. This is due to the fact that the country is mainly a net exporter of the product in many production seasons. Positive growth in terms of quantity imported and value of imports was experienced for wheat and meslin, and sunflower seed, while soybeans experienced negative growth in the quantity of imports between 2001 and 2005.

Lorenz curves and GINI coefficients were also used to measure the concentration in grain imports by South Africa. Over 98 percent of South African imports of maize (corn) in 2005 originated from Argentina and the USA, with a GINI coefficient of 0.982.

In the case of wheat, over 94 percent of South Africa's imports in 2005 came from four countries, namely Argentina, the USA, Germany and Australia. South African imports of soybeans were concentrated mainly from Argentina in 2005. Argentina accounted for 99 percent of the imports of soybans into South Africa. China and Malawi were the two largest exporters of sunflower seed to South Africa in 2005. China accounted for 50 percent and Malawi 45 percent of the imports of sunflower seed to South Africa in 2005.

The competitiveness of suppliers was also analysed using bubble graphs. The result shows that Argentina and Malawi were the dynamic and competitive suppliers of maize to South Africa in 2005. For wheat or meslin, the USA, Australia and Argentina were the dynamic and competitive supplier to South Africa in 2005. Argentina was a dynamic and competitive supplier of soybeans to South Africa in 2005. China and Malawi were the dynamic and competitive suppliers of sunflower to South Africa in 2005.

6.2.3 Summary of estimation results

All the products considered in this study have significant Armington elasticities at 10 percent level of significance. All the products, with the exception of soybeans, have short-run and long-run Armington elasticities. Short-run Armington elasticities range from 0.60 to 3.31 and long-run elasticities range from 0.73 to 3.21. Considering the long-run elasticity results, meat of bovine animals (frozen) is the most import-sensitive product followed by maize, meat of bovine animals (fresh or chilled) and sunflower seed, while wheat and the meat of swine (fresh, chilled or frozen) are the least import-sensitive products. With regard to short-run elasticities, soybeans is the most import-sensitive product followed by the meat of bovine animals (fresh or chilled), while the meat of swine (fresh, chilled or frozen) is the least import-sensitive product.

The study also considered seasonality of agricultural products by including dummy variables in the estimated equations. Dummy variables for livestock products were found to be statistically insignificant, except for quarter four for meat of swine (fresh, chilled or frozen). However, the dummy variables for the grain products are statistically significant. This suggests that seasonality is an important factor in determining import demand for grain products. The dummy variables included to control for outliers were not significant, nor were the dummy variables included for trade liberalisation.

The value of this research is that the estimated Armington elasticities will allow researchers to evaluate more precisely the economic impacts of trade liberalisation and changes in tariffs, as well as other trade policies, in partial and general equilibrium models that include South African agriculture.

6.3 Recommendations for further study

Further research into the following aspects is necessary:

- **Estimation of Armington elasticities for other agricultural products:** This study has been able to provide estimates for seven agricultural products in South Africa. It is however recommended that Armington elasticities for other agricultural products that have a relatively high trade percentage relative to domestic production are also estimates using a similar methodological approach. In addition, such a study should take note that this study have not considered stocks as part of the aggregate availability of grains due to data limitations, but future studies should attempt to include stocks as it could potentially influence the "willingness" to import. Also, shifts in trade regimes, i.e. moving from being an importer to an exporter and vice versa, should be addressed in more detail.

- **Modelling trade in processed food products:** The majority of the studies applying the Armington model to agricultural trade deal mainly with bulk commodities. Trade modeling in processed food products has received little attention. These set of products are important because of their differentiated nature and the growing importance of these products in world trade. It is therefore important that further research be done in this area.

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APPENDIX A

Recursive estimates of residuals for the different products considered

Figure A1 indicates that in the case of meat of bovine animals (fresh or chilled) the residuals passed the 2 standard error band in the fourth quarter of 1998, the first quarter of 2000, the second quarter of 2001, and the third quarter of 2003. Dummy variables are introduced into the equation for each of the quarters.

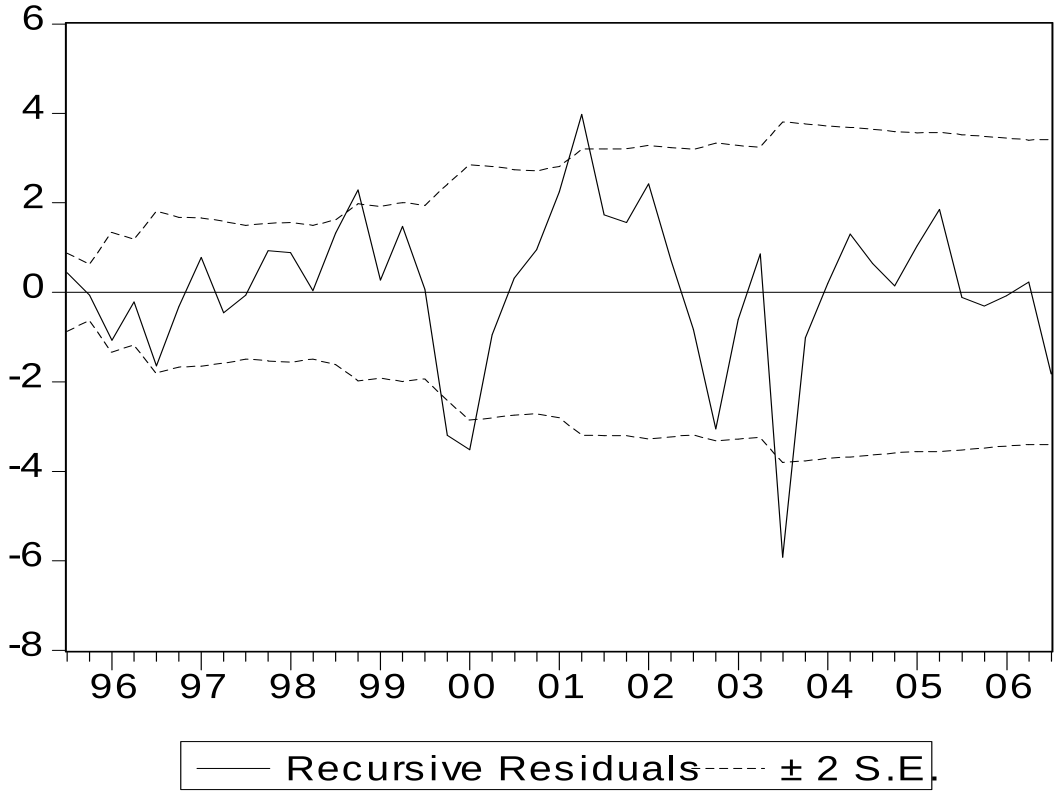

Figure A1: Recursive estimates of residual for meat of bovine animals (fresh or chilled)

The residual plot for meat of bovine animals (frozen) is shown in Figure A2. The residuals for the first quarter of 1998, the second quarter of 2002 and the fourth quarter of 2003 passed the 2 standard error band. Dummy variables are introduced into the equation for each of these quarters.

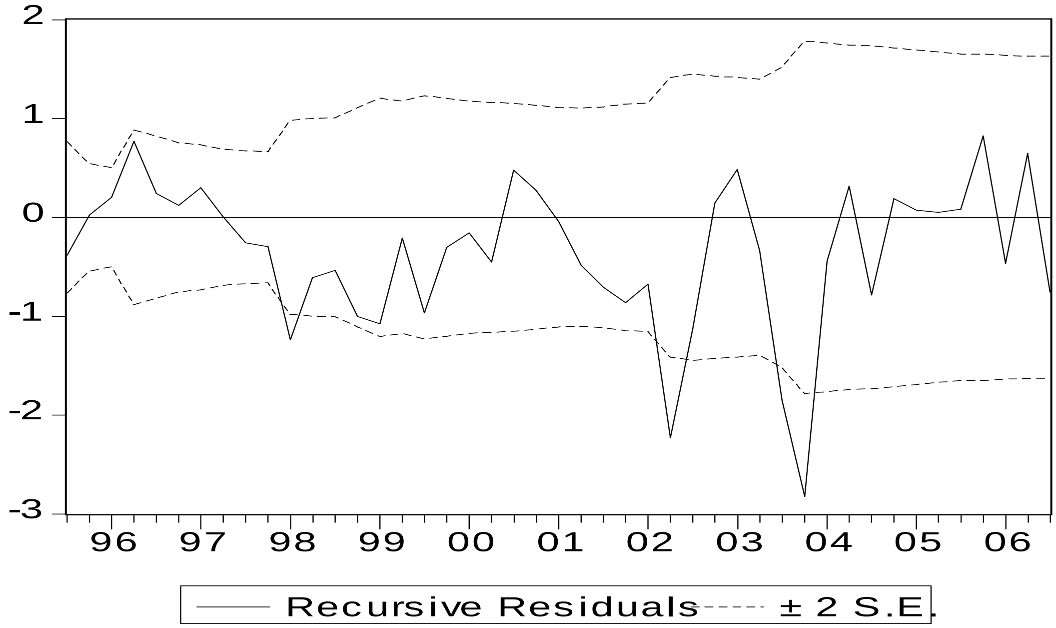

Figure A2: Recursive estimates of residual for meat of bovine animals (frozen)

The residual plot for meat of swine (fresh, chilled or frozen) is presented in Figure A3. The residual for the second quarter of 2005 passed the 2 standard error band and a dummy variable is introduced for that quarter.

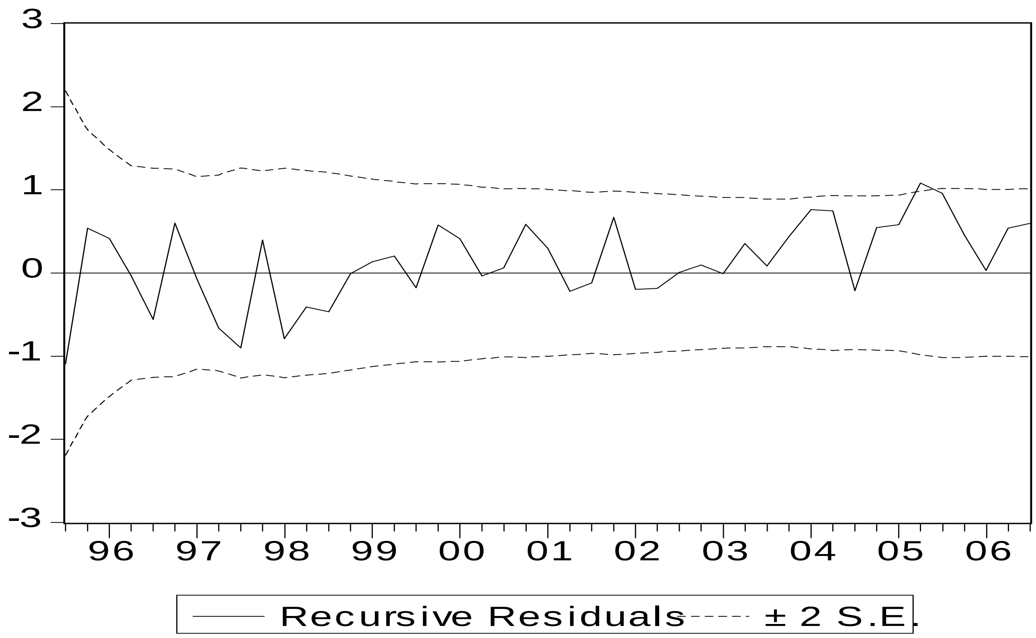

Figure A3: Recursive estimates of residual for meat of swine (fresh, chilled or frozen)

Figure A4 indicates the residual plot for maize (corn). The residual passed the 2 standard error band in the first quarter of 2000 and a dummy variable is introduced for this quarter in the equation.

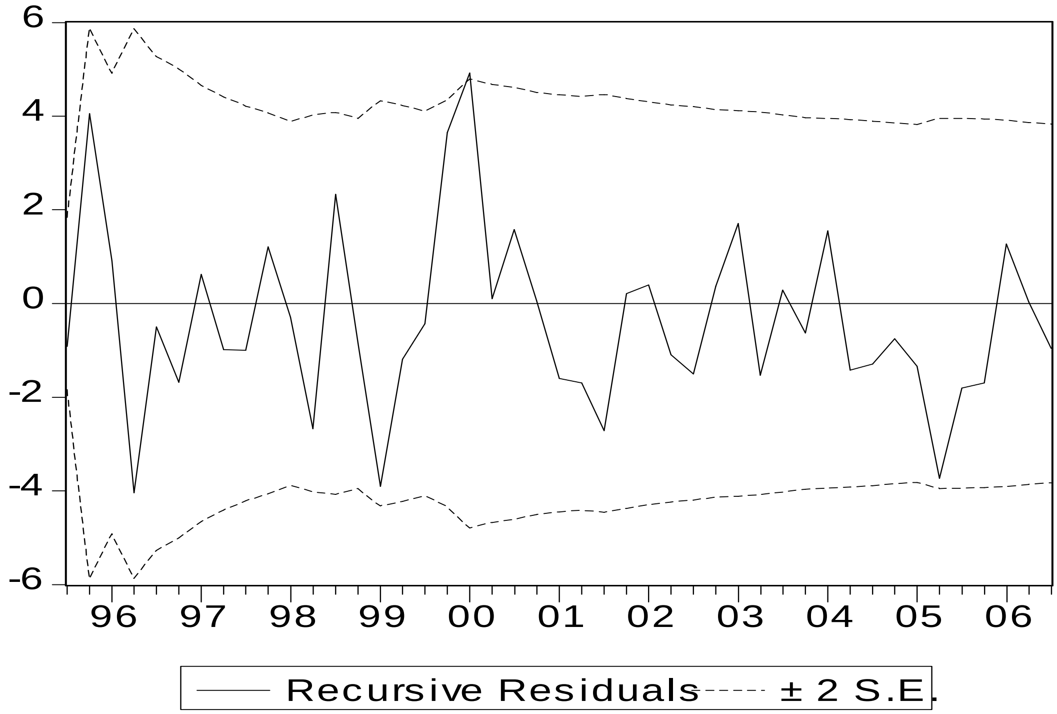

Figure A4: Recursive estimates of residual for maize (corn)

The residual plot for wheat and meslin is shown in Figure A5. The residual for the fourth quarter of 2001 and the third quarter of 2002 passed the 2 standard error band and dummy variables are introduced for each of these quarters in the equation.

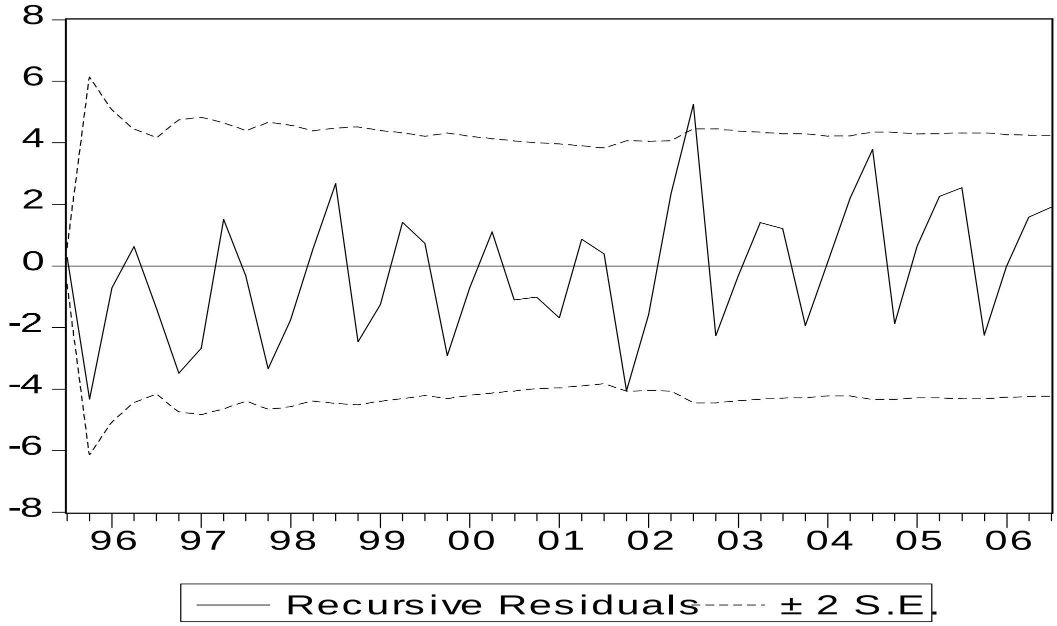

Figure A5: Recursive estimates of residual for wheat and meslin

The residual plot for soybeans (broken or not broken) is shown in Figure A6. The residual for the second quarter of 1999 and the second quarter of 2004 passed the 2 standard error band. Dummy variables are introduced for each of these quarters in the equation.

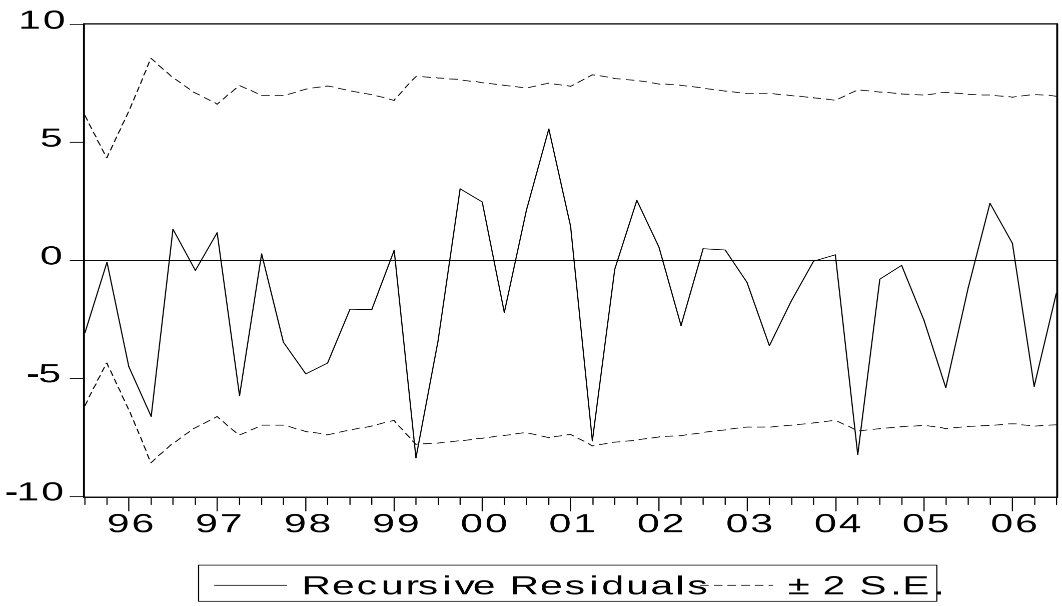

Figure A6: Recursive estimates of residual for soybeans (broken or not broken)

The residual plot for sunflower seeds (broken or not broken) is shown in Figure A7. The residuals vary between the 2 standard error bands. Thus, there is no need to add dummy variables.

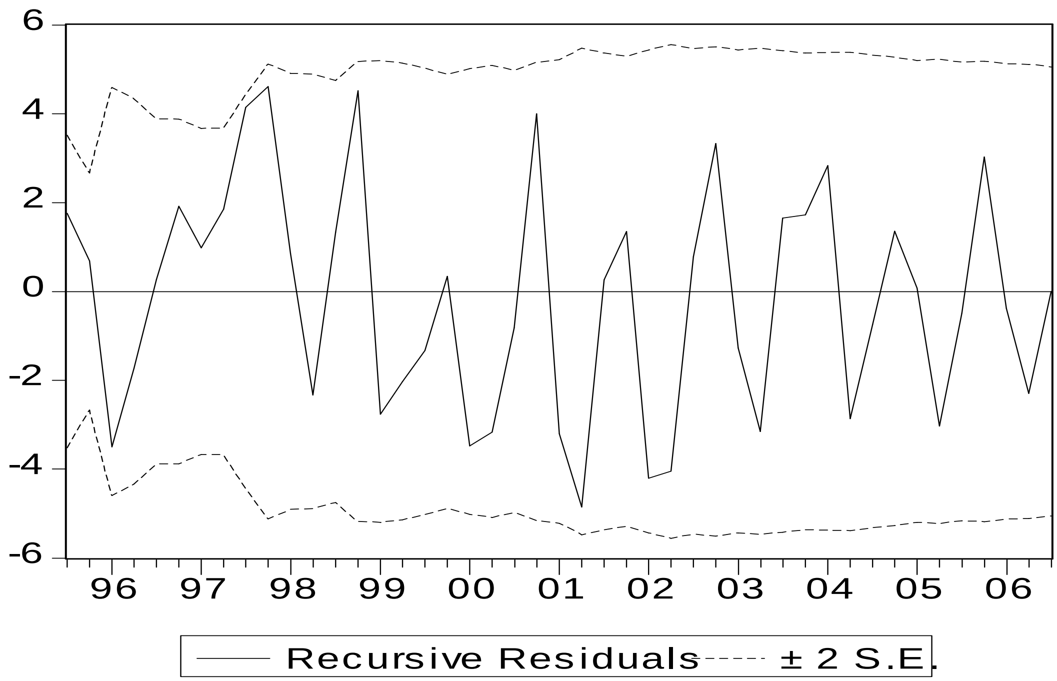

Figure A7: Recursive estimates of residual for sunflower seeds (broken or not broken)