

**MODELING TARIFF RATE QUOTAS IN THE SOUTH AFRICAN LIVESTOCK
INDUSTRY**

By

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ABSTRACT

The Uruguay Round of trade negotiations resulted in three main areas of trade liberalization in agriculture, namely market access, domestic support, and export subsidies. In terms of market access, the introduction of tariff rate quotas (TRQs) was one of the main tools to facilitate greater market access. After the liberalization of the agricultural sector and phasing out of past protection mechanisms South Africa introduced a process of tariff reform in compliance with WTO regulations. Furthermore, a system of TRQs was introduced in compliance with WTO regulations.

Literature on South African agricultural trade shows that very little research has been conducted on the impacts of TRQs. In this study the impacts of further TRQ liberalization on the South African livestock industry were investigated using four TRQ liberalization scenarios, namely: 33 per cent expansion of import quotas, 33 per cent reduction in ad valorem MFN tariffs, a combination of the first two scenarios and a complete removal of tariffs.

The approach followed in this study is spatial partial equilibrium in nature and consists of the primary (beef cattle, broilers, pigs, and sheep) and secondary (beef, poultry, pork

and sheep meat) sub-sectors. The model delineates South Africa into its nine provinces, as well as neighbouring important meat producers – Namibia and Botswana.

For the four secondary products (beef, poultry, pork and sheep meat) the border prices declined by between 0.89 and 2.39 per cent for scenario one, 2.35 and 7.96 per cent for scenario two, 2.96 and 9.97 per cent for scenario three and 8.25 and 25.19 per cent for scenario four. The largest decline in beef and sheep meat prices due to liberalization was recorded in the Eastern Cape and KwaZulu-Natal Provinces. Cattle and sheep numbers owned by emerging producers are more than those of the established commercial farmers in these two provinces. The implication is that the development efforts by government aimed at commercializing emerging commercial stock farming in order to address equity and poverty may be slowed down considerably with further trade liberalization.

The study used the consumer and producers surplus concepts, as well as the equivalent variation concept to measure the impact on welfare of potential trade policy changes mentioned. Welfare as measured by consumer surplus increases by R230.8 million in scenario 1 to R1 880.8 million in scenario 4. Producer surplus decreases by R77.6 million in scenario 1 to R656.89 million in scenario 4. Welfare as measured by equivalent variation increased by R60.6 million in scenario 1 to R468.2 million in scenario 4. The equivalent variation concept revealed much more moderate changes to consumer well being. The reason for this is that consumer and producer surplus estimations assume linearity of the demand and supply curves, whereas the model used in this study accounts for the non-linearity of demand and supply curves. Consumer and producers surplus estimates nevertheless provide useful insight into the relative impact of trade policy changes.

Should further TRQ liberalization be considered in the South African livestock industry, consideration should first be given to expanding the existing quota rather than reducing tariffs.

Further research on the following aspects is recommended, (i) products differentiated by place of origin based on the Armington assumption, (ii) expansion of current modelling framework to include additional products and (iii) explicit modelling of TRQs such as the creation of rents and its distribution.

Keywords: Tariff Rate Quotas (TRQ), Livestock and Meat Trade, Trade Liberalization, Partial Equilibrium Model, Applied Welfare Economics.

MODELERING VAN TARIEFKOERS KWOTAS IN DIE SUID-AFRIKAANSE LEWENDEHAWE BEDRYF

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UITTREKSEL

Die Uruguay-rondte handelsonderhandelinge het gelei tot handelsvryheid op drie belangrike landbougebiede, naamlik marktoegang, die ondersteuning van plaaslike produkte en uitvoersubsidies. Wat marktoegang betref, het die instelling van tariefkoers kwotas (TKK's) onder meer die toon aangegee om groter marktoegang in die hand te werk. Na die liberalisering van die landbousektor en die uitfasering van voormalige beskermingsmeganismes, het Suid-Afrika in ooreenstemming met WHO-regulasies, 'n proses van tariefhervorming ingestel. Voorts is 'n stelsel van TKK's ingestel in ooreenstemming met WHO-regulasies.

Literatuur oor die Suid-Afrikaanse landbousektor dui daarop dat baie min navorsing oor die uitwerking van TKK's gedoen is. In hierdie studie is die uitwerking van verdere TKK-liberalisering op die Suid-Afrikaanse lewende hawe sektor ondersoek deur gebruik te maak van vier TKK-liberalisering scenario's, naamlik: 33 persent uitbreiding van invoerkwotas, 33 persent vermindering in MFN-tariewe volgens waarde, 'n kombinasie van die eerste twee scenario's en 'n algehele wegdoen met tariewe.

Die benadering wat in hierdie studie gevolg is, is ruimtelik gedeeltelike ewewig van aard en is saamgestel uit die primêre (vleisbeeste, braaikuikens, varke en skape) en sekondêre (bees-, hoender-, vark- en skaapvleis) sub-sektore. Die model verteenwoordig Suid-Afrika se nege provinsies, asook belangrike vleisproduserende buurlande – Namibië en Botswana.

Sover dit die vier sekondêre produkte (bees-, hoender-, vark- en skaapvleis) aangaan, het die marginale pryse met tussen 0.89 en 2.39 persent afgeneem vir scenario een, tussen 2.35 en 7.96 persent vir scenario twee, tussen 2.96 en 9.97 persent vir scenario drie en tussen 8.25 en 25.19 persent vir scenario vier. Die grootste afname in bees- en skaapvleispryse as gevolg van liberalisering is in die provinsies van die Oos-Kaap en KwaZulu-Natal aangeteken. Bees- en skaapgetalle in besit van opkomende produsente oorskry dié van gevestigde kommersiële boere in dié twee provinsies. Die aanduiding is dat die ontwikkelingspogings deur die regering wat daarop gemik is om opkomende kommersiële veeboerdery te kommersialiseer om sodoende gelykheid te weeg te bring en armoede hok te slaan aanmerklik vertraag kan word deur verdere handelsliberalisering.

Die studie het gebruik gemaak van die verbruikers- en produsentesurplus konsepte, sowel as die ekwivalent variasie konsep om vas te stel wat die uitwerking van genoemde potensiële handelsbeleidsveranderinge op welvaart sal wees. Welvaart soos gemeet deur verbruikersurplus neem met R230.8 miljoen toe in scenario 1 tot R1 880.8 miljoen in scenario 4. Produsentesurplus neem met R77.6 miljoen af in scenario 1 tot R656.89 miljoen in scenario 4. Welvaart soos gemeet deur ekwivalent variasie het in scenario 1 met R60.6 miljoen toegeneem tot R468.2 miljoen in scenario 4. Die ekwivalent variasie konsep het heelwat meer gematigde veranderinge aan verbruikersbelange aan die lig gebring. Die rede hiervoor is dat verbruikers- en produsentesurplus beramings aanneem dat daar lineariteit in die vraag- en aanbod-kurwes is, terwyl die model wat in hierdie studie gebruik is, voorsiening maak vir die nie-lineariteit van vraag- en aanbodkurwes. Desnieteenstaande verskaf verbruikers- en produsente surplus beramings dienlike insig in die relatiewe uitwerking van handelsbeleidsveranderinge.

Indien verdere TKK-liberalisering in die Suid-Afrikaanse lewendehawe bedryf oorweeg sou word, moet daar eers aandag geskenk word aan die vergroting van die bestaande kwota, eerder as om die tariewe te verlaag.

Verdere navorsing oor die volgende aspekte word aanbeveel, (i) onderskeid tussen produkte op grond van die plek van oorsprong soos gegrond op die Armington-aanname, (ii) uitbreiding van die huidige model raamwerk om bykomende produkte in te sluit en (iii) eksplisiete modellering van TKK's, soos die daarstelling van hure en die verspreiding daarvan.

Sleutelwoorde: Tariefkoers Kwotas (TKK), Lewendehawe- en vleishandel, Handelsliberalisering, gedeeltelike ewewigsmoedelle, Toegepaste Welvaartsekonome.

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LIST OF ACRONYMS

ACP	African Caribbean and Pacific countries
AGOA	African Growth and Opportunity Act
AoA	Agreements on Agriculture
BLNS	Botswana, Lesotho, Namibia and Swaziland
CBOT	Chicago Board of Trade
CIF	Cost insurance and freight
CMOB	Common Market Organisation for Bananas
DBSA	Development Bank of Southern Africa
EU	European Union
EUROPA	European Union portal site
FAO	Food and Agriculture Organisation
FTA	Free Trade Agreement
GAMS	General Algebraic Modelling System
GATT	General Agreement on Tariffs and Trade
HS	Harmonized System codes
IATRC	International Agricultural Trade Research Consortium
IIT	Intra Industrial Trade
Kg	Kilograms
MAC	Minimum Access Commitments
MCP	Mixed Complementarity Problem
MERCOSUR	<i>Mercado Común del Sur</i> (Southern Common Market)
MFN	Most Favoured Nation
MMA	Minimum Market Access
NDA	National Department of Agriculture
NTB	Non Tariff Barriers
OECD	Organisation for Economic Cooperation and Development
SA	South Africa
SACU	Southern Africa Customs Union
SADC	Southern African Development Community

SAMIC	South African Meat Industry Company
SAPA	South African Poultry Association
SARB	South African Reserve Bank
SAPPO	South African Pork Producers' Organisation
SPE	Spatial Partial Equilibrium
STE	State Trading Enterprises
TRQ	Tariff Rate Quota
Tons	Tonnes
TDCA	Trade Development and Cooperation Agreement
URAA	Uruguay Round Agreement on Agriculture
USDA	United States Department of Agriculture
WATSIM	World Agricultural Trade Simulation Model
WTO	World Trade Organisation

INTRODUCTION

1.1 Background

South Africa's agricultural sector, as presently constituted, has undergone fundamental changes in three main areas in respect of WTO rules since 1995, namely domestic support, export subsidies and market access. Furthermore, South Africa is currently a signatory to several trade agreements within the Southern African region, the African continent and across the globe.

According to Vink and Kirsten (2003), prior to the trade reform of the 1990s, South Africa's trade regime had been characterized by quantitative restrictions, a multitude of tariff lines, a wide dispersion of tariffs and formulae, specific and ad valorem duties and surcharges. However, the introduction of the Marketing of Agricultural Products Act of 1996 led to the elimination of all marketing boards, removal of price regulations and single channel markets. Furthermore, the termination of the General Export Incentive Scheme in 1997 resulted in the elimination of export subsidies; while the replacement of import permits by import duties, the reduction of the bound levels, as well as various market access quota commitments, improved access to the South African market (Jooste, Van Schalkwyk and Groenewald, 2003).

Trade has continued to play a major role in the South African agricultural economy. For instance, although the economy as a whole went into a recession from the early 1990s up until 1997 when the economy began to experience some growth, agriculture remained a net earner of foreign exchange throughout the period. Between 1990 and 2000, agricultural exports contributed a substantial annual average of 8.4% of total exports (Fenyés and Meyer, 2003). In addition, despite the drop in the contribution of the agricultural sector to GDP from about 20% in the 1930s to around 4% in early

2000s, it remains an important sector to the economic growth of the country contributing 13% to employment while the gross value of agricultural production reached R67 billion in 2004/05 (NDA, 2005c).

South Africa's commitment to trade liberalization has resulted in strong growth in import demand. Import intensity in South African agriculture increased from 4% in 1995 to 7% in 2000, with an average change of 52.8% between 1994 and 2000 (Jooste *et al.*, 2003). However, the increasing potential for agricultural imports is linked to the challenge of monitoring the impact of such imports on both the producers and consumers of agricultural products. For instance, Cassim, Onyango, and Van Seventer (2002) observed that the South African tariff schedule is still complex and that a cumbersome tariff structure may mean uneven protection, and may limit gains from openness, while Lewis, Robinson and Thiefelder (1999) observed a slight worsening of South Africa's terms of trade due to increased demand for imports.

Given the foregoing, it is worth mentioning that the effects of an increase in import demand for agricultural products in South Africa are unevenly distributed among sectors and product groups. For instance, apart from rice imports, which increased by about 9 per cent annually in value terms, and wheat and meslin increasing by 14 per cent annually between 1993 and 2004, other grains have experienced either major decreases (for instance, maize imports declined drastically following liberalization), slight decreases or constant import values.

For oilseeds, the value of imports showed an annual increase of about 9.56% over this period. The imports of livestock products generally increased between the period prior to and following trade liberalization.

South Africa is a net importer of major livestock products such as beef, sheep meat, pork and poultry. The gross value of imports of livestock products has grown by 9 per cent annually since 1995, from R530 million in 1995 to R1.25 billion in 2004. Between 1994 and 1995, at the commencement of trade liberalization, total imports of livestock products increased by 21.1 per cent from R437 million to R530 million. Beef imports increased by about 29.5 percent in value terms at the commencement of trade

liberalization in 1995, but have experienced a decrease of 3.3 per cent annually since then. From 1995 to 2004, pork imports increased by 11.4 per cent annually, sheep-meat imports by 9.3 per cent annually, and poultry meat imports by 13.6 per cent annually. Cognizance should be taken however, that imports are usually of specific cuts and these values represent the aggregates.

Therefore, the challenge of monitoring the impact of import demand *viz a viz* trade policy would prove more rewarding if conducted on an industry level. In this study, the impact of tariffs and tariff rate quotas (TRQs) by South Africa on its livestock industry are investigated.

1.2 Problem statement and need for the study

The liberalization of the agricultural sector in South Africa has wide ranging implications for the domestic agricultural sector in general. Favourable prices for commodities guaranteed by a fair trading regime is an important factor in granting market access and aiding continued production by South African farmers. However, factors such as accessibility of markets, opportunities to trade, as well as price and policy variables (especially tariffs and tariff rate quotas) will greatly impact on the performance of agricultural subsectors. The resulting state of events, as well as the current global agricultural trade policy regime, especially for livestock trade, promises distributional and allocational effects within the domestic livestock sector.

Of the many tools available to governments to liberalise trade, tariffs and tariff rate quotas are frequently used. According to Kindleberger and Lindert (1978) a tariff can be justified by the existence of a distortion in a less than perfect world. Houck (1992) also provides various reasons why countries will implement measures to protect its agricultural sector. On the other hand Van Schalkwyk, Van Zyl and Jooste (1995) point out that users of agricultural commodities may rightfully claim that prices of these commodities should be as low as possible, which implies that it may also be imported if it is cheaper than the locally produced product. Having stated the opposing arguments the fact remains that countries through history have opted to protect their national agricultural sectors, but have at the same time also shown resilience to change trade distorting measures.

The question is how to use various trade policy instruments so that they have the least distortionary effects. The agreements reached during the Uruguay Round of trade negotiations in terms of agriculture are evidence to this. Of specific importance are TRQs, as these have become one of the principal mechanisms for trade liberalization, especially in the agricultural sector, after the Uruguay Round of Agreements on Agriculture (URAA) (Tangermann, 1996; Ingco and Townsend, 1998).

Several studies have attempted to model the impact of trade and tariff policies using South African data. Van Seventer and Edwards (2001) attempted to measure the welfare impact of tariffs on South African consumers by using data which cut across a wide array of domestic sectors in South Africa. Ad valorem tariffs were specifically modelled within a partial equilibrium framework, with data being a mixture of HS classifications. This analysis gave a broad indication of the cost impact of tariffs.

Jooste (2001) conducted a comparative static analysis within a spatial partial equilibrium framework to measure the impact of various economic and trade interventions on the red meat industry in South Africa. Specifically, the effect of tariff liberalization was analyzed using different liberalization scenarios. The modeling framework differentiated South Africa into its nine provinces and also integrated the neighbouring countries (Botswana and Namibia), which are important meat producers. Although the study quantified the welfare effects of tariff liberalization, it did not incorporate tariff rate quotas in its simulations. This study emphasized the necessity of analyzing the impact of tariff rate quotas, not only on the red meat industry, but the entire livestock industry in South Africa.

Using a partial equilibrium multi-commodity multi-country model, Pustovit and Schmitz (2003) conducted a comparative static analysis to quantify the effects of protection in OECD countries combined with South Africa's own agricultural and trade policies on its agriculture. A variety of crop and livestock products, including wheat, coarse grain, rice, oilseeds, sugar, milk, beef, pork, and poultry, were taken into account. Although simulations were conducted to measure the impact of trade liberalization on South Africa, only domestic policy interventions such as net protection rates, intervention

prices, and production quotas, direct payments to farmers, input subsidies and general subsidies were considered. They did not directly consider the effects of tariffs or TRQs.

However, various studies outside South Africa have modeled TRQs, either in a country-specific or in a global context. Among these, Von Lampe (2000), and Junker, Wieck, Jansson and Perez (2003) provided descriptions of the handling of TRQs in the WATSIM and CAPRI models, respectively, using the sigmoid function approach. Elbehri, Hertel, Ingco and Pearson (2000), and later Elbehri and Pearson (2005), provided revised versions of the technical aspects involved in the implementation of TRQs in the Global Trade Analysis Project (GTAP) – a standard general equilibrium model. Other studies modelled TRQs in a global context as a Mixed Complementarity Problem (MCP); these include Van der Mensbrugghe, Berhin and Mitchell (2003), Kuhn (2003), and Nicholson and Bishop (2004). While these studies have modeled TRQs with different regional aggregates and product coverage, this study specifically models the TRQs applicable to the South African livestock industry. The majority of the studies mentioned that a major difficulty when studying the potential impacts of tariffs and TRQs on trade is quantifying the variables to be used.

The regional approach to modelling the agricultural sector in South Africa offers an opportunity for analyzing varying policy implications across the provinces; of particular importance is livestock production which exhibits certain peculiarities across provinces. For instance, Jooste (1996) discovered that, if tariffs were to be reduced to zero in the beef industry, emerging farmers would be affected, even in the coastal regions where herd size in the emerging sector exceeds that of the commercial sector. In order to ensure that domestic producers of livestock products become more competitive and are guaranteed greater market access it is, however, necessary to account for the important policy instruments that regulate prices. The importance of TRQ in this regard can not be over-emphasized.

South Africa, with 46 per cent, is ranked sixth in the world in terms of the percentage of agricultural tariff lines covered by tariff rate quotas (US, CBO report, 2005). As far as the livestock and meat industry is concerned, of the total initial TRQs reported at the WTO by 2000, 18% were used for meat products, while 13% of South Africa's TRQs covers the meat sector. Considering the economic importance of the livestock

industry in South Africa, it is important to determine the impact of TRQs, viz-à-viz trade liberalization on the industry, particularly:

- the impact of increases in import quotas on consumers;
- the impact of tariff reduction on farm income; and
- the balance between the two; that is where does the interest of producers and consumers meet.

Another question of interest relates to the impact of further liberalization of trade on the livestock industry in South Africa when the volume of trade is constrained by TRQs. It is expected that the use of TRQs will serve to balance the effects of uneven benefits of trade liberalization. However, the behavioural pattern of both consumers and producers (that is, on the demand and supply side) will influence the terms of trade.

1.3 Objectives of the study

The primary objective of this study is to design a spatial equilibrium model which is capable of quantifying the effects of trade liberalization *vis-à-vis* sophisticated trade policy instruments (particularly TRQs) on trade flows, terms of trade and consumer welfare for the South African livestock industry. The secondary objectives of the study include:

- The establishment of a regional database of relevant parameters such as prices, demand, supply, demand and supply elasticities, quota and tariff levels, and transport costs for the major livestock products in South Africa.
- A review of literature on similar studies done world-wide, especially in countries with similar patterns of trade to South Africa. Particularly, the methodological approach of such studies will be reviewed critically with a view to explicitly model trade policy instruments that constrain both prices and quantities (like tariff rate quotas).
- To determine both the welfare and trade effects of policy changes on the demand and supply sides of the livestock industry in each of South Africa's provinces using well-behaved demand and supply systems.

- To measure the impact of increases in import quotas on farm income, the impact of quota reduction on consumers, as well as the balance between the two; that is, the determination of where the interests of producers and consumers meet.

1.4 Motivation

The need to balance the effects of trade liberalization of the agricultural sector in South Africa has led to the introduction of trade rationing instruments such as the TRQ. With this comes the challenge of measuring the impact of such two-edged policies on the domestic sector. There is therefore an urgent need for a model which will simulate South Africa's commitment in multilateral trade negotiations, particularly for the livestock industry. It is furthermore important to determine how much benefit South African producers and consumers derive from trade liberalization and import rationing, given the changing landscape of livestock trade. For example, the European Union, which used to be South Africa's major source of imports of livestock products, has been sidelined by more competitive countries such as Brazil, Argentina, Australia and New Zealand, despite the implementation of the EU-SA Trade Development and Cooperation Agreement (TDCA).

1.5 Research hypothesis and method used

Further trade liberalization may result in an unfavourable trade regime for South Africa. It is therefore important that South African policymakers, as well as trade negotiators, understand how much additional trade is needed to offset the loss of South Africa's quota rents. Modelling trade in the presence of TRQs is the only way to obtain this information.

Furthermore, it is expected that net welfare gains will change with changes in import quotas, tariff rates and the combination of the two. With the incorporation of TRQs it is expected that the modeling framework will be capable of measuring the following in the domestic livestock industry:

- Effects of changes in tariff rates on regional production, trade flows, demand, and prices.
- Effects of changes in import quota levels on regional production, trade flows, demand and prices.
- Effects of combined changes in import quota levels and tariff rates on regional production, trade flows, demand and prices.

As TRQs are applied continuously, it is expected that any expansion in quota, decrease in over-quota tariffs or the combination of the two has the potential to further liberalize the livestock industry. It is also expected that, with the introduction of TRQs, imports can be rationed, possibly in a way that the interests of both producers and consumers are represented.

Empirical literature reports several approaches to studying the implications of trade liberalization on the agricultural sector. The approach taken by this study is based on the mathematical programming models developed by Samuelson (1952), Takayama and Judge (1964a, b, 1971) and McCarl and Spreen (1980). This approach allows for sectoral analyses of the allocation of resources among spatially separated markets. Based on this framework, several extensions and empirical applications have been implemented for different combinations of commodities and regions (see Van Tongeren and Van Meijl (1999, 2003); and Westoff, Fabiosa, Beghin and Meyers (2004) for developments in agricultural trade modeling). However, quite unique is the explicit modeling of the processing level (that is the slaughtering process) within a regionalized framework such as this. A further strength of this study is the integration of a globally well-behaved demand system in a spatial equilibrium model, as it is required of a system explicitly incorporating welfare in the objective function.

1.6 Chapter outline

Chapter 2 presents an overview of relevant developments in trade theory leading to the modern-day perception of trade, including applicable literature on issues such as TRQs, mathematical and economic programming, as well as the methodological approach to TRQ modelling. An overview of the industry as well as trends in South

Africa's livestock trade is presented in chapter 3. Chapter 4 describes the methodological framework involved in spatial partial equilibrium modeling, as well as the calibration of an applied economic model. Empirical results of the analyses are reported in chapter 5, while chapter 6 concludes with a discussion of the trade liberalization implications of TRQ scenarios, with conclusions and recommendations.

LITERATURE REVIEW

2.1 Introduction

The concept of trade has two diverging viewpoints. One involves recognition of the benefits of international exchange, while the other relates to concerns that certain domestic industries could be harmed by foreign competition (Ohlin, 1933; Samuelson, 1962; Porter, 1990). Although notable authors have proven the advantages of free trade theoretically with such arguments as comparative advantage and competitiveness, the world of the late twentieth century, up to the present day, has not been ready to acknowledge and implement a full free market regime. Instead, countries have opted for trade blocs (which include Free Trade Areas, Customs Unions, Common Markets and Economic Unions) and trade-restricting instruments (tariffs, quotas and tariff rate quotas).

The increasing interdependence of world trade has led to the emergence of policies that affect agricultural trade, albeit in lesser or greater magnitude. Following the progress made at the Uruguay Round Agreements of the General Agreement on Trade and Tariffs (GATT), the World Trade Organization (WTO) has continued to attempt to liberalize agricultural trade further. The ongoing Doha Round, which was planned to conclude in Hong-Kong in December 2005, provides another opportunity for trade liberalization, as trading countries are prepared to negotiate at a multilateral level. Measuring the performance of trade liberalization has been difficult, given the existence of the various mechanisms involved. In this case economic models have been useful, both for the implementation and assessment of trade policies.

This chapter provides a review of theoretical literature on tariff rate quotas as a trade policy instrument, including its complexity and value to trade. Its implementation,

administration and liberalization will be emphasized. In addition, selected studies relevant to the methodology involved in modelling tariff rate quotas are reviewed. This includes the evolving trend in the use of mathematical programming for trade policy analyses, as well as the economic background of the properties of the functional forms, including the demand and supply systems used in this study.

2.2 Comparative advantage and trade theory

The fundamental trade theory by Ricardo is based on the notion that international exchange patterns are determined on the basis of comparative advantage. 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. The premise for exchange in such a situation is the difference in "comparative cost of production" (Gandolfo, 1998), which results from technological differences. However, the sufficient condition is that the terms of trade must lie between these two comparative costs. Salvatore (2004) described the Ricardian concept of comparative advantage using the relative cost concept to arrive at equilibrium price, export and import quantities. Figure 2.1 shows how the equilibrium relative price of a commodity is determined under trade in a partial equilibrium condition.

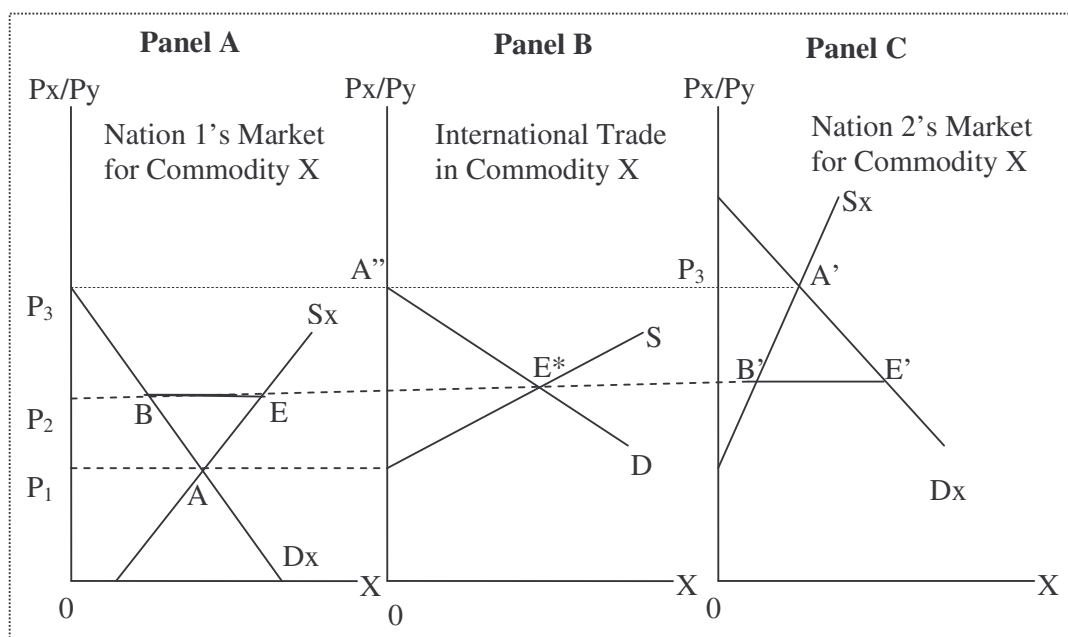


Figure 2.1: A representative price equilibrium for a partial equilibrium trade analysis

Source: Salvatore, 2004

Panels A and C represent the demand and supply conditions of the commodity being traded by the two trading countries A and B. The exporting country (nation 1) has a lower relative price than the relative price in the importing country (nation 2), i.e. $P_1 < P_3$. This situation gives rise to an excess supply of the commodity by nation 1 (i.e. export quantity represented by the line BE), while nation 2 demands the excess supplied by nation 1 (i.e. import quantity represented by the line B'E'). The import demanded equals the export supplied at the price P_2 , where the equilibrium relative price (P_x/P_y) with trade is attained; as represented in panel B.

Heckscher (1919) and Ohlin (1933) approached the two issues raised by both Smith and Ricardo, namely the basis of comparative advantage and the effects of international trade on earnings of factors of production in two trading nations. They introduced another viewpoint to the theory of international trade by explaining the causes of comparative cost advantage (rather than assuming it) and gains from trade on the basis of relative scarcity of factors of production among countries. Heckscher (1919) extends Ricardo's theory of trade when he argues that the relative difference in endowment of factors of production is the basis for international exchange. He contends that Ricardo's assumption of relative factor immobility must be relaxed,

since international exchange has an influence on the prices of factors of production which, in turn, affects factor mobility. He therefore concludes that relative factor abundance is the basis for international exchange and that factor price convergence could result from trade among trading partners.

Further expounding Heckscher's theory, Ohlin (1933) postulates that the free mobility of factors of production can be partially substituted by the free mobility of commodities under the condition of international exchange. He argues that this situation will lead to a partial equalization of relative and absolute factor prices. However, Stolper and Samuelson (1941) argue that, when two trading economies use different factors of production intensively, the rate of return to the scarce factor in the respective economies reduces. Furthermore, in terms of both factors, the relative price of the scarce factor will decrease and more of the scarce factor than can be utilized in the economy will be freed as the economy moves toward specialization in the commodity that absorbs its more abundant factor. The Stolper-Samuelson theorem provides an indication of the possibility of factor equalization. This means that free trade equalizes factor rewards between countries and thus serves as a substitute for external factor mobility.

Based on the reasoning behind the Stolper-Samuelson theorem, the Heckscher-Ohlin theorem was critically analyzed by Samuelson (1948); its assertion that, whilst free factor mobility equalizes factor prices fully, free commodity movements can only be achieved by a partial equalization of factor prices. There are four situations which guarantee that perfect mobility of goods results in complete factor-price equalization as proven by Samuelson (1948). One is partial specialization, that is, the production of a quantity of goods to be exchanged by both trading partners. Secondly, the initial factor endowments, although unequal, should not be too unequal. Thirdly, even with an extreme inequality of factor endowment, factor mobility would migrate to an extent which is sufficient for full price equality. Lastly, as long as commodity movements are perfect substitutes for factor movement, absolute and relative returns on factors will ensure optimum world productivity. Samuelson's analyses sufficiently demonstrate that the partial and incomplete nature of factor-price equalization postulated in the Heckscher-Ohlin theorem is, after all, a rare exception rather than the norm.

Using the two-good, two-factor assumption, Rybcynski (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 which uses the factor whose supply has risen will fall. Taking the two-good, two-factor assumption further, Krugman (1979) proves, by means of a simple model, that economies of scale are the drivers of trade, and not factor endowment or technology. He shows that, when factor endowment and technology between countries are assumed equal, the potential for trade and gains from trade still exists. However, some aspects of his analysis correlate with the Heckscher-Ohlin theory. For instance, the Heckscher-Ohlin theory proved substitution between global trade and factor mobility. It also supported the notion of movements of factors being induced by such impediments as tariffs and transportation costs. These issues are also alluded to by Krugman (1979).

Krugman (1980) extended the theory of trade by developing a model that explains the pattern of trade between imperfectly competitive economies with similar factor endowments and technology, where economies of scale and product differentiation exist. The analyses reveal that, when increasing returns to scale exists, an individual differentiated product is produced in only one country, leading to trade among countries. Gains from trade thus emanate from the increased variety of goods available within the global economy which permits wider range of choices. However, as with other models of trade which are based on economies of scale, Krugman's model can only determine the magnitude (in terms of volume) of trade, while the direction of trade flow remains undetermined.

In his subsequent writing, Krugman (1999) agreed that, although not explicitly stated, the notions of trade raised by subsequent authors are all embedded in Ohlin's theory. However, he further expresses a view of trade in which a combination of differences in factor endowments (comparative advantage) and increasing returns to scale economies are drivers of trade. He agrees with the notion that factor intensity or abundance results in trade. Furthermore he showed how change in factor prices after

trade affects the purchasing power of two trading countries. Finally, gains from trade will be reinforced by economies of scale where constant returns allow more purchasing power than before trade, and increasing returns guarantees purchase of additional units of the goods.

2.3 Trade liberalization and protection

There is overwhelming cross-country evidence that trade liberalization and openness to trade increase the growth rate of income and output (Sachs & Warner, 1995; Dollar, 1992; Edwards, 1998; Ben-David, 1996; Frankel & Romer, 1996), especially in sub-Saharan Africa (Rodrik, 1998). The inward-looking approach of many African economies has been identified as the cause of their insignificance in global trade (Collier, 1995). Whereas a liberal trade policy is necessary for growth and poverty reduction (Hoekman, Michalopoulos, Schiff, Tarr, 2001), substantial tariff and non-tariff barriers remain the norm rather than exception in most sub-Saharan African countries (Rodrik, 1998). Although the adjustment costs associated with trade reforms may be escalating, empirical evidence shows that the adjustment costs are relatively low compared to the benefits of trade liberalization to the economy (Matusz & Tarr, 2000). For his part, (Yeats (1997), quoted by Rodrik, 1998) concludes that appropriate trade and structural adjustment policies must be installed if Africa is to reverse its unfavourable export trend and capitalize on opportunities offered by foreign markets.

Developed countries are, however, not exempt from protectionist tendencies. For instance, Pustovit and Schmitz (2003) observed that, assuming complete liberalization of agricultural policies in all OECD countries, South Africa would be a net exporter of all the major meat products, including beef, pork and poultry. Presently, however, South Africa remains a net importer of most of these products due to the high level of government support and other non-tariff measures in OECD countries. This fact necessitates some sort of protection to, at least, provide a level playing field for domestic agricultural producers; typically tariffs and tariff rate quotas can be used, which are the only legal measures of protection allowed under the Marrakech Agreement (Skully, 2001a).

While it is obvious that Africa's participation in global trade must increase in order to reverse the continent's marginalization (Rodrik, 1998), it has been said in many forums that industrialized countries are partly responsible for the negative effects of trade in many developing countries. For instance, Pustovit & Schmitz (2003) mention that, in industrialized countries, the level of protection afforded the domestic agricultural sector against imports from developing countries, coupled with the dumping of surpluses through massive export subsidies, have had a negative effect on developing countries. This development necessitates some type of protection to, at least, provide a level playing field.

2.3.1 Trade policy and instruments

The strong theoretical argument for free trade, notwithstanding legitimate demands for protection, has necessitated the formulation of protectionist policies by governments. In opting for policies such as tariffs, import quotas, domestic content regulations, packing and labeling requirements, export subsidies, sanitary restrictions, variable import levies, export controls etc., governments strive to protect local interests (Houck, 1992). It is common knowledge that almost every nation that can afford to support its food and agricultural sector (and even some that cannot) channel public expenditure into this sector. In many cases, the motives are not ill-conceived, as nations strive to influence domestic and, where possible, international markets to the benefit of their local producers and to ensure food self-sufficiency.

Recent developments relating to global trade policy have seen agricultural trade taking centre stage. Issues which have come to fore relate mostly to how governments implement domestic policies which impact on the long-term behaviour of prices and income, terms of trade and ultimately producer and consumer welfare. Houck (1992) reasons that government intervention in agricultural markets is mostly due to the essential nature of food and fiber to human welfare, the biological character of agricultural production, as well as the long-term behaviour of prices and incomes in agriculture. Sodersten and Reed (1994) state that, while there are many reasons for a country to restrict trade, tariffs have long been used for this purpose. In fact, Houck (1992) describes tariffs and import quotas as the meat and potatoes of protective trade policy.

Sodersten and Reed (1994) are of the opinion that governments' motives for restricting imports include a desire to "protect" domestic producers from the imported, competing goods, a wish to reduce the consumption of the good, a desire to reduce imports for reasons relating to balance of payments, and a need to raise revenue. Demands for protection by industries, farmers and consumers has led to the formulation of protection policies by governments (Houck, 1992), and these include import limiting policies (e.g. import tariff). An import tariff is a tax on the affected foreign item, levied as it passes into the domestic economy, while an import quota is a physical limit on the amount of the affected foreign item that can be imported within a specified time period (Houck, 1992). However, according to Sodersten and Reed (1994), tariffs may be either specific (the tariff is specified in money terms per unit) or ad valorem (the tariff is a set proportion of the price of the good at the border).

2.3.2 The three pillars of agricultural trade reform

The aim of the 1994 Uruguay Round of the General Agreement on Tariffs and Trade (GATT) was to achieve freer trade among member countries (Skully, 2001a). A major landmark was the inclusion of agriculture in GATT negotiations at the Uruguay Round (Ingco, 1995), which saw agricultural trade liberalization negotiated under three broad disciplines of agricultural policy. The three disciplines, often referred to as "pillars" of the URAA, include (WTO, 2000):

- market access;
- domestic support;and
- export subsidies.

Countries who were signatories to the URAA agreed that liberalization of agriculture should continue beyond the 1994 agreement and that, one year before the end of the implementation period, progress in implementation should be reviewed (Europa, 1999).

At the 2001 Doha Ministerial Conference, member countries of the WTO again committed themselves to liberalization based on the three pillars of agricultural trade:

- Substantial improvements in market access;
- Reduction, with a view to phasing out, of all forms of export subsidies;
- Substantial reductions in trade-distorting domestic support (WTO, 2004).

Due the scope of this study only issues related to market access will be discussed further.

2.3.3 Market access

The market access provision of the URAA involves the conversion of non-tariff barriers to tariffs (the so called “tariffication”) and the establishment of bound tariffs, i.e. the maximum tariff that may be applied at a border (Ingco, 1995). Following tariffication, the minimum access commitment (MAC) was established to eliminate existing limitations on trade due to non-trade barriers (Abbott and Paarlberg, 1998). In addition, measures were established to safeguard existing market access, through the so called “current access”, which was set at the initial base period of 1986-88 (IARTC, 2001).

Newly established bound tariffs had to be reduced by not less than 36 per cent over six years and 24 per cent over ten years in industrial and developing countries respectively on a simple (unweighted) average, while previously existing tariffs were to be reduced by not less than 15 per cent and 10 per cent over the same period for industrial and developing countries respectively (Ingco, 1995). In complying with the market access provision, which stipulates that countries convert all their non-tariff trade barriers to bound tariffs (with reduction commitments) and the minimum access commitment in the form of import quotas, it was considered necessary that a compromise instrument in the form of a “tariff rate quota” (TRQ) be introduced (Abbott, 2001).

Several concerns were, however, raised with regard to the implementation of TRQs for market access at the time of its introduction. Many analysts believed that minimum access may be the only real improvement to market access permitted by the

tariff rate quota (Tangermann, 1996). While Tangermann (1996) is opposed to such views, he noted that the likelihood of exports taking place under TRQs depends on whether the tariffs are prohibitive or not. Some studies have concluded that the conversion of non-tariff barriers (NTB) to tariffs (under the “tariffication” obligation) has mostly led to tariffs being much higher than the NTB equivalents (Ingco, 1995; Josling, 1998; Monnich, 2003). In addition, setting a current access agreement to a base period of 1986-1988 has been criticized, as world prices were generally low during this period, which meant high levels of protection (Ingco, 1995).

The establishment of TRQs emphasized such issues as licensing procedures and administration methods, which continue to permit government interference in trade (Ingco and Townsend, 1998). The FAO (2000) states that uncertainty surrounding procedures for allocating minimum access quotas has caused countries to allocate licenses to domestic traders, rather than foreign traders, even though this may be entirely inconsistent with most favoured nation (MFN) principles. Ingco and Townsend (1998) further state that traders, in turn, will have an incentive to lobby for continuation of the high levels of applied and bound tariffs. The conclusion, however, was that the challenge for the next round of WTO negotiation on market access will be to prevent TRQs from interfering more than necessary in the competitive development of trade. These issues will be discussed in detail in subsequent sections of this chapter.

2.4 Tariff rate quotas

The aim of introducing TRQs as a compromise policy instrument was to ensure that minimum access commitments were met, contrary to the fear among negotiators that tariff bindings at base period trade would result in very high tariffs, and thus prevent the minimum access commitment from being met (as they could discourage greater imports rather than permit imports up to their minimum access commitments at very low or zero tariffs, and would set higher MFN tariff binding) (Abbott, 2001).

Even though TRQs were virtually absent from world agricultural trade until the early nineties, at the introduction of TRQs to agricultural trade in 1999, 37 countries notified the WTO of 1 368 TRQs, with South Africa reporting 53 (WTO, 2000). By

2002, the number had increased only slightly to 1 425, of which the EU accounts for about 54 per cent and North American countries 6 per cent. Africa accounts for 5.8 per cent, Asia 11 per cent, South America 18.8 per cent and Oceania 0.35 per cent. Of the total number of TRQs 217 are country specific and the EU and North America account for 187 of them (WTO, 2002).

The low rate of adoption of TRQs, especially by developing countries, has been attributed to many factors, ranging from its complexity to lack of administrative capacity and know-how (IATRC, 2001). For instance, it has been observed that, while most developed countries have implemented their TRQs as applied tariffs (Walkenhorst and Dihel, 2003), developed countries have implemented TRQs in a variety of ways, including granting preferential access and implementing trade agreements (Khorana, 2004).

There is a belief that, if market access improvement focuses on successive reduction of MFN tariffs, it has the potential of eliminating TRQs (Matthews and Laroche-Dupraz, 2002). Nevertheless, since their introduction TRQs has continued to generate research interest and debate. Several studies have examined the effectiveness of TRQs in granting market access (Abbott and Paarlberg, 1998; Abbott and Morse, 1999; 2000, Boughner, De Gorter and Sheldon, 2000; Skully, 2001a; Matthews and Laroche-Dupraz, 2002; Walkenhorst and Dihel, 2003; Khorana, 2004). Noteworthy is that Abbott and Morse (2000) are strongly of the opinion that at the time of introduction of TRQs many did not fully understand the working of the two-tier tariff.

Despite mixed perceptions about TRQ usage for market access, it is certain to continue forming part of agricultural trade negotiations, as shown by discussions at the 2002-2003 preparations for “modalities”, where the major part of the discussions about market access focused on TRQs and related subjects (WTO, 2004).

2.4.1 Economics of tariff rate quotas

A TRQ is a trade policy instrument which is basically a two-tier tariff on the import of a commodity. Figure 1 shows how a tariff quota works and how it can influence the incentive to import. The effect of a tariff quota on trade depends on excess

demand for imports. A certain amount of the commodity may be imported at a lower tariff (the in-quota tariff), while imports exceeding this quantitative import quota are taxed at a higher tariff (over-quota tariff).

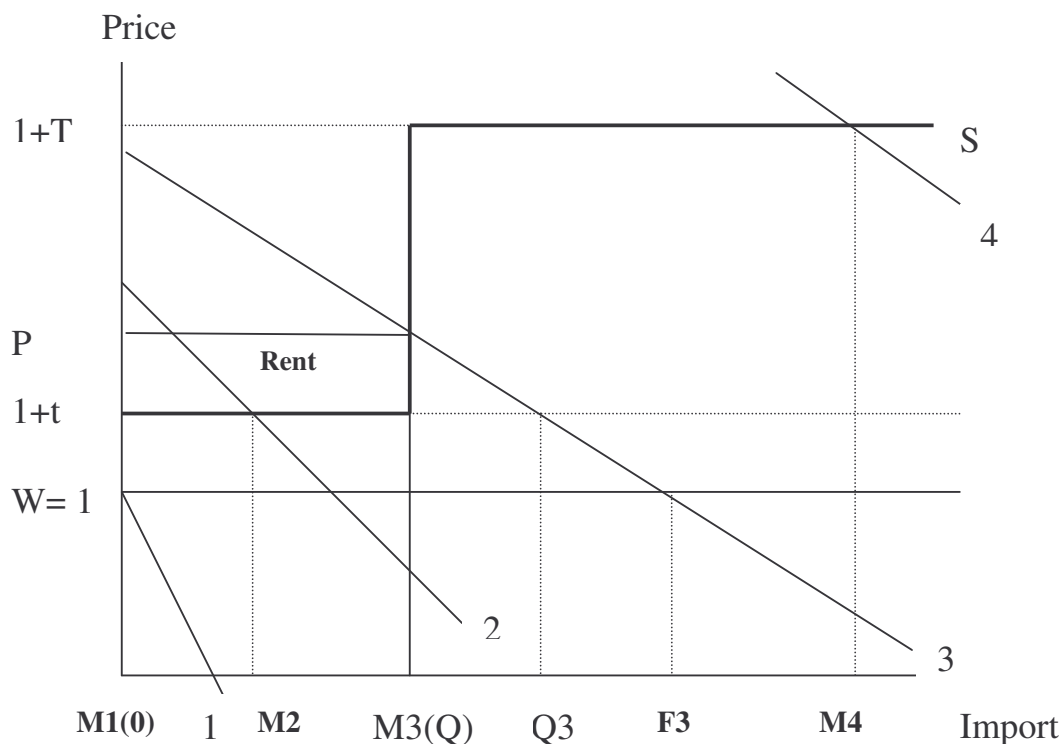


Figure 2.2: Effect of tariff rate quotas on import demand

Source: Adapted from Skully, 2001b

Four possible outcomes of increasing levels of import demand can be observed in Figure 2.2. No trade occurs at $M1$ because domestic excess demand is insufficient to support imports at world prices, even without the in-quota tariff. This is reflected by the low domestic price, lower than the world price, plus the in-quota tariff. At $M2$, the quota is not binding ($M2 < Q$), although domestic excess demand is sufficient to result in imports of $M2$; they are not high enough to cause the quota to bind and therefore the tariff quota functions as an ordinary tariff. The quota is binding ($M3 = Q$) at $M3$; if a tariff quota did not exist and a tariff was merely applied at the in-quota rate imports of $Q3$ would result¹. With free trade, i.e. a tariff applied at the rate of zero, imports of $F3$ would result (F represents free trade). At $M4$, the quota is no longer binding.

¹ Although not indicated in the graph, $Q1 = M1$ and $Q2 = M2$.

Imports can be less in the case of a binding TRQ than with an unconstrained in-quota tariff, as shown in this case, where M3 units of imports must be rationed among Q3 units of demand due to the TRQ restriction.

2.4.1.1 Trade regimes under tariff rate quotas

Issues of interest in the implementation of TRQs can be divided into administration and liberalization, both of which have reasonable impact on trade. While TRQ administration provides information about how countries implement their TRQ system (Liapis and Britz, 2002), tailoring reforms to individual TRQ fill-rates can expand market access and reduce trade bias, hence liberalization (Skully, 2001a). The IATRC (2001) highlighted major challenges in TRQ administration and implementation:

- Discrimination among exporters and importers;
- Under-fill, i.e. the extent to which the minimum access commitments are not met;
- State trading as an implementation mechanism; and
- The impact on protectionism (or liberalization) resulting from its adoption.

It has been said that the TRQ system was not well understood at the time of its adoption at the Uruguay Round negotiations (Abbott and Morse, 2000), leading to its low level of adoption by developing countries (IATRC, 2001). However, as shown by Skully (2001b), TRQs can serve as an important instrument for import rationing.

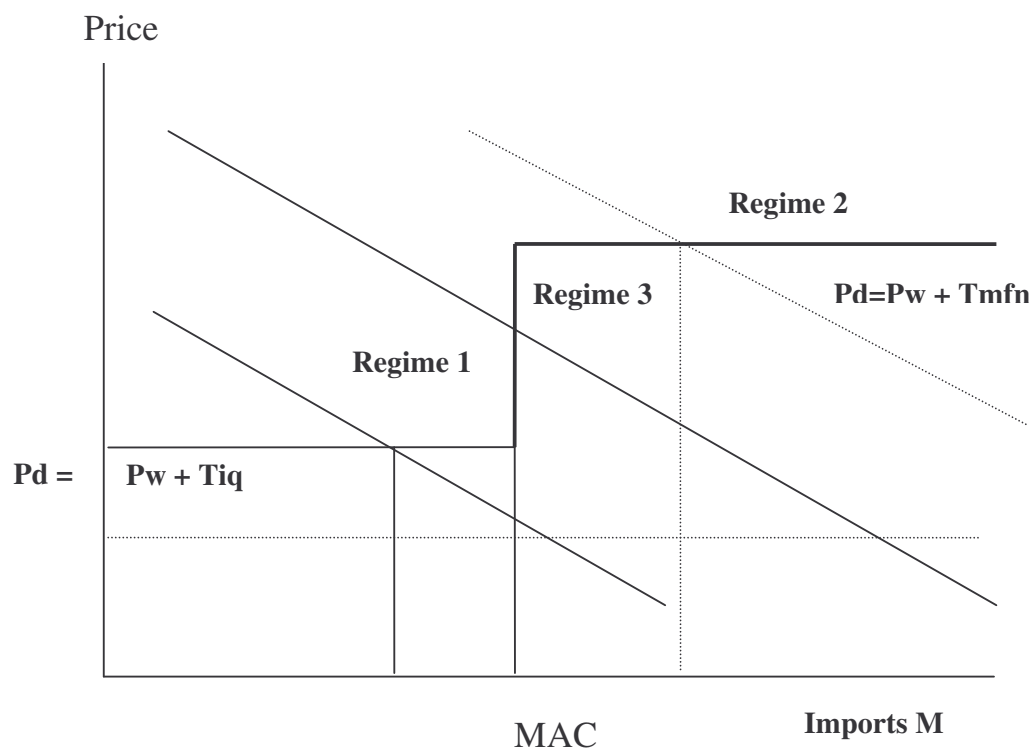
Most of the (few) developing countries which have adopted TRQs have implemented it as either applied MFN tariffs well below the relatively high GATT stipulated in-quota tariff bindings (making import levels well in excess of minimum access requirements), or as a modification of state trading and licensing regimes (IATRC, 2001). In the case of developed countries, for instance the US-China agreement on agricultural trade, TRQs have been used as maximum trade levels (USTR, 1999 as reported in IATRC, 2001). However, notifications of TRQs by some countries have not been transparent. For instance, the EU notifies the WTO of the level of imports

issued in licenses rather than the actual imports (Bureau and Tangemann, 2000), making it difficult to measure the extent of market access.

The minimum market access and tariffication commitments have been implemented by several WTO member countries. For instance, Matthews and Laroche-Dupraz (2001) showed that EU TRQs were established in three ways: current access quotas (which allow for maintaining pre-existing preferential access commitments e.g. Cotonou, previously the Lomé Convention), minimum access quotas and non-tariffed product quotas (that is, quotas established for products for which non-tariff barriers are converted to tariffs without necessarily undergoing tariffication, while still complying with the AoA). This trend exists mainly because many European countries proposed and implemented tariff rate quotas before signing the Uruguay Round Agreements in 1994 (Abbott and Morse, 2000).

Figure 2.3 shows three possible alternative trade regimes under TRQs (Abbott and Morse, 2000). In regime 1 weak demand results in net import demand being less than the minimum access requirements. Thus, the domestic price is the sum of the world price and the low in-quota tariff. This therefore functions as a pure tariff. A second regime (regime 2) functions as a pure TRQ. Due to strong demand, imports exceed the minimum access requirements. Thus the domestic price is the sum of the world price and the MFN tariff. This was the original intention of introducing TRQs, i.e. to constrain imports. This is therefore a pure TRQ regime. A third regime (regime 3) functions as a quota. Due to a “prohibitive” MFN tariff, imports exceed the minimum access requirements at the lower in-quota tariff, but are lower than the minimum access requirement at the MFN tariff. Therefore, the domestic price lies between the world price plus the in-quota tariff and the world price plus the MFN tariff.

The two latter cases result in rent creation and hence the need for an administration mechanism for distributing the rent. Table 2.1 shows the outcomes of emerging domestic price, rent creation and whether administration is required under the alternative TRQ regimes discussed above.



Regime 2: True TRQ

Regime 1: Pure tariff

Regime 3: Quota

Figure 2.3: Alternative TRQ regimes

Source: Adapted from Abbott and Morse, 2000

Table 2.1: Outcomes of alternative TRQ regimes

Trade regime	Domestic price	Rent	Administrative method
Quota unfilled	$Pd = Pw + Tiq$	–	Not required
Quota overfilled	$Pd = Pw + Tmfn$	$(Pd - Pw - Tiq) * MAC$ or $(Tmfn - Tiq) * MAC$	Required
Import at quota	$Pw + Tiq < Pd < Pw + Tmfn$	$(Pd - Pw - Tiq) * MAC$	Required

Source: Compiled from Abbott and Morse, 2000

2.4.1.2 Tariff bindings

Tariff bindings are countries' commitments to maximum tariffs. Applied tariffs are often lower than these bindings, both for TRQs and for MFN tariffs (Ingco, 1995). Walkenhorst and Dihel (2003) report that in most developed countries, particularly Canada, the European Union and the United States, MFN-applied tariffs equal bound rates. On the other hand, OECD (reported by Walkenhorst and Dihel, 2003) reports the largest difference between applied and bound tariff rates for Brazil, India and South Africa, giving an indication of the level of unused protection in the agri-food sector in these countries.

Furthermore, the combination of specific (i.e. per unit) and ad valorem rates has been considered a very effective means of protecting particular segments of the market (Bureau, Fulponi and Salvatic, 2000 quoted in Walkenhorst and Dihel, 2003). However, the complementarity and substitutability between products, the equilibrium effects and changes in terms of trade have created linkages which are difficult to evaluate without the use of economic models (Walkenhorst and Dihel, 2003).

While developing countries have mostly implemented TRQs as MFN tariffs short of GATT bindings, or as modifications of previously existing state trading or licensing regimes, true TRQs have been widely used in Eastern European countries to protect certain markets (Abbott and Morse, 2000).

2.4.1.3 Market stability under TRQ

In a TRQ regime, either one of the three (in-quota tariff, quota limit and over-quota tariff) can be effective for specific import quantities, while the two others are redundant. When a policy instrument determines the level of the domestic and world prices directly, it is considered "effective"; it is however redundant when the domestic price is determined by another policy instrument (Boughner *et al.*, 2000). A prohibitively high over-quota tariff allows for the same volume of imports as a pure quota (Skully, 2001a). However, if the over-quota tariff is less than the difference between domestic and international prices, more imports are allowed than under a normal tariff (Khorana, 2004).

Abbott and Paarlberg (1998) observed that price variations and market behaviours under TRQs depend on the level of excess demand and excess supply. That is, when demand and supply conditions bring imports to the quota, price variations and market conditions are as under a pure quota, and can result in the alteration of policy regime. Boughner et al., (2000) showed regime switches under TRQs due to changes in market conditions. Changes in market conditions (due to changing intersections of demand and supply curves) determine which policy instrument is effective and under what conditions. These outcomes are reported in Table 2.2.

Table 2.2: Effective policy and market conditions under alternative TRQ regimes

Effective policy	Redundant policies	Conditions
Quota	Tiq and $Tmfn$	$Tmfn + Pw > Pd$ and $Tiq + Pw < Pd$
$Tmfn$	Quota and Tiq	$Tmfn + Pw < Pd$
Tiq	Quota and $Tmfn$	$Tiq + Pw > Pd$

Source: Boughner *et al.*, 2000

2.4.2 TRQ administration

There is an on-going debate about the impact of administration of TRQs on market access. Abbott (2001) observed two characteristics of commodities for which TRQs exist. One is that they are politically sensitive commodities and the other is that they are likely to be essentially non-tradable. The political sensitivity of these products emphasizes the issue of TRQ administration, because as the commodities become more tradable (especially meat and dairy products), exporting countries seek improved market access.

For TRQ administration, it is important to determine how quotas are distributed. It is noteworthy however that the distribution of licenses does not correlate with the distribution of quota shares. While the former serves as a rule by which import licenses are allocated, permitting potential individual traders to import under the

quota, the latter determines the amount of quota reserved for particular exporting countries. When an importing country sets the in-quota tariff, quota level and out-of-quota tariff without country preferences, it is referred to as a global quota, while quotas reserved for specific countries are termed country specific allocations (Hermann, Kramb and Monnich, 2000).

Matthews and Laroche-Dupraz (2002) state that preferential TRQs could be administered in favour of developing countries in three ways; firstly by lowering or eliminating in-quota tariffs for imports from developing countries, secondly by reserved quota allocation for developing countries and thirdly by transferring quota rents to exporters from these countries using licensing arrangements. They further show, using evidence from the EU agricultural market, that increasing quotas could influence market access positively for developing countries. However, the conclusion was that MFN tariff reductions are more important for developing countries' market access.

However, Hermann *et al.*, (2000) show that country-specific allocations introduce inefficiencies, as the favoured countries are excluded from competition with other exporters, in contrast to a global quota regime where market forces would determine how imports are allocated. It can therefore be concluded that, with country specific quotas in place, high-cost suppliers are granted access to markets, displacing low-cost suppliers (Skully, 2001b).

2.4.2.1 Description of TRQ usage

Of the initial 1 368 TRQs declared in 1999, 47 per cent were administered as applied tariffs (WTO, 2000). The consequence of using simple applied tariffs is that the over-quota tariff is not applied and there is no effective limitation on imports at the in-quota tariff. However, as observed by Skully (2001b), the administration of TRQs as applied tariffs is associated with the challenge of the importing country enforcing the TRQ at any time, thereby distorting trade flows.

Examining the use of TRQs in meeting the minimum access commitments by developing countries, Abbott and Morse (2000) observed that, since developing

countries have met the minimum access commitments by applying TRQs to particular commodities in 1999, imports have increased in 72 per cent of cases and decreased in 28 per cent of cases. They also found that in 23 per cent of the cases where imports increased the increase exceeded two standard deviations of imports, while in 1 per cent of the cases where imports decreased it exceeded two standard deviations of imports. They added however that it will be incorrect to attribute this trend to TRQs, as most developing countries' TRQs are implemented as pure tariffs.

The form of tariffs in place under TRQs (i.e. either ad valorem or specific tariff) has implications for domestic price stability. Using an empirical model for the Philippine pork trade, Abbott and Paarlberg (1998) show that, when all tariffs are ad valorem under TRQs, the domestic price is more stable than with a pure tariff, but less stable than for a pure quota. However, the specific tariffs showed the greatest stability. Therefore, under a TRQ regime, domestic price shows greater stability when the above and below quota tariffs are specific rather than ad valorem.

Some complex TRQ or TRQ-like regimes have been established for politically sensitive products, involving several rates applied to the same products. One such example is the Common Market Organization for Bananas (CMOB) for the EU. As it is presently constituted, the CMOB established two different quota systems for the TRQs, namely the African, Caribbean and Pacific (ACP) quota and the MFN quota. These quota systems ensure that the in-quota and out-of-quota tariffs are lower for the ACP countries than for third countries (Hermann et al., 2000). Another country-specific quota was allocated under the MFN quota system to four "substantial suppliers"; this accounted for 91 per cent of the MFN quota. The remaining 9 per cent is left as a global quota (in which the ACP countries can partake).

It is interesting to note that TRQs, if implemented in the spirit of the URAA, will result in greater market access. Some countries, like New Zealand, have demonstrated the spirit of the agreement by keeping their in-quota tariff at zero per cent. A recent study by Drogue and Ramos (2005) simulated the impact of greater market access through TRQs on major agricultural products in the EU and MERCOSUR. The results show that, although relatively low increases in global welfare will be experienced, there will be substantial changes in the terms of trade and quota rent

transfer. Due to the competitiveness of MERCOSUR countries in most of these products, there would be greater market access to EU markets and quota rents would accrue to MERCOSUR exporters.

2.4.2.2 “Dirty tariffication”

Consequent to the adoption of tariffication and tariff bindings to convert NTBs to tariffs at the end of the URAA, Ingco (1995) observed that many countries set both their specific and ad valorem tariffs at levels higher than the tariff equivalent (that is, the difference between the domestic and world market prices), a situation she termed “dirty tariffication”.

Boghner *et al.*, (2000) identified various examples of dirty tariffication. These include: manipulation of calculations pertaining to domestic consumption in setting current access and minimum access commitments, reduction of already low tariffs relatively more than that of other sectors with higher tariffs in order to meet the required 36% average reduction and the miscalculation of tariff equivalents to allow for a wider gap between in-quota and over-quota prices.

Abbott and Morse (2000) found evidence of dirty tariffication in the initial 14 developing countries (South Africa not included) which notified the WTO of their TRQs. They however added that the trend is an indication of the extent of trade liberalization in developing countries’ markets. Bureau and Tangermann (2000) confirmed the presence of manipulation in domestic consumption calculations in the United States and Canada dairy trade, as well as in the meat trade of the EU.

Given the prevalence of dirty tariffication in agricultural TRQs, the current schedule “unweighted average” approach has been criticized. As an alternative, different approaches have been proposed (Josling, 1998) to remove the high bound tariffs and thus unused protection from agricultural TRQs. These include the Swiss Formula, which was applicable to industrial goods at the Tokyo Round, the zero-to-zero tariff reductions agreement and several other alternatives differentiated or across the board tariff reductions. The major issue however is how to remove much of the unused protection in tariff bindings.

2.4.2.3 Quota fill-rates

Fill rates, measured by the actual imports as a ratio of potential imports under TRQs (Bureau and Tangermann, 2000), remain a common means of measuring the performance of TRQ administration methods (Matthews and Laroche-Dupraz, 2002). However, it is not a perfect measure of countries' implementation of market access commitments due to the effects of market forces (Bureau and Tangermann, 2000). Abbott (2001) identified two causes of underfill. One is inadequate demand at the price determined by the in-quota tariff. A second cause is the case of transaction cost incurred in complying with TRQ administration methods. In the second case, the effective tariff will be the in-quota tariff plus the transaction cost. Therefore, the domestic price will be the world price plus the in-quota tariff and transaction costs.

When demand is sufficient, the level of quota fill risk is still attributable to the TRQ administration method. For instance, quota fill risks are limited under state trading and producer groups (Skully, 2001a). However, the issue of trade distribution resulting from transparency persists with these administration methods. One measure of transparency is the level of consistency in setting in-quota tariffs across commodities. Bureau and Tangermann (2000) reported that, in meeting its market access obligation the EU has set its in-quota tariffs at 32 per cent of the out-of-quota (MFN), initial or base tariff, except for a few cases. However, unlike the trend with the EU, neither the United States nor Canada specify their in-quota tariff nor distinguish between current access and minimum access; a situation which indicates a lack of transparency.

Skully (2001a) explains that TRQ fill rates, due to the random year-to-year changes, may be considered as a "Markov Process" due to such effects as weather, which affects changes in supply, while demand is subject to macro-financial and exchange rate shocks. Khorana (2004) however contends that quota fill rates alone do not measure the effectiveness of TRQs in granting market access adequately. He concludes that the effectiveness of TRQ administration must be judged by whether it allows for full utilization of import quotas, transparency and whether it efficiently separates distribution of trade from distribution of rents.

De Gorter and Sheldon (2000) argue that quota underfill does not necessarily imply inefficiency, just as a filled quota is not a reflection of efficiency. Abbott and Morse (2000) show that the prevalence of overfilled quotas in developing countries is the result of extensive use of applied tariffs which are set below the tariff rate under a TRQ regime, bilateral quotas, as well as varying quotas emanating from domestic “need” and production (which is reminiscent of state trading or licensing). Underfill may result from inefficiency due to insufficient demand, unavailable supply or effective in-quota tariff (De Gorter and Sheldon, 2000).

Abbott and Morse (2000) observed two trade regimes which result in underfill or overfill. The effect of complex TRQ administration mechanisms, which effectively lead to transaction costs, may be high enough to raise domestic prices to a level where imports are less than the minimum access commitments, resulting in underfill. On the other hand, the practice of using applied tariffs without setting appropriate mechanisms for limiting imports to the minimum access requirements (common in developing country TRQ regimes) mostly set the applied tariff below the over-quota tariff, thus allowing for over-fill.

A recent empirical study by Carter and Li (2005) reports that an in-quota tariff has much more influence on quota fill rates than the over-quota tariff, despite the high protection offered in value terms by the over-quota tariff. This may explain the situation in the OECD countries, where an under-utilization of TRQs measured by the fill rates has been reported. From an average fill rate of 67 per cent in 1995 to 57 per cent in 1999 (OECD, 2001), the case of TRQs in the OECD countries serves as an example of under-performance of TRQs in granting improved market access and increased trade flows.

2.4.2.4 Administration methods

The administration methods permitted for TRQs under WTO rules include applied tariffs, first come-first served, licenses on demand, auctioning, historical importers, state trading, producer groups and miscellaneous categories (WTO, 2000). Table 2.3 provides a description of each of these methods.

Table 2.3: Categories of principal TRQ administration methods

Code	Description
AT	"applied tariff": No shares are allocated to importers. Imports of the products concerned are allowed into the territory of the Member in unlimited quantities at the in-quota tariff rate or below.
FC	"first come-first served": No shares are allocated to importers. Imports are permitted entry at the in-quota tariff rates until such a time as the tariff quota is filled; then the higher tariff applies automatically. The physical importation of the good determines the order and hence the applicable tariff.
LD	"licenses-on-demand": Importers' shares are generally allocated, or licenses issued, in relation to quantities demanded and often prior to the commencement of the period during which the physical importation is to take place. This includes methods involving licenses issued on a first come-first served basis and those systems where license requests are reduced pro rata where they exceed available quantities.
AU	"auctioning": Importers' shares are allocated, or licenses issued, largely on the basis of an auctioning or competitive bid basis.
HI	"historical importers": Importers' shares are allocated, or licenses issued, principally in relation to the past imports of the product concerned.
ST	"imports undertaken by state trading entities": Import shares are allocated entirely or mainly to a state trading entity which imports (or has direct control of imports undertaken by the relevant Member) the product concerned.
PG	"producer groups or associations": Import shares are allocated entirely or mainly to a producer group or association which imports (or has direct control of imports undertaken by the relevant Member) the product concerned.
OT	"other": Administration methods which do not clearly fall within any of the above categories.
MX	"mixed allocation methods": Administration methods involving a combination of the methods set out above, with no single method being dominant.
NS	"non-specified": Tariff quotas for which no administration method has been notified.

Source: WTO (2000).

Several studies have shown that the administrative method used by an importing country determines the level of transparency, efficiency and distribution of trade (Abbott, 2001; Skully, 2001a; Khorana, 2004). Using theoretical arguments, Skully (2001a) ranked these administration methods into three groups based on the risk of biased trade and quota underfill. These are market allocation methods, quasi-market methods and discretionary methods. Market allocation methods comprise auctions and applied tariffs. These methods are inherently unbiased toward trade. A market-based approach has been described as the most transparent and economic method of quota administration. However, the performance of TRQ administration under auctioning depends on the degree of liquidity of the market (Skully, 2001a).

Quasi-market methods comprising first come-first served, license on demand and historical allocation, is the second category. The random effects introduced to market allocation processes by these methods result in the displacement of efficient low-cost suppliers by inefficient high-cost foreign suppliers. However, the absence of a large volume of buyers and sellers may make the application of auctioning methods difficult in which case “licenses-on-demand”, being a combination of market and political processes, may be used.

Matthews and Laroche-Dupraz (2001) identified two impediments to trade brought about by the method of TRQ administration concerned with quasi-market methods, namely business risks and misallocation of resources. Under a first come-first serve administration method long-term contracts without specific allocation of quota rights may result in business risks. For instance, in the absence of specific rights an exporter could find that the quota for a specific product is filled only at the border of the importing country. Furthermore, over-dependence on preferential TRQs by an importing country, even for products for which it has no long term comparative advantage, results in wasteful misallocation of resources.

De Gorter, Falk and Hranaiova (2003), using a game theoretical analysis, established that competition for import quota licenses under a licenses-on-demand method of quota administration allows higher cost firms to meet their desired quota allocation while lower cost firms receive increasingly lower quota licenses from their desired quota allocation. Furthermore, the analysis shows that the absolute inefficiency may

be reduced by reducing in-quota tariffs due to the possible elimination of highest cost importers, while increases in quota can progressively lead to a 100 per cent quota fill. Based on the foregoing, trade liberalization in the face of license-on-demand must be implemented by reducing in-quota tariffs or expanding quotas because these measures have the ability to reduce the inefficiency of the license-on-demand method.

Skully (2001a) argues that the distribution of trade may be inefficient if allocation is based on the quasi-market methods. His argument arises from the fact that rents generated by applying these methods may not be absorbed fully through a tariff or auction, thereby creating an incentive for higher-cost suppliers to gain access to the market, displacing lower-cost suppliers. Despite this trend, however, these two methods, “licenses-on-demand” and “first come-first served”, are the most commonly used in TRQ administration.

The third category comprises the discretionary methods which include state trading entities (STEs) and producer groups. These methods are the least efficient TRQ administration methods with the greatest potential for distortionary trade and rent-seeking; the same as that reported to be an impediment to trade rather than market access (Abbott, 2001, Skully, 2001a, Khorana, 2004). In addition, these methods introduce market uncertainty and high transaction costs in some cases. These impede imports and result in a high probability of underfill. Nonetheless, Abbott (2001) reported the highest fill rates in developing countries for these less transparent administration methods. However, he attributes this trend to attempts by countries to meet their market access obligations, prompting them to use these methods in bringing imports to commitment levels.

In order to ensure transparency of state trading enterprises, WTO rules require member countries to report the mark-up on domestic prices in their notifications of state trading, making it easier to determine whether the mark-up level exceeds the bound tariff rate. This can however be avoided using institutional arrangements (McCoriston and MacLauren, 2001). McCoriston and MacLauren (2001) further argue that, since import licenses are either auctioned or allocated to importing or exporting firms using other administration methods, state trading enterprises as a stand-alone cannot reduce the level of quota utilized or lower quota fill rates.

A recent empirical study conducted by Carter and Li (2005) to measure the impact of the administration methods on market access (proxied by the quota fill rates) in all the countries which notified the WTO of TRQs, revealed that administration methods are of great importance for TRQ performance. As expected, applied tariff methods (although not a real TRQ, in that it does not pose any quantitative restriction), appear superior to other methods. However, the results of this study show some deviation from theory. For instance, despite their varying method of allocation, first come-first served, license-on-demand and historical importer methods show similar effects on market access. Furthermore, although “state trading and producer groups” is the least transparent method of TRQ allocation, results of the empirical study show it has a moderate impact on market access. This argument is supported by WTO data on the average fill rates of the principal administration methods (WTO, 2000) where STEs demonstrate better fill rates than other theoretically better administration methods.

Monnich (2003) conducted an empirical study to determine the impact of administration methods on EU fill rates. As expected, it was established that administration methods do matter, albeit not following theoretical expectations. For instance, historical allocation (although it limits market competition), as well as export certification, were found to not cause quota underfill, while license-on-demand was reported to be the poorest in terms of performance of all the administration methods applied by the EU.

A more surprising result from Monnich (2003) is that the in-quota tariff, as well as the wedge between domestic and import prices, does not have a significant impact on fill rates; in contrast, out-of-quota tariffs as well as quota limits do. This trend was attributed to domestic policies (e.g. subsidies to farmers) in the EU, which are still effective despite the introduction of TRQs to EU agricultural trade (OECD, 2002, quoted by Monnich, 2003). Furthermore, the analysis shows the intermingling of two aspects in which WTO rules apply, i.e. market access and domestic support. In fact, OECD (2002) reports that, even with a general expansion of quotas by 50 per cent in the EU, domestic prices will not be affected.

Apart from the principal TRQ administration methods in Table 2.3, additional conditions which have the potential to cause biased trade and affect fill rates were

specified by the WTO. These include domestic purchase requirements, limits on TRQ shares per allocation, export certification, past trading performance and combinations of the listed conditions (WTO, 2000). Of these four, limits on TRQ shares per allocation remains the most intensively used, accounting for about 40 per cent of total additional administration methods in 1999. Past trading performance followed with about 30 per cent, domestic purchase requirements with about 20 per cent, while the other 10 per cent is administered by export certificates and a combination of past trading performance and limits on shares (WTO, 2000).

2.4.3 TRQ liberalization

TRQs were introduced as a transitional instrument to free trade (Boughner *et al.*, 2000). Skully (2001b) reported that, although TRQs were introduced as an intermediate step towards converting quota restrictions to tariffs, in order to effect the greatest increase in non-discriminatory market access using TRQ, it must be ascertained which of the three elements present in a TRQ regime (in-quota tariff, quota, and over-quota tariff) constrain trade or is likely to constrain it.

Several studies (Bureau and Tangermann, 2000; De Gorter and Sheldon, 2000; Khorana, 2005) examined approaches to liberalizing TRQs which will result in greater market access. While it is obvious that increasing the quota volume or lowering the in-quota tariff can both result in improved market access, Bureau and Tangermann (2000) argue that each of the two forms of reform are applicable under different scenarios. They maintain that both the fill rate and import demand can influence the mode of TRQ reform which would be effective. A low fill rate combined with limited import demand (even at a lower tariff) would not respond to either larger quota volume or lower in-quota tariffs. However, substantial TRQ liberalization exists with the expansion of import quota when existing TRQs are filled, but in such cases a reduction in in-quota tariff will only create rents (Bureau and Tangermann, 2000).

Using the case of Switzerland, Khorana (2004) established that TRQs in itself does not reduce market access for developing countries. However, except for a few developing countries like Argentina, Brazil, China, Thailand and South Africa, which

have advanced integration into the global trading system, many developing countries have not fully utilized their export potentials under TRQs, given the generalized system of preferences.

Matthews and Laroche-Dupraz (2002) observed that the distribution of EU imports under TRQs between developed and developing countries was 60 and 40 per cent respectively in 1997, with a high share in imports of meat products. This was confirmed by Khorana (2004), who established that the largest share of Switzerland's imports from developing countries in 2001 under TRQ was in meat and meat products.

The practice of allocating quotas to specific countries, as opposed to allowing imports at MFN basis for all countries, determines the extent of liberalization. Matthew and Laroche-Dupraz (2001) examined the appropriateness of allocating TRQs to developing countries from an economic, legal and negotiation cost perspective. They concluded that, while preferential access seems to be a development approach to developing countries, there seems to be conflict in the legal provisions² allowing such approach to trade under TRQs. From an economic point of view, sometimes, quotas are allocated to countries with low capacity to meet the quota. Considering the extent to which preferential agreements allow greater access to certain markets, preferential TRQ allocation is a major consideration when evaluating the implementation of countries' market access commitments (Bureau and Tangermann, 2000).

2.4.3.1 Rent creation under TRQ

Theoretically, the percentage increase in quota required to prevent an in-quota tariff reduction from creating quota rent is proportional to the price elasticity of import demand (Skully, 2001b). Boughner *et al.*, (2000) identified the lack of uniformity across countries and commodities in the implementation and reduction of both in-quota and out-of-quota tariffs as the cause of varying trade liberalization effects. They

² Special Binding Commitment and the Reform Programme of GATT versus Enabling clause 2(a) of the Decision on Differential and More Favourable Treatment, Reciprocity and Fuller participation of developing Countries

further pointed out that inflation of tariffs (dirty tariffication) and deflation of quotas resulting from protection tendencies both imply rent-seeking.

Rent creation is a direct consequence of the TRQ administration method. Market-based administration methods remove the incentive for quota rents. In contrast, the risk of displacement of a lower-cost seller by a higher-cost seller, and thus biased trade, is enhanced by increasing deviation of the TRQ administration method from market equilibrium (Skully, 2001a). Since deviation from market equilibrium creates a potential for rent generation the risk of displacement of a lower-cost seller by a higher-cost seller is directly proportional to the extent of quota rent generated.

In auctioning, quotas are allocated to the highest bidder based on prices; therefore all quota rents are absorbed (Skully, 2001b). Despite this trend, however, auctioning is rarely used in developing countries (Abbott and Morse, 2000). Moreover, the two elements of TRQ administration, namely distribution of trade and distribution of rent, affect how much trade-distorting risks are associated with quota rent allocation. However, prioritizing the distribution of trade over the distribution of rents results in the elimination of the trade distorting risk element in quota rent allocation, since the economic principle guiding the distribution of trade is the minimization of trade distortions in the face of TRQ (Skully, 2001a).

2.4.3.2 Quota rent and trade liberalization

The tendency for TRQs to function as a quota, thereby generating rents, brings to the fore the issue of import allocation and rights (Abbott and Morse, 2000). Using arguments of economic efficiency, Skully (2001b) explains how quota rents can result in biased trade. He argued that the generation of quota rents provides an opportunity for higher-cost suppliers to displace lower-cost suppliers when a binding quota increases the demand price to a level that permits higher-cost suppliers' entry into the market. This however results in a reduction in global welfare, as higher-cost suppliers make inefficient use of resources.

Abbott and Morse (2000) report that most developing countries implement their TRQs using MFN regimes which are devoid of mechanisms for allocating rents or means of

enforcing quotas or limits. However, the re-introduction or continuation of state trading permits governments' involvement in managing trade; hence issues of "rent seeking" remain prominent. However, Boughner et al., (2000) are of the opinion that, since the share of rent and tariff revenue depends on both the relative gap between the in-quota and over-quota tariffs, combined with the import quota, it is expedient to ascertain which policy instrument is effective and what potential exists for regime switches. The result will determine how to liberalize trade effectively.

Any TRQ liberalization reform which ultimately results in an increase in rent increases the likelihood for biased trade and reduction in welfare (Skully, 2001b). Furthermore, Boughner et al., (2000) demonstrated how the tariff equivalent (i.e. $P_d - P_w$) relative to the quota provides information about the effectiveness of a quota increase and tariff reductions in causing trade liberalization. They observe that reductions in the over-quota tariff are effective in causing trade liberalization where it is either less than or greater than, but close to the tariff equivalent. In a situation where the over-quota tariff is far greater than the tariff equivalent, trade liberalization is guaranteed to a greater extent with an increase in import quota. In the same vein, when the in-quota and the over-quota tariffs are close to each other both tariffs must be reduced for trade liberalization to take effect, except when the tariff equivalent is much less than the in-quota tariff (in which case only a quota increase will result in trade liberalization).

The ability to transfer TRQ rights could determine who captures the revenue from quota allocation. Where transfer of rights is allowed private traders mostly capture the rent, unlike when rights are not transferable, in which case the distribution of rent is determined by the distribution of trade (Skully, 2001a).

2.5 Competitive equilibrium and trade modelling

Early trade theory built on the concept of comparative advantage by Ricardo raised a lot of questions which economists have subsequently responded to with further economic theories. However, a major limitation inherent in all the early concepts of

international trade was the inability to explicitly incorporate transport costs in trade analysis (Finner, 1959)

Judge and Wallace (1958) observed that the general equilibrium contained in the early trade theories focused on an economy in which neither factors, producers, products or consumers are separated by geographical location and space (that is, transportation costs are assumed to be non-existent). For instance, according to Ricardo's theory, the location of production is to be determined by relative, rather than absolute, costs of production. This concept has serious limitations when more than two regions and/or two products are considered in that it does not explicitly incorporate transportation costs of commodities among regions, and the fact that it takes factor costs as point values instead of price-quantity functions (King and Henry, 1959).

Finner (1959) reports that early formulations of international trade analysis based on economic theory were mainly concerned with national aggregates and the significance of time as an influencing variable. Enke (1951) and Samuelson (1952) were among the first trade theorists to take into account the interconnectedness of competitive markets that led to the development of the notion of competitive locational equilibrium and spatial pricing systems.

2.5.1 Mathematical programming approach to trade modelling

Takayama and Judge (1971) report the efforts of economists to develop a general theory which would address all the concerns and challenges of the earlier theory, such as the spatial pricing and allocation problem, the problem of partial equilibrium among spatially separated markets and the problem of inter-connection of competitive markets. Pioneering work by notable authors such as Koopmans (1949 and 1951), Dantzig (1951) (mentioned in Takayama and Judge (1971)), Enke (1951) and Samuelson (1952) resolved these problems with spatial equilibrium and transportation formulations which could be solved using mathematical programming. King and Henry (1959) confirmed that transportation models provide valuable insights into the interrelationships of markets during change in supply and demand conditions. Finner (1959) further stated that the inclusion of interregional commodity

movements as significant variables in the analysis of trade flows has provided a measure of the economic effects of changes in a given region on national aggregates and on the economies of other regions within the national aggregate.

2.5.2 Use of mathematical programming for policy analysis

Earlier uses of mathematical programming for regional trade analysis employed the linear programming technique to arrive at equilibrium price and trade flows. For instance, Judge and Wallace (1958), using comparative static analysis, demonstrated how regional trade analysis can be used to determine the response to changes such as transport costs, the level of regional distribution of production, the level and distribution of consumer income, as well as the level and regional distribution of population on regional prices, production, consumption and commodity flows. This was done by determining the optimum regional price differentials, equilibrium prices, consumption and surpluses, as well as deriving minimum cost commodity flows among regions using the mathematical programming approach.

Empirical applications of theoretical formulations of existing competitive equilibrium and trade theories stand as a bridge between theory and reality, as it ascertains the practicability of such theories. The need for such empirical application has given mathematical programming an increased importance in the past century as an analytical approach to agricultural problems (McCarl & Spreen, 1980).

2.5.3 Developments in trade models of the agricultural sector

The bias in the regional emphasis of models with global coverage to date has been to the disadvantage of developing countries. For instance, the regional composition of WATSIM, as modelled by Kuhn (2003), does not take developing countries into account, while the market module of the CAPRI model described by Wieck, Dominguez and Britz, (2003) divides the world into 12 regions, with only an aggregation of the ACP countries. However, while almost all existing agricultural policy models have been developed mainly for the developed countries, the FAO World Food Model takes into account the consequences of policies in developing countries. Conforti (2001) describes the latest version of this model, which has

incorporated TRQs and takes intra-industry trade into account. However, the level of product aggregation assumed in the model limits its analytical capability.

Even with the existence of a few disaggregated models that are capable of simulating the effects of trade policies on developing countries (including South Africa), such models are not necessarily dependable. As Westhoff, Fabiosa, Beghin and Meyers, (2004) point out, obtaining reliable and current information on applied tariffs and TRQs is not easy. However, even if initial data are accessible, they are difficult to update, leading to erroneous and biased results. Therefore it is important that a country-specific model be developed for regular and updated results.

2.5.3.1 Measuring the impact of agricultural trade policy

Most of the existing product-specific models of agriculture have concentrated on trade in developed countries, whilst those focussing on livestock trade have focused more on dairy products (IATRC, 2001; Cox and Yhu, 1997; Nicholson and Bishop, 2004). The reason is that dairy trade attracts much political attention in the developed world and is perceived to be highly distorted. In addition, Nicholson and Bishop (2004) point out that most of the product-specific models have aggregated policy instruments, i.e. not being specific with regard to a particular instrument, and have not included explicit representation of discriminatory ad valorem tariffs.

Among the new tools introduced to agricultural trade policy making, TRQs seems to be the most ignored in trade policy analysis (Conforti, 2001). The introduction of TRQs to global agricultural trade at the end of the URAA has added new dimensions to trade policy modelling. This is the case because the administration and implementation of this policy instrument requires high levels of sophistication. Rae (2001) makes a case for the inability of most trade models to explicitly model TRQs. He suggests either data or modeling complexities, or both, as the common reasons for this trend. Being a relatively new policy instrument, few of the existing models have been adjusted to accommodate TRQs. Van Tongeren, Van Meijl and Surry (2001) note that switching cost and the degree of adaptability are the major factors responsible for the slow rate of redesigning existing models to accommodate newer policies.

2.5.3.2 Model specification for policy analysis

In terms of identifying areas of research pertaining to interregional trade analysis, Finner (1959) points out that the principal problems that could be solved by such specifications include spatial and locational problems, industry studies, demand and consumption studies, transportation problems, business operating decisions, as well as regulatory programs. King and Henry (1959) add to this by stating that the study of the economic effects of interregional changes in production and consumption levels, imposition of duties, introduction of subsidies, blocking of trade on particular routes and changes in transport costs on particular routes can be conducted by using comparative statics in the transportation model.

Francois and Reinert (1997) make a case for the appropriateness of economic and trade models for policy analysis within a comparative static framework. They argue that the three major factors impacting on the accuracy of the model results are the functional forms adopted, the base data used and behavioural elasticities. However, measuring change in trade policies using economic models requires the conversion of such policies to price effects in order to determine their impact on such variables as trade flows, economic welfare and other useful variables. Therefore, the level of impact (in terms of both magnitude and direction) of the change in trade policy on particular variables will respond to both the price effects (i.e. the shocks) and the behavioural relationships in the target economy (McDaniel and Balistreri, 2003). In this regard, the model structure can be analyzed either by using the assumption of homogeneity or imperfect substitution between imported and domestic goods.

A limitation of model structures which assume homogeneity of goods is that they seldom capture the intra-industrial trade that takes place between the importing and exporting countries. Therefore, although consistent with theory, the assumption of perfect substitutes in demand for goods does not represent a real-life situation (Francois and Reinert, 1997). However, Armington (1969) proposed a theory which takes into account the imperfect substitution in demand between domestic and imported goods using a constant elasticity of production (CES) functional form. This phenomenon of differentiating demand for products by place of production or origin has been termed the Armington Assumption. Although this assumption has been used

widely in both general and partial equilibrium trade models, it is not without its critics.

According to McDaniel and Balistreri (2003), the major criticism against the Armington elasticities relates to the estimated level of substitutability of domestic and imported goods, which many trade economists believe are smaller than the real situation. Furthermore, McDaniel and Balistreri (2003) reviewed studies which employed econometric methods for estimating the Armington elasticity and came up with three major findings. One is the level of trade response to short-run and long-run estimates, i.e. the long-run Armington elasticities are more responsive than the short-run. Secondly, the level of aggregation is directly proportional to the size of Armington elasticity estimates. Lastly, the methodological approach is of importance due to observed differences in results recorded by cross-sectional as against time-series studies. Substitution rates are higher for the studies that apply cross sectional data than for those that used time-series data.

2.5.4 Spatial equilibrium modeling

Almost all the agricultural trade modeling approaches can be traced back to the Samuelson-Takayama and Judge (STJ) framework (Samuelson 1952; Takayama and Judge 1964, 1971). The analysis of the “equilibrium” flow of trade was derived by Samuelson (1952) when he applied the fundamental principle of “marginalism” to economic analysis. He proposed that the relationship among production, costs and revenue can be represented by both marginal equality and non-equality equations. His explanation arises from the fact that where marginal equalities (while accounting for transport costs and price differentials between regions) fail to explain equilibrium in trade and comparative advantage among spatially separated markets, marginal inequalities apply.

One important element in trade modeling is the regional composition of the model due to its implications on the efficiency of economic models in policy recommendation. In conducting sectoral analysis two major approaches can be employed for defining the regions involved in order to measure the impact of policy, as well as the impact of various trade scenarios. As described by Kuhn (2004), a

country (say South Africa) could be separated into regions based on existing categories (for instance on a provincial basis) and then the aggregate market named “rest of the world”. Another way of doing this, as reported by Pustovit (2003), is to use certain reasonable forms of categorization. For instance, the country's regions (say South Africa's provinces) could be aggregated and then trade relations (for instance EU-SA TDCA) could be separated rather than having an aggregate “rest of the world”.

2.5.5 Partial equilibrium modeling

Market equilibrium models can take the form of an economy-wide model (general equilibrium) or a partial equilibrium model. Although general equilibrium models take an economy-wide approach, the complexity of such models, as well as their huge data requirements, have constrained modelers to partial equilibrium models, which are better at handling many sector-specific analyses (Hertel, 1993 and Francois, 1999; quoted by Jooste, 2001). As concluded by Jooste (2001), the modeling framework adopted for any trade analysis should be driven by such considerations as the specific problem at hand, the anticipated solution, the sectoral or regional focus of the potential model and the representation of trade.

Van Tongeren and Van Meijl (1999) observed that most of the partial models of agricultural trade capture the demand and supply relations of primary products while processed commodities are not modeled explicitly. Notwithstanding the higher share of secondary commodities in agricultural trade, many partial models have not fully exploited the linkages between primary and secondary agricultural sectors such as beef processing or dairy processing. Conforti (2001) also observes that in almost all existing partial trade models, all the supply relations fail to consider food processing and distribution. However, some more recent partial equilibrium models like the WATSIM (Kuhn, 2003) and @2030 model (Britz, 2003) take such linkages into account by introducing technical coefficients which handle the conversion of primary to secondary products.

Another equilibrium concern raised by Conforti (2001) is that most existing models (general and partial) have depended extensively on the use of trends and calibration to

derive their parameters, while failing to test existing behavioural hypotheses based on micro-economic theory. However Britz (2003) shows in the @2030 framework that, whilst missing model parameters can be derived by calibration of model parameters, the same can be formulated to ensure compliance with requirements of micro-economic theory for supply and demand parameters.

2.6 Quadratic programming

Following the formulation of spatial price equilibrium models using Samuelson's (1952) linear programming approach, in replacing marginal equalities with marginal inequalities for defining such relations as competitive equilibrium and comparative advantage in economic models, Takayama and Judge (1964a) showed that the Enke-Samuelson formulation can be converted to a quadratic programming problem.

The linear dependencies for interconnected competitive markets require that the supply and demand prices be equal for any given region, the supply and demand relations between each region be represented by a linear function and transport costs between demand and supply regions to be included for flow activities between demand and supply points. Based on this foundation Takayama and Judge (1964a) further added equations which specify the handling of (a) linear regional demand functions and fixed regional demand, (b) fixed regional demands and linear regional supply functions, as well as (c) multi-product linear regional demand and supply functions which involves linear substitution and complementarities. Such relations can however only be handled mathematically within a quadratic programming framework.

2.6.1 Scope of quadratic programming

Market equilibrium models ensure the determination of both equilibrium prices and quantities, given sets of interrelated markets, as well as the behaviour of economic agents to changes in prices. One major requirement in such a situation is for the market to “clear” in which case endogenous prices have to be generated, which are linked to both the domestic and world markets (Van Tongeren and Van Meijl, 1999).

Although the basic spatial equilibrium model developed by Takayama and Judge (1971) is a price endogenous model which extends the basic transportation problem by relaxing the assumption of fixed supply and demand; modelling of this class only addresses the questions of who will produce and consume what quantities and what level of trade will occur (McCarl and Spreen, 2000). However, in core economic analysis, the behavioural response of market agents can be determined by imposing certain optimizing assumptions, which involves the specification of the demand and supply relations as a function of income, prices and elasticities (Van Tongeren and Van Meijl, 1999). In such analyses, the quadratic programming approach easily accommodates the additional constraints and allows for the determination of market equilibrium.

2.7 Duality theory

Diwert (1974) identified the two major applications of duality theory; one is that it allows for deriving demand systems which satisfy the maximizing or minimizing behavior of the consumer or producer within the context of consumer or producer theory. Secondly, it provides a basis for the generation of “comparative static” results consistent with the maximizing behaviour of an economic agent.

In many studies of the type conducted here, the need to generate demand parameters required for the modeling approach necessitates the calibration of available elasticity estimates from econometric studies. When the equilibrium price and quantity in the base year are available, the slope and intercept coefficients can be calibrated using these elasticity estimates by specifying a linear price dependent demand form (Howitt, 2005). This approach is derived from the first application of the duality theory mentioned above.

2.7.1 The derived demand

The calibration of the demand system of an economic model is not as straightforward as mentioned by Howitt (2005), since some theoretical conditions must be satisfied for the derived demand function to be judged credible. Deaton and Muellbauer (1980) summarized the basic properties of a demand function as being homogenous of

degree zero in prices and total expenditure, having symmetrical compensated price responses and forming a negative semi-definite matrix (that is the curvature condition). Since few empirically estimated functional forms satisfy all of these conditions, it is important to impose them on the specified demand function, so as to satisfy the associated conditions implied by economic theory.

Diewert (1971) identifies two distinct methods to obtain solutions to a cost minimizing production function. The first method would be to obtain the derived demand function through mathematical programming techniques from a production function using a plausible functional form. An alternative method is to generate the derived demand function from a cost function using partial differential techniques with respect to the input prices. Based on the uncertainties associated with satisfying the regularity conditions when a production function (derived from a cost function) is transformed back to the original cost function, the second method may prove more complicated. However, the latter method must satisfy the micro-economic conditions.

2.7.2 Flexible functional forms

The estimation of utility, demand or cost functions within a production or consumer context often fails to satisfy the theoretical curvature conditions required by economic theory. However, a major factor in complying with these conditions is the flexibility of the chosen functional form. Diewert (1974) defines a flexible functional form for a cost function as one which allows for a second order approximation to an arbitrary twice continuously differentiable cost function that satisfies the linear homogeneity in prices, as well as the concavity conditions at any point in an admissible domain. By extending the Samuelson-Shephard and Shephard-Lemma duality theorems, Diewert (1974) developed the now commonly used generalized Leontief “flexible” functional form.

Ryan and Wales (1996) estimated consumer demand functions which permit income flexibility by allowing for the curvature conditions to be imposed while constraining the demand function with two price functions; one which is homogenous of degree one in prices and the other which is homogenous of degree zero. The price function homogenous of degree one in prices is a quadratic form normalized by a linear form

to yield a function linear in prices, hence the term “Normalized Quadratic-Quadratic Expenditure System”. By deriving a demand system from the indirect utility function in this manner, Ryan and Wales (1996a) proved that the first derivative of demand with respect to prices and income can take up arbitrary values at a particular point, and that the second derivatives of demand with respect to income can also take up arbitrary values at the same point. Hence the curvature condition can be imposed during estimation without making the function inflexible.

2.7.3 Model integrability

The symmetry condition, also termed “integrability” (Hurwicz and Uzawa, quoted by McCarl and Spreen, 1980), is the fundamental constraint associated with deriving factor demand equations from a cost minimization process (Diewert, 1971). For a demand function this condition can be guaranteed by the matrix of the first derivative of the Slutsky equation by treating maximization of utility as the minimization of costs (Deaton and Muellbauer, 1980), since the expenditure function is to a consumer what the cost function is to the producer. This can be proven by showing that the Hicksian demand function can be rewritten as a derivative of the cost function that integrated into it. That is:

$$\frac{dC}{dP_i} = g_i(c, p)$$

This solves for C as a function of price. However, the mathematical conditions to ensure that the cost function solves the partial differential are:

$$\frac{dg_i}{dx} g_j(x, p) + \frac{dg_i}{dp_i} = \frac{dg_j}{dx} g_i(x, p) + \frac{dg_j}{dp_i}$$

Deaton and Muellbauer (1980) conclude that, since the left-hand side of the above equation is the Slutsky equation it shows that the Slutsky substitution matrix is a fundamental integrability condition of the demand theory. Following Ryan and Wales (1996a) it has been proven using a number of consumer demand functions that, with the identification of the appropriate reference point, the Slutsky matrix can be forced to be semi-definite by imposing the curvature conditions at that point.

According to McCarl and Spreen (1980), the integrability condition requires that the effect of income on consumption is uniform across a combination of commodities in an economic model if the cross-price effects are to be symmetric. In ensuring that this condition holds, Ryan and Wales (1996b) estimate demand systems in which quantities demanded are quadratic functions of total expenditure or income, while also satisfying the flexibility condition.

2.7.4 Elasticities

Ryan and Wales (1996b) tested two of their postulated derived demand systems, i.e. the Normalized Quadratic-Quadratic Expenditure System and the Translog-Quadratic Expenditure System, by comparing the results obtained when the demand systems are calibrating against the micro-economic conditions and otherwise. The coefficients on the quadratic terms (elasticities) obtained were found to be highly significant when the micro-economic conditions were imposed. The result demonstrated the relevance of these demand systems and the micro-economic conditions in economic modeling.

The integrability conditions require the cross-price effects to be symmetric. According to McCarl and Spreen (1980), this implies that the effect of income on consumption is identical across all commodities of interest. However, Takayama (1994, as reported by Waquil and Cox, 1995) distinguishes mathematical integrability from economic integrability. While mathematical integrability refers to the condition in which the matrix of the first derivatives is symmetric, economic integrability refers to the condition in which the matrix of first derivatives is positive semi-definite for supply functions, and negative semi-definite for demand functions.

2.8 Conclusion

This chapter provided an overview of the emergence of the fundamental theory of trade and the developments thereafter. Current challenges in trade among nations and the structures in place to regulate the global trade arena, especially as it concerns agricultural trade, were highlighted. Within this context, the emergence of complex

trade policy instruments and the need for proper understanding of these instruments was emphasized.

TRQs are one of the trade policy instruments currently widely used in agricultural trade. The assertion that the functioning of this instrument is not properly understood has led to an in-depth literature survey which covers the three major facets of TRQs, namely implementation, administration, and liberalization. This is especially important if considers the fact that no extensive study has been conducted on this subject in South Africa. It is therefore important to give an elaborate insight of this nature before conducting an empirical study on TRQs.

INDUSTRY OVERVIEW AND TRENDS IN THE LIVESTOCK TRADE OF SOUTH AFRICA

3.1 Introduction

About 80% of South Africa's 1 million km² agricultural land is suitable only for animal husbandry due to climatic and natural resource constraints. Moreover, livestock farming forms the core of agriculture for both commercial and emerging commercial farmers. It is therefore not a coincidence that the Integrated Sustainable Rural Development Strategy (ISRDS, 2004) identifies livestock farming as the agricultural enterprise with the most likely chance of improving household food security and addressing poverty alleviation in the small-scale communal farming areas of South Africa (Coetzee, Montshwe and Jooste, 2005). Furthermore, the livestock 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 and the floor price removal scheme etcetera before the commencement of deregulation in the 1990s (Jooste, 2001). The industry became totally deregulated when all control boards were abolished in 1997.

The livestock industry remains a major employer of rural labour, with about 425 000 people employed in 2001 and 2 125 000 depending on it for their livelihood (Meissner, 2004). Livestock products accounted for an average of 40% of gross farming income since 2000 (NDA, 2005a). Due to the high rate of utilization of products of other industries (for instance, the poultry industry alone uses about 30 per cent of all maize produced) and increasing output by both established and emerging farmers, the livestock industry through forward and backward linkages (to such industries as the

food industry), increased its contribution to the national economy by 10% in 2003 (Meissner, 2004).

In South Africa 40% of the livestock are owned by emergent producers from previously disadvantaged communities, the same group that forms the focus of government development policies (NERPO, 2005). Therefore, the livestock industry takes priority in government's fundamental objective of equitable access and participation, global competitiveness and profitability of the agricultural sector.

This chapter consists of three major parts. Firstly, an overview of the South African livestock industry will include production, consumption and trade trends. Secondly, the tariff regime on imports and market access quota on meat products in South Africa, as well as the relative importance of TRQs in South Africa's meat imports will be presented. The chapter ends with a brief conclusion.

3.2 Livestock production in South Africa

3.2.1 The beef sector

Figure 3.1 shows the South African cattle herd and animals slaughtered since 1975. From a total herd size of 12.6 million in 1994 the cattle herd size in South Africa increased to 13.8 million in 1998. Since then, it has remained within the range of 13.5 and 13.6 million to date. In addition, the number of cattle slaughtered in South Africa which dropped to about 2.1 million in 1994 rose again to about 2.66 in 1999. It has since ranged between 2.2 and 2.6 million per annum. According to latest statistics, the commercial herd comprises approximately 60% of the total cattle herd. This means that approximately 40% of all cattle in South Africa are owned by non-commercial farmers. Of the total commercial herd, 88% is used for meat production while the remaining 12% is for dairy.

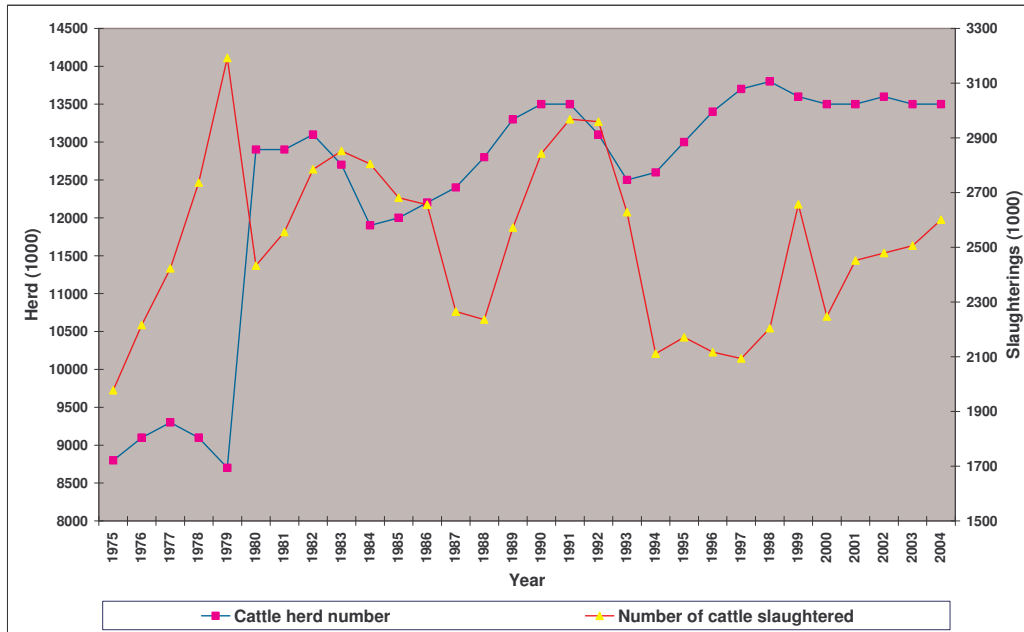


Figure 3.1: The South African cattle herd and slaughtering (1975-2004)

Source: NDA, 2005a; own computations.

3.2.2 The pork sector

SAPPO (1999) reported that approximately 80% of the total pigs in South Africa are found in commercial areas while approximately 20% are in the developing areas. Figure 3.2 shows the trend in the number of commercial pigs slaughtered in South Africa and the domestic pig herd. There has been an upward trend in both the number of pigs slaughtered and the herd size in this industry from 1975 to the early 1990s. This trend can be largely attributed to the continued investment in the technical, scientific and marketing aspects of pig production. For instance, the acquisition of computerized feeding and environmental maintenance equipment, better disease control by improved housing facilities and the free market approach has aided the production efficiency and competitiveness of the industry (Visser, 2004).



Figure 3.2: The South African pig herd and slaughtering (1975-2004)

Source: NDA, 2005a; own computations.

Although a general upward trend is observed, the period following the early 1990s until 2004 has experienced stagnation in both the number of pigs slaughtered and herd number. The sharp drop in swine herd numbers around 1999 can be attributed to the outbreak of Foot and Mouth disease in that year. Many producers went out of business or at least cut back on their herd numbers after the incident. Many herds were being fed but were not marketable. The sub-sector has however recuperated from the crisis.

3.2.3 The sheep sector

The South African sheep flock and number of sheep slaughtered is depicted in Figure 3.3. From about the early 1980s, sheep numbers began to drop but picked up appreciably towards the end of that decade. The significant drop in the number of sheep during the 1980s can be largely attributed to the collapse of the wool industry. However the recovery of the late 1980s did not last long as it dropped again shortly thereafter and has continued to drop. Since 1994 to 2005, production of sheep meat has dropped annually by about 2.8 per cent.

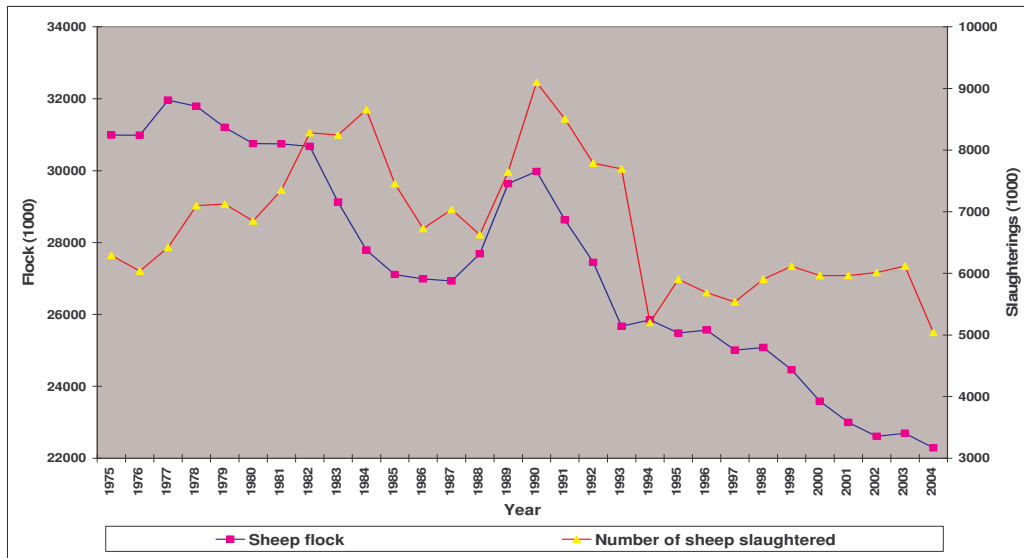


Figure 3.3: The South African sheep flock and slaughtering (1975-2004).

Source: NDA, 2005a; own computations.

3.2.4 The poultry sector

According to Table 3.4, the number of broilers produced per week in South Africa has experienced an upward trend since 1992, with a peak value of 11.8 million per week in 2002.

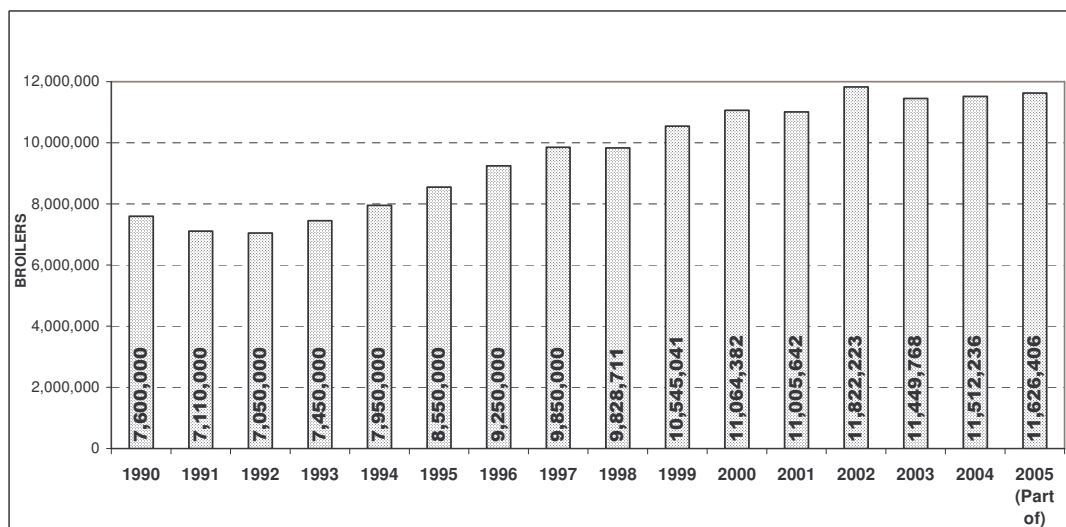


Figure 3.4: Average broiler production per week in South Africa: 1990 - 2005

Source: South African Poultry Association – SAPA (2005)

Of the total production of poultry meat, 65% amounting to about 0.9 million tonnes in 2004, was contributed by 30 major producers while the total production of the small-scale emerging producers amounted to about 2 % of the national aggregate (SAPA, 2005). According to SAPA statistics, the Western Cape Province is the largest producer of broilers accounting for 26.9% of total production, followed by Gauteng with 16.3%, North West with 15.8%, and Mpumalanga with 15%.

The poultry sector uses 69% of the production output of the feed industry, as well as between 15 and 25% of the total maize output. Therefore, feed prices have an appreciable impact on poultry production. However, in recent years feed prices have decreased, partly due to the strong rand. The size of domestic grain production which has resulted in excess supply, coupled with the linkage to the Chicago Board of Trade (CBOT) prices which affect the import and export parities, largely account for low feed prices. For poultry producers this state of affairs resulted in lower feed costs.

3.3 Consumption of meat in South Africa

3.3.1 The beef sector

The per capita consumption of beef experienced a downward trend from 1978 up until the late 1980s, then picked up and increased until the early 1990s. Since then, there has been a sharp decline in the per capita consumption of beef as shown in Figure 3.5. From the figure, it is evident that trends in per capita consumption of beef and per capita disposable income have a very close correlation. Therefore, the downward trend experienced in per capita beef consumption since the early 1990s can be attributed to a large extent to the stagnating per capita disposable income. This perceived correlation was confirmed by Nieuwoudt (1998) who reported a high-income elasticity of demand for beef. Taljaard, Jooste and Asfaha (2005) also argue that the decline in per capita consumption can be explained by increased consumer sophistication.

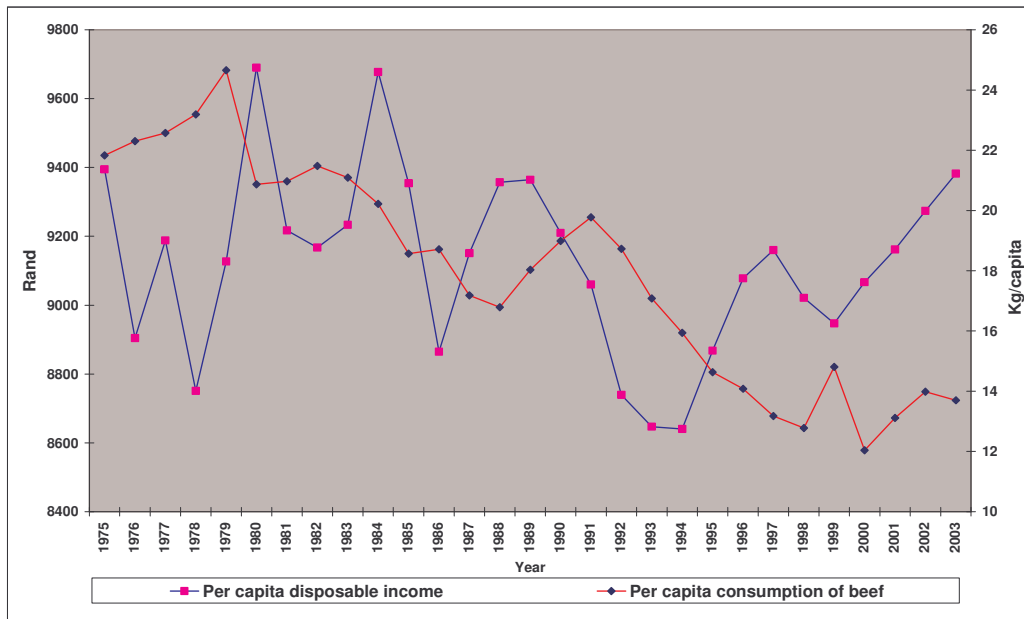


Figure 3.5: Relation between real per capita disposable income and the per capita consumption of beef (1975-2003)

Source: SARB; 2004; NDA, 2005a; own computations.

According to Nieuwoudt (1998), the racial distribution of the South African population has serious implications for food demand. For instance, the highest population growth rate is recorded among the black population but this does not necessarily translate into an increase in average per capita food consumption. That is, although all the population groups may experience increasing growth in per capita consumption, the average per capita food consumption may decline. Nieuwoudt (1998) explained that this phenomenon is attributable to the impact of the group with the highest population growth, which most often records the lowest per capita demand and consumption of livestock products.

3.3.2 The pork sector

The per capita consumption of pork has remained relatively constant for a couple of decades now (Figure 3.6), as opposed to the declining trends in other red meat (beef and mutton). This is similar to global trends, with pork and poultry serving as substitutes for beef. One of the reasons for this is that pork is considered as the alternative white meat, which tends to increase the level of acceptance of pork.

Figure 3.6 depicts the extent of correlation between trends in per capita disposable income and per capita pork consumption. The figure reveals that even in periods of sharp decline or rise in per capita disposable income, per capita pork consumption has been relatively stable. This relationship confirms the finding of Nieuwoudt (1998) with regard to the income elasticity of pork.



Figure 3.6: Relation between real per capita disposable income and the per capita consumption of pork (1975-2003)

Source: SARB; 2004; NDA, 2005a; own computations.

Nieuwoudt (1998) reported a much lower income elasticity of pork relative to other red meat products. The implication of this finding is that even when per capita income increases, consumers will purchase, in relative terms, more other red meat products, and vice versa. As reported by Nieuwoudt (1998), the demand for pork will increase relatively lower than other red meat products under growth in the economy and low-income scenarios. This result can be attributed to the fact that pork is mainly consumed by whites, who have the lowest potential for increase in per capita income.

3.3.3 The sheep sector

Figure 3.7 shows the relation between per capita disposable income and per capita consumption of sheep meat. As with beef, the trends in per capita consumption of sheep meat and changes in per capita disposable income are highly correlated.

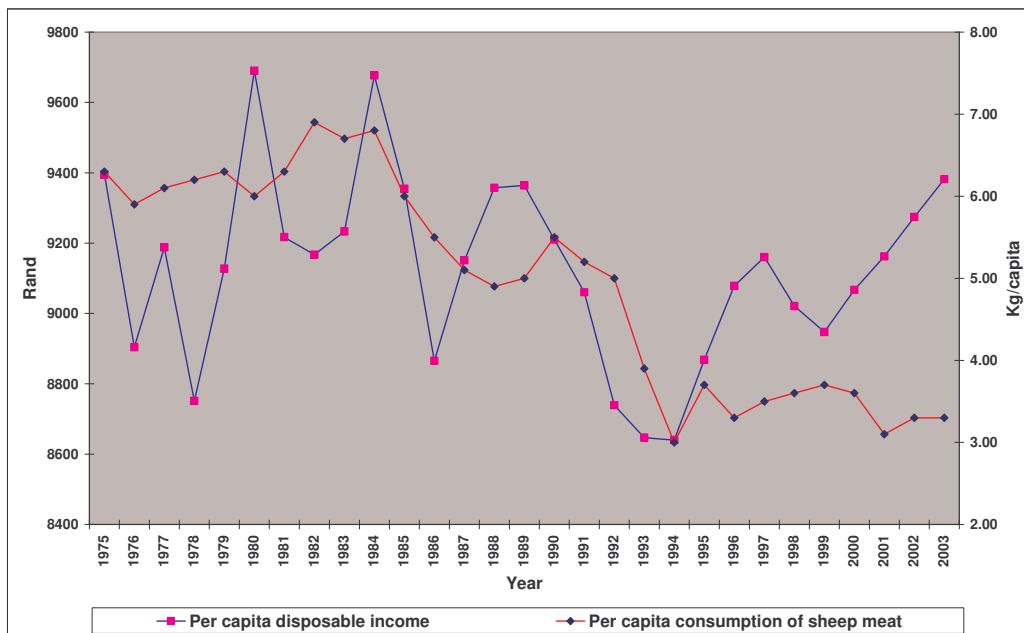


Figure 3.7: Relation between real per capita disposable income and the per capita consumption of sheep meat (1975-2003)

Source: SARB; 2004; NDA, 2005a; own computations.

Nieuwoudt (1998) projected a similar trend unfolding in the demand for meat of sheep as with the demand for beef.

3.3.4 The poultry sector

Poultry meat remains the largest and most affordable source of protein for South African households. Per capita consumption of poultry meat has been consistently higher than that of red meat with a 14.45 kg per capita in 1992 and 21.13 kg per capita in 2004 (See Figure 3.8).

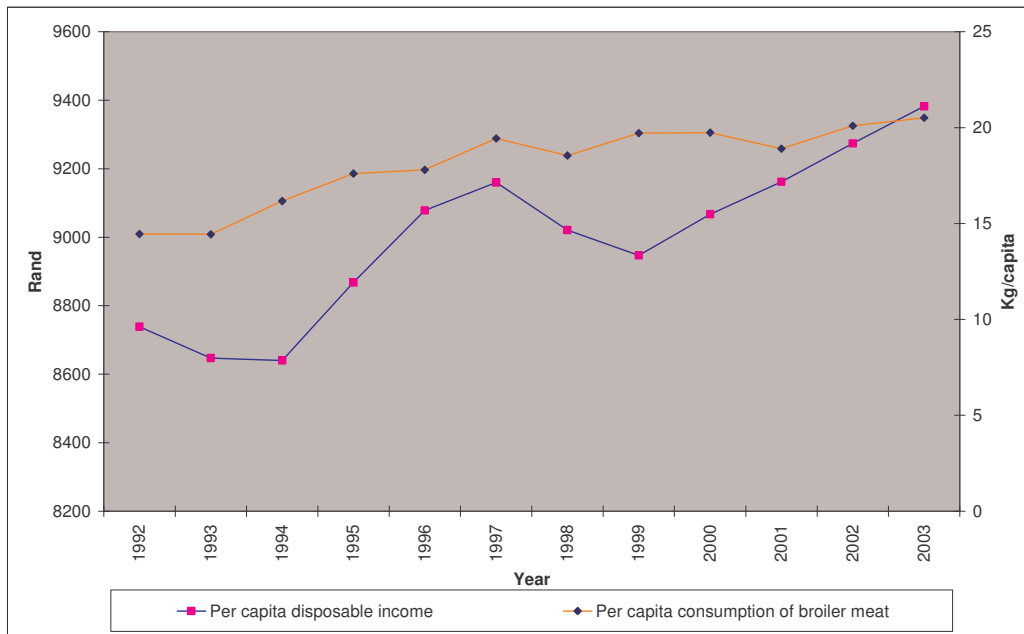


Figure 3.8: Relation between real per capita disposable income and per capita consumption of broiler meat in South Africa: 1992-2003

Source: South African Poultry Association – SAPA (2005), own computations.

The unfolding trend in meat consumption in South Africa may be attributed to affordability and the racial composition relative to income distribution of the South African population. The greater percentage of the South African population is made up of blacks, many of whom prefer to consume poultry meat due to reasons of affordability resulting from sparsely distributed income growth.

3.4 Trade in livestock products by South Africa/SACU

3.4.1 Distribution of trade

By means of a Lorenz curve, the distribution of market shares among the firms in an industry can be established graphically. Earlier uses of the Lorenz curve compared income distributions to the cumulative function of income. Using a similar analogy, the distribution of market shares among importers or exporters of a particular commodity 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 a function of the share of trade on the vertical axis. Therefore, the

straight line Lorenz curve (at 45 degrees from the origin) corresponds to an equal distribution of import or export shares.

However, Lubbe (1992) established that the GINI-coefficient is a more precise measure of concentration; it is determined as the ratio of the area between the Lorenz curve and the 45 degree line. Hanson and Simmons (1995) showed that this ratio (the GINI coefficient) can be expressed as a percentage, i.e.

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

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

A GINI-coefficient equal to zero denotes that trade is equally distributed amongst countries; while it means trade is restricted to one country if it is equal to one.

3.4.1.1 Imports of bovine meat into South Africa³

The GINI-coefficient for bovine meat imports was calculated at 0.768, which indicates a relatively high degree of import concentration. Figure 3.9 shows the relative skewness of South Africa's imports of bovine meat in 2003. The concentration curve shows a high level of convexity to the 45 degree Lorenz curve, meaning that imports of bovine meat in 2003 were concentrated in a few countries (that is Argentina and Brazil). In fact, as the declining part of the graph shows, over 80% of the total imports of this product into South Africa came from these two countries.

³ Bovine meat is the international classification used in the Harmonised System Code. In the context of this study it refers primarily to beef.

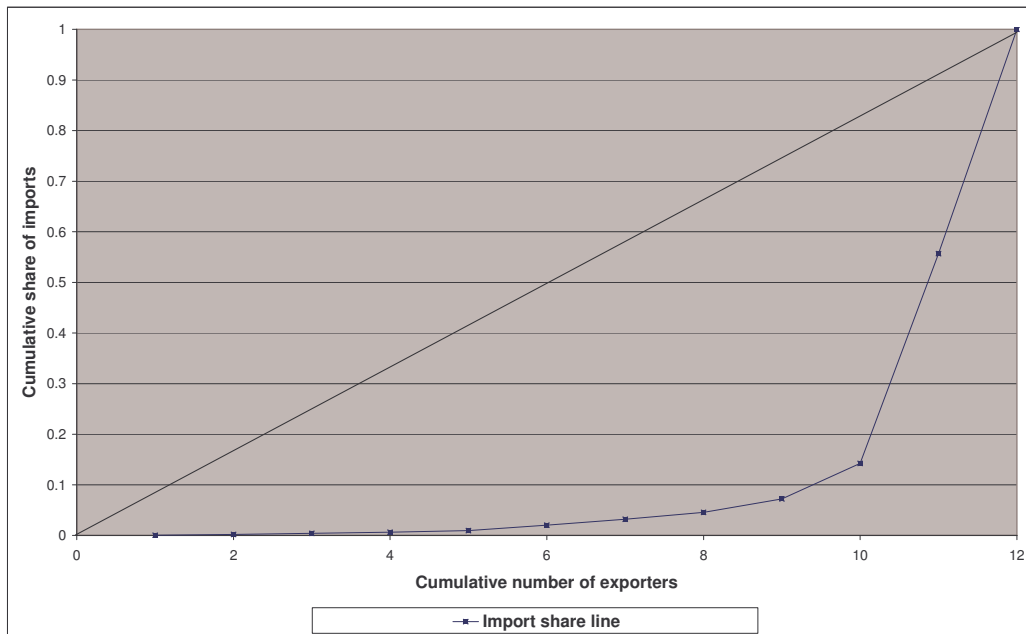


Figure 3.9: Lorenz trade inequality curve: South Africa's imports of bovine meat in 2003

Brazil and Argentina were ranked eight and tenth largest producers of the product respectively in 2003 (ITC, 2005). This trend can be attributed to the competitiveness of these countries in the production of bovine meat.

3.4.1.2 Imports of pork in South Africa

The GINI-coefficient for pork imports was calculated at 0.745, which indicates a relatively high degree of import concentration. Figure 3.10 shows the relative skewness of South Africa's import of pork in 2003. The concentration curve shows a high level of convexity to the 45 degree Lorenz curve, meaning that imports of swine meat was concentrated in a few countries (that is Brazil, France and Belgium).

As shown by the upper part of the Lorenz curve convex to the perfect equality line, about 79% of the total imports of pork by South Africa in 2003 came from three countries, namely Belgium, France and Brazil. These countries were ranked sixth, eight and ninth largest exporters of this product respectively in 2003 (ITC, 2005).

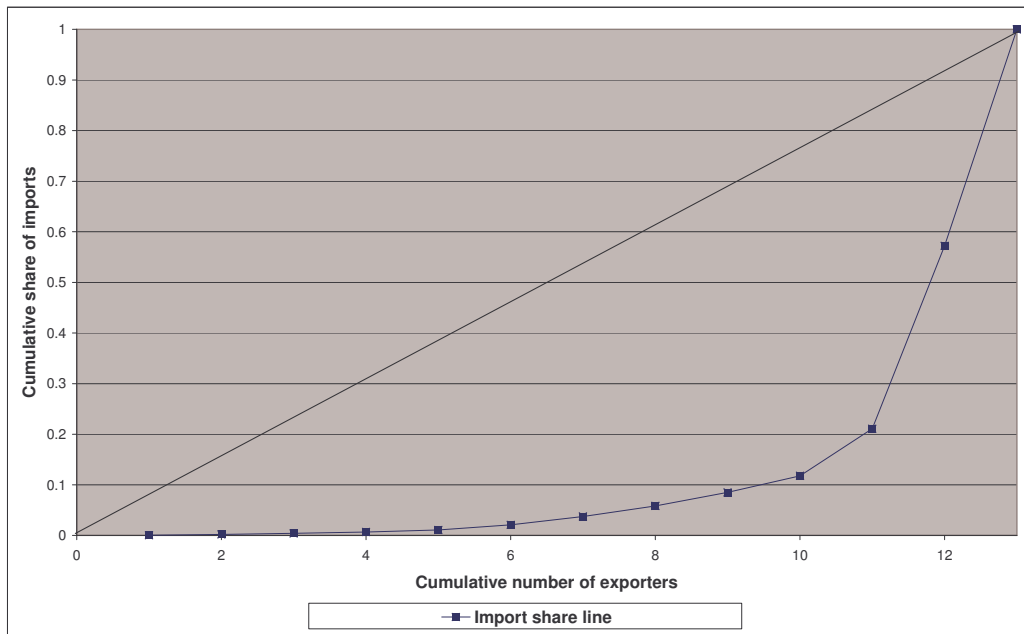


Figure 3.10: Lorenz trade inequality curve: South Africa's import of pork in 2003

The outbreak of classical swine fever in France late in 2002 affected South Africa's imports of pork from France in 2003. The South African Department of Agriculture placed a ban on the importation of French pork. Despite this, a large percentage of South Africa's pork imports in 2003 still came from France. South Africa has increased its imports from Brazil to make up for French supplies, making Brazil the largest exporter of pork to South Africa to date.

3.4.1.3 Imports of meat of sheep in South Africa

The GINI-coefficient for sheep meat imports was calculated at 0.655, which also indicates a relatively high degree of import concentration. Figure 3.11 shows the relative skewness of South Africa's imports of sheep meat in 2003. The concentration curve shows a considerable level of convexity to the 45 degree inequality curve. This reflects the concentration of the share of imports of sheep meat between the two large exporters to South Africa. The result shows that imports were almost equally shared by the two largest exporters (New Zealand and Australia) while imports from the other two exporters do not have any appreciable impact on concentration.

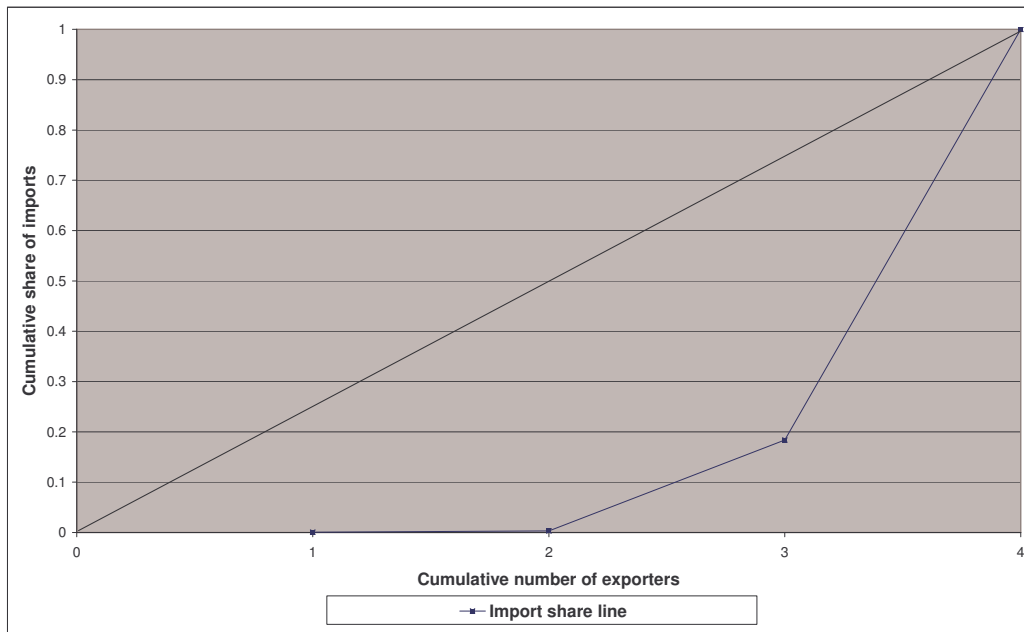


Figure 3.11: Lorenz trade inequality curve: South Africa's import of sheep meat in 2003

It is evident from the figure that about 80% of South Africa's imports of sheep meat came from Australia alone. New Zealand and Australia were the first and second largest exporters of meat of sheep respectively in 2003 in the world. Therefore, the high share of these countries in South Africa's imports of meat of sheep can be attributed to their global competitiveness.

3.4.1.4 Imports of poultry meat in South Africa

Poultry meat produced in South Africa has over the decades accounted for over 90% of domestic consumption. In 2004, however, imports of poultry meat amounted to as high as 18% of domestic production, a value that matches the total production of the third largest domestic producer (SAPA, 2005).

The rather stable level of imports of poultry meat from 1998 to 2001 has experienced an upward trend since then owing to a strong rand, which has aided cheap imports of the product. Figure 3.12 shows the relative skewness of South Africa's imports of poultry meat in 2004.

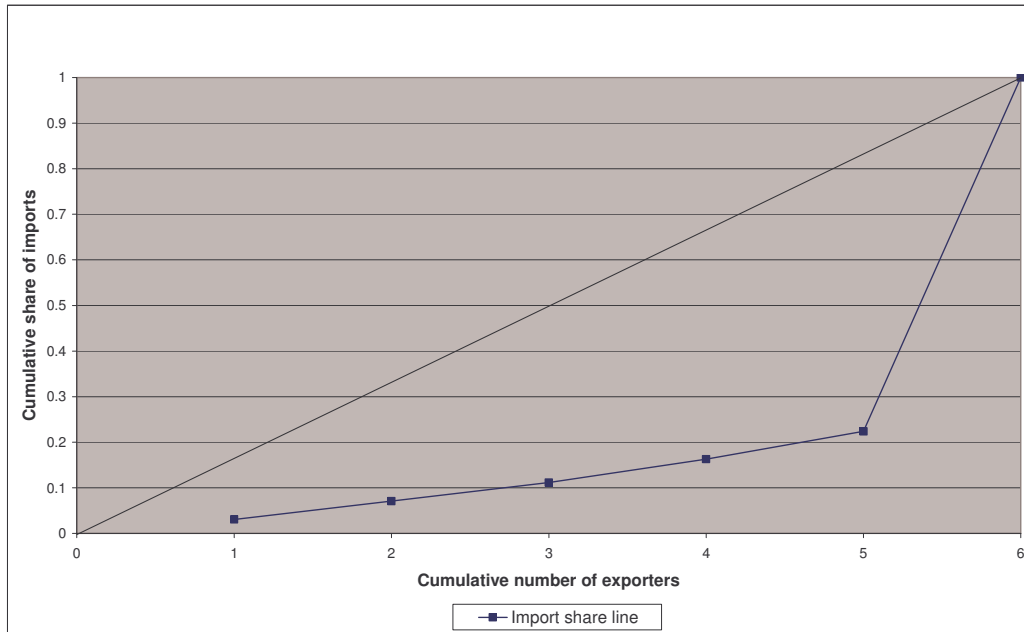


Figure 3.12: Lorenz trade inequality curve: South Africa's import of poultry meat: 2004

Imports from Brazil accounted for 76% of poultry meat imports into South Africa, followed by the United Kingdom with 6% and Canada with 5%, while Argentina and Australia have 4% each (SAPA, 2005). This portends a high level of concentration and may reflect the competitiveness of Brazilian producers in a highly competitive world market.

3.4.2 Intra-industrial trade

The degree of trade among countries has been proxied by the intra-industrial trade (IIT) index (Grubel and Lloyd, 1971). The intra-industrial trade index has been used to measure the extent of diversity of a sector and also to explain the simultaneous export and import of commodities with reference to the competitiveness and the response of the sector to the changing policy environment (Oleh and Peter, 1997). Based on the most commonly used Grubel-Lloyd index, the intra-industrial trade index of a home country j ($=1, \dots, m$) for an industry i ($=1, \dots, n$) is defined as follows:

$$IIT_{ij} = 1 - \frac{|X_{ij} - M_{ij}|}{(X_{ij} + M_{ij})}$$

Where X_{ij} and M_{ij} is the export and import of the product i to country j . If the amount of exports equals that of imports ($X_{ij} = M_{ij}$), all trade in industry i is intra-industry trade, and $ITT_{ij} = 1$. The index of intra-industry trade takes values from 0 to 1, and increases as the extent of intra-industry trade increases.

3.4.2.1 Intra-industrial trade in bovine meat

Figure 3.13 shows the intra-industrial trade indices of bovine meat between 1992 and 2004 in South Africa. As shown by the figure, the value of the intra-industrial trade index for bovine meat between 1994 and 2004 has remained higher than the 0.6. Therefore since the liberalization of agriculture in South Africa, the extent of intra-industrial trade has been consistently high in this product (meaning both imports and exports have been high).

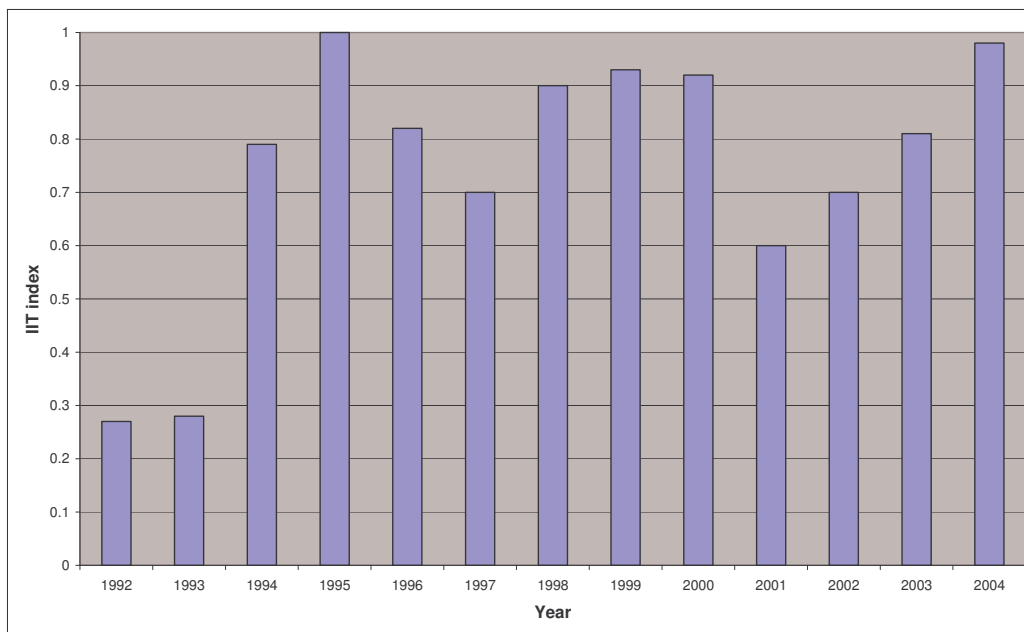


Figure 3.13: Intra-industry trade between South Africa and the rest of the World: Bovine meat (1992-2004)

The results of the analysis show that whilst trade liberalization has led to increased import of the meat of bovine into South Africa, the increase in exports nearly equals the increase in imports.

3.4.2.2 Intra-industrial trade in pork

The intra-industrial trade indices for pork between 1992 and 2004 in South Africa are as shown in Figure 3.14. The figure shows that the level of intra-industrial trade in pork by South Africa has remained lower than 0.5 from 1994 to 2004 owing to the high dominance of imports over exports.

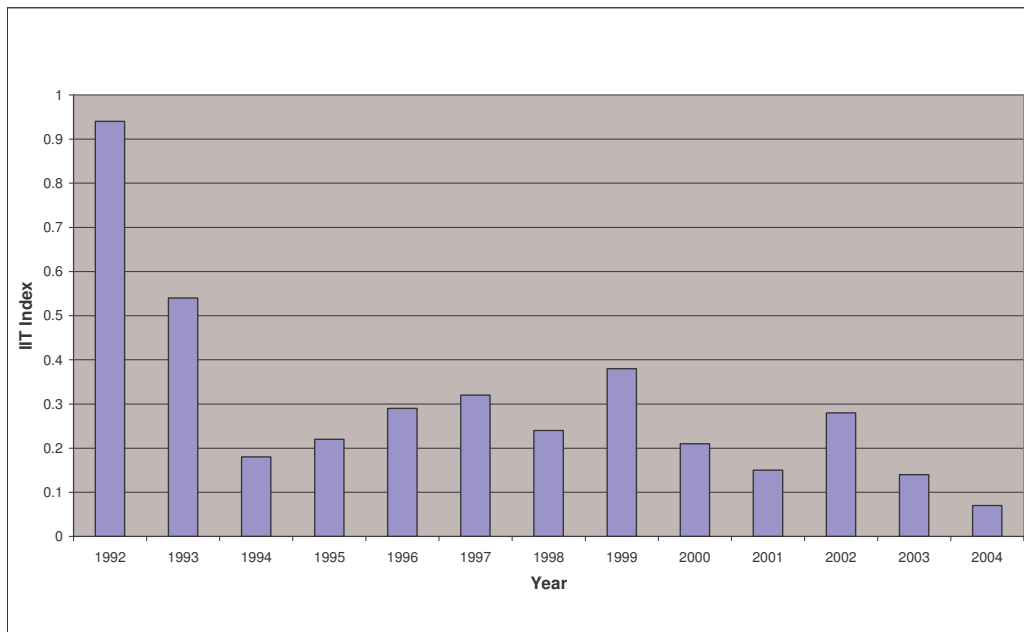


Figure 3.14: Intra-industry trade between South Africa and the rest of the World: Pork (1992-2004)

3.4.2.3 Intra-industrial trade in sheep meat

Figure 3.15 shows the intra-industrial trade indices for sheep meat between 1992 and 2004 in South Africa. As shown by the figure the level of intra-industrial trade in the sheep meat of South Africa has consistently been low (lower than 0.2) over the period under consideration, trade liberalization notwithstanding. This is due to the continuous dominance of imports over exports of this product.

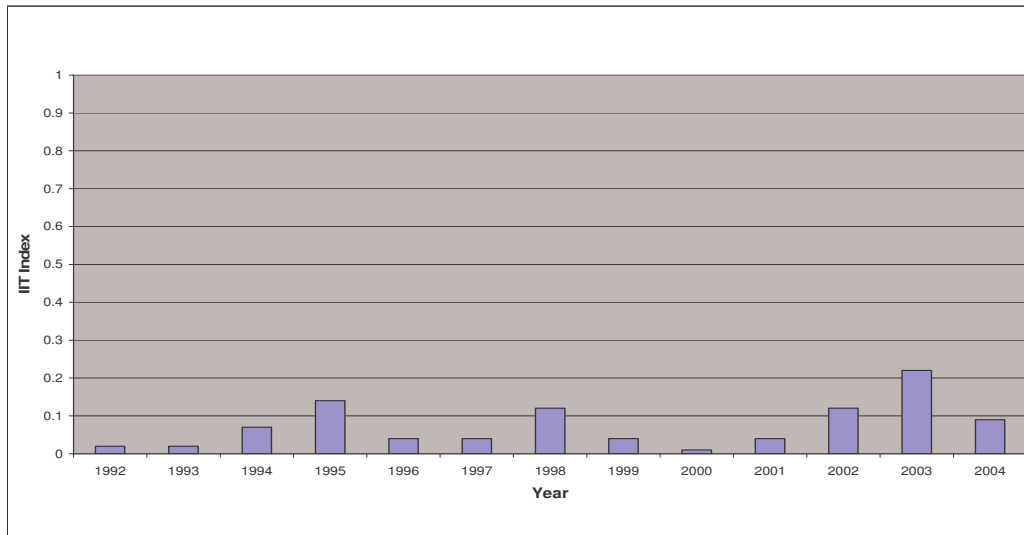


Figure 3.15: Intra-industry trade between South Africa and the rest of the World: Sheep meat (1992-2004)

3.4.2.4 Intra-industrial trade in meat and edible offal of poultry

The intra-industrial trade indices of the meat and edible offal of poultry between 1992 and 2004 in South Africa are shown in Figure 3.16. The figure does not show any regular trend in intra-industrial trade of this product (although largely greater than 5).

The results of the analysis show that in spite of the effects of various other variables, such as the exchange rate on trade in this product, South African producers have remained competitive. This is evidenced by the domination of exports over imports, and thus consistently low intra-industrial trade value.

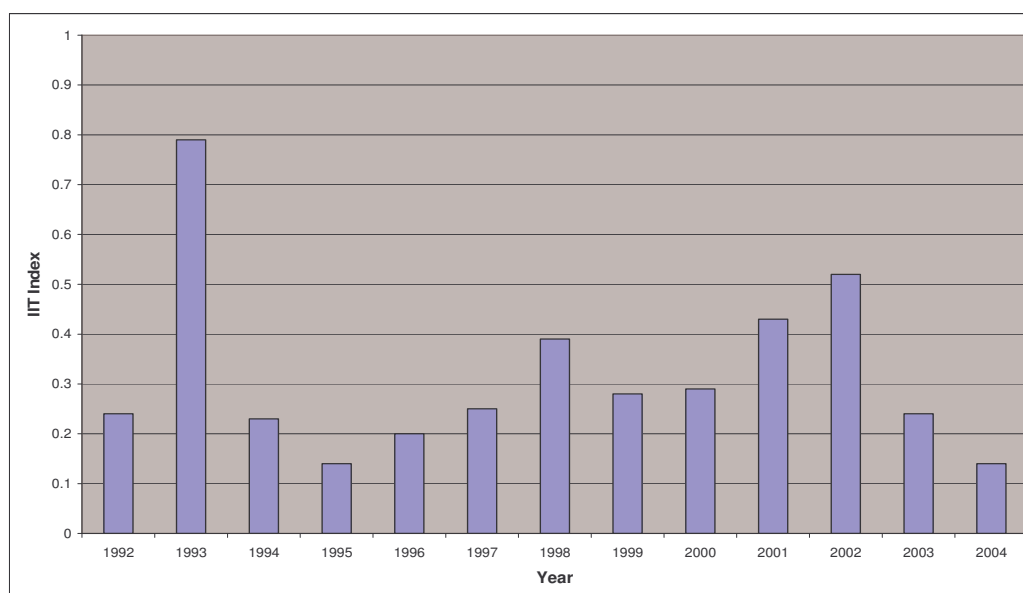


Figure 3.16: Intra-industry trade between South Africa and the rest of the World: Meat and edible offal of poultry 1992-2004.

3.5 Market access commitments of South Africa in livestock meat trade

3.5.1 Tariff regime in South Africa livestock industry

South Africa, through liberalization of its agricultural sector and phasing out of past protection mechanisms, introduced a process of tariff reform in compliance with WTO regulations. Table 3.1 shows the tariff regime on imports of livestock meat products of South Africa applicable to exporting countries other than those belonging to SACU and SADC.

Table 3.1: Current RSA tariff regime on imports of livestock meat products*

HS8 Tariff line	Description of product	Base Rate %	Bound Rate %	Applied Tariff % or R/kg
02.01	Meat of Bovine Carcasses, Fresh or Chilled:			
0202.10	-Carcasses and half carcasses	115	69	40 /2.4
0202.20	-Other cuts with bone in	115	69	40 /2.4
0202.30	-Boneless	400	160	40 /2.4
02.02	Meat of Bovine Animals, Frozen:			
0202.10	-Carcasses and half carcasses	115	69	40 /2.4
0202.20	-Other cuts with bone in	115	69	40 /2.4
0202.30	-Boneless	400	160	40 /2.4

HS8 Tariff line	Description of product	Base Rate %	Bound Rate %	Applied Tariff % or R/kg
02.03	Meat of swine, Fresh, Chilled or Frozen			
0203.1	-Fresh or chilled:			
0203.11	=Carcasses and half carcasses	50	37	15 /1.3
0203.12	=Hams, shoulders and cuts thereof, with bone in	50	37	15 /1.3
0203.19	=Other:			
0203.19.10	-Rib	50	37	15 /1.3
0203.19.90	-Other	50	37	free
0203.2	-Frozen:			
0203.21	=Carcasses and half carcasses	50	37	15 /1.3
0203.22	=Hams, shoulders and cuts thereof, with bone in	50	37	15 /1.3
0203.29	=Other:			
0203.29.10	-Rib	50	37	free
0203.29.90	-Other	50	37	15 /1.3
02.04	Meat of Sheep or Goats, Fresh, Chilled or Frozen:			
02.04.10	-Carcasses and half-carcasses of lamb, fresh or chilled	190	95	40 /2.0
02.02.2				
0204.21	-Other meat of sheep, fresh or chilled:	190	95	40 /2.0
0204.22	=Carcasses and half carcasses	110	66	40 /2.0
0204.23	=Other cuts with bone in	110	66	40 /2.0
0204.30	=Boneless	190	95	40 /2.0
0204.4	-Carcasses and half-carcasses of lamb, frozen			
0204.41	-Other meat of sheep, frozen:	190	95	40 /2.0
0204.42	=Carcasses and half carcasses	110	66	40 /2.0
0204.43	=Other cuts with bone in	110	66	40 /2.0
0204.50	=Boneless	150	82	40 /2.0
	-Meat of goats			
02.07	Meat and Edible Offal of the Poultry of Heading No. 01.05, Fresh, Chilled or Frozen :			
02.07.1	-Of fowls of the species Gullus domesticus:		82	free
02.07.11	=Not cut in pieces, fresh or chilled		82	27 /2.2
02.07.12	=Not cut in pieces frozen		82	free
02.07.13	=Cut and offal fresh or chilled		82	free
02.07.14	=Cut and offal frozen			
02.07.14.05	-Boneless (excluding cuts)		82	free
02.07.14.10	-Boneless cuts		82	5 /2.0
02.07.14.20	-Offal		82	27 /2.0
02.07.14.90	-Other		82	0 /2.2

In terms of the Marrakech Agreement, the actual rate of duty should be phased down from a level that does not exceed the base rate to a level that does not exceed the bound rate within the specified period.

Source: NDA, 2005b

Allowing imports of livestock products at zero tariff level from the SACU-member countries while imposing higher tariff rate on imports from other countries has far-reaching consequences on the trade pattern of South Africa in these products. Some

of these countries are highly dependent on the South African market for exports (for instance, Namibia) and thus benefit immensely from the non-reciprocal agreement.

3.5.2 Market access quotas in South Africa livestock industry

The deregulation of agricultural marketing, globalisation and trade agreements have exposed South African farmers and agribusiness to increased foreign competition (Groenewald and Nieuwoudt, 2003), most of which are protected by government policies. In line with South Africa's WTO commitments, market access quotas provide a basis to comply with minimum access requirements. Table 3.2 shows South Africa's market access commitments in the livestock industry.

Table 3.2: Minimum market access quotas for livestock meat products*

Tariff Heading	Description of product	In-quota tariff (20% of Bound Rate)	Annual Quota Tonnage
02.01 0202.10 0202.20 0202.30	Meat of Bovine Carcasses, Fresh or Chilled: -Carcasses and half carcasses -Other cuts with bone in -Boneless	Full duty less 13.8% Full duty less 13.8% Full duty less 13.8%	26254
02.02 0202.10 0202.20 0202.30	Meat of Bovine Animals, Frozen: -Carcasses and half carcasses -Other cuts with bone in -Boneless	Full duty less 13.8% Full duty less 13.8% Full duty less 32%	
02.03 0203.1 0203.11 0203.12 0203.19 0203.19.10 0203.19.90 0203.2 0203.21 0203.22 0203.29 0203.29.10 0203.29.90	Meat of swine, Fresh, Chilled or Frozen -Fresh or chilled: =Carcasses and half carcasses =Hams, shoulders and cuts thereof, with bone in =Other: -Rib -Other -Frozen: =Carcasses and half carcasses =Hams, shoulders and cuts thereof, with bone in =Other: -Rib -Other	Full duty less 7.4%** Full duty less 7.4%** Full duty less 7.4%** Full duty less 7.4%** Full duty less 7.4%** Full duty less 7.4%** Full duty less 7.4%** Full duty less 7.4%**	4691
02.04 02.04.10 02.02.2 0204.21 0204.22 0204.23	Meat of Sheep or Goats, Fresh, Chilled or Frozen: -Carcasses and half-carcasses of lamb, fresh or chilled -Other meat of sheep, fresh or chilled: =Carcasses and half carcasses =Other cuts with bone in =Boneless	Full duty less 19% Full duty less 19% Full duty less 13.2% Full duty less 13.2%	

Tariff Heading	Description of product	In-quota tariff (20% of Bound Rate)	Annual Quota Tonnage
0204.30	-Carcasses and half-carcasses of lamb, frozen	Full duty less 19%	
0204.4	-Other meat of sheep, frozen:		
0204.41	=Carcasses and half carcasses	Full duty less 19%	
0204.42	=Other cuts with bone in	Full duty less 13.2%	
0204.43	=Boneless	Full duty less 13.2%	
0204.50	-Meat of goats	Full duty less 16.4%	
02.07	Meat and Edible Offal of the Poultry of Heading No. 01.05, Fresh, Chilled or Frozen :		29033
02.07.1	-Of fowls of the species <i>Gallus domesticus</i> :		
02.07.11	=Not cut in pieces, fresh or chilled	Full duty less 16.4%	
02.07.12	=Not cut in pieces frozen	Full duty less 16.4%	
02.07.13	=Cut and offal fresh or chilled	Full duty less 16.4%	
02.07.14	=Cut and offal frozen		
02.07.14.05	-Boneless (excluding cuts)	Full duty less 16.4%	
02.07.14.10	-Boneless cuts	Full duty less 16.4%	
02.07.14.20	-Offal	Full duty less 16.4%	
02.07.14.90	-Other	Full duty less 16.4%	

*The National Department of Agriculture has a complete list of companies that qualified to import meat under MMA. They indicated that such information is confidential and could only be supplied on request by the Competition Commission.

**Calculated based on the agreement that in-quota tariff must not exceed 20% of the bound rate.

Source: NDA, 2003

The minimum market access quotas commitments are implemented by imposing a lower in-quota tariff to imports within the quota while imports above this level attract a higher tariff (thus functioning like a tariff rate quota).

3.5.3 Importance of TRQs in South Africa's meat trade

Table 3.3 provides information about the importance of TRQs in the South African livestock industry in value terms. In order to allow for a good presentation, the product categories were aggregated to the HS4 categories. Two indicators are employed for the measurements. Firstly, the potential value of imports in the HS8 tariff lines for which TRQs are applicable and their importance relative to total value of imports are shown in column 2. Secondly, the actual value of imports are represented in value terms. This is done by multiplying the actual quantity of imports under TRQ by the unit price of each product (as in column 4).

Table 3.3: Relative importance of TRQ to meat products and TRQ imports by main commodity (2003)

Product	Total imports	Of which: imports of HS8 products for which TRQs are opened	As per cent of total imports	Actual value of TRQ imports	As per cent of total imports	Ratio of actual to potential TRQ imports i.e. fill rate
	1	2	(3) =(2)/(1)	4	(5) = (4)/(1)	(6) = (4)/(2)
	Rand ('000)	Rand ('000)	%	Rand ('000)	%	%
Meat of bovine animals	280,000	185,878	66	163,180	58	88
Meat of swine	113,066	35,511	31	35,511	31	100
Meat of sheep	64,823	29,350	45	29,350	45	100
Meat and edible offal of poultry	551,105	104,519	19	104,519	19	100
Total	1,008,994	355,258	35	332560	33	94

Source: own calculations

The above analysis shows that of all imports of meat products in South Africa in 2003 (which is worth about R1.01 billion), TRQs were used to administer 35% (worth about R0.36 billion). It should be noted that this is a substantial amount considering the fact that total imports included those from the SACU countries which attract a zero tariff.

At a product-specific level, TRQs opened for bovine meat covered a greater value of trade than those of the other products. The value of TRQ imports of the meat and edible offal of poultry followed while sheep meat carries the lowest value. However, as a percentage of total imports, TRQs applicable to sheep meat followed those of bovine meat, ahead of swine meat and meat and edible offal of poultry, respectively.

In terms of actual imports under TRQs, all the products except bovine meat carry the same value as the potential value of the TRQ opened for the respective products (as shown by column 4). The implication is that all the products, except bovine meat

have a fill rate of 100% – shown by Column 6 (reflecting the spirit of the URAA). Overall, the average quota fill rates expressed in value terms was 94%.

3.6 Conclusion

This chapter provided an overview of the latest trends in production, consumption and trade in livestock meat products in South Africa. The market access commitment of South Africa was highlighted. More specifically, the importance of TRQs in South Africa's livestock meat trade was analyzed. The results show that livestock meat imports under the TRQ in South Africa is high enough to affect the pattern of trade in this industry.

**SPECIFICATION AND CALIBRATION OF THE
SPATIAL PARTIAL EQUILIBRIUM MODEL FOR THE
SOUTH AFRICAN LIVESTOCK INDUSTRY**

4.1 Background and aims of the modeling work

The regional approach to modelling the agricultural sector in South Africa offers an opportunity for analyzing the effects of various policies which may lead to varying impacts across provinces; especially regions with certain peculiarities. This is especially important when modeling the livestock industry of South Africa, which has the potential for different policies to generate diverse effects across provinces. The present model divides South Africa into its nine provinces. However, the domestic regions could be aggregated when specific trade relations need to be analyzed.

A unique feature of this modeling framework is the explicit modeling of the processing (i.e. slaughtering) sector. Incorporating a conversion factor which reflects the intermediate stage of production ensures a closer representation of reality. More importantly, however, is the derivation of a set of parameters for the demand system in line with consumer theory. This is a fundamental requirement for a modeling system explicitly incorporating consumer welfare in the objective function.

4.2 Empirical framework

The model consists of a total of 12 regions between which livestock and meat are shipped. Eleven of the 12 regions are taken to be domestic regions while the last is classified as a foreign region. Domestic regions include the Western Cape, Eastern Cape, KwaZulu-Natal, Northern Cape, North-West, Free State, Gauteng,

Mpumalanga and the Limpopo Provinces. In addition, Namibia and Botswana are regarded as domestic regions. Three transit points, Cape Town Harbour, Port Elizabeth Harbour and Durban Harbour are also included while Rest-of-the-World component is the foreign region. The regions are denoted as:

$r, r1$ denote all regions; $r, r1 = 1, 2, \dots, 12$.
 rd denotes all domestic regions; $rd = 1, 2, \dots, 9$.
 where $rd \subset r$
 rfn denotes all foreign regions; $rfn = 1$.
 where $rfn \subset r$

The commodities in the model are denoted as:

i, j denote all commodities $i, j = 1, 2, \dots, n$
 where $i = j$
 ip, jp denote all primary commodities (cattle, sheep, broilers and pigs);
 $ip, jp = 1, 2, \dots, n$
 where ip and $jp \subset i$
 is, js denote all final commodities (beef, sheep-meat, poultry-meat, and pork);
 $is, js = 1, 2, \dots, n$
 where is and $js \subset i$
 ic, jc denote all commodities in the calibration (i.e. final commodities; i.e. beef, sheep-meat, poultry-meat, pork and all other commodities not incorporated in the model per se);
 $ic, jc = 1, 2, \dots, n$
 where ic and $jc \subset i$

4.2.1 Data specification

The model takes the year 2000 as its base. The data were obtained from various sources; data on prices of domestic products were obtained from the South African

Meat Industry Company and the Annual Report of the South African Poultry Association (SAPA, 2005) which contains data for previous years as far back as the late 1990s.

Other data sources include the South African National Department of Agriculture (NDA, 2000) where trade data were sourced, while the elasticities were obtained from Taljaard (2003) and Meyer (2003).

4.2.1.1 Demand and supply of livestock

The original demand and supply of livestock are represented as follows:

DEM_r^{ip} denotes the given quantity demanded of a primary commodity ip in region r .

$$SUP_r^{ip} = HrdSiz_r^{ip} \times O_r^{ip}$$

where:

SUP_r^{ip} denotes the given quantity supplied of a primary commodity ip in region r .

$HrdSiz_r^{ip}$ denotes the amount of the primary commodity ip that could be utilized for further processing in region r .

O_r^{ip} denotes the off-take rate (constant proportion at all output levels) at which a primary commodity ip is made available for further processing in region r .

4.2.1.2 Demand and supply of meat

The original demand and supply of meat are represented as follows:

DEM_r^{is} denotes the given quantity demanded of a secondary commodity in region r .

$$SUP_r^{is} = CONV_r^{ip,is} \times DEM_r^{ip}$$

where:

SUP_r^{is} denotes the given quantity supplied of a secondary commodity is in region r .

$CONV_r^{ip,is}$ denotes the rate (constant proportion at all output levels) at which a primary commodity ip is converted, per unit, into a final commodity is in region r .

DEM_r^{ip} denotes the given quantity demanded of a primary commodity is in region r .

4.2.1.3 Prices of livestock and meat

The original livestock and meat prices in domestic regions are represented as follows:

$BASPRD_{rd}^{ip}$ denotes the base price of a primary commodity ip in region rd .

$BASPRD_{rd}^{is}$ denotes the base price of a secondary commodity is in region rd .

The tariff protection method was used to calculate world prices for the different secondary subcategory products. Derivation of world prices using the tariff protection method is denoted as follows:

$$W_p = D_p / (1 + T_{pr})$$

where:

W_p = World price

D_p = Domestic price, and

T_{pr} = Tariff protection rate expressed as a percentage.

The original meat prices that enter through the transit regions are represented as follows:

$$BASPRD_{rfn}^{is} = BASPRD_{row}^{is} + CIFCST^{is}$$

where:

$BASPRD_{rjn}^{is}$ denotes the base price of secondary commodities in region rjn (in this case the transit regions).

$BASPRD_{row}^{is}$ denotes the base price of secondary commodities in region row (in this case the rest of the world).

$CIFCST^{is}$ denotes the *cif* cost associated with secondary commodities is .

4.2.2 The algebraic setup

For the current version of the model, each region has primary commodity supply, conversion and demand functions. Given this, prices are expressed as a function of the quantities in the different functional relations, and are referred to as the quantity formulation. The specification of supply and demand functions are specified in this manner to comply with the Takayama and Judge (1971) approach to calculating the net quasi-welfare function.

Given the above clarification, the supply, demand and conversion functions used in the model are specified as follows:

4.2.2.1 Commodity supply functions

The supply functions are represented as follows:

$$PP_r^{ip} = \alpha_r^{ip} + \sum_{ii} \beta_{ii,r}^{ip} \cdot QS_r^{ip}$$

where:

PP_r^{ip} denotes the endogenous producer price of primary commodity ip in region r .

α_r^{ip} and $\beta_{ii,r}^{ip}$ denote the intercept and slope coefficients respectively for the supply function of primary commodity ip in region r .

QS_r^{ip} denotes the endogenous quantity supplied of the primary commodity

ip in region r .

The underlying assumption of the above specification is that the actual supply quantity QS_r^{ip} is to be greater than or equal to the effective supply from region r to all other regions. Mathematically this is expressed as $QS_r^{ip} \geq \sum_{r1}^n QS_{r,r1}^{ip}$.

4.2.2.2 Commodity demand functions

The demand functions are represented as follows:

$$PD_r^{is} = \lambda_r^{is} + \sum_{ii} \omega_{ii,r}^{is} \cdot QD_r^{is}$$

where:

PD_r^{is} denotes the endogenous consumer price of secondary commodity is in region r .

λ_r^{is} and $\omega_{ii,r}^{is}$ denote the intercept and slope coefficients respectively, for the demand function of secondary commodity is in region r .

QD_r^{is} denote the endogenous quantity demanded of the secondary commodity is in region r .

The underlying assumption of the above specification is that the actual demand QD_r^{is} is less than or equal to the quantity shipped from all the supply regions.

Mathematically, this is expressed as $QD_r^{is} \geq \sum_{r1}^n QD_{r,r1}^{is}$.

It is noteworthy that this specification of the demand function would be taken over by the Marshallian demand system and then calibrated in order to allow for appropriate welfare measurement. However, the above specification is useful for ensuring market equilibrium.

4.2.2.3 Commodity conversion function

The conversion functions denote the intermediate industry, i.e. the demand for livestock and the supply of meat. The matrix for the conversion functions is different from the above functions in so far as it represents prices for final products and prices for live animals. It also contains both commodity groups, i.e. the demand side contains only live animals and the supply side only meat. The conversion functions are denoted as follows:

$$PP_r^{ip} = \theta_r^{ip} + \sum_{ii} v_{ii,r}^{ip} \cdot QC_r^{ip}$$

$$PD_r^{is} = \theta_r^{is} + \sum_{ii} v_{ii,r}^{is} \cdot QP_r^{is}$$

where:

- PP_r^{ip} denotes the endogenous producer price of primary commodity ip in region r .
- PD_r^{is} denotes the endogenous consumer price of secondary commodity is in region r .
- θ_r^{ip} and θ_r^{is} denote the intercepts respectively for the demand and supply functions of the primary and secondary commodities in the processing sector in region r .
- v_r^{ip} and v_r^{is} denote the slope coefficients respectively for the demand and supply functions of the primary and secondary commodities in the processing sector r .
- QC_r^{ip} denotes the endogenous quantity demanded of the primary product for conversion into secondary commodities in region r .
- QP_r^{is} denotes the endogenous quantity supplied of the secondary commodity in region r .

In this model, conversion factors are assumed “about” constant across regions. The reasoning behind this is that if livestock input increases by 1 per cent, meat output increases only by the percentage conversion factor due to inefficiencies with rising

output. Thus it may not be efficient to increase output beyond certain levels as this may incur higher costs of transformation. Therefore production efficiencies are implicitly accounted for.

4.2.2.4 Determination of slope variables and constant parameters

The slope coefficients of price in the supply and demand equations are computed from elasticities pertaining to final demand and supply of primary and secondary commodities in region r by means of the following simple algorithm:

$$\varphi_r^i = \varepsilon_r^i \frac{q_r^i}{p_r^i}$$

where:

- φ_r^i denotes the slope coefficient of price in the demand and supply functions of commodity i in region r .
- ε_r^i denotes the elasticity of supply (demand) of commodity i in region r .
- q_r^i denotes the quantity supplied (demanded) of commodity i in region r .
- p_r^i denotes the supply (demand) price of commodity i in region r .

Given the slope coefficients, the intercept terms α_r^{ip} , λ_r^{is} and θ_r^{conv} are computed as follows:

$$\begin{aligned} \lambda_r^{is} &= \text{BASPRD}_r^{is} - \omega_r^{is} \text{DEM}_r^{is} \\ \alpha_r^{ip} &= \text{BASPRD}_r^{ip} - \beta_r^{ip} \text{SUP}_r^{ip} \\ \theta_r^{conv} &= \text{BASPRD}_r^{conv} - \nu_r^{conv} \text{CONV}_r^{conv} \end{aligned}$$

4.3 Properties of the partial equilibrium model

The model is technically set up within the General Algebraic Modeling System (GAMS) framework. GAMS is a tool widely used for quantitative economic analysis.

The model however involves partial equilibrium analyses. That is, all variables outside the agricultural sector (particularly the livestock industry), including factor availability and factor prices, are assumed to be exogenous and not influenced by changes on agricultural markets. Other properties of the model are:

- **Comparative static**

The spatial equilibrium model used in this study is comparative static. This means that, while outcomes of simulations for a particular target year can be compared with the base year (presently 2000), the linkage between the target year and the base year cannot be traced within this framework. In addition, the model assumes perfect competition and homogeneity of products. Therefore domestic and imported quantities of any product in a particular region are assumed to be the perfect substitute in production and utilization in any other region.

- **Deterministic**

The model is assumed non-stochastic. This means that, for all processes, risk free conditions are assumed. In addition, production, consumption and processing are assumed to take place at the same location and correspond to that used in Jooste (2001).

- **Synthetic**

The parameters, in particular elasticities used in the model, are not estimated specifically for this study. They originate from other studies and are calibrated to fit the theoretical conditions derived from microeconomic theory.

4.4 Market equilibrium

The model allows for the interregional flow of commodities among the domestic regions, or imports from the rest of the world. Hence, equilibrium is established for production, consumption and transfer of commodities across regions.

The initial (base) market equilibrium, i.e. optimal transport flow is a validation of the adequacy of the structure of the model, as well as its ability to provide policy analyses and forecasts under alternative trade scenarios.

Tables 4.1, 4.2, 4.3 and 4.4 show the interregional trade flows for secondary commodities beef, sheep meat, pork and poultry, respectively. The results reflect the optimum allocation of domestic production among regions and the Rest-of-the-world through the harbours (Durban, Cape Town and Port Elizabeth) due to cost efficiency.

According to Table 4.1, Western Cape is unable to meet half its domestic demand for beef and thus receives imports through the Cape Town harbour as well as from Namibia to meet its excess demand. On the other hand, the Northern Cape, Free State, Limpopo and the North-West are self-sufficient in beef production. Moreover, the excess production in the Northern Cape, Free State, Limpopo, North-West, Namibia and Botswana are transported to Gauteng where production is about 60 per cent of the demand.

Table 4.1: Base optimum interregional trade flow: beef (tonnes)

Region	Western Cape	Northern Cape	Free State	Eastern Cape	KwaZulu-Natal	Mpumalanga	Limpopo	Gauteng	North-West	Namibia	Botswana	Rest-of-the-world	Total production
Western Cape	25663												25663
Northern Cape		11917						9728					21645
Free State			34075					3531					37606
Eastern Cape				46108									46108
KwaZulu-Natal					63693								63693
Mpumalanga						47829							47829
Limpopo						791	22297	918					24007
Gauteng								78351					78351
North-West								20257	28920				49176
Namibia	951							8638		28702			38291
Botswana								3842			21051		24893
Durban Harbour					6133							6133	50000000
Port Elizabeth Harbour				4100								4100	
Cape Town Harbour	36831											36831	
Rest-of-the-world												49952936	
Total demand	63445	11917	34075	50208	69826	48620	22297	125265	28919.700	28702.341	21051	50000000	

The result of the optimum interregional flow for sheep meat in Table 4.2 shows that the Western Cape, Northern Cape, Free State and Eastern Cape produce sufficient amounts of sheep meat to meet their domestic demand. However, imports from the Rest-of-the-world through Durban Harbour are used to meet demand in KwaZulu-Natal, Mpumalanga and Gauteng. North-West receives supplies from the Northern Cape and a little (less than 1 tonne) from Namibia to meet its demand, while Limpopo receives supplies from the Northern Cape.

According to Table 4.3, only KwaZulu-Natal, Limpopo and Gauteng are self-sufficient in the production of pork. Excess production in KwaZulu-Natal is supplied to the Northern Cape, Free State, and Mpumalanga. Excess production in Limpopo is supplied to Mpumalanga, while the excess production in Gauteng is sold in Mpumalanga and North-West. Imports entering through the Durban Harbour are supplied to Mpumalanga, imports through Port Elizabeth to the Eastern Cape and those entering through Cape Town are sold in the Western Cape.

Table 4.4 shows that individual regions consume the total of their own production of poultry meat. The commodity is also imported through the three harbours. Imports entering through Durban Harbour are supplied to Northern Cape, Free State, KwaZulu-Natal, Mpumalanga, Limpopo, Gauteng, as well as North-West. Imports entering through Port Elizabeth Harbour are sold in the Eastern Cape, while those entering through Cape Town Harbour are sold in the Western Cape.

Table 4.2: Base optimum interregional trade flow: sheep-meat (tonnes)

Region	Western Cape	Northern Cape	Free State	Eastern Cape	KwaZulu-Natal	Mpumalanga	Limpopo	Gauteng	North-West	Namibia	Botswana	Rest-of-the-world	Total production
Western Cape	21365							696					22061
Northern Cape		3739					3702	15753	3755				26950
Free State			7638					2291					9929
Eastern Cape				11495				3634					15129
KwaZulu-Natal					3475								3475
Mpumalanga						2402							2402
Limpopo							381						381
Gauteng								4040					4040
North-West									2478				2478
Namibia										3938			3938
Botswana													
Durban Harbour					19096	7108		4109				30313	10000000
Port Elizabeth Harbour													
Cape Town Harbour													
Rest-of-the-world												9969687	
Total demand	21365	3739	7638	11495	22571	9510	4084	30523	6233	3938		10000000	

Table 4.3: Base optimum interregional trade flow: pork (tonnes)

Region	Western Cape	Northern Cape	Free State	Eastern Cape	KwaZulu-Natal	Mpumalanga	Limpopo	Gauteng	North-West	Namibia	Botswana	Rest-of-the-world	Total production
Western Cape	20069												20069
Northern Cape		1553											1553
Free State			9470										9470
Eastern Cape				9200									9200
KwaZulu-Natal		2669	864		18570	245							22348
Mpumalanga						4237							4237
Limpopo						3112	4938						8050
Gauteng						3415		41937	114				45466
North-West									8274				8274
Namibia													
Botswana													
Durban Harbour						1188						1188	80000000
Port Elizabeth Harbour				4539								4539	
Cape Town Harbour	5182											5182	
Rest-of-the-world												79989091	
Total demand	25251	4222	10334	13739	18570	12197	4938	41937	8388			80000000	

Table 4.4: Base optimum interregional trade flow: poultry (tonnes)

Region	Western Cape	Northern Cape	Free State	Eastern Cape	KwaZulu-Natal	Mpumalanga	Limpopo	Gauteng	North-West	Namibia	Botswana	Rest-of-the-world	Total production
Western Cape	75568												75568
Northern Cape		15930											15930
Free State			52110										52110
Eastern Cape				123124									123124
KwaZulu-Natal					166838								166838
Mpumalanga						55258							55258
Limpopo							96762						96762
Gauteng								147324					147324
North-West									66086				66086
Namibia													
Botswana													
Durban Harbour		1049	3431		10984	3638	6370	9699	4351			39522	6000000
Port Elizabeth Harbour				8106								8106	
Cape Town Harbour	4975											4975	
Rest-of-the-world												5947397	
Total demand	80543	16978	55541	131230	177822	58896	103132	157023	70437			6000000	

4.5 Calibration of the economic model

Within a modeling framework, the requirements of micro-economic consumer theory translate into restricting the demand system (homogeneity of degree zero in prices and income, adding up to unity of the first derivatives to income and utility decreasing in increasing price, the symmetry condition and utility decreasing in increasing prices, the so-called curvature condition) . However, a functional form which will allow for these restrictions being imposed globally, as required for a system which explicitly integrates consumer welfare in the objective function, is a necessity in this case.

Ryan and Wales (1996) proved how the (symmetric) normalized quadratic expenditure system and the generalized Leontief demand system ensure that these conditions are imposed. However, the Generalized Leontief demand system was chosen as it is capable of imposing the curvature restriction by restricting the sign of certain parameters in the system. Therefore, a Generalized Leontief demand system will be specified for final demand for regions, including Rest-of-the-world, using the welfare measurement of equivalent variation in the objective function.

4.5.1 The demand system (Marshallian demand)

Following Ryan and Wales (1996), the demand system specified for model calibration is based on the following family of indirect utility functions depending on consumer prices PD and per capita income $Valuesum$ ⁴.

$$\text{Equ (5.1) } U(PD, Valuesum) = \frac{-G}{(Valuesum - F)}$$

where G and F are functions of degree zero in prices. The budget-share of meat consumption in total per capita income (value-sum) is defined as:

⁴ Note: Per capita income and total expenditure are separated. Total expenditure on meat was calculated from per capita income and represented as budget-share; since expenditure on meat does not exhaust available income.

$$\text{Equ (5.2) } \text{Budgetshare} = (PD_i^r * QD_i^r) / \text{Valuesum}$$

Using Roy's identity, the following Marshallian demands QD are derived:

$$\text{Equ (5.3) } QD_i^r = F_i^r + \frac{G_i^r}{G} (\text{Valuesum} - F_i^r) \quad [\text{Xi}_-]$$

where the F_i and G_i are the first derivatives of F and G versus own prices. The function F is defined as follows:

$$\text{Equ (5.4) } F_r = \sum_i D_i^r PD_i^r \quad [\text{FGI}_-]$$

where D_i^r represents the constant terms of the Marshallian demand functions and can be interpreted as "minimum commitment levels" or consumption quantities independent of prices and income. The term in brackets, that is, $\text{Valuesum} - F_i^r$ in the Marshallian demands above, captures the expenditure remaining after the value of price and income independent commitments F had been subtracted from available income Valuesum . The function G , based on the Generalised Leontief formulation is defined as:

$$\text{Equ (5.5) } G = \sum_r \sum_i \sum_j (B_{ij}^r + B_{ji}^r) \sqrt{PD_i^r * PD_j^i} \quad [\text{GGI}_-]$$

whereby the derivative of G with respect to the product price is labelled G_i and defined as:

$$\text{Equ (5.6) } G_i^r = \sum_j (B_{ij}^r + B_{ji}^r) \sqrt{PD_j^r / PD_i^r} \quad [\text{GiGI}_-]$$

Symmetry is guaranteed by a symmetric B matrix describing the price-dependent terms, correct curvature by non-negative off-diagonal elements of B , adding up is automatically given as Euler's Law for a homogenous function of degree one:

$\left(a(x) = \sum_i \frac{\partial a(x)}{\partial x_i} x_i \right)$, leads to:

$$\text{Equ (5.7)} \quad \sum_r \sum_i X_i^r PD_i^r = \frac{\sum_r \sum_i G_i^r PD_i^r}{G_{-gl}} (\text{Valuesum} - F) + \sum_r \sum_i D_i^r PD_i^r,$$

$$X_i^r = \frac{G_i^r}{G_{-gl}} (\text{Valuesum} - F) + D_i^r$$

and homogeneity is guaranteed by the functional forms as well. The expenditure function can be derived from the indirect utility functions and gives:

$$\text{Equ (5.8)} \quad \text{Valuesum} = e(U, PD) = F - \frac{G}{U(p, \text{Valuesum})}$$

Using the expenditure function above, the equivalent variation can be calculated in monetary terms as a measure of change in consumer welfare compared to a reference situation. This will be demonstrated in the next chapter while measuring consumer welfare.

4.5.2 Calibration of demand elasticities

The inconsistencies of elasticities derived from different sources motivated the need to calibrate the model based on microeconomic theory: Inconsistencies in the sense that, in some cases, short term elasticities were estimated while long-term elasticities were estimated in others. Table 4.5 shows the elasticities used in the model before calibration.

Table 4.5: Raw elasticities for secondary livestock products⁵

Commodity	Poultry	Beef	Sheep meat	Pork
Poultry	-0.315	0.180	0.051	0.131
Beef	0.593	-0.871	0.216	0.131
Sheep-meat			-0.850	0.574
Pork	0.552	0.613		-1.171
Income	0.480	0.480	0.904	0.347

Source: Meyer, 2003

The demand elasticities available from other studies have been derived from time series data using single equation estimates. However, as shown in Table 4.5, in some cases, these elasticities (especially the cross price elasticities) were found not significant while some also carry the wrong signs leaving some gaps in the data matrix. It is necessary to ensure that omitted data are generated endogenously by imposing appropriate micro-economic restrictions in line with consumer theory (that is, the aggregate consumer maximizes utility under a budget constraint) while also ensuring that the modeling framework complies with these conditions.

Taking into account that the budget share of the products is rather small, the added cross price elasticities for all products not included (other agricultural commodities, as well as non-agricultural - housing, medicare, transportation etc.) should be close to the income elasticities, so that the own price elasticity, in absolute terms, can be expected to be almost equal to the sum of cross-price effects for agricultural products. Based on the above-mentioned factors, there is a need for adjustment of the elasticities in order to define a well-behaved demand system; hence the need for calibration.

⁵ Missing cross price elasticities will be generated during simulation using appropriate constraints.

Symmetry and non-negativity conditions are imposed during the calibration of the parameters (i.e. the price and income elasticities) estimated by Meyer (2003). The calibration necessitates derivatives of Marshallian demands versus prices and income from the expenditure system above and is determined as follows⁶:

$$\text{Equ (5.9)} \quad \frac{\partial QD_i^r}{\partial \text{Valuesum}} = \frac{Gi_i^r}{G}$$

$$\frac{\partial QD_i^r}{\partial PD_j^r} = \left(\frac{Gij_{ij}^r}{G} - \frac{Gi_i^r Gi_j^r}{G_r^2} \right) (\text{Valuesum} - F) \wedge i \neq j$$

where :

$$Gij_{ij}^r = \frac{\partial Gi_i^r}{\partial PD_j^r} = \frac{1}{2} B_{i,j}^r B_{j,i}^r / \sqrt{PD_i PD_j} \quad \wedge i \neq j$$

The terms for the own price effects are somewhat more complicated, and therefore determined indirectly via the homogeneity condition for elasticities during calibration. The parameters D_i are calibrated at the base year of the simulation period as X_i in equation (4.7) above. The D_i s are then adjusted to observed demand quantities.

In order to close the system all other products not introduced in the model are represented by a price index. The following steps had been taken to derive starting values for elasticities:

- The matrix was first filled with the available (raw) elasticities.
- Missing own price elasticities were set to -0.8 for the meat products in the model.
- Missing income elasticities for the meat products in the model were set to $+1$.
- Missing cross price elasticities were calculated from the symmetry condition, but were restricted to $\pm 2\%$.

⁶ An alternative to the Generalized Leontief demand system used in this study, which was also tested, is a normalized quadratic expenditure system. According to the family of indirect utility functions discussed above, the function G is then replaced by a form that is quadratic in normalized prices. However, Cholesky decomposition is then necessary to ensure correct curvature during the calibration process, which renders the solution more cumbersome. An advantage of the NQ system is the fact that it allows formally for complementarity in the Hicksian effects. In practice, that would mean that the Marshallian elasticities created by the calibration of the NQ system have to be checked carefully for such complementarities to ensure a plausible behaviour of the demand system in simulations. However, complementarities are not of interest to this modeling system as all products currently included can be safely assumed to be Hicksian substitutes.

- Where cross price elasticities were missing between commodities, they were constructed by dividing 0.8 by the quantity of meat products consumed in that province.
- The elasticity with respect to changes in the price index for other products was then calculated from the homogeneity condition.
- The income elasticity for other products not included in the model was derived from the adding condition for income elasticities, cross price elasticities based on the symmetry condition and the own price elasticity calculated from the homogeneity condition.

After the defining the starting values for elasticities, a non-linear optimization program defines a set of parameters for each province, which lead to point elasticities minimizing squared differences between the raw elasticities and these calibrated elasticities, i.e.

$$\text{Equ (5.10)} \quad \min \sum_{i,j} \left(\frac{\mathcal{E}_{i,j}^{trim}}{\mathcal{E}_{i,j}^{orig}} \right)^2$$

subject to all the conditions earlier defined.

where

\mathcal{E}^{trim} = calibrated elasticities

\mathcal{E}^{orig} = raw (original) elasticities

The results for the calibrated elasticities are reported in Table 4.6. As expected, the added up cross price elasticities for all products not included in the model are close to the income elasticities in absolute terms. Also the own price and cross price elasticities carry the expected signs. However, the own price elasticity in absolute terms is not exactly equal to the sum of cross-price effects for meat products, due to their low budget-share.

Table 4.6: Calibrated elasticities for secondary livestock products

Commodity	Poultry	Beef	Mutton	Pork
Poultry	-0.315	0.603	0.225	0.551
Beef	0.041	-0.871	0.233	0.615
Mutton	0.005	0.007	-0.850	0.371
Pork	0.015	0.021	0.037	-1.171
Others	-0.211	-0.240	-0.719	-0.633
Income	0.216	0.245	0.736	0.648

Source: Own computations

4.6 Summary

This chapter covers the empirical framework, data specification, model properties as well as the procedure followed for calibrating the spatial equilibrium model. Firstly, the chapter defines the sets and parameters used and how they were used to generate the variables needed for modelling. Secondly, the model properties were briefly defined and the market equilibrium property demonstrated by the base interregional shipment of secondary products (beef, pork, mutton and poultry). The transfer of all the secondary products among the domestic regions and the rest-of-the-world reflected the adequacy of the model structure to provide analyses and forecasts under alternative scenarios.

Lastly, the model was calibrated in line with theory using a Generalized Leontief demand system. The driving force for this process was the need for well-behaved behavioral parameters as a requirement for a model which explicitly incorporates consumer welfare in the objective function. The results of the calibration generate own and cross price elasticities with expected signs. Also as expected, the income

elasticity was, in absolute terms, almost equal with the cross-price elasticities of all other products not included in the model. However, the own price elasticities in absolute terms are not exactly equal to the sum of cross-price effects for meat products. This is not unexpected as the budget share of meat products is low relative to other products unaccounted for.

**EMPIRICAL APPLICATION OF ECONOMIC MODEL
AND TARIFF RATE QUOTA (TRQ) LIBERALIZATION
SCENARIOS**

5.1 Theoretical framework

TRQs are not ‘pure’ import restrictions *per se*, as they allow more market access to imports than a quota in principle; in practice however many over-quota tariffs are so high that they effectively exclude imports in excess of the quota. For instance, South Korea on average charges in-quota tariffs of 21%, while charging a hefty 366% for over-quota imports (Kuhn, 2003). TRQs are indeed a useful tool for import rationing.

Theoretical evidence has established that the lowering of in-quota tariffs will always lead to a welfare gain or at least no harm to imports. However it will require empirical studies of this kind to measure the impact of the two other instruments (that is, over-quota tariff and quota limit) under a TRQ regime (Skully, 2001b). In addition, it has become a burden for many of the analytical models that have been developed to account for these important facets of TRQ functioning (Nicholson and Bishop, 2001).

In order to replicate the regime switching inherent in TRQs (that is, the change in the binding instrument among the three – in-quota tariff, over-quota tariff and the quota limit), a formulation that can accommodate a non-smooth policy measure such as a two-tier tariff is needed. Nicholson *et al.* (1994) showed that the Spatial Price Equilibrium (SPE) model with discriminatory ad valorem tariffs (that is, tariffs on imports that differ

by importing region) cannot be directly solved using a simple optimisation model, because the value of the tariff depends on the endogenously determined supply price⁷. It becomes even more difficult when modelling TRQs within an SPE framework.

5.1.1 The Kuhn-Tucker conditions

For any general optimization problem written as

$$\text{Equ (5.1)} \quad \text{Max } Z = f(X)$$

such that:

$$\text{Equ (5.2)} \quad g^i(X) \leq 0, \text{ all } i$$

$$\text{Equ (5.3)} \quad X_j \geq 0, \text{ all } j$$

Kuhn-Tucker (1951) provided the necessary and sufficient conditions which must be satisfied by X if it is to be an optimal solution to the problem. A version of these conditions can be expressed by equation (5.5) below in terms of the Langragian function L in equation (5.4), i.e.

$$\text{Equ (5.4)} \quad L = f(X) + \sum \lambda_i g^i(X)$$

$$\text{Equ (5.5)} \quad \begin{array}{lll} \frac{dL}{dX_j} \leq 0, & X_j = 0, & X_j \frac{dL}{dX_j} = 0 \\ \frac{dL}{d\lambda_i} \geq 0, & \lambda_i = 0, & \lambda_i \frac{dL}{d\lambda_i} = 0 \end{array} \quad \text{all } i \text{ and } j$$

Equations 5.4 and 5.5 show that with each variable type, i.e. the choice variables (X_j) and the Langragian multipliers (λ_i), there is a corresponding marginal condition that must be satisfied by the optimal solution. However, the last two terms in equation 5.5 are known as the “complementary slackness conditions”.

⁷ It is possible however, to iteratively solve the SPE as an optimisation problem to obtain unit tariff values equivalent to the applicable ad valorem tariff.

Bishop *et al.* (2001) summarized the three possibilities for the optimal solution for each X_j , i.e.

- that the marginal condition holds with a strict equality (as in the classical context); or
- the choice variable in question must take on a zero value; or
- both of the conditions hold.

The same way, for each λ_i , it is either that the associated marginal conditions hold as an equality in the optimal solution (which means that the i^{th} constraint is satisfied exactly) or the Lagrangian multiplier vanishes (i.e. becomes zero) or both. In the economic sense, the Kuhn-Tucker conditions show that, in an optimal solution, when a constraint holds with a strict equality, then by complementarity slackness, the associated shadow prices must be zero (the Lagrangian multipliers are regarded as shadow prices). In the same way, if an activity level is strictly greater than zero, then the associated marginal condition must hold with strict equality.

5.1.2 Complementary slackness conditions

As mentioned, the last two terms in equation 5.5 are known as the “complementary slackness conditions”. These conditions provide a bridge between constrained optimisation and the mixed complementarity problem (MCP) problem (Bishop *et al.*, 2001). For instance the demand and supply equations of a basic spatial equilibrium model are of the form:

$$\text{Equ (5.6)} \quad \sum_j X_{ij} \leq Q_i^s \text{ or } P_i^s \geq 0$$

$$\text{Equ (5.7)} \quad Q_j^d \leq \sum_i X_{ij} \text{ or } P_j^d \geq 0$$

$$\text{Equ (5.8)} \quad g_j^d(Q_j^d) \leq P_j^d \text{ or } Q_j^d \geq 0$$

$$\text{Equ (5.9)} \quad g_i^s(Q_i^s) \leq P_i^s \text{ or } Q_i^s \geq 0$$

$$\text{Equ (5.10)} \quad P_j^d \leq P_i^s + c_{ij} \text{ or } x_{ij} \geq 0$$

where

Q_j^d = quantity demanded in region j

Q_i^s = quantity supplied in region i

x_{ij} = quantity shipped from supply region i to demand region j

P_j^d = demand price in region j

P_i^s = supply price in region i

c_{ij} = constant unit transport costs from supply region i to demand region j

$g_i^s(Q_i^s)$ = inverse supply function in supply region i

$g_j^d(Q_j^d)$ = inverse supply function in supply region j

The problem of endogenous regime switching (found in the TRQ) can be easily handled as a MCP by modifying the condition relating supply and demand prices of the basic SPE model as follows:

$$\text{Equ (5.11)} \quad P_j^d \leq (P_i^s + C_{ij})(1 + \tau_{ij}) \text{ or } X_{ij} \geq 0$$

where the τ represents the ad valorem tariffs imposed by demand region j on imports from supply region i . It should be noted that the above equation allows for both price and quantity values to be simultaneously and directly constrained. Because both prices and quantities can be simultaneously constrained, policy instruments that target prices or quantities (like price supports, ad valorem tariffs, and tariff rate quotas) can be modelled simultaneously and directly. With the implementation of a TRQ, both the quota limit and tariffs have been incorporated, since a TRQ embodies both quantitative restrictions

in the form of a quota and a price instrument in the form of a tariff (which may be specific or ad valorem).

However, due to the fact that the present model does not solve for the first order condition of an optimum, a specification that is compatible with the model framework and which also replicates the TRQ mechanism will be employed.

5.1.3 The “fudging” sigmoid function approach

It has been shown that the TRQ mechanism can be replicated by a sigmoid function to be able to smoothly replicate the functioning of a TRQ (Von Lampe, 2000; Britz, 2001, Kuhn, 2002; Junker *et al.*, 2003). The use of this approach, that is, the “fudging” of an if-else condition by the help of a sigmoid function has its origin in a short note by Arne Drud, the developer behind the CONOPT solvers (Junker *et al.*, 2003). This approach fudges the TRQ mechanism by expressing it as an effective tariff while the effective tariff is a function of imports.

The sigmoid function is based on the following equation:

$$\text{Equ (5.12)} \quad \text{Sigmoid}(X) = \exp(\min(X,0))/(1 + \exp(-\text{abs}(X)))$$

This expression is symmetrically S-shaped and is overall differentiable. Its limits are zero for $X = -\infty$, and one for $X = \infty$, respectively. The function yields 0.5 when X equals zero.

When used for the representation of a two-tiered tariff line such as TRQs, the sigmoid function ensures that the preferential tariff is the effective tariff on the in-quota quantity of imports while the MFN tariff is effective on over-quota imports. Von Lampe (2000) summarized the three general cases as follows:

- Quota unfilled: effective tariff at preferential level
- Over-quota imports: effective tariff at MFN level

- Quota exactly filled: effective tariff between the two

The sigmoid function approximation of TRQs can be represented by Figure 5.1.

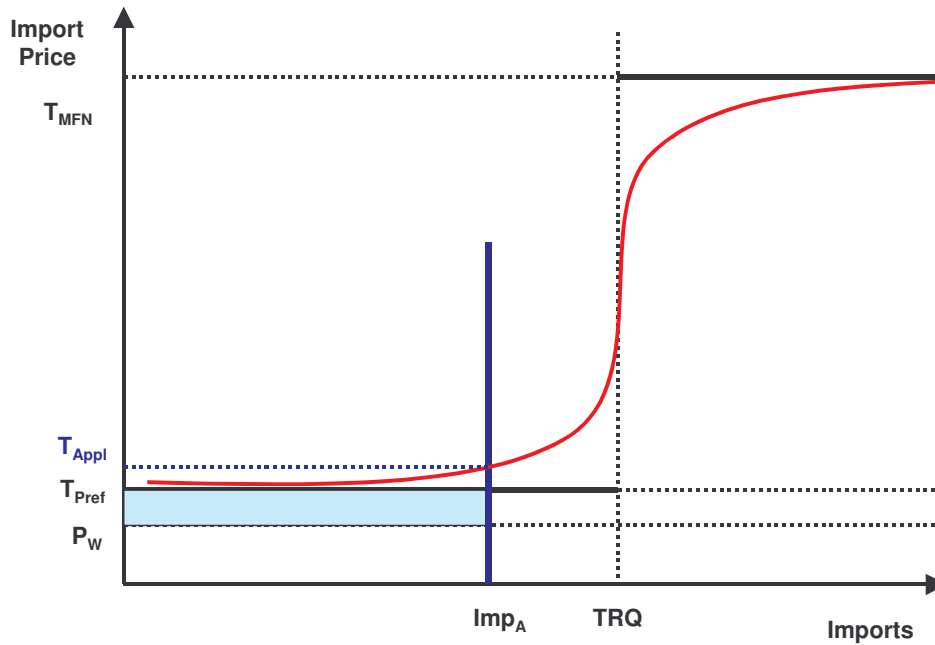


Figure 5.1: TRQ modelling solution using the sigmoid function

Source: Junker *et al.* (2003).

where:

- P_W : average domestic price for the corresponding country aggregate
- T_{MFN} : domestic price plus most favourite nation specific tariff (for the ad-valorem $T_{MFN} * P_W$)
- T_{PREF} : domestic price plus preferential specific tariff (for the ad-valorem $T_{PREF} * P_W$)
- T_{APPL} : domestic price plus applied tariff (reflects the margin of error incurred when using this functional form)
- TRQ: level of quota

Figure 5.1 shows how a TRQ works using the sigmoid approximation function. The TRQ is not binding when imports are above the quota but binding for import flows not

deviating much from the quota (say + or – 1% deviation). The public revenue generated by imports combined with the imposition of preferential tariffs for a single product is given by the average domestic price with or without tariff (this is shown by the blue area of the diagram).

5.2 Empirical framework

5.2.1 Tariff rate quota handling

Based on the sigmoid function, the functioning of the two-tier tariff (TRQ) can be represented by the following expression:

Equ (5.13)

$$TARR_i^{eff} = TARR_i^{pref} + (TARR_i^{MFN} - TARR_i^{pref}) \left[\text{sigmoid} \left(\frac{\alpha}{QIMP_i^{trq}} (QIMP_i - TRQ_i * 1.01) \right) \right]$$

where:

$TARR_i^{eff}$	= Effective tariff (ad-valorem or specific)
$TARR_i^{pref}$	= Preferential tariff
$TARR_i^{MFN}$	= Most favoured nation tariff
$QIMP_i$	= Gross import quantity
TRQ_i	= Tariff rate import quota
α	= Positive parameter

The following differences should be noted about the formulations in (5.13) as compared to the ordinary sigmoid expression in equation (5.12):

- The in-quota tariff ($TARR_i^{pref}$) is added as a constant term (even at zero imports, the in-quota tariff is applied) and is thus working as a lower bound for the function.
- The sigmoid expression is pre-multiplied with the difference of the out-of-quota and

in-quota-tariff, i.e. if the term in outer round brackets becomes infinity; the second term is equal to the difference between the out- and in-quota tariffs, yielding together with the mentioned constant term the out-of-quota or MFN tariff. On the other hand, if the imports are at zero, the sigmoid expression gets a value close to zero, and (almost) solely, the in-quota tariff is applied.

- (c) The sigmoid function is applied to the relation of (Imports – TRQ*1.01) divided by the TRQ and multiplied with a positive parameter α . The bigger α , the faster the sigmoid expression reaches its limits. Very large α renders the function similar to a step function, and will hence yield numerically to an (almost) non-differential expression. In the model α is currently set to 100 for TRQs, a value which in practice still allows the solver to find a feasible solution for the market model.
- (d) The “1.01” factor in the equation ensures that a large fraction of the out-of-quota tariff is applied if imports are at the TRQ. Otherwise, exactly 50% of the difference between the two tariff lines would be added to the in-quota tariff if the imports fill the TRQ (Junker *et al.*, 2003).

Therefore combining equations (5.12) and (5.13) gives the expression that represents the implementation of effective tariffs in the model under a TRQ regime as:

Equ (5.14)

$$TARR_{i,r}^{eff} = TARR_{i,r}^{pref} + \frac{\exp(\min(0, (QIMP_{i,r} - TRQ_{i,r}) * \alpha))}{1 + \exp[-abs((QIMP_{i,r} - TRQ_{i,r}) * \alpha)]} * (TARR_{i,r}^{MFN} - TARR_{i,r}^{pref})$$

With this expression, effective tariff levels have now become a variable rather than parameters. The preferential tariff and gross import values are observed in the base year but endogenously generated in the simulation year. The applied or effective tariff (either specific or ad valorem) generated using equation (5.14) may be different from the observed tariff rate by a value representing the error of approximation incurred by using the sigmoid function.

With the ad valorem and specific tariff values endogenously generated in the model, the import or border price can also be generated endogenously using the following equation:

$$\text{Equ (5.15) } \text{Im } pp_{i,r} = ((\text{Domprice}_{i,r}) * (1. + 0.01 * \text{Tariff}A_{i,r}^{\text{eff}})) + \text{Tariff}S_{i,r}^{\text{eff}}$$

where:

- $\text{Im } pp_{i,r}$ = Import price
- $\text{Domprice}_{i,r}$ = Average domestic price
- $\text{Tariff}S_{i,r}^{\text{eff}}$ = Effective specific tariff
- $\text{Tariff}A_{i,r}^{\text{eff}}$ = Effective ad valorem tariff

5.2.2 Simulation results

In Chapter 3, the current South Africa tariff regime and the minimum market access quota commitments of South Africa for meat products were shown in Tables 3.4 and 3.5, respectively. Based on this information, four liberalization scenarios were modelled for all products. The different scenarios examined include:

- Scenario 1: A 33% expansion of quota
- Scenario 2: A 33% decrease in MFN ad valorem tariff.
- Scenario 3: A scenario combining the two reforms described above.
- Scenario 4: Full liberalization scenario with all tariffs set to zero.

The objective of the scenarios was to examine how regional supply, demand and prices, as well as welfare will respond to policy changes under alternative policy reforms.

Table 5.1 shows the border price on imports of meat products. The border price was derived from equation 5.15 as defined previously. The border prices declined by between 0.89 and 2.39 per cent for scenario one, 2.35 and 7.96 per cent for scenario two, 2.96 and 9.97 per cent for scenario three and 8.25 and 25.19 per cent for scenario four.

Table 5.1: Impact of TRQ liberalization on border price of livestock meat products

Commodity	Base border price (R/kg)	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
		Border price (R/kg)	% change	Border price (R/kg)	% change	Border price (R/kg)	% change	Border price (R/kg)	% change
Beef	11.71	11.43	-2.39	10.97	-6.33	10.78	-7.94	9.33	-13.47
Mutton	16.48	15.98	-3.00	15.17	-7.96	14.83	-9.97	12.33	-25.19
Pork	10.38	10.29	-0.89	10.14	-2.35	10.08	-2.96	9.53	-8.25
Poultry	12.35	12.14	-1.69	11.80	-4.47	11.66	-5.62	10.54	-14.63
Average	12.73	12.46	-1.99	12.02	-5.28	11.84	-6.62	10.43	-15.39

Using a price transmission elasticity of unity between the border and domestic markets, and therefore assuming the same percentage change in border prices due to policy change on the domestic prices, the impact of TRQ liberalization on the domestic markets will be simulated for the four scenarios in subsequent sections.

5.2.2.1 The impact of 33% quota expansion

The impact of TRQ liberalization by expanding the quota by 33% on meat imports is derived by comparing the base-run⁸ situation with a situation where the quota is expanded by 33%. According to Table 5.2, the total beef supply in South Africa will reduce by 2 444 tons or 0.62%. Conversely, beef demand will increase by 8 635 ton or 1.9% as a result of lower prices. Prices will on average drop by 2.08%; Western Cape, KwaZulu-Natal and the Eastern Cape will experience the largest decline in prices, while Mpumalanga will experience the smallest decline in prices.

⁸ The base-run was derived by setting the shift factors at one, so that the result reflects the base year situation.

Table 5.2: The impact of 33% expansion of quota on the beef industry

Region	Beef supply (ton)			Beef demand (ton)			Beef price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	25663	25437	-0.88%	63445	64868	2.24%	12.77	12.44	-2.58%
Northern Cape	21645	21529	-0.54%	11917	12126	1.75%	12.67	12.42	-1.97%
Free State	37606	37405	-0.53%	34075	34671	1.75%	12.69	12.43	-2.05%
Eastern Cape	46108	45690	-0.91%	50208	51333	2.24%	12.79	12.46	-2.58%
KwaZulu-Natal	63693	63122	-0.90%	69826	71393	2.24%	12.77	12.44	-2.58%
Mpumalanga	47829	47671	-0.33%	48620	49329	1.46%	12.78	12.57	-1.64%
Limpopo	24006	23926	-0.33%	22297	22624	1.47%	12.70	12.49	-1.65%
Gauteng	78351	77938	-0.53%	125265	127439	1.74%	12.80	12.55	-1.95%
North West	49176	48915	-0.53%	28920	29425	1.75%	12.74	12.48	-2.04%
Total	394077	391633	-0.62%	454573	463208	1.90%	12.74	12.48	-2.08%
Deviation	-2444			8635			-0.26		

Table 5.3 shows that cattle supply in South Africa will reduce by 9 141 or 0.46% due to a 33% expansion of quota. In addition, the number of cattle slaughtered in South Africa will reduce by 0.52% or 11 616. The producer price of cattle on average will decrease by 1.46% or R27 per head.

Table 5.3: The impact of 33% expansion of quota on the cattle industry

Region	Cattle supply (number)			Cattle demand (number)			Producer price(R/head)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	82407	82088	-0.39%	146647	145525	-0.76%	1881	1854	-1.44%
Northern Cape	80437	80047	-0.48%	123686	123148	-0.43%	1833	1806	-1.47%
Free State	363323	361616	-0.47%	214892	213960	-0.43%	1831	1804	-1.47%
Eastern Cape	337208	335747	-0.43%	263475	261402	-0.79%	1797	1770	-1.50%
KwaZulu-Natal	406158	404291	-0.46%	363961	361130	-0.78%	1821	1794	-1.48%
Mpumalanga	230499	229410	-0.47%	273306	272648	-0.24%	1878	1851	-1.44%
Limpopo	170197	169410	-0.46%	137180	136845	-0.42%	1859	1832	-1.45%
Gauteng	44642	44436	-0.46%	447720	445805	-0.43%	1868	1841	-1.45%
North West	257878	256563	-0.51%	281008	279796	-0.43%	1855	1828	-1.46%
Total	1972749	1963608	-0.46%	2251875	2240259	-0.52%	1847	1820	-1.46%
Deviation	-9141			-11616			-27		

Table 5.4 shows the impact of a 33% expansion of the quota on the sheep meat sub-sector. In total, the demand for sheep meat will increase by 1.99% or 2 335 ton in South Africa; supply however falls by 0.50% or 435 ton. This is caused by a price decrease of 2.36% or R0.40 on the average. The Free State will experience the largest drop in price, i.e. 2.39 per cent.

Table 5.4: The impact of 33% expansion of quota on the sheep meat industry

Region	Sheep meat supply (ton)			Sheep meat demand (ton)			Sheep meat price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	22061	21954	-0.49%	21365	21794	2.01%	16.61	16.22	-2.35%
Northern Cape	26950	26815	-0.50%	3739	3813	1.98%	16.75	16.36	-2.33%
Free State	9929	9879	-0.50%	7638	7790	1.99%	16.77	16.37	-2.39%
Eastern Cape	15129	15050	-0.52%	11495	11724	1.99%	16.69	16.30	-2.34%
KwaZulu-Natal	3475	3458	-0.49%	22571	23022	2.00%	16.77	16.38	-2.33%
Mpumalanga	2402	2390	-0.50%	9510	9698	1.98%	16.88	16.49	-2.31%
Limpopo	381	379	-0.52%	4084	4164	1.96%	16.88	16.49	-2.31%
Gauteng	4040	4020	-0.50%	30523	31130	1.99%	16.88	16.49	-2.31%
North West	2478	2465	-0.52%	6233	6358	2.01%	16.84	16.45	-2.32%
Total	86845	86410	-0.50%	117158	119493	1.99%	16.79	16.39	-2.36%
Deviation	-435			2335			-0.40		

According to Table 5.5, supply of sheep in South Africa will decline by 0.42% or 18 149 as a result of the quota expansion. The number of sheep slaughtered will decrease by 0.45% or 23 219. The producer price drops by 0.94% or R2 per head on average. The Eastern Cape and KwaZulu-Natal will experience the largest drop in prices.

Table 5.5: The impact of 33% expansion of quota on the sheep industry

Region	Sheep supply (number)			Sheep demand (number)			Producer price(R/head)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	523956	521949	-0.38%	1297722	1292003	-0.44%	231	229	-0.87%
Northern Cape	1184503	1178860	-0.48%	1585265	1578094	-0.45%	217	215	-0.92%
Free State	924448	920776	-0.40%	584044	581361	-0.46%	211	209	-0.95%
Eastern Cape	1050895	1046640	-0.40%	889929	885705	-0.47%	196	194	-1.0%
KwaZulu-Natal	152274	151596	-0.45%	204434	203486	-0.46%	203	201	-0.99%
Mpumalanga	296189	294913	-0.43%	141310	140662	-0.46%	206	204	-0.97%
Limpopo	25328	25222	-0.42%	22435	22332	-0.46%	207	205	-0.97%
Gauteng	16638	16568	-0.42%	237639	236569	-0.45%	217	215	-0.92%
North West	106514	106072	-0.41%	145736	145083	-0.45%	218	216	-0.92%
Total	4280745	4262596	-0.42%	5108514	5085295	-0.45%	212	210	-0.94%
Deviation	-18149			-23219			-2.0		

The impact of a 33% expansion of the quota on the pork sub-sector is shown in Table 5.6. According to the results, pork supply will decline by 0.92% or 1 179 ton while demand will increase by 2.57% or 3 586 ton. Prices of pork will decline by 2.12% or R0.22 per kg on the average. The largest decline in prices will occur in the Western Cape and Gauteng since about 50% of pork supply in South Africa originates from these two provinces.

Table 5.6: The impact of 33% expansion of quota on the pork industry

Region	Pork supply (ton)			Pork demand (ton)			Pork price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	20069	19880	-0.94%	25251	25929	2.69%	10.38	10.14	-2.31%
Northern Cape	1553	1542	-0.71%	4222	4315	2.20%	10.49	10.29	-1.91%
Free State	9470	9403	-0.71%	10334	10563	2.22%	10.46	10.26	-1.91%
Eastern Cape	9200	9104	-1.00%	13739	14107	2.68%	10.40	10.17	-2.20%
KwaZulu-Natal	22348	22191	-0.70%	18570	18988	2.25%	10.31	10.11	-1.94%
Mpumalanga	4237	4193	-1.04%	12197	12520	2.65%	10.51	10.27	-2.28%
Limpopo	8050	7967	-1.03%	4938	5070	2.67%	10.40	10.17	-2.21%
Gauteng	45466	45018	-0.99%	41937	43059	2.68%	10.40	10.16	-2.31%
North West	8274	8190	-1.02%	8388	8611	2.66%	10.46	10.22	-2.29%
Total	128667	127488	-0.92%	139576	143162	2.57%	10.42	10.20	-2.12%
Deviation	-1179			3586			-0.22		

According to Table 5.7, a 33% quota expansion will result in a reduction of 0.78% or 16718 in pig numbers in South Africa. The number of animals slaughtered will drop by 0.78% or 16 716. The producer price of pigs will drop by 2.02% or R7 per head on average.

Table 5.7: The impact of 33% expansion of quota on the pig industry

Region	Pig supply (number)			Pig demand (number)			Producer price(R/head)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	334475	331811	-0.80%	334475	331811	-0.80%	364	356	-2.20%
Northern Cape	29666	29375	-0.98%	25883	25730	-0.59%	331	324	-2.11%
Free State	250451	248426	-0.81%	157838	156909	-0.59%	339	332	-2.06%
Eastern Cape	159419	158272	-0.72%	153328	151947	-0.90%	326	319	-2.15%
KwaZulu-Natal	331256	328765	-0.75%	372461	370312	-0.58%	365	358	-1.92%
Mpumalanga	296974	294661	-0.78%	70614	69991	-0.88%	336	330	-1.79%
Limpopo	182505	181058	-0.79%	134162	132968	-0.89%	339	332	-2.06%
Gauteng	296355	294078	-0.77%	757763	751340	-0.85%	364	357	-1.92%
North West	263320	261257	-0.78%	137897	136697	-0.87%	352	345	-1.99%
Total	2144421	2127703	-0.78%	2144421	2127705	-0.78%	346	339	-2.02%
Deviation	-16718			-16716			-7		

The impact of a 33% expansion of quota on the poultry sub-sector is shown in Table 5.8. The results show that the total demand will increase by 7.06% or 60 115 ton while supply will reduce by -0.92% or 9 242 ton. Prices will drop by an average of 3.41% or R0.40 per kg. KwaZulu-Natal, Eastern Cape and Western Cape will experience the greatest drop in prices.

Table 5.8: The impact of 33% expansion of quota on the poultry meat industry

Region	Poultry meat supply (ton)			Poultry meat demand (ton)			Poultry meat price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	75568	75144	-0.56%	80543	85942	6.70%	11.82	11.42	-3.43%
Northern Cape	15930	15743	-1.17%	16978	17839	5.07%	11.97	11.56	-3.39%
Free State	52110	51688	-0.81%	55541	58969	6.17%	11.94	11.53	-3.40%
Eastern Cape	123124	121670	-1.18%	131230	139860	6.58%	11.84	11.44	-3.43%
KwaZulu-Natal	166838	164891	-1.17%	177822	191957	7.95%	11.82	11.41	-3.44%
Mpumalanga	55258	54848	-0.74%	58896	63586	7.96%	11.95	11.54	-3.40%
Limpopo	96762	95757	-1.04%	103132	110781	7.42%	11.98	11.58	-3.39%
Gauteng	147324	146291	-0.70%	157023	167755	6.83%	11.93	11.52	-3.40%
North West	66086	65626	-0.70%	70437	75028	6.52%	11.95	11.55	-3.40%
Total	799000	791657	-0.92%	851602	911717	7.06%	11.91	11.51	-3.41%
Deviation	-9242			60115			-0.40		

5.2.2.2 The impact of a 33% decrease in MFN ad valorem tariff

Tables 5.9 and 5.10 show the impact of a 33% reduction in the MFN ad valorem tariffs on the beef and cattle sub-sectors respectively. According to Table 5.9, the total beef supply in South Africa will reduce by 7271 ton or 1.83%. Conversely, beef demand will increase by 25468 ton or 5.56% as a result of lower prices. Prices will on average drop by 0.81%; Western Cape, KwaZulu-Natal and the Eastern Cape will experience the largest decline in prices, while Mpumalanga will experience the smallest decline in prices.

Table 5.9: The impact of 33% decrease in MFN ad valorem tariff on the beef industry

Region	Beef supply (ton)			Beef demand (ton)			Beef price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	25663	25128	-2.08%	63445	67218	5.95%	12.77	11.90	-6.80%
Northern Cape	21645	21264	-1.76%	11917	12570	5.48%	12.67	11.87	-6.31%
Free State	37606	36940	-1.77%	34075	35942	5.48%	12.69	11.89	-6.30%
Eastern Cape	46108	45123	-2.14%	50208	53188	5.94%	12.79	11.92	-6.80%
KwaZulu-Natal	63693	62331	-2.14%	69826	73979	5.95%	12.77	11.89	-6.89%
Mpumalanga	47829	47088	-1.55%	48620	51127	5.16%	12.78	12.02	-5.95%
Limpopo	24006	23632	-1.56%	22297	23454	5.19%	12.70	11.94	-5.98%
Gauteng	78351	76983	-1.75%	125265	132066	5.43%	12.80	12.00	-6.25%
North West	49176	48317	-1.75%	28920	30497	5.45%	12.74	11.94	-6.28%
Total	394077	386806	-1.83%	454573	480041	5.56%	12.74	11.93	-6.40%
Deviation	-7271			25468			-0.81		

Table 5.10 shows that cattle supply in South Africa will reduce by 34 522 or 1.38% due to a 33% reduction in MFN ad valorem tariff. In addition, the number of cattle slaughtered in South Africa will reduce by 1.52% or 34 522. The producer price of cattle on average will decrease by 4.38% or R81 per head on average.

Table 5.10: The impact of 33% decrease in MFN ad valorem tariff on the cattle industry

Region	Cattle supply (number)			Cattle demand (number)			Producer price(R/head)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	82407	81446	-1.17%	146647	144064	-1.76%	1881	1800	-4.31%
Northern Cape	80437	79264	-1.46%	123686	121890	-1.45%	1833	1752	-4.42%
Free State	363323	358201	-1.41%	214892	211750	-1.46%	1831	1750	-4.42%
Eastern Cape	337208	332800	-1.31%	263475	258715	-1.81%	1797	1716	-4.51%
KwaZulu-Natal	406158	400595	-1.37%	363961	357368	-1.81%	1821	1740	-4.45%
Mpumalanga	230499	227237	-1.42%	273306	269882	-1.25%	1878	1797	-4.31%
Limpopo	170197	167838	-1.39%	137180	135449	-1.26%	1859	1779	-4.31%
Gauteng	44642	44025	-1.38%	447720	441272	-1.44%	1868	1787	-4.34%
North West	257878	253938	-1.53%	281008	276963	-1.44%	1855	1774	-4.37%
Total	1972749	1945344	-1.38%	2251875	2217353	-1.52%	1847	1766	-4.38%
Deviation	-27405			-34522			-81		

Table 5.11 shows the impact of a 33% decrease in MFN ad valorem tariff on the sheep meat sub-sector. In total, the demand for sheep meat will increase by 5.14% or 6 021 ton in South Africa; supply however falls by 1.27% or 1 102 ton. The price will decline by 6.13% or R1.03 on the average. The Eastern Cape will experience the largest drop in price, i.e. 6.29 per cent.

Table 5.11: The impact of 33% decrease in MFN ad valorem tariff on the sheep meat industry

Region	Sheep meat supply (ton)			Sheep meat demand (ton)			Sheep meat price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	22061	21840	-1.00%	21365	22327	4.50%	16.61	15.73	-5.30%
Northern Cape	26950	26586	-1.35%	3739	3937	5.30%	16.75	15.70	-6.27%
Free State	9929	9793	-1.37%	7638	8043	5.30%	16.77	15.72	-6.26%
Eastern Cape	15129	14919	-1.39%	11495	12107	5.32%	16.69	15.64	-6.29%
KwaZulu-Natal	3475	3428	-1.35%	22571	23766	5.29%	16.77	15.73	-6.20%
Mpumalanga	2402	2370	-1.33%	9510	10010	5.26%	16.88	15.84	-6.16%
Limpopo	381	376	-1.31%	4084	4298	5.24%	16.88	15.84	-6.16%
Gauteng	4040	3987	-1.31%	30523	32130	5.26%	16.88	15.84	-6.16%
North West	2478	2444	-1.37%	6233	6561	5.26%	16.84	15.80	-6.18%
Total	86845	85743	-1.27%	117158	123179	5.14%	16.79	15.76	-6.13%
Deviation	-1102			6021			-1.03		

According to Table 5.12, supply of sheep in South Africa will reduce by 1.11% or 47 348 as a result of the drop in the MFN ad valorem tariff. The number of sheep slaughtered will decrease by 1.15% or 58 762. Producer price drops by 2.52% or R5.33 per head on average. The Eastern Cape and KwaZulu-Natal will experience the largest drop in prices.

Table 5.12: The impact of 33% decrease in MFN ad valorem tariff on the sheep meat industry

Region	Sheep supply (number)			Sheep demand (number)			Producer price(R/head)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	523956	518624	-1.02%	1297722	1286041	-0.90%	231	226	-2.16%
Northern Cape	1184503	1170046	-1.22%	1585265	1565828	-1.23%	217	211	-2.76%
Free State	924448	915140	-1.01%	584044	576747	-1.25%	211	206	-2.37%
Eastern Cape	1050895	1039329	-1.10%	889929	878742	-1.26%	196	190	-3.06%
KwaZulu-Natal	152274	150509	-1.16%	204434	201902	-1.24%	203	197	-2.96%
Mpumalanga	296189	292825	-1.14%	141310	139576	-1.23%	206	201	-2.40%
Limpopo	25328	25032	-1.17%	22435	22169	-1.19%	207	202	-2.42%
Gauteng	16638	16453	-1.11%	237639	234792	-1.20%	217	212	-2.30%
North West	106514	105439	-1.01%	145736	143955	-1.22%	218	213	-2.29%
Total	4280745	4233397	-1.11%	5108514	5049752	-1.15%	212	206	-2.52%
Deviation	-47348			-58762			-5.33		

The impact of a 33% reduction in MFN ad valorem tariff on the pork sub-sector is shown in Table 5.13. According to the results, pork supply will decline by 2.37% or 3 054 ton, while demand will increase by 6.69% or 9 333 ton. Prices of pork will decline by 5.75%

or R0.60 per kg on average. The largest decline in prices will occur in the Western Cape, while the smallest decline will be experienced in Gauteng.

Table 5.13: The impact of 33% decrease in MFN ad valorem tariff on the pork industry

Region	Pork supply (ton)			Pork demand (ton)			Pork price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	20069	19570	-2.49%	25251	27049	7.12%	10.38	9.75	-6.07%
Northern Cape	1553	1514	-2.51%	4222	4501	6.61%	10.49	9.90	-5.62%
Free State	9470	9238	-2.50%	10334	11018	6.62%	10.46	9.87	-5.64%
Eastern Cape	9200	8938	-2.85%	13739	14716	7.11%	10.40	9.77	-6.06%
KwaZulu-Natal	22348	21805	-2.43%	18570	19824	6.75%	10.31	9.72	-5.72%
Mpumalanga	4237	4119	-2.78%	12197	13055	7.03%	10.51	9.88	-5.99%
Limpopo	8050	7826	-2.78%	4938	5289	7.11%	10.40	9.77	-6.06%
Gauteng	45466	44524	-2.07%	41937	44524	6.17%	10.40	9.85	-5.29%
North West	8274	8079	-2.36%	8388	8933	6.50%	10.46	9.88	-5.54%
Total	128667	125613	-2.37%	139576	148909	6.69%	10.42	9.82	-5.75%
Deviation	-3054			9333			-0.60		

According to Table 5.14, a reduction in the MFN ad valorem tariff will result in a reduction of 2.02% or 43 377 in pig numbers in South Africa. The number of animals slaughtered will drop by 2.02% or 43 378. The producer prices of pigs will drop by 5.23% or R18.11 per head on average.

Table 5.14: The impact of 33% decrease in MFN ad valorem tariff on the pig industry

Region	Pig supply (number)			Pig demand (number)			Producer price(R/head)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	334475	327413	-2.11%	334475	327413	-2.11%	364	344	-5.49%
Northern Cape	29666	28916	-2.53%	25883	25331	-2.13%	331	313	-5.44%
Free State	250451	245183	-2.10%	157838	154517	-2.10%	339	321	-5.31%
Eastern Cape	159419	156472	-1.85%	153328	149539	-2.47%	326	308	-5.52%
KwaZulu-Natal	331256	324759	-1.96%	372461	364715	-2.08%	365	347	-4.93%
Mpumalanga	296974	290978	-2.02%	70614	68918	-2.40%	336	319	-5.06%
Limpopo	182505	178744	-2.06%	134162	130930	-2.41%	339	321	-5.31%
Gauteng	296355	290570	-1.95%	757763	744553	-1.74%	364	346	-4.95%
North West	263320	258009	-2.02%	137897	135127	-2.01%	352	334	-5.11%
Total	2144421	2101044	-2.02%	2144421	2101043	-2.02%	346.22	328.11	-5.23%
Deviation	-43377			-43378			-18.11		

The impact of a 33% reduction in MFN ad valorem tariffs on the poultry sub-sector is shown in Table 5.15. The results show that the total demand will increase by 18.05% or

159 553 ton, while supply will reduce by 2.38% or 72 092 ton. Prices will drop by an average of 9.05% or R1.08 per kg. KwaZulu-Natal and Western Cape will experience the largest decline in prices.

Table 5.15: The impact of 33% decrease in MFN ad valorem tariff on the poultry meat industry

Region	Poultry meat supply (ton)			Poultry meat demand (ton)			Poultry meat price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	75568	74442	-1.49%	80543	94920	17.85%	11.82	10.74	-9.14%
Northern Cape	15930	15435	-3.11%	16978	19268	13.49%	11.97	10.89	-9.02%
Free State	52110	50984	-2.16%	55541	64661	16.42%	11.94	10.86	-9.05%
Eastern Cape	123124	119295	-3.11%	131230	153985	17.34%	11.84	10.77	-9.04%
KwaZulu-Natal	166838	161649	-3.11%	177822	215378	21.12%	11.82	10.74	-9.14%
Mpumalanga	55258	54169	-1.97%	58896	71358	21.16%	11.95	10.87	-9.04%
Limpopo	96762	94082	-2.77%	103132	123490	19.74%	11.98	10.90	-9.02%
Gauteng	147324	144584	-1.86%	157023	185570	18.18%	11.93	10.85	-9.05%
North West	66086	64870	-1.84%	70437	82524	17.16%	11.95	10.88	-8.95%
Total	851602	779510	-2.38%	851602	1011155	18.05%	11.91	10.83	-9.05%
Deviation	-72092			159553			-1.08		

5.2.2.3 The impact of a 33% quota expansion and a 33% decrease in MFN ad valorem tariffs

As explained earlier in this chapter, the functioning of the sigmoid function is such that when the quota is unfilled, the effective tariff is at the preferential level. Therefore, a scenario of a reduction in the quota depicts this case. However, since the MFN tariff is the upper bound, a decrease in the MFN tariff would mean a reduction in over-quota tariff. Hence, a scenario combining an expansion of the quota and a reduction in the MFN tariff would entail the combination of the two conditions applicable to the in-quota and over-quota tariff just described.

Tables 5.16 and 5.17 show the impact of a 33% quota expansion and a 33% reduction in the MFN ad valorem tariffs on the beef and cattle sub-sectors, respectively. According to Table 5.16, the total beef supply in South Africa will reduce by 9179 ton or 2.30%. Conversely, beef demand will increase by 32 181 ton or 6.93% as a result of lower prices.

Prices will on average drop by 8.04% or R1.04 per kg; Western Cape and KwaZulu-Natal will experience the largest decline in prices, while Limpopo will experience the lowest decline in prices.

Table 5.16: The impact of a 33 % quota expansion and decrease in MFN ad valorem tariff on the beef industry

Region	Beef supply (ton)			Beef demand (ton)			Beef price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	25663	24995	-2.60%	63445	68176	7.46%	12.77	11.68	-8.54%
Northern Cape	21645	21150	-2.29%	11917	12751	6.70%	12.67	11.65	-8.05%
Free State	37606	36747	-2.28%	34075	36459	6.70%	12.69	11.67	-8.04%
Eastern Cape	46108	44881	-2.66%	50208	53945	7.44%	12.79	11.70	-8.52%
KwaZulu-Natal	63693	62008	-2.65%	69826	75034	7.46%	12.77	11.67	-8.61%
Mpumalanga	47829	46846	-2.06%	48620	51861	6.67%	12.78	11.80	-7.67%
Limpopo	24006	23625	-1.59%	22297	23640	6.02%	12.70	11.82	-6.93%
Gauteng	78351	76584	-2.26%	125265	133954	6.94%	12.80	11.78	-7.97%
North West	49176	48062	-2.27%	28920	30934	6.96%	12.74	11.72	-8.01%
Total	394077	384898	-2.30%	454573	486754	6.93%	12.74	11.72	-8.04%
Deviation	-9179			32181			-1.02		

Table 5.17 shows that cattle supply in South Africa will reduce by 34 671 or 1.75%. In addition, the number of cattle slaughtered in South Africa will reduce by 1.90% or 43 574. The producer price of cattle on average will decrease by 5.52% or R102 per head. KwaZulu-Natal and Eastern Cape will experience the largest drop in prices.

Table 5.17: The impact of a 33 % quota expansion and decrease in MFN ad valorem tariff on the cattle industry

Region	Cattle supply (number)			Cattle demand (number)			Producer price(R/head)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	82407	81198	-1.47%	146647	143423	-2.20%	1881	1779	-5.42%
Northern Cape	80437	78958	-1.84%	123686	121347	-1.89%	1833	1731	-5.56%
Free State	363323	356837	-1.79%	214892	210828	-1.89%	1831	1729	-5.57%
Eastern Cape	337208	331647	-1.65%	263475	257554	-2.25%	1797	1695	-5.68%
KwaZulu-Natal	406158	399088	-1.74%	363961	355833	-2.23%	1821	1719	-5.60%
Mpumalanga	230499	226367	-1.79%	273306	268722	-1.68%	1878	1776	-5.43%
Limpopo	170197	167213	-1.75%	137180	135492	-1.23%	1859	1757	-5.49%
Gauteng	44642	43861	-1.75%	447720	439364	-1.87%	1868	1766	-5.46%
North West	257878	252909	-1.93%	281008	275738	-1.88%	1855	1753	-5.50%
Total	1972749	1938078	-1.75%	2251875	2208301	-1.90%	1847	1745	-5.52%
Deviation	-34671			-43574			-102		

Table 5.18 shows the combined impact on the sheep meat sub-sector. In total, the demand for sheep meat will increase by 6.49% or 7 596 ton in South Africa; supply, however, falls by 1.60% or 1 392 ton. Price decreases on average by 7.72% or R1.30 per kg. The Eastern Cape will experience the largest drop in price, i.e. 7.81 per cent.

Table 5.18: The impact of a 33 % quota expansion and decrease in MFN ad valorem tariff on the sheep meat industry

Region	Sheep meat supply (ton)			Sheep meat demand (ton)			Sheep meat price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	22061	21764	-1.35%	21365	22618	5.86%	16.61	15.47	-6.86%
Northern Cape	26950	26500	-1.67%	3739	3987	6.63%	16.75	15.44	-7.82%
Free State	9929	9761	-1.69%	7638	8145	6.64%	16.77	15.46	-7.81%
Eastern Cape	15129	14866	-1.74%	11495	12262	6.67%	16.69	15.38	-7.85%
KwaZulu-Natal	3475	3416	-1.70%	22571	24070	6.64%	16.77	15.46	-7.81%
Mpumalanga	2402	2362	-1.67%	9510	10137	6.59%	16.88	15.57	-7.76%
Limpopo	381	375	-1.57%	4084	4353	6.59%	16.88	15.57	-7.76%
Gauteng	4040	3973	-1.66%	30523	32537	6.60%	16.88	15.57	-7.76%
North West	2478	2436	-1.69%	6233	6645	6.61%	16.84	15.53	-7.78%
Total	86845	85453	-1.60%	117158	124754	6.49%	16.79	15.49	-7.72%
Deviation	-1392			7596			-1.30		

In the sheep sub-sector, as in Table 5.19, sheep supply will decline by 1.41% or 60 244. The number of sheep slaughtered will also decrease by 1.45% or 74 176. The producer price drops by 3.31% or R7 per head. The impact generated by this scenario is again greatest in KwaZulu-Natal and Eastern Cape.

Table 5.19: The impact of a 33 % quota expansion and decrease in MFN ad valorem tariff on the sheep industry

Region	Sheep supply (number)			Sheep demand (number)			Producer price(R/head)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	523956	517416	-1.25%	1297722	1281969	-1.21%	231	224	-3.03%
Northern Cape	1184503	1165865	-1.57%	1585265	1561271	-1.51%	217	210	-3.23%
Free State	924448	912254	-1.32%	584044	575094	-1.53%	211	204	-3.32%
Eastern Cape	1050895	1036491	-1.37%	889929	875882	-1.58%	196	189	-3.57%
KwaZulu-Natal	152274	150064	-1.45%	204434	201256	-1.55%	203	196	-3.45%
Mpumalanga	296189	291899	-1.45%	141310	139152	-1.53%	206	199	-3.40%
Limpopo	25328	24975	-1.39%	22435	22091	-1.53%	207	200	-3.38%
Gauteng	16638	16403	-1.41%	237639	234100	-1.49%	217	210	-3.23%
North West	106514	105134	-1.30%	145736	143523	-1.52%	218	211	-3.21%
Total	4280745	4220501	-1.41%	5108514	5034338	-1.45%	212	205	-3.31%
Deviation	-60244			-74176			-7		

In the case of pork, the results show that pork supply will decline by 3.02% or 3 881 ton, while demand will increase by 8.48% or 11 842 ton. Prices of pork will decline by 7.30% or R0.76 per kg on the average. The largest decline in prices will occur in the Western Cape, while the smallest decline will be experienced in Gauteng.

Table 5.20: The impact of a 33 % quota expansion and decrease in MFN ad valorem tariff on the pork industry

Region	Pork supply (ton)			Pork demand (ton)			Pork price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	20069	19443	-3.12%	25251	27506	8.93%	10.38	9.59	-7.61%
Northern Cape	1553	1504	-3.16%	4222	4577	8.41%	10.49	9.73	-7.25%
Free State	9470	9176	-3.10%	10334	11205	8.43%	10.46	9.70	-7.27%
Eastern Cape	9200	8877	-3.51%	13739	14964	8.92%	10.40	9.61	-7.60%
KwaZulu-Natal	22348	21663	-3.07%	18570	20155	8.54%	10.31	9.56	-7.27%
Mpumalanga	4237	4091	-3.45%	12197	13273	8.82%	10.51	9.72	-7.52%
Limpopo	8050	7772	-3.45%	4938	5378	8.91%	10.40	9.61	-7.60%
Gauteng	45466	44234	-2.71%	41937	45277	7.96%	10.40	9.69	-6.83%
North West	8274	8026	-3.00%	8388	9083	8.29%	10.46	9.72	-7.07%
Total	128667	124786	-3.02%	139576	151418	8.48%	10.42	9.66	-7.30%
Deviation	-3881			11842			-0.76		

In the pig sub sector, supply will decline by 2.57% or 55 130 pigs. The number of pigs slaughtered will drop by 2.57% or 55 129. The producer price of pigs will drop by 6.68% or R23 per head on average. Northern Cape and Eastern Cape will experience the greatest drop in producer prices.

Table 5.21: The impact of a 33 % quota expansion and decrease in MFN ad valorem tariff on the pig industry

Region	Pig supply (number)			Pig demand (number)			Producer price(R/head)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	334475	325619	-2.65%	334475	325619	-2.65%	364	339	-6.87%
Northern Cape	29666	28709	-3.23%	25883	25185	-2.70%	331	308	-6.95%
Free State	250451	243708	-2.69%	157838	153638	-2.66%	339	316	-6.78%
Eastern Cape	159419	155648	-2.37%	153328	148672	-3.04%	326	303	-7.06%
KwaZulu-Natal	331256	323024	-2.49%	372461	362692	-2.62%	365	342	-6.30%
Mpumalanga	296974	289356	-2.57%	70614	68516	-2.97%	336	314	-6.55%
Limpopo	182505	177724	-2.62%	134162	130164	-2.98%	339	316	-6.78%
Gauteng	296355	288980	-2.49%	757763	740428	-2.29%	364	341	-6.32%
North West	263320	256523	-2.58%	137897	134378	-2.55%	352	329	-6.53%
Total	2144421	2089291	-2.57%	2144421	2089292	-2.57%	346	323	-6.68%
Deviation	-55130			-55129			-23		

For poultry, the results show that the total demand will increase by 23.45% or 199 701 ton while supply will decline by -3.06% or 26 059 ton. Prices will drop by an average of 11.33% or R1.35 per kg. KwaZulu-Natal and Western Cape will experience the largest decline in prices.

Table 5.22: The impact of a 33 % quota expansion and decrease in MFN ad valorem tariff on the poultry meat industry

Region	Poultry meat supply (ton)			Poultry meat demand (ton)			Poultry meat price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	75568	74162	-1.86%	80543	98512	22.31%	11.82	10.47	-11.42%
Northern Cape	15930	15310	-3.89%	16978	19842	16.87%	11.97	10.62	-11.28%
Free State	52110	50708	-2.69%	55541	66938	20.52%	11.94	10.59	-11.31%
Eastern Cape	123124	118298	-3.92%	131230	159930	21.87%	11.84	10.49	-11.40%
KwaZulu-Natal	166838	160365	-3.88%	177822	224749	26.39%	11.82	10.47	-11.42%
Mpumalanga	55258	53899	-2.46%	58896	74486	26.47%	11.95	10.6	-11.30%
Limpopo	96762	93414	-3.46%	103132	128575	24.67%	11.98	10.63	-11.27%
Gauteng	147324	143891	-2.33%	157023	192730	22.74%	11.93	10.58	-11.32%
North West	66086	64546	-2.33%	70437	85701	21.67%	11.95	10.6	-11.30%
Total	851602	825543	-3.06%	851602	1051303	23.45%	11.91	10.56	-11.33%
Deviation	-26059			199701			-1.35		

5.2.2.4 The impact of the removal of all tariffs (full liberalization)

The last scenario involves the removal of all tariffs applicable to meat products. This scenario, when compared to the base, gives an indication of the overall effectiveness of the tariff regimes on meat products in South Africa in rationing imports.

Table 5.23 shows the impact of the removal of all tariffs on the beef industry. The total beef supply in South Africa will reduce by 22 000 ton or 5.54%. Conversely, beef demand will increase by 76 947 ton or 16.84% as a result of lower prices. Prices will on average drop by 19.34% or R2.46 per kg. The Western Cape, Eastern Cape and KwaZulu-Natal will experience the largest decline in prices, while Limpopo will experience the smallest decline in prices.

Table 5.23: The impact of the removal of all tariffs on the beef industry

Region	Beef supply (ton)			Beef demand (ton)			Beef price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	25663	24160	-5.86%	63445	74441	17.33%	12.77	10.23	-19.89%
Northern Cape	21645	20436	-5.59%	11917	13937	16.95%	12.67	10.21	-19.42%
Free State	37606	35606	-5.32%	34075	39719	16.56%	12.69	10.27	-19.07%
Eastern Cape	46108	43350	-5.98%	50208	58895	17.30%	12.79	10.25	-19.86%
KwaZulu-Natal	63693	59904	-5.95%	69826	81932	17.34%	12.77	10.23	-19.89%
Mpumalanga	47829	45293	-5.30%	48620	56658	16.53%	12.78	10.36	-18.94%
Limpopo	24006	22845	-4.84%	22297	25847	15.92%	12.70	10.38	-18.27%
Gauteng	78351	74033	-5.51%	125265	146293	16.79%	12.80	10.33	-19.30%
North West	49176	46450	-5.54%	28920	33798	16.87%	12.74	10.27	-19.39%
Total	394077	372077	-5.54%	454573	531520	16.84%	12.75	10.28	-19.34%
Deviation	-22000			76947			-2.46		

Table 5.24 shows that cattle supply in South Africa will reduce by 83 228 or 4.19% due to the total removal of tariffs. In addition, the number of cattle slaughtered in South Africa will reduce by 104 406 or 4.6%. The producer price of cattle on average will decrease by 13.27% or R245 per head. KwaZulu-Natal and Eastern Cape will experience the largest price drop.

Table 5.24: The impact of the removal of all tariffs on the cattle industry

Region	Cattle supply (number)			Cattle demand (number)			Producer price(R/head)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	82407	79507	-3.52%	146647	139457	-4.90%	1881	1636	-13.02%
Northern Cape	80437	76886	-4.41%	123686	117954	-4.63%	1833	1588	-13.37%
Free State	363323	347755	-4.28%	214892	205476	-4.38%	1831	1586	-13.38%
Eastern Cape	337208	323865	-3.96%	263475	250282	-5.01%	1797	1552	-13.63%
KwaZulu-Natal	406158	389207	-4.17%	363961	345833	-4.98%	1821	1576	-13.45%
Mpumalanga	230499	220569	-4.31%	273306	261346	-4.38%	1878	1633	-13.05%
Limpopo	170197	163016	-4.22%	137180	131790	-3.93%	1859	1614	-13.18%
Gauteng	44642	42767	-4.20%	447720	427248	-4.57%	1868	1623	-13.12%
North West	257878	245949	-4.63%	281008	268083	-4.60%	1855	1610	-13.21%
Total	1972749	1889521	-4.19%	2251875	2147469	-4.60%	1847	1602	-13.27%
Deviation	-83,228			-104406			-245		

Table 5.25 shows the impact of the total removal of tariffs on the sheep meat sub-sector. In total, the demand for sheep meat will increase by 15.27% or 17 892 ton in South Africa; supply however falls by 3.77% or 3 278 ton. The price declines by 18.05% or

R3.03 per kg on the average. The Eastern Cape will experience the largest drop in price, i.e. 18.27 per cent.

Table 5.25: The impact of the removal of all tariffs on the sheep meat industry

Region	Sheep meat supply (ton)			Sheep meat demand (ton)			Sheep meat price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	22061	21301	-3.44%	21365	24514	14.74%	16.61	13.73	-17.34%
Northern Cape	26950	25918	-3.83%	3739	4316	15.43%	16.75	13.71	-18.15%
Free State	9929	9544	-3.88%	7638	8817	15.44%	16.77	13.72	-18.19%
Eastern Cape	15129	14521	-4.02%	11495	13278	15.51%	16.69	13.64	-18.27%
KwaZulu-Natal	3475	3338	-3.94%	22571	26054	15.43%	16.77	13.73	-18.13%
Mpumalanga	2402	2309	-3.87%	9510	10968	15.33%	16.88	13.84	-18.01%
Limpopo	381	367	-3.67%	4084	4710	15.33%	16.88	13.83	-18.07%
Gauteng	4040	3886	-3.81%	30523	35203	15.33%	16.88	13.84	-18.01%
North West	2478	2383	-3.83%	6233	7190	15.35%	16.84	13.80	-18.05%
Total	86845	83567	-3.77%	117158	135050	15.27%	16.79	13.76	-18.05%
Deviation	-3278			17892			-3.03		

Table 5.26 shows that total sheep supply will decline by 3.36% or 143777. The total number of sheep slaughtered will drop by 3.42% or 174579. The producer price will decline by 7.61% or R16 per head on average.

Table 5.26: The impact of the removal of all tariffs on the sheep industry

Region	Sheep supply (number)			Sheep demand (number)			Producer price(R/head)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	523956	508067	-3.03%	1297722	1257351	-3.11%	231	215	-6.93%
Northern Cape	1184503	1139989	-3.76%	1585265	1530255	-3.47%	217	200	-7.83%
Free State	924448	895221	-3.16%	584044	563549	-3.51%	211	195	-7.58%
Eastern Cape	1050895	1016798	-3.24%	889929	857548	-3.64%	196	180	-8.16%
KwaZulu-Natal	152274	147015	-3.45%	204434	197131	-3.57%	203	187	-7.88%
Mpumalanga	296189	286128	-3.40%	141310	136316	-3.53%	206	190	-7.77%
Limpopo	25328	24492	-3.30%	22435	21644	-3.53%	207	191	-7.73%
Gauteng	16638	16089	-3.30%	237639	229435	-3.45%	217	201	-7.37%
North West	106514	103169	-3.14%	145736	140706	-3.45%	218	202	-7.34%
Total	4280745	4136968	-3.36%	5108514	4933935	-3.42%	212	196	-7.61%
Deviation	-143777			-174579			-16		

The impact of the total removal of tariffs on the pork sub-sector is shown in Table 5.27. According to the results, pork supply will decline by 7.22% or 9 289 ton, while demand will increase by 20.25% or 28 262 ton. Prices of pork will decline by 17.32% or R1.80

per kg on the average. The largest decline in prices will occur in the Western Cape, while the smallest decline will occur in Gauteng.

Table 5.27: The impact of the removal of all tariffs on the pork industry

Region	Pork supply (ton)			Pork demand (ton)			Pork price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	20069	18615	-7.25%	25251	30494	20.76%	10.38	8.54	-17.73%
Northern Cape	1553	1436	-7.53%	4222	5071	20.11%	10.49	8.69	-17.16%
Free State	9470	8765	-7.44%	10334	12419	20.18%	10.46	8.66	-17.21%
Eastern Cape	9200	8473	-7.90%	13739	16586	20.72%	10.40	8.56	-17.69%
KwaZulu-Natal	22348	20763	-7.09%	18570	22312	20.15%	10.31	8.54	-17.17%
Mpumalanga	4237	3908	-7.76%	12197	14699	20.51%	10.51	8.67	-17.51%
Limpopo	8050	7423	-7.79%	4938	5961	20.72%	10.40	8.56	-17.69%
Gauteng	45466	42321	-6.92%	41937	50228	19.77%	10.40	8.65	-16.83%
North West	8274	7674	-7.25%	8388	10068	20.03%	10.46	8.67	-17.11%
Total	128667	119378	-7.22%	139576	167838	20.25%	10.42	8.62	-17.32%
Deviation	-9289			28262			-1.80		

In the pig sub sector, the total removal of tariffs will result in a reduction of 6.15% or 131 985 in pigs supplied in South Africa. The number of animals slaughtered will drop by 6.15% or 131 986. The producer price of pigs will drop by 15.95% or R55 per head. Northern Cape and Eastern Cape will experience the largest fall in producer prices.

Table 5.28: The impact of the removal of all tariffs on the pig industry

Region	Pig supply (number)			Pig demand (number)			Producer price(R/head)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	334475	313888	-6.16%	334475	313888	-6.16%	364	306	-15.93%
Northern Cape	29666	27363	-7.76%	25883	24222	-6.42%	331	276	-16.62%
Free State	250451	234284	-6.46%	157838	147792	-6.36%	339	284	-16.22%
Eastern Cape	159419	150318	-5.71%	153328	142921	-6.79%	326	271	-16.87%
KwaZulu-Natal	331256	311414	-5.99%	372461	349947	-6.04%	365	310	-15.07%
Mpumalanga	296974	278643	-6.17%	70614	65909	-6.66%	336	282	-16.07%
Limpopo	182505	171018	-6.29%	134162	125189	-6.69%	339	284	-16.22%
Gauteng	296355	278550	-6.01%	757763	713205	-5.88%	364	309	-15.11%
North West	263320	246958	-6.21%	137897	129362	-6.19%	352	297	-15.63%
Total	2144421	2012436	-6.15%	2144421	2012435	-6.15%	346	291	-15.95%
Deviation	-131985			-131986			-55		

The impact of total removal of tariffs on the poultry meat sub-sector is reported in Table 5.29. The results show that the total demand will increase by 54.64% or 465 315 ton,

while supply will reduce by 7.12% or 60 634 tons. Prices will drop by an average of 26.39% or R3.14 per kg. KwaZulu-Natal and Western Cape will experience the largest decline in prices.

Table 5.29: The impact of the removal of all tariffs on the poultry meat industry

Region	Poultry meat supply (ton)			Poultry meat demand (ton)			Poultry meat price (R/kg)		
	Base run	Scenario	Change	Base run	Scenario	Change	Base run	Scenario	Change
Western Cape	75568	72288	-4.34%	80543	122345	51.90%	11.82	8.68	-26.57%
Northern Cape	15930	14484	-9.08%	16978	23661	39.36%	11.97	8.82	-26.32%
Free State	52110	48837	-6.28%	55541	82128	47.87%	11.94	8.79	-26.38%
Eastern Cape	123124	111895	-9.12%	131230	197987	50.87%	11.84	8.7	-26.52%
KwaZulu-Natal	166838	151756	-9.04%	177822	287005	61.40%	11.82	8.68	-26.57%
Mpumalanga	55258	52097	-5.72%	58896	95135	61.53%	11.95	8.81	-26.28%
Limpopo	96762	88982	-8.04%	103132	162299	57.37%	11.98	8.84	-26.21%
Gauteng	147324	139310	-5.44%	157023	240292	53.03%	11.93	8.78	-26.40%
North West	66086	62511	-5.41%	70437	105937	50.40%	11.95	8.81	-26.28%
Total	851602	790968	-7.12%	851602	1316917	54.64%	11.91	8.77	-26.39%
Deviation	-60634			465315			-3.14		

5.2.3 Model specification for welfare measurement

The traditional measurement of welfare uses the consumer and producer surplus concepts. The consumer welfare (CS) measures the difference between what consumers are willing to pay for a good and what he/she has to pay. Moreover, it can be used to measure the effect on the consumer's welfare of a change in price of a good, *ceteris paribus*. Producer's surplus (PS), on the other hand, measures the effect on the producer's welfare of a change in price of a good, *ceteris paribus*.

In addition, and following Britz (2003), this modelling framework uses the equivalent variation to integrate a well-behaved demand system to welfare analysis, as an extension of the Takayama-Judge type spatial equilibrium models. This is presented mathematically as:

$$\begin{aligned}
 & + \sum_r Pop_r Equ\ var_r \\
 & - \sum_i^r QS_i^r \left(as_i^r + \frac{1}{2} \sum_j bs_{i,j}^r - QS_j^r \right) \\
 \text{Equ (5.16)} \quad & - \sum_i^r QC_i^r \left(ac_i^r + \frac{1}{2} \sum_j bc_{i,j}^r QC_j^r \right) \\
 & - \sum_{r,i}^{r'} x_{r,i}^{r'} imprprice_{r,i}^{r'} - \sum_{r,i}^{r'} x_{r,i}^{r'} t_{r,i}^{r'}
 \end{aligned}$$

s.t.

$$(a) QS_i^r + QC_i^r + \sum_{r'} x_{r,i}^{r'} = QD_i^r + \sum_{r'} x_{r,i}^{r'}$$

$$(b) PP_i^r = as_i^r + \sum_j bs_{i,j}^r * QS_j^r$$

$$(c) PP_{is}^r + PD_{ip}^r = ac_{is}^r + \sum_j bc_{i,j}^r . QS_j^r + \sum_{ip} PD_{ip}^r / p_to_f_{ip}^{is}$$

$$(d) QD_i^r = PerCap_i^r Pop_r$$

$$(e) PerCap_i^r = d_i^r + \left(\frac{\sum_j B_{i,j}^r \sqrt{\frac{PD_j^r}{PD_i^r}}}{\sum_j \sum_k B_{j,k}^r \sqrt{PD_j^r PD_k^r}} \right) \left(Valuesum - \sum_i D_i^r PD_i^r \right)$$

$$\begin{aligned}
 (f) EquVar_r = & \left(\frac{\sum_j \sum_k B_{j,k}^r \sqrt{PD_{r,j}^b PD_{r,k}^b}}{\sum_j \sum_k B_{j,k}^r \sqrt{PD_{r,j} PP_{r,k}}} \right) \left(Valuesum - \sum_i D_i^r PD_i^r \right) \\
 & - \left(Valuesum - \sum_i D_i^r PD_{r,i}^b \right)
 \end{aligned}$$

where:

Pop_r = population by province

$PerCap_i^r$ = per capita demand per commodity per province

$EquVar_r$ = Equivalent variation in by province

The objective function comprises the sum of revenues plus equivalent variation (first line), minus production costs as the integral under the marginal cost function (second line), minus slaughtering costs and profits as the integral under the marginal variable cost function of the slaughter houses (third line), minus imports and transport costs.

The equivalent variation measures the per capita income change necessary to reach at simulated prices the same utility level as at original prices. For a decrease in one of the prices, it is always positive and greater than savings in expenditure for that product at fixed demand quantities, at least for a well-behaved demand system.

Constraint (a) is the market clearing identity, and equations (b) to (d) state that marginal willingness to pay respective marginal costs are equal to prices. Equation (c) states that the prices for meat are equal to the marginal costs to operate the slaughterhouses plus the price of the slaughtered animal per ton of meat produced.

It can be easily checked that the derivative of the objective function for the quantity variables (meat, supply, slaughter) returns the prices comprised in constraints (b) to (d).

5.2.3.1 Welfare measurement

The welfare implication of changes in prices due to the four scenarios was measured using the CS and PS measures as well as equivalent variation as a money-metric measure of consumer welfare compared to the base situation. For a demand system which satisfies the micro-economic conditions, a decrease in one of the prices should result in a positive value, and greater than savings in expenditure at fixed demand quantities.

- CS and PS measures

In terms of scenario 1, Table 5.30 shows that consumers will experience welfare gains of R230.8 million. This translates into a 0.04% increase in real gross national income or 0.06% increase in real disposable income. Table 5.30 also shows that producers' welfare

will drop by a total of R77.6 million. The loss in producers' welfare will be more pronounced in KwaZulu-Natal, Eastern Cape and the Free State – the three provinces that contribute the largest share of South Africa's total livestock production (NDA, 2004). Relative to the real gross farm income, the total loss in producer welfare is 0.24 per cent, while it represents 0.96% of real net farm income.

Table 5.30: Change in welfare as a result of an expansion in the quota (scenario 1)

Region	Consumer surplus	Producer surplus
	Total monetary change (Million rand)	
Western Cape	36.0	-5.8
Northern Cape	5.4	-4.6
Free State	13.9	-13.6
Eastern Cape	24.5	-12.5
Kwazulu-Natal	35.9	-13.8
Mpumalanga	17.2	-9.2
Limpopo	30.9	-6.1
Gauteng	54.9	-3.3
North West	12.1	-8.7
South Africa	230.8	-77.6

According to Table 5.31, the welfare implications of a 33% reduction in MFN tariff amounts to an increase in consumer welfare of R592.1 million, while producers welfare will decline by R220.1 million. The welfare change to consumers amounts to only a 0.10% increase in real gross national income or a 0.16% increase in real disposable income. As a percentage of the real gross farm income, the total loss in producer welfare is 0.69 per cent, while it represents 2.7% of real net farm income.

The results obtained for scenarios 1 and 2 have quite important policy implications, especially over the short to medium run if one considers the positive impact on consumer welfare compared with the relatively large impact on producer welfare combined with the status and potential welfare creation capabilities of this industry. On the one hand, consumers could benefit from cheaper meat, but one also has to take cognizance of the potential impact on the livestock industry since this sub-sector is vitally important to the rural economy of South Africa, and hence the economy as a whole. A potential recommendation based on the relative difference between the

impacts of these two scenarios therefore, is that further liberalization if considered in the South African livestock industry should first be implemented by expanding the existing quota rather than reducing tariffs.

Table 5.31: Change in welfare as a result of a reduction in MFN tariff

Region	Consumer surplus	Producer surplus
	Total monetary change (Million rand)	
Western Cape	92.7	-16.0
Northern Cape	16.4	-13.3
Free State	42.5	-38.7
Eastern Cape	66.4	-35.6
Kwazulu-Natal	98.2	-39.4
Mpumalanga	56.0	-25.3
Limpopo	25.0	-17.0
Gauteng	159.4	-8.9
North West	35.5	-25.9
South Africa	592.1	-220.1

A combination of scenarios 1 and 2 will result in a welfare gain to consumers amounting to R753.6 million; while the total loss to producers' will be R277.9 million (see Table 5.32). The total welfare gain to consumers' amounts to a 0.13% increase in real gross national income or 0.20% increase in real disposable income. Welfare loss to producers translates into a drop of 0.87% in real gross farm income or 3.4% in real net farm income.

Table 5.32: Change in welfare as a result of a combined expansion of quota and reduction in MFN tariff

Region	Consumer surplus	Producer surplus
	Total monetary change (Million rand)	
Western Cape	118.0	-20.0
Northern Cape	21.0	-16.9
Free State	54.5	-48.9
Eastern Cape	83.8	-45.2
Kwazulu-Natal	124.3	-49.6
Mpumalanga	72.1	-31.9
Limpopo	29.8	-21.4
Gauteng	204.6	-11.3
North West	45.5	-32.7
South Africa	753.6	-277.9

Table 5.33 shows the welfare implications of a complete removal of tariffs on both the producers and the consumers. In total, consumers will have a welfare increase of R1 880.8 million. This amounts to only a 0.33% increase in real gross national income or a 0.50% increase in real disposable income. On the producers side welfare will drop by a total of R656.89 million. This represents a drop of 2.05 per cent in real gross farm income or 8.1% in net farm income.

Table 5.33: Change in welfare as a result of a complete removal of tariff

Region	Consumer surplus	Producer surplus
	Total monetary change (Million rand)	
Western Cape	292.6	-46.9
Northern Cape	52.5	-39.8
Free State	134.6	-115.4
Eastern Cape	204.2	-106.4
Kwazulu-Natal	303.1	-117.6
Mpumalanga	183.7	-75.79
Limpopo	79.4	-50.9
Gauteng	516.3	-26.7
North West	114.4	-77.4
South Africa	1880.8	-656.89

Evidently, the complete removal of tariffs will result in net welfare gains to the society, but the impact on the agricultural sector would be much more substantial in relative terms.

Cognisance should be taken that CS and PS estimations assume quasi-linearity of the demand and supply curves, whereas the model used in this study accounts for the non-linearity of demand and supply curves. Hence, the CS and PS estimates could be an over-estimation of the welfare impacts. For this reason welfare was also estimated with the equivalent variation.

- Equivalent variation

Equivalent variation defines the minimum (maximum) amount of money which would have to be given to (taken away from) an individual to make them as well off as they would have been after the price fall (rise).

Table 5.34 shows the equivalent variation due to potential policy changes expressed by the four scenarios. In respect of scenario 1, it will require R60.6 million to make consumers as well off as they would have been after the price fall. Consumers in the Western Cape, Gauteng, Northern Cape and Mpumalanga require the largest change in income. Expressed as a percentage of real gross national income it translates into 0.01 per cent change or 0.02% change in real disposable income under this scenario.

Table 5.34: Equivalent variation as a result of the four trade liberalization scenarios

Region	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Total monetary change (Million rand)			
Western Cape	9.4	25.0	35.5	73.2
Northern Cape	8.5	22.5	28.2	65.4
Free State	7.1	18.8	23.6	54.9
Eastern Cape	5.1	13.4	16.8	39.0
Kwazulu-Natal	5.5	14.5	18.2	42.3
Mpumalanga	8.4	22.3	28.0	65.2
Limpopo	2.5	6.6	8.3	19.4
Gauteng	8.8	23.3	29.3	68.0
North West	5.3	14.0	17.6	40.8
South Africa	60.6	160.4	205.5	468.2

In terms of scenario 2 consumers will require an income increase of R160.4 million to make them as well off as they would have been after the price fall. In relative terms, the equivalent variation represents a change of 0.03% in the real gross national income or 0.04% in real disposable income.

The equivalent variation due to the combined effect of quota expansion and the reduction of ad valorem MFN tariff (scenario 3) amounts to R205.5 million. Consumers in the Western Cape will be the most affected and consumers in Limpopo the least affected. In relative terms, the equivalent variation represents a change of 0.04% in the real gross national income, or 0.05% in real disposable income under this scenario.

In a scenario of full liberalisation income would have to rise by R462.8 million to make consumers as well off as they would have been after the price fall. In relative terms, the

equivalent variation represents a change of 0.08% in the real gross national income, or 0.12% in real disposable income.

5.3 Conclusion

In this chapter the model discussed in chapter 4 was applied by simulating the effects of four TRQ liberalization scenarios on the demand, supply and prices of livestock products in South Africa. The welfare effects were also measured, first by using the more traditional consumer and producer surplus measurements and then by the equivalent variation method.

In order to make well-informed policy decisions that balance the interests of both consumers as well as producers, it was necessary to investigate the relative effects of these scenarios on consumers and producers. Taking this into consideration, the gains to consumers were related to the real gross national income and the real disposable income while producers' losses were related changes in the real gross farm income and real net farm income. In the case of further liberalization of the South African livestock industry, policy makers should first consider expanding the existing quotas rather than reducing tariffs. This is even more so if one considers the fact that the rural economy of South Africa (e.g. the livestock sector) has a GDP multiplier of 1.53 (Mullins, 2004). In effect, a one rand drop in the production of livestock will result in a R1.53 drop in the GDP of South Africa.

One could relax the assumption of comparative static analysis (that producers react to a price drop by cutting down on production) used in this study and argue that a reduction in prices due to further liberalization would induce increased productivity, i.e. a move of the supply curve outward. This would mean an increase in the producer surplus for those producers that remain in the industry (i.e. those who have been able to increase productivity) rather than exit due to lower prices. However, the question that arises is that how much productivity can be increased, given the available natural resources, volatility in input prices (especially maize) and the dependency and interaction of the

livestock sector with related agricultural sub-sectors. In many areas in South Africa, at least as far as the commercial sector is concerned, only a marginal level of productivity increase would be possible (for instance, the calving percentage in this sector is between 80 and 90 per cent while off-take rate is approximately 25 per cent). In addition, in many areas livestock farming is the only viable agricultural enterprise, whilst it also provides some form of security (reduces overall risk of mixed farming enterprises).

In terms of the emerging commercial sector, large productivity improvements can be made and should be made. Currently off-take rates are between 5 and 10 per cent while calving percentage is approximately 30 per cent. Should this sector be able to achieve the productivity level of the commercial sector, one could expect significant increases in supply. However, significant changes to the extent mentioned are not likely over the short to medium run due to impediments inherent in this sub-sector. Therefore it will take considerable time to effect an appreciable level of change in productivity due to issues such as training, infrastructure impediments, the current composition of the emerging commercial sector herds, etc. In addition, and as earlier alluded to, not all producers will be able to make the necessary changes, causing some to exit the industry to be replaced by other/new producers. The extent and the ability of the producers to act will also be determined by the value of the marginal product in relation to input prices, i.e. trends in input prices are upward and volatile, whilst end product prices will be further forced down. This raises the question of what gap producers have left to absorb lower prices even if productivity increases.

This issue however falls beyond the scope of this study and needs to be further researched. Given the absence of concrete evidence on the ability of producers to absorb lower prices through increased productivity, policy makers need to adopt the second best option. Incorrect decisions in terms of trade policy could seriously damage the livestock industry with marginal benefits to consumers. In addition, it will impede on presidential imperatives on lowering poverty and establishing a vibrant rural economy.

SUMMARY AND RECOMMENDATIONS

6.1 Introduction

The focus of this study was to model TRQs with the aim of measuring their impact on the livestock industry in South Africa. The study involved a literature survey which aimed at a better understanding of the functioning of TRQs. It further identified two major approaches to modelling TRQs from empirical literature and applied the one which better suits the modelling framework to be used. Moreover, due to the fact that the objective function of the present model is of the quadratic functional form, it does not solve for the first order condition of an optimum. Therefore a representation which is compatible, i.e. the sigmoid approximation function, was used for the representation of TRQs. In addition two different concepts of welfare measurement were employed.

The model, which was set up in the General Algebraic Modelling System (GAMS), is further strengthened by the specification of a generalized Leontief demand system which was calibrated in line with micro-economic theory. The next section of this chapter discusses the implications of the results generated from this study. The last section provides policy recommendations on the application and liberalization of TRQs in the South African livestock industry.

6.2 Summary of findings of the study

6.2.1 South Africa's meat trade

The study employed Lorenz curves and GINI-coefficients to measure the concentration in meat imports by South Africa. The imports of meat products by South Africa are highly concentrated for beef, sheep meat, pork and poultry. Over 80 per cent of South Africa's imports of beef in 2003 originated from Brazil and Argentina. Sheep meat imports mainly originated from Australia in 2003; it accounted for approximately 80 per cent of South Africa's imports of this product. In the case of pork, three countries, namely Brazil, France and Belgium, supplied about 80 per cent of South Africa's imports in 2003. For poultry, Brazil supplied 76 per cent of South Africa's imports in 2003.

Intra-industrial trade was measured with the intra-industrial trade coefficient (IIT). The results revealed a relatively high IIT for beef since 1994. The IIT for pork shows a declining trend since 1992, while sheep meat maintained a low IIT over the whole period. Poultry has a low, but fluctuating IIT.

Trade statistics since 1994 show that the increase in import demand for agricultural commodities and products in South Africa is unevenly distributed among sub-sectors and product groups. Therefore, the challenge of monitoring the impact of import demand *viz a viz* trade policy would prove more rewarding if conducted on a sub-sector level.

6.2.2 The use of TRQs in South Africa's meat trade

After the liberalization of the agricultural sector and phasing out of protection mechanisms South Africa introduced a process of tariff reform in compliance with WTO regulations. Furthermore, a system of TRQs was introduced in compliance with WTO regulations; this is achieved by imposing a lower in-quota tariff to imports within

the quota limit imposed, while imports above this level attract a higher tariff (in meat trade, the applied tariff represents the over-quota tariff rate).

Of all imports of meat products in South Africa in 2003 (which is worth about R1.01 billion), TRQs were used to administer 35 per cent (worth about R0.36 billion). At a product-specific level, TRQs opened for bovine meat covered a greater value of trade than those of the other products. The value of TRQ imports of the meat and edible offal of poultry followed while sheep meat carries the lowest value. However, as a percentage of total imports, TRQs applicable to sheep meat followed those of bovine meat, ahead of swine meat and meat and edible offal of poultry, respectively. All meat products, except bovine meat have a fill rate of 100%. Overall, the average quota fill rates expressed in value terms was 94%.

6.2.3 The impact of tariff and TRQ liberalization

The different scenarios examined in this study include:

- Scenario 1: A 33% expansion of quota
- Scenario 2: A 33% decrease in MFN ad valorem tariff.
- Scenario 3: A scenario combining the two reforms described above.
- Scenario 4: Full liberalization scenario with all tariffs set to zero.

Using the SPE model it was estimated that border prices for the mentioned products will declined by between 0.89 and 2.39 per cent for scenario one, 2.35 and 7.96 per cent for scenario two, 2.96 and 9.97 per cent for scenario three and 8.25 and 25.19 per cent for scenario four. Using a price transmission elasticity of unity between the border and domestic markets, the impact of tariff and TRQ liberalization on the domestic markets was simulated.

The main findings per scenario can be summarized as follows:

- **Scenario 1: A 33% expansion of quota**

- Beef: Total beef supply in South Africa will reduce by 0.62%, while demand will increase by 1.9%. Beef prices will on average drop by 2.08%.
- Cattle: Total cattle supply and demand in South Africa will reduce by 0.46% and 0.52%, respectively. Cattle prices will on average drop by 1.46%.
- Sheep-meat: Total sheep meat supply in South Africa will reduce by 0.50%, while demand will increase by 1.99%. Sheep meat prices will on average drop by 2.36%.
- Sheep: Total sheep supply and demand in South Africa will reduce by 0.42% and 0.45%, respectively. Sheep prices will on average drop by 0.94%.
- Pork: Total pork supply in South Africa will reduce by 0.92%, while demand will increase by 2.57%. Pork prices will on average drop by 2.12%.
- Pigs: Total pig supply and demand in South Africa will reduce by 0.78% and 0.78%, respectively. Pig prices will on average drop by 2.02%.
- Poultry: Total poultry supply in South Africa will reduce by 0.92%, while demand will increase by 7.06%. Poultry prices will on average drop by 3.41%.

- **Scenario 2: A 33% decrease in MFN ad valorem tariff**

- Beef: Total beef supply in South Africa will reduce by 1.83%, while demand will increase by 5.56%. Beef prices will on average drop by 0.81%.

- Cattle: Total cattle supply and demand in South Africa will reduce by 1.33% and 1.52%, respectively. Cattle prices will on average drop by 4.38%.
 - Sheep-meat: Total sheep meat supply in South Africa will reduce by 1.27%, while demand will increase by 5.14%. Sheep meat prices will on average drop by 6.13%.
 - Sheep: Total sheep supply and demand in South Africa will reduce by 1.11% and 1.15%, respectively. Sheep prices will on average drop by 2.52%.
 - Pork: Total pork supply in South Africa will reduce by 2.73%, while demand will increase by 6.69%. Pork prices will on average drop by 5.75%.
 - Pigs: Total pig supply and demand in South Africa will reduce by 2.02% and 2.02%, respectively. Pig prices will on average drop by 5.23%.
 - Poultry: Total poultry supply in South Africa will reduce by 2.38%, while demand will increase by 18.05%. Poultry prices will on average drop by 9.05%.
- **Scenario 3: A scenario combining scenarios 1 and 2**
- Beef: Total beef supply in South Africa will reduce by 2.3%, while demand will increase by 6.93%. Beef prices will on average drop by 8.04%.
 - Cattle: Total cattle supply and demand in South Africa will reduce by 1.75% and 1.90%, respectively. Cattle prices will on average drop by 5.52%.
 - Sheep-meat: Total sheep-meat supply in South Africa will reduce by 1.60%, while demand will increase by 6.49%. Sheep-meat prices will on average drop by 7.72%.

- Sheep: Total sheep supply and demand in South Africa will reduce by 1.41% and 1.45%, respectively. Sheep prices will on average drop by 3.31%.
- Pork: Total pork supply in South Africa will reduce by 3.02%, while demand will increase by 8.48%. Pork prices will on average drop by 7.30%.
- Pigs: Total pig supply and demand in South Africa will reduce by 2.57% and 2.57%, respectively. Pig prices will on average drop by 6.68%.
- Poultry: Total poultry supply in South Africa will reduce by 3.06%, while demand will increase by 23.45%. Poultry prices will on average drop by 11.33%.

- **Scenario 4: Full liberalization scenario with all tariffs set to zero.**

- Beef: Total beef supply in South Africa will reduce by 5.54%, while demand will increase by 16.84%. Beef prices will on average drop by 19.34%.
- Cattle: Total cattle supply and demand in South Africa will reduce by 4.19% and 4.6%, respectively. Cattle prices will on average drop by 13.27%.
- Sheep-meat: Total sheep-meat supply in South Africa will reduce by 3.77%, while demand will increase by 15.27%. Sheep-meat prices will on average drop by 18.05%.
- Sheep: Total sheep supply and demand in South Africa will reduce by 3.36% and 3.42%, respectively. Sheep prices will on average drop by 7.61%.
- Pork: Total pork supply in South Africa will reduce by 7.22%, while demand will increase by 20.25%. Pork prices will on average drop by 17.32%.

- Pigs: Total pig supply and demand in South Africa will reduce by 6.15% and 6.15%, respectively. Pig prices will on average drop by 15.95%.
- Poultry: Total poultry supply in South Africa will reduce by 7.12%, while demand will increase by 54.64%. Poultry prices will on average drop by 26.39%.

6.2.4 Welfare measurements

The study used the consumer and producers surplus concepts, as well as the equivalent variation concept to measure the impact on welfare of potential trade policy changes mentioned.

The consumer and producer surplus measures revealed, as *a priori* expected, that a more liberalized trade regime for meat will result in net welfare benefits for South Africa. An expansion of the current quotas by 33% would result in an increase in consumer welfare by R230.8 million. This is equivalent to a 0.04% increase in real gross national income or 0.06% increase in real disposable income. Producers' welfare will drop by a total of R77.6 million. Relative to the real gross farm income, the total loss in producer welfare is 0.24 per cent, while it represents 0.96% of real net farm income.

A reduction of 33% in the MFN ad valorem tariffs would increase consumer welfare by R592.1 million, while producers' welfare will decline by R220.1 million. The total increase in consumers' welfare amounts to only a 0.10% increase in real gross national income or a 0.16% increase in real disposable income. As a percentage of the real gross farm income, the total loss in producer welfare is 0.69 per cent, while it represents 2.7% of real net farm income.

A combination of scenarios 1 and 2 will result in a welfare gain to consumers amounting to R753.6 million, while the total loss to producers will be R277.9 million.

Total welfare gain to consumers amounts to a 0.13% increase in real gross national income or 0.20% increase in real disposable income. Welfare losses by producers translate into a drop of 0.87% in real gross farm income or 3.4% in real net farm income.

A complete removal of tariffs will increase consumers' welfare by R1 880.8 million. This amounts to only a 0.33% increase in real gross national income or a 0.50% increase in real disposable income. On the producers' side, welfare will drop by a total of R656.89 million. This represents a drop of 2.05 per cent in real gross farm income or 8.1% in net farm income.

The equivalent variation concept revealed much more moderate changes to consumer well being. The reason for this is that consumer and producer surplus estimations assume linearity of the demand and supply curves, whereas the model used in this study accounts for the non-linearity of demand and supply curves, hence, the over-estimation of the welfare impacts. Consumer and producers surplus estimates nevertheless provide useful insight into the relative impact of trade policy changes.

6.3 Policy recommendations

- The high level of concentration of South Africa's imports of meat products has important implications to the administration of tariff rate quotas applicable to the livestock sector. The allocation of quotas to importing countries must be competitive and market-based; however, the level of support afforded to such countries must be taken into consideration. Therefore further trade liberalization should allocate more quotas to highly competitive but less subsidized exporting countries. In this regard, "mixed allocation methods" of quota administration suitable to each product must be used in order to cater for imbalances introduced by highly subsidized countries; this requires knowledge of and expertise in TRQ administration.

- As a result of increased trade liberalisation producer prices of cattle and sheep will on average show the largest declines in the coastal regions of South Africa. This is noteworthy since in the Eastern Cape and KwaZulu-Natal cattle and sheep numbers in the hands of emerging producers is more than that of the established commercial farmers. Given the prominence of this sector in respect of achieving government's development and poverty reduction objectives as highlighted in, amongst others, the Integrated Sustainable Rural Development Strategy careful consideration should be given to the measures used to liberalise meat trade, if further liberalisation is considered at all given the results of this study.

The results obtained for scenarios 1 and 2 have quite important policy implications, especially over the short to medium run, and if one takes into account the level of support afforded to, for example OECD countries. On the one hand, consumers could benefit from cheaper meat, but one also has to take cognizance of the potential impact on producers of livestock (as stated this sub-sector are vitally important). A potential recommendation based on the relative difference between the impacts of these two scenarios is that TRQ liberalization (if considered necessary) in the South African livestock industry should first be implemented by expanding the existing quota rather than reducing tariffs. Although, it could be argued that price reduction due to trade liberalization would induce increased productivity, the state of the livestock industry in South Africa does not support this argument over the short to medium run. Also, proving this hypothesis falls beyond the scope of this study.

6.4 Recommendations for further studies

Further research on the following aspects is necessary:

- **Products differentiated by place of origin:** The model assumes perfect substitution (homogeneity) between domestic and imported goods. The model can be improved by differentiating commodities and products (i.e. assume imperfect substitution) based on the Armington assumption. This would further strengthen the

analytical capacity of the model in that it would allow further disaggregating of products based on the HS classification. It will also allow for the handling of bilateral trade flows.

- **Expansion of current modelling framework to include additional products:** The linkages among commodities are mainly explored through the cross-price elasticity effects in multi-commodity models. Considering the linkage between the animal feed sector and the livestock industry, further developments to the modelling framework should explore the effects of changes in the feed sector on the livestock industry and vice-versa.
- **Sub-sector modelling of the current and additional products:** the current model takes a sectoral approach. Further insights could be gained if modelling is done at sub-sector level, in which case products are further disaggregated. However, the challenge associated with the use of this approach is largely that of insufficient data.
- **Explicit modelling of TRQ:** The present model allows for measuring the price, demand and supply impacts of TRQs on the domestic market. However, there are yet other aspects of this instrument not yet explored. The creation of rents and its distribution entail an effective administration method for TRQs. In South Africa however, this is not yet in place; whereas revenues from TRQ can serve as incentive for development as was practiced in Korea (Choi & Summer, 2000).

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