

**A GRAVITY APPROACH TO THE DETERMINANTS OF  
INTERNATIONAL BOVINE MEAT TRADE**

by

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Submitted

in partial fulfilment of the requirements

for the degree

MCom Agricultural Economics

FACULTY OF ECONOMIC AND MANAGEMENT SCIENCES

UNIVERSITY OF PRETORIA

Date of submission:

2013-08-26

## ACKNOWLEDGEMENTS

This research would not have been possible without the support and guidance of several individuals. Firstly, I wish to express my utmost gratitude to Dr. Ferdi Meyer<sup>1</sup> for his excellent guidance, supervision and for providing me with all the necessary opportunities to complete this study. I also want to thank Prof. André Jooste<sup>2</sup> for his support and guidance throughout this research.

My appreciation is also extended to Dr. Claus Deblitz<sup>3</sup> for his assistance with data from the UNCOMTRADE and Agribenchmark databases, as well as for sharing his extensive knowledge on international beef markets. To Ronald Ramabulana<sup>2</sup> and Bonani Nyhodo<sup>2</sup> goes my deepest appreciation for their encouragement, insights and providing me with time to work on this research during my employment at the National Agricultural Marketing Council (NAMC). I would also like to extend my gratitude to my dear friend Jonathan Vosloo for his assistance during the creation of the database that was used during this study. Much appreciation also goes to Rika Verwey<sup>2</sup> for her assistance and insights into many of the complex statistical issues faced during this study.

To my parents Nick and Tokkie, I wish to thank them for their love and support throughout my studies, the sacrifices that they made to allow me to attend university and for instilling in me the qualities that enabled me to complete this research. Lastly, I wish to thank God for all His blessings, to Him be all the praise.

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August 2013

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## ABSTRACT

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**Degree:** MCom Agricultural Economics

**Department:** Agricultural Economics, Extension and Rural Development

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Due to the complexity and dynamism of the global beef market, policymakers need a theoretically consistent, rigorous and quantitative analysis to validate and quantify the effects of different factors that are believed to drive beef trade. The general objective of this dissertation was to validate and quantify the factors that drive and influence international beef trade in order to facilitate and improve the decision-making behaviour of policymakers. The gravity model methodology was identified as the ideal framework to address the general objective of this dissertation, and was used as the primary tool to analyse the factors that drive and influence beef trade. The specific objectives were to gain an understanding of prominent issues that influence international beef trade, to review the gravity modelling methodology and to model the effects of various issues on the volume of beef trade based on trade data among leading importers and exporters between 1996 and 2010.

A model was estimated using two separate equations, referred to as Model B1 and Model B2. For each of these equations the dependant variable varied to represent: bovine cuts boneless, fresh or chilled (HS 020130); bovine cuts boneless, frozen (HS 020230); and an aggregation of these two products designated as "Total beef". Model B1 was estimated with the full gravity model specification, including export prices  $p_{ijt}$ . Since very few studies on commodity specific gravity models exist and have never modelled beef exports prices directly, it was decided to run an additional model, Model B2, without the export price variable  $p_{ijt}$ . The Wald Chi-square test confirmed that the variables included in the model were significant in explaining the variation in the volume of exports. Issues that were included in the specification included beef production in a beef exporter, beef consumption in a beef importer, tariff measures applied by importing countries, income per capita of consumers in importing countries, export prices and trade bans due to animal diseases.

The coefficients of individual variables estimated were found to be plausible while the signs of the coefficients indicated the expected relationships between the volume of beef trade and each of the individual issues. After comparing the two models it was found that the price variable exhibited statistically significant and plausible results, and did not affect the estimates of the other variables. A comparison with similar studies revealed that the model developed in this dissertation estimated similar results in some areas, and even more plausible results in others. When all of the statistical tests and validation criteria are taken into account, the gravity model developed in this dissertation was successful in validating and quantifying the factors that drive and influence international beef trade.

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# CHAPTER 1

## INTRODUCTION

### 1.1 BACKGROUND

Since its inception in the early 1960s, the gravity model became the workhorse of the applied international trade literature. Gravity models are econometric models of trade which acquire their name from their similarity to the Newtonian theory of gravitation. Newton's law states that the force of gravity between two bodies is directly related to the mass of the attracting bodies and inversely related to the square of the distance between them. Gravity models were initially developed on an empirical basis, and emphasized the role of country size and the geographical distance between countries as sufficient predictors of trade. These models have proven to be empirically successful in explaining trade flows and are accepted by both international researchers and policymakers (see Tinbergen, 1962; Pöynönen, 1963; Anderson, 1979; Bergstrand, 1985; Anderson & Van Wincoop, 2003, Feenstra, 2004). The successes of these models lead Leamer and Levinsohn (1995) to argue that the gravity model has produced “some of the clearest and most robust findings in empirical economics”.

Unlike traditional gravity models that model aggregate trade of all goods between two countries as the dependent variable, a commodity specific gravity model focuses only on trade flows of one specific commodity. This allows the researcher to incorporate variables in the gravity model that are unique to trade flows of a specific commodity, such as beef. For example, issues that are thought to play a significant role in global beef trade include beef production in a beef exporter, beef consumption in a beef importer, tariff measures applied by importing countries, income per capita of consumers in importing countries, export prices and animal diseases. Gravity models provide

policymakers with a theoretically consistent, rigorous and quantitative method of evaluating how these different factors influence trade. This information is especially relevant to policymakers in countries that value the trade in beef and can in turn help improve decision-making during the formulation of domestic- and trade policies to stimulate trade in these products.

Recent efforts to improve the gravity modelling methodology have identified three areas of concern regarding how modern gravity models are estimated. The first area relates to how the data is treated and the subsequent statistical implications that these have on the estimation results. For example the omission of “multilateral resistance terms” (MRT’s), using the average of imports and exports as the dependant variable or the deflation of trade data using price indices will lead to estimation results being biased. A second area of concern is the log-linearization of the gravity model and the inability of regularly used regression techniques to provide unbiased, efficient and consistent results (see Haworth & Vincent, 1979; Flowerdew & Aitken, 1982; Santos Silva & Tenreyro, 2006). The third area is related to the fact that the traditional specification of gravity model used in trade-flow analysis cannot process zero-valued trade flows. In data considering only a single commodity, such as beef, zero- valued trade flows are common since not all countries possess the same ability to produce or demand a single commodity. Therefore when investigating bovine meat trade flows, zero-trade flows and how they are dealt with is an important consideration. To produce policy research that is credible and robust, it is necessary to take full account of these changes when undertaking research using the gravity model.

Fortunately the methodology used in gravity modelling has received numerous improvements during the past decade, addressing the above mentioned issues and making results obtained from these models even more robust. By combining the understanding gained from an overview of the global beef market in Chapter 2 and the recent advances in gravity modelling methodology discussed in Chapter 3, this study will develop a gravity model to analyse the factors that influence the bilateral trade of beef.

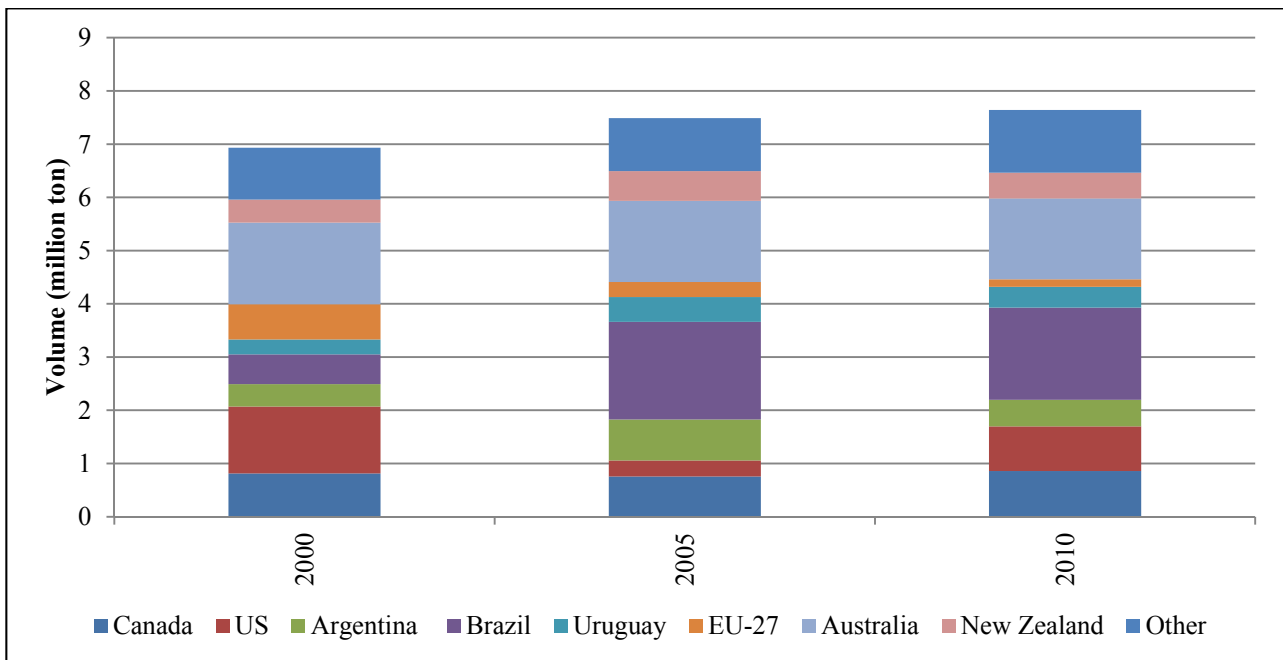
## 1.2 PROBLEM STATEMENT

Beef is one of the most traded agricultural commodities in the world, even surpassing the trade in corn, coffee and sugar during 2012 (ITC, 2012). Since 2000, three significant changes occurred within the global market for beef. The first of these changes was that on aggregate, the volume of beef being traded increased by 26.2 percent between 2000 and 2010 (ITC, 2012). This substantial growth in international beef trade was the result of additional supply and demand for beef in developing countries and import demand created by lower beef production in the European Union (EU) (ITC, 2012). Additionally, aggregate beef trade was also stimulated by improved market access provisions under various trade agreements and efficiency gains in production, processing and transportation (Morgan & Tallard, 2006). However, even though beef trade grew since 2000, trade was still constrained by food safety and animal health issues, protectionism of sensitive domestic production in some of the key markets and the high price of beef compared to other meats such as poultry and pork (GIRA, 2010).

The second significant change was that the majority of global beef production and consumption moved from developed countries to developing countries. The share of global beef production and consumption accounted for by developing countries increased from 49 percent to 54 percent between 2000 and 2010 (FAO-OECD, 2013). This shift was largely driven by: i) the increased demand created by population growth in developing countries and the changing diets of consumers to more protein rich food such as beef associated with increases in per capita incomes experienced in these countries; and ii) the additional production created in these countries to meet the growing demand for beef (Morgan & Tallard, 2006). These increases in production and demand for beef in developing countries allowed these countries to play a more prominent role in the global beef trade. For example, the share in global imports of developing countries increased from 26.9 percent to 40.3 percent between 2000 in 2010, whereas the share in global imports of developing countries rose from 14.8 percent to 32.5 over the same period (ITC, 2012).

Lastly, the respective influences of many of the leading beef exporters on the global beef market have changed significantly between 2000 and 2010 (see Figure 1.1). Continued increases in Brazilian beef production during the late 1990's allowed the country to move from being a relatively minor exporter in 2000 to become the world's largest beef exporter by 2003, a position the country held even until 2010. The discovery of bovine spongiform encephalopathy (BSE) in a dairy cow that had been imported from Canada during December of 2003 led to United States (US) beef being banned or restricted beef from most of the country's export markets, especially the Japan and South Korea. US beef exports fell from US\$3.5 billion during 2003 to US\$625 million during 2004. Even in 2010, the US only exported 66 percent of the volume exported during 2003 (ITC, 2012). The EU was a notable beef exporter during 2000, but the EU's role among global beef exporters steadily declined over the next decade as a result from changes in domestic policies that reduced the support provided to EU beef producers from 60.7 percent to 12.4 percent of farm receipts between 2000 and 2010 (OECD, 2012).

**Figure 1.1: Current and expected leading beef exporters, 2000-2010**



Source: GIRA, 2010

Due to the complexity and dynamism of the global beef market, policymakers need a theoretically consistent, rigorous and quantitative analysis to validate and quantify the effects of different factors that are believed to drive beef trade. This study aims to address this need by applying a gravity model analysis on beef trade among twenty leading beef importers and exporters between 1996 and 2010. In the face of the above-mentioned changes in the global beef market, such knowledge will facilitate and improve the decision-making behaviour of policymakers when guiding agricultural policy, negotiating trade agreements and creating an environment in which domestic producers and consumers can benefit from trade.

### **1.3 OBJECTIVES OF THIS STUDY**

The general objective of this dissertation is to validate and quantify the factors that drive and influence international beef trade in order to facilitate and improve the decision-making behaviour of policymakers. In order to reach the general objective of the study, several specific objectives need to be met:

- Firstly, a detailed review on the trends and issues in beef production, consumption, trade, animal disease outbreaks and agricultural policy needs to be provided in order to gain an understanding of prominent issues that influence international beef trade. This knowledge will inform the researcher on the issues that need to be considered in the specification of the gravity model and the expected relationships between the volume of trade and each of the individual issues.
- Secondly, a literature review will be compiled on the gravity modelling methodology. This process will ensure that the model being developed in this study conforms to established international practices and benefits from the latest advances in the methodology.
- Thirdly, a gravity model will be developed and estimated to determine the effects of various issues on the volume of beef traded between two trading partners. The estimated results will be

validated both by traditional statistical testing and a subjective assessment of whether the estimated results are plausible given the understanding gained from the review of the international beef market. A short discussion will also be provided to compare the findings of this research to the findings of similar studies.

The model developed in this dissertation will provide results that can serve as an indication of how various issues included in the specification of the model have affected trade in chilled and frozen bovine meat in the past, thereby providing policy-makers with an understanding of the implications of future changes in these issues on the volume of beef trade. The model can also be updated over time to include methodological improvements, be adapted to focus on the trade among specific countries and additional variables can be included in the specification to study the effects on trade of recently introduced policies, trade restrictions or trade agreements.

#### **1.4 OUTLINE OF THE STUDY**

This dissertation is arranged into five chapters. The first chapter introduced the problem statement and the objectives of this research. The second chapter provides an overview of the global market for beef products by focusing on beef consumption, production, trade, animal diseases and agricultural policy. Chapter three motivates the use of the gravity model to reach the research objectives and contains a literature review of the gravity modelling methodology. The fourth chapter provides the specification of the gravity model and presents the empirical results of this research. A summary of the study and concluding remarks are given in Chapter five.

# CHAPTER 2

## THE GLOBAL BEEF MARKET

### 2.1 INTRODUCTION

As mentioned in chapter one the subject matter of this study relates to determining factors that affect international beef trade through using econometric methods. However in order to understand this issue properly a holistic overview of the international trade environment and factors influencing it is necessary. This chapter will provide a detailed discussion on the trends and issues in beef consumption, production, trade, animal diseases outbreaks and agricultural policy in order to inform the researcher on the issues that need to be considered in the specification of the gravity model and the expected relationships between the volume of trade and each of the individual issues

### 2.2 GLOBAL BEEF CONSUMPTION

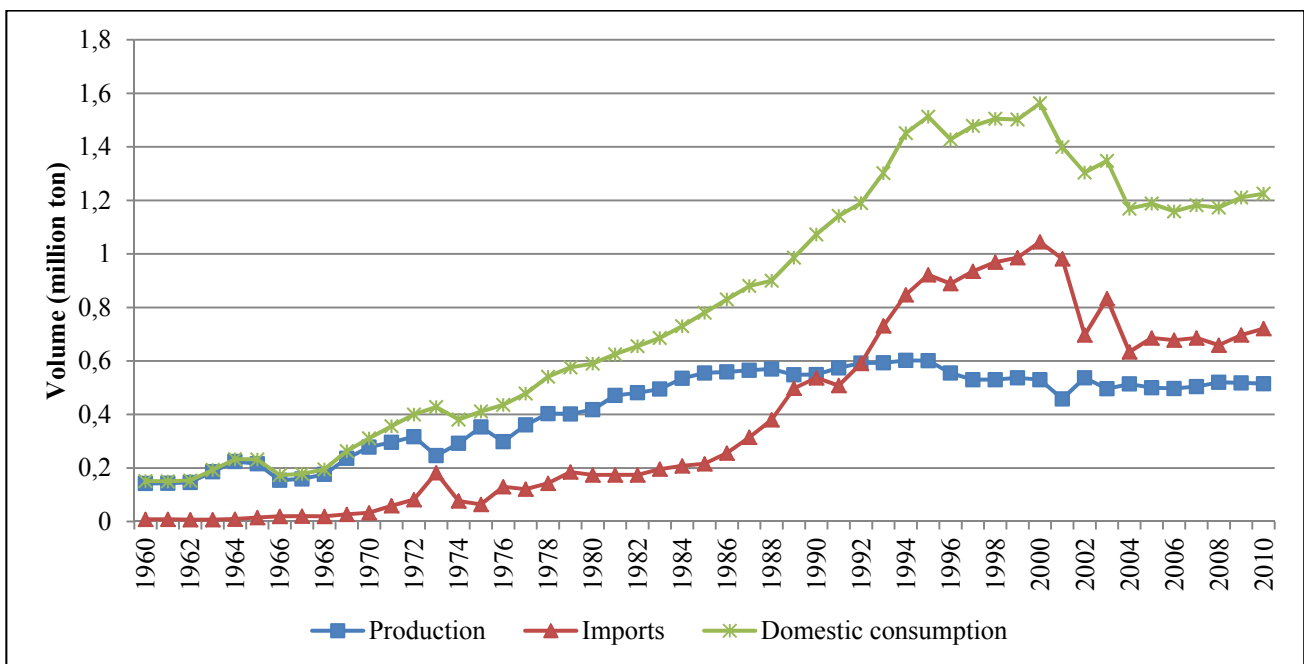
#### 2.2.1 Overview

Global consumption of meat (beef, poultry, pork and lamb) increased from 234 million tons in 2000 to 282 million tons in 2010 (GIRA, 2010). This tremendous growth of meat consumption was driven mostly by growth in the global population and the increases in per capita incomes and consumption in developing countries. The United States Department of Agriculture (USDA) estimates that 55.8 million tons of beef was consumed worldwide during 2011 (USDA FAS, 2011a). Compared to other meats, such as pork and chicken, global beef consumption has remained relatively stable, only increasing 5.5 percent between 2000 and 2011. Over the same period, pork and chicken consumption increased by 19.6 percent and 48 percent respectively. Reasons for this low level of growth have been attributed to consumers substituting beef with pork and poultry due to: i) the relatively high retail prices of beef compared to poultry and pork; ii) the negative health

risks associated with beef consumption; and iii) the high environmental costs associated with beef production.

The importance of including beef consumption in the specification of the gravity model developed in Chapter 4 can be illustrated by Japan’s trends in production, consumption and trade between 1960 and 2010. Japan’s beef imports grew rapidly due to increased consumption between 1967 and 1995, when consumption increased by 850 percent (see figure 2.1). Increased beef consumption occurred during a period in which Japan experienced growing incomes, larger populations living in urban areas and increased exposure to international foods. Japanese beef production remained stable since the early 1980s, forcing Japan to import from international markets to supply the demand for beef that cannot be supplied by domestic production.

**Figure 2.1: Japanese production, imports and domestic consumption of beef, 1960-2010**



Source: USDA FAS, 2011a

**2.2.2 Beef consumption trends in major beef consuming countries**

Beef consumption varies significantly across the world due to differences in consumer preferences, beef prices and the availability of beef across the different regions of the world. As with overall



meat consumption, beef consumption is driven by growth in consumer incomes and a country's population. This section will briefly outline trends in consumption in the US, the EU, Brazil and China, the four largest consumers of beef in the world.

### **2.2.2.1 *United States***

In terms of volume, the US was the largest consumer of beef in the world during 2011. The US possesses a strong domestic market and an expanding population. However, consumption was dampened in recent years by the country's economic woes and competition from substitute products, with beef losing market share to both pork and poultry as beef becomes comparatively more expensive and less convenient to prepare. US consumption of beef reached an estimated 11.7 million tons during 2011, down from the 12 million tons consumed 2010. The US was able to supply 92.3 percent of domestic consumption from domestic production during 2011. Even though consumption per capita has fallen from 39.8 kg in 2009 to 37.5 kg in 2011, US per capita consumption remains the 3<sup>rd</sup> highest in the world (GIRA 2010; USDA FAS, 2011a).

### **2.2.2.2 *European Union***

The EU market is a large and diverse market, and many types of beef and beef products are consumed. Beef consumption is mature in Western Europe, with a demand for healthier living, competition from pork and poultry and environmental concerns placing downward pressure on beef demand. However, rising incomes of the 12 New Member States (NMS-12) is driving increased beef consumption in these countries (GIRA, 2010). Beef consumption in the EU has declined from 8.2 million tons in 2009 to 7.9 million tons in 2011. The EU was able to supply 95.4 percent of domestic consumption from domestic production during 2011. Per capita beef consumption declined from 16.2 kg to 15.5 kg between 2009 and 2011 (USDA FAS, 2011a).

### 2.2.2.3 *Brazil*

Brazil's beef consumption has shown remarkable growth since the turn of the century, increasing by 25 percent between 2001 and 2011. This growth in consumption was enabled by the development of the Brazilian beef industry and the increasing purchasing power of Brazilian consumers. Between 2009 and 2011, Brazilian beef consumption increased from 7.3 million tons to 7.7 million tons. On a per capita basis, beef consumption increased from 37.1 kg to 38.1 kg between 2009 and 2010. Brazilian beef production supplied virtually all of the domestic consumption during 2011 (USDA FAS, 2011a).

### 2.2.2.4 *China*

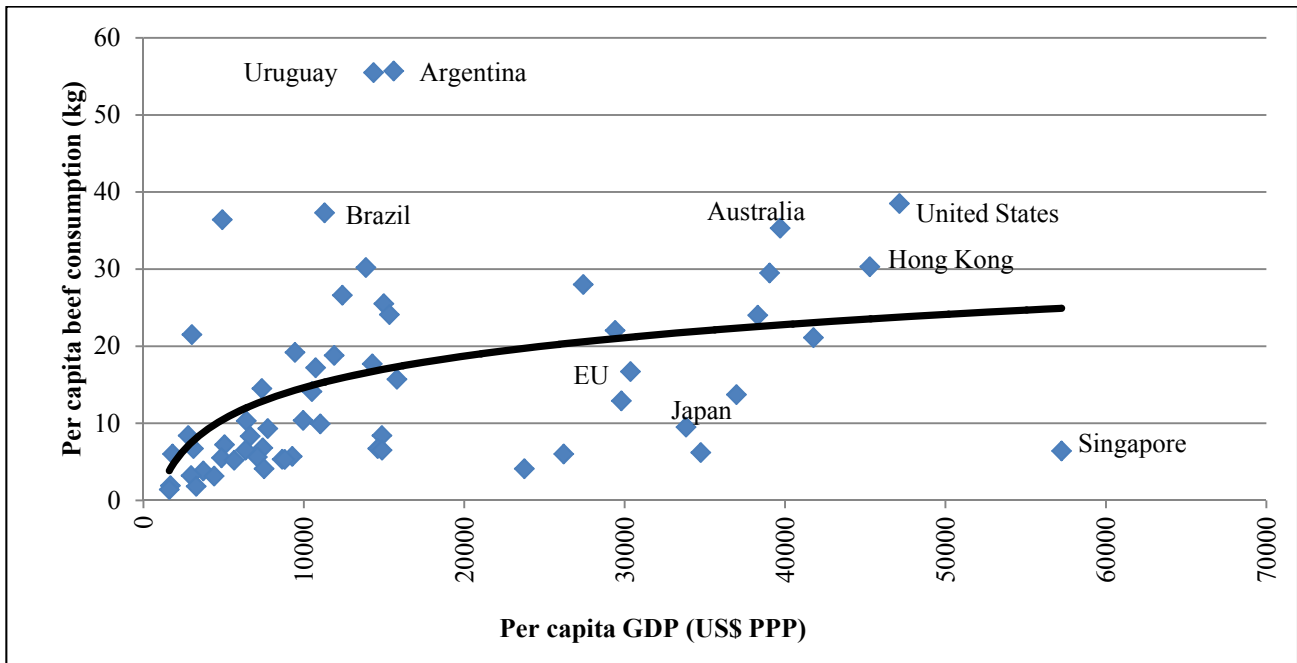
Total beef consumption in China declined from 5.7 million tons to 5.5 million ton between 2009 and 2011. Per capita consumption decreased from 4.3 kg to 4.1 kg over the same period (USDA FAS, 2011a). In July 2011, China's average beef price was USD5.77 per kilogram, compared to USD4.58 and USD2.73 per kilogram for pork and poultry respectively. This high cost of beef compared to pork and poultry continues to dampen the demand for beef in China. Beef is mainly produced, frozen and shipped from grassland areas in Western China to major markets. Although beef accounts for a significant share of total meat consumption in the western regions of China, beef is mainly consumed in more affluent urban regions. China's urbanization and expanding middle class will remain key drivers in future beef consumption growth. Chinese beef production supplied virtually all of the domestic consumption during 2011 (USDA FAS, 2011b).

### 2.2.3 **The impact of income per capita on beef consumption**

Figure 2.2 indicates the strong positive relationship between increasing income and beef consumption at lower income levels, and a less positive relationship at higher income levels. The positive relationship between income per capita on consumption per capita supports the general

economic theory which suggests that as incomes increase, consumers tend to increase their consumption of high income-elastic foods such as meat.

**Figure 2.2: Relationship between per capita beef consumption and income, 2010**



Source: IMF, 2011; USDA FAS, 2011a

Gallet (2010) performed a meta-analysis of the income elasticity of meat that involved regressing 3357 estimated income elasticities collected from 393 studies. The author found that increases in income will cause consumers to shift a greater share of their budget towards buying beef and fish, away from lamb, pork, and poultry. The relationship between income and beef consumption is further emphasized by a USDA Economic Research Service (ERS) reported set of income elasticities estimated for various food groups in 114 countries during 2005 (USDA ERS, 2011). The data indicated that demand for meat in low income countries was significantly more responsive to changes in income than high income countries. For example income elasticities for meat ranged from 0.84 in the Democratic Republic of the Congo, to 0.78 in Kenya, 0.69 in Brazil and South Africa, 0.66 in Argentina, 0.48 in Japan, and 0.34 in the US.

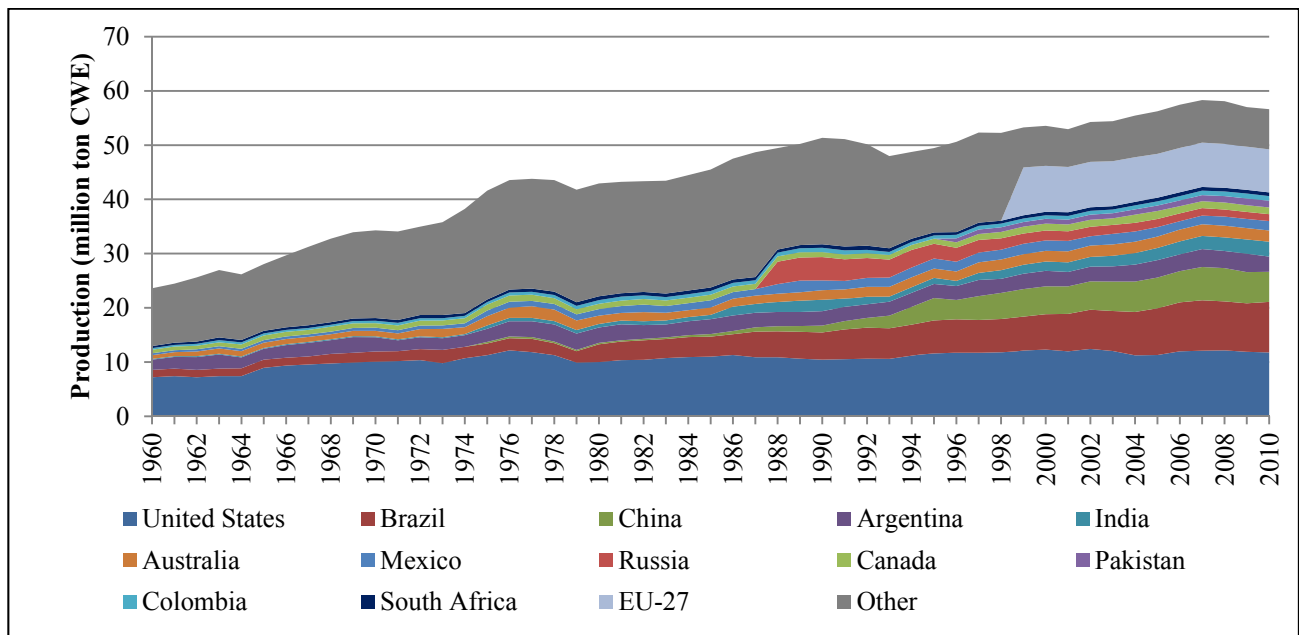
This section briefly discussed trends in beef consumption and highlighted the importance of including both consumption and income per capita in the specification of the gravity model developed in Chapter four. The following section will discuss trends in global beef production, production trends among leading producers and international beef prices.

## **2.3 GLOBAL BEEF PRODUCTION**

### **2.3.1 Overview**

World beef and veal production reached a maximum at 58 million tons during 2007, after which production steadily declined to 56 million tons during 2010 (see figure 2.3). On average global production grew by 2 percent annually between 1961 and 2000, and only 0.67 percent between 2000 and 2010. Figure 2.3 further shows the contribution of selected countries to global beef and veal production. The US is and was historically the largest beef producing country in the world, contributing on average 24.8 percent to world production since 1961 and 20.8 percent in 2010. Brazil and the EU are the second and third largest beef producers, each producing 16.4 percent and 14 percent of world supplies respectively (USDA FAS, 2011a). Interestingly, some of the largest beef exporters such as Canada, Australia, Argentina and Uruguay have a relatively small share in global meat production.

**Figure 2.3: Composition of beef production over time, 1960-2010**



Source: USDA FAS, 2011a

\*CWE=Carcass Weight Equivalent

### 2.3.2 Beef production trends in major beef producers

The US, Brazil, China and the EU produce more than half of global beef, chicken meat and pork. Beef and chicken production is favoured in the US and Brazil, whereas pork and sheep meat production is favoured in China and the EU. The US is the largest beef and chicken meat producer, producing 19.3 percent and 19.7 percent of global production. The following section will discuss beef production amongst these influential beef producers.

#### 2.3.2.1 *United States*

The beef production system in the US consists of three major components: i) backgrounding operations, ii) cow-calf operations and iii) cattle feedlot operations. In 2011, although there were about 734 thousand beef cow operations in the US, most of these operations were located in the Corn Belt and South West. The sector is characterized by a high degree of concentration, with a small number of operations accounting for a disproportionately large share of inventory. For

example, in 2011, operations having a 100 or more head of cattle constituted 9.5 percent of the total number of beef cow operations, yet accounted for 54.9 of inventory (USDA NASS, 2012). The U.S. beef production system is cyclical, such that production and prices often rise and fall fairly regularly over a period of several years. This cycle, known as the cattle cycle, is the expansion and contraction of cattle inventory in response to changes in price. Historically, the beef cattle cycle was a period of 8 to 12 years that consists of an expansion phase, a consolidation phase, and a liquidation phase (USDA ERS, 2008). The combination of high prices and limited beef supplies usually marks the beginning of expansion. In response to high prices, cow-calf producers retain heifers to rebuild the herd, and culling rates decline. The US beef industry remains being driven by intensive, grain fed beef systems. Large scale feedlots allow US beef producers to benefit from scale efficiencies and being able to adopt new technologies faster than producers in other regions. Production is expected to increase from 11.65 million tons in 2010 to 12.3 million tons in 2020. An growing population and growth in export demand to the Far East for cuts not in demand within the US will be the drivers of increased production. The strong demand for in the US is expected to make restocking viable for many producers, leading to an increase in the cattle herd from 93.7 million head in 2010 to 97 million head in 2020 (GIRA, 2010).

### **2.3.2.2**     *China*

The beef herd in China struggles to grow due to poor pasture conditions and price sensitive consumers. Strong development and the high profitability of the Chinese dairy industry, in spite of the 2008 Melamine outbreak, will lead to Chinese cattle herd growing to 112 million head in 2020. Therefore the growth in cattle will be driven by the milk industry rather than the beef industry. The Chinese beef industry is characterized by low quality cattle and a lack of investment due to slow returns compared to poultry and pork ventures. However the rapid development of the Chinese dairy industry will drive beef production, albeit as a by-product of dairy production, with poor

quality dairy cows entering beef production. Beef production in China is expected to increase from 5.7 million tons to 6.3 million tons between 2010 and 2020 (GIRA, 2010).

### **2.3.2.3 *Brazil***

The Brazilian cattle herd has suffered destocking since 2007, mainly due to depressed farm gate prices and competition for land from more profitable arable production. Although the herd size is expected to recover, the diminished profitability of the beef export sector will limit growth from 182 million head in 2010 to 184.5 million head in 2020. Brazil's beef production is expected to increase from 7.5 million tons to 8.4 million tons between 2010 and 2020. Production is likely to intensify with more supplementary feed used in the later stages of production to improve carcass weights, quality and reduce finishing time. However the focus on grass finishing will persist and will result in Brazil still being the lowest-cost producer among the leading producers (GIRA, 2010).

### **2.3.2.4 *European Union***

The EU cattle herd is expected to decrease from 88.1 million head in 2010 to 82 million head in 2020. This decline is due to increasing competition from South American beef imports and the decline in the dairy herd due to increasing yields. The EU is the only major beef producer that is expected to reduce its production. Production is expected to decline 7.8 million tons to 7.2 million tons between 2010 and 2020, despite strong domestic demand. The decline can be attributed to the strong competition from South American beef producers and the declining dairy herd. However the rate of decline will be slower than in the previous decade as the effects the decoupling of agricultural subsidies, previously provided under the EU's Common Agricultural Policy have already been felt and the expected strengthening of the global dairy markets will slow own the decline experienced in the dairy herds (GIRA, 2010).

### 2.3.2.5 *Australia*

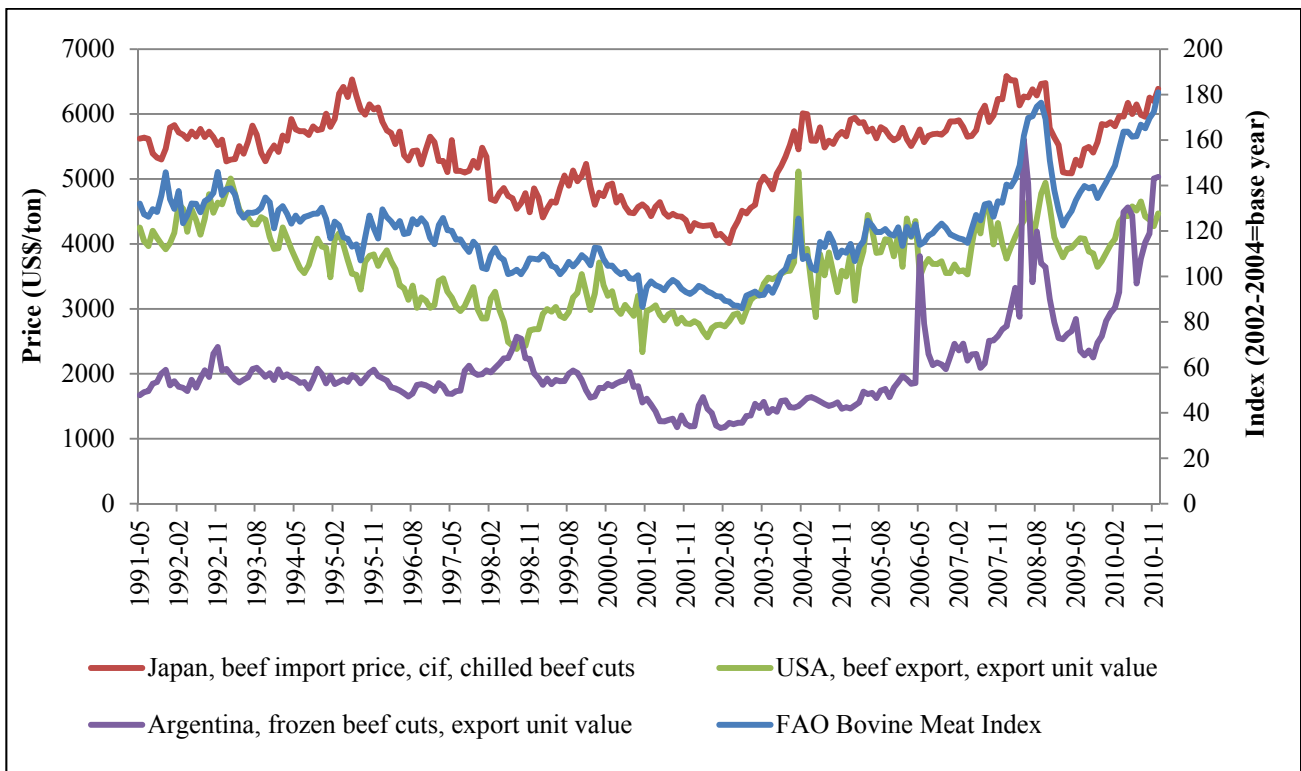
The Australian beef industry is large and diverse, and production occurs under a variety of climatic and environmental conditions. Beef is also produced on properties that vary in size and management regimes. These differences result in a range of beef of differing qualities being produced, and causes Australian beef to be marketed to a portfolio of domestic and export destinations according to different quality requirements and price points. Beef production is expected to grow from 2 million tons to 2.2 million tons between 2010 and 2012. The strong export demand for Australian beef will lead an increase in the herd size from 27.9 million head in 2010 to 29.9 million head in 2020 (GIRA, 2010).

### 2.3.3 **Beef prices**

Economical inputs, technological advances and scale efficiency gains in recent decades have resulted in declining prices for livestock products (FAO, 2009). Declining grain prices have contributed to increased use of grains as feed and downward trends in transportation costs have facilitated the movement not only of livestock products but also of feed. However, recent increases in grain and energy prices may signal the end of the era of cheap inputs (FAO, 2009; Trostle, 2008; De Gorter, 2008). This notion is confirmed by figure 2.4, which indicates that international beef prices have trended downward until the middle of 2002, and then started to show an increasing trend. Jarvis, Cancino and Bervejillo (2005a) found that international beef prices converged since the 1960's due to i) changes in commercial policy following the Uruguay Round of the trade negotiations, ii) the erosion of the price penalty traditionally faced by beef-producing countries with endemic FMD, and iii) the industry's shift toward the export of cuts instead of carcasses.



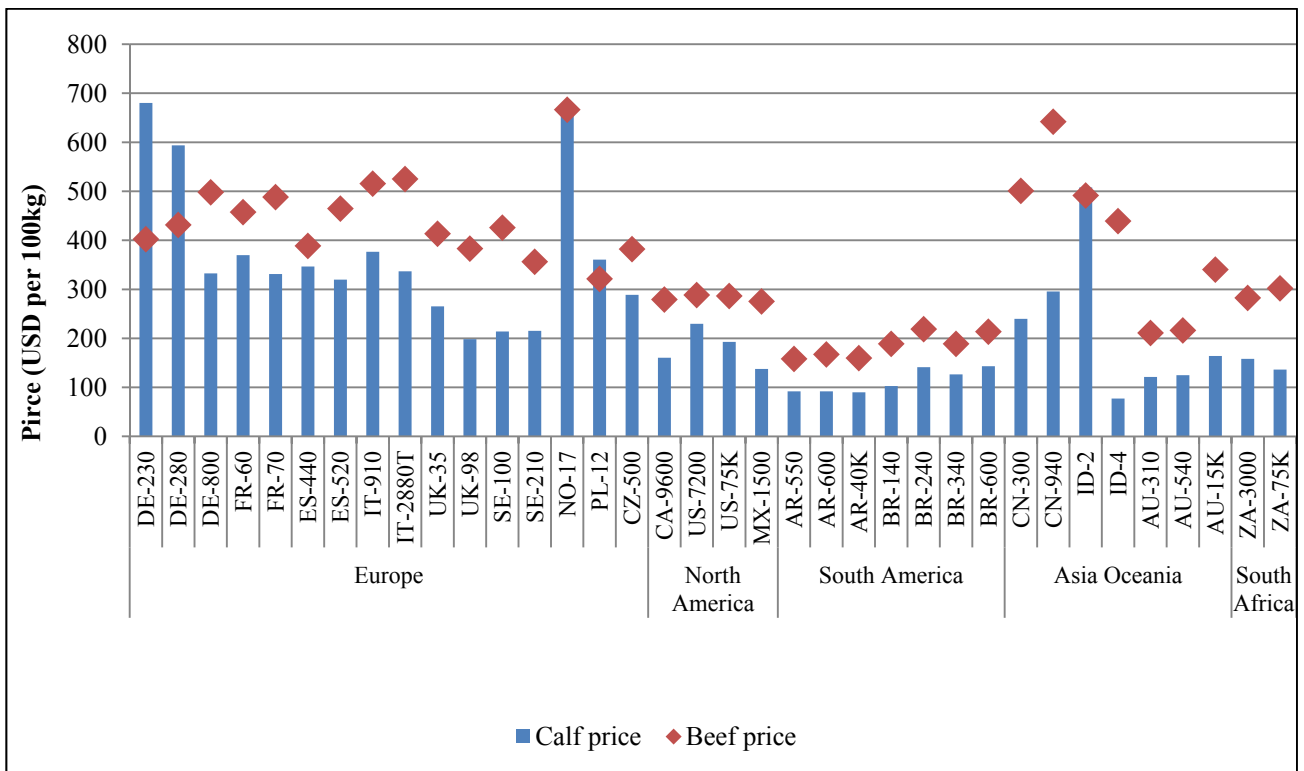
**Figure 2.4: International beef prices, 1991-2010**



Source: FAOSTAT, 2012

Figure 2.5 shows that both livestock and beef prices vary significantly across regions. Beef was the most expensive in Norway, China, Italy and Indonesia during 2009. Prices in Europe tended to be the most expensive, followed by Asia Oceania, South Africa, North America and the lowest priced region being South America. Overall beef prices seemed to follow livestock prices, which support the economic notion that beef and livestock prices are closely related (Deblitz, 2010). Differences in the beef prices among different regions stimulate trade, since exporters in countries with relatively low beef prices are more likely to export to regions that offer prices higher than domestic market, with the opposite being true for importers.

**Figure 2.5: Beef prices and livestock prices for selected countries, 2009**



Source: Deblitz, 2010

This section discussed trends in beef production and explained the importance of including both production and prices in the specification of the gravity model developed in Chapter four. The following section will discuss trends in global beef trade, production trends among leading producers and international beef prices.

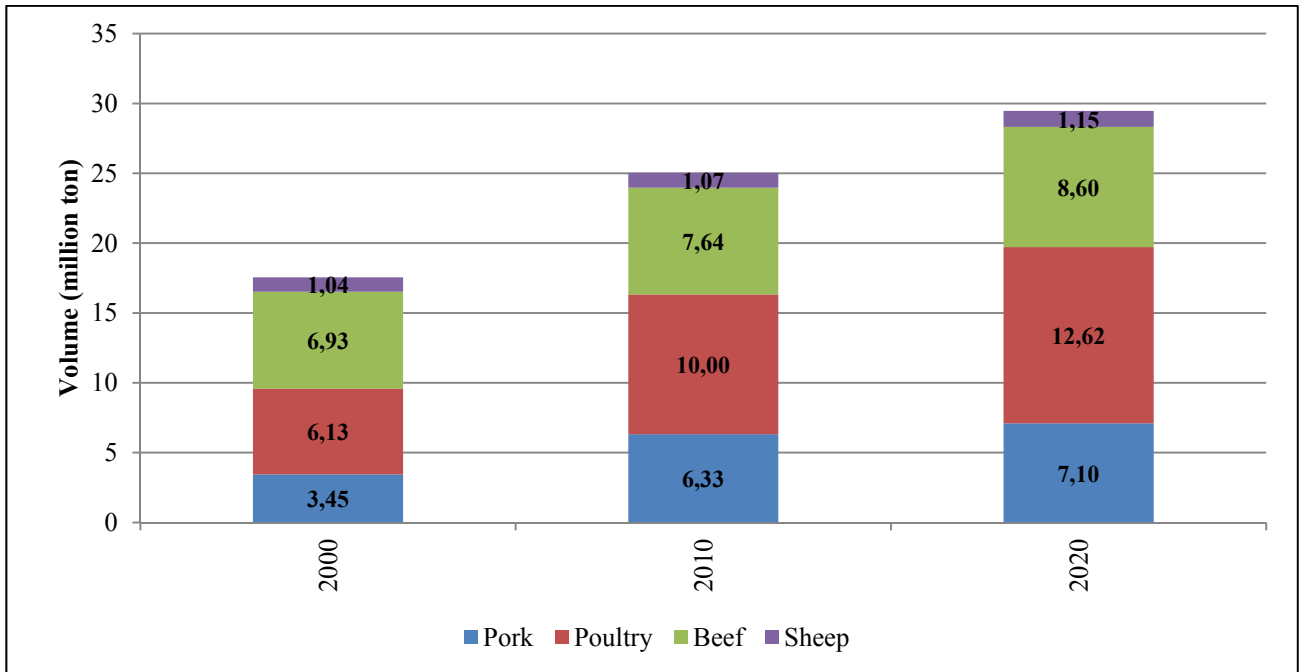
## 2.4 GLOBAL BEEF TRADE

### 2.4.1 Overview

Stimulated by improved market access provisions under various trade agreements, growing meat demand in developing countries and efficiency gains in production, processing and transportation, meat trade expanded from 17.56 million tons to 25.04 million tons between 2000 and 2010 (GIRA, 2010). Figure 2.6 shows how additional meat trade is expected to be distributed among different species in 2020. In 2010 poultry meat was the most traded meat, constituting 39.9 percent of global

meat trade. Beef and pork were the second and third most traded meats, each representing 30.5 percent and 25.2 percent of global meat trade respectively. Trade in poultry, beef and pork is expected to grow by 26.2 percent, 12.4 percent and 12.2 percent respectively between 2010 and 2020.

**Figure 2.6 Distribution of global meat trade in 2000, 2010 and 2020**



Source: GIRA, 2010

Increases in global incomes in a number of key regions and the advent of a more liberalized trading environment have contributed to substantial growth in international beef trade. The share of global beef production being exported rose from 4.3 percent to 12.1 percent between 1960 and 2010 (USDA FAS, 2011a). However trade in beef products is expected to grow more modestly than poultry meat due to beef trade being constrained by (GIRA, 2010):

- food safety and animal and plant health issues, also known as Sanitary and Phytosanitary (SPS) issues,
- protectionism of sensitive domestic production in some of the key markets (most notably the US, the EU, Korea and Japan),

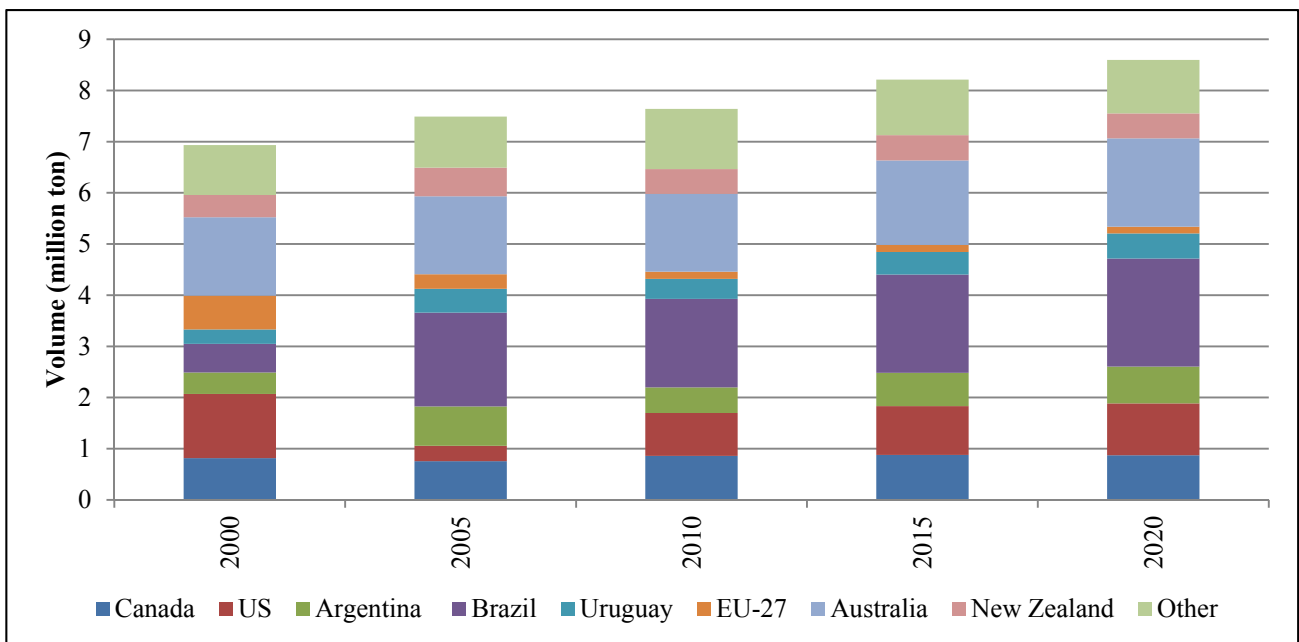
- increasing domestic consumption for some of the South American exporters (most notably Brazil and Argentina), and
- difficulties in significantly increasing production due to resource constraints and more attractive investment opportunities in other agricultural ventures.

Although a brief overview of meat and beef trade was provided, the complex nature of the international beef trading environment necessitates that beef trade be explored at a country-specific level. For this reason, the rest of the following section will discuss the dynamics of beef trade in key exporters and importers of beef products.

### 2.4.2 Trends in key beef exporters

Global beef trade is driven by a handful of exporting countries that have the domestic conditions to produce sufficient volumes of beef to satisfy domestic markets and significant volumes to export. Brazil, Australia, Canada and the US were the four largest beef exporters during 2011 (USDA FAS, 2011a). The beef export dynamics of each of these countries will now be discussed.

**Figure 2.7: Current and expected leading beef exporters, 2000-2020**



Source: GIRA, 2010

#### 2.4.2.1 *Brazil*

Among the four leading exporters, Brazil is the lowest cost beef exporter in the global market. In recent years, Brazilian exporters have focused on improving customer service and establishing regional sales offices in key markets, providing these exporters with the ability to target the cuts to the most profitable markets. Fears over disease and sanitary issues in Brazil have been used to restrict market access in a number of key regions, especially North America. In 2008 the EU imposed a ban on Brazilian beef, claiming that the ban was based largely on the fact that Brazil did not comply with the same traceability, welfare and environmental standards required of EU farmers. However, Brazil has a broad portfolio of beef export markets providing exporters a degree of risk reduction to specific trade barriers (GIRA, 2010).

Brazil exported 1.3 million tons of beef during 2011, or 14.6 percent of the country's total beef production (USDA FAS, 2011a). Russia, Hong Kong and Iran were Brazil's leading export destinations in 2011, representing 24.7 percent, 15.4 percent and 14.1 percent of Brazilian exports respectively (ITC, 2012). Current export volumes have been negatively affected by the reduction in domestic production following the herd reduction in 2006 and 2007, lower global demand for premium cuts and trade access issues with the EU. Brazil's export potential is limited by the supply of cattle in Brazil, with ongoing herd rebuilding, as well as a strengthening of the Brazilian Real against the US Dollar, which makes Brazilian beef less competitive (GIRA, 2010). Brazilian exports are however expected to recover, although at a slower pace, in the EU beef market as more Brazilian cattle farms are enrolled in a traceability program, which is critical to gain market access in the EU. In addition, processed beef exports to the US are expected to recover after a major decline in 2010 and 2011 because of the Ivermectin residue issue (USDA FAS, 2011c).

#### **2.4.2.2**     *United States*

The US is the global benchmark for high quality grain fed beef, with export prices setting the ceiling for acceptable prices for this type of beef in many international markets. Although US beef exports play a significant role in international beef trade, the focus of US production is aimed primarily at the domestic market. US beef exports have been recovering from the US's initial case of BSE in December 2003, which reduced exports from 1.14 million tons in 2003 to 209 thousand tons in 2004. Market access for US beef exports remain restricted in many key export markets with age restrictions limiting the availability of suitable beef for key Asian markets, and a total ban still in effect in China. The US exported 1.24 million tons of beef during 2011, or 10.3 percent of the country's total beef production (USDA FAS, 2011a). Mexico, Canada and Japan were US's leading export destinations in 2011 representing 18.2 percent, 13.4 percent and 13.2 percent of US beef exports respectively (ITC, 2012). Gradual recovery of market access and a weak US Dollar will drive future US beef exports. Long term export growth is supported by economies of scale at slaughter that allow the US to target containers of specific cuts to the best markets. However packers are characterised by a commodity mentality and lack of attention to detail with respect to customer requirements (GIRA, 2010).

#### **2.4.2.3**     *Australia*

Australia has a thoroughly robust export portfolio reflecting the specific demand from different markets and the mix of cattle breeds, pastoral conditions and the degree of grain finishing. For example, Australia exports manufacturing grade beef to North America and Russia, high quality grain fed cuts to the Far East and stewing and kebab type cuts to the Middle East and North Africa (MENA) region. Australian beef exporters are well established in many key markets, especially after the North American BSE crisis in 2003, taking significant market share from the US and Canada in Japan and Korea. Australian grass fed beef prices are traditionally higher than grass fed

beef originating from South America, although cattle shortages in South America makes this difference smaller. In terms of grain fed beef, Australian export prices are lower than US export prices, but still regarded as being of a good quality (GIRA, 2010). The Australian beef industry is mostly export orientated, which is reflected by the fact that 63 percent of the 2.1 million tons beef produced during 2011 being exported (USDA FAS, 2011a). Japan, South Korea and the US were Australia's leading export destinations in 2011, representing 32.6 percent, 15.8 percent and 15 percent of Australian beef exports respectively (ITC, 2012). Australia is the most significant competitor to the US in the Japanese imported beef market. A traditional advantage of US beef exporters is their ability to supply full shipments of the specific cuts favoured in the Japanese market. A large share of Australian beef exports to Japan are on a full set basis, meaning that buyers are required to purchase all the cuts from a carcass, resulting in a surplus of cuts that are less desirable in the Japanese market, and reduces the substitutability of Australian beef compared to US beef. Australia's ability to supply the Japanese market is also constrained by the country's production capacity, particularly of its feeding operations (US ITC, 2008).

#### **2.4.2.4**     *Canada*

The Canadian and US cattle and beef sectors are highly integrated as a result of their geographic proximity, similar production systems and consumer demand characteristics. Large multinational companies have operations on both sides of the border, and with minimal trade restrictions, live cattle and beef move both ways across the border largely in response to relative prices and other market factors in each country. Canada exported 415 thousand tons of beef during 2011, or 35.9 percent of the country's total beef production (USDA FAS, 2011a). The US, Mexico and Hong Kong were Canada's leading export destinations in 2011, representing 74 percent, 8.8 percent and 6.5 percent of Canadian beef exports respectively (ITC, 2012). The Canadian beef industry produces beef that is of a similar (grain-fed) quality to beef produced in the US. The strength of the Canadian dollar against the US dollar and US beef demand significantly influences beef production and

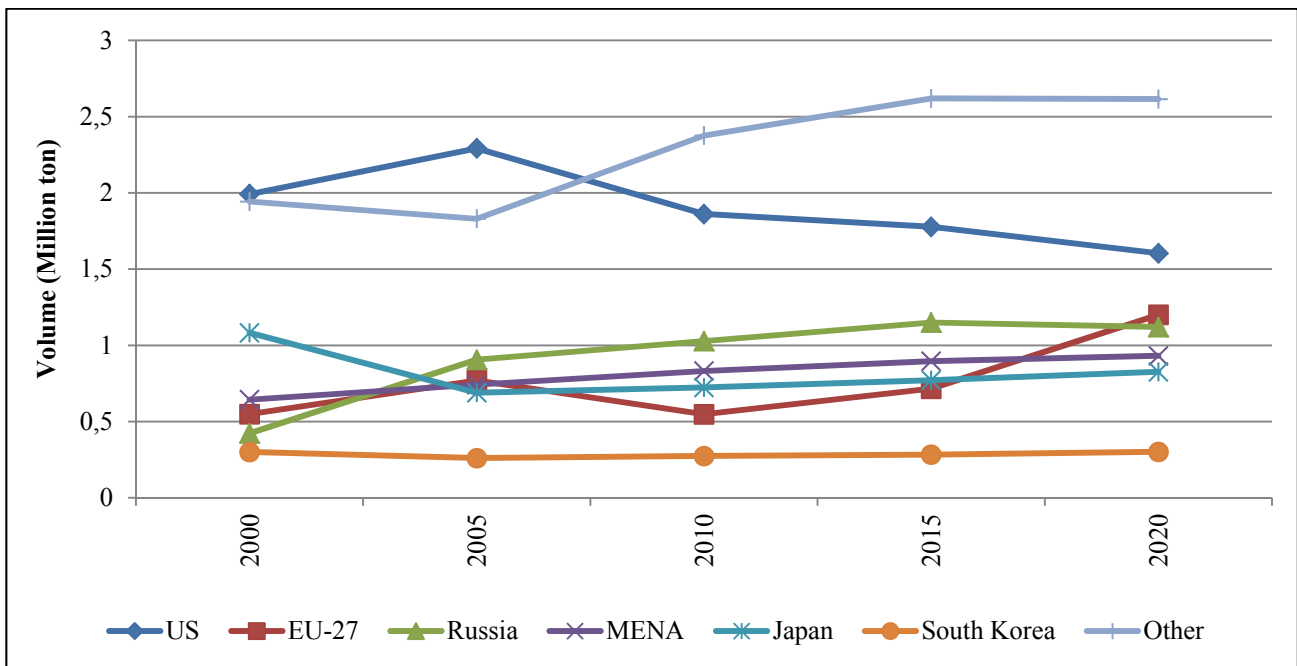
export volumes in Canada. Canadian exporters are however expected to divert exports from the US to more attractive markets in the future, most notably Asia and the EU, which will reduce the this dependency. Canadian beef exports are more responsive to specific customer demands than US exporters; mainly due to production plants being smaller than in the US and a growing recognition within the industry that there is scope for a differentiated approach to marketing and customer service. The discovery of BSE in Canada's cattle herd in 2003 led to Canada losing market access in many key export markets. Due to Canada lacking the same political power as the US, Canadian beef exporters are behind US exporters in terms of regaining lost market access (GIRA, 2010).

### **2.4.3 Trends in key beef importers**

Global imports of beef are driven by demand increases in countries that are not able to produce sufficient amounts of beef to satisfy the domestic market. Demand increases are fuelled by growing populations, increases in disposable incomes and the spread of beef eating culture. This growing demand for beef products will however be limited by the supply of beef, with the resulting higher prices dampening consumption growth. Under current market conditions many markets remain restrictive to importers in an effort to protect and encourage domestic producers. The World Trade Organization (WTO) and other trade negotiations aim to open these markets. Disease and sanitary issues, as well as food safety concerns are likely to continue disrupting trade. The US, the EU, Russia, the MENA region and Japan were the four largest beef importers during 2010 (GIRA, 2010). The beef import dynamics of each of these countries and regions will now be discussed.



**Figure 2.8: Current and expected leading beef importers, 2000-2020**



Source: GIRA, 2010

#### 2.4.3.1 *Unites States*

The US is an interesting market in the sense that during 2011 it was both the world's largest producer of beef, yet at the same time the world's second largest beef importer (USDA FAS, 2011a). As mentioned earlier, the US is a producer and exporter of grain-fed beef. Most of the beef imported by the US is grass-fed lean beef, which is more suitable for the use in the production of processed meat such as ground beef. The US produces beef that is highly marbled (i.e., the meat contains veins of fat tissue) and is more tender than grass fed beef. While marbling is derisive in the high value beef cuts, it is not suited for producing ground beef. US imports of lean beef are mixed with domestic beef, which contains a higher fat content, to produce a ground beef that is preferred by the domestic market. Imports of lean grass-fed beef allow US producers to concentrate on producing high value beef cuts that and still fulfil domestic demand for ground beef (Elam, 2003). Canada, Australia and New Zealand were the US's leading sources of beef imports in 2011, respectively supplying 36.4 percent, 22.9 percent and 21.7 percent of US beef imports (ITC, 2012).

### **2.4.3.2**     *European Union*

The EU imported 370 thousand tons of beef during 2011, which is significantly lower than the 410 thousand tons imported during 2010 (USDA FAS, 2011a). The EU currently has very restrictive import tariff-rate quotas (TRQ) on beef, designed to prevent imports from displacing domestic production (GIRA, 2010). The import supply of beef is historically predominantly sourced from South America. Brazil, Argentina and Uruguay being the EU's leading sources of beef imports in 2010, respectively supplying 45.6 percent, 23.7 percent and 15.6 percent of EU beef imports (GIRA, 2010). During 2010 and the first half of 2011, beef prices in South America almost reached EU domestic prices. The high price level, in combination with the import duty is limiting imports. However changes in the supply side of the market could lead to imports increasing, such as a drastic reduction of domestic demand in South America, a significant change of the Euro exchange rate with the South American currencies or a change in the Argentinean export policy. An improvement in trade would above all be accomplished by a relaxation of the main barrier for trade, namely the EU import policy. Besides the limited supply, an important factor affecting EU beef imports is weak EU demand. Higher domestic beef prices, in combination with the economic recession, reduced EU beef sales. The countries which have been hit the most by the financial crisis, namely Greece, Spain and Portugal, reported the most pronounced cuts in beef consumption during 2010. But also in France, the United Kingdom and Germany, beef consumption is on the decline. Another factor behind the falling beef consumption is the increasing popularity of broiler meat due to its lower price, perceived health advantages and convenience (USDA FAS, 2011d).

### **2.4.3.3**     *Russia*

Russia is the world's largest beef importer, importing 1.05 million tons of beef during 2011. Russia continues to protect its domestic beef market with beef imports remaining highly regulated by TRQ for suppliers outside the Commonwealth of Independent States. Current TRQ quantities for chilled

beef and frozen beef are 30 thousand tons and 530 thousand tons respectively. Brazil, Uruguay and Paraguay were Russia's leading sources of beef imports in 2011, respectively supplying 36.4 percent, 22.9 percent and 21.7 percent of Russian beef imports (ITC, 2012). The main demand for imported beef is grass-fed beef used to produce processed beef products, which explains why grass-fed beef exporters such as Brazil dominate imports into Russia (GIRA, 2010). Beef imports have remained stable during 2009 and 2010, with Russia importing 639 thousand tons in 2009 and 627 thousand tons in 2010. However beef imports seem to be increasing, as Russia imported 21 percent more beef by volume in January to June 2011, compared to the same period of 2010. In June 2011, 45 percent of the beef TRQ was utilized, representing 84 percent of total trade. Beef imports are however expected to decline as the beef industry develops under the "Development of Beef Cattle in Russia 2009-2012" state program, which amongst others include subsidies, state co-financed regional programs and the development of beef production facilities (USDA FAS, 2011e).

#### **2.4.3.4 *Japan***

Beef is a relatively minor source of protein for Japanese consumers, with seafood being the predominant source of protein in the Japanese diet. In 2006, the total volume of fishery products for consumption was 7.8 million tons, compared to the 1.2 million tons of beef and veal, 2.5 million tons of pork and the 1.9 million tons of poultry meat (USDA FAS, 2007). During 2011, Japan was the world's third largest beef importer, importing 725 million tons during that year. Japanese domestic production accounted for 40 percent of domestic beef consumption during 2011 in terms of volume, with imports supplying the remaining 60 percent (USDA FAS, 2011a). Imports of grain-fed beef are largely from the US and are predominantly consumed away from home in the foodservice sector (US ITC, 2008). Imported grass-fed beef is less marbled and not suitable for dishes that require thinly sliced beef that is cooked rapidly. Supplied mainly by Australia and New Zealand, most grass fed beef products are used in processed products, such as hamburgers (US ITC, 2008). Between 2001 and 2007, health and food safety concerns related to BSE significantly

affected Japanese beef consumption. BSE was discovered in the Japanese domestic herd in 2001 and then in the country's largest import source, the US, in December 2003. The discovery of BSE in the US resulted in US beef being banned from Japan. The ban forced U.S. exporters to find alternative domestic and foreign markets for products that were previously destined for the Japanese market, but for many beef cuts, Japan is the preferred market, and sales to alternative markets are significantly less profitable. The nuclear accident at the Fukushima Daiichi Nuclear Power Plant led to radiation contamination in a wide variety of field-grown vegetables and fruits, pasture for fodder, milk, and beef. A detection of Caesium, a toxic element used in nuclear reactors, in July 2011 in domestic beef has temporarily put Japan's beef consumption, both domestic, as well as imported, into an overall slump (USDA FAS, 2011f). Australia, the US and New Zealand were Japan's leading sources of beef imports in 2011, respectively supplying 63.5percent, 25.9 percent and 5.7 percent of Japanese beef imports (ITC, 2012).

This section provided an overview of global beef trade by discussing the trade dynamics in the leading beef importing and exporting countries. The next section will discuss the effect of animal disease outbreaks and the subsequent repercussion of these outbreaks on a country's ability to trade.

## **2.5 THE EFFECT OF ANIMAL DISEASES ON TRADE**

Outbreaks of animal diseases such as Foot and Mouth Disease (FMD) and Bovine Spongiform Encephalopathy (BSE), commonly known as mad cow disease, have shown to have potentially fundamental effects on international beef supply, demand and trade. The impact of outbreaks depends on the ability to contain the disease within a region, whether the country is an exporter or importer or how dependant the country is on trade. An outbreak in any of the major beef exporting countries such Australia, Brazil, Canada and the US will affect domestic and international markets (Dyck & Nelson, 2003). This section will briefly discuss these diseases and also provide the impacts that these diseases have on beef production, demand and trade.

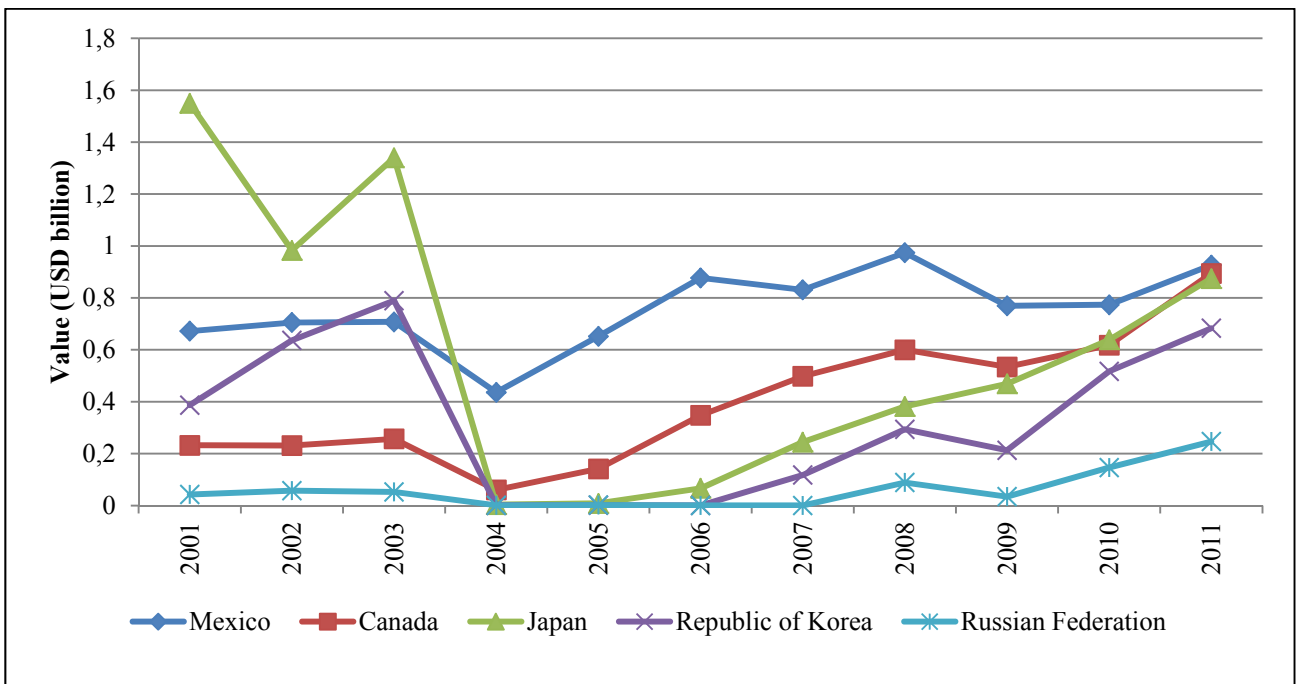
### 2.5.1.1 *Bovine Spongiform Encephalopathy (BSE)*

BSE is a lethal neurological disease afflicting adult cattle that was first documented in the UK in 1986. Researchers believe that BSE is caused by a prion, a protein that is not destroyed by cooking or other commonly used measures to control pathogens such as bacteria. BSE is spread by consumption of meat and bone meal containing the infective agent that is incorporated into cattle feed. The World Organisation for Animal Health (OIE) determines the risk status of each member country with regard to BSE and has established guidelines for products that should be authorized for import based on the BSE risk status of the exporting country. Countries are placed in one of three categories, namely negligible risk, controlled risk, or undetermined risk based on an assessment of the risk to animal and human health in the importing country.

On May 2012, the OIE published a list of member countries categorized by BSE risk (OIE, 2012). Argentina, Australia, New Zealand, Brazil, India and Uruguay were recognized as negligible risk countries and can export beef if no cattle have not been exposed to BSE and were born after the date of an effective feed ban. Mexico, Canada, Chile, Germany, Italy, and the US were recognized as controlled risk countries that can export beef if control procedures are in place. The OIE guidelines recommend that beef from cattle 30 months of age or less can be exported from all countries regardless of BSE risk. However, in all cases specified risk materials must be removed and compressed air or gas may not have been used during the stunning process.

The detection of BSE in the US and the UK had drastic consequences for the beef industries within both these countries. The discovery of BSE in a dairy cow that had been imported from Canada during December of 2003 led to US beef being banned or restricted beef from most markets, especially the Japanese and South Korean markets (see figure 2.9). US beef exports fell from US\$3.5 billion during 2003 to US\$625 million during 2004. Total beef exports only recovered to 2003 levels during 2010 when exports amounted to US\$3.8 billion (ITC, 2012).

**Figure 2.9: US beef exports to leading trade partners, 2001-2011**



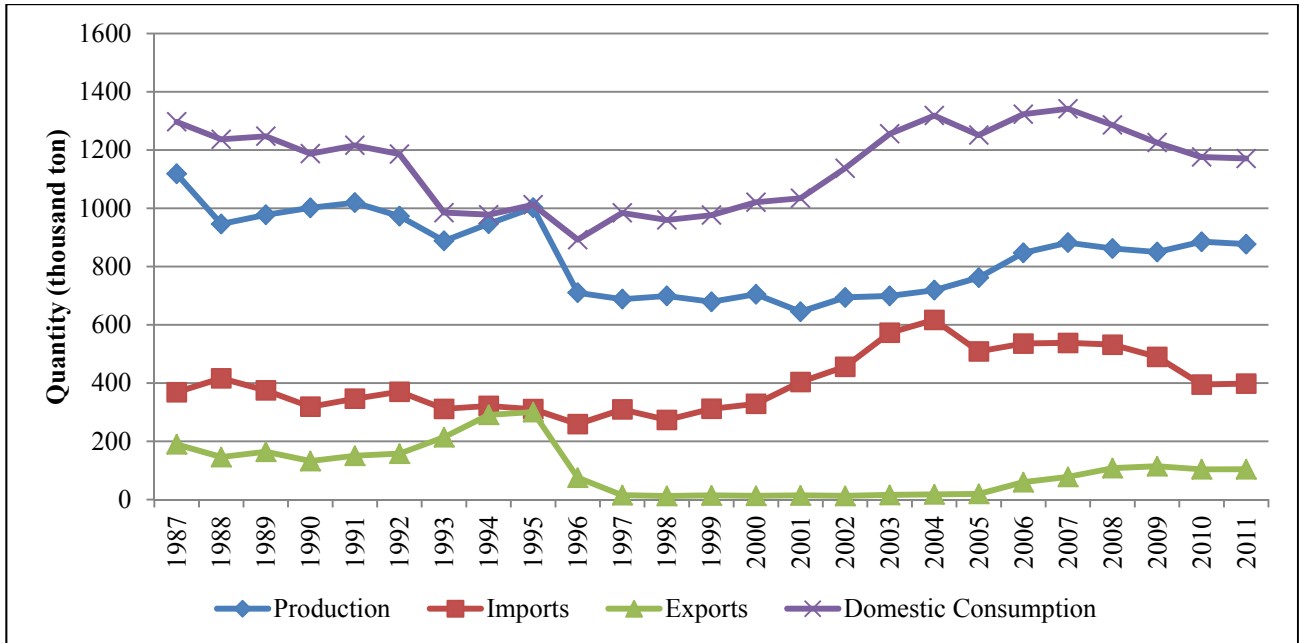
Source: USDA FAS, 2011a

Coffey (2005) studied the export market response to the December 2003 BSE case in the US, in which a number of countries, including Canada, Japan, Korea, and Mexico, banned U.S. cattle and beef products. Prior to the BSE outbreak in 2003, U.S. beef exports were valued at \$3.95 billion and accounted for approximately 10 percent of U.S. beef production (Coffey, 2005). Coffey developed a comparative static trade model to estimate the price and revenue effects of the 2003 beef export bans on two aggregate product categories: i) beef and by-products, and ii) beef offal. The model results indicated that beef industry revenue losses in 2004 from bans on U.S. exports of beef and offal ranged from \$3.2 billion to \$4.7 billion, and that boxed beef prices and beef offal prices were 8 to 11 percent and 34 to 41 percent lower, respectively (Coffey, 2005).

Even though BSE was known to be present in the UK since 1986, the EU banned all UK beef exports since March 1996 following a ministerial announcement to the UK parliament suggesting a link between BSE and the fatal Creutzfeld-Jakob disease (CJD). The export ban lasted for 10 years

before being lifted during May 2006 (EUROPA, 2006). Figure 2.10 indicates how the BSE ban virtually halted UK beef exports between 1996 and 2006.

**Figure 2.10: UK beef production, trade and consumption, 1987-2011**



Source: FAO, 2012; DEFRA, 2012

From the above it is clear why BSE was considered the most expensive and most disruptive animal disease in recent years that had far reaching implications on the global beef industry. GIRA (2010) provides an overview of how BSE outbreaks have changed the global beef market:

- *Demand threat:* The incredibly negative perception that consumers have regarding BSE and the human health threat of CJD severely affects beef demand. Consumer demand was negatively affected in Europe and the Far East through the 1990's and in the early 2000's, with specific crises in 1996 and 2001. Although these crises are now history and incidences of CJD have not escalated as once feared, BSE is still a sensitive issue in some markets such as Japan and Korea.
- *Barrier to trade:* The United Kingdom was banned from exporting beef for nearly 10 years, with Canada and to a lesser extent the US having been severely restricted as a result of smaller prevalence of BSE. Even a single case of BSE has and may well again totally undermine

established commercial trade flows, with a major revenue reduction impact on producers. Therefore beef exporting countries cannot afford to be complacent regarding the implementation of measures to control or prevent BSE outbreaks.

- *Production cost increase*: The costs of implementing BSE risk reduction measures are borne by the government and the farmers. Governments need to erect and maintain an institutional framework to prevent and deal with outbreaks. Farmers are affected not only by additional costs on farm to comply with risk reduction measures, but also face lower beef prices during and after an outbreak. However recent trends in the reduction of some BSE measures and the adoption of similar risk management measures by other exporters have narrowed the production cost divide between beef exporting countries.
- *Vertical communication and alignment*: In order to restore the confidence in beef supply chains to provide BSE free beef, these chains had to become more efficient by improving communication and coordination between members of the supply chain.

#### **2.5.1.2 Foot and Mouth Disease (FMD)**

FMD is a highly contagious animal disease that reduces milk yield and permanently damages the hooves of the animal. Outbreaks can significantly disrupt livestock production, result in exports of beef and cattle being banned and require considerable resources to control and eradicate (Aftosa, 2007). It is a far bigger issue in intensive agriculture due to reduced profitability, as well as the fact that it is one of the key non-tariff barriers to trade imposed by countries which are FMD-free, but to varying degrees of severity (GIRA, 2010).

The cost of an FMD outbreak can be considerable as evidenced by the 2001 UK crisis which lasted from February to September of that year. The UK had been FMD free for 35 years, which partly explains why safeguards were lower and the industry slow to identify and contain rapid spread of



the disease. To recover FMD-free status was considered crucial to the meat industry and the UK government due to the fall in livestock prices as a result of the outbreak. The FMD outbreak in 2001 led to around 2000 farms being slaughtered-out and the destruction of over 10 million cattle and sheep. The total cost of the outbreak was put at £8 billion. Associated cases were also reported in Ireland and mainland Europe but these were quickly contained due to forewarning and also better biosecurity standards (GIRA, 2010).

Jarvis, Cancino and Bervejillo (2005b) used a two step quantitative model to analyze the effect of FMD on international beef markets using monthly data from 1990 to 2002 for seven major beef exporters and for 22 major importers. The first part of the study estimated the impact of FMD on the likelihood to trade using a Probit model. The authors tested 21 dummies capturing the FMD status of the exporter, the sanitary policy of the importer regarding FMD and the type of beef product. Sixteen of the 21 dummy variables were found to be highly significant, indicating that FMD was a major determinant of the probability to trade beef. The second part of the study focused on using Ordinary Least Squares (OLS) to estimate the effect of FMD on beef prices. The model indicated that FMD had a strong negative effect on beef prices, reducing prices by 15 to 30 percent. The model was also used to estimate how the eradication of FMD in Brazil and Uruguay would affect beef exports prices. Prices of chilled and frozen boneless cuts were predicted to rise by 4 and 19 percent for Brazil; and also rise 5 and 9 percent for Uruguay. The authors concluded that FMD impeded trade and accordingly reduced the prices received for beef originating from FMD countries.

The increasing use of regionalization in beef producing areas led to only affected areas being blocked from exporting, therefore allowing other regions to still export. This process has helped reduce the disruptive effects of national restrictions (GIRA, 2010). During the Uruguay Round (UR), numerous countries including the EU, the US and Canada, agreed to base sanitary policies on scientific evidence. As a result, these countries also began to import beef from countries where

FMD was indigenous, provided that the beef had been correctly processed and deboned (Jarvis, Cancino & Bervejillo, 2005a).

This section discussed the effect of animal disease outbreaks a country's ability to trade, advocating the inclusion of variables indicating animal disease outbreaks in the specification of the gravity model developed in Chapter four. The following section will discuss the influence of agricultural policy on beef trade by discussing prominent domestic agricultural policies and developments in global trade policy.

## **2.6 AGRICULTURAL POLICY**

Agricultural policy refers to a set of legislation and practices that affect the domestic agricultural sector and the trade in agricultural products. These policies are created by governments to ensure that the domestic agricultural sector is able to achieve societal objectives such as food security, food affordability or to protect domestic industries from foreign competition. Due to the potential of these policies to influence a countries ability to produce and trade beef products, it is necessary to review these policies to ensure that the model developed in Chapter four is able to capture the consequences of these policies, albeit indirectly, on the volume of beef trade.

### **2.6.1 Domestic agricultural policy**

Domestic agricultural policies differ between countries due to varying national interests, strengths of the farming lobby and differences in priorities between developed and developing economies. Due to this variation, this section will explore domestic agricultural policy in some of the leading beef importers and exporters. Agricultural policies that affect the beef industry in China, Russia, the US, Brazil and the EU will now be discussed.

### 2.6.1.1 *Chinese and Russian self-sufficiency*

In China and Russia government policy is actively directed to increase domestic production (GIRA 2010). In both countries, autocratic governments have allowed or encouraged significant increases in beef producer prices in order to stimulate production. Both governments accept the inevitable increase in consumer prices, but act when consumer prices become unreasonably high. The key point is that both consumer- and producer prices are considerably higher than in the past, resulting in domestic beef production in both countries to grow.

In Russia, the government has a strategic objective of decreasing import dependency from the current high level of meat imports. The price rise for beef was sufficient to attract considerable new investment in integrations which are rapidly increasing production. In order to protect investors, the Russian government imposes a range of import restrictions including: i) decreasing the import quota volumes, and keeping a high rate of tariff on over-quota shipments; and ii) using a variety of SPS barriers to impede imports.

The Chinese government has a strategic objective of maintaining the very high level of self-sufficiency, and having a dynamic domestic production base which will be sufficiently profitable to encourage farmers to stay in the countryside and to curb the economic motivation for urban migration. There are a variety of examples by which government policy is facilitating:

- Intervention buying of meat during 2009, to absorb surplus meat in the market at that time, to provide a floor to the producer price;
- providing extension services such as disease containment programmes and subsidized insurance to help rural producers become more productive;
- various SPS controls on imports and selective Tariff Rate Quota (TRQ) protection.

### **2.6.1.2 *US Farm Bill***

The key legislation for agriculture in the US is the Farm Bill, which provides limited direct support for domestic beef production, and continues meeting the objective of stimulating agriculture. The OECD estimated that in 2011, the value of commodity-specific support provided to beef and veal producers in the US was zero percent of farm gate receipts (OECD, 2012). Government support for the U.S. beef industry focuses on market access, research and development, and recovery assistance following natural disasters. Some examples are the Market Access Program (MAP) and the Foreign Market Development program (FMDP) operated by the USDA's Foreign Agricultural Service (FAS). Similar to MAP, the FMDP assists U.S. producers and exporters to develop new foreign markets and expand access in existing markets by promoting U.S. agricultural products (US ITC, 2008).

### **2.6.1.3 *Brazilian agribusiness expansion***

Brazilian government policies have been instrumental in shaping the evolution of Brazil's agricultural sector, as well as its current size and structure. Brazil's agricultural policies comprise a wide array of instruments that provide support in areas such as farm prices, research and development, market and income assistance, rural credit and agricultural financing, rural insurance, and export financing, as well as special programs that target small family farms. By and large, these policies have served to support the international competitiveness of Brazil's agricultural goods. In contrast, tax and environmental policies, as well as restrictions on foreign ownership of land, impose costs on agricultural producers and erode their competitiveness in export markets (US ITC, 2012). Agriculture is one of Brazil's most powerful and strategic industries, and expansion is expected to continue to serve growing domestic demand and exports. The government continues to actively push for improved international market access for a broad range of products in which Brazil is a competitive producer.

Through its control of the Brazilian National Development Bank (BNDES) the government has also been proactive in encouraging a concentration of the main Brazilian beef processors in Brazilian ownership and the expansion of these firms in other markets (GIRA, 2010). Within Brazil, the meat and poultry agribusinesses have experienced extensive consolidation in recent years, allowing them to reap ownership benefits from growing economies of scale. Particularly large acquisitions within Brazil include the merger of Sadia and Perdigão, two of Brazil's largest poultry companies, to create BRF; JBS' acquisition of Bertin, a major rival in the beef business; and Marfrig's acquisition of Seara Alimentos SA (Seara), formerly controlled by Cargill, all in 2009 (US ITC, 2012). The aim of this consolidation is to assist Brazilian firms to become major global players and promote the development of Brazilian agriculture (GIRA, 2010).

#### **2.6.1.4 EU Common Agricultural Policy (CAP)**

The CAP is the EU's system of agricultural subsidies and programmes that has had a vast impact on EU agriculture since its inception in 1957. The CAP budget was agreed until the year 2013, with the consultation and negotiating process for the revised CAP for 2014 being underway. Radical reform is unlikely as the CAP is still delivering the fundamental objectives of the Treaty of Rome and enables the EU to negotiate in international trade talks. Key trends in EU agricultural policy are as follows (GIRA, 2010):

- An inevitable trend toward less direct support to farmers;
- higher environmental compliance requirements to address climate change, reduce pollution, and enhance biodiversity;
- higher animal welfare, animal disease and food safety standards;
- increased market access;
- progress in trade negotiations without undermining domestic production;
- less market management, e.g. the abolition of milk production quotas in 2015.

EU beef producers benefit from government support from the CAP. Changes made to domestic policies such as the decoupling of direct support to beef producers in 1992 and the elimination of the intervention price in 2002 have reduced the incentives to produce beef in the EU (Ramos, Bureau & Salvatici, 2010). According to OECD data, domestic support provided to EU beef producers have declined from 69.35 percent of farm receipts in 2002 to 11.16 percent in 2011 (OECD, 2012).

### **2.6.2 Trade policy within the WTO framework**

Since the mid-1980's there was a general reduction in barriers to trade, mostly encouraged by the UR settlement in 1994, as well as bilateral agreements made within the framework of the General Agreement on Tariffs and Trade (GATT) and subsequently the WTO. In addition to lower tariffs in the main importing countries, there have been major reductions in export support measures, most notably in the EU. These trends have contributed significantly to the increase in the world trade in beef from 10.5 percent in 1980 to 14.5 percent in 2012 (USDA FAS, 2011a). Despite these reductions, levels of protection for the meat and livestock sector remain at a high level, particularly for beef. Additionally the situation varies considerably for different parts of the world. This section will discuss pivotal agricultural trade policy developments within the WTO framework and highlight the positions taken by selected countries during the latest round of WTO negotiations, namely the Doha Round.

The GATT, the predecessor of the WTO, was established in Geneva in 1947. The goal of the GATT was to establish a framework that would regulate international trade and stimulate international commerce (FAO, 1998). Since 1947, eight GATT negotiating rounds were held to further expand and develop the rules created during its inception. Due to the unique role of agriculture in its provision of food security, the sector was largely excluded from seven of these rounds. Agricultural

sectors across the world benefited from either the exemption or lack of key GATT rules (FAO, 1998):

- Quantitative restrictions on agricultural commodities were allowed if these commodities were subject to domestic production restrictions, domestic price stabilisation or price support policies.
- Agricultural export subsidies were allowed upon the observance of “equitable” market shares. However due to the vagueness of the condition, the amount of subsidies increased rapidly.
- Due to variable import levies and domestic subsidies not being covered by the GATT, policy makers were able to protect the agricultural sector.

It was only during the last round of the GATT, the UR, that agriculture received significant attention in negotiations. Issues related to comparative advantages, world market instabilities and the effects of protectionism were among the reasons for this inclusion. During the UR it was increasingly realised that an institutional framework enabling greater clarification and enforcement of the procedures and commitments under the GATT was needed. This led to the subsequent creation of the WTO and replacement of the GATT on January 1, 1995 under the Marrakech Agreement. The WTO provides a framework for negotiating trade agreements as well as a dispute resolution process aimed at enforcing adherence to WTO agreements. The bulk of the WTO’s current work comes from the 1986–94 negotiations called the UR and earlier negotiations under the GATT (WTO, 2011).

#### **2.6.2.1 *The Uruguay Round***

The UR of WTO negotiations was the source of dramatic change for agricultural policy in many countries world-wide. It was for the first time in history multilateral trade negotiations, where a large group of countries agreed on a set of principles and disciplines that were aimed at correcting the trade distortions caused by the agricultural policies of the past. Even though global trade negotiations existed from 1947 in the form of the WTO predecessor, the GATT, it was not until

after the conclusion of the UR that countries agreed to apply to agriculture similar trade disciplines governing international commerce in manufactured goods, hence the UR is noted as a round of negotiation that marked a historical change in agricultural trade.

The Agreement on Agriculture (AoA) developed during the UR brought agricultural policies of member countries under multilateral rules and disciplines. The long-term objective of the AoA was to establish a fair and market-oriented agricultural trading system through significant and progressive reductions in agricultural support and protection. The Agreement includes specific commitments by WTO members to advance market access, to lessen domestic support and export subsidies which distort the production and trade of agricultural products. The AoA also aimed to reduce surplus production caused by mounting levels of support and protection in a number of developed countries during the 1980s and early 1990s (WTO, 1994).

#### **2.6.2.2 *The Agreement on Agriculture***

The AoA significantly changed the way agricultural goods were treated under the rules governing trade among WTO member countries. Under the Agreement, members agreed to significantly reduce support and protection previously provided to agricultural goods in the areas of market access, domestic support, and export subsidies (OECD, 1998). Other important developments for agricultural products included the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS) and Technical Barriers to Trade Agreement (TBT). The SPS was established to prevent members from instituting unfair and unjustifiable health and environmental regulations in order to protect trade in native agricultural products. The TBT included the technical requirements relating to SPS measures, such as product content requirements, processing methods and packaging.

Before the AoA was established, trade in agricultural goods were exempted from a large number of rules and principles that applied to manufactured goods, and as a result were largely ineffective at



creating a fair and disciplined trade environment among WTO members. Prior to the AoA, many members:

- provided significant support to their agricultural industries and employed export subsidies to dispose of excess production, which artificially lowered world market prices for agricultural goods.
- applied high levels of tariff protection and established nontariff barriers such as prohibitions, import quotas and licensing requirements. These measures inhibited the transmission of global market prices to domestic markets and limited trade in agricultural goods.

Earlier negotiating rounds of the GATT focused on reducing the level of tariff protection applied to agricultural goods, even though other forms of trade distortion beyond tariffs had significant and often larger effects on agricultural trade (OECD, 1998). It became clear that members had to adjust domestic policies to achieve effective liberalization of agricultural trade.

The UR was the first round of multilateral negotiations that treated agricultural trade in a truly comprehensive manner (OECD, 1998). In the present WTO Agreement on Agriculture that was concluded in 1994 under the UR, separate provisions were agreed for three categories of support, namely market access, domestic support and export subsidies. Measures that restrict and distort agricultural markets were subjected to agreed reductions and limitations, as these measures would fall within at least one of these categories.

### **2.6.2.3     *The Agreement on Sanitary and Phytosanitary measures (SPS)***

A separate agreement in the UR, the SPS Agreement, also had a significant role in liberalizing agricultural trade. The SPS Agreement aimed to reduce trade distortions created by abusing valid food safety and animal and plant health measures. SPS measures must be based both on scientific principles and applied only to protect human, animal, or plant life. These measures may not be applied as a disguised trade barrier or discriminate unjustifiably between members where the same

conditions prevail. Members were encouraged to base SPS measures on international standards and to recognize the standards of the trade partner when the same degree of protection is provided (USDA ERS, 2012).

#### **2.6.2.4 *An overview of current WTO negotiations with regard to meat***

The current trade-negotiating round of the WTO, called the Doha Round (DR), commenced in November of 2001 with the aim of lowering trade barriers across the world in order to facilitate global trade (Fergusson, 2008). Agriculture has become the most important and controversial issue during the DR. The US is being requested by the EU and developing countries to further reduce trade-distorting domestic support for agriculture. The position of the US on the other hand is that the EU and developing countries need to make substantial reductions in tariffs and limit the number products that would be exempt from tariff reductions. Import-sensitive products are important to developed countries like the EU, while developing countries focus on special products that are exempted from tariff cuts and subsidy reductions due to development, food security, or livelihood considerations (Hanrahan, 2005). The DR was due to conclude a final agreement in Hong-Kong in December 2005, but talks broke down during July of 2008 due to members failing to reach a compromise on agricultural import rules. Currently there is no indication of when talks will resume again, although there have been attempts made to resume the negotiations during May of 2012 (WTO, 2012).

It was initially expected that the WTO DR would be one of the dominant forces for change in the global meat sector, by reducing import tariff and quota protection, forcing increased market access, removing export aids, and reducing domestic production support measures. These changes would have enhanced the trade in meat from the lowest cost producing regions into higher cost and price markets. However as negotiations at the DR continued, it became apparent that domestic food security has become the dominant driver behind negotiations, and that agricultural and trade policy

for many of the key countries has shifted to encourage and defend domestic production, and to limit the increase in import access to volumes which will not undermine domestic food security (GIRA, 2010).

This section discussed the influence of agricultural policy on beef trade by discussing prominent domestic agricultural policies and developments in global trade policy. The review of domestic agricultural policies indicated that these policies mostly affected beef production, whereas trade policies focused on increasing market access and reducing domestic support and export subsidies. By including variables for beef production and tariff protection in the specification of the gravity model developed in Chapter four, the effects on beef trade of agricultural policy can be estimated.

## **2.7 SUMMARY**

Traditional gravity models focused on aggregate trade in all goods and services between countries, and hence included variables that are relevant to aggregate trade between countries. However, the advent of disaggregated trade and agricultural data has allowed researchers to study variables that are more applicable to a specific agricultural product such as beef. This chapter provided a detailed discussion on the trends and issues in beef production, consumption, trade and agricultural policy in order to gain an understanding of how these trends and issues influence international beef trade. The knowledge gained from this chapter informs the researcher on the issues (represented by variables) that need to be considered in the specification of the gravity model that will be developed in Chapter 4.

# CHAPTER 3

## METHODOLOGY OF THE STUDY

### 3.1 INTRODUCTION

This chapter will focus on relevant literature related to the study. The first section motivates the use of gravity model methodology to achieve the objectives of this study. Thereafter, sections will be devoted to the theoretical foundations-, the mathematical derivation- and the development of the traditional gravity equation. These sections will be followed by discussions regarding the methodological problems associated with traditional gravity models and the proposed use of Poisson Pseudo Maximum Likelihood (PPML) estimators as a replacement for traditionally used Ordinary Least Squares (OLS) estimators. The last section will focus on the methodological issues created by zero-valued trade flows and reviews research that indicate PPML estimators are ideally suited to accommodate these values.

### 3.2 MODEL CONSIDERATION AND MOTIVATION

As was mentioned in Chapter 1, the primary objective of this study is to validate and quantify the factors that drive and influence international beef trade in order to facilitate and improve the decision-making behaviour of policymakers. Gravity models possess several features that make these models the ideal framework to study international beef trade flows:

- Firstly, gravity models have proven to be successful explaining bilateral trade flows between countries and can be easily adapted to investigate specific factors that affect beef trade such as animal diseases and tariffs (Feenstra, 2004).
- Secondly, these models are also theoretically justified, empirically successful and the results estimated by these models are accepted by both international researchers and policymakers (see

Tinbergen, 1962; Pöynönen, 1963; Anderson, 1979; Bergstrand, 1985; Anderson & Van Wincoop, 2003, Feenstra, 2004).

- Thirdly, the gravity modelling methodology has received numerous improvements during the past decade; making results obtained from these models even more credible and robust (see Santos Silva & Tenreyro, 2006, 2011).
- Fourthly, gravity econometric equations are not sensitive to data, and hence could be estimated using various types of data, i.e. cross-section, time-series and panel data, depending on the type of research question to be addressed (see Bun & Klaassen, 2002).
- Lastly, the gravity equation makes use of raw data without reliance on prior estimation of various elasticities.

These features make the gravity model methodology the ideal framework to address the general objective of this dissertation, and will therefore be used as the primary tool to analyse the factors that drive and influence beef trade. Now that the use of the gravity model is motivated, the following section will discuss development of the theoretical foundation of the gravity model from first attempts by Linneman in 1966 to the recent contributions of Anderson and Van Wincoop in 2003.

### **3.3 THEORETICAL FOUNDATION OF THE GRAVITY MODEL**

Initially gravity models were developed on a mostly empirical basis, with researchers emphasizing that country size and transportation costs between countries were good predictors of trade volumes. Despite the success of employing gravity models in the empirical analysis of trade patterns, the gravity model was criticized for its lack of a strong theoretical foundation. Several authors have contributed to reconciling international trade theories with gravity model specifications.

Linnemann (1966) was amongst the first authors attempting to provide a theoretical foundation for the gravity model. Linnemann claimed that these models were essentially a reduced form of a

partial equilibrium model of export supply and import demand. However, this initial attempt was found to be inconsistent with the multiplicative form of the partial equilibrium model.

Anderson (1979) made the first formal attempt to provide a theoretical foundation for the gravity model. Using the properties of the expenditure demand function in economies that exhibited the same preferences for traded goods, Anderson derived a gravity model. This derivation rested on the assumption that goods were differentiated by country of origin (the so-called Armington assumption) and that consumers were assumed to have homothetic preferences across all regions, i.e. that consumers will demand goods in the same proportions when facing the same prices. This structure would imply that, whatever the price, a country will consume at least some of every good from every country. All goods are traded, all countries trade and, in equilibrium, national income is the sum of home and foreign demand for the unique good that each country produces. For this reason, larger countries would import and export more. Under these assumptions Andersons concluded that the gravity equation can be estimated from the properties of the expenditure system under both Cobb-Douglas and constant elasticity of substitution (CES) preferences.

Continuing the work of Linneman (1966), Bergstrand (1985) derived a gravity model using the general equilibrium framework. Bergstrand demonstrated that a gravity model could be derived from a sub-system of a general equilibrium model of world trade. Trade flows were found to be a function of a country's resources, transportation costs and trade barriers. These findings were based on the assumptions of perfect substitutability, single factor production and product differentiation.

Deardorff (1995) established a relationship between the gravity model and Heckscher-Ohlin theory of international trade by deriving the gravity model under two separate cases of the Heckscher-Ohlin theory. During the first case it was assumed that producers and consumers of homogeneous products are indifferent between trading partners, which is also known as the assumption of

frictionless trade. In the second case he considered countries that produce different goods and derived a gravity model with Cobb-Douglas preferences and then with CES preferences.

The most recent theoretical contribution to the gravity model literature is that the traditional specification of the gravity model bears an omitted variable bias, since this specification does not consider the effect of relative prices on trade. Anderson and Van Wincoop (2003) discovered that bilateral trade is not only affected by bilateral trade costs such as transportation costs or imports tariffs, but also on average weighted multilateral trade costs indices or multilateral resistance terms (MRT). Excluding these terms from the gravity model specification can result in the remaining parameter estimates in being biased, which makes MRT's a critical issue for modern gravity models.

This section illustrated that the gravity model's theoretic foundation was improved and that its use is now theoretically justified. The following section will demonstrate how the modern gravity equation can be derived from microeconomic expenditure functions.

### 3.4 DERIVING THE GRAVITY EQUATION

Now that the theoretical foundation of the gravity model was discussed, it is now important to show that the gravity model can be mathematically derived from microeconomic expenditure functions (Baldwin & Taglioni, 2006). The first step of this derivation is to start with the expenditure share identity for a single good exported from the 'origin' country to the 'destination' country:

$$p_{ij}x_{ij} \equiv share_{ij}E_j \quad (1)$$

where  $x_{ij}$  is the quantity of bilateral exports of a single commodity from country 'i' to country 'j' (where 'i' represents the country of origin and 'j' the country of final destination),  $p_{ij}$  is the price of the good inside the importing country also called the 'landed price', i.e. the price of the imported good that is faced by customers in the importing country; and is measured in terms of the

numeraire. This makes  $p_{ij}x_{ij}$  the value of the trade flow measured in terms of the numeraire.  $E_j$  is the destination country's expenditure on goods that compete with imports, i.e. tradable goods. By definition,  $share_{ij}$  is the share of expenditure in country  $j$  on a typical variety made in country  $i$ .

The expenditure share is assumed to depend only on relative prices. Adopting the CES demand function and assuming that all goods are traded, the imported good's expenditure share is linked to its relative price by:

$$share_{ij} \equiv \left( \frac{p_{ij}}{P_j} \right)^{1-\sigma}, \text{ where } P_d \equiv \left( \sum_{k=1}^R n_k (p_{kj})^{1-\sigma} \right)^{\frac{1}{(1-\sigma)}}, \sigma > 1 \quad (2)$$

where  $p_{ij}/P_j$  is the real price of  $p_{ij}$ . Also,  $P_j$  is country- $d$ 's ideal CES price index,  $R$  is the number of countries from which country- $d$  buys goods, and  $\sigma$  is the elasticity of substitution among all varieties;  $n_k$  is the number of different commodities exported from country  $k$ . It is assumed symmetry of commodities by source-country to avoid introducing a variety index. Combining equation (1) and (2) yields a product specific import expenditure equation. The landed price in country- $j$  of goods produced in country- $i$  are linked to the production costs in country- $i$ , the bilateral mark-up, and the bilateral trade costs via:

$$p_{ij} = \mu p_i \tau_{ij} \quad (3)$$

where  $p_i$  is the producer price in country- $i$ ,  $\mu$  is the bilateral markup, and  $\tau_{ij}$  reflects all trade costs, natural and manmade. To keep the derivation simple, assume  $\mu = 1$  as in Dixit-Stiglitz monopolistic competition or perfect competition with Armington goods.

Equation 3, however indicates the landed cost of only a single commodity. For total bilateral exports from country 'i' to country 'j', multiply the expenditure share function by the number of symmetric commodities that country 'i' has to offer, namely ' $n_i$ '. Using upper case  $V$  to indicate to actual value of trade as:



$$V_{ij} = n_i (p_i \tau_{ij})^{1-\sigma} \frac{E_j}{p_j^{1-\sigma}} \quad (4)$$

Lacking data on the number of varieties  $n_i$  and producer prices  $p_j$  can be compensated by turning to country- $i$ 's general equilibrium condition. The producer price,  $p_i$ , in the exporting country- $i$  must adjust such that country- $i$  can sell all its output, either at home or abroad. Equation 4 indicates country- $i$  sales to each market. Summing over all markets, including country  $i$ 's own market, indicates the total sales of country- $i$  goods. Assuming markets clear, country  $i$ 's wages and prices must adjust so the country- $i$ 's production of traded goods equals its sales of trade goods. The total sales of country- $i$  goods can be stated as follows:

$$Y_i = \sum_{j=1}^R V_{ij}$$

Where  $Y_i$  is country- $i$ 's output measured in terms of the numéraire. Relating  $V_{od}$  to underlying variables with Equation 4, the market clearing condition for country- $i$  becomes:

$$Y_i = n_i p_i^{1-\sigma} \sum_{j=1}^R \left( \tau_{ij}^{1-\sigma} \frac{E_j}{p_j^{1-\sigma}} \right) \quad (5)$$

where the summation is over all markets. Solving this for  $n_i p_i^{1-\sigma}$ :

$$n_i p_i^{1-\sigma} = \frac{Y_i}{\Omega_i} \text{ where } \Omega_i \equiv \sum_{l=0}^R \left( \tau_{ol}^{1-\sigma} \frac{E_l}{p_l^{1-\sigma}} \right) \quad (6)$$

In Equation 6,  $\Omega_i$  measures what is called 'market potential' and measures the openness of country- $i$  to export to world markets. In the economic geography literature this openness is often measured by the sum of the real GDP of all country- $i$ 's trade partners divided by bilateral distance. Substituting Equation 6 into Equation 4:

$$V_{ij} = \tau_{ij}^{1-\sigma} \left( \frac{Y_i E_j}{\Omega_i p_j^{1-\sigma}} \right) \quad (7)$$

Equation 7 is a microeconomics based gravity equation. Taking the Gross Domestic Product (GDP) of country-i as a proxy for its production of traded goods, and country-j's GDP as a proxy for its expenditure on traded goods, can be re-written to appear similar to the physical law of gravity.

$$bilateral\ trade = G \frac{Y_i Y_j}{(D_{ij})^{elasticity-1}} \text{ where } G \equiv \frac{1}{\Omega_i P_j^{1-elasticity}} \quad (8)$$

where the Y's are the countries' GDPs and it is assumed that bilateral trade costs depend only upon bilateral distance  $D_{ij}$  in order to make the economic gravity equation resemble the physical one as closely as possible. G in Equation 8 is not a constant as it is in the physical world however, and is referred to as the gravitational un-constant since it includes all bilateral trade costs and will therefore vary over time.

This section validated that the gravity model can be mathematically derived from microeconomic expenditure functions. The following section will demonstrate how the gravity model evolved from its initially simple specification into the log-normal specification that became one of the most commonly used analytical tools to investigate international bilateral trade flows.

### 3.5 THE DEVELOPMENT OF THE TRADITIONAL GRAVITY EQUATION

Gravity models were first applied to international trade by Tinbergen (1962) and Pöyhönen (1963). Tinbergen developed a model to determine the trade that would occur among 42 countries when trade barriers were removed. Pöyhönen (1963) presented a "tentative trade volume" model to analyze trade flows of ten European countries. The gravity equation for trade states that exports from country i to country j are proportional to the product of the economic masses, and inversely proportional to the geographic distance between the two countries. This simplistic gravity model can be expressed as follows:

$$X_{ij} = G \left( \frac{M_i^{\beta_1} M_j^{\beta_2}}{D_{ij}^{\beta_3}} \right) \eta_{ij} \quad (9)$$

where  $X_{ij}$  represents the volume of trade between countries  $i$  and  $j$ ,  $G$  is the gravitational unconstant,  $M_i$  refers to the economic mass of the exporting country,  $M_j$  refers to the economic mass of the importing country,  $D_{ij}$  is the geographical distance between the countries,  $\beta_1$  refers to the potential to create exports,  $\beta_2$  refers to the importers potential to attract imports,  $\beta_3$  reflects the impedance of trade as distance changes, and  $\eta_{ij}$  represents the error term. Taking the logarithm on both sides of the basic gravity Equation 9 and adding a random disturbance variable, the gravity model can be converted into the following equation:

$$\ln X_{ij} = \beta_0 + \beta_1 \ln M_i + \beta_2 \ln M_j - \beta_3 \ln D_{ij} + \varepsilon_{ij} \quad (10)$$

where  $\varepsilon_{ij}$  represents an independent and identically distributed error term (note that  $G$  becomes part of  $B_0$ ). Equation 10 represents the gravity model in a linear stochastic form, which is better known as the empirical or traditional gravity model (Burger, Linders & Van Oort, 2009). This basic gravity model can easily be augmented to include other variables, such as the presence of a border or trade agreement (Feenstra, 2004).

Gravity models were initially developed on an empirical basis, and emphasized the role of country size and the geographical distance between countries as sufficient predictors of trade. Anderson and Van Wincoop (2003) however argued that using a remoteness variable which solely depended on distance does not capture all the factors affecting bilateral trade. Subsequently, gravity models using the remoteness-variable approach were deemed to suffer from an omitted variable bias.

To solve this bias, Anderson and Van Wincoop (2003) altered McCallum's (1995) gravity equation (in which bilateral trade flows depend on country output, distance from the trade partner and the presence of a border) by including multilateral resistance terms (MRT's), which consist of price indices of the trading countries. Since multilateral resistance variables are not observable, the authors proposed the use of both importer and exporter fixed effects to substitute the resistance

variables. Formally the log-normal fixed-effects specification of the basic gravity model (including only geographical distance as a barrier to trade) would be the following equation:

$$\ln X_{ij} = \beta_0 + \beta_1 \ln M_i + \beta_2 \ln M_j - \beta_3 \ln D_{ij} + \gamma_i + \lambda_j + \varepsilon_{ij} \quad (11)$$

where  $\gamma$  is the fixed effect of the exporting country and  $\lambda$  is the fixed effect of the importing country. Equation 11, known as the Anderson and Wincoop- or log-normal specification of the gravity model was one of the most commonly used analytical tools to investigate international bilateral trade flows (Burger, Linders & Van Oort, 2009).

### 3.6 CRITICISMS OF THE TRADITIONAL GRAVITY MODEL

Recent efforts to derive a theoretically founded gravity equation have identified a number of mistakes found in modern gravity model studies. In order to produce research that is credible and robust, these mistakes and the methods to address them are of utmost importance when developing a gravity model to study international beef trade flows. The first set of mistakes relate to how the data is treated and the subsequent statistical implications that these have on the estimation results. Baldwin and Taglioni (2006) identified these mistakes as the gold, silver and bronze mistakes, respectively:

- **Gold medal mistake:** Traditionally, the gravity equation uses the natural logarithm of GDPs (and possibly other variables) as proxies for importer- and exporter-specific factors and omits the multilateral resistance terms discussed in the previous section. The omitted MRT's are however correlated with trade costs and lead to estimations being biased. The gold medal mistake can be avoided in cross-sectional data studies by including dummy variables for importers and exporters as proxies for MRT's. In panel data applications the researcher needs to add time dummy variables and use random effects estimators when estimating important time invariant variables such as the distance between the trading partners (UN, 2012).

- Silver medal mistake: The second common mistake found in traditional applications is when researchers use the average of imports and exports as the dependant variable. The theoretically founded gravity model suggests that trade should preferably be treated separately each way, i.e. either as exports from Country A to Country B at time  $t$  being one observation, or exports from Country B to Country A at time  $t$  another. Therefore the researcher should either choose imports or exports as the dependant variable, not the average of the two.
- Bronze medal mistake: The third mistake is to deflate trade and GDP data using a price index. The gravity equation is an expenditure function allocating nominal GDP into nominal imports. Although it is easy to deflate GDP using national price indices, very few nations have accurate trade price indices. Therefore inappropriate deflation of import or export data using national price indices will create biases via spurious correlations. Note, however, that time dummies or country effects eliminate the bronze medal mistake. Therefore, if the researcher corrects for the gold medal mistake, the bronze medal mistake is automatically resolved (UN, 2012).

The second set of mistakes relates to the log-linearization of the gravity model (see Equation 11) and the inability of regularly used regression techniques to provide unbiased, efficient and consistent results. Firstly, the logarithmic transformation in Equation 11 changes the nature of the estimation process, generating estimates of the  $\ln(X_{ij})$ , not of the actual values  $X_{ij}$ . For a long time economists applying gravity models to trade-flow analysis ignored Jensen's inequality, which implies that the expected value of the logarithm of a random variable is different from the logarithm of its expected value, or  $E(\ln y) \neq \ln E(y)$ . Subsequently, the concavity of the log function would create a downward bias when using Ordinary Least Squares (OLS) to estimate the gravity equation. This may lead to the antilogarithms of these estimates to be biased, which will result in the under-prediction of large or total trade flows (Haworth & Vincent, 1979; Flowerdew & Aitken, 1982; Santos Silva & Tenreyro, 2006).

Secondly, the practice of interpreting the parameters of the log-linearized traditional model estimated by OLS as elasticities is based on the assumption of homoscedasticity, which requires that all pairs of data need to have the same variance. This is a strong assumption that is not likely to be met when using empirical data consisting of sometimes thousands of pairs of data. If this condition is not met, both the efficiency and the consistency of the estimators may be compromised (Santos Silva & Tenreyro, 2006).

Thirdly, the traditional model used in trade-flow analysis cannot process zero-valued trade flows, since a logarithm of zero is undefined. These flows are found in data representing countries that do not trade due to trade policies or large transaction costs (Frankel, 1997; Ghazalian, Tamini & Gervais, 2007). In data considering only a single commodity such as beef, zero-valued trade flows are common since not all countries possess the same ability to produce or demand a single commodity. Therefore when investigating bovine meat trade flows, zero-trade flows and how they are dealt with is an important consideration.

The most common methods to avoid the issue of zero-valued trade flows is to either omit zero-valued data pairs or to randomly add a positive value to every trade flow in order to allow for defined logarithms (Linders & de Groot, 2006). By omitting a zero-valued trade pair, or truncating the data, necessary information regarding small trade flows will not be considered by the model (Eichengreen & Irwin, 1998). Truncation of data may therefore lead to biased results, especially when the data omitted is not randomly distributed. Regarding the second method, altering data not only lacks empirical or theoretical justification, but small changes in the data can lead to drastically different results (Flowerdew & Atkin, 1982; Linders & de Groot, 2006, Santos Silva & Tenreyro, 2006). Therefore both of these methods should be avoided.

The discussion above illustrates the need to use alternative regression techniques when estimating gravity equations. Even though related fields such as regional science and quantitative geography

have already noted the dangers of using the log-normal specification (Senior, 1979; Flowerdew & Aitkin, 1982; Bohara & Krieg, 1996), the international economics discipline has only recently started developing improved gravity models (Haveman & Hummels, 2004; Linders & de Groot, 2006; Santos Silva & Tenreyro, 2006, Helpman, Melitz & Rubenstein, 2008). Poisson and modified Poisson models were subsequently developed in order to address the problems of using traditional gravity models. The next section will discuss and focus on the Poisson Pseudo-Maximum Likelihood (PPML) estimation method and how this method is superior to traditional estimation methods used in gravity modelling.

### **3.7 POISSON PSEUDO-MAXIMUM LIKELIHOOD GRAVITY MODELS**

Santos Silva and Tenreyro (2006) suggested that the PPML specification of the gravity model does not suffer from the same problems as the traditional OLS model as discussed in the previous section. Firstly, the Poisson gravity model creates estimates  $X_{ij}$  and not  $\ln(X_{ij})$  due to the fact that it is based on a log-linear function instead of a log-log function, avoiding under-prediction of large or total trade flows. Secondly, the Poisson regression estimates are both efficient and consistent in the presence of heteroscedasticity. The authors found that heteroscedasticity is an often underestimated issue for gravity models and that elasticities estimated by OLS are misleading if it is present in the data. Heteroscedasticity refers to the situation in which the variation in the dependant variable is not consistent over all levels of the explanatory variable.

As a hypothetical example of heteroscedasticity as it would relate to this research, consider the influence of income per capita on beef demand and the subsequent influence on beef trade. As discussed in the previous Chapter, there exists a strong positive relationship between increasing income and beef consumption at lower income levels, and a weaker positive relationship at higher income levels. Therefore the explanatory variable, namely income per capita in the importer, will have lesser effects on the dependant variable, namely the volume of beef traded to supply the

demand, as the income per capita in the importer increases. It is therefore important for the estimation method used in this study to be able to provide reliable estimates in even in the presence of heteroscedasticity. The interpretation of the coefficients from the Poisson model is also straightforward, and follows exactly the same pattern as under OLS. Although the dependent variable for the Poisson regression is specified as exports in levels rather than in logarithms, the coefficients of any independent variables entered in logarithms can still be interpreted as simple elasticities.

Poisson estimators are also able to naturally include observations for which the observed trade value is zero. Such observations are dropped from the OLS model because the logarithm of zero is undefined. Dropping zero observations necessitated by the traditional OLS estimation method leads to sample selection bias, which has become an important issue in recent empirical work. Thus the ability of Poisson models to include zero observations naturally and without any additions to the basic model is highly desirable for this research due to beef trade data presenting zero trade values in many years among the countries selected.

As an alternative estimation method, Silva and Tenreyro (2006) have suggested that the model should be estimated in its multiplicative form:

$$X_{ij} = \exp(\beta_0 + \beta_1 \ln M_i + \beta_2 \ln M_j - \beta_3 \ln d_{ij}) \eta_{ij} \quad (12)$$

using a PPML estimator usually used for count data. Santos Silva and Tenreyro (2006) used PPML estimators to generate estimates for both the traditional gravity equation introduced by Tinbergen (1962) and a gravity equation that takes into account MRT's as suggested by Anderson and Van Wincoop (2003). In the presence of heteroscedasticity, the authors found that standard estimation methods such as OLS, Non-linear Least Squares (NLS), Gamma Pseudo-Maximum-Likelihood (GPML) or the Eaton-Tamura Tobit (ET-Tobit) can severely bias the estimated coefficients, casting doubt on previous empirical findings. The proposed PPML method was however found to be robust



to different patterns of heteroscedasticity and, in addition, provided a natural way to deal with zeros in trade data.

This section advocated the use of a PPML estimation method when estimating a gravity model to address issues associated with traditional estimation methods. There have however been recent criticisms on applying the PPML approach to gravity models when the dataset contains a large amount of zero trade flows. The next section will highlight these criticisms and discuss the zero-inflated gravity models that have been suggested as an improvement upon the PPML methodology.

### **3.8 METHODOLOGICAL ISSUES REGARDING ZERO-TRADE**

As mentioned earlier, agricultural bilateral trade flow data frequently contains large amounts of zero-valued trade flows, and that these values present a problem when estimating log-linear gravity equations. Many researchers have to either add an arbitrary number to each dependant variable or simply omit the observation completely. After studying bilateral trade flows of 46 agri-food products between 1990 and 2000 for 52 countries (Haq, Meilke & Cranfield, 2013) discovered that selection bias choosing only positive values does not often affect the signs of coefficients but does influence the magnitude, statistical significance and economic interpretation of these coefficients. Hence, treating zero trade flows properly is important from both a statistical and an economics perspective.

Martínez-Zarzoso, Novak-Lehmann and Vollmer (2007) as well as Martin and Pham (2008) argued that using PPML on gravity models severely biases estimates when zero trade flows are frequent. However Santos Silva and Tenreyro (2011) pointed out the simulations performed by these authors are unsatisfactory due to: i) the data used in these studies not being generated by a constant elasticity model; and ii) the probability of observing zero trade was independent of the value of the regressors. These results were therefore not relevant to measure the performance of alternative estimators for constant elasticity models.

Burger, Linders and Van Oort (2009) criticized the PPML on the grounds that although Poisson models are technically able to allow the researcher to study zero-valued trade flows, these models are not suitable if number of zero-valued trade flows in the sample exceeds the number of zero-valued trade flows that the model predicted. This is due to Poisson model assuming equidispersion, or that the conditional variance and -mean of the dependant variable should be equal, within the Poisson model. Instead of using PPML estimators, the authors recommended using negative binomial and zero-inflated Poisson estimators.

To clear any doubts of the usefulness of the PPML approach in gravity modelling, Santos Silva and Tenreyro (2011) used a Monte Carlo simulation in which data was generated by a constant elasticity model, the dependent variable had a large proportion of zeros, and the probability of observing a zero varied with the regressors. The results indicated that even when the conditional variance was far from being proportional to the conditional mean, the PPML estimates of  $B_1$  were only biased by 3.5 percent when the sample size was a 1000 observations. This bias however decreased to 0.5 percent when the sample size was increased to 10 000 observations. Simulating estimates using the ET-Tobit estimator as recommended by Martin and Pham (2008) yielded biases of 45 percent under both sets of sample sizes. These results confirmed that the Poisson pseudo-maximum likelihood estimator is generally well behaved, even when the conditional variance is far from being proportional to the conditional mean. Moreover, the fact that the dependent variable has a large proportion of zeros did not affect the performance of the estimator.

Santos Silva and Tenreyro (2012) noted that using the negative binomial- and zero-inflated Poisson models feature an important drawback when applied to gravity modelling. Both these suggested alternatives to the PPML are not invariant to the scale of the dependant variable. Therefore measuring the dependant variable in tons or in thousands of tons will lead to different estimates of the elasticities, which is unacceptable. Santos Silva and Tenreyro (2012) stated that although some estimators may perform better than PPML estimators in very specific conditions, to their

knowledge, all the proposed alternatives to PPML were either simply invalid or valid only under unreasonably strong distributional assumptions.

### **3.9 SUMMARY**

Far too frequently are econometric results accepted as the all-encompassing answers with more attention given to the results than to the methodology deriving the results (Meyer, 2002). The purpose of this chapter was to critically review the gravity modelling methodology itself, to identify faults with the traditional application of these models and to present recent contributions to address these issues. In order to conform to established international practices and benefit from the latest advances in the gravity modelling methodology, the model developed in the following chapter will address the three “medal” mistakes identified by Baldwin and Taglioni (2006), model the gravity model in the multiplicative form and employ the PPML estimation method as advocated in this chapter.

# CHAPTER 4

## MODEL DEVELOPMENT AND RESULTS

### 4.1 INTRODUCTION

This chapter presents the development of the gravity model used in this dissertation and the empirical results estimated by the model. The first section discusses the variables that were investigated in terms of the reasons these variables were selected, the expected relationship with the dependent variable and the source of data for that specific variable. The second section is devoted to discussing the specification of the model and motivations for using panel data and random effects estimators. Thereafter, the empirical results of two different model specifications are validated, presented and discussed. A comparison between the findings of this research to the findings of similar studies is provided in the last section of this chapter.

### 4.2 DATA AND VARIABLE SELECTION

Beef trade was analyzed among 20 countries (Argentina, Australia, Brazil, Canada, China, France, Germany, India, Italy, Ireland, Japan, Mexico, New Zealand, Paraguay, Russia, South Africa, South Korea, the United Kingdom, the United States and Paraguay) between 1996 and 2010, totalling 5700 observations for each of the two groups of meat investigated, namely chilled and frozen bovine meat. These specific countries were selected to represent leading importers and exporters of beef from different parts of the world. These countries accounted for 57.9 percent of world imports and 80.4 percent of world exports of chilled and frozen bovine meat during 2010 (ITC, 2012). The dataset was tested for signs of multicollinearity, or the situation when two or more of the explanatory variables are linearly related, which can cause the model to inaccurately estimate the coefficients of the related variables. After considering the correlation- and partial correlation

coefficients among the variables, none of these values indicated a value higher than 0.8, which is the recommended threshold to indicate if multicollinearity is problematic (Gujarati, 2003).

As described in the previous chapter, gravity models traditionally include variables that measure transportation costs and the potential to produce and consume tradable goods of both the importer and exporter. However, these models can be adapted to model other factors that are thought to influence trade by including additional variables, in which case the model is known as an augmented gravity model. Unlike traditional gravity models that model aggregate trade of all goods as the dependent variable, a commodity specific gravity model focuses only on trade flows of one specific commodity. This allows the researcher to incorporate variables in the gravity model that are unique to trade flows of a specific commodity. For example, the overview of the global beef market in Chapter 2 suggested that beef production and consumption, tariffs, income per capita, export prices and animal diseases play a significant role in global beef trade. These factors were included in the gravity model developed in this study and are discussed in more detail below.

#### **4.2.1 Volume of exports**

The volume of exports (measured in tons) was selected as the dependant variable of the model to represent trade flows between trade partners. Beef trade was investigated for two different groups of beef products, namely: bovine cuts boneless, fresh or chilled (HS<sup>4</sup> 020130); and bovine cuts boneless, frozen (HS 020230). In terms of volume, these products represented 34.08 percent and 51.19 percent of all bovine cuts traded between 1996 and 2010 respectively. Beef trade for an aggregate of these two products was also investigated. The values of the dependant variable coincided with the exports of the specific product (or aggregate) between two countries for a

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4 The Harmonized Commodity Description and Coding System (HS) of tariff nomenclature is an internationally standardized system of names and numbers for classifying traded products developed and maintained by the World Customs Organization (WCO).

selected year. The data used in this variable were collected from the United Nations Commodity Trade Statistics Database (UN IMTS, 2012). The volume of exports is denoted as  $x_{ijt}$  in the model, and possesses an importer-, exporter- and time dimension.

#### 4.2.2 Prices

The average price of exports was selected to represent export prices. In cases of actual trade, values were calculated by dividing the value of exports by the volume of exports. If no trade occurred during a specific year to a specific importer, the average yearly export price of that exporter was assumed. This variable was included in the model to estimate how prices affect beef exports. The *a priori* expectation is that prices will have a negative relationship with the volume of exports. This is because of the assumption that if an importer was to choose between importing from Country A or Country B, and the only difference between importing from these countries was the price of beef, a rational importer will choose to import from the country with that will supply the demand at the lowest price. In other words, as export prices increase, the observed volume of beef exports will decrease, and *vice versa*. Data for this variable were calculated from the United Nations Commodity Trade Statistics Database (UN IMTS, 2012). Export prices are denoted as  $p_{ijt}$  in the model, and possess an importer-, exporter- and time dimension.

#### 4.2.3 Distance and contiguity

As was mentioned in the previous chapter, one of the key notions of the gravity model is that as the distance between countries increases, the cost of transporting goods between these countries is assumed to increase. This notion implies that exporters will favour trading with importers in countries that are geographically closer than with importers in countries that are geographically distant, because the cost of transportation is lower in the former transaction than in the latter. A variable for the distance between the capitals of each trade partner and a dummy variable for geographically contiguity were selected to represent the cost of transportation. Geographic distance

was proxied by distance in kilometres between capital cities of exporting and importing countries. Both these measure implicitly assume that transportation costs do not vary depending on transport mode. The *a priori* expectation is that the model will estimate a negative relationship and a positive relationship for distance and contiguity respectively. Distance is denoted by  $d_{ij}$  and contiguity by  $contig_{ij}$  in the model and both possess an importer and exporter dimension.

#### **4.2.4 Exporter production, importer income per capita and importer consumption**

Traditional gravity models use the Gross Domestic Product (GDP) to represent the demand for all tradable goods in the importer and the supply of all tradable goods in the exporter respectively. However, in the case of a single commodity, GDP will not provide an accurate representation of the demand and supply of that specific commodity. More suitable proxies to represent the demand for beef in the importer would be beef consumption (in thousand tons) and income per capita (in thousand US dollar), while the capacity to supply beef of the exporter can be represented by beef production (in thousand tons). The *a priori* expectation is that the model will estimate that beef production in the exporter, beef consumption in the importer and income per capita in the importer all have a positive relationship with the volume of exports. Data was collected from the European Commission's (EC) EUROSTAT Statistics database (EUROSTAT, 2011), the United States Department of Agriculture Foreign Agricultural Service's Production, Supply and Distribution Database (USDA FAS, 2011a), and the International Monetary Fund (IMF, 2011). Beef production in the exporter and beef consumption in the importer is denoted by  $prod_{it}$  and  $cons_{jt}$  respectively, and both variables possess an importer and exporter dimension. Income per capita in the importer is denoted as  $inc_{jt}$  in the model, and has an importer and time dimension.

#### **4.2.5 Import tariffs**

Tariffs refer to taxes imposed by the government of an importing country on goods being imported by an exporting country. The model uses the applied *ad valorem* tariff (expressed as a percentage of

the value of the good) that was applied by the importer during 2010. The ideal situation would be to include data of tariffs applied for that specific year. Tariffs were not recorded in the World Bank's World Integrated Trade Solution Database if no trade occurred. To the best knowledge of the author, no database provides year-specific tariff data for the products investigated among all of the selected countries between 1996 and 2010. Fortunately, tariffs applied to beef products have remained fairly unchanged since 1994 after the Uruguay Round of trade negotiations mentioned in Chapter 2. Therefore modelling beef trade with a complete set of applied tariffs in 2010 is still a reasonable approach to model the effects of tariffs on beef trade flows. An equivalent of a tenth of a percent was added to allow for the logarithmic transformation. The *a priori* expectation is that the model will estimate a negative relationship between *ad valorem* tariffs and the volume of trade. This is due to the assumption that an exporter will rather export to a country where the applied *ad valorem* tariff is lower than to a country that applies a high *ad valorem* tariff, *ceteris paribus*. The data for this variable were collected from the International Trade Centre's Market Access Map database (ITC, 2011). The applied tariff is denoted by  $t_{ij}$  in the model, and possesses an importer and exporter dimension.

#### **4.2.6 Animal diseases**

As discussed in Chapter 2, animal diseases have had a profound impact on the dynamics of global beef trade. Other studies investigating meat trade flows using the gravity model methodology usually include a single dummy variable to either represent the presence of an animal disease in the exporter (see Yang, Saghaian & Reed, 2010; Kotchoni & Larue, 2011) or when a trade restriction is instituted against the exporter (see Tapia *et al.* 2011). The latter approach is more appropriate, since many countries in which FMD is indigenous still trade and face no formal trade restrictions, although these countries still need to take preventative measures. Therefore the mere presence of a disease is not enough to influence trade flows. In this study, six dummy variables were incorporated



into the model to represent periods in which selected importers were affected by trade restrictions related to Foot and Mouth Disease (FMD) or Bovine Spongiform Encephalopathy (BSE). The *a priori* expectation is that the model will estimate a negative relationship between the volume of exports and the trade restriction dummies. This is due to importers either ceasing or severely limiting imports from a country that poses a threat to consumers or domestic industries due to an animal disease outbreak.

These six variables are denoted in the model as follows:  $UKbseEU9606_{ijt}$  represents the trade restrictions imposed by the European Union (EU) on UK beef due to BSE between 1996 and 2006 (EU, 2006);  $USbseJAP0305_{ijt}$  represents the trade restrictions imposed by Japan on US beef due to BSE concerns between 2003 and 2005 (US ITC, 2008);  $USbseKOR0407$  denotes the South Korean ban on beef imports from the US between 2004 and 2007 due to BSE (US ITC, 2008);  $CANbseJAP0305_{ijt}$  represents Japanese import restrictions placed on Canadian beef between 2003 and 2005 (LeBlanc, 2008);  $URUfmdUS0103_{it}$  represents the trade restrictions imposed by the US on Uruguayan beef due to FMD between 2001 and 2003 (US ITC, 2008);  $ARGfmd0103_{it}$  represents the period between the 2001 outbreak of FMD in Argentina and the reinstatement of the country's "disease-free with vaccination" status by the World Organization for Animal Health (OIE, 2003).

**Table 4.1: Description of data used**

Variable	Observations	Unit	Mean	Standard Deviation	Minimum value	Maximum value
Volume of exports (Total)	5700	Ton	6856.18	35563.58	0	447329.5
Volume of exports (Fresh and Chilled)	5700	Ton	2740.17	18496.46	0	334186.8
Volume of exports (Frozen)	5700	Ton	4116.01	24956.83	0	447271.1
Price (Total)	5700	USD/kg	3.63	9.88	0.04	200.6224
Price (Fresh and Chilled)	5700	USD/kg	10.53	23.26	0.268017	200.6224
Price (Frozen)	5700	USD/kg	6.20	13.32	0.1	196.8571
Distance	5700	Thousand kilometers	9.54	4.86	0.22	19.63
Production	5700	Thousand ton	2234.47	2859.78	182	12427
Consumption	5700	Thousand ton	2140.08	2860.04	47	12833
Tariff (Total)	5700	Percent of value	0.24	0.18	0.0001	0.60
Tariff (Fresh and Chilled)	5700	Percent of value	0.25	0.22	0.0001	0.64
Tariff (Frozen)	5700	Percent of value	0.22	0.17	0.0001	0.61
UKBSEEU9606	5700	Dummy variable	N/A	N/A	0	1
USBSEJAP0305	5700	Dummy variable	N/A	N/A	0	1
USBSEKOR0407	5700	Dummy variable	N/A	N/A	0	1
CANBSEJAP0305	5700	Dummy variable	N/A	N/A	0	1
ARGFMD0103	5700	Dummy variable	N/A	N/A	0	1
URUFMDUS0103	5700	Dummy variable	N/A	N/A	0	1
Contiguity	5700	Dummy variable	N/A	N/A	0	1
Income per capita of Importer	5700	Thousand USD	18740.02	15297.17	390.219	59901.95

### 4.3 MODEL SPECIFICATION

The literature reviewed in the previous chapter advocates the use of the Poisson Pseudo Maximum-Likelihood (PPML) method for estimating gravity models for trade. Estimates from this method are robust, even with different patterns of heteroskedasticity. Additionally, this model is compatible with the presence of zeros in trade data. This is relevant to this study, not only because of the

presence of heteroskedasticity inherent in trade flow data, but also because UN COMTRADE beef trade data presents zero trade values in many years among the countries selected. The specification of the multiplicative gravity model used in this study is denoted as follows:

$$\begin{aligned}
 x_{ijt} = & p_{ijt}^{\beta_1} d_{ij}^{\beta_2} prod_{it}^{\beta_3} cons_{jt}^{\beta_4} t_{ij}^{\beta_5} inc_{jt}^{\beta_6} \exp(\beta_7 contig_{ij} + \beta_8 UKbsebanEU9606_{ijt} + \\
 & \beta_9 USbsebanJAP0305_{ijt} + \beta_{10} USbsebanKOR0407_{ijt} + \\
 & \beta_{11} CANbsebanJAP0305_{ijt} + \beta_{12} UKfmd2001_{it} + \beta_{13} ARGfmd0103_{it} + \\
 & exporter_i + importer_j + time_t) \eta_{ijt}
 \end{aligned} \tag{13}$$

where:

- $x_{ijt}$ : Trade flow volume in ton from exporter i to importer j at time t.
- $p_{ijt}$ : Average price of export in US dollar per kilogram from exporter i to importer j at time t.
- $d_{ij}$ : Distance in thousand kilometers between exporter i and importer j.
- $prod_{it}$ : Production quantities in thousand ton of exporter i at time t.
- $cons_{jt}$ : Consumption quantities in thousand ton of importer j at time t.
- $t_{ij}$ : *Ad valorem* tariff applied by importer j to product originating from exporter i during 2010.
- $inc_{jt}$ : Income per capita in US dollars of importer j at time t.
- $contig_{ij}$ : Dummy variable indicating if importer j and exporter t are contiguous.
- $UKbseEU9606_{ijt}$ : Dummy variable indicating the period during which the EU banned imports from the UK due to BSE risk.
- $USbseJAP0305_{ijt}$ : Dummy variable indicating the period during which Japan banned imports from the US due to BSE risk.

- $USbseKOR0407_{ijt}$ : Dummy variable indicating the period during which South Korea banned imports from the US due to BSE risk.
- $CANbseJAP0305_{ijt}$ : Dummy variable indicating the period during which Japan banned imports from Canada due to BSE risk.
- $URUfmdUS0103_{ijt}$ : Dummy variable indicating the period during which Uruguayan beef were restricted to enter the US due to FMD.
- $ARGfmd0103_{it}$ : Dummy variable indicating the 2001 outbreak of FMD in Argentina and the reinstatement of the country's "disease-free with vaccination" status by the OIE in 2003.
- $exporter_i$ : Exporter dummy variable.
- $importer_j$ : Importer dummy variable.
- $time_t$ : Time dummy variable.
- $\eta_{ijt}$ : Error term.
- If  $E(\eta_{ijt}|x) = 1$ : According to Silva and Tenreyro (2006, p.644).

Then, equation 13 can be written as an exponential function:

$$x_{ijt} = \exp(\beta_1 \ln p_{ijt} + \dots + time_t) + \varepsilon_{ijt} \quad (14)$$

Traditional gravity models estimate gravity equations using cross-sectional data. However, standard cross-section estimates of the gravity model yield biased estimates of the volume of bilateral trade because unobserved differences among the country pairs is not considered. Consequently, results may vary substantially depending on the countries selected, leading to an estimation bias. To mitigate this problem, researchers have turned towards panel data, that is, gravity models that study trade between the same cross-sectional units (importer and exporter pairs) for several consecutive years (Egger, 2000; Rose & Van Wincoop, 2001; Egger & Pfaffermayr, 2003; Glick & Rose, 2002; Brun *et al.*, 2002; Melitz, 2007). The use of panel data, with a time dimension in addition to

the traditional importer and exporter dimensions, can address the issue of unobservable heterogeneity of country pairs by introducing three specific effects: exporter, importer, and time dummy variables (see Matyas 1997; Soloaga & Winters 2001). Furthermore, as Baltagi (1995) states, panel data also give “more informative data, more variability, less collinearity among variables, more degrees of freedom and more efficiency” when compared to time series and cross-section data.

Using random effects estimators preserves the possibility of separately estimating the effect of bilateral time-invariant factors (variables that only possess an importer and exporter dimension) such as distance, contiguity and tariffs. Although the majority of gravity models are estimated using fixed effects estimators using cross sectional data, estimating the coefficient of a bilateral time-invariant variable using panel data is not possible with fixed effect estimation due to importer- and exporter dummy variables being perfectly collinear with the time invariant variables. Fixed effects specifications were tested, but results estimated under these specifications showed no significant difference to results estimated by the random effects specification. Random effects estimators also remove the serial correlation associated with panel data (Murray, 2005). A panel data PPML estimation with Random Effects estimators was performed using Stata/IC package version 12.

#### **4.4 EMPIRICAL RESULTS**

The results of estimating the proposed model with the variables discussed above are presented in Table 4.2 and Table 4.3. The model was estimated using two separate equations, hereafter referred to as Model B1 and Model B2, each based on 5700 observations. Model B1 was estimated with the full gravity model as specified above, including average prices  $p_{ijt}$ . The average price of exports can serve as a good indication for exports prices of single commodities. Since very few studies on commodity specific gravity models exist and, to the knowledge of the author, have never modelled beef exports prices directly, it was decided to run an additional equation with no price variable  $p_{ijt}$ .

The Model B2 was estimated with the full gravity model as specified above, but excluding average prices  $p_{ijt}$ . As mentioned above, for each of these equations the dependant variable varied to represent: bovine cuts boneless, fresh or chilled (HS 020130); bovine cuts boneless, frozen (HS 020230); and an aggregation of these two products designated as "Total beef". As each dependant variable changes, so does the data used for prices and tariffs, as these variables have product-specific values.

#### 4.4.1 Results estimated from Model B1

Most of the variables in equation 13 are expressed in natural logarithms, so coefficients obtained from the estimation can be read directly as elasticities. The elasticity of trade to distance, for instance, is usually between  $-0.7$  and  $-1.5$ , so a 10 per cent increase in distance between two countries reduces trade, on average, by 7 to 15 per cent (UNCTAD & WTO, 2012). Note, however, that while the coefficients for the natural logarithm of continuous variables (e.g. beef production and distance) are elasticities, the coefficients of dummy variables are not. Coefficients of dummy variables need to be transformed as follows in order to be interpreted as elasticities: elasticity =  $\exp(\text{coefficient}) - 1$  where  $a$  is the estimated coefficient of the dummy variable<sup>5</sup>. Table 4.2 shows the results of Model B1.

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<sup>5</sup> - To derive this formula, consider that  $\ln X_{ij}(1)$  is the predicted value of trade when the dummy is equal to 1, while  $\ln X_{ij}(0)$  is the value of trade when the dummy takes the value 0. It follows that the difference  $\ln X_{ij}(1) - \ln X_{ij}(0) = a$ , where  $a$  is the estimated coefficient for the dummy variable. It follows that  $X_{ij}(1)/X_{ij}(0) = \exp(a)$ , which in turn implies that the percentage change in trade value due to the dummy switching from 0 to 1 is:  $X_{ij}(1) - X_{ij}(0)/X_{ij}(0) = \exp(a) - 1$  (UNCTAD and WTO, 2012).

**Figure 4.2: Modelling results using the B1 model specification**

Dependant Variable: Volume of Exports (ton)	Total beef	Boneless fresh and chilled trade (HS 020130)	Boneless frozen trade (HS 020230)
Share in total beef trade of the HS0201 and HS0202 groups between 1996 and 2010 (%)	85.27	34.08	51.19
<i>Ln p</i>	-0.40208***	-0.41795***	-0.68973***
<i>Ln d</i>	-0.67201**	-1.3201***	-0.69167**
<i>Ln prod</i>	2.572775***	1.410325***	3.750958***
<i>Ln cons</i>	0.528191***	1.044816***	0.234588***
<i>Ln t</i>	-0.49432***	-0.37434***	-0.359***
<i>UKbseEU9606</i>	-1.30739***	-1.4672***	-0.85594***
<i>USbseJAP0305</i>	-0.69483***	-0.63169***	-0.74171***
<i>USbseKOR0407</i>	-2.58997***	-2.55368***	-2.55064***
<i>URUfmdUS0103</i>	-0.80624***	-0.41634***	-0.4129***
<i>CANbseJAP0305</i>	-1.91422***	-1.38599***	-2.25039***
<i>ARGfmd0103</i>	-0.48844***	-0.1297***	-0.88118***
<i>Contig</i>	0.819673	2.012862**	0.487688
<i>Lninc</i>	0.982265***	0.924938***	1.010527***
Wald Chi-square (65)	4.19e+06	1.11e+06	3.82e+06
Prob>Chi-square	0.0000	0.0000	0.0000
Observations	5700	5700	5700
R-square	0.0965	0.0455	0.0650

\*\*\*, \*\*, \* denoted a significant test statistic at the 10 percent, 5 percent and 1 percent level respectively.

Before discussing and testing the individual statistical significance of each independent variable, the Wald Chi-square test was performed to measure the overall significance of the estimated regression by testing the joint significance of the independent variables included in the model. Table 4.3 indicates that for each product group the Wald test rejected the hypothesis that the parameters associated with the independent variables were zero. Therefore, the selected independent variables

should be included in the model and the overall regression is significant for each of the product groups.

**Figure 4.3: The Wald test**

Null hypothesis: $H_0: \beta_1 = \dots = \beta_{13} = importer_1 \dots importer_{19} = exporter_1 \dots exporter_{19} = time_1 \dots time_{14} = 0$			
Product group	Wald Chi-square (65)	Probability > Chi-square	Accept or reject null hypotheses
Total beef	4.19e+06	0.0000	Reject
Fresh and Chilled beef	1.11e+06	0.0000	Reject
Frozen beef	3.82e+06	0.0000	Reject

The explanatory power of the model as measured by R-squared reported in the above specifications is rather low. The frequency of low R-squared values are, however, rather common in panel data models, as they are a combination of cross sectional and time series data. According to a study applying the gravity model by Ishutkina and Hansman (2009), cross-sectional models typically report low R-squared values when compared to the time-series models that provide R-squared values near one. On the same issue, another study by Schaefer, Anderson, and Ferrantino (2008) which conducted a Monte Carlo study to reach an optimal specification in gravity modelling also reported the commonality of having low values of R-squared in the application of fixed-effect panel models, despite significant F-statistics of the overall significance of the model. This same observation can be made in all of the specifications employed in this study. Although the reported R-squares are low, the Wald Chi-squared statistic of the overall significance of the model reported in Tables 4.2 and 4.3 is highly significant, the individual variables were significant and all of the estimates displayed the expected relationships.



#### 4.4.1.1 *Price coefficient*

As discussed above, the *a priori* expectation was that the model will estimate a negative relationship between the volume of trade and the average price of exports. Model B1 estimated price coefficients that were in accordance with *a priori* expectations for each of the product groupings. For "Total beef" exports an export price coefficient of -0.40 was estimated, indicating that a 10 percent increase in the average export price for both chilled and frozen beef products, the volume of exports on average decreases by 4 percent. The export price coefficient for fresh and chilled beef was estimated at -0.41, indicating that a 10 percent increase in the average export price will reduce the volume of exports by 4.1 percent on average. For frozen beef an export price coefficient of -0.68 was estimated, indicating that a 10 percent increase in the average export price for frozen beef products, the volume of exports will on average be reduced by 6.8 percent. These results indicate that the exports of frozen beef products are more sensitive to changes in exports prices than fresh or chilled beef products. This may be due to the fact that more competition is present in the market for frozen beef since it is traded in larger volumes compared to other beef products, representing 51.19 percent of all exports between 1996 and 2010. All of the results were statistically significant.

#### 4.4.1.2 *Distance and contiguity coefficients*

The *a priori* expectation was that Model B1 will estimate a negative relationship between the volume of trade and distance; and a positive relationship between the volume of trade and contiguity. Results estimated by Model B1 were in accordance with *a priori* expectations for each of the product groupings. The model estimated a distance coefficient of -0.67 for "Total beef", indicating that a 10 percent increase in the distance between trade partners decreases the volume of beef exports by 6.7 percent. The distance coefficient for fresh and chilled beef was estimated -1.32 by Model B1, signifying that a 10 percent increase in the distance between trade partners will

reduce the volume of exports by 13.2 percent. Model B1 estimated a distance coefficient of -0.69 for frozen beef. This value indicates that a 10 percent increase in the average export price for frozen beef products leads to the volume of exports being reduced by 6.9 percent. All of the results were statistically significant at the 5 percent level.

Since the variable representing contiguity is a dummy variable, results need to be transformed before being interpreted as elasticities. The contiguity coefficient for "Total beef" was estimated at +0.81 by Model B1, signifying that if trade partners are geographically contiguous, the volume of exports is on average increased by 126 percent. Model B1 estimated a contiguity coefficient of +2.01 for fresh and chilled beef. This value indicates that if trade partners are geographically contiguous, the volume of exports of fresh and chilled beef products is on average increased by 646 percent. The model estimated a contiguity coefficient of +0.48 for frozen beef, indicating that if trade partners are geographically contiguous the volume of frozen beef exports increase by 62.8 percent. Although all the estimates for contiguity estimated the expected positive relationship, contiguity was only statistically significant at the 5 level for the fresh and chilled beef group.

The results for distance and contiguity show that transportation costs do have a significant impact on the volume of beef exports. It is also noted that the model estimated results that show that transportation costs have a larger effect on fresh and chilled beef than on frozen beef. Generally frozen beef can be shipped easier over vast distances without becoming rotten than fresh or chilled beef.

#### **4.4.1.3 *Exporter production, importer income per capita and importer consumption coefficients***

The *a priori* expectation was that Model B1 will estimate a positive relationship between the volume of exports and production, consumption and income per capita. For "Total beef" exports a production coefficient of +2.57 was estimated, indicating that a 10 percent increase in beef

production of the exporter, the volume of exports on average increases by 25.7 percent for both chilled and frozen beef products. The production coefficient for fresh and chilled beef was estimated at +1.41, indicating that a 10 percent increase in beef production in the exporter will increase the volume of exports by 14.1 percent on average. For frozen beef a production coefficient of +3.75 was estimated, signifying that a 10 percent increase in beef production in the exporter, the volume of frozen beef exports will on average increase by 37.5 percent. All of these coefficients were statistically significant at the 1 percent level.

The model estimated a consumption coefficient of +0.52 for "Total beef", indicating that a 10 percent increase in beef consumption in the importer increases the volume of beef exports by 5.2 percent. The consumption coefficient for fresh and chilled beef was estimated +1.04 by Model B1, signifying that a 10 percent increase in the consumption in the importer will increase the volume of exports by 10.4 percent. Model B1 estimated a consumption coefficient of +0.23 for frozen beef. This value indicates that a 10 percent increase in the consumption of beef in the importer leads to the volume of frozen beef exports being increased by 2.3 percent on average. All of these coefficients were statistically significant at the 1 percent level.

For "Total beef" exports an income per capita coefficient of +0.98 was estimated, indicating that a 10 percent increase in the income per capita in the importer, the volume of exports on average increases by 9.8 percent for both chilled and frozen beef products. The income per capita coefficient for fresh and chilled beef was estimated at +0.92, indicating that a 10 percent increase in the income per capita in the importer will increase the volume of exports by 9.2 percent on average. For frozen beef an income per capita coefficient of +1.01 was estimated, indicating that a 10 percent increase in the average export price for frozen beef products, the volume of exports will on average increase by 10.1 percent. All of the results were statistically significant at the 1 level.

Model B1 estimated coefficients for production, consumption and income per capita that were in accordance with *a priori* expectations, indicating that a positive relationship exists between the volume of exports and these variables. Beef production in the exporter had a significantly positive effect on the volume of beef exports, indicating that leading beef producers tended to be able to export larger volumes. Beef consumption in the importer had a positive effect on the volume of beef exports, but to a lesser degree than beef production in the exporter. The model estimated coefficients for income per capita that indicate elasticities close to unity, showing that percentage increases in income per capita lead to similar percentage increases in the volume of exports on average.

#### 4.4.1.4 *Tariff coefficient*

The *a priori* expectation was that Model B1 will estimate a negative relationship between the volume of trade and the level of tariff protection imposed by the importer. The model estimated a tariff coefficient of -0.49 for "Total beef", indicating that a 10 percent increase in the level of tariff protection reduces the volume of beef exports by 4.9 percent. The tariff coefficient for fresh and chilled beef was estimated -0.37 by Model B1, signifying that a 10 percent increase in the *ad valorem* tariff rate in the importer will on average reduce the volume of exports by 3.7 percent. Model B1 estimated a consumption coefficient of -0.35 for frozen beef. This value indicates that a 10 percent increase in *ad valorem* tariff rate imposed by the importer leads to the volume of frozen beef exports being reduced by 3.5 percent on average. All of these coefficients were statistically significant at the 1 percent level. Model B1 estimated a coefficient for *ad valorem* tariffs that were in accordance with the *a priori* expectation, indicating that a negative relationship exists between the volume of exports and the level of tariff protection imposed by the importer.

#### 4.4.1.5 *Animal disease coefficients*

As discussed earlier in this chapter, the *a priori* expectation was that Model B1 will estimate a negative relationship between the volume of trade and the variables related to trade restrictions related to animal diseases. As with the contiguity variable, the variables representing trade restrictions due to animal diseases are dummy variables, and require results to be transformed before being interpreted as elasticities:

- For the dummy variable indicating the trade restrictions imposed by the EU on UK beef due to BSE between 1996 and 2006,  $UKbseEU9606_{ijt}$ , the model estimated that the volume of UK beef exports to the EU was reduced by 72 percent, 76 percent and 57 percent for "Total beef", fresh and chilled beef; and frozen beef respectively during that period. The results were statistically significant at the 1 percent level.
- Estimated coefficients for the dummy variable indicating the trade restrictions imposed by Japan on US beef due to BSE between 2003 and 2005,  $USbseJAP0305_{ijt}$ , show that the volume of US beef exports to Japan was reduced by 50 percent, 46 percent and 52 percent for "Total beef", fresh and chilled beef; and frozen beef respectively during that period. The results were statistically significant at the 1 percent level.
- For the dummy variable indicating the trade restrictions imposed by Korea on US beef due to BSE between 2004 and 2007,  $USbseKOR0407_{ijt}$ , the model estimated that the volume of US beef exports to Korea was reduced by 92.4 percent, 92.2 percent and 92.1 percent for "Total beef", fresh and chilled beef; and frozen beef respectively during that period. The results were statistically significant at the 1 percent level.
- The coefficients estimated for the dummy variable indicating the trade restrictions imposed by the US on Uruguayan beef due to FMD between 2001 and 2003,  $URUfmdUS0103_{ijt}$ , reveal that the volume of Uruguayan beef exports to the US was reduced by 55 percent, 34 percent and

33 percent for "Total beef", fresh and chilled beef; and frozen beef respectively during that period. The results were statistically significant at the 1 percent level.

- Estimated coefficients for the dummy variable indicating the trade restrictions imposed by Japan on Canadian beef due to BSE between 2003 and 2005,  $CANbseJAP0305_{ijt}$ , the model estimated that the volume of Canadian beef exports to Japan was reduced by 85 percent, 75 percent and 89 percent for "Total beef", fresh and chilled beef; and frozen beef respectively during that period. The results were statistically significant at the 1 percent level.
- For the dummy variable indicating the period between the 2001 outbreak of FMD in Argentina and the reinstatement of the country's "disease-free with vaccination" status by the World Organization for Animal Health,  $ARGfmd0103_{it}$ , the model estimated that the volume of Argentinean exports was reduced by 38 percent, 12 percent and 58 percent for "Total beef", fresh and chilled beef; and frozen beef respectively during that period.

The above mentioned results were in accordance with *a priori* expectations, indicating that a negative relationship exists between the volume of exports and the variables representing trade restrictions related to animal diseases. These results stress the importance of maintaining measures to prevent disease outbreaks, and in doing so maintain access to export markets.

#### **4.4.2 Results estimated from Model B2**

As mentioned earlier in this chapter, the average price of exports can serve as a good indication for exports prices of single commodities. However, since very few studies on commodity specific gravity models exist and, to the knowledge of the author, have never modelled exports prices directly, it was decided to run an additional equation excluding the price variable  $p_{ijt}$ . The Model B2 was estimated with the full gravity model as specified above, but excluding average prices  $p_{ijt}$ . Results estimated by Model B2 are presented in Table 4.4 on the following page.

**Figure 4.4: Modelling results using the B2 model specification**

<b>Dependant Variable: Volume of Exports (ton)</b>	<b>Total beef</b>	<b>Boneless fresh and chilled trade (HS 020130)</b>	<b>Boneless frozen trade (HS 020230)</b>
Share in total beef trade of the HS0201 and HS0202 groups between 1996 and 2010 (%)	85.27	34.08	51.19
$\ln p$	-	-	-
$\ln d$	-0.67965**	-1.40511***	-0.6742**
$\ln prod$	2.661152***	1.227846***	3.744824***
$\ln cons$	0.476519***	1.205483***	0.06615***
$\ln t$	-0.47862***	-0.36717***	-0.37573***
<i>UKbseEU9606</i>	-1.3595***	-1.52067***	-1.10388***
<i>USbseJAP0305</i>	-0.75305***	-0.63511***	-0.8483***
<i>USbseKOR0407</i>	-2.5249***	-2.42259***	-2.4547***
<i>URUfmdUS0103</i>	-0.52998***	-0.4334***	-0.36045***
<i>CANbseJAP0305</i>	-1.9472***	-1.45307***	-2.25337***
<i>ARGfmd0103</i>	-0.41465***	-0.01239***	-0.75909***
<i>contig</i>	0.479098	1.959757**	0.388316
$\ln inc$	0.847041***	0.708878***	0.890448***
Wald Chi-square (65)	4.49e+06	1.06e+06	3.82e+06
Prob> Chi-square	0.0000	0.0000	0.0000
Observations	5700	5700	5700
R-square	0.0920	.0452	.0637

\*\*\*, \*\*, \* denoted a significant test statistic at the 10 percent, 5 percent and 1 percent level respectively.

By comparing results estimated by Model B1 and Model B2, the effect of the inclusion of the export price variable  $p_{ijt}$  on the coefficients of the other independent variables included in the model can be observed. Although the values of the coefficients estimated by the two models differ slightly, all of the relationships and statistical significance of the variables remained the same. Therefore the conclusions being drawn regarding the independent variables, except for the export price  $p_{ijt}$ , of both these models will be the same.

## 4.5 RESULTS FROM SIMILAR STUDIES

Kotchoni and Larue (2011) pursued to measure the impact of trade barriers on international beef trade using Non-linear Least Squares (NLS) and NLS Frontier estimators. Results estimated by Kotchoni and Larue (2011) are presented in Table 4.5. The authors concluded that results from the NLS-Frontier estimator are preferred. The data used for this study describes 41 countries and covers the period 1995 to 2005. Although different values were recorded, similar and statistically significant relationships were recorded for distance, income per capita in the importer, tariffs and contiguity.

**Table 4.5: Gravity model results of Kotchoni and Larue (2011) using NLS Frontier model**

Variables	NLS		NLS Frontier	
	Coefficient	P-value	Coefficient	P-value
Log-distance	-0.6754	0.0004	-0.6216	0.0005
BSE importer	-0.0767	0.5494	-0.0756	0.5046
BSE exporter	0.0024	0.9875	0.0017	0.9903
Log production importer	-0.0337	0.5682	-0.0573	0.2025
Log production exporter	0.1251	0.0743	0.0034	0.9518
Log GDP per capita importer	0.3483	0.2690	0.4872	0.0865
Log GDP per capita exporter	-0.3610	0.0483	-0.2182	0.1694
Log population importer	2.9225	0.2294	2.8286	0.2007
Log population exporter	1.7115	0.4136	2.2596	0.2233
Log tariffs	-0.2424	0.0105	-0.2104	0.0170
Trade agreement	-0.4129	0.0107	-0.1975	0.2222
Tariffs are specific	-2.1294	0.0000	-1.6380	0.0000
Tariff rate quotas	0.3400	0.3847	0.7236	0.0301
Contiguity	0.5524	0.0179	0.4211	0.0528
Common official language	0.4271	0.0027	0.4825	0.0003

Source: Kotchoni and Larue, 2011



However, the NLS Frontier model estimated highly insignificant coefficients for variables related to the presence of BSE in the importer and exporter, and even estimated a positive relationship between exports and the presence of BSE in the exporter. Another point of concern is that the model estimated a minute and highly insignificant impact of beef production in the exporter on beef exports.

Tapia *et al.* (2011) analyzed the effect of Sanitary and Phytosanitary (SPS) regulations on the Argentine and German beef trade among its more important markets using a non-linear panel data gravity model by Poisson pseudo-maximum likelihood (PPML). Results estimated Tapia *et al.* (2011) are presented in Tables 4.6 and 4.7. The model developed by Tapia *et al.* (2011) is similar to the model developed in this study with regards to also employing PPML with random effects on beef trade. However, the two studies differ in terms of the period, country selection, data and variables being studied.

In the German case study of Tapia *et al.* (2011), the period analyzed was 1995 to 2007 and bilateral beef trade consisting of chilled and frozen beef between Germany and 22 countries (rest of EU(15), Russia Federation, Israel, Switzerland, USA, Egypt, Korea, Poland and Japan) was taken into consideration. These countries account for roughly 95 percent of Germany beef exports. Although different values of the coefficients were estimated, similar and statistically significant relationships were estimated for distance, beef production, beef consumption, income per capita in the importer, tariffs and BSE trade restrictions between this study and the Argentinean case study of Tapia *et al.* (2011). However, the model of Tapia *et al.* (2011) estimated a statistically significant negative relationship between the value of German exports and contiguity, which is contrary to the notion that countries will trade more if the trade partners are geographically contiguous due to lower transportation costs. Also, the coefficient of the dummy variable indicating if trade restrictions are imposed on the exporter due to FMD showed a statistically positive relationship

between these trade restrictions and the value of trade. This relationship is not intuitive of the effect of a trade restriction, which is expected to be negative.

**Table 4.6: Gravity model results for German trade of Tapia *et al.* (2011)**

Variable	Coefficient	P-value
Ln Beef Production in exporter	0.633	0
Ln Beef Consumption in importer	1.657	0
Ln Distance	-10.176	0
Ln Remoteness importer	-3.836	0
Ln Remoteness exporter	-2.883	0
Ln GDP per capita importer	0.285	0
LnGDP per capita exporter	-0.007	0
Tariff in ad valorem rate	-1.199	0
Exporter is landlocked	-11.327	0
Importer is landlocked	0.894	0.167
Contiguity	-12.318	0
Common official language	-1.784	0.042
Common second language	2.987	0.002
FMD trade restrictions	6.428	0
BSE trade restrictions	-0.296	0
Growth hormones trade restrictions	0.084	0.92

Source: Tapia *et al.* 2011

In the Argentine case study of Tapia *et al.* (2011), the period analyzed was between 1995 to 2007 and bilateral beef trade consisting of chilled and frozen beef between Argentina and 24 countries (EU (15), Brazil, Russia Federation, Israel, Switzerland, Peru, Canada, Chile, USA and Venezuela) was taken into consideration. These countries account for 90 percent of Argentine beef exports. Again, although different values of the coefficients were estimated, similar and statistically significant relationships were estimated for distance, beef production, beef consumption, income per capita in the importer, BSE and FMD trade restrictions between this study and the Argentinean

case study of Tapia *et al.* (2011). However, the model of Tapia *et al.* (2011) estimated a statistically positive relationship between tariffs and the value of Argentinean beef exports. Intuitively a higher level of tariff protection is expected to discourage exports to the country applying the protection. As was the case of German beef exports, the model estimated a statistically significant negative relationship between the value of exports and contiguity, which is contrary to the notion that countries will trade more if the trade partners are geographically contiguous due to lower transportation costs.

**Table 4.7: Gravity model results for Argentinean trade of Tapia *et al.* (2011)**

Variable	Coefficient	P-value
Ln Beef Production in exporter	1.270	0
Ln Beef Consumption in importer	0.495	0
Ln Distance	-10.372	0
Ln Remoteness importer	-5.727	0
Ln Remoteness exporter	2.407	0
Ln GDP per capita importer	0.961	0
Ln GDP per capita exporter	-0.023	0
Tariff in ad valorem rate	1.423	0
Exporter is landlocked	-6.278	0
Importer is landlocked	-4.431	0
Contiguity	-13.746	0
Common official language	-0.484	0.855
Common second language	-3.652	0.157
Common market agreement	0.632	0
FMD trade restrictions	-3.207	0
BSE trade restrictions	-0.227	0
Growth hormones trade restrictions	-2.213	0

Source: Tapia *et al.* 2011

## 4.6 SUMMARY

This chapter discussed the development of the gravity model used in this dissertation and presented the empirical results estimated by the model. The model and the estimates generated by the model were validated both by traditional statistical validation procedures and by a subjective assessment of whether the estimated results are plausible given the understanding gained from the review of the international beef market. This chapter showed that the model was exceptional in validating and quantifying the factors that drive and influence international beef trade when all of the statistical tests and validation criteria are taken into account.

## CHAPTER 5

# SUMMARY AND CONCLUSION

The general objective of this dissertation was to validate and quantify the factors that drive and influence international beef trade in order to facilitate and improve the decision-making behaviour of policymakers. The gravity model methodology was identified as the ideal framework to address the general objective of this dissertation, and was used as the primary tool to analyse the factors that drive and influence beef trade. The specific objectives were to gain an understanding of prominent issues that influence international beef trade, to review the gravity modelling methodology and to model the effects of various issues on the volume of beef trade based on trade data among leading importers and exporters between 1996 and 2010.

The first part of this dissertation provided an overview of the global beef market in order to gain an understanding of the prominent issues that affect beef trade. The overview consisted of sections discussing production, consumption, trade, animal disease outbreaks and agricultural policy. The aim of these discussions was to inform the researcher on the issues that needed to be considered in the specification of the gravity model developed in this dissertation. From these discussions it became clear that the specification of a model aiming to study the factors that drive and influence beef flows should include explanatory variables to represent beef production, beef consumption, tariffs, income per capita, export prices, animal disease outbreaks and transportation costs.

The next step was to review the gravity modelling methodology in order to ensure that the model being developed in this study conforms to established international practices and benefits from the latest advances in the methodology. Recent efforts to improve the gravity modelling methodology have identified data treatment methods, the log-linearization of the gravity model and the inability of the traditional specification of gravity model to process zero-valued trade flows as major areas of

concern. To address these concerns, the review suggested the model developed in this dissertation needed to avoid the three “medal” mistakes identified by Baldwin and Taglioni (2006), model the gravity model in the multiplicative form and generate estimates using the PPML estimation method. Applying these improvements will enable the model to estimate unbiased, efficient and consistent results.

The final part of this dissertation focused on the development of the gravity model and the estimated results. After discussing the data and variable selection, the model was specified and used to study the impact of various issues on beef trade among leading importers and exporters between 1996 and 2010. The model was estimated using two separate equations, referred to as Model B1 and Model B2. For each of these equations the dependant variable varied to represent: bovine cuts boneless, fresh or chilled (HS 020130); bovine cuts boneless, frozen (HS 020230); and an aggregation of these two products designated as "Total beef". Model B1 was estimated with the full gravity model specification, including export prices  $p_{ijt}$ . Since very few studies on commodity specific gravity models exist and have never modelled beef exports prices directly, it was decided to run an additional model, Model B2, without the export price variable  $p_{ijt}$ .

The Wald Chi-square test confirmed that the variables included in the model were significant in explaining the variation in the volume of exports. The coefficients of individual variables estimated were found to be plausible while the signs of the coefficients indicated the expected relationships between the volume of beef trade and each of the individual issues. After comparing the two models it was found that the price variable exhibited statistically significant and plausible results, and did not affect the estimates of the other variables. A comparison with similar studies revealed that the model developed in this dissertation estimated similar results in some areas, and even more plausible results in others. When all of the statistical tests and validation criteria are taken into

account, the gravity model developed in this dissertation was successful in validating and quantifying the factors that drive and influence international beef trade.

The results estimated in this dissertation provided quantitative evidence that serve as an indication of how various issues included in the specification of the model have affected beef trade in the past, and can potentially assist policymakers during the formulation of future government programs and policies to stimulate beef trade. Increases in beef production profoundly increased exports among the countries studied, especially for frozen beef products. Policymakers aiming to increase beef exports need to focus on creating an environment that is conducive of beef production and that enables producers to increase production as export opportunities arise. Countries that are members of the WTO should however allow producers to produce and compete in international markets on their own accord, without the assistance of government payments or export subsidies.

The expected growth in beef consumption and incomes in developing countries presents an opportunity for beef exporters to supply these markets. Although most of the additional beef consumption in the developing world is expected to be supplied by these countries themselves, policymakers can assist beef exporters to gain access to these markets by negotiating lower barriers to trade and establishing trade relationships with developing countries in which beef consumption is expected to grow significantly, especially China, India and the MENA region. Results also confirmed the notion that exporters favour trading with importers in countries that are geographically closer than with importers in countries that are geographically distant, due to the cost of transportation being lower in the former transaction than in the latter. In terms of policy these results advocate that policymakers first strengthen trade relationships with neighbouring countries, develop infrastructure that allows beef to be transported inexpensively and efficiently, and reduce the amount of time necessary to clear exports at customs offices.

Since the mid-1980's there has been a general reduction in barriers to trade as well as bilateral trade agreements made within the framework of the GATT and subsequently the WTO. Despite these reductions, levels of tariff protection present in the global meat market remain at a high level, particularly for beef. As negotiations at the DR continued, it became apparent that domestic food security has become the dominant driver behind negotiations, and that agricultural and trade policy for many of the key countries has shifted to encourage and defend domestic production, and to limit the increase in import access to volumes which will not undermine domestic food security. Model results indicated that tariffs had a significantly negative impact on the volume of beef trade among the countries studied. Until disputes regarding the treatment of agricultural products are resolved in the DR the level of tariff protection in the global beef market will likely remain high for beef products, especially in lucrative markets such as the US, the EU, South Korea and Japan. This situation should however not discourage policymakers from negotiating lower tariffs and negotiating trade agreements with countries in which future consumption of beef is expected to grow.

The beef export price usually reflects the production conditions in the exporter. These conditions enable countries with favourable production conditions to produce and export beef at lower prices than countries with production conditions that do not favour beef production. The constraints on increasing the global cattle supply, the increasing demand for beef products in developing countries and increasing grain and energy prices will cause beef prices to increase in the future. The model estimated that export prices had a negative relationship with the volume of exports. Therefore countries that exported beef at relatively high prices tended to export lower volumes of beef, and *vice versa*. Policymakers will first need to identify beef prices and levels of quality that domestic production conditions will allow a country to produce and export. Thereafter a strategy can be developed to stimulate trade with viable markets given the possible price and quality constraints.



Trade restrictions imposed due to disease outbreaks had a devastating effect on the trade between countries affected by a disease outbreak and the markets imposing these restrictions. The results of this study highlight the importance of maintaining measures to prevent disease outbreaks, and in doing so maintain access to export markets. Policymakers and governments need to be vigilant and focus on ensuring that measures preventing the outbreak and spread of animal diseases are maintained. An approach that is prescribed by the Organisation for Animal Health (OIE) and that is increasingly becoming a standard in leading beef exporters is the process referred to as “zoning”. Maintaining disease control measures across an entire country is a considerable challenge, and a single case of a disease can result in the country losing access to many export markets. Policymakers can however divide the country into geographical regions, or zones, each maintaining a distinct animal disease status. If zoning is applied, an animal disease outbreak in one region will only affect the exports from that specific zone, and not affect exports in the other regions.

This study explored and quantified the issues that affect beef trade among leading beef exporters and importers. Will these results hold for each individual country? Certainly not. However this study does provide a framework that individual exporters and importers can use to study their own trade in beef products. Although a distinction was made on how various issues affect trade of fresh and frozen bovine meat, most of the beef traded today occurs in specific cuts or pieces. One may therefore ask whether it is perhaps not necessary to study beef trade in terms of the different cuts rather than as one or two homogenous groups? The emergence of many developing countries as major beef consumers and producers will have a profound effect on the future structure of global beef market. Even during the development of this study, India became one of the leading beef exporters when the country's exports grew threefold, a feat in itself considering the volumes that was exported. How will this trend affect the export ability of current leading exporters and countries that rely on imports to meet domestic consumption needs? As more and more countries enter to compete in the global beef market, will domestic or foreign consumers benefit from this

competition? What is clear however is that countries that engage and value the trade in beef products will need to understand and manage trade, otherwise these changes in the global beef market can be the detriment of domestic consumers and producers.

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