The Impact of Ocean Freight Rate Fluctuation on Wheat Flow

A Thesis Submitted to the College of Graduate Studies and Research in Partial Fulfillment of the Requirements for the Degree of Master of Science in In the Department of Bioresource Policy, Business & Economics University of Saskatchewan

Saskatoon

By

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ABSTRACT

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The global economy is increasingly defined by access to international markets, with reduced barriers to trade between many countries. Continued reduction in the costs of moving products both within a country and around the world is crucial for modern business to remain competitive. International trade in grain is no different, and presents its own unique challenges for study in a Canadian context.

Ocean freight rates for grain have recently been very unstable. After a long period of low freight rates, capacity became limited in 2003 and 2004 more than tripling freights rates. Although freight rates have subsequently declined, the increasing dominance of containerized ocean traffic may perpetuate the recent instability in bulk freight rates. The impact of ocean freight rates on Canada's competitiveness in the grain markets is poorly understood. The theory for the flow of commodities over space has been well studied in the context of trade and while there have been a number of studies concerning the spatial nature of grain handling and transportation in Canada. However, to date there has been minimal effort to analyze ocean freight transportation prices and their impact on wheat flows from Canada. The purpose of this study is to analyze the impact of ocean freight rates on international competitiveness of Canadian wheat.

To analyze the impact of ocean freight rates on Canada's competitiveness a spatial, product-differentiated, equilibrium model of international wheat market is developed in this research that allows for two way trade and explains the linkages among the various locations of production and consumption. The model incorporates changes in ocean freight rates and the geographical distances with non-homogeneous wheat originated from different wheat exporters. The model is used to examine the potential impact of changes in freight rates on Canada and other main players in world wheat market. The model is a tool to compare the price and quantity changes and compare the comparative advantages and disadvantages that are created by changes in wedges due to freight rate fluctuation. The result implies that shorter geographical distances and lower freight rates do not necessarily result in increasing export to the regions with lower per unit freight rates. This is why before any decision making, it is reasonable to adopt such a tool that is capable of measuring the reactions to price changes that are associated with freight rates considering different demand and supply parameters.

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CHAPTER 1

INTRODUCTION

The introduction of this thesis details the purpose of the study, offers a justification for the study, defines the research objectives, and lays out the organization of the study.

1.1. Background

Today's global economy is characterized by easier access to international markets for all countries and reduced barriers to trade. Once a country is open to international trade, domestic producers face strong competition created by global changes. In a competitive environment, the introduction of cost-reducing technologies, improved product marketing techniques, and, in particular, reduction in transportation costs both within the country and to the world market, are crucial matters for producers. Any changes in transaction costs that affect the border price of a product will have an impact on the producer country's market share. For many products, the transportation cost is an important component of transaction costs in trade, which creates wedges between domestic prices and foreign markets.

While technological improvements have significantly reduced transportation costs over time, this downward trend has often been disrupted by significant changes in input prices and increasing demand. During the past decade, ocean freight rates increased significantly because of changes in fuel costs as well as increasing demand for bulk transportation for products such as iron and ore along some routes, besides the regular increasing demand in transportation services due to growing trade in the world. As shown by Hammels (2007), improvements in transportation technologies have significantly increased trade. On the other hand, the growing rate of the trade has resulted in higher demand and transportation rates. It is important for trade parties to be aware of these ongoing changes. Depending on the type of commodity and the sensitivity of demand for the final product, there will be different reactions and strategies for minimizing costs or maintaining the market share. The grain markets are no exception in this regard.

Grains trade on many major exchanges and are shipped around the globe. As such market dynamics are influenced by local, regional and global supply disposition. Among all factors affecting the worldwide grain market, the cost of transportation is known as one of the factors that greatly influence the competitive position of a region's grain production. Transportation costs affect the arbitrage opportunities forgrain exporters and importers, which impact price paid by consumers and the prices received by producers, and consequently the global pattern of international demand and supply of grain.

The cost of transportation is critical for wheat, which is a bulky and a particularly widely traded commodity. Given the great distances between wheat exporting and importing regions, transportation often makes up a large share of marketing costs. Figure 1.1 illustrates a simple graphical journey of wheat from farm storage to the consumer. As shown, transportation and handling play various roles before the final product reaches the consumer. Whereas ocean transportation is an important intermediate level in the wheat trade, the cost of ocean transportation varies from region to region. In 2007, the ratio of the ocean transportation costs to total average wheat producing prices across the world varied from 13% to 20% due to different wheat premium prices and freight costs. The question is how ocean transportation costs may affect the competitiveness of wheat from one region in another region. How do changes in freight rates change the global pattern of wheat trade?

Answering this question is particularly important for the countries like Canada, United States, and Australia with fewer land borders and more overseas importers.

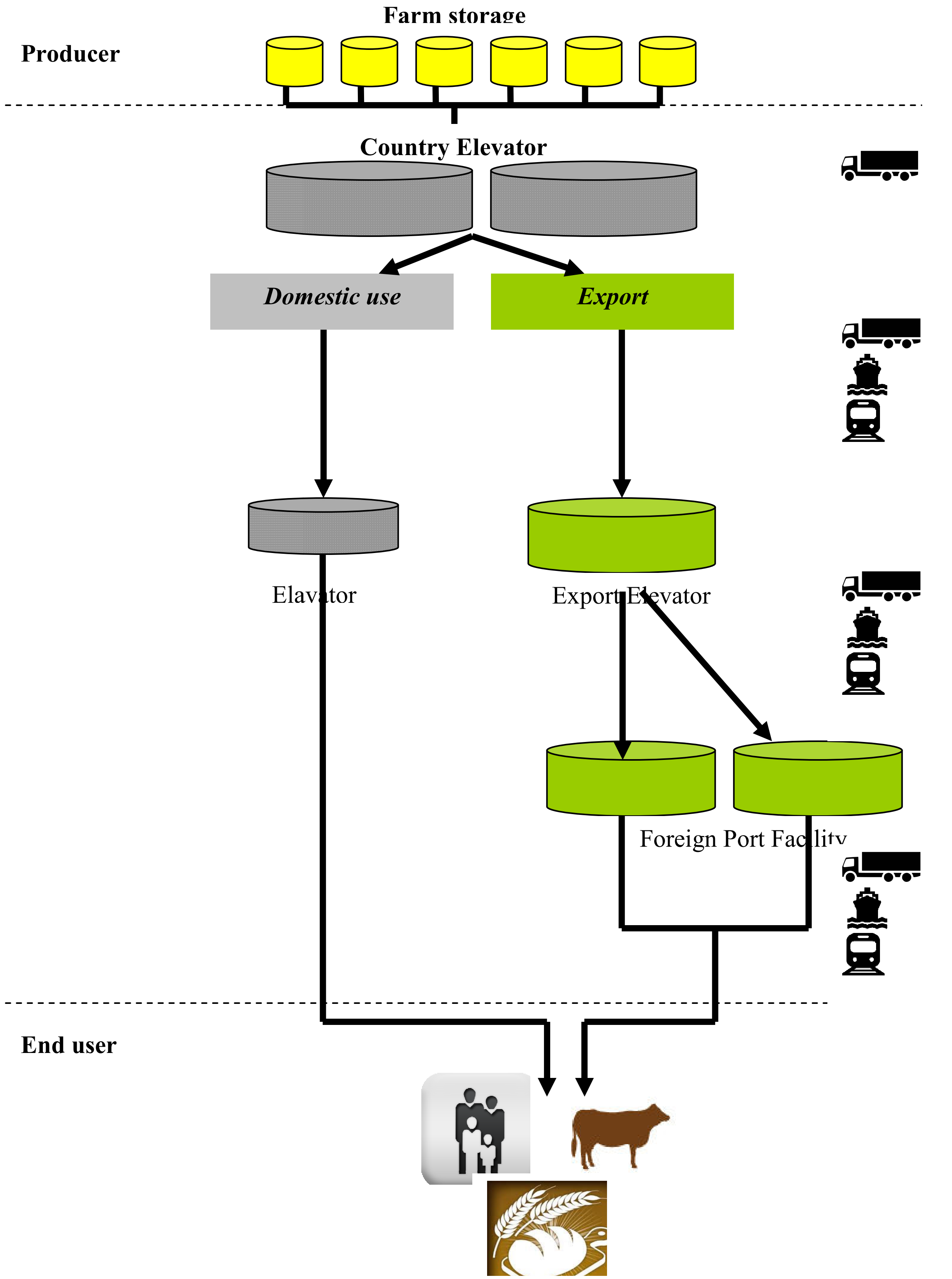


Figure 1.1 Wheat Supply Chain with focus on Transportation required levels

1.2. Problem Statement

Western Canadian wheat farmers in particular face some of the longest inland and overseas distances to reach exporting regions. Ocean freight rates are a very important component of transaction cost and change in thiscost willaffect price level and the relative competitiveness in foreign markets.

Despite the potential importance of these impacts, while a significant numbers of studies have addressed the barriers, policies, and logistics of inland wheat handling and transportation, very little is known about the size and direction of impacts ocean freight rate impacts. A search of the literature,(outlined in Chapter 3), was unable to reveal a single study that addresses the impact of changes in the ocean freight rate, in the context of a multilateral trade flows within a global market.

Given the potential impact of ocean freight rates on Canada's competitive position in various wheat markets, and the lack of prior analysis, there is an important need to develop an economic model that can be used as tool to anticipate the impacts ocean freight rate changes have on Canada's competitive position in various export markets. This will allow Canadian grain marketers to more readily adopt their sales strategies to changing ocean freight conditions.

1.3. Objectives of the Study

The primary objective of this study is to develop an economic model that can estimate the impact of ocean freight rate changes on Canada's wheat export patterns, prices and sales volumes. Because Canada is not isolated from global market this will involve modeling the international wheat market along with the ocean transportation market, and the role of other players in determining trade patterns. Specifically, the model must accommodate both spatial and product-differentiated characteristics of wheat. The model must therefore incorporate changes in ocean freight rates and geographical distances with non-homogeneous wheat originating from various wheat exporters. The model can then be used to examine the potential impact of changes in freight rates on Canada and other major players in the global wheat market.

This research will first examine the structure of the operating ocean freight market and then construct an appropriate vertical model for wheat flow. While our focus will be on the Canadian wheat market, we will study the global wheat market and its reaction to freight rate changes as well. This theoretical framework will then be applied to a simulation of the global wheat market. The results will clarify how changes in ocean freight rates will affect the competitiveness of Canadian wheat in various regions.

In summary, the specific objectives of this study are:

1. To develop a spatial model of the global wheat trade market that allows for two-way trade and explains the linkages among the various locations of production and consumption.
2. To identify the impact of freight rate changes, as an exogenous variable, on wheat flow and address the issue of model validation.
3. To evaluate the impact of select rate changes on regional supply, demand, and trade patterns of wheat as an illustration of the performance of the model.

1.4. Scope and Organization of Study

Pursuing the objectives of the study, it is necessary to be familiar with the structure of the ocean freight market. Chapter 2 introduces some of the theoretical concepts that bolster understanding of ocean freight market specification and freight determination.

Chapter 3 will focus on trade studies and theories that cover commodity trade transaction costs with a focus on transportation costs as a base for the spatial wheat trade model. Chapter 4, describes the structure of the spatial wheat trade model, the process of parameterization, then simulates the impact of changes in the ocean freight rate on prices and quantities of the wheat produced, traded, and consumed across these regions.

Finally, Chapter 5 summarizes the results and conclusions of the thesis.

CHAPTER 2

THE STRUCTURE OF OCEAN FREIGHT MARKET AND WHEAT FLOW

2.1 Introduction

Ocean freight transportation has an essential role in grain flow across the world. Because of the distribution of grain production and consumption across the world, it is one of the most important intermediate linkages between producers and consumers. Yet, grain producers and consumers are not the only users of ocean freight services. Recent trends in globally traded merchandise involve more and more competitors in the ocean freight market (OFM) on both the producer and consumer sides of the industry. As a result, the OFM is affected by reactions from all sorts of players, including both service users and providers. To follow the impact of ocean freight rate changes on grain, specifically wheat flow in this thesis, there is a need to examine the ocean freight market structure and its impact on the final product.

The purpose of this chapter is to look into the ocean shipping market structure and the factors driving freight rates for seaborne agricultural transportation. To examine how fluctuation in ocean freight rates may affect wheat movement across the world, it is essential to understand how these fluctuations happen in the OFM, which player has more power in the market and which is more intense as regards to fluctuations. This requires identifying the market players, looking into consumers' and producers' motivations, opportunities, and decisions in the shipping industry, and analyzing the market structure of the ocean freight services to identify the parties' market power in price (ocean freight rate) determination. This knowledge of market structure provides key insights into ocean freight rate changes. It helps to develop understanding of the various exogenous and endogenous factors that affect the commodity, or in case of this thesis, wheat movement. Finally, knowledge of the OFM structure allows this thesis to construct basic assumptions for a trade-transportation model that explains wheat movement across the world.

As Sussman (2000) mentions in the Introduction to Transportation, from the different shipping services within the OFM and variety of service users arise a complex industry. Consumers may choose between liner shipping or sending goods as bulk cargo depending on freight rates, parcel size, shipping routes, and specialized services offered along each route. Not all choices are available from all countries; some have a greater suite of options given terrestrial and airborne freight. However, ocean-going vessels still remain the most viable and efficient transportation option for large volumes of basic commodities and finished products throughout the global market, especially agricultural products, because of the distribution of commodity markets across the world. While consumers seek the most viable and efficient system of transportation considering the changes in ocean freight rates and other factors, service providers look for sustainability and maximizing their profit. Service users compete to obtain their preferred services on a specific route and producers maintain or increase their share in the route accordingly. These competitions have given certain characteristics to the demand and supply of ocean freight services and will be discussed in the coming sections of this chapter.

This chapter is organized into five sections. Section 2.2 describes the basic definitions in the sector, including types of the services, followed by trade parties' motives for choosing a specific type of grain shipping services. Ocean freight markets, supply and demand, and price determination are discussed in section 2.3. After describing basic market factors, this section focuses on the types of markets for services that are used to move bulk cargo, especially services used for grain and wheat movement. Section 2.4 outlines the relationship between the evolution of market power within the sector and the historical technological changes in the industry. It also summarizes some of the regulations on ocean freight market during the past decades. Finally a summary of the chapter and the role of ocean service users in determining the ocean freight rate are discussed in Section 2.5.

2.2 Basic Definitions

This section of Chapter 2 addresses the basic definitions of necessary components of the ocean shipping industry used in this thesis. Cargo shipping types and various shipping services are briefly described, and their advantages, disadvantages, and specifications are compared. The motivation behind choosing one service versus another is explained.

2.2.1 Types of Cargo Shipping and Shipping Services

Ocean shipping includes a variety of services depending on the type of cargo. Combined passenger-cargo vessels, dry cargo vessels, bulk cargo ships, refrigerator ships, container ships, tankers, ore carriers, and various combinations of the aforementioned are examples of the vessels and services offered in the industry. The focus of this thesis is on dry bulk cargo vessels and services, as these are typically used for transporting grain.

The bulk commodities traded by sea can be generally divided between dry bulk and liquid bulk cargo. All grains, dry edibles (alfalfa pellets, citrus pellets, livestock feed, flour, meal, peanuts, raw sugar, seeds, starches, etc.), iron ore, dry bulk mine (sand, gravel, copper, salt, etc.), wood chips, cement, and chemicals (fertilizer, plastic granules and pellets, resin powder, synthetic fiber, etc.), are all examples of dry bulk cargo.[1]Sometimes there is a need for

[1] Liquid bulk cargos includes oil, liquefied natural gas, gasoline, chemicals, liquid edibles (vegetable oil, cooking oil, etc.) and is not discussed in this thesis.

special services and containers to transport some cargo such as chemical and special-order grains, etc., while general vessels can be used for some dry bulk cargo shipping and the parcels[2] can be mixed.

Various resources provide slightly different definitions for bulk cargo. Based on the United Nations (UN) definition in maritime transportation study, bulk cargo is "cargo that is unpacked (un-bundled or unbound) and is of the same or a similar kind of nature (homogeneous)." As per W. Stopford (1997), bulk cargo is "any cargo that is transported by sea in large consignment in order to reduce the unit cost". This definition puts the ultimate objective of cost reduction as an end rather than the means by which the aim is achieved.

The question is which criteria and specifications make a commodity suitable for bulk shipment. General cargo and bulk cargo are the main categories for the purpose of Parcel Size Distribution Function (PSDF). Bulk cargo consists of cargo parcels that are big enough to fill a whole ship while general cargo includes parcels that are too small for a ship and have to be transported with other cargo. Grain shipped from different location, as dry bulk cargo, has a very different PSDF and sometimes has to be transported as general cargo. As volume of trade flow increases and the size of cargo parcels grow, the industry will migrate to bulk shipment.

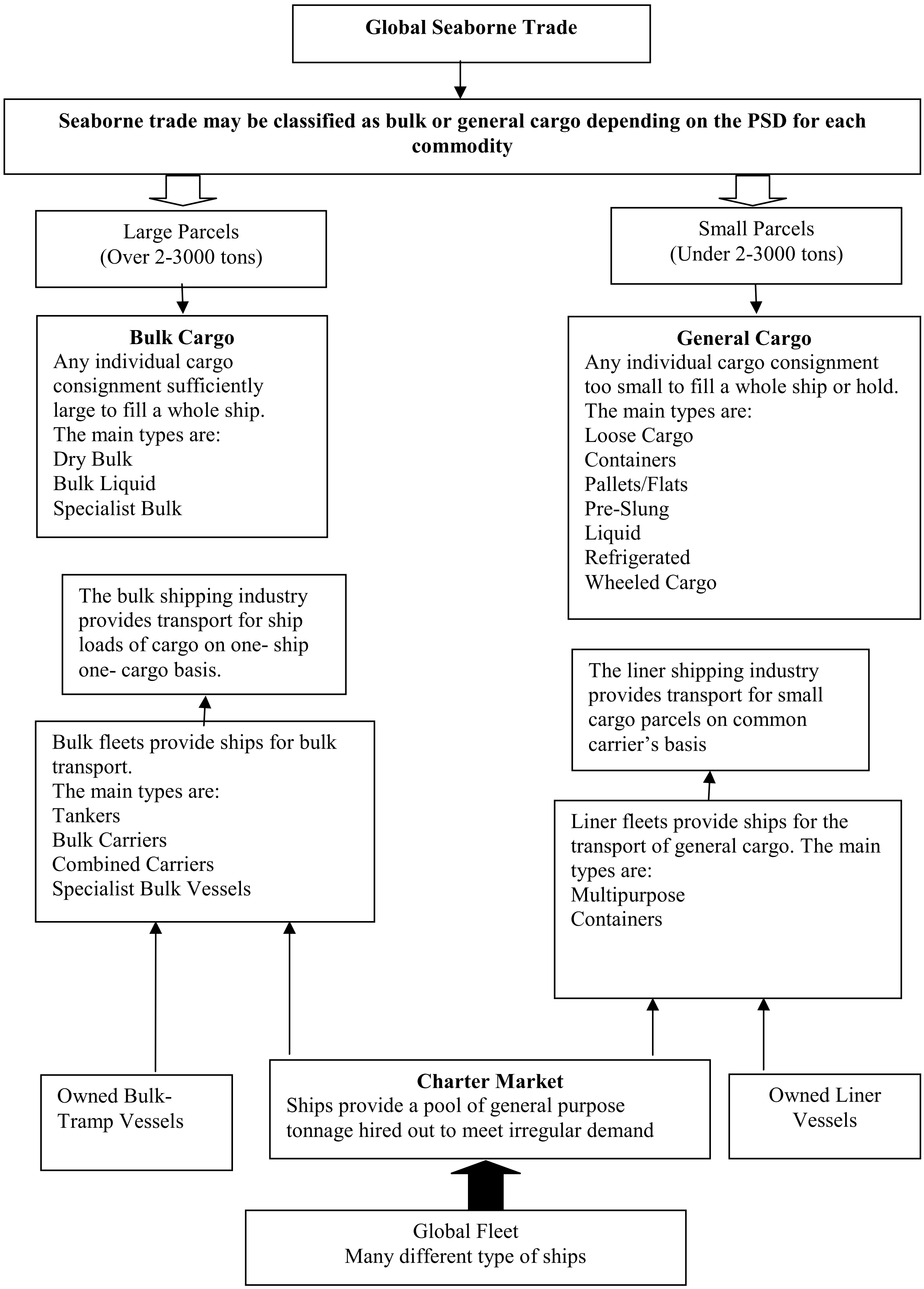
Stopford identifies four characteristics for deciding between bulk and general cargo: cargo volume, handling characteristics, regularity, and stock: there must be a sufficient volume of cargo to justify a tailored shipping operation, the cargo must be physically suitable for bulk handling, the bulk shipping operation must be adapted to the overall transportation system, and finally the size of cargo parcel must be compatible with the stock held by the producer and the consumer. Service providers can apply the Parcel Size Distribution Function (PSDF) to manage

[2] Stopford (1997) defines a "parcel" as an individual consignment of cargo for shipment.

mixed cargos. Since different sizes of parcels need different types of shipping operations, the PSDF determines which cargo goes in which ship. The PSDF depends on a variety of factors. Stopford identifies economies of scale as the most important decision making factor. However this is always subject to the availability of ships and transport infrastructure such as ports for the origin and destination. Figure 2-1 summarizes the cargo types and the appropriate shipping option for each.

It is important to identify whether wheat is being shipped as general cargo or bulk because these two operate in different market structure. According to Stopford, general cargo mostly operates under the liner regime while bulk cargo operates under both the tramp and liner system. Liner and tramps operate in different market structure and therefore impact the market of the final good and products in a different way. Modern ocean shipping, consisting of different type of vessels, can be divided into two major classes: liner shipping and tramp shipping. Based on the types of services offered and duplication along certain routes, tramp or liner service providers may turn to competitors on a specific route. Although consumers have the choice between tramp and liner services, they may rank one service over the other based on price or the quality of service. Some definitions and market characteristics of these services follow.

Figure2-1 Global Seaborne Trade Chart: Bulk vs. General Cargo



Source: Maritime Economics, Martin Stopford, 1988, p 11

2.2.2 Liner vs. Tramp Services

The coming section will explain the definitions of and differences between liner and tramp services, and will explain the different types of services used to ship grain, especially wheat, across the globe. As implied in the last section, dry bulk carriers are flexible, and due to the economy of scale of services they provide, are capable of offering relatively low prices for packaging and handling. But bulk carriers are not the only desired made of transportation for grains. Grain is transported across the world in containerized vessels, as general cargo, and bulk cargo in bulk or containerized carriers. These cargo types and their operating markets are significantly different from each other. This section will demonstrate the justifications for selecting any of these services so as to build a set of assumptions for the theoretical framework for wheat movement.

Fayle (1933) describes a liner service as one with ". . . a fleet of ships, under common ownership or management, which provides a fixed service, at regular intervals, between named ports, and offer themselves as common carriers of any goods or passengers requiring shipment between those ports and ready for transit by their sailing dates. A fixed itinerary, inclusion in a regular service, and the obligation to accept cargo from all comers and to sail, whether filled or not, on the date fixed by a published schedule . . ."

In contrast, he defines a tramp ship as a "seeker" or a "general trader", as one that "can be hired as a whole, by the voyage or the month, to load such cargo and to carry it between such ports as the charterer may require . . ."

In short, liners are characterized by regular service along specified route. Unlike liner shipping, tramp ships are very flexible. Tramps do not have a fixed schedule or published ports of call and the shipping is arranged between the shipper and receiver, with transportation operators offering vessels for hire to carry bulk (dry or liquid) cargo to any suitable port in the world. All types of carriers in ocean shipping services, may work under tramp or liner shipping.

Like other ocean transportation service users, grain traders have the option of using liner or tramp services. Users select between liner and bulk services based on their requirements, cargo mass, timing, special services, and prices. They try to minimize their cost of transportation, subject to maintaining a standard level of transportation facilities to preserve the quality of the commodity.

While grain exporters have a tendency to ship grain in bulk carriers, which are generally chartered on a per-voyage basis in the tramp market, there has been an upward trend toward transporting containerized shipments of grain. This increased attraction toward containerized shipping may arise from special features of container shipments such as easier handling and transportation, better or more appropriate port facilities, or specific needs like identity preservation. Moreover, market structure changes in the liner shipping industry in recent years have turned containerized carriers into a competitive mode of transportation for bulk carriers. Section 2.3 expands this discussion and examines the reasons behind this transformation, first showing how grain movers choose between container and bulk carriers.

2.2.3 Container vs. Bulk Carriers

Containerized or bulk carriers may be used to transport different types of grains across the world. One important characteristic of grain that separates it from a lot of other bulk commodities is its seasonal and uncertain nature. According to Stopford (1997), because of the yield uncertainty and unpredictable harvest fluctuations, it is hard to plan transportation ahead of time. He specifically uses the term “opportunist cargo” for grain because after other trade contracts are secured, grains have to be shipped using the ports and ships that are available. The unpredictable harvest fluctuations of grains make trade prediction and, as a result, planning shipping arrangements difficult and complex task. The tramp option with no restricted schedule seems an obvious choice.

Considering the type of cargo and transportation costs, hiring a bulk carrier may seem like the appropriate method for ocean grain transportation, in this case wheat movement. Looking into the supply chain of grain, after cost of production, transportation cost is the most important element that significantly affects the final price of the product. There is a general bulk option with a lower service price, and there is a more specialized option with probably a higher price but higher quality service: containerized shipping. What makes a service user choose the more expensive service?

While the characteristics of grain transportation make the bulk carriers the appropriate mode for ocean transportation, there has been a trend toward containerized exports of traditionally bulk commodities. According to Reichert & Vachal (2003), during the past two decades the cost of hiring containers has decreased and their prices are becoming more compatible to those of bulk carriers along some routes. Reichert & Vachal studied the impact of identity preservation on grain movement and addressed the increasing demand for containerized shipments. In their research, animal feed and soybeans were the proxy for grain and were used as indicators for containerized grain exports. They picked these two grains because they represent more than 50 percent of all grain container exports. Their study is definitely among the works proving the increasing trend of the containerized.

According to Vachal & Reichert, Identity Preservation (IP) is the most important reason for the accelerated trend toward using containerized vessels instead of regular bulk carriers. Farmers and consumers who are looking for more diverse or specialized products prefer to use

Identity Preserved products and wheat is not an exception among the grains. With evolution of technology and the emergence of Genetically Modified (GM) grain in the world market, this concept has become more important to some exporters. Generally non- GM wheat, the quantity and quality of protein, moisture content, and the quantity of non-millable material encourage some buyers to choose containerized shipment. While producers' focus in the past has been to increase yields in order to increase income, another option has emerged. According to Vachal& Reichert, the producers now focus on providing the customer with a higher-value product. The containerized system has the capability of providing special packaging that commands a premium and may even offer higher profits to the producer, especially because of increased demand for more specified grain movement and IP facilities to control the quality of the product, ensure customer specifications are met, and decrease the possibility of vertical price discrimination because of quality differences. In the case of grain flow, especially wheat flow, the cost-benefit analysis requires more details, depending on the origin and destination of the commodity and special orders made by costumers, the choice may vary.[3]

Another advantage of containerized transportation is in minimizing the loss from poor handling, according to Prentice 1998. In the bulk system, handling and transportation from the farm gate to the consumer, involves loading and unloading the products at least four times during the transportation process. But in the containerized system, the grain is loaded into a container once and is not handled until it is unloaded at its final destination. The easy storage of containers in intermodal stations is another notable advantage of containerized transport. Eventually, ports with poor storage facilities can to be used due to the storage abilities of containers.

[3] This discussion is beyond the scope of this thesis.

The above motives have persuaded some shippers to consider containerized grain movements in lieu of the bulk system during the past few decades. Apart from necessities that forces a choice of ocean transportation method, the final decision between the bulk and containerized services still remain subject to the freight rates offered by the service providers. This part will be discussed further after reviewing the market characteristics of each service.

2.3 The Market Structure of Ocean Freight Services

The Ocean Freight Market (OFM) is one of the most important and costly intermediate-level processors in the grain/wheat supply chain and is a key component identifying the pattern of wheat flow from exporter regions to importer regions.

The service offered by bulk and containers is different, but they also operate in different markets. Due to historical and technological changes, the markets of ocean shipping services have undergone major structural changes. While these markets have been affected by technological and regulatory changes, there has been some influence from consumers' preferences, especially in recent years. This section of thesis will investigate and summarize these structural changes and explain the current market situation and outcomes. The result of this discussion will be used to build the base assumption about the ocean transportation market characteristics as the intermediate level of wheat supply chain and develop the final model based on this assumption.

This section examines the market power that ocean transportation providers bring to bear on the final product. This requires recognition of the active elements of the market and their characteristics. The variety of service users on the demand side and the specific characteristics of the supply of shipping services make this different from the common supply and demand framework. In this section supply and demand of shipping services and their effects on ocean shipping rates will be briefly discussed, as will the process of price determination in the ocean shipping market before investigating the literature and historical origin of market structure changes.

2.3.1 Ocean Freight Market

The market elements of ocean freight services consist of the ocean freight service users on the demand side and ocean freight service providers on the supply side. As mentioned earlier in this chapter, there are different types of services offered in the ocean shipping industry. The focus of this chapter and thesis is on the services available for bulk cargo; as such ocean freight services refer to bulk cargo services unless otherwise specified. A simple competitive market for ocean freight services will be considered first, assuming that all the products and services offered for bulk cargo are homogeneous and the general supply and demand for the services will be described. Thereafter the active elements that affect demand and supply will be described and it will be determined how these factors work and whether it can be assumed that the services offered in ocean shipping the homogeneous or not.

Supply and demand of ocean freight services are affected by several factors. Considering transportation as the intermediate processing level, the demand for these services is a derived demand and is highly dependent on demand for the final product; any factor that influences the final product demand affects the ocean transportation demand. On the supply side, a change in policy or regulation of ocean shipping services supply, or even production factors like the price of oil and crew, affects the cost and may result in freight rate changes. This section categorizes factors affecting the ocean freight rate and determines how the ocean freight market is affected and how these changes of the intermediate level may affect the choices of consumers.

2.3.2 Demand

In this context, ocean freight transportation demand is defined as the demand for bulk carriers along a specific route. We assume that the cargo size is large enough to necessitate hiring a bulk carrier. Ocean freight transportation is generally the intermediate processing stage of getting a finalized, raw, or intermediate material from its origin to its destination. As a result, the demand for shipping services is strongly affected by the factors that influence final product.[4] The demand for ocean transportation is derived from demand for the commodities carried, and is therefore affected by the elasticity of demand for the commodity itself, by the elasticity of substitutes for the commodity being transported, and by transportation competition for instance, competing shipping companies along the same routes or alternative routes, and also modes of alternative transportation such as air or rail transport. Sometimes the change in demand along a specific ocean shipping route may arise from changing freight rates along other possible routes or changes in the price of alternative modes of transportation.

Wheat must also compete for services with other dry bulk cargo, including other types of grain as well as non-grain bulk cargo such as iron ore, cooking coal, steel products, bauxite, etc. Any change in the supply and demand of any of these major bulk commodities can easily affect the demand of shipping services for other bulk commodities and consequently affect the supply of shipping services available for grain; the demand for ocean transportation services is directly influenced by trends in the global economy and trade fluctuation. Many textbooks and time series show that when there is an increase in global trade, peaks in demand for seaborne transportation follows it.[5]

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[4]We assume that the wheat in the importer region is the final product in the wheat vertical supply chain.

[5]Stopford 1997, Bridgman 2003, and Hummel et al 2008 are examples of the above statement.

There are many examples of changes in the economies and trade flow of a region that act as the "primary driver" of changes in the dry bulk carrier market. For instance, in the 1990s Japan acted as the primary driver due to the increased demand for seaborne trade and growth in Japanese industrial production.[6]China has been the main driving force behind the recent increase in seaborne dry bulk trade and the demand for dry bulk carriers. Increased demand for bulk ocean cargo tends to increase ocean freight rates, which in turn affect commodity markets. Specifically in the grain market, where transportation costs make up a substantial part of grain production and supply costs, these fluctuations in freight rates and their effects are a matter worth investigation.

In the case of global wheat transportation due to the distribution of origins destinations, and mass of cargo, ocean freight remains the most viable transportation method. Therefore, other shipping services are considered the main rivals to ocean shipping in this thesis and the impact of the alternative shipping modes is not considered. The demand side of ocean shipping services is quite competitive since there are many service users and they cannot influence the market individually.

2.3.3 Supply

Like the demand for ocean freight services, the supply side of ocean shipping services is very complex due to technological regulatory, and policy changes. Ocean shipping services offered along a specific route may produce one or several types of services, including liner shipping or tramp shipping, and can carry different commodities including dry and wet bulk shipping. After the technological changes in the ocean shipping industry in the early 1880s, coalitions and regulations have deeply affected the supply of ocean transportation services. In

[6] Web link last accessed in June 2011 : http://sec.edgar-online.com/2005/05/17/0001047469-05-015066/Section24.asp

this section, however, the assumption is that there is no monopoly or oligopoly on the supply side of shipping services and the ocean shipping market is competitive along a specific route. Therefore, the supply of bulk cargo shipping services along a specific route consists of all bulk carriers available and able to carry bulk cargo. The supply of services will be discussed based on fixed and variable costs and accessibility of the route to other carriers, as well as historical changes and the impact of technological changes, policies, and regulations on the OFM.

Just like the supply of other goods and services, production cost structure plays a significant role in the supply function of ocean shipping services, but it has some characteristics that are important to understand the market. According to Sussman (2000), supply for shipping services on a route is relatively price inelastic in the short run because the maximum available capacity of the world fleet is fixed and the entrance of carrier vessels from other routes tends to be limited. New entrants to specific routes are ships reentering a route after downtime (laid-up ships) or they may be new vessels added to existing fleets. Since the process of producing new vessels is time-consuming, only in the long run does the capacity of the world fleet change. In the short run, as long as there are no laid up ships that can enter the market, the supply become inelastic.

Stopford (1997) restricts the cost of supplying shipping services to three categories: voyage costs, operating costs, and capital costs. Voyage costs consist mainly of port charges and the cost of bunker (fuel). These costs are influenced by ship size and propulsion type. Operation costs are incurred regardless of whether the vessel is employed or not; these consist of crew costs, repair and maintenance, insurance, and administration costs. The last category is capital, which includes depreciation charges on the hull and interest expenses. For a bulk carrier, the capital expense is 50% of overall costs, voyage expenses are 30-33% of costs, and operating costs are 17-20% of total costs. These costs can be termed economically as fixed and variable. Voyage costs and some operation costs that are flexible in the short run are considered variable costs, while the cost of buying a ship and its maintenance costs are fixed. The variable costs are eliminated when the ship is laid up. When there is not enough demand for shipping services, vessel owners lay up their extra vessels to avoid expenses; these ships will be used again when demand increases.

According to Gregory (2000) the ocean shipping industry is often characterized by increasing returns to scale because of the fuller utilization of carrying capacity. The average unit cost can simply be reduced by expanding the scale of operations. Another characteristic specific to this industry is the mobility of the "plant" compared to most other manufacturing or services industries. This ease of movement results in producers' sensitivity to opportunity costs along different routes and a desire to transfer to routes with more demands and higher prices. However, some regulations have prohibited ship owners from changing routes.[7]On the other hand, like other services there is no possibility of storing while there is extra capacity along the route. The ship has to "lay up" or change routes when there is not enough demand.

Figure 2.2 illustrates the supply and demand functions of the ocean shipping services explained above. As can be seen in the diagram, as quantity increases it moves from elastic to inelastic in the short run. Due to laid-up ships or the full use of the capacity of ships along similar routes, when the demand for shipping services increases from D_0 to D_1, both the price and service quantity increase. When the demand shifts to D_2, it reaches the point of no capacity. In this situation only the price increases. In the long run, new entrants will shift the supply forward resulting in a new equilibrium price. The increase in capacity in the long run is the result

[7] This will be further discussed in the "Policies and Regulations in the Ocean Shipping Industry" section.

of the current high rate and the expectation of higher rates in the future. When rates are below those required to yield a normal rate of return and if owners expect such rates to continue in the immediate future, some existing capacity will be laid up and there will be a backward shift in the supply of services.

In the case of demand for global wheat transportation, demand for shipping services is a function of crop yield in the exporting countries, which will be more inelastic when shipments arelarge. Therefore, the consumer can decide on shipping services based on the freight rate and the trade situation up to the maximum crop yield point.

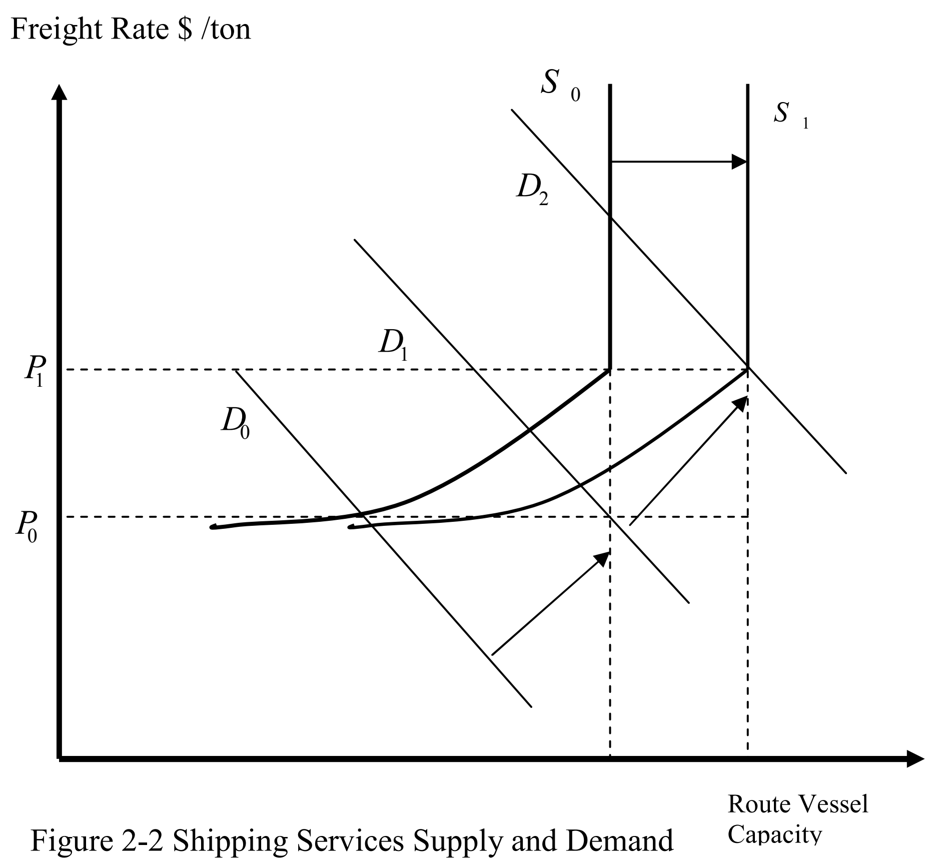

Figure 2-2 Shipping Services Supply and Demand

2.3.4 Price determination

As Marx (1953) indicates in his famous book, “International Shipping Cartels”, the price of ocean transportation services, like other services, is subject to the forces of supply and demand. The freight rate is affected by any change in the balance of supply and demand of shipping services. For instance, the freight rate goes up when there is a shortage of transport capacity along a route. In such situations it is likely that the vessels available along the route will operate at full capacity, at full speed, and will minimize any avoidable time out of service for routine maintenance to maximize revenue. Laid-up vessels are brought back into service again. Whereas when there is an oversupply of ships, freight rates fall. The low-performance fleets and those that cannot cover their operating costs are laid-up and other fleets decrease their performance level for instance, they will reduce speed to conserve fuel.

In order to determine whether ocean freight markets operate in a competitive market, and the factors causing market power in this industry, a historical review of ocean freight market (OFM) is useful. This history will help with understanding the current market structure of this industry. The following section briefly reviews the historical evolution of OFM.

2.4 Ocean Freight Market Characteristics

Liner shipping and tramp shipping, two different options for bulk movement, operate under different market regimes. Liners are active under the conferences, while tramps’ market is a more competitive one. It is important to be familiar with both of these markets since both of them are used in wheat movement. The definition and formation of the conferences are discussed in the coming section, followed by an examination of relevant regulations and market characteristics of tramp carriers and the charter market.

2.4.1 Historical Changes in Ocean Shipping Markets

Bulk shipping has played a significant role in seaborne transportation from old ages to the present. People have always been looking for the best and most economical way of transporting commodities. According to Stopford (1997), 2000 years ago Romans used ships to carry grain from Africa. Because of the dependence of seaborne transportation on unpredictable and uncontrollable factors like wind and weather, and also a lack of communication services, the shipping industry could not offer regular sailing routes in the past. Changes in technology and a constant growth in trade have changed this. Technology has helped temper uncontrollable factors, and tremendous changes in communication facilities and services have turned the ocean shipping industry into a more viable mode of transportation for trade. Technological changes in the mid-19th century and the growth of trade precipitated the development of the bulk shipping industry that exists today.

The invention of the steam ship completely changed shipping methods. Regular schedules, improvements in postal facilities, and the laying of transoceanic cables made it possible for traders to send goods to market with precision. This as Marx (1953) says "permitted an increase in the total volume of trade." According to Marx, soon after the revolution in the ocean shipping industry with the introduction of steam ships, increasing economy ofscale encouraged shipping companies [8]to use bigger vessels with greater capacity. They improved speeds and offered more reliable schedules such that ships could sail on advertised dates whether they were full or not. As a result, the potential profits from the industry attracted new players and shipping companies started to compete. Soon after these changes, the supply of shipping services

[8] Like all other transportation services, the ocean shipping industry is often characterized by increasing returns to scale because of the fuller utilization of carrying capacity, and at times the average unit cost can be reduced by expanding the scale of operations.

exceeded the demand and, according to Marx, "bitter cutthroat competition" followed as a consequence of this increasing supply. The freight rate decreased to unprofitable levels. Consequently some shipping lines failed, but their ships remained and the excess of supply over demand continued. The surviving shipping companies responded to this failure by combining their resources, making special contracts with large-scale traders, and forming organizations called "conferences" to eliminate the competition and its impact on the freight rate to remain in the business. [9]

According to Sjostorom (2004), the conference system spread rapidly and soon included most of the world's liner routes. Some conferences covered traffic in both directions along a route and some in one direction only. They started to capture more shares and market power with certain rules and contracts. There have been several studies on the formation, nature, failure of the conferences.

2.4.2 Conferences: Definitions and Theories

This section reviews the definition of the conferences, the literature on theories that explain their structure, and the necessary market key points that help to understand the conferences structure.

Marx (1953) defines shipping conferences, or rings, as ". . . agreements organized by shipping lines to restrict or eliminate competition, to regulate and rationalize sailing schedules and ports of call, and occasionally to arrange for the pooling of cargo, freight monies or net earnings. They generally control prices, i.e. freight rates and passenger fares. The nature of their organization varies considerably, depending on the market structure of the trade route. Some

[9] Conferences are organizations of shipping lines operating along a particular route. The U.K. Calcutta conference is usually described as the first conference (Sjostrom 2004).

have been conferences quite literally, informal oral conferences, but many have employed written agreements establishing a permanent body with a chairman or secretary, and containing carefully described rights and obligations of the conference membership . . .” Marx’s definition of conferences shows the broad range of activities and realms of influence enjoyed by shipping service providers. Many researchers tried to address the essence and performance of the shipping conferences based on market structure theories. Monopoly, cartel behavior, oligopoly, and alliances are some theories for the market regime that conferences formed. Alfred Marshall (1921) argued that shipping conferences could act as monopoly because there were substantial economies of scale in the industry that led to a small number of firms.

McGee (1960), Bennathan& Walters (1969), Fox (1992, 1994, and 1995),Clyde&Reitzes (1998), andPodolny& Morton (1999) investigated cartel behavior in shipping conferences. According to Clyde &Reitzes (1995) the regulation of world maritime transportation has caused conference cartel to fail. The coming paragraphs examine the definition of cartels to clarify this researches focus on conference market structure.[10]

According to Carlton &Perloff (2004), a cartel is an arrangement among small numbers of firms to act as joint monopolists to control prices and increase profit. In a perfect competition situation, the output is allocated automatically based on demand and supply and a single producer or consumer can’t affect it. In a competitive market without collusion, each profit-maximizing firm produces outputs such that the marginal cost is equal to marginal revenue; in a cartel, the firms do not act individually. There is collusion among firms to set either the price or the quantity and participants are limited to the set price or production quantity. To establish a cartel, there should

[10] There are other theories that have tried to explain the performance of conferences like categories of explanations arose largely as responses to the cartel model. Contestable market (Sjostrom 2002), destructive competition and its modern variant, the empty cores models are alternative explanations of why conferences exist. These theories are beyond the scope of this research.

be incentives greater than those available to an individual make without cooperating, given the legal liability of joining a cartel[11]. The elasticity of demand and the cartel's ability to set the price above the non-cartel prices a resourceof potential profits. The more inelastic the demand curve, and therefore the greater potential profits from higher price fixing, the more likely firms are to join or form a cartel. There are other factors that influence the sustainability and efficiency of a cartel by affecting this initial incentive. The formation of a cartel may seem reasonable in an industry like ocean shipping, but according to Dick (1996) a cartel's longevity is dependent on the cost of self-enforcement and its value to members. This cost can be greatly affected by the number of cartel members and the entry of non-member firms and substitutes. When the number of participants in a cartel goes up, it is harder to monitor the members and as a result the cartel member control cost rises and cartel cheaters push the product price down. The price is also affected by the entrance of new firms to a cartel. According to Schmalenzee (1992), an increase in the level of profit in the industry may induce other firms to enter the cartel; increasing the number of firms in the cartel consequently will push the product price down in the long run. Changes in the number of firms in the cartel depend on the terms and conditions of entrance to the cartel. The cartel price also depends on the cartel's market share compared to competitors in the industry. If the cartel has only a small share of the relevant market, which includes all close substitutes produced in other industries, it cannot influence the market price, even if all similar firms make a cartel and raise the price.

As per Perloff& Carlton (2004), the other necessary basis for establishing a cartel is the ability to avoid charges of collusion. In some countries there are antitrust regulations for some

[11]There are a number of text books and papers that address the issue of cartel organization and sustainability. In this part I have mostly use the definitions in the Perloff and Carleton (2004) industrial organization book.

industries that forbid establishing cartels, such as the Sherman Act in the U.S. Large penalties reduce the incentive to form cartels.

According to Carlton &Perloff, the third essential factor in the formation of a cartel is low organizational costs which depend on a number of factors: the number of firms in the cartel, market concentration, and the degree of differentiation among products in the industry. If the number of participating firms grows, the organization costs become larger given more complex negotiations. As the number of rivals increases, the lower the market concentration and power, and the greater the organizational costs of gathering information on rivals' activities and harder challenges to gain a greater market share for the cartel, and more expenses to prevent cheating. If the firms engaged in a cartel produce similar products, supervision expenses and therefore the organizational costs decrease. When cartel member firms' products are of varying quality and specifications, it is harder to agree on a relative price and avoid cheating when there is more than a single commodity and price.

After the technological changes and increased capacity of vessels in the early 1880s, excess supply in shipping services pushed shipping rates down, causing many firms to fail. Conferences were a reaction to these trends, ensuring the survival of firms by increasing the freight rates and restricting or eliminating the competition. The new born conferences agreed to develop some barriers to restrict the number of firms in the cartel and prevent the falling prices that arise from competition from new entrants. The first key element of a cartel's foundation, "its ability to increase the competitive price level," was satisfied by historical structural changes in its shipping industry and firms' moves to sustain the industry by creating entry barriers to conferences, guarantying cartel-level prices and long-run benefits for participants in the process.

In transforming shipping companies from competitive firms to conference cartels, conference members needed to investigate the punishment for forming a cartel. This cost should have been low relative to the expected gains. The anti-trust immunity law[12] protected shipping cartels and assured their sustainability. As mentioned by Herman (1983)and Clyde &Reitzes (1995), since 1870 ocean carriers could enter into price-fixing agreements that were exempt from antitrust scrutiny and litigation in most of the world. As a result of this exemption, the potential costs of entering into collusive agreements, and expected punishment were lowered and another essential factor for cartel sustainability was guaranteed.

Control over the number of entrants and detection of cheating in the cartel are other preconditions for the sustainability of cartel conferences. According to Stigler (1983), the primary issue for any monopolizing cartel is enforcement. In a cartel, each firm produces a restricted amount of output such that the marginal cost is less than the price, giving each firm an incentive to raise output above the agreed level and upset the cartel arrangement. "Enforcement" means to detect output increases and punish members that violate such restrictions. A successful cartel should be able to detect cheaters and penalize them; individual members have a large incentive to cheat or "chisel." Figure 2-3 illustrates the increase in a cartel member's profit due to chiseling. The representative shipping firm would operate at price of P_c and produce $q_c$units of output. The competitive output of the industry will occur at the intersection of this supply curve with the market demand curve. Establishing a cartel causes the production level to fall such that marginal revenue (MR) equals marginal cost (MC), which guarantees that profits are maximized. The cartel increases its profits by lowering the aggregate cartel output to $Q_{m.}$

[12] **Antitrust or competition laws** are laws that prohibit anti-competitive behavior and unfair business practices. Conferences in ocean shipping have existed since the late 1800's on U.S. international routes. Since then, they have been granted varying degrees of antitrust immunity under the Shipping Act of 1916.

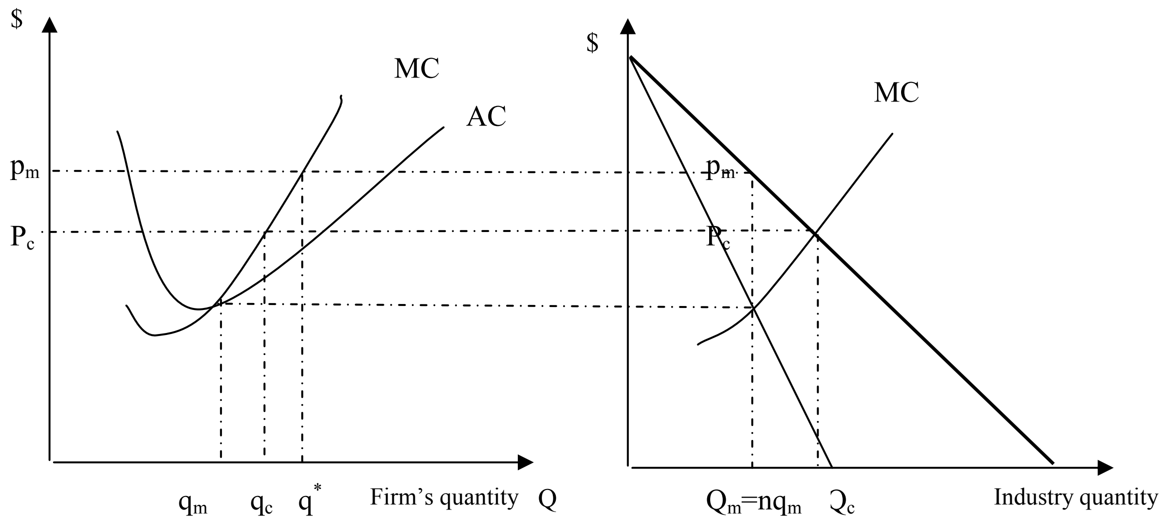

Figure 2- 3 Cartel Members' Incentive to "Chisel"

where MR equals MC, with the price at P_m. Assuming the cartel is made up of n identical firms, each firm would reduce its level of production to $q_m=Q_m/n$. However, the price level set by the cartel creates incentives for individual firms to increase output to q*.

According to Prentice (1998), improvements to the containerized shipping services in recent decades have made it harder to keep cartel members from cheating, because they may easily offer more differentiated services that attract customers.

Cartels must also control the number of entrants, often through liner conferences. There are different types of the conferences, identified by to the concept of entrants of the new members.As mentioned earlier, non-member firms' or a close substitute's, entrance into the market prevents a cartel from raising its prices. According to Sjostorom (1989), there is a significant difference between types of new entrants. Some entrants are called potential entrants while others are potential producers. Potential entrants are the firms that have not yet committed to sunk costs. Sunk costs are what a firm incurs in order to enter the industry, and these costs are avoidable only in the long run. Firms that have incurred those costs must decide whether to produce having incurred sank costs. When a potential producer starts to produce, it becomes an active producer. In the ocean shipping industry, a firm that decides to provide ocean shipping services must first purchase a ship, which is largely a sunk investment. Once the ship is purchased, the firm must decide whether to operate the ship and thereby incur the short-run costs such as crew and fuel costs. Before the ship is purchased, the firm is a potential entrant. After the investment in purchasing the ship, but before the firm goes through the variable costs level and decides whether to produce, the firm is a potential producer. When the firm begins to produce, it is an active producer. Therefore the difference between the potential entrants and the ship owners should be noted in other routes or laid-up vessels. Sjostrom(1989) makes the definition more precise by specifying some assumptions in costs of negotiations in the industry. As he mentions, in an industry in which it is costly to negotiate and renegotiate contracts before they are made binding, firms and their customers complete the contracts before any production occurs. As a result there are no sunk costs and consequently all potential entrants are automatically potential producers. Accordingly, when the market price falls below the firm's minimum average cost, the firm can drop its offer and prevent any losses until the price increases again. However, in the liner shipping industry the initial investment costs of buying ships is high and it is a barrier for potential entrants. All other ships along different routes or laid-up ships along the same route are "potential producers," while there may be some "potential entrants" that may find the route attractive enough to make some sunk investments and enter the route.

Conferences were established to save shipping firms from collapsing, and therefore they set certain barriers to deter new entrants. Based on the available literature on conferences, there are two types of conferences: “close” or “open” conferences. The Trade and Export Finance Online (TEFO) glossary defines an “open” conference as a “shipping conference in which there are no restrictions upon membership other than ability and willingness to serve the trade and abide by the rules of the conference,” while in a “closed” conference, potential entrants face barriers to enter. As Sjostrom (2004) mentions in the OECD (2001), by 1916 conferences around the world, except for routes to or from the United States, were closed. The U.S. Shipping Act of 1916 requires conferences to be open on trade routes to or from the United States. This Act basically forbid conferences from restricting potential entrants; eventually, according to Herman (1983), since the Act was not entirely clear, open conferences could restrict entry by imposing entry fees and by challenging the ability of the entrant to provide common carrier service. McGee (1960) gives six examples of entrants blocked from the U.S. conferences that appealed to the U.S. Shipping Board (established by the 1916 Shipping Act); but their appeals were rejected. The shipping Acts were amended or elaborated upon in further Acts that will be discussed later in this chapter.[13] A historical review of the shipping conferences reveals that despite legal restrictions, their attempt to restrict entry into the industry was highly successful in preventing the entry of non-conference members.

While conferences were trying to restrict conference membership and have more control over members, their market share along a particular route was always threatened by nonmember rivals. As a response to this threat, they used “predatory pricing” and “loyalty contract” practices, as Letwin (1965) and Yamey (1972) explain. Sjostorom (1989) has described conferences’ hiring “fighting” ships to put non-conference carriers out of business whenever

[13] Section 2.4.3 Regulation on ocean shipping industry

there were no legal restrictions[14]. These fighting ships were hired or subsidized by the conference to follow a non conference vessel from port to port and undercut their rates. As soon as the “discounter” withdrew from the route, rates went up to the conference level again. “Deferred rebates” and “patronage contracts” were other tools that conferences used to reduce the incentive for shippers to switch to cheaper non-conference carriers. As Marx (1953) mentions, conferences used to have two kinds of loyalty contracts: the deferred rebate and the dual rate contract (sometimes called contract rates)[15]. In the deferred rebate system, if the shipper chose to use conference services for a certain length of time, he or she will receive a rebate of an agreed upon proportion of his or her freight bill during that time.[16]Under the dual rate contract system, the shipper is restricted to using the service with a lower freight rate from a specific conference, signing an agreement to deal completely with this conference. In turn, if the shipper uses a non-conference carrier, the conference imposes a fine. According to McGee (1960), the two important distinctions between these two systems relate to price fluctuations and enforcement costs. Under the deferred rebate system, the shipper loses interest on the price cut and the conference bears lower enforcement costs because it does not have to enforce the fine by going to court.[17]Perhaps because of these differences, discounts under deferred rebates tended to be larger than under dual rate contracts. Marx (1953) states that discounts under the deferred rebate system before legal restrictions, were typically double the size of the other methods.

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[14]For instance, based on the Merchant Shipping Act of 1982 in England, members of a conference shall not use fighting ships in the conference for the purpose of excluding, preventing or reducing competition.

15 Loyalty contracts are designed to persuade customers to use a particular service provider.

[16] The deferred rebate system was prohibited in U.S. trade by the 1916 Shipping Act.

[17](McGee 1960, 232-35).

Anyhow, under both systems, the conference must incur the costs of determining whether the contract has been broken.

In the following sections, some of the important policies and regulations that have influenced the efficiency of the conferences' cartel behavior are briefly reviewed.[18] These regulations are mostly these that have affected antitrust immunity and the cartel operation of liner shipping conferences in the North American routes.These have affected the entry of new members to the conference and conference price setting, eventually leading to cartels' dissolution.

2.4.3 Regulations in the Ocean Shipping Industry

Following technological changes in the ocean shipping industry in the late 1860, hefty overhead costs and price wars caused many failures. Mergers and conferences formation occurred as a response to these. Ocean shipping service users and exporters started to benefit from low rates because of excess supply in the shipping market; in some cases they received preferential treatment. But with introduction of the conferences, they started to witness higher rates and increased market power within shipping conferences. Shipping service users started to complain about the power of the conferences and the limitations that they were putting on world trade. Eventually they managed to formulate the regulatory portions of the United States Shipping Act of 1916 to protect themselves from the higher prices dictated by shipping conferences. But conferences resisted these changes, and despite the legal prohibition looked into ways to maintain and even increase their market share. The Act was amended to eliminate ambiguities that contributed to the concentration of among shipping companies. The following

[18] Although this research looks at ocean globally, the main focus will be the routes from North America and Canada.

sections touch on these Acts, from the Shipping Act of 1916 to 1998 (OSRA), the most recent and comprehensive Act and their impact on shipping conferences and their market power.

2.4.3.1 The Shipping Act of 1916

Marx (1953) mentions the Americans shipping Act of 1916 granted anti-trust immunity to shipping companies on one hand but prohibits "deferred rebates," "fighting ships," discrimination against any shipper, and unfair or unjustly discriminatory contracts with any shipper on the other hand.

According to Max, the most important restrictive aspect of the 1916 Shipping Act was to mandate conferences to be open conferences to and from North American seaborne routes. This meant cartel could not exclude outsiders from entering the cartels. Also, prohibiting the fighting ship system made price controls more difficult for the conferences. As a result of these restrictions, conferences tried to take advantage of "loyalty contracts" to bind costumers to the conferences and restrict non-conference competitors. This was likely one of the reasons that the Act had to be reviewed and amended.

2.4.3.2 The Shipping Act of 1984

Although there had been several discussions of, and minor amendments to, the Shipping Act of 1916 after its inception, the most comprehensive modification of it was proposed in 1984. In a new amendment, all liners, including conference carriers that call at United States ports, were subject to the provisions of the 1984 Shipping Act. Under the regulatory structure defined in the Shipping Act of 1984, the conferences were forced to be open so that any carrier may join or exit a conference with limited notice, without explicit penalties. As Wilson&Casavant (1991) state, this Shipping Act reduced conference market power by introducing a new provision representing "competitive intrusion".[19]

According to the 1984 Shipping Act, all conference and non-conference carriers were obligated to report their rates to the Federal Maritime Commission (FMC). This obligation increased the control over conference and non-conference pricing and helped provide clear information to the market.[20]If any secret discounting from published rates by either a conference or independent carrier was detected by the FMC, the involved party was subject to a fine. The amendment also removed the freight rate change notice. According to the Act, conference members were not obligated to follow the conditional 10 days' notice of violating conference rates publishing their own freight rate on a particular transaction. This rule allowed members to of deviate from conferences and increase the incentive to cheat via collusive arrangements, but as Clyde and Reitzes (1998) show, the conference still prohibited their members from independently entering into contractual agreements with shippers. Fox (1995) looked at this provision in the U.S. Shipping Act of 1984 and investigated whether the Act made any difference to collusive agreements. Under this Act it is expected that public price-cutting undercuts conferences because it affects conferences' enforcement costs. Her research rejected this result. According to her, the weak supervision of the FMC and/or the low ratio of fines to profit yields were causing this failure. Her results were replicated by Clyde and Reitzes (1998). They showed that from 1985 through 1988, the FMC collected approximately $6 million in fines. This amount was below 0.1% of the liner shipping industry's revenue on U.S. international

[19]These provisions include the Mandatory Right to Independent Action (MIA) and the right to form Service Contracts (SC). For more information look to the Shipping Act of 1984.

[20]The Federal Maritime Commission (FMC), an agency of the U.S. government, is charged with monitoring and enforcing the published rates.

routes over this period. This issue prompted another amendment to clarify the legislation and set boundaries for the conferences

2.4.3.3 The Shipping Act of 1998 (OSRA)[21]

The Ocean Shipping Reform Act of 1998 (OSRA) represented a significant change in the regulation of the maritime shipping industry by the government of the United States. While some of the old practices were maintained in this Act, a number of the aspects of ocean shipping practices were changed. One of the major additions was to restrict the power of the shipping conferences by prohibiting them from involving themselves in negotiations for service contracts apart from collusive agreements. The Act clearly stated that conferences should not require members to reveal a negotiation or the terms and conditions of a contract. Conferences were also prohibited from adopting mandatory rules affecting member's right to negotiate for or enter into service contracts. However, OSRA left the right of adopting voluntary guidelines relating to the terms and conditions of service contracts to the conferences.[22]

Lewis and Vellenga (2000) highlight the changes in FMC's role in the OSRA as another major difference between it and past Acts. According to OSRA, rate tariffs reflecting the regular (non-service contract) rates charged by the carrier will be published on the Internet instead of being filed with the FMC. As a result of this change, the freight rate has to be publicly available, but the FMC's enforcement obligations are eliminated. It appears to add more transparency in the market and make entry easier. However, as Lewis and Vellenga state, OSRA's elimination of the tariff-filing requirement and rate enforcement by the FMC raises the member price

[21]Public Law 105-258, 112 Stat. 902, Ocean Shipping Reform Act of 1998, approved October 14, 1998 (hereafter "OSRA").

[22]"FMC allows guidelines for contracts," American Shipper, 41(4), April 1999, p.10.

controlling costs for the conferences. They point out while OSRA is a logical continuation of the trend toward deregulation established by the Shipping Act of 1984, its main goal is to provide more choice and flexibility for shippers and ocean carriers to enter into contractual relationships with shippers for ocean transportation and intermodal services. While the previous legislation gave conferences the right to prohibit member firms from entering into service contracts, probably the most significant change made by the OSRA is to allow members of ocean carrier agreements (such as shipping conferences) to negotiate and enter into confidential service contracts with one or more shippers, and to do so independently of the other member carriers. Under OSRA, carriers can join together through alliances, or similar agreements, to sign service contracts, bypassing their conferences' jurisdiction over a given route.

Reitzes&Sheran (2002) investigated the outcomes of the OSRA after two years and provided evidence of how it affected conferences' behavior. Based on their report from the FMC, between May 1, 1999 and June 30, 1999 (the first two months under the OSRA) 15,000 service contracts were signed in comparison to 3,400 in the same period of the previous year. Despite the increase in contracts, several conferences broke up. Based on the FMC report in 2000, the number of conferences declined from 32 in 1997 to 22 by May 2000 (Reitzes&Sheran (2002)).

As Reitzes&Sheran note after the OSRA took effect shippers are able to engage in contracts with single carriers that could cover multiple trade lanes instead of entering into contract agreements with multiple conferences in which each of them covers only a single trade lane. Hence, conference stability is affected apparently by the new granted right of individual carriers to enter into service contracts covering multiple trade routes. This is one of the important causes of the changes in the liner conferences from price-setting cartels to a more competitive market. These changes turned the liner companies into a substitute option for the competitive tramp market and prepared the ground for different options for bulk wheat transportation.

The main objectives of these Acts were to restrict the power of conferences by challenging the anti-trust immunity law in the ocean shipping industry.They enforce pressure through affecting cartel stability factors like increasing enforcement costs for the conference and eliminating entry barriers. Changes in conferences' market behavior, anti-cartel Acts, and ant-monopolistic activities helped non-member carriers to become serious competitors. As a result, liner shipping has become another option for shippers.

2.4.4 Tramp Market: Definition and Theories

The most common method of bulk movement, if there is not a need for specialized services, is to use tramp vessels. It means using one ship to carry cargo. The bulk shipping market is highly competitive and satisfies many of the characteristics of the perfect competition model. As Perloff and Carleton (2004) state, in a competitive market all firms produce homogeneous products. Perfect information exists for all of the buyers and sellers, neither the buyers nor the sellers incur costs to participate in the market, both are price-takers, and there are no externalities. According to the above conditions and the definition of services in the tramp market, the characteristics of the services offered in the bulk shipping industry, the firms in the industry, and the buyers of services amount to a close to perfect competitive market.

The process of hiring a bulk ship to move commodity starts with "fixing" the ship. When a ship is chartered or a freight rate is agreed upon, the ship is said to be "fixed." There is cargo to be shipped and ship owners have vessels to provide the service, and brokers put the deal together. The following example shows a fixture arrangement.[23] Assume a couple of bulk carriers, free of cargo, are in a Canadian port and are ready to be fixed along different routes from Canada. There are also cargo owners who decide on the type of shipping contract based on the quantity, timing, and physical characteristics of their cargo. There is a possibility that the two parties could create a contract together, but there is also possibility that the ship owner or cargo owner will appoint a shipbroker who may provide them with information on various routes and fix the cargo. Finding available cargo or ships, applicable fees, and freight rates are the duties of the shipbroker. Brokers compete and try to negotiate a better deal for their clients. As a result, the available information plays a significant role. [24] The availability and flow of the information, especially after the introduction of on-line information, make the markets very transparent. The service offered in the tramp bulk carrier market is almost homogeneous; however, the homogeneity of services in the industry depends on the speed, safety, timing, and availability of transporting specific commodities.[25] Unlike containerized carrier, the bulk carriers are not specifically designed for carrying specific commodities, and in this context we assume that they offer homogenous service.

Comparing to liner shipping, tramp shipping has relatively few barriers to entry. Entry costs are very low for active carriers along different routes, and many firms are competing for business (each ship is considered a separate competitive unit); the commercial structure of the

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[23]"The Tramp Shipping Market." produced by Clarkson Research Studies can be viewed online at http://www.marisec.org/shippingfacts. (accessed September 2005).

[24]Brokers tend to gather in shipping centers. London remains the largest, with other major centers in New York, Tokyo, Hong Kong, Singapore, Piraeus, Oslo, Hamburg, Copenhagen, Bergen, etc.

[25]The major bulk commodities are iron ore, grain, coal, phosphates and bauxite, which can be transported satisfactorily in conventional dry bulk carriers.

shipping business allows for the free entry and exit of companies. In addition, the costs of operating different types and sizes of vessels can be viewed in companies' published reports and websites, [26] which make it easier for potential investors to estimate future profit levels.

The freight rate and the need for specialized services are important factors that influence service users' decision-making. When the prices of liner and tramp options are similar, the tendency toward containerized liners become pronounced because it is more like a vertically differentiated services and in such models apparently the more efficient service is preferred.[27]

As discussed, the service-producing side has faced major changes and challenge in the past century. Changes include technical and industrial changes that have affected the shipping market's structure and caused major policy changes that influenced their enrollment in the OFM and as a result have affected the OFM.

2.5 Ocean Freight Options

As Stopford (1997) states bulk cargo transport can be approached by the shipper in several different ways depending on the cargo itself and the nature of the commercial operation. Choices range from total involvement, by owning one's own ships, to handing the whole job over to a specialist bulk shipper. Some large companies ship substantial quantities of bulk materials may run their own shipping fleets to handle a portion of their transport requirements. But a shipper with a long-term requirement for bulk transport and no tendency to be actively involved as a ship owner may decide to hire or fix a ship from a shipping company. An

[26]For instance, the following link available to the general public under Shipping Facts: http://www.marisec.org/shippingfacts/home/ (accessed in June 2011).

[27]As per Perloff and Carlton (2004), different types of product or service differentiation exists. If the products possess different characteristics, for example different colors, they are differentiated "horizontally." Some consumers will prefer one option and some may prefer the other. If the quality of the services or products is different with the same price, in this context the efficiency and quality of containerized handling and transportation, the more efficient service is preferred. This is called "vertical" differentiation.

individual firm selling agricultural products, such as wheat, does not have market power in the wheat trade. Production is heavily dependent on seasonal factors and the volatility of the market plays a significant role for this firm. There are different freight contract possibilities for the firm. One of the main goals of the exporter firm is to find the best transportation plan to minimize transaction costs. The firm faces two principle costs: the value of the product and the transportation cost. In the case of transportation, a buyer usually faces three choices and each choice has important implications for the division of responsibilities between buyer and seller: Free on Board (FOB), Cost and Freight (CNF) and Cost, Insurance, Freight (CIF) are the options that will be described briefly.[28]

2.5.1 Free on Board (FOB)

United States Grain Council outlines the responsibility of each party in the F.O.B option as follows:

In this option, the commodity is delivered "end spout." It means the seller is not responsible for the commodity once it is loaded in the vessel. In the case of wheat, as contractually agreed, the seller will produce a certain quantity of wheat, as weighed by the Grain Inspection Service, during a specific period and delivered to a specific port or ports. The seller may even be willing to agree to a specific elevator if the buyer desires it. This is generally the end of the seller's obligations. The buyer is responsible for moving the wheat to the destination country. In the case of a shipment moving by sea, this entails the chartering of an ocean going vessel. The buyer's responsibilities include appointing agents to oversee loading and documentation, monitoring the

[28]The US Grain Council has provided an import manual in which each of these choices is explained; I have used it as the main source of the definitions in this section. URL: http://www.grains.org/importer-manual/chapter-1, last visited June 2011

vessel's progress as it sails, and settling claims with the vessel loader in addition to chartering the vessel.[29]

2.5.2 Cost and Freight (CNF):

In this case, the seller contractually agrees to deliver the commodity to the destination of the buyer's choice and the buyer is in charge of arranging for the availability of discharge facilities. The buyer usually has to specify, and guarantee, the port conditions (draft, available berth, and so forth) at the destination. Title passes upon the issuance of bills of lading even if the buyer has not actually paid for the commodity. Those bills of lading, along with the rest of the vessel's documentation, are what the seller will use to collect payment due under the contract. Since the buyer has bought the commodity delivered, the importer "owns" the commodity on board the vessel even though it is still weeks from its destination. Consequently, the buyer should insure the value of that cargo against losses.[30]

2.5.3 Cost, Insurance, Freight (CIF):

This option is quite similar to CNF except that the seller is responsible for insuring the value of the cargo. This method is used for exporters who load cargo without a prearranged sale, hoping to find a buyer once the commodity is on the vessel. Therefore, the seller will be self-insuring the cargo and will deliver it via CIF at the appropriate time.[31]

In all of the above cases, the wheat may be transported by a competitive tramp carrier or a specialized container that belongs to a conference according to the needs of the buyer. Regardless of the contract shipping options and the type of services that the parties may choose,

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[29] U.S. Grains Council – Importer Manual, Chapter 5, p. 67.
[30] Same source as the foot note 30 and 31.
[31] Same source as the foot note 30 and 31.

they are normally price-takers in ocean freight markets. The transportation price will be added per tonne-age and mileage and all other costs will be added to the price of the wheat in producing company. Therefore our model will not be affected by the type of contract between the seller and the buyer, unless one of them has market power on the ocean freight transportation. This case is beyond the scope of this thesis and can be investigated in further studies.

2.6 Summary and Conclusion

World trade growth is accelerating even more rapidly than it has in past centuries and as a result there is a growing demand for the derived maritime transportation demand. Grain traders, specifically wheat traders, select maritime freight as the most appropriate mode of transportation since there is an economy of scale and it minimizes the cost of trade. In terms of moving wheat, there are two different types of ocean transportation modes: containerized ships that are mostly under the regulation of the liner shipping industry, and conferences and bulk ships active either in the tramp shipping industry or the liner industry. Whereas the bulk shipping market shows competitive characteristics, liner shipping conferences are more concentrated. Both of these services are used to ship wheat across the world, but as mentioned in the past chapter, there is a trend toward hiring containerized services since this market is moving toward competitiveness and offers more efficient services.

The investigation about market structure of the liner and bulk shipping appeals that while the bulk shipping market is operating in a nearly competitive market, the liner shipping conferences have a more concentrated market. These conferences used to act as cartels. As discussed, research has addressed the market structure of shipping conferences and debated the efficiency of the cartels. Recent shipping acts, especially the OSRA, resulted in the failure of the cartels and limited their market power. They had to offer rates and services comparable with those of conference operators from independent shipping lines to be able to stay in the business. This leads the industry to a more competitive operating system and more choices for consumers of transportation services. The regulations have affected anti-trust immunity in the industry and have reduced barriers to entry in such a way that the conference cartels have fallen apart. As a result, they are now a substitute mode of transportation for bulk carriers. Apart from the impact of the historical organizational structure that has increased the tendency toward hiring containerized liners, other factors like special consumer preferences and especially Identity Preservation (IP) are contribute to using container liners. This may have affected the use of more specified containers and, one can argue, the homogeneity of the shipping services offered by different companies. This concept is beyond the scope of this thesis and can be investigated in future studies. Easier handling and transportation, storage capability and port facilities are some other factors that were discussed in this chapter as motivates for ocean transportation service users to choose container liners. Assuming the entry of a competing containerized vessel along a specific route, the freight rate will fall. There is always a possibility that a decrease in the freight rate will affect the balance of the relative freight rates such that shippers switch from bulk ships to container ships because of vertical differentiation.

Exporters and importers face different freight options such as CIF, FOB, and CNF. No matter which option is chosen, both parties try to minimize their trade costs, which allow for the hiring any of the freight options in this trade model without being concerned with structural changes in the model. Considering the tremendous number of bulk commodities, service users, especially grain and wheat producers, are generally price-takers in the ocean transportation market.

Chapter 3 is a review of the spatial trade models, resulting in a trade framework that shows the changes in bulk flow that come from the changes in relative freight rates along different routes globally. Following market behavior, the coming chapter will focus on the impact of freight rate fluctuations on bulk flow regardless of the source of fluctuation and assuming that the service users are price-takers. There will be an attempt to quantify the reaction of grain traders and follow the changes in grain movement because of the changes in ocean freight rates.

CHAPTER 3

THEORETICALFRAMEWORK

3.1 Introduction

The Chapter 2 of this thesis examined the structure of the ocean transportation market and the various choices available to wheat trade parties for ocean shipping. Regardless of whether tramps or liners are used, wheat movers can be assumed to be price takers in this market. This chapter outlines a theoretical model to examine how the fluctuation in transportation costs may affect production, consumption, and trade flows. This theoretical model will be used as a framework to develop a simulation model of the international wheat market in Chapter 4. This simulation model will show whether the impact of transportation costs can be captured immediately and responded to maintain the market share. If so, the market players can use this tool to help with the exporters' decision-making as regards setting competitive prices and maintaining or increasing their share in regions in which they may have comparative advantage.

In order to construct a theoretical trade model and answer the main question of this research, we need to define the vertical supply chain and clarify the role of ocean transportation in wheat flow across the world. To get to this point, we need to know more about the specifications of the traded commodity (in this context, wheat), its logistics, and identify the market players, supply chain levels, and related assumptions that can help us to narrow down the applicable models.

First, an overview of the global wheat market and its logistics, with a focus on ocean transportation, will be provided. Next, the literature of trade theories that have considered the issue of transportation as a factor in commodity flow will be reviewed to find an appropriate framework to explain wheat trade patterns with respect to ocean transportation. The Armington framework will be discussed, as the seemingly appropriate framework for this study; finally, a market simulation model of the wheat trade will be applied to three exemplar countries, considering ocean freight transportation as a viable mode of transportation. The last section of this chapter will summarize our findings.

3.2 An Overview of the Wheat Market and Logistics

The logistics concern the intermediate level in the supply chain of a product; in order to analyze and determine the logistics of a good and its impact on the different levels of the supply chain, we need to have some knowledge about the initial product, its market characteristics, and the various market players, as well as the logistical steps, market characteristics, and the final product. The movement of wheat from the point of export to the importing destination is the process under investigation in this thesis. Wheat in the exporting and importing gates will be the initial and final product, respectively, and ocean transportation is the intermediate level on which we will focus in this thesis. In particular we must have some basic knowledge about the ocean freight process, which is the main subject of this research. In chapter 2, we explained the various available options from an economical point of view. We explained the market of each option and the availability of services. In this section, a brief explanation about the players in the world wheat market will be provided and then technologies at the processing level will be reviewed. We will also briefly examine the supply chain using either the bulk or container systems.

One should note that the trade flow of a commodity depends on a variety of macroeconomic and microeconomic factors. In the case of wheat, these factors and their impacts have been the subject of many studies. Some microeconomic factors include characteristics that affect the supply and demand of wheat, such as quality, available substitutes, yield- and production-affecting factors, prices, and spatial considerations. The economic situation, Gross Domestic Product (GDP) and per-capita income, and the country's population growth are examples of macroeconomic factors. Additional factors such as exchange rates, transportation and fuel rates, major players' policies and international trade issues, and many other factors can be measured and focused on in research and calculations. In this research we only focus on a single factor, that of ocean transportation. Even the effects of the factors that influence the ocean transportation costs are considered exogenous and shown as changes in ocean freight rates in this research. A breakdown of the world wheat market will be provided in the next sections, keeping in mind those policies and other factors outside of transportation are not within the scope of this study.

Wheat is produced and used in many regions of the world. To set up a global trade model for wheat, it is important to know the main players in the global wheat market. In the first part of this section we look briefly into world wheat production, consumption, export, and import.

3.2.1 World Wheat Market Players

Wheat is a common grain produced and used in much of the world. While wheat is consumed all over the world, some regions do not have the required conditions for growing this grain or do not have a comparative advantage in producing it. Therefore, wheat is heavily traded across the world, from regions that have excess supply to regions with excess demand. The average global per-capita consumption of wheat has been reported at 79.1 kg annually (Canadian Wheat Board 2011-12 forecast report). The global trade in wheat, including flour and durum, is increasing. The available statistics for wheat show that some countries play a dual role, being both buyer and seller, in the wheat market. Some big producers are not necessarily big exporters, and some major exporting regions are among the biggest producers of wheat.

As per statistics retrieved from the Food and Agriculture Organization of the United Nations (FAO) International Grain Council in 2009, the first ten wheat producing countries in order were China, India, Russia, United States, France, Canada, Germany, Pakistan, Australia, and Ukraine. The European Union (EU) is the largest wheat-producing region, with a total production of 138.7 million tons of product in 2009.

As for wheat exports, in the context of a relatively open global market there is a large number of wheat producers competing for a share of the market while some are dominant players. The United States, the European Union, Canada, Australia, and Argentina are, and for many years have been the main players on the supply side and are the principal sources of wheat globally.[32] As mentioned, some of these players play a dual role in the wheat market. For instance, the United States is one of the world's largest wheat producing and exportingcountries, yet imports a significant amount of wheat. We should note that not all of the big producers are necessarily big exporters of wheat, and big exporters are not necessarily producing the largest amount of wheat in the global market. Also, while some of the suppliers in exporting countries act as individual competitors in the market, in some other exporting countries (up to 2007) there are big single-seller desks like the Canadian Wheat Board and the former Australian Wheat Board or large multinational grain merchants such as Cargill. Different players, depending on their share in the market, may affect the global wheat market in different ways as a result of changes in their strategies and policies. However, in this context we ignore these types of impacts.

All countries and regions in the world consume wheat for different purposes and with a variety of preferences. The domestic supply of wheat within a region is rarely the only source. With the exception of Canada and Australia, all regions of the world are dependent on both domestic and foreign sources of wheat. The demand side is also affected by factors that have direct and indirect impacts on the price of a specific type of wheat, as well as the price of

[32]Same source

substitute products (the same type of wheat produced in other regions, or another type of wheat or grain). In general, the availability of substitutes for different types of wheat, or even substitute starch sources such as rice, cultural differences in diet, and reliance on a single-buyer, such as in China are important factors that the literature shows has an effect on the demand for wheat in the market.

The dual role of some regions as both exporters and importers is very important and worth giving special attention to in this context. As Sumner and Boltuck (2001) mention, this dual role may arise for different reasons. It can arise as a result of natural internal trading patterns that economize on shipping costs and reflect demand for distinct classes or quantities of wheat. For instance, many urban marketing areas within the United States are within a cheaper shipping distance to Canadian sources, turning the Canadian wheat into a more attractive good in that area compared to US-produced wheat. Similarly, many US wheat-growing sources are located within cheaper shipping distance to ocean ports than to domestic demand centers and are therefore more appropriate for export purposes. Besides, the type of the wheat cultivated in a specific region may not be the exact variety demanded by the consumers in that region.

Included in the above paragraphs were a few highlights of the characteristics of the wheat market. The market players will be discussed in more detail in Chapter 4 of this thesis, at which point we will divide the whole market into different regions and construct a framework for the empirical model. The next section will examine how ocean transportation affects wheat's movement from one region to another and will provide some information about wheat logistics.

3.2.2 Wheat Logistics

The internal and external logistics of wheat has been a hot topic in wheat-related studies. Figure 1-1 in Chapter 1shows a simplified summary of wheat's journey from farm gate to the destination country and consumer. This thesis is mainly concerned with transportation from the exporting country's port to the importing country's port. The availability of the required facilities in the origin and destination ports, special requests from buyers, and the amount of cargo all affect ocean shipping choices. The following paragraphs will address some of the key points concerning the logistics of wheat.

Generally wheat destined for export should move from primary elevators to terminal elevators in the exporting ports of the country. Depending on the location of the farm elevator and terminal elevator, there may be different options available. Trucks, rail cars, or barges are the main options.[33]

In Canada's case, the main exporting ports are Thunder Bay, Vancouver, Prince Rupert, and Churchill.[34]There have been several studies that address different aspects of the inland handling and transportation of wheat in Canada for instance Baylis (1998). After the wheat reaches the terminal elevator, the vessel is loaded. The type of loading vessels will depend on the size of the vessel, dock depth, and the number and variety of grains stored in the elevator. In some locations, the ship has to be half-loaded and the rest is loaded in deeper sections of the sea. The movement of wheat from Thunder Bay to the Atlantic is via the Great Lakes St. Lawrence Seaway System. This is an inland water route of about 2400 km. As per the Coasting Trade Act, if there is not a suitable Canadian vessel available, Canadian residents can apply for permission to bring a foreign flagged vessel into Canadian waters for a specific period. [35]The cost associated

[33]Handling from farm gate to primary elevator and from primary elevator to the terminal elevators are not in the scope of this thesis.

[34]Grain and Oilseeds: Handling, Marketing, Processing, Volume I, 4th edition 1993

[35]Canadian Transportation Agency, https://www.otc-cta.gc.ca/doc.php?sid=1086&lang=eng, Link accessed in July 2011.

with this Act is not considered in this study and we assume that the movers can simply access flagged ships along different routes. Most of the grain is shipped via bulk carriers.

As explained in Chapter 2, bulk and container carriers are different viable ocean transportation options to ship grain. Although bulk movement is the dominant mode of ocean transportation, one should be aware of the existence of, and increasing trend toward, containerized movement since the relatively stable and declining cost of container shipping has made it a more attractive option during the past decade. But despite the recent trend, there are some limitations for the containerized shipping method in the movement of grain. Container availability (both in terms of location and load unit), the seasonality of agriculture products, the availability of empty containers in the route, container size, port facility for loading and unloading, terminal issues, and container preparation[36] are some factors that have limited the use of containers in moving agricultural products, especially grains. Nowadays 10 percent of Canadian grain is being shipped via containers, but bulk movement still remains the dominant mode of ocean transportation. We can tentatively accept that all ocean freight service users, of both liner ships and tramp bulk ships, are price takers. If comparing two services is the goal of a study, one need to examine all of the steps of handling and transportation, from farm gate to loading the vessel; according to Kosior (2002), the steps involved with handling and storage for the two methods are significantly different and they require different port facilities. Appendix A shows the flow map of shipping wheat via container and bulk carrier.

After a review of the initial and final product and the mode of transportation, we will see how the transportation system enters trade models.

[36] Many products require a container to be thoroughly cleaned before being loaded to avoid any form of shipment contamination.

3.3 Literature Review of Transportation Role in Trade Models

The subject of the flow of commodities is neither a new nor an uncommon issue in geographic and trade economics literature. Many researchers ranging from regional scientists and geographers (Israd(1951); Bon(1984)) to international trade theorists (Frankel & Wei (1998); Krugman(1980)), transportation planners, and spatial interaction modelers, have worked on the issue and have developed and employed a variety of methods of modeling the movement of commodities. Intervening opportunities models (Fotheringham(1983), optimization models(Wilson (2005)), general equilibrium models such as inter- and multi-regional input-output models, conventional gravity models (Celik&Guldmann (2002)), regression-based models, and Artificial Neural Network (ANN) models (Doughetry (1995),Cleik (2004)), are all methods that have been applied to modeling commodity transportation.

Ever since the role of transportation found its place in trade theories, economists have proposed various models to predict patterns of trade and analyze the effects of transportation. As Corden(1984) mentions in the older literature, either the transportation cost is missing and the researcher has regretted the absence of transportation costs in trade theory, or the researcher suggests the role it might play if it were introduced; unfortunately, in the past, it has not gone further than that. Fujita et al. (1999) believe the lack of addressing this issue was not because of the economists' lack of interest or knowledge, but because of a limitation in tools. The development of modeling tricks to analyze industrial organizations, international trade, and economic growth has made it an easier and more viable field within which to work and has made researchers more willing to work on trade now that they can consider transaction costs and their effects and combine these issues with economic geography.

Geography and space entered into the framework of trade models after Enke (1951) and Samuelson's iceberg theory (1952). Since then, the literature of trade theories can be divided between spatial and non-spatial models. The first category, as mentioned, goes back to papers by Enke (1951) and Samuelson (1952) on Spatial Price Equilibrium (SPE). In this category, world trade in a single commodity or homogeneous commodity space is considered. The backbone of the model is classical demand and supply curves for the commodity in each country and bilateral transportation costs between countries.

In the SPE problem, one seeks to calculate the commodity supply and demand prices and find the trade flows satisfying the equilibrium condition that the demand price is equal to the supply price plus the cost of transportation; there is no trade between the pair of supply and demand markets if the demand price is less than supply price plus the transportation cost.

Samuelson (1952) showed that the prices and commodity flows satisfying the SPE conditions could be determined by solving a mathematical programming problem. He assumed that part of the goods to be delivered is consumed by the transportation cost.

Fox (1953) and Judge and Takayama& Judge (1971) are sample papers based on the Samuelson-Enke SPE model.Fox(1953) presents the first empirical application of this approach, estimating an SPE model of the livestock feed industry in the United States. Takayama& Judge (1971) provide a textbook treatment of the approach and describe numerous extensions and generalizations. More recently, economists have developed several global spatial price equilibrium models, such as the World Dairy Markets Model (Cox et al. 1999) and the Global Forest Products Model such as that which Baughman (2004) presents.

One of the main assumptions in SPE-based models is that goods produced in different regions are perfect substitutes for one another, that each region has classical demand and supply curves for commodities, and that there are bilateral transportation costs between pairs of regions. SPE is a set of region-specific prices and quantities produced, consumed, and traded, such that all markets clear and there is no arbitrage. This approach, while relatively easy to apply, has a major shortcoming as a consequence of the perfect substitution assumption. As Srivastava (1997) mentioned, the spatial and non-spatial models that consider domestically produced and imported goods perfect substitutes have not adequately explained historical trade flows. The reason is that two countries trade the same commodity not only because of the transportation cost differences, but also because of quality differences (and other differences) in the two products based on the source.

There are some studies with a focus on grain and agricultural products and ocean freight. However despite the focus on agricultural product, identifying the overtime trend of ocean freight rates or costs has been the main objective of these studies. Wilson et al. (2005) used an optimization-based model and stated that changes in the world grain market affect the spatial distribution of grain flows. Based on spatial equilibrium theory and a transport optimization problem, Wilson et al. (2005) investigated the effects of ocean freight rate changes on the United States' grain distribution. Identifying the ocean freight rate as a major factor in the shipment patterns of grain, they used a cross-sectional econometric model to evaluate structural changes and price differentials in ocean freight rates for grain shipments from U.S. ports to various major importing countries. They limited their cost factors to distance and ship size, and they considered other factors including shipping seasons, shipping frequencies, multiple destinations, commodity types, and port and storage characteristics of origins and destinations. Their results show that cost factors play a significant role in determining ocean freight rates. Like Jonalla et al. (2002), they found that the freight rate increases when the distance between the country of origin and the destination increases, and the ocean shipping industry charges different rates by season and commodity. They emphasized the structural changes in the ocean freight rate during the period from 1987 to 1998. However, they do not make comparison among various countries, relative distances, and the sensitivity of the wheat flow to the changes in freight rate.

Jonnala et al. (2002) follow a GARCH[37] approach in modeling ocean freight rates for grain, empirically examining the major factors that affect them. By employing a directed autoregressive conditional heteroskedastic error process they developed ocean freight rate equations. Based on their results, the voyage distance, ship size, contract terms, flag, and season are important determinants of rates, as is ship tonnage contracted for hauling selected dry bulk commodities. Their results emphasized the direct relationship between distance and freight rate, but did not acknowledge the relative distances between countries and the impact changes in freight rate have on the relative advantages of rival countries.

There are studies such as that of Reichert &Vachal (2003). In their report, prepared for the USDA, they examined various ocean transportation options based on available marketing solutions, specifically with an emphasis on the importance of grain identity preservation services offered by the exporter country or demanded by the consumer country. In the case of wheat, they mentioned that in the past 5 or 6 years prior to their research, approximately 25% of wheat was exported as "premium" and they predicted an increasing trend toward exporting premium wheat. Therefore, Reichert &Vachal (2003) established a cost analysis and made a comparison of bulk versus container movement. The logistics in grain transport, from farm storage up to its final destination, is compared in bulk shipping and container shipping. They mentioned that this process involves 21 days for the containerization of Canadian wheat and 97 days for bulk handling and transportation. While bulk shipping is traditionally a cheaper way of moving grain because of economies of scale, due to changes in ocean shipping acts, specifically the Ocean

[37]GARCH stands for Generalized Auto-Regressive Conditional Heteroskedasticity and is an econometrics tool that has become widespread for dealing with time series heteroskedastic models.

Shipping Reform Act of 1998 (OSRA),[38] and the presence of vessels with higher container capacity on major routes, container shipping is becoming a competitor to bulk grain shipping. However, while Reichert &Vachal, in their research on marketing "identity preserved" grain vs. generic marketing of raw grain, discuss the development of containerization in grain movement and look for ways to reduce costs through logistics, their focus is on economic decision models for marketing grain. As a result, while exploring the grain export steps from storage and handling to transportation and marketing, there is no discussion of the relative advantages that may exist because of location differences.

There have been a number of recent reports and studies that have examined the efficiency of Canadian handling and transportation systems, including Baylis (1998), Khakbazan et al. (1997), Vercammen (1996), and John Head (1994). Despite the magnitude of ocean transportation costs in trade costs, there is not sufficient research on the impact of the ocean freight transportation market on grain (especially wheat) flow from Canada that investigates the particular opportunities that are created by differences in distance.

In summary, there have been numerous studies that have modeled commodity flow, applying various transportation modeling methods in doing so. There are further studies that focus on ocean freight for grain, but there has been less work done to simulate the global grain trade and, especially, wheat trade considering the important role of ocean transportation as the intermediate level of wheat delivery and the immediate impact of changes in this level on the final product.

The variety of transportation modeling methods raises questions about their relative reliability and efficiency, although these are outside of the scope of this research. But it is important to know that, as Celik (2004) mentions; there are no uniformly good or bad models for

[38] To be discussed further in Section 2.4.3 of Chapter 2

replicating the flow of commodities. However, he argues that the acceptability of the method is highly correlated with the degree of homogeneity of the commodity under investigation. The more homogeneous the product group, the better the models predictions; in many cases it is not possible to obtain data with the desired level of disaggregation. Aside from aggregation problems, while the homogeneity assumption is a simplifying assumption that may help to adopt a standard transportation method, it may not always be an applicable solution. Therefore, in modeling the flow of wheat on a global scale, we should first investigate how the assumption of homogeneity may affect the purpose of our study and whether it is an appropriate assumption in our model.

In the case of wheat, differentiations both by country of origin and by end use have been analyzed by many researchers. There is evidence that while the same type of wheat produced and cultivated in different regions may be considered close substitutes, they are unlikely to be a perfect substitute for each other. As Sumner et al. (1994) say, this is an accepted fact both in literature and trade. For instance, durum wheat produced in Canada has different qualities than durum wheat produced in Australia, resulting in different preferences for consumers across the world. Larue (1991) in the paper titled "Is wheat a homogeneous product?" provides a glossary of the studies that have looked at the differentiation of wheat in different ways. Based on this classification, most previous studies have assumed perfect substitutability across classes and origins of wheat. Some studies allow imperfect substitutability of wheat from different origins. However, most of these studies assume perfect substitutability among wheat classes originating from the same source country. Larue found that the assumption of one form of product differentiation or the other would be appropriate if countries specialize in one product type and the given product type is exported by only one country. In the case of wheat, this is not applicable because most countries trade more than one class of wheat.

Sumner et al. (1994) argued that differentiation of wheat is clearly evident given the fact that many countries both export and import wheat. According to Sumner et al., if the goods are perfect substitutes, exports and imports would not coexist except in marginal border trade, where one region of a country imports and another region of the same country exports. In this thesis, the main objective is to find a general framework for wheat flow globally; following Sumner et al, we accept the idea of differentiation for wheat.[39]

Considering the importance of differentiation in the issue of wheat flow, there is a need to look for a model that includes this feature. As Sumner et al. (1994) mention, accepting the assumption of homogeneity or perfect substitution of wheat originated from different producing regions results in overestimations of trade flow predictions in the model. Referring to works that make use of this assumption, Sumner et al. show that such models do not match the actual trade flow patterns for most goods. For instance, the outcome of making such an assumption is to end up with many importers buying goods from only one country – the one for which the sum of production and transportation costs is the lowest – and similarly, many exporters sell goods to only one country.

In the trade literature, classical trade models from the Ricardianmodel to the Heckscher-Ohlin model[40] assume that the goods of one producer perfectly substitute for those of another. In

[39]Further in chapter 4, we will face a model with several variables that urge us to summarize the model by ignoring the fact that wheat has different types. This is just an assumption to help with ease of calculation and in practical studies a specific type of wheat can be investigated in the same framework.

[40] Build on David Ricardo's theory of comparative by predicting patterns of trade and production based on the factor endowments of a trading region, Eli Heckscher and Bertil Ohlin introduced the Heckscher–Ohlin model (H–O model). This is a general equilibrium mathematical model of international trade. Based on this model, countries will export products that use their abundant and accessible resources for production and import products that use the countries' scarce and expensive factor(s).

other words, they assume that all products are homogeneous. Assuming this is the situation, if the number of suppliers is sufficiently large, the market will approach perfect competition and the price across all suppliers will be equal. The result of accepting such an assumption in trade models is to label the market players either as an importer or exporter of the specific product and not both. Another outcome of such models and assumptions is that since the prices are all equal and there are no other distinguishing characteristics of the goods produced by a supplier, it can be explained as a "pooled market," in which case we only concern ourselves with the share that each supplier brings to the market and the share that each consumer takes from the market. This category can be treated as a non-spatial model.

Relaxing the homogeneity assumption in some trade models heralded a new approach in trade literature. In this approach, goods are called "heterogeneous" and they are not perfect substitutes. The importance of product differentiation in international trade has been examined in both theoretical and empirical research. However, in trade theory, the departure from the assumption of perfect substitution goes back to Armington's model (1969). The new structure presented by Armington may cause departures from known theoretical results, as mentioned by Lloyd and Zhang (2006). In fact, as they mention, the Armington structure changes some of the fundamentally properties and definitions of classical trade models. This issue will be discussed in the coming section. Davis and Kruse (1993), Sumner et al. (1994), Alston et al. (1990), and Babula (1987) are some samples for works that adopted Armington's framework or have worked through improving the misspecifications that have occurred in adapting this method.

As explained earlier in this chapter, the characteristics of wheat and its market forbid us from using a model with an assumption of homogeneity. Even simplifying the model such that we do not consider the end use differentiation, we cannot ignore the fact that consumers around the world have different preferences for wheat from different regions. This fact makes the Armington model an appropriate framework for modeling wheat flow.

In the coming section, some key points of the Armington model is explained and then the model for wheat ocean freight and trade will be illustrated.

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3.4 Armington Model Fundamentals

Armington (1969) introduced a model with the assumption that final products traded internationally could be differentiated on the basis of the location of production.

Lloyd and Zhang (2006) have reviewed the Armington framework and have brought it to a global computable general equilibrium (CGE) framework and looked at the multi-country models, attempting to provide a comparison between the properties of an Armingtonmodel on one hand and the standard Heckscher-Ohlin model on the other. They construct a mathematical illustration of the Armington model and compare the results of three-goods, three-country model by the Global Trade Analysis Project (GTAP) to a Heckscher-Ohlin model. Based on their results, a unilateral across-the-board cut in tariffs in the Armington model resulted in a larger shift in consumption from domestically produced goods to imported goods, a larger decline in terms of trade, and a smaller resource reallocation across industries. The following paragraphs show the mathematical model of the application of the Armington model on the demand and supply of traded products.

To mathematically illustrate the Armington model, Lloyd and Zhang consider a world in which there are m countries and n goods. Each good is a “type” of good that may be produced in each country, thus there are mn differentiated products by country of origin and consumers have preferences among them.

Let $i = 1,...,n$ denote the type of good and $j = 1,...,m$ the country of origin of good and $k = 1,2,...,k$ the country in which the consumer is located. Then X_{ijk} denotes the consumption of the product from i's group when the product originated from country j and the consumer is located in country k. For simplicity they assume that there is only one household in each country With the Armington differentiation, the utility function of the household of one country, country k, takes the following form:

$$U_k = U(X_{11k},...,X_{1mk};...;X_{i1k},...,X_{imk};...;X_{n1k},...,X_{nmk}) \quad \text{Equation 3- 1}$$

$$\equiv U(X_{1k},...,X_{ik},...,X_{nk})$$

$$\equiv U(X_k)$$

In this model, the utility function is assumed to be identical across countries and $X_{ik} = (X_{i1k},...X_{imk})$ denotes the set of products of type i originating in the different countries and consumed in country k and X_k is the set of quantities consumed in country k of all products in all groups. Also based on Armington (1969), the utility function is assumed to be weakly separable in the types of goods. Therefore for any country k,

$$U(X_k) = V(v^1(x_{1k}),...,v^i(x_{ik}),...v^n(x_{nk})) \quad \text{Equation 3- 2}$$

Where the linearly homogeneous sub-functions $v^i(x_{ik})$ are indices of the consumption in the country of each type of good and are homogeneous separable. Therefore, with this type of utility function, the household can allocate its budget in two stages: initially at the top stage or level among the groups of products and then at the bottom stage or level among the products within a group.

Therefore, one of the major assumptions of the Armington model is that the allocation of expenditures within a particular broad group is independent of the allocation to the other broad group.

Armington adopted a Constant Elasticity of Substitution (CES) form for the functions at the second level for the :

$$v^i(x_{ik}) = [\alpha_{i1k} x_{i1k}^{-\rho i} ... + \alpha_{ijk} x_{ijk}^{-\rho i} ... + \alpha_{imk} x_{imk}^{-\rho i}]^{-1/\rho i} \alpha_{ijk} \geq 0, \rho_i > -1; \forall i, k$$

Equation 3- 3

According to Lloyd and Zhang, in the original Armington model only the demand side is specified. On the supply side, the specification adopted is as general as possible with only one constraint: there are constant returns to scale everywhere and perfect competition in all markets.

Despite the simple assumption on the supply side, the Armington framework and assumption still have affected some aspects of the regular Heckscher-Ohlin model and have an advantage over it.

Armington's model has some advantages over the Heckscher-Ohlin model as a framework for the wheat trade. Perhaps, as Sumner, Alston and Gray (1994) mentioned, the most apparent reason for this differentiation is the fact that exports and imports coexist. In such a situation there is no option other than to use an appropriate framework that considers the heterogeneity of the traded products. While the heterogeneity may arise from different reasons and sources, in this context, wheat from one region cannot be considered the same as that of another region. As Grennes et al. (1978) mention, several reasons may cause us to classify a group of goods in global trade as differentiated products according to their country of origin. Some of those reasons are as follows:

First, the good may be naturally heterogeneous and there may be differences in the average quality of goods aggregated to the national or regional level. In the case of wheat, this reason is quite acceptable in both trade and academic literature.

The second reason mentioned in their work is "national factors," meaning that some naturally homogeneous goods are viewed as heterogeneous goods by importers according to their country of origin.

The third reason is related to relatively technical arguments about aggregation across countries, for example having different harvest times, which allow for imperfect competition. As Blanford (1988) mentions, some differentiation might be due to rigidities of commercial relationships, traditions in language and customs, or imperfect information, all of which may apply to wheat. Based on the preferences and premium prices and trade policies of wheat in different countries, this reason looks quite reasonable.

In conclusion the Armington framework, which introduces product differentiation, looks like an appropriate model for world wheat trade flow. There are some critics like Chami Batista (2005) who mention that the econometrics estimation of elasticity in the Armington framework are larger than real elasticities, but as long as the framework is not made for estimation, it does not invalidate the approach. Another advantage of using the Armington framework for this research is that it allows us to use aggregated trade data. This point will be discussed later.

In the next section, the Armington model is adapted to formulize the worldwide wheat trade issue with respect to ocean freight transportation.

3.5 The Model Description

In this section a market-clearing model is developed to show how changes in transportation costs due to fluctuations in freight rates affect the quantities and prices of exported wheat in destination countries.

First we must make some simplifying assumptions. The first fundamental assumption is related to defining the homogeneity or heterogeneity of the product and the level of aggregation. The various classes and qualities of wheat produced in a specific country, although different, will be aggregated in this context. The second main assumption refers to the level of substitution between wheat produced in different regions. Wheat produced by different countries, while generally close substitutes, is considered a differentiated product and an imperfect substitute. The assumption of differentiated wheat, as discussed before, is well accepted in trade and academic literature.

In the framework of a preliminary model, a world consisting of four countries, as shown infigure 3.1, is considered. Country A and Country B are the exporter countries and country 1 and 2 are the importers. The supply and demand equations are represented by functions that are linear in prices and quantities over the range of changes being analyzed.

Again, for simplicity, we assume that country A and B only export their wheat to country 1 and 2. There is no trade between country A and B and there is no trade between country 1 and 2. While generally close substitutes, wheat from country A is unlikely to be a perfect substitute for wheat from another source (country B). In any region, we assume the supply of each type of wheat only depends on its own price. Therefore, the supply of wheat in each exporting country depends on the anticipated producer prices of wheat, which are the weighted average of corresponding market prices for wheat. We assume all the wheat producers are acting in a competitive market and they do not have a market power.

The supply function in country A and B are represented in the following set of equations:

$$Q_A = \alpha_a + \beta_{A1} PS_A$$
$$Q_B = \alpha_B + \beta_{B1} PS_B \qquad \text{Equation 3-4}$$

In these equations, PS_i is the producer price of wheat produced in country i (i=A, B), is the quantity of wheat supplied in each region, the α_i s are the intercepts, and β_{ij} s are the slopes of each supply function.

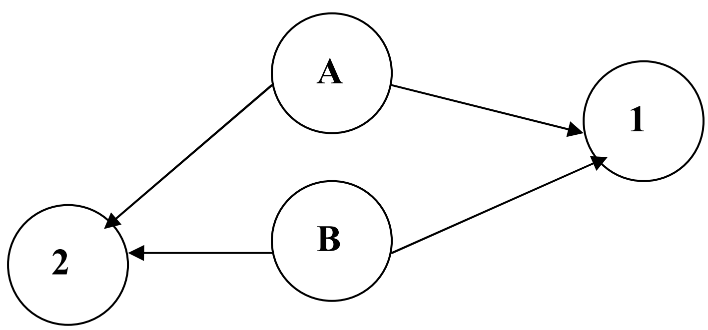

Figure 3-1 Exporters and Importer Location in a Hypothetical Two by Two Trade Model

While there is no interaction among wheat from different origins on the supply side, on the demand side different types of wheat (i.e. Canadian wheat, Australian wheat, etc.) are consumed as close substitutes; grains from different sources are less-than-perfect substitutes. The consumers in the importing country consume the wheat imported from either of these countries as a close substitute. The demand in importing country j will be a simultaneous system of demands for each importer country (j=1, 2) and we assume it is a function of own price effect as well as the cross price effect of the substitute types as well.

In these demand equations, C_i^j is the consumption of wheat originating from country i(i = A, B) in country j (j=1, 2). δ_{AA}^1 , δ_{BB}^1, δ_{AA}^2, and δ_{BB}^2 are the own price effects coefficients in importing demand countries and δ_{AB}^1, δ_{BA}^1, δ_{BA}^2, δ_{AB}^2 are the cross price effect coefficients in related equations.

$$C_A^1 = \gamma_A^1 + \delta_{AA}^1 P_A^1 + \delta_{AB}^1 P_B^1 \qquad \text{Equation 3- 5}$$

$$C_B^1 = \gamma_B^1 + \delta_{BA}^1 P_A^1 + \delta_{BB}^1 P_B^1$$

$$C_A^2 = \gamma_A^2 + \delta_{AA}^2 P_A^2 + \delta_{AB}^2 P_B^2$$

$$C_B^2 = \gamma_B^2 + \delta_{BA}^2 P_A^2 + \delta_{BB}^2 P_B^2$$

In order to solve the system of supply and demand equations for equilibrium prices and quantities, there is a need for a set of market clearing conditions that reflect the total utilization of the product, freight rate fluctuations, and arbitrage conditions.

On the price side, for wheat originating from a given source, differences in prices among consuming regions and between producers and consumers in the region where it is produced are specified as wedges due to transportation costs. As the last sections made clear, the focus of this thesis is ocean freight costs and all other internal transportation costs; transaction costs and policies that may affect grain prices are not considered.

The set of equations in 3-6 shows the price of wheat originating from country A in countries 1 and 2. Likewise equation 3-7 shows the price of wheat originated from country B in consuming countries 1 and 2.

$$P_{A1} = PS_A + T_{A1}$$ Equation 3-6

$$P_{A2} = PS_A + T_{A2}$$

$$P_{B1} = PS_B + T_{B1}$$ Equation 3- 7

$$P_{B2} = PS_B + T_{B2}$$

For such a small model, we should use twelve linear equations described above, two supply, four demands, four prices, and two market clearing conditions, and solve the indentifiedsystem using linear algebra through matrix inversion and calculate the twelve unknown variables: six quantities and six prices.

Now if we add the other importing regions to this our simple model, the results will be more complicated and almost impossible to solve without the help of proper computer software.[41]Increasing the number of regions, adds to the complexity of the model. This is because the prices and quantities are the function of too many different endogenous variables, which increases the dimensions of the matrix. As we add more countries on the export and demand sides, and relaxing the assumption that the exporter country is not only an exporter and imports from other countries as well, we will face an ambiguous situation that must be solved with the use of specified parameters and quantities. Although building an analytic mathematical model looks impossible, building a simulation model based on the same structure will help us to change the exogenous variables and follow the changes. In the next chapter this model will be built and its validation will be investigated.

[41] The maximum acceptable dimensions for the matrix in Mathcad are 10 by 10.

3.6 Summary and Results

Keeping in view the importance of the role of transportation in trade, the wedges between the prices in exporting ports and importing ports created by ocean transportation expenses, and the geographical distribution of countries and ocean masses around the world, there is a need for a model that simulates the changes in wheat flow around the world considering the fluctuations in the ocean transportation rate.

As per the literature review of the trade models in this chapter, we followed the progress of trade models in making use of geography and distance through spatial models and using the assumption of non-homogeneity of traded commodities. Among all the models discussed, the Armington framework, which looks at the wheat originating from different countries as differentiated products, fits our purpose. However, we needed to make it a spatial framework to illustrate the impact of changes in the freight rate on the traded quantity and prices. While the Armington framework may be criticized for its biased econometrics elasticity estimates, that does not invalidate its use in our market simulation models. Many researchers agree that the Armington framework is the best way of modeling differentiated products, especially the market simulation model.

So far there has been no attempt to simulate the international spatial wheat trade model such that it treats wheat from different origins as differentiated products. Therefore, as the first attempt I constructed a small trade flow model to explain the impact of freight rate fluctuations on wheat flow quantities and prices in the global market. The Armington framework develops a vertical linkage between the wheat in the country of origin's port, ocean freight services, and the importer country's port, and that can be used to examine the impact of shocks as a result of various variables that may affect the transportation links and consequently the freight rates.

The developed model based on a simplified world consisting of the two exporters and one importer resulted in solving an eight-by-eight matrix. Adding another importing country makes the calculations even more complicated and renders the parametric results even more ambiguous. The prices and quantities are the function of all own price and cross price demand elasticities, the supply elasticities, and all the transportation rates. To achieve more practical result there is a need to construct the market simulation model and insert the available base prices, quantities, and elasticities into the model to calculate how much prices and quantities change when the ocean freight rate changes.

In Chapter 4, the same frame work will be adopted. In order to follow the impact of the freight rate changes on the wheat flow, actual prices and quantities, along with some parameters will be used to construct a simulation of the real world.

CHAPTER 4

MARKET SIMULATION MODEL

4.1. Introduction

The main purpose of this chapter is to quantify the Armington framework developed in Chapter 3 to be used as a tool to examine the magnitude of the impacts of the changes in freight rate on global wheat flow. The result will help one to follow the pattern of changes in the price of wheat occurring as a result of freight rate changes.

Following the aim of this research, the global market of wheat will be divided into different geographical regions and the market clearing conditions in the global market will be set, with consideration for the interaction among regions. The global model will be parameterized using elasticities from the literature, prices and quantities from 2007 data set, and ocean freight rates in the same year. Then, a model validation procedure will be followed to check whether the developed market simulation model will have the ability to reflect the real world situation and make predictions. Finally, the impact of changes in freight rates on global wheat flow will be simulated to examine different scenarios and the magnitude of the effects under each scenario.

4.2. Market Simulation

Based on definition any imitation of some real fact or process is a “simulation”. Simulations are used in many sciences, ranging from modeling natural systems, human systems, safety engineering, testing, training, to – the most important for us – economic models and conditions, in order to gain insight into their functions. Source information is fed into the simulator with consideration for the selected characteristics and behaviours. The simplifying assumptions within the simulation are designed not to interfere with the basic aim of the simulation and the fidelity and validity of the simulation outcomes.

As Csaki (1985) says, while a simulation model should be as simple and concise as possible, it should have the ability to reflect reality and should be able to predict future outcomes with precision. One of the objectives of this chapter is to construct a mathematical model that meets the requirements of a well-functioning simulation model and illustrates the global wheat spatial market. The global spatial market and trade will be simplified as much as possible to obtain a tool to observe changes in the quantity and price of wheat from origins according to freight rate fluctuations. To pursue this aim, we have to clarify the types of related parameters and data sets used in this simulation. Also, definitions and notations should be specified. First, the regions and rationale behind the categorizing regions will follow, the wheat market in selected regions will be briefly described, the overall supply and demand parameters will be verified and set in the model, and finally the selected scenarios and sensitivity analyses will be implemented and analyzed.

4.2.1 Determining Key Players in the Global Wheat Market

During the past few decades, the global wheat market has undergone significant changes. Some regions like China, one of the major wheat importing regions of the world, have turned into large wheat producers. China was among the top ten importers of wheat before 2000, but after 2000, with exception of 2004, China has not been among the top ten importers. While the major exporters of wheat have maintained their market position, more competition is predicted on the supply side of the market as per the USDA wheat market outlook for the period of 2011-2020 (USDA, 2011). Some players like the Former Soviet Union (FSU) are submitting a place as market shareholders. On the other side, changes in import demand due to changes in natural factors like population, income share, and wheat replacement have changed the players on the import side.

This section is intended to clarify the regions of the global wheat market model such that it can address the probable changes that accompany maritime transportation costs, as well as changes in the pattern of the global wheat trade. In order to simplify the global wheat market and establish the simulation, the current major players in the global wheat market have been identified with consideration for the importance of maintaining consistency with the available data and creating a comprehensive categorization that resembles the global market. The following paragraphs will give a summary of this categorization of the export supply side and import demand side.

Wheat Exporters in the Global Model:

According to USDA (2011) and several issues of the International Grain Council (IGC) data set, during the past decade United States, Canada, Australia, the EU (27), the former Soviet Union (including three major wheat exporters: Russia, Ukraine, and Kazakhstan), and Argentina have accounted for about 90% of the global wheat export market. Therefore, in order to cover the major exporting regions in the global wheat market, the regions have been divided as shown in table 4-1 of this chapter. As seen in this table, some of the supplier regions consist of a single country, while others are a group of producing countries. To simplify our model, if the region consists of more than one country, the intra-region trade is assumed to be domestic production and consumption in the same region. This will not affect the model in terms of analysis and only helps to reduce the number of variables. According to trade data, the trade in other regions except the six above-mentioned areas is either intra-regional trade or so small that can be reasonably categorized as Rest of the World (ROW) exports to the region with a minimum effect on the model.

While the Commonwealth of Independent States (CIS) represents more countries than those mentioned above,[42] since the major producers are Russia, Kazakhstan, and Ukraine, the total exports of these three countries have been considered the exports of this region. This is also consistent with the data available through IGC. The rest of the wheat exported has been captured through adding the Rest of the World (ROW) section.

Table 4-1Wheat Exporting Regions and Abbreviations Used in Simulation

Exporting Regions	*Abb.*	*Countries in Region*
Argentina	*AR*	
Australia	*AU*	
Canada	*CN*	
Commonwealth of Independent States	*CIS*	Armenia,Azerbaijan,Belarus,Kazakhstan,Kyrgyzstan.Moldova,Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan
EU(27)	*EU*	Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy ,Latvia, Lithuania, Lux embourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spa in, Sweden, United Kingdom
United States	*US*	
Rest of the World	*ROW*	All other countries not included in above classification

Based on the 2011 USDA market outlook report,it is predicted that the total share of the

[42] The CIS consisted of ten former Soviet Republics: Armenia, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan at its inception. The nations of Azerbaijan and Georgia later joined the association in 1993.

traditional wheat exporting regions, (the United States, Australia, Canada, the EU, and Argentina) will fall from 70% to 60% in the prediction period (2010-2020) due to increasing exports from the Black Sea area. Low cost of production, new investment in agricultural production and marketing, and favourable weather conditions for producing wheat in the area[43] are increasing production and export share factors in this region. Argentina's share in the global wheat market is anticipated not to fall. But global changes, more ethanol in the EU, and oil seeds in Canada may also decrease the level of production, and consequently trade, from these regions. However, this research is only concerned with a static snapshot that considers the other changes constant and focuses on ocean transportation cost variations.

Wheat Importers in the Global Model

While all exporting regions are wheat consumers and have a local market, some of the exporting regions are also wheat importers.Unlike these regions, there are some regions that lack the necessary growing conditions to produce wheat and this factor may not change over time.

Categorizing the wheat importing regions is more complicated than the supply side because of the number of regions involved and the dual role of some regions. There is no region that does not consume wheat, although there are some regions that only use wheat produced within the region. We must disregard intra-regional trade as a main assumption in this section. This assumption is made to reduce the number of variables in the simulation and to simplify the model. On the other hand, we have to keep the key self-sufficient region, Canada, among the regions to maintain consistency with the global equilibrium approach. Therefore table 4-2 summarizes the wheat "consuming regions," including the description of each region, instead of

[43]The drought in 2009-2010 has reduced the positive effects of this factor on wheat production in CIS region.

wheat "importing regions." Canada is the only region that does not import wheat from other countries. In Oceania, the main producer, Australia, also does not import a significant amount, but other countries in the region import wheat mostly from Australia. The following paragraphs briefly describe the role of each region in the global wheat market.

European Union

The EU was both an importer and exporter of wheat in 2007. In this market simulation model, as specified in the World Grain Statistics in 2007, EU (27) countries have been considered one importing and exporting region. While France, Germany, the UK, Poland, and Italy were the largest wheat producers in the EU in 2007, Italy, Spain, and the Netherlands were the largest importers and France, the UK, and Germany are among the eight largest importers in the EU. On the export side, France, Germany, the UK, Italy, and Belgium are the largest wheat exporters in the EU. The combination of exports and imports in the EU easily shows the nature of dual exporter and importer countries in the wheat market and constitutes a good reason to consider differentiations based on the country of origin in the local wheat market.

The geographical situation of the EU region is quite different from those of the North- and Central-American countries and regions. The countries in the EU mostly have land borders with each other and other European countries. However, for the purposes of this thesis, internal trade between EU members has been assumed to be domestic consumption of the region's production, and its trade with other European countries has been considered a differentiated region. Also, we assumed that the active transportation mode is ocean transportation and the origin or destination port has been specified based on the closest geographic distance and available data set in and out of the region. As shown in figure 4-1, Canada and the CIS region are the major exporters to this region.

Other European Countries

The rest of the European countries have been placed in this category. There is difference between the other European countries defined as exporting and importing region in this research. Since most of the wheat in this region is produced in Russian Federation, Ukraine, and Kazakhstan, and almost all of the wheat exported across the globe is originated from mentioned countries, therefore, CIS which includes Russian Federation, Ukraine, and Kazakhstan and represents the exporting region. The demand and import of Other European countries (OE) including CIS region (except the European Union (EU)) are considered and is shown as OE in all figures and equations of this simulation. Again, as with the EU countries, the intra-regional trade among these countries has been considered domestic consumption and ocean transportation is assumed to be the main shipping mode.

While the countries in this region have imported about 97% of the wheat imported from the CIS region, the remaining imported wheat in 2007 was imported from the EU, with about 1% coming from the US. The wheat produced in this region has been generally exported to countries in the EU region, South Asia, North Africa, Sub-Saharan Africa, and Near East Asia.

Canada

Canada is a large producer and exporter of wheat. While Canadian wheat is consumed in most countries of the world, the import of wheat from other regions to Canada is so negligible that it has been ignored in this market simulation model. While the quality of wheat produced in

Canada isdemanded in many regions, the geographic location of Canada relative to other importing countries is a disadvantage. Canada's only land border is with the United States; therefore ocean freight is the best and only viable freight option to and from Canada. In this research the ocean freight rates from the West Coast (Pacific ports/Vancouver port) and East Coast (Atlantic ports/St. Lawrence) are considered the main exporting ports, based on the geographical distance from the destination country. In this model, Canada exports to all other ten regions. Export from Canada to Oceania is negligible. Figure 4-1 illustrates the export and domestic consumption share of different producing regions.

United States

The United States is also one of the major players in the wheat market. The US shares land borders with Canada and Central America; however, ocean freight remains the main mode of transportation for grain in this region. The US both exports and imports a large amount of wheat to and from different regions. US wheat is being consumed in all of our specified regions except Canada. In 2007, the US imported an enormous amount of wheat from Canada.

The US is the second biggest source of wheat imported to Central America. Central America is considered a part of the Latin America region in this thesis.

Latin America

On the export side, Argentina is the main player and is considered the main exporter to various world regions from Latin America. On the import side, this region contains all the countries in South and Central America. However, the main data were gathered from Argentina, Brazil, Chile, Mexico, Uruguay, Costa Rica, Cuba, the Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Ecuador, Peru, and Venezuela. Among the countries of this region, Argentina and Brazil are the main producers and exporters of wheat and Brazil and Mexico are the main importers of wheat. The countries of this region import wheat from Argentina, Canada, and the US. Like the regions described previously, the intra-regional trade between countries of this region is included in the demand for domestic production and is not differentiated. Excluding the wheat produced and consumed inside the region, the main exports from this region are to Sub-Saharan Africa.

Figure 4-1 Regional Wheat Export Market According to Base Year Prices and Quantities (2007)
Source: World Grain Statistics, International Grain Council 2007

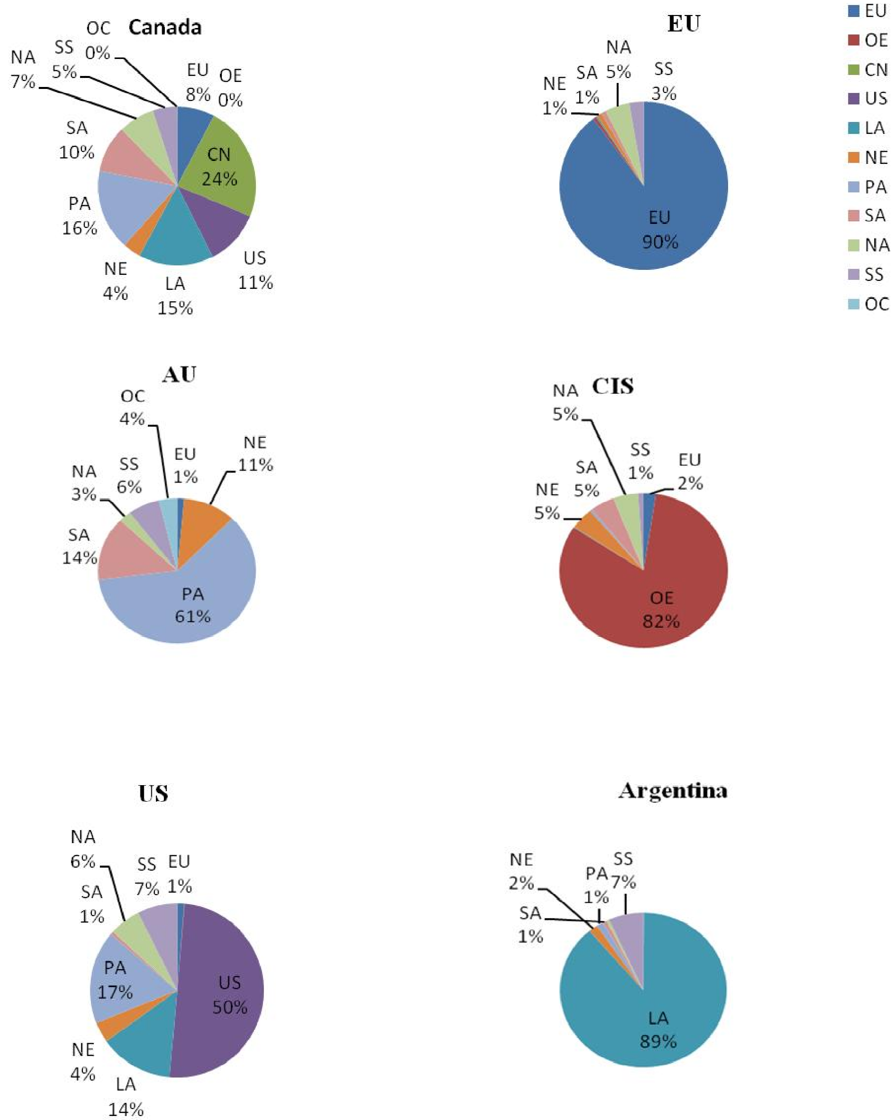

Table 4-2 Wheat Importing Regions and Abbreviations Used in Simulation

Importing Regions	*Abb.*	*Countries included in region*
EU (27)	*EU*	Since 2006/7, the EU (27) includes Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom
Rest of Europe	*OE*	Other European countries including the CIS & Baltic
Canada	*CN*	
United States	*US*	
Latin America	*LA*	This region includes Latin Central American countries, as well as South American countries : Costa Rica, Cuba, Dominican Republic., El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Panama, Trinidad & Tobago, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Venezuela, and others
Near East Asia	*NE*	Cyprus, Iraq, Iran, Israel, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen, and others
Pacific Asia	*PA*	China, Chinese Taipei, Hong Kong, Indonesia, Japan, North Korea, South Korea, Malaysia, Mongolia, Philippines, Singapore, Thailand, Vietnam, and others.
South Asia	*SA*	Afghanistan, Bangladesh, India, Nepal, Pakistan, Sri Lanka, and others
North Africa	*NA*	Algeria, Egypt, Libya, Morocco, Tunisia
Sub Saharan Africa	*SS*	Angola, Cameroon, Congo, Cote d'lvoire, Ethiopia, Ghana, Guinea, Kenya, Mauritania, Mozambique, Nigeria, Senegal, Somalia, South Africa, Sudan, Tanzania, Zimbabwe, and others
Oceania	*OC*	Australia, Fiji, New Zealand, Papua New Guinea, and others

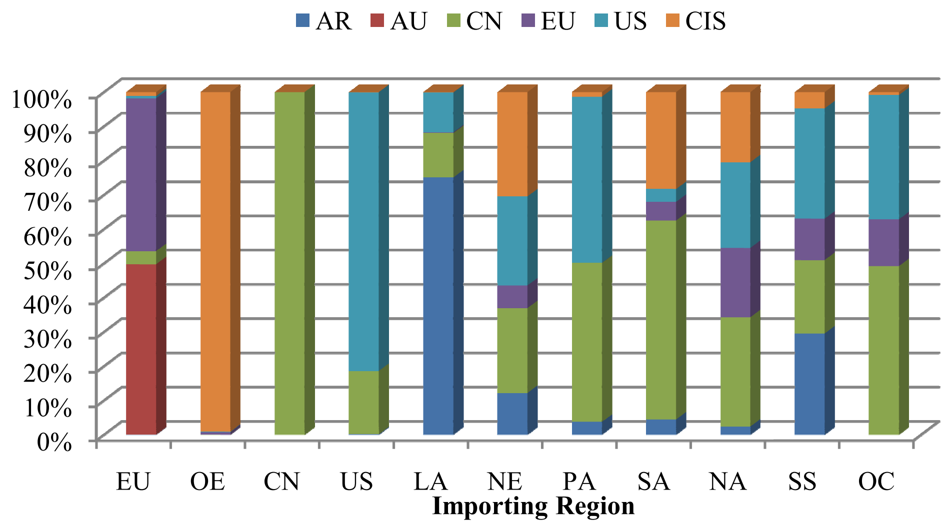

Figure 4-2 Global Export Share Retrieved from Base Quantities and Prices
Source: World Grain Statistics, International Grain Council 2007

Near East Asia

Asia has been divided into three different regions considering the geographical distance and major ocean freight routes to the regions. Near East Asia region contains Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Saudi Arabia, Syria, Turkey, the United Arab Emirates, and Yemen. This regionalso imports from Canada, United States, Australia, and the EU.

Pacific Asia

The countries included in this region are China, Taiwan, Hong Kong, Indonesia, Japan, North Korea, South Korea, Malaysia, Philippines, Singapore, Thailand, and Vietnam. Although there are large producers in this category, such as China, this region is a major importing region and does not have significant exports. China is the largest producer, and exporter, but has moved from being a major importer during the past years. Again, the intra-regional trade is included as the domestic consumption of the region, which imports mainly from Australia, the US, Canada, and, to a lesser extent, from the CIS.

South Asia

The South Asian region includes Bangladesh, India, Pakistan, and Sri Lanka as the main representatives of the countries of this region. Again, the wheat produced in this region is consumed domestically and the countries of this region mainly imported wheat from the EU, the CIS, and Canada in 2007.

North Africa

Based on the geographic reality of Africa and the availability of data, we have divided the countries located in Africa into two regions. North Africa contains the Northern countries: Algeria, Egypt, Libya, Morocco, and Tunisia. The wheat produced in this region is only consumed domestically and this region is a major importer of wheat. The EU, the CIS, and Canada were the main exporters to this region in 2007.

Sub-Saharan Africa

The rest of the African countries are included in this region. The main countries in this category are: Angola, Cameroon, Congo, Ethiopia, Ghana, Guinea, Kenya, Madagascar, Mauritania, Mauritius, Mozambique, Nigeria, Senegal, Somalia, South Africa, Sudan, Tanzania, Zambia, and Zimbabwe. This region is also a major importing region. In 2007, this region imported mainly from the EU, the US, Argentina, Canada, and Australia

Oceania

This region, which geographically does not have land borders with its wheat consumers, is another big player in the wheat market. Ocean freight is their only available transportation option. The main producer in this region is Australia. The region exports wheat to the EU, Latin America, Sub-Saharan Africa, North Africa, the Middle East, Pacific Asia, and South Asia.

All of the above regions are assumed to have a system of demand equation for different types of wheat that they mainly import. Considering the market clearing conditions and the geographic distances between regions, this system of demand will be constructed in the next section and the market clearing conditions will be set.

4.2.2. Setting Supply and Demand Equations

This section describes the parameters used to set the simulation model and examine alternative scenarios for global wheat flow when the ocean freight rate changes. In order to perform such an assessment, a series of supply and demand equations for wheat in different regions need to be specified. The supply and demand equations used in our model are linear and constructed based on Armington'sassumptions. The model is supposed to show the changes that follow from increases and decreases in freight rates.

Demand Equations

As described in Chapter 3, the demand in importing country j for wheat originating from country i is a function of own price effects and cross price effects of the substitute types of wheat, which is wheat originating from other regions or produced in the same region. Considering the number of exporting regions, each importing region has a set of simultaneous demands consisting of eight equations for wheat from different origins. For instance, Sub-Saharan Africa (SS) imports wheat from all of the above-mentioned exporting regions. Therefore the wheat demand system in the SS region is expressed with the following set of equations:

$$C_{SS-AR} = \gamma_{SS-AR}^{AR} + \partial_{SS-AR}^{AR} P_{SS-AR} + \partial_{SS-AR}^{AU} P_{SS-AU} + \partial_{SS-AR}^{CN} P_{SS-CN} + \partial_{SS-AR}^{CIS} P_{SS-CIS} + \partial_{SS-AR}^{EU} P_{SS-EU} + \partial_{SS-AR}^{US} P_{SS-US} + \partial_{SS-AR}^{SS} P_{SS-SS} + \partial_{SS-AR}^{ROW} P_{SS-ROW}$$

$$C_{SS-AU} = \gamma_{SS-AU}^{AU} + \partial_{SS-AU}^{AR} P_{SS-AR} + \partial_{SS-AU}^{AU} P_{SS-AU} + \partial_{SS-AU}^{CN} P_{SS-CN} + \partial_{SS-AU}^{CIS} P_{SS-CIS} + \partial_{SS-AU}^{EU} P_{SS-EU} + \partial_{SS-AU}^{US} P_{SS-US} + \partial_{SS-AU}^{SS} P_{SS-SS} + \partial_{SS-AU}^{ROW} P_{SS-ROW}$$

$$C_{SS-CN} = \gamma_{SS-CN}^{CN} + \partial_{SS-CN}^{AR} P_{SS-AR} + \partial_{SS-CN}^{AU} P_{SS-AU} + \partial_{SS-CN}^{CN} P_{SS-CN} + \partial_{SS-CN}^{CIS} P_{SS-CIS} + \partial_{SS-CN}^{EU} P_{SS-EU} + \partial_{SS-CN}^{US} P_{SS-US} + \partial_{SS-CN}^{SS} P_{SS-SS} + \partial_{SS-CN}^{ROW} P_{SS-ROW}$$

$$C_{SS-CIS} = \gamma_{SS-CIS}^{CIS} + \partial_{SS-CIS}^{AR} P_{SS-AR} + \partial_{SS-CIS}^{AU} P_{SS-AU} + \partial_{SS-CIS}^{CN} P_{SS-CN} + \partial_{SS-CIS}^{CIS} P_{SS-CIS} + \partial_{SS-CIS}^{EU} P_{SS-EU} + \partial_{SS-CIS}^{US} P_{SS-US} + \partial_{SS-CIS}^{SS} P_{SS-SS} + \partial_{SS-CIS}^{ROW} P_{SS-ROW}$$

$$C_{SS-EU} = \gamma_{SS-EU}^{EU} + \partial_{SS-EU}^{ARR} P_{SS-AR} + \partial_{SS-EU}^{AU} P_{SS-AU} + \partial_{SS-EU}^{CN} P_{SS-CN} + \partial_{SS-EU}^{CIS} P_{SS-CIS} + \partial_{SS-EU}^{EU} P_{SS-EU} + \partial_{SS-EU}^{US} P_{SS-US} + \partial_{SS-EU}^{SS} P_{SS-SS} + \partial_{SS-EU}^{ROW} P_{SS-ROW}$$

$$C_{SS-US} = \gamma_{SS-US}^{US} + \partial_{SS-US}^{AR} P_{SS-AR} + \partial_{SS-US}^{AU} P_{SS-AU} + \partial_{SS-US}^{CN} P_{SS-CN} + \partial_{SS-US}^{CIS} P_{SS-CIS} + \partial_{SS-US}^{EU} P_{SS-EU} + \partial_{SS-US}^{US} P_{SS-US} + \partial_{SS-US}^{SS} P_{SS-SS} + \partial_{SS-US}^{ROW} P_{SS-ROW}$$

$$C_{SS-SS} = \gamma_{SS-SS}^{SS} + \partial_{SS-SS}^{AR} P_{SS-AR} + \partial_{SS-SS}^{AU} P_{SS-AU} + \partial_{SS-SS}^{CN} P_{SS-CN} + \partial_{SS-SS}^{CIS} P_{SS-CIS} + \partial_{SS-SS}^{EU} P_{SS-EU} + \partial_{SS-SS}^{US} P_{SS-US} + \partial_{SS-SS}^{SS} P_{SS-SS} + \partial_{SS-SS}^{ROW} P_{SS-ROW}$$

$$C_{SS-ROW} = \gamma_{SS-ROW}^{ROW} + \partial_{SS-ROW}^{AR} P_{SS-AR} + \partial_{SS-ROW}^{AU} P_{SS-AU} + \partial_{SS-ROW}^{CN} P_{SS-CN} + \partial_{SS-ROW}^{CIS} P_{SS-CIS} + \partial_{SS-ROW}^{EU} P_{SS-EU} + \partial_{SS-ROW}^{US} P_{SS-US} + \partial_{SS-ROW}^{SS} P_{SS-SS} + \partial_{SS-ROW}^{ROW} P_{SS-ROW}$$

Equation 4-1

C_{SS-i} is the demand for wheat originating from region i (i=Argentina (AR), Australia (AU), Canada (CN), Commonwealth of Independent States (CIS), European Union (EU), the United States (US), Rest of the World (ROW), and Sub-Saharan Africa (SS)).

γ^{i}_{SS-i} is the constant parameter for linear demand, δ^{i}_{SS-i} is the own price or cross price coefficients of demand, and finally P_{SS-i} is the price of wheat from different origins in the destination region. In this thesis, this price is calculated by the sum of FOB (Free On Board) per thousand-ton premium price of wheat offered to the Sub-Saharan Africa region from the exporting country's port plus a per-thousand-ton ocean freight transportation price for delivering wheat from region i to Sub-Saharan Africa. To simplify the model, all other additional trade costs associated with other factors aside from ocean freight costs are not included.

Supply Equations

As described in Chapter 3, supply equations are not specified in the Armington framework. In the simulation model presented in this thesis, the supply equation is considered to be linear and the supply of wheat in each region depends on the production price of wheat in the same region. Therefore the general supply function for country i is specified as:

$Q_i = \alpha_i + \beta_i PS_i$ Equation 4-2

This equation PS_i expresses the producer price at the exporting farm gate (for instance, in the case of Canadian wheat, at the Saint Lawrence port) and Q_i is the total production of the region; α_i is the intercepts, and β_i is the slope of the supply function.

Market Clearing Condition:

As described in Chapter 3, adding a set of market clearing conditions for all of the markets will solve the system of equations and provide the equilibrium prices and quantities. These conditions should reflect the total utilization of the products in all markets with consideration for ocean transportation costs and arbitrage conditions.

The market clearing conditions in each producing market will be expressed as follows.

$$Q_{AR} \equiv C_{AR}^{EU} + C_{AR}^{OE} + C_{AR}^{CN} + C_{AR}^{US} + C_{AR}^{LA} + C_{AR}^{NE} + C_{AR}^{PA} + C_{AR}^{SA} + C_{AR}^{NA} + C_{AR}^{SS} + C_{AR}^{OC} + C_{AR}^{ROW}$$

$$Q_{AU} \equiv C_{AU}^{EU} + C_{AU}^{OE} + C_{AU}^{CN} + C_{AU}^{US} + C_{AU}^{LA} + C_{AU}^{NE} + C_{AU}^{PA} + C_{AU}^{SA} + C_{AU}^{NA} + C_{AU}^{SS} + C_{AU}^{OC} + C_{AU}^{ROW}$$

$$Q_{CN} \equiv C_{CN}^{EU} + C_{CN}^{OE} + C_{CN}^{CN} + C_{CN}^{US} + C_{CN}^{LA} + C_{CN}^{NE} + C_{CN}^{PA} + C_{CN}^{SA} + C_{CN}^{NA} + C_{CN}^{SS} + C_{CN}^{OC} + C_{CN}^{ROW}$$

$$Q_{EU} \equiv C_{EU}^{EU} + C_{EU}^{OE} + C_{EU}^{CN} + C_{EU}^{US} + C_{EU}^{LA} + C_{EU}^{NE} + C_{EU}^{PA} + C_{EU}^{SA} + C_{EU}^{NA} + C_{EU}^{SS} + C_{EU}^{OC} + C_{EU}^{ROW}$$

$$Q_{US} \equiv C_{US}^{EU} + C_{US}^{OE} + C_{US}^{CN} + C_{US}^{US} + C_{US}^{LA} + C_{US}^{NE} + C_{US}^{PA} + C_{US}^{SA} + C_{US}^{NA} + C_{US}^{SS} + C_{US}^{OC} + C_{US}^{ROW}$$

$$Q_{CIS} \equiv C_{CIS}^{EU} + C_{CIS}^{OE} + C_{CIS}^{CN} + C_{CIS}^{US} + C_{CIS}^{LA} + C_{CIS}^{NE} + C_{CIS}^{PA} + C_{CIS}^{SA} + C_{CIS}^{NA} + C_{CIS}^{SS} + C_{CIS}^{OC} + C_{CIS}^{ROW}$$

$$Q_{NE} \equiv C_{NE}^{NE}$$

$$Q_{PA} \equiv C_{PA}^{PA}$$

$$Q_{SA} \equiv C_{SA}^{SA}$$

$$Q_{NA} \equiv C_{NA}^{NA}$$

$$Q_{SS} \equiv C_{SS}^{SS}$$

$$Q_{ROW}^{EU} \equiv C_{ROW}^{EU}$$

$$Q_{ROW}^{OE} \equiv C_{ROW}^{OE}$$

$$Q_{ROW}^{CN} \equiv C_{ROW}^{CN}$$

$$Q_{ROW}^{US} \equiv C_{ROW}^{US}$$

$$Q_{ROW}^{LA} \equiv C_{ROW}^{LA}$$

$$Q_{ROW}^{NE} \equiv C_{ROW}^{NE}$$

$$Q_{ROW}^{PA} \equiv C_{ROW}^{PA} \qquad \text{Equation 4-3}$$

$$Q_{ROW}^{SA} \equiv C_{ROW}^{SA}$$

$$Q_{ROW}^{NA} \equiv C_{ROW}^{NA}$$

$$Q_{ROW}^{SS} \equiv C_{ROW}^{SS}$$

As shown in the above market clearing conditions, there is a set of conditions for the ROW region. This is because the rest of the world regions relative to each region are different from the others. For example, a country in PA may import some wheat from a country in NE, while a country in SS may import from NA. Therefore a set of supply and demand equations for each market and its conditions is defined, and the market clearing conditions for each market are considered separately. In this model, C_{ROW}^{i} stands for the demand for wheat originating from ROW in region i.

The market clearing quantity in each producing region is equal to sum of the internal consumption of wheat in that region and the exported wheat from that region to other regions.

Role of the Ocean Freight Rate

As explained, ocean transportation is the shipping method used to transport wheat from all of the above-mentioned producing regions' ports to the consuming regions' ports. Therefore, the differences in the price of wheat from a specific source among different regions are attributed to the freight rate differences between regions.

In this research all other differences in costs associated with internal wheat movement or regions' exporting and importing policies are not modelled. It means that the wedge between the export price and import price is the per-unit ocean freight rate. This cost is treated as a pure average per-unit cost that is added to the export price. Thus:

$$P_j^i = PS^i + t_j^i \qquad \text{Equation 4-4}$$

i: AR, AU, CN, EU, US, CIS, ROW

j: EU, OE, CA, US, LA, NE, PA, SA, NA, SS, OC

As per this equation, any changes in the freight rate will affect the price of wheat at its destination and it will impact the initial supply and driven demand of wheat in the origin and the destination. The amount of changes in quantity is associated with the sensitivity of demand in the region. Therefore the next important step is to set the supply and demand parameters.

Supply and Demand Parameters

The variables required to construct the supply and demand function of each region in this model include the prices and quantities of wheat produced in each region in the base year (2006/7).

Wheat prices, quantities, and market shares for each region, as well as the per-unit ocean freight rate, can be obtained from different sources and publications. To maintain consistency in the data set, especially when there is a need for aggregation, we gathered the data from one specific source. The data gathered in this thesis are from the International Grain Council's World Grain Statistics, 2007. Table 4-4 shows the initial quantities and prices in the eleven wheat-consuming regions. The signs and notations have been chosen such that they clarify the origin and destination of wheat consumption; for instance, $C_{US\text{-}CN}$ shows the consumption of Canadian wheat in the United States. Q stands for the quantity (000 tons) and P is the average unit price of wheat in US dollars. Production in each region is denoted by Q_i. For example, Q_{CN} denotes the wheat produced in Canada, which again has a quantity in metric tons and a production price in US dollars. The ocean freight rate is the annual average rate of bulk carriers along selected routes.

Using the base year quantities, prices, freight rates, and own-price and cross-price elasticities, the slope and intercepts of the supply and demand equations are calculated. Table 4-3 shows the initial freight prices and figure 4-3compares the initial freight from exporting regions to various destinations. The overall elasticities of demand and supply for each region need to be borrowed from earlier studies and literature that have estimated them. Since different studies have used different data sources and different assumptions and stimulation procedures, to use the appropriate elasticities some judgment is required for the purpose of simulating alternative scenarios. Since an Armington framework has been chosen, we cannot consider the estimated elasticities from works that have treated the wheat produced in different regions as homogeneous products since they all suffer from aggregation bias. However, in the model presented in this thesis, the only differentiation we consider is based on the country of origin. Different types of wheat are not separated based on their end use since separating different classes of wheat, while not impossible in our framework, would increase the number of variables unnecessarily.

Wheat from these sources is treated as less than perfect substitutes. As Sumner et al. (1994) maintain, this is an acceptable assumption as regards the behaviour of buyers. Such an assumption has been used in a large number of studies that have found imperfect substitution among types of wheat originating from different countries due to differences in wheat quality alone.[44]

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[44] Sumner et al. (1994) summarize some of the studies that support a differentiated product approach for wheat. As per their review, some of the past work treating wheat as differentiated products include Johnson(1971); Cappel and Rigaux (1974); Johnson, Grennes and Thursby (1977, 1979); Grennes, Johnson and Thursby (1978); Honma and Heady (1984); Abbotte and Paarlberg (1984); Figueroa (1986), Figueroa and Webb (1986), Blanford (1988), Blanford(1988); AhmadiEsfahani (1989, 1992), Kim and Lin (1990), Alston et al. (1990) Larue (1992), and Sumner et al. (1994).

Table 4-3 Freight Rates from Major Exporting Regions to different Consuming Regions ($/ 000 tonnes)

FROM	AR	AU	CN	EU	US	CIS	ROW
TO	**$/000 t**						
European Union (EU)	$45,620	$58,388	$30,500	$0.00	$32,190	$31,370	$20,000
Other European Countries(OE)	$53,451	$45,485	$40,440	$31,370	$43,190	$0	$20,000
Canada (CN)	$37,900	$68,192	$0	$30,500	$28,040	$40,440	$20,000
United States (US)	$28,040	$69,957	$28,040	$32,190	$0	$43,190	$20,000
Latin America (LA)	$0	$48,676	$37,900	$45,620	$28,040	$53,451	$20,000
Near East Asia (NE)	$50,946	$43,850	$41,507	$47,388	$46,010	$37,996	$20,000
Pacific Asia(PA)	$80,091	$36,170	$56,400	$81,352	$55,870	$57,460	$20,000
South Asia(SA)	$59,354	$42,690	$42,828	$49,230	$57,460	$37,554	$20,000
North Africa (NA)	$45,778	$44,630	$50,500	$29,150	$47,020	$11,611	$20,000
Sub Saharan Africa (SA)	$26,927	$25,897	$36,571	$46,060.	$51,490	$49,230	$20,000
Oceania (OC)	$59,461	$0	$68,192	$58,388	$77,413	$45,485	$20,000

Source: World Grain Statistics, International Grain Council 2007 and authors calculations

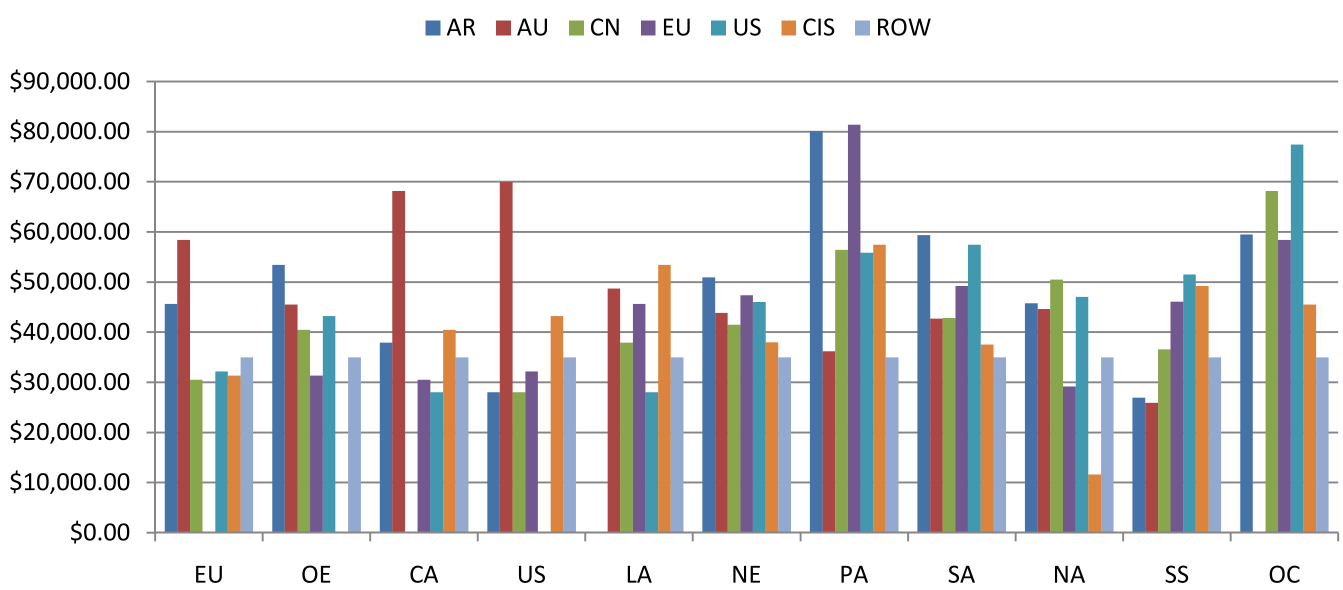


Figure 4- 3 Base Year Freight Rates from Major Exporting Ports to Importing Regions
Source: World Grain Statistics, International Grain Council 2007 and authors calculations

Table 4-4 2006/07 Prices and Quantities Used for Base Simulation

	Consuming region	quantity 000 tons	price US $ per 000 tons	Freight rate calculation
EU	C_{EU_AR}	14	$233,453 (a)	From Argentina to Antwerp, Rotterdam, Hamburg
	C_{EU_AU}	160	$315,138 (b)	
	C_{EU_CN}	1,938	$268,583 (a)	From St. Lawrence to Antwerp, Rotterdam, Hamburg
	C_{EU_EU}	112,274	$198,417(c)	
	C_{EU_US}	644	$254,190 (a)	From US Gulf to Antwerp, Rotterdam, Hamburg
	C_{EU_CIS}	2,107	$244,370 (a)	From Black Sea
	C_{EU_ROW}	388	$200,211 (b)	Author's estimation based on weighted average per unit freight cost to EU
	Q_{EU}	125,095	$198,417	
OE	C_{OE_AR}	1	$241,284 (a)	
	C_{OE_AU}	0	$302,235(b)	Author estimations based on relative geographic distance and alternate routes
	C_{OE_CN}	3	$278,523 (a)	From St. Lawrence to Black sea
	C_{OE_EU}	751	$229,787 (a)	
	C_{OE_US}	47	$265,190 (a)	From US Atlantic
	C_{OE_CIS}	73,737	$213,000 (c)	
	C_{OE_ROW}	59	$213,203(b)	
	Q_{OE}	89,910	$213,000	
CN	C_{CN_AR}	0	$225,733(b)	From Buenos Aires port to Halifax
	C_{CN_AU}	0	$324,941(b)	From Fremantle to Halifax
	C_{CN_CN}	5,959	$238,083(c)	Canadian FOB Export Price
	C_{CN_EU}	0	$228,917 (a)	Antwerp, Rotterdam, Hamburg to St. Lawrence
	C_{CN-US}	0	$250,040 (b)	Average of alternate routes was considered
	C_{CN-CIS}	0	$253,440 (a)	From St. Lawrence to Black sea
	C_{CN-ROW}	0	$238,083(b)	
	Q_{CN}	25,265	$238,083	
US	C_{US_AR}	23	$215,873 (a)	From US Gulf to Venezuela
	C_{US_AU}	0	$326,706(b)	From Fremantle to US Gulf
	C_{US_CN}	2,862	$266,123(b)	Average of alternate routes was considered
	C_{US_EU}	4	$230,607 (a)	From US Gulf to Antwerp, Rotterdam, Hamburg
	C_{US-US}	24,661	$222,000 (c)	
	C_{US-CIS} C_{US-ROW}	17 98	$256,190 (a) $225,795 (b)	From US Gulf to Black sea
	Q_{US}	49,316	$222,000	

Continued . . .

	Consuming region	quantity 000 tons	price US $ per 000 tons	Freight rate calculation
LA	C_{LA_AR}	20,069	$187,833(c)	
	C_{LA_AU}	1	$305,426(b)	From Australia to Brazil
	C_{LA_CN}	3,867	$275,983 (a)	From Venezuela to St. Lawrence
	C_{LA_EU}	349	$244,037 (a)	From Argentina to Antwerp, Rotterdam, Hamburg
	C_{LA_US}	6,758	$250,040 (a)	From Argentina to US Gulf
	$C_{LA\text{-}CIS}$	122	$266,451 (a)	From Argentina to Black sea
	$C_{LA\text{-}ROW}$	664	$208,752 (a)	
	Q_{LA}	22,635	$187,833	
NE				
	C_{NE_AR}	406	$238,779(b)	From Argentina to Iran
	C_{NE_AU}	1,206	$300,600(b)	From Australia to Iran
	C_{NE_CN}	923	$279,590(b)	From Halifax to Iran
	C_{NE_EU}	1,218	$245,805 (a)	From Rotterdam to Iran
	$C_{NE\text{-}US}$	1,890	$268,010 (a)	From US Gulf to Yemen
	C_{NE_CIS}	4,037	$250,995 (a)	From Black sea to Persian Gulf-Iran
	C_{NE_ROW}	1,794	$224,304 (a)	
	C_{NE_NE}	42,570	$225,172(d)	
	Q_{NE}	42,570	$225,172	
PA				
	C_{PA_AR}	300	$267,923 (a)	From Argentina to China
	C_{PA_AU}	6,779	$292,920 (a)	From Australia to China
	C_{PA_CN}	4,163	$294,483 (a)	From St. Lawrence to China
	C_{PA_EU}	22	$279,769 (a)	From EU to China
	$C_{PA\text{-}US}$	8,493	$277,870 (a)	From US Gulf to China
	$C_{PA\text{-}CIS}$	421	$270,460 (a)	From Black sea to China
	C_{PA_ROW}	3,421	$276,680(b)	
	C_{PA_PA}	109,822	$283,575(d)	
	Q_{PA}	109,822	$283,575	
SA				
	C_{SA_AR}	166	$247,186(b)	From Argentina to Pakistan
	C_{SA_AU}	1,580	$299,440 (a)	From Australia to Pakistan
	C_{SA_CN}	2,424	$280,911(b)	From St, Lawrence to Pakistan
	C_{SA_EU}	1,128	$247,647 (a)	From EU Gulf to Pakistan
	$C_{SA\text{-}US}$	304	$279,460 (a)	From US Gulf to Pakistan
	$C_{SA\text{-}CIS}$	4,208	$250,554 (b)	From Black sea to Pakistan
	C_{SA_ROW}	564	$240,010 (b)	
	C_{SA_SA}	97,330	$238,737 (d)	

Continued . . .

	Q_{SA}	97,330	$238,737	
NA	Consuming region	quantity 000 tons	price US $ per 000 tons	Freight rate calculation
	C_{NA_AR}	124	$233,611(b)	From Argentina to Egypt
	C_{NA_AU}	283	$301,380 (a)	From Australia to Egypt
	C_{NA_CN}	1,869	$288,583 (a)	From St. Lawrence to Algeria
	C_{NA_EU}	5,870	$227,567 (a)	From EU to Algeria
	C_{NA-US}	2,860	$269,020 (a)	From US Gulf to Algeria
	C_{NA-CIS}	4,277	$224,610(b)	From Black Sea to Algeria
	C_{NA_ROW}	939	$234,932(b)	
	C_{NA_NA}	18,996	$239,754(d)	
	Q_{NA}	18,996	$239,754	
SS				
	C_{SS_AR}	1,532	$214,760(b)	From Argentina to South Africa
	C_{SS_AU}	725	$282,647(b)	From Australia to South Africa
	C_{SS_CN}	1,241	$274,654(b)	From St. Lawrence to South Africa
	C_{SS_EU}	3,457	$244,477 (a)	From EU to Sudan
	C_{SS-US}	3,636	$273,490 (a)	From US Gulf to South Africa
	C_{SS-CIS}	983	$262,230(b)	From Black Sea to South Africa
	C_{SS_ROW}	439	$246,224(b)	
	C_{SS_SS}	5,228	$243,503(d)	
	Q_{SS}	5,228	$243,503	
OC				
	C_{OC_AR}	0	$247,294(b)	From Argentina to Australia
	C_{OC_AU}	418	$256,750(c)	
	C_{OC_CN}	16	$306,274(b)	From St. Lawrence to Australia
	C_{OC_EU}	22	$256,805(b)	From Amsterdam to Australia
	C_{OC-US}	23	$299,413(b)	From US Gulf to Australia
	C_{OC-CIS}	1	$258,485(b)	From Black Sea to Australia
	C_{OC_ROW}	9	$255,657(b)	
	Q_{OC}	11,152	$256,750	

Source: Canadian grain Council, 2007 and author's calculations

*The countries whose quantity of consumption of wheat from a specific origin is less than 1000 tons is considered zero is not included in the table.

a) Price of wheat in destined regions are calculated based on the 2007 average FOB Export Price in the country of origin port plus ocean transportation costs from International Grain Council..
b) Freight rates are calculated by author's estimations based on relative geographic distance and alternate routes
c) The average farm gate price in producing region
d) Author's calculation based on the weighted average price of wheat from different origins. The transportation cost varies according to the region.

As indicated above, the slopes and intercepts are derived using base year prices and quantities, using equation 4-1 and 4-2. In order to get the own priceelasticities and cross price elasticities of demand equations for each region, we used the Armington formula. Considering the linear demand equations mentioned in Chapter 3, a series of demand equations can be set up having all demand elasticities and elasticities of substitution between wheat from different origins in each country.

Inserting the appropriate variables in equation 4-5 calculates the own price elasticity of demand and equation 4-6 gives the cross price elasticity of demand.

$$\eta_{xx} = -1(1 - S_{ix})\sigma_i + S_{ix}\overline{\eta}_i \qquad \text{Equation 4- 5}$$

$$\eta_{xy} = S_{iy}(\sigma_i + \overline{\eta}_i) \qquad \text{Equation 4- 6}$$

Where S_{ix} indicates the share of consumption of wheat originating from country x in region i, σ_i is the elasticity of substitution and $\overline{\eta}_i$ is the overall elasticity of demand in region i.

The overall elasticity of demand in region i is the percentage change in total quantity demanded as a result of one percent change in the aggregate price of all the products.

$$\overline{\eta}_i = \frac{\Delta Q_d}{\Delta P}\frac{\overline{P}}{\overline{Q}_d} \qquad \text{Equation 4- 7}$$

To consider an appropriate approximation for the overall elasticity of demand, as Sumner et al. (1994) suggested, we considered the overall demand of wheat to be demand derived from the demand for milling and pasta-making.

The elasticity of substitution in demand measures the degree to which the two (or more) goods' ratio in region ichanges in reaction to changes in the ratio of their prices.

$$\sigma_i = \frac{\%\Delta(X/Y)}{\%\Delta(P_x/P_y)} \qquad \text{Equation 4- 8}$$

According to Sumner et al. (1994), borrowing elasticities from the literature is an important and confusing task due to the factors that affect the estimations and elasticity of substitution for wheat from different origins. These factors include the original functional form used by the researcher, different aggregation of data, and the use of different data series. They show that many previous estimates may have been underestimated because of the use of the wrong functional form. Also, using annual data in most studies yields much smaller values for the elasticity of substitution than in cases in which quarterly data were used. Moreover, aggregation issues are the other factor that may have affected the study and estimations. Regularly, if the researcher aggregates the data without any partitioning according to end use, the estimations of elasticity of substitution will be smaller than if they were estimated separately according to types, because the elasticity of substitution are smaller when commodities are more heterogeneous. The finer the commodity classes, they will be more homogeneous and as a result the elasticity of substitutions rises. Thus, if we face a category of a specific type of wheat like durum or milling wheat, it has greater substitution elasticity than the total wheat.

As Sumner et al. (1994) suggest the appropriate elasticity of substitute for the wheat not differentiated by the end use, is around 6 or more (Calculated by Alston et al. (1990)).Therefore, in our initial equilibrium, the base elasticity of substitution in aggregated wheat is considered $\sigma_i = 6$, and the robustness of this model will be examined by replicating the model changing the elasticity of substitution to 3, 9 and 12. In terms of overall demand elasticity, as per Sumner et al. (1994), we assume $\overline{\eta_i} = -0.15$.

Given the base prices and quantities in 2006-07 and an overall demand elasticity of $\overline{\eta_i} = -0.15$ table 4-5 shows the demand elasticities implied by applying $\sigma_i = 6$. As shown by Sumner et al (1994), in such Armingtonframework that has allowed for imperfect substitution for the types of wheat, there is no need to use price transmission elasticity modification to reduce the calculated elasticity.

Table 4-5 Armington Own Price and Cross Price Elasticity of Demand in Importing Regions

Implied Demand Elasticities									
Eta=-0.15 **Sigma=6**									
EUROPEAN UNION DOMESTIC MARKET									
Demand Elasticities in EU Domestic Market with Respect to the Price of									
Source	**Share**								
AR	0.000	-5.999	0.008	0.096	5.589	0.032	0.105	0.019	
AU	0.001	0.001	-5.992	0.096	5.589	0.032	0.105	0.019	
CN	0.016	0.001	0.008	-5.904	5.589	0.032	0.105	0.019	
EU	0.955	0.001	0.008	0.096	-0.411	0.032	0.105	0.019	
US	0.005	0.001	0.008	0.096	5.589	-5.968	0.105	0.019	
CIS	0.018	0.001	0.008	0.096	5.589	0.032	-5.895	0.019	
ROW	0.003	0.001	0.008	0.096	5.589	0.032	0.105	-5.981	
OTHER EUROPEAN COUNTRIES DOMESTIC MARKET									
Demand Elasticities in OE Domestic Market with Respect to the Price of									
AR	0.000	-6.000	0.000	0.000	0.059	0.004	5.787	0.005	
AU	0.000	0.000	-6.000	0.000	0.059	0.004	5.787	0.005	
CN	0.000	0.000	0.000	-6.000	0.059	0.004	5.787	0.005	
EU	0.010	0.000	0.000	0.000	-5.941	0.059	5.787	0.005	
US	0.001	0.000	0.000	0.000	0.059	-5.996	5.787	0.005	
CIS	0.989	0.000	0.000	0.000	0.059	0.004	-0.213	0.005	
ROW	0.001	0.000	0.000	0.000	0.059	0.004	5.787	-5.995	
CANADA DOMESTIC MARKET									
Demand Elasticities in CN Domestic Market with Respect to the Price of									
AR	0.000	-6.000	0.000	5.850	0.000	0.000	0.000	0.000	
AU	0.000	0.000	-6.000	5.850	0.000	0.000	0.000	0.000	
CN	1.000	0.000	0.000	-0.150	0.000	0.000	0.000	0.000	
EU	0.000	0.000	0.000	5.850	-6.000	0.000	0.000	0.000	
US	0.000	0.000	0.000	5.850	0.000	-6.000	0.000	0.000	
CIS	0.000	0.000	0.000	5.850	0.000	0.000	-6.000	0.000	
ROW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-6.000	
UNITED STATES OF AMERICA DOMESTIC MARKET									
Demand Elasticities in US Domestic Market with Respect to the Price of									
AR	0.001	-5.995	0.000	0.605	0.001	5.215	0.004	0.021	
AU	0.000	0.005	-6.000	0.605	0.001	5.215	0.004	0.021	
CN	0.103	0.005	0.000	-5.395	0.001	5.215	0.004	0.021	
EU	0.000	0.005	0.000	0.605	-5.999	5.215	0.004	0.021	

Continued . . .

Implied Demand Elasticities									
Eta=-0.15									
Sigma=6									
Demand Elasticities in US Domestic Market with Respect to the Price of									
Source	**Share**								
EU	0.000	0.005	0.000	0.605	-5.999	5.215	0.004	0.021	
US	0.891	0.005	0.000	0.605	0.001	-0.785	0.004	0.021	
CIS	0.001	0.005	0.000	0.605	0.001	5.215	-5.996	0.021	
ROW	0.004	0.005	0.000	0.605	0.001	5.215	0.004	-5.979	
LATIN AMERICA DOMESTIC MARKET									
Demand Elasticities in LA Domestic Market with Respect to the Price of									
AR	0.631	-2.312	0.000	0.711	0.064	1.242	0.022	0.122	
AU	0.000	3.688	-6.000	0.711	0.064	1.242	0.022	0.122	
CN	0.121	3.688	0.000	-5.289	0.064	1.242	0.022	0.122	
EU	0.011	3.688	0.000	0.711	-5.936	1.242	0.022	0.122	
US	0.212	3.688	0.000	0.711	0.064	-4.758	0.022	0.122	
CIS	0.004	3.688	0.000	0.711	0.064	1.242	-5.978	0.122	
ROW	0.021	3.688	0.000	0.711	0.064	1.242	0.022	-5.878	
NEAR EAST ASIA DOMESTIC MARKET									
Demand Elasticities in NE Domestic Market with Respect to the Price of									
AR	0.008	-5.956	0.131	0.100	0.132	0.205	0.437	0.194	4.608
AU	0.022	0.044	-5.869	0.100	0.132	0.205	0.437	0.194	4.608
CN	0.017	0.044	0.131	-5.900	0.132	0.205	0.437	0.194	4.608
EU	0.023	0.044	0.131	0.100	-5.868	0.205	0.437	0.194	4.608
US	0.035	0.044	0.131	0.100	0.132	-5.795	0.437	0.194	4.608
CIS	0.075	0.044	0.131	0.100	0.132	0.205	-5.563	0.194	4.608
ROW	0.033	0.044	0.131	0.100	0.132	0.205	0.437	-5.806	4.608
NE	0.788	0.044	0.131	0.100	0.132	0.205	0.437	0.194	-1.392
PACFIC ASIA DOMESTIC MARKET									
Demand Elasticities in PA Domestic Market with Respect to the Price of									
AR	0.002	-5.987	0.297	0.183	0.001	0.372	0.019	0.150	4.815
AU	0.051	0.013	-5.703	0.183	0.001	0.372	0.019	0.150	4.815
CN	0.031	0.013	0.297	-5.817	0.001	0.372	0.019	0.150	4.815
EU	0.000	0.013	0.297	0.183	-5.999	0.372	0.019	0.150	4.815
US	0.064	0.013	0.297	0.183	0.001	-5.628	0.019	0.150	4.815
CIS	0.003	0.013	0.297	0.183	0.001	0.372	-5.981	0.150	4.815
ROW	0.026	0.013	0.297	0.183	0.001	0.372	0.019	-5.850	4.815
PA	0.823	0.013	0.183	0.183	0.001	0.372	0.019	0.150	-1.185
SOUTH ASIA DOMESTIC MARKET									
Demand Elasticities in SA Domestic Market with Respect to the Price of									
AR	0.002	-5.991	0.086	0.132	0.061	0.017	0.229	0.031	5.287
AU	0.015	0.009	-5.914	0.132	0.061	0.017	0.229	0.031	5.287
CN	0.023	0.009	0.086	-5.868	0.061	0.017	0.229	0.031	5.287
EU	0.010	0.009	0.086	0.132	-5.939	0.017	0.229	0.031	5.287
US	0.003	0.009	0.086	0.132	0.061	-5.983	0.229	0.031	5.287
CIS	0.039	0.009	0.086	0.132	0.061	0.017	-5.771	0.031	5.287
ROW	0.005	0.009	0.086	0.132	0.061	0.017	0.229	-5.969	5.287

Continued . . .

Implied Demand Elasticities									
Eta=-0.15 Sigma=6									
Source	**Share**	**Demand Elasticities in SA Domestic Market with Respect to the Price of**							
SA	0.904	0.009	0.086	0.132	0.061	0.017	0.229	0.031	-0.713
NORTH AFRICA DOMESTIC MARKET									
Demand Elasticities in NA Domestic Market with Respect to the Price of									
AR	0.004	-5.979	0.047	0.310	0.975	0.475	0.710	0.156	3.155
AU	0.008	0.021	-5.953	0.310	0.975	0.475	0.710	0.156	3.155
CN	0.053	0.021	0.047	-5.690	0.975	0.475	0.710	0.156	3.155
EU	0.167	0.021	0.047	0.310	-5.025	0.475	0.710	0.156	3.155
US	0.081	0.021	0.047	0.310	0.975	-5.525	0.710	0.156	3.155
CIS	0.121	0.021	0.047	0.310	0.975	0.475	-5.290	0.156	3.155
ROW	0.027	0.021	0.047	0.310	0.975	0.475	0.710	-5.844	3.155
NA	0.539	0.021	0.047	0.310	0.975	0.475	0.710	0.156	-2.845
SUB SAHARAN AFRICA DOMESTIC MARKET									
Demand Elasticities in SS Domestic Market with Respect to the Price of									
AR	0.089	-5.480	0.246	0.421	1.173	1.234	0.334	0.149	1.774
AU	0.042	0.520	-5.754	0.421	1.173	1.234	0.334	0.149	1.774
CN	0.072	0.520	0.246	-5.579	1.173	1.234	0.334	0.149	1.774
EU	0.201	0.520	0.246	0.421	-4.827	1.234	0.334	0.149	1.774
US	0.211	0.520	0.246	0.421	1.173	-4.766	0.334	0.149	1.774
CIS	0.057	0.520	0.246	0.421	1.173	1.234	-5.666	0.149	1.774
ROW	0.025	0.520	0.246	0.421	1.173	1.234	0.334	-5.851	1.774
SS	0.303	0.520	0.246	0.421	1.173	1.234	0.334	0.149	-4.226
OCEANIA DOMESTIC MARKET									
Demand Elasticities in OC Domestic Market with Respect to the Price of									
AR	0.000	-6.000	5.001	0.191	0.263	0.275	0.012	0.108	
AU	0.855	0.000	-0.999	0.191	0.263	0.275	0.012	0.108	
CN	0.033	0.000	5.001	-5.809	0.263	0.275	0.012	0.108	
EU	0.045	0.000	5.001	0.191	-5.737	0.275	0.012	0.108	
US	0.047	0.000	5.001	0.191	0.263	-5.725	0.012	0.108	
CIS	0.002	0.000	5.001	0.191	0.263	0.275	-5.988	0.108	
ROW	0.018	0.000	5.001	0.191	0.263	0.275	0.012	-5.892	

Source: Simulation Calculations

In terms of supply elasticity, the overall elasticity of the wheat production in each region is a function of variety of production factors. It is assumed the producers are all price takers and operate in a competitive market both in input and output market. This assumption does not harm the model in this thesis and in future studies different assumption on supply side can be examined on such a simulation. As mentioned by Sumner et al. (1994), considering the key factors deriving the supply response, the long run supply function can be assumed to be highly elastic. However, due to the biases in econometric estimations because of the variety of unpredictable factors in agriculture production, expectations, uncertainties, and the difficulty of modeling the supply in long run, using estimation for the elasticity of supply specially is critical for the models that are concerned with investigating the policy changes. Therefore in this research, the supply elasticity from Sumner et al. (1994) has been adopted that has accounted for these biases. The supply elasticity of different producing regions is assumed to be 0.5.

Considering the market clearing condition and the geographic distances between regions, the market clearing quantity and prices are calculated.The model includes constraints to obtain the market clearing conditions for wheat market in all eleven regions. Through the process of simulation, the model calculates the prices of all the products in all the regions that provide the market clearing conditions. In the next step it is verified whether the simulation is working accurately, or on the other word the model validation is tested.

4.3. Model validation

As Srivastava (1997) mentions there is not a fully established methodology for simulation, and especially the market simulation models. Based on Trade Analysis Simulation System (TASS) developed by Agriculture Canada (1988), sensitivity analysis, using of reliable parameters and inspection of obvious errors are some solutions to validate a model. One of the key tests emphasized by TASS to get a reliable simulation model is replacing the original base year data. This is known as Base Year Calibration. Following this solution and obtaining the based year data successfully, supports the conclusion that the model has been specified correctly. The other suggestion in this method is to compare the results of the developed model with results of similar models. However this suggestion does not seem applicable since other studies may not look at the same question and scenario and even may not have been constructed under the same circumstances and assumptions. Also they may have use different based year data and different set of initial assumptions. While it may be hard to find another study that works as a comparison scope, it may be helpful solution to look at the results in detail where they appear to be unusual or inconsistent in terms of the direction and magnitude of outcomes.

In this study the following verification procedure has been followed:

All the intercepts and coefficients were calculated by the steps explained in last section. Then the base year prices and freight rates were used in all the equations to estimate the quantities using the calculated intercepts and coefficients. The calculated quantities for all countries and regions came out exactly the same as in the base year. A detailed sensitivity analysis is also carried out in the following sections to analyze the impact of changes in all the parameters one by one on the important variables in different regions, and examine the robustness of the model toward these parameters. As a result the whole spatial market simulating model seems to work properly. A variety of simulations (corresponding to different combination of parameters) are summarized in tables in next section of this research and the appendices. As the next step the impact of changes in freight rate in the wheat flow between regions is investigated and then some robustness analysis is added to see how the variation of different parameters affects the results.

4.4. Scenarios

The main purpose of this chapter is to present and analyze the result of the changes in the freight rate on the world wheat flow. In this section, the developed base simulation in this thesis is used to follow the result of changing ocean freight on flow of wheat. The scenarios developed in this section are described as follows:

Scenario A)Increasing freight rates in all routes simultaneously in base model:

The freight rates are increased in all routes for 10%, 50 %, and 100 % given the initial base year prices and quantities, elasticity of substitution equals to 6, own price elasticity of -0.15, and supply elasticity of 0.5.

Scenario B)Model reaction to the changes in demand elasticity and elasticity of Substitution:

The impact of the changes in the freight rate are examined with elasticity of substitution and over all elasticity of demand for wheat changes.

Scenario C)The Impact of the freight rate changes to or from a specific region:

i. The impact of the changes to a specific importing regions
ii. The impact of the changes from a specific exporting region

Scenario A:IncreasingFreightRates in all Routes Simultaneously

Under this scenario it is assumed that the freight rates in all routes increase proportionally. Table A-1 in Appendix B provides the equilibrium quantity demanded, supplied, and prices for all the regions under the assumption of 10%, 50%, and 100% increase in freight rates.

Table 4-6 shows the percentage changes in quantities and prices, after a50% and 100% shock in freight rates. Figure 4-4 compares the impact of 50% and 100% increase in freight rates on quantity of supply in different regions, and wheat supply prices across the producing regions. This increase in freight rate affects the supply of wheat in country of origin. Depending on elasticity of supply in region, the percentage of the change in production and prices varies. As illustrated in the graph, some regions are forced to decrease their production and the supply price to compensate the increase in freight rate, while the others increase the supply due to a price increase.As shown in the figure, most of the importing regions will increase their domestic production in reacting to the freight rate increases. Among the producing regions, only the Latin America (LA) has slightly increased the price and supply of wheat after the increase in freight rate. One should note that considering the natural delay in the reaction of agricultural production to price changes, the producing region cannot react to the price changes immediately. In short term the regions will probably use their stocks and after reaching the maximum level of the stock, they will not be able to increase the supply quantity more. Considering the dynamic nature of freight rates and delay in reacting to price changes in agricultural products, producers can only be inspired by predicting the changes and forecast the trend in long term and adjust the supply quantity accordingly. In short run, they can only react to the price changes by adjusting the supply to different regions and playing with the stock level to react to immediate price changes. Among producing regions, Canada and United States show the biggest price reduction followed by Oceania. SS and NE on the other hand, show the biggest supply price and quantity increase.

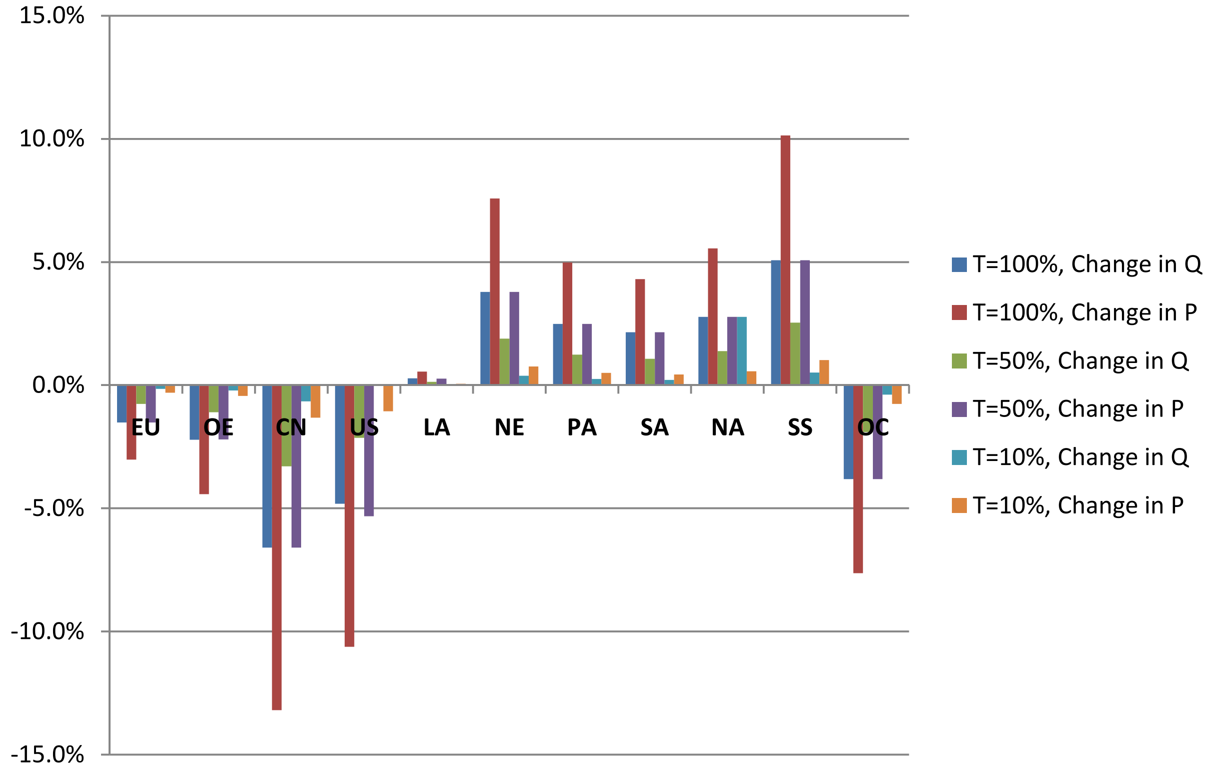
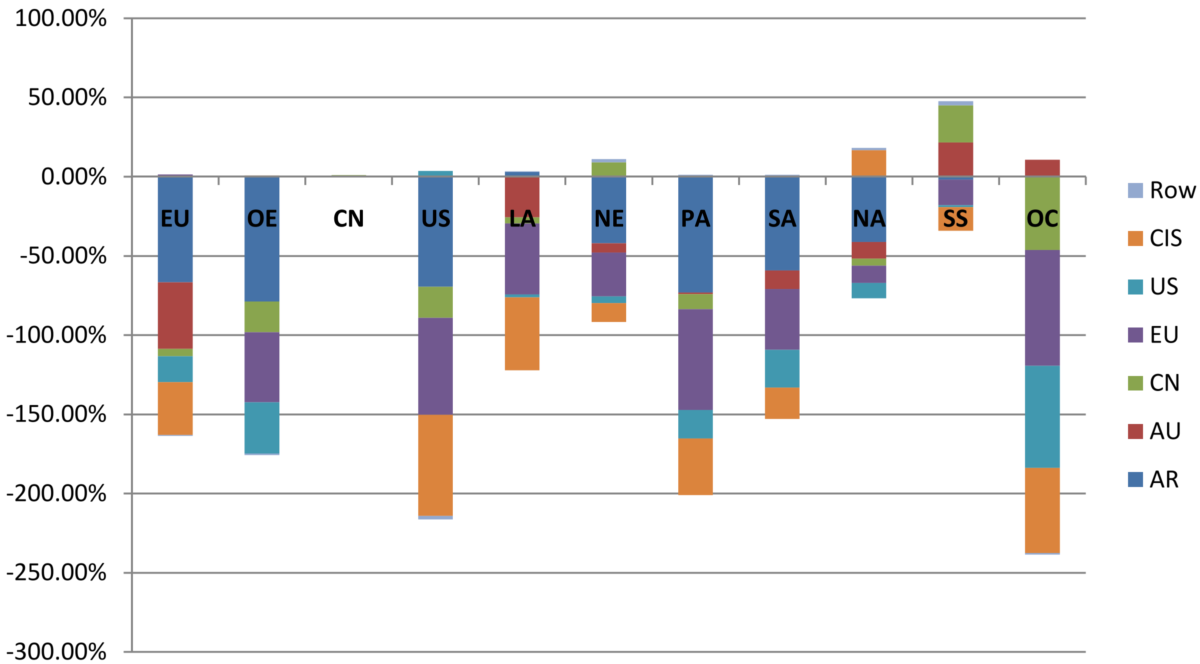


Figure 4-4 Impact of 50% Freight Rate Increase on Supply Price and Quantity using Base Elasticities
Source: Simulation Results

Figure 4-4to 4-6 show the impact of the increasing freight rate on prices and quantities of the wheat originated from different source. As it is shown the compatibility of the wheat produced in different exporting regions in consuming regions varies. Again, as shown in these graphs, although the freight rate costs has gone up with equal coefficient in different regions, the price of wheat in the destination varies from region to region. This is coming from the fact of different distances and accumulated transportation costs as a result of it, and different demand coefficients. In addition, the premium price of wheat in different regions varies. Therefore, the price and quantity of exported wheat from one region changes from region to region.

Figure 4- 5 Impact of 50% Freight Increase in all Routes on the Global Wheat Quantity



Source: Simulation Results

Figure 4- 6 Regional Change in Wheat Price after 50% Freight Rate Increase in all Routes
Source: Simulation Results

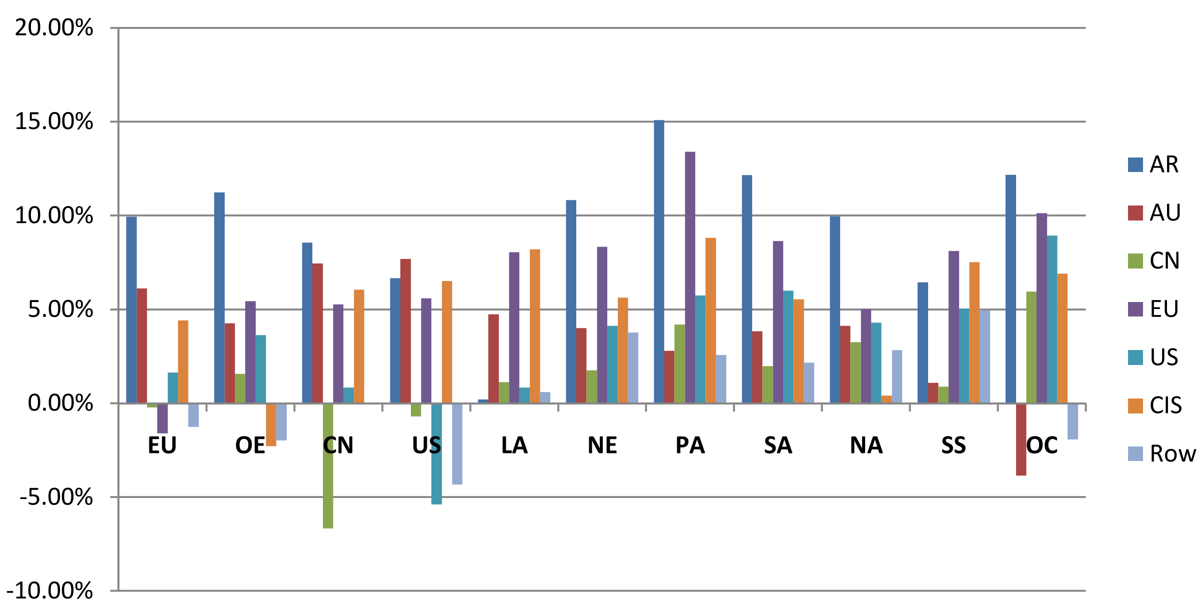
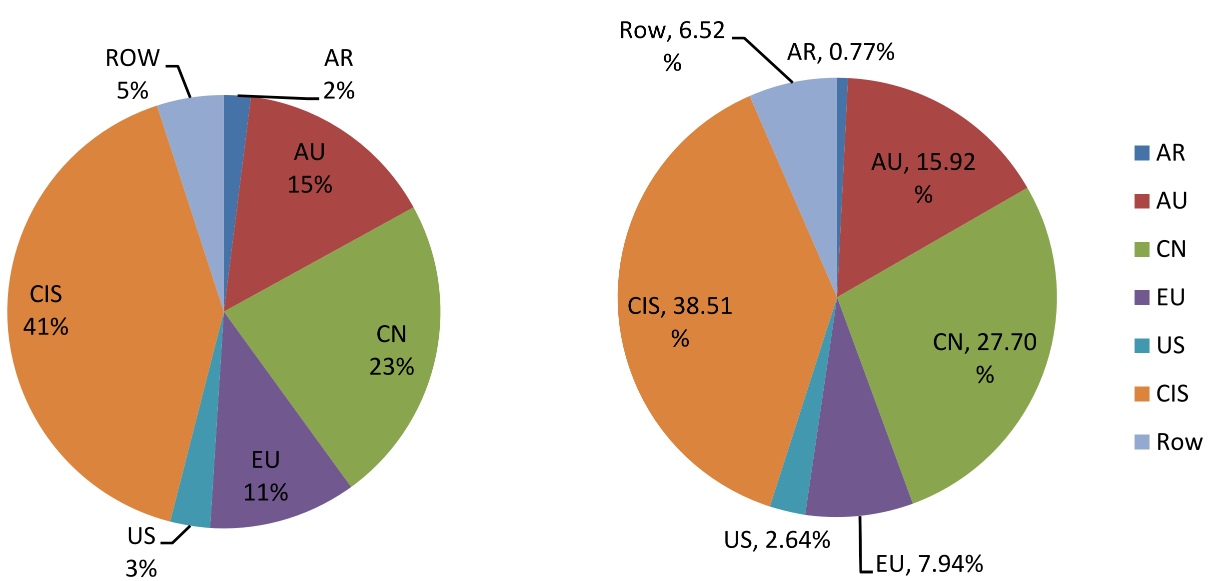


Figure 4-6 compares the changes in prices in different consuming regions. It also implies the opportunities and advantages that are created or lost in each region for the exporter after increasing freight rates. One can compare the changes from base simulation and use the result of the simulation to make marketing decisions. For instance, as per the result of this simulation, after a 50% increase in freight rates toSouth Asia (SA), the changes in price of wheat originated from AR and EU are the largest and the changes in price of Canadian wheat is the smallest followed by Australian wheat.

Figure 4-7 illustrates the SA regional wheat market and the share of wheat produced in different regions before the price changes. The wheat originated from CIS and Canada is the dominant importing wheat to the region, followed by Australia. Although after the shock in freight market, there is an opportunity to compete with other regions for Canada to obtain and maintain a bigger share in this market.

Figure 4- 7 Comparison of Import Share of Different Originated Wheat in South Asia According to Base Price and Quantities and 50% Increase in Freight Rates
Source: International Grain Council (2007) and Simulation results



Original Shares **Shares after 50% Increase in Freight Rates**

Table 4-6 Percentage Changes in Wheat Quantity and Prices after a 50%, and 100% Increase in Freight Rate Using Armington Base Simulation Assumptions

	Quantities	**Prices**	**Quantities**	**Prices**
EU Markets	% change	% Change	% change	% Change
Domestic demand	**T= 100%**	**Sigma=6**	**T=50 %**	**Sigma=6**
C_{EU_AR}	-100.0%	20.0%	-66.52%	9.99%
C_{EU_AU}	-83.6%	12.3%	-41.81%	6.16%
C_{EU_CN}	-9.4%	-0.3%	-4.70%	-0.17%
C_{EU_EU}	2.6%	-3.0%	1.31%	-1.51%
C_{EU_US}	-32.4%	3.4%	-16.19%	1.69%
C_{EU_CIS}	-66.5%	9.0%	-33.24%	4.49%
C_{EU_ROW}	-1.2%	-2.4%	-0.59%	-1.18%
Q_{EU}	-1.5%	-3.0%	-0.75%	-1.51%
OE Market				
Domestic Demand				
C_{OE_AR}	-100.0%	22.6%	-78.70%	11.29%
C_{OE_AU}	0.0%	8.6%	0.00%	4.29%
C_{OE_CN}	-38.4%	3.2%	-19.22%	1.62%
C_{OE_EU}	-88.8%	11.0%	-44.42%	5.52%
C_{OE_US}	-64.3%	7.4%	-32.15%	3.70%
C_{OE_CIS}	1.7%	-4.4%	0.83%	-2.21%
C_{OE_ROW}	-1.9%	-3.8%	-0.95%	-1.91%
Supply				
Q_{OE}	-2.2%	-4.4%	-1.10%	-2.21%
CA Market				
Domestic Demand				
C_{CA_AR}	0.0%	17.2%	0.00%	8.62%
C_{CA_AU}	0.0%	15.0%	0.00%	7.48%
C_{CA_CN}	2.0%	-13.2%	0.99%	-6.60%
C_{CA_EU}	0.0%	10.7%	0.00%	5.35%
C_{CA_US}	0.0%	1.8%	0.00%	0.89%
C_{CA_CIS}	0.0%	12.2%	0.00%	6.12%
C_{CA_ROW}	0.0%	0.0%	0.00%	0.00%
Domestic Supply				
Q_{CA}	-6.6%	-13.2%	-3.30%	-6.60%
US Market				
Domestic Demand				
C_{US_AR}	-100.0%	13.5%	-69.39%	6.73%
C_{US_AU}	0.0%	15.4%	0.00%	7.71%
C_{US_CN}	-39.4%	-1.3%	-19.72%	-0.63%

Continued . . .

	% change	% Change	% change	% Change
	T= 100%	**Sigma=6**	**T=50 %**	**Sigma=6**
C_{US_EU}	-100.0%	11.4%	-61.24%	5.68%
C_{US_US}	7.4%	-10.6%	3.69%	-5.31%
Domestic Supply				
Q_{us}	-5.3%	-10.6%	-2.66%	-5.31%
LA Market				
Domestic Demand				
C_{LA_AR}	6.2%	0.5%	3.10%	0.27%
C_{LA_AU}	-51.3%	9.5%	-25.66%	4.76%
C_{LA_CN}	-7.7%	2.4%	-3.83%	1.18%
C_{LA_EU}	-90.2%	16.2%	-45.08%	8.12%
C_{LA_US}	-3.6%	1.8%	-1.78%	0.89%
C_{LA_CIS}	-92.5%	16.5%	-46.25%	8.26%
C_{LA_ROW}	0.7%	1.3%	0.33%	0.66%
Domestic Supply				
Q_{LA}	0.3%	0.5%	0.14%	0.27%
NE Market				
Domestic Demand				
C_{NE_AR}	-84.1%	21.8%	-42.06%	10.88%
C_{NE_AU}	-11.5%	8.1%	-5.75%	4.04%
C_{NE_CN}	18.0%	3.6%	9.02%	1.81%
C_{NE_EU}	-55.9%	16.8%	-27.96%	8.42%
C_{NE_US}	-8.8%	8.4%	-4.39%	4.18%
C_{NE_CIS}	-24.1%	11.4%	-12.06%	5.69%
C_{NE_ROW}	3.8%	7.6%	1.91%	3.81%
C_{NE_NE}	3.8%	7.6%	1.90%	3.79%
Domestic Supply				
Q_{NE}	3.8%	7.6%	1.90%	3.79%
PA Market				
Domestic Demand				
C_{PA_AR}	-100.0%	30.3%	-73.34%	15.14%
C_{PA_AU}	-2.0%	5.7%	-0.99%	2.83%
C_{PA_CN}	-19.1%	8.5%	-9.54%	4.24%
C_{PA_EU}	-100.0%	26.9%	-64.07%	13.47%
C_{PA_US}	-36.0%	11.6%	-17.98%	5.81%
C_{PA_CIS}	-71.9%	17.8%	-35.97%	8.88%
C_{PA_ROW}	2.6%	5.2%	1.30%	2.61%
C_{PA_PA}	2.5%	5.0%	1.25%	2.49%
Domestic Supply				
Q_{PA}	2.5%	5.0%	1.25%	2.49%

Continued . . .

SA Market	Quantities	Prices	Quantities	Prices
	% change	% Change	% change	% Change
Domestic Demand	**T= 100%**	**Sigma=6**	**T=50 %**	**Sigma=6**
C_{SA_AR}	-100.0%	24.4%	-59.45%	12.21%
C_{SA_AU}	-23.5%	7.7%	-11.73%	3.86%
C_{SA_CN}	0.0%	4.1%	-0.02%	2.03%
C_{SA_EU}	-77.2%	17.5%	-38.58%	8.73%
C_{SA_US}	-48.2%	12.1%	-24.12%	6.06%
C_{SA_CIS}	-40.1%	11.2%	-20.05%	5.62%
C_{SA_ROW}	2.2%	4.4%	1.10%	2.19%
C_{SA_SA}	2.2%	4.3%	1.08%	2.16%
Domestic Supply				
Q_{sa}	2.2%	4.3%	1.08%	2.16%
NA Market				
Domestic Demand				
C_{NA_AR}	-82.5%	19.9%	-41.25%	9.96%
C_{NA_AU}	-20.8%	8.2%	-10.39%	4.12%
C_{NA_CN}	-9.0%	6.5%	-4.51%	3.25%
C_{NA_EU}	-22.0%	10.0%	-11.01%	5.00%
C_{NA_US}	-19.4%	8.6%	-9.69%	4.29%
C_{NA_CIS}	33.6%	0.8%	16.81%	0.40%
C_{NA_ROW}	2.8%	5.7%	1.41%	2.83%
C_{NA_NA}	2.8%	5.5%	1.39%	2.77%
Domestic Supply				
Q_{NA}	2.8%	5.6%	1.39%	2.78%
SS Market				
Domestic Demand				
C_{SS_AR}	-3.5%	12.9%	-1.77%	6.45%
C_{SS_AU}	43.1%	2.2%	21.55%	1.08%
C_{SS_CN}	47.2%	1.8%	23.59%	0.88%
C_{SS_EU}	-32.5%	16.2%	-16.26%	8.11%
C_{SS_US}	-2.5%	10.1%	-1.26%	5.04%
C_{SS_CIS}	-29.8%	15.0%	-14.89%	7.52%
C_{SS_ROW}	5.0%	9.9%	2.48%	4.95%
C_{SS_SS}	5.0%	10.0%	2.50%	5.01%
Domestic Supply				
Q_{ss}	5.0%	10.0%	2.50%	5.01%
OC Market				
Domestic Demand				
C_{OC_AR}	0.0%	24.4%	0.00%	12.18%
C_{OC_AU}	21.2%	-7.7%	10.62%	-3.85%
C_{OC_CN}	-92.4%	11.9%	-46.18%	5.95%
C_{OC_EU}	-100.0%	20.2%	-73.26%	10.12%
C_{OC_US}	-100.0%	17.9%	-64.33%	8.93%

Continued . . .

OC Market	Quantities	Prices	Quantities	Prices
	% change	% Change	% change	% Change
	T= 100%	**Sigma=6**	**T=50 %**	**Sigma=6**
$C_{OC\ CIS}$	-100.0%	13.8%	-53.85%	6.90%
$C_{OC\ ROW}$	-1.9%	-3.9%	-0.97%	-1.93%
Domestic Supply				
Q_{oc}	-3.9%	-7.7%	-1.93%	-3.85%

Scenario B:Model Reaction to the Changes in Demand Elasticity and Elasticity of Substitution:

To conduct a test to examine the impact of variation of the different parameters in the model, a sensitivity analysis needs to be done. The overall elasticity of demand (η), and the elasticity of substitutions (δ) are varied in this section and the simulation is resolved for each change to obtain the market clearing solution.

In this scenario, the elasticity of substitution between wheat originated from different region ischanged from 6 to 12 (higher bound), and from 6 to 3 (lower bound), and the overall elasticity of demand is changed from -0.15 to -0.2 (higher bound) and to -0.1 (lower bound).To measure the magnitude of the effect, the model has been solved for lower bound and higher bound elasticity and 50% freight rate increase in all routes. Table A-2 shows the own price and cross price elasticities using lower bound and higher bound overall demand elasticity and elasticity of substitution, using base prices, quantities, and shares in different markets. Table 4-7 shows the result of the changes in flow and price of the wheat in different regions with 50%increase in the freight rates in all routes.In addition to elasticity of substitution and overall elasticity, the magnitude of the changes in own price and cross price elasticityalso dependson the share of the imported wheat in each destination. It is expected as the elasticity of substitution increase, and the different originated wheat get closer substitute, the reaction to the freight rate fluctuations become larger.

The lower bound simulation is a replication of lower elasticity of substitution between the different originated wheat . Therefore the different originated wheat arenot treated as substitutes and the importing countries show less sensitivity to price changes that are the result of higher freight rates. In this scenario, the magnitude of the changes in quantities is smaller than the time that the elasticities are higher. When the model is solved with higher bound elasticities, which in case of elasticity of substitution means greater sensitivity toward substituting different type of wheat, it shows that the model reacts even more to the changes. This is because the consuming region can replace the more expensive wheat with the less expensive one. Our model is capable of showing this result. Table 4-7 shows the changes in flow and prices of the wheat in different regions, with higher bound and lower bound elasticity.

Consider the Pacific Asia (PA) region. United States, Australia, and Canada are the first three importers to the region according to the base year prices and quantities. After a 50% increase in the freight rate, with the higher bound over all elasticity and elasticity of substitution, Argentina loses its compatibility. The region does not import from Argentina at all, while with lower bound elasticity not only the region imports from Argentina, but even the amount of import increases comparing to the base amount and quantity when the freight rate increases. This is because with higher elasticity of substitution, the region is more sensitive between the wheat from different origins, and replaces the less expensive type of the wheat. The domestic production has increased in all cases, but with different rates. Again, the most increase is associated with the higher elasticity of substitution and over all elasticity of demand.

Table 4-7 Wheat Flow and Price Comparison between Base Model (Sigma=6, Eta= -1.5), Higher Bound Elasticity (Sigma= 12, Eta= -0.2), and Lower Bound Elasticity (Sigma= 3, Eta= -0.1),T=50%

MODEL PARAMETERS	BASE ELASTICITIES T= 0 %		BASE ELASTICITIES T= 50%		HIGH BOUND ELASTICITIES T= 50%		LOW BOUND ELASTICITIES T=50%	
	Quantities	**Prices**	**Quantities**	**Prices**	**Quantities**	**Prices**	**Quantities**	**Prices**
EU Markets	Q_{EU-i}	P_{EU-i}	Q_{EU-i}	P_{EU-i}	Q_{EU-i}	P_{EU-i}	Q_{EU-i}	P_{EU-i}
Domestic demand	000 t	$/t	000 t	$/t	000 t	$/t	000 t	$/t
C_{EU_AR}	14	$233,452	5	$256,642	-5	$255,854	9	$257,508
C_{EU_AU}	160	$315,136	93	$334,437	16	$334,718	128	$334,552
C_{EU_CN}	1,938	$268,582	1,846	$267,957	1,750	$266,751	1,876	$269,848
C_{EU_EU}	112,274	$198,418	113,767	$195,223	115,289	$193,974	113,019	$196,371
C_{EU_US}	644	$254,189	539	$258,323	434	$257,098	587	$260,128
C_{EU_CIS}	2,107	$244,370	1,406	$255,158	681	$254,149	1,757	$256,297
C_{EU_ROW}	388	$200,210	386	$197,667	384	$196,371	387	$198,829
Domestic Supply								
Q_{EU}	125,095	$198,418	124,088	$195,223	123,694	$193,974	124,450	$196,371
OE Market	Q_{OE-i}	P_{OE-i}	Q_{OE-i}	P_{OE-i}	Q_{OE-i}	P_{OE-i}	Q_{OE-i}	P_{OE-i}
Domestic Demand	000 t	$/t	000 t	$/t	000 t	$/t	000 t	$/t
C_{OE_AR}	1	$241,283	0	$268,389	-1	$267,601	1	$269,255
C_{OE_AU}	0	$302,233	0	$315,083	0	$315,364	0	$315,198
C_{OE_CN}	3	$278,522	2	$282,867	2	$281,661	3	$284,758
C_{OE_EU}	751	$229,788	418	$242,278	92	$241,029	584	$243,426
C_{OE_US}	47	$265,189	32	$274,823	17	$273,598	39	$276,628
C_{OE_CIS}	73,737	$213,000	74,359	$208,103	74,874	$207,094	74,051	$209,242
C_{OE_ROW}	59	$213,203	58	$208,959	58	$207,795	59	$210,241
Domestic Supply								
Q_{OE}	89,910	$213,000	88,876	$208,103	88,663	$207,094	89,117	$209,242
CA Market	Q_{CA-i}	P_{CA-i}	Q_{CA-i}	P_{CA-i}	Q_{CA-i}	P_{CA-i}	Q_{CA-i}	P_{CA-i}
Domestic Demand	000 t	$/t	000 t	$/t	000 t	$/t	000 t	$/t
C_{CA_AR}	0	$225,732	0	$245,062	0	$244,274	0	$245,928
C_{CA_AU}	0	$324,939	0	$349,142	0	$349,423	0	$349,257
C_{CA_CN}	5,959	$238,082	6,019	$222,207	6,045	$221,001	5,994	$224,098

Continued . . .

Model PARAMETERS	Base Elasticities t= 0 %		Base Elasticities T= 50%		High BoundElasticities T= 50%		Low Bound Elasticities T=50%	
C_{CA_EU}	0	$228,918	0	$240,973	0	$239,724	0	$242,121
CA Market	**Q_{CA-i}**	**P_{CA-i}**	**Q_{CA-i}**	**P_{CA-i}**	**Q_{CA-i}**	**P_{CA-i}**	**Q_{CA-i}**	**P_{CA-i}**
C_{CA_US}	0	$250,039	0	$252,098	0	$250,873	0	$253,903
C_{CA_CIS}	0	$253,440	0	$268,763	0	$267,754	0	$269,902
C_{CA_ROW}	0	$238,083	0	$238,083	0	$238,083	0	$238,083
Domestic Supply								
Q_{CA}	25,265	$238,082	24,423	$222,207	24,359	$221,001	24,523	$224,098
US Market	**Q_{US-i}**	**P_{US-i}**	**Q_{US-i}**	**P_{US-i}**	**Q_{US-i}**	**P_{US-i}**	**Q_{US-i}**	**P_{US-i}**
Domestic Demand	000 t	$/t	000 t	$/t	000 t	$/t	000 t	$/t
C_{US_AR}	23	$215,872	7	$230,272	-10	$229,484	15	$231,138
C_{US_AU}	0	$326,704	0	$351,790	0	$352,071	0	$351,905
C_{US_CN}	2,862	$266,122	2,298	$264,267	1,723	$263,061	2,579	$266,158
C_{US_EU}	4	$230,608	2	$243,508	-1	$242,259	3	$244,656
C_{US_US}	24,660	$221,999	25,572	$210,038	26,392	$208,813	25,129	$211,843
C_{US_CIS}	17	$256,190	6	$272,888	-5	$271,879	12	$274,027
C_{US_ROW}	99	$225,497	97	$215,732	96	$214,236	97	$217,762
Domestic Supply								
Q_{us}	49,316	$221,999	47,987	$210,038	47,851	$208,813	48,188	$211,843
LA Market	**Q_{LA-i}**	**P_{LA-i}**	**Q_{LA-i}**	**P_{LA-i}**	**Q_{LA-i}**	**P_{LA-i}**	**Q_{LA-i}**	**P_{LA-i}**
Domestic Demand	000 t	$/t	000 t	$/t	000 t	$/t	000 t	$/t
C_{LA_AR}	20,069	$187,832	20,685	$188,212	21,143	$187,424	20,466	$189,078
C_{LA_AU}	1	$305,423	1	$319,869	0	$320,150	1	$319,984
C_{LA_CN}	3,867	$275,982	3,721	$279,057	3,625	$277,851	3,763	$280,948
C_{LA_EU}	349	$244,038	192	$263,653	41	$262,404	271	$264,801
C_{LA_US}	6,758	$250,039	6,642	$252,098	6,627	$250,873	6,646	$253,903
C_{LA_CIS}	122	$266,451	66	$288,280	10	$287,271	94	$289,419
C_{LA_ROW}	664	$208,747	666	$209,985	665	$209,162	667	$210,872
Domestic Supply	000 t	$/t	000 t	$/t	000 t	$/t	000 t	$/t
Q_{LA}	22,635	$187,832	22,658	$188,212	22,610	$187,424	22,710	$189,078
NE Market	**Q_{NE-i}**	**P_{NE-i}**	**Q_{NE-i}**	**P_{NE-i}**	**Q_{NE-i}**	**P_{NE-i}**	**Q_{NE-i}**	**P_{NE-i}**
Domestic Demand	000 t	$/t	000 t	$/t	000 t	$/t	000 t	$/t
C_{NE_AR}	406	$238,778	235	$264,632	98	$263,843	311	$265,498
C_{NE_AU}	1,206	$300,597	1,136	$312,630	1,093	$312,911	1,156	$312,745

Continued . . .

Model PARAMETERS	Base Elasticities t= 0 %		Base Elasticities T= 50%		High BoundElasticities T= 50%		Low Bound Elasticities T=50%	
C_{NE_CN}	923	$279,590	1,007	$284,468	1,172	$283,262	936	$286,359
C_{NE_EU}	1,218	$245,807	880	$266,306	665	$265,056	1,016	$267,453
NE Market	Q_{NE-i}	P_{NE-i}	Q_{NE-i}	P_{NE-i}	Q_{NE-i}	P_{NE-i}	Q_{NE-i}	P_{NE-i}
C_{NE_US}	1,890	$268,009	1,809	$279,054	1,902	$277,829	1,788	$280,859
C_{NE_CIS}	4,036	$250,996	3,557	$265,096	3,432	$264,087	3,689	$266,236
C_{NE_ROW}	1,798	$224,208	1,832	$232,638	1,837	$233,817	1,826	$231,023
C_{NE_NE}	42,569	$225,162	43,366	$233,595	43,474	$234,732	43,221	$232,057
Domestic Supply								
Q_{NE}	42,569	$225,162	43,366	$233,595	43,474	$234,732	43,221	$232,057
PA Market	Q_{PA-i}	P_{PA-i}	Q_{PA-i}	P_{PA-i}	Q_{PA-i}	P_{PA-i}	Q_{PA-i}	P_{PA-i}
Domestic Demand	000 t	$/t	000 t	$/t	000 t	$/t	000 t	$/t
C_{PA_AR}	300	$267,922	80	$308,348	0	$307,559	184	$309,214
C_{PA_AU}	6,779	$292,917	6,714	$301,110	6,837	$301,391	6,669	$301,225
C_{PA_CN}	4,163	$294,482	3,773	$306,807	3,749	$305,601	3,845	$308,698
C_{PA_EU}	22	$279,771	8	$317,252	0	$316,002	14	$318,400
C_{PA_US}	8,493	$277,869	6,980	$293,843	6,267	$292,618	7,479	$295,648
C_{PA_CIS}	421	$270,460	271	$294,293	157	$293,284	336	$295,432
C_{PA_ROW}	3,422	$276,665	3,466	$283,796	3,474	$285,004	3,458	$282,417
C_{PA_PA}	109,822	$283,573	111,175	$290,560	111,405	$291,749	110,912	$289,202
Domestic Supply								
Q_{PA}	109,822	$283,573	111,175	$290,560	111,405	$291,749	110,912	$289,202
SA Market	Q_{SA-i}	P_{SA-i}	Q_{SA-i}	P_{SA-i}	Q_{SA-i}	P_{SA-i}	Q_{SA-i}	P_{SA-i}
Domestic Demand	000 t	$/t	000 t	$/t	000 t	$/t	000 t	$/t
C_{SA_AR}	166	$247,185	68	$277,242	-15	$276,454	113	$278,108
C_{SA_AU}	1,580	$299,437	1,396	$310,890	1,271	$311,171	1,467	$311,005
C_{SA_CN}	2,424	$280,911	2,429	$286,449	2,685	$285,244	2,347	$288,341
C_{SA_EU}	1,128	$247,648	696	$269,068	400	$267,819	880	$270,216
C_{SA_US}	304	$279,459	231	$296,228	191	$295,003	258	$298,033
C_{SA_CIS}	4,208	$250,554	3,377	$264,433	2,995	$263,424	3,675	$265,573
C_{SA_ROW}	565	$239,909	572	$245,107	573	$246,534	570	$243,630
C_{SA_SA}	97,329	$238,735	98,367	$243,823	98,652	$245,223	98,077	$242,404

Continued . . .

Model PARAMETERS	Base Elasticities t= 0 %		Base Elasticities T= 50%		High BoundElasticities T= 50%		Low Bound Elasticities T=50%	
Domestic Supply	000 t	$/t	000 t	$/t	000 t	$/t	000 t	$/t
Q_{sa}	97,329	$238,735	98,367	$243,823	98,652	$245,223	98,077	$242,404
NA Market	**Q_{NA-i}**	**P_{NA-i}**	**Q_{NA-i}**	**P_{NA-i}**	**Q_{NA-i}**	**P_{NA-i}**	**Q_{NA-i}**	**P_{NA-i}**
Domestic Demand	000 t	$/t	000 t	$/t	000 t	$/t	000 t	$/t
C_{NA_AR}	124	$233,610	73	$256,880	23	$256,091	98	$257,746
NA Market	**Q_{NA-i}**	**P_{NA-i}**	**Q_{NA-i}**	**P_{NA-i}**	**Q_{NA-i}**	**P_{NA-i}**	**Q_{NA-i}**	**P_{NA-i}**
C_{NA_AU}	283	$301,377	254	$313,800	214	$314,081	269	$313,915
C_{NA_CN}	1,869	$288,582	1,785	$297,957	1,748	$296,751	1,799	$299,848
C_{NA_EU}	5,872	$227,568	5,225	$238,948	4,781	$237,699	5,494	$240,096
C_{NA_US}	2,861	$269,019	2,584	$280,568	2,387	$279,343	2,679	$282,373
C_{NA_CIS}	4,278	$224,611	4,998	$225,518	5,812	$224,509	4,598	$226,658
C_{NA_ROW}	934	$235,157	947	$241,812	946	$241,397	947	$241,918
C_{NA_NA}	18,996	$239,765	19,260	$246,414	19,248	$246,104	19,257	$246,332
Domestic Supply								
Q_{NA}	18,996	$239,765	19,260	$246,414	19,248	$246,104	19,257	$246,332
SS Market	**Q_{SS-i}**	**P_{SS-i}**	**Q_{SS-i}**	**P_{SS-i}**	**Q_{SS-i}**	**P_{SS-i}**	**Q_{SS-i}**	**P_{SS-i}**
Domestic Demand	000 t	$/t	000 t	$/t	000 t	$/t	000 t	$/t
C_{SS_AR}	1,532	$214,759	1,505	$228,603	1,492	$227,814	1,514	$229,469
C_{SS_AU}	725	$282,644	881	$285,700	1,010	$285,981	807	$285,815
C_{SS_CN}	1,241	$274,653	1,534	$277,063	1,858	$275,858	1,371	$278,955
C_{SS_EU}	3,457	$244,478	2,895	$264,313	2,439	$263,064	3,155	$265,461
C_{SS_US}	3,636	$273,489	3,590	$287,273	3,641	$286,048	3,567	$289,078
C_{SS_CIS}	983	$262,230	837	$281,948	708	$280,939	904	$283,087
C_{SS_ROW}	439	$246,238	450	$258,432	450	$258,316	449	$258,132
C_{SS_SS}	5,228	$243,504	5,359	$255,697	5,358	$255,587	5,356	$255,385
Domestic Supply								
Q_{ss}	5,228	$243,504	5,359	$255,697	5,358	$255,587	5,356	$255,385
OC Market	**Q_{OC-i}**	**P_{OC-i}**	**Q_{OC-i}**	**P_{OC-i}**	**Q_{OC-i}**	**P_{OC-i}**	**Q_{OC-i}**	**P_{OC-i}**
Domestic Demand	000 t	$/t	000 t	$/t	000 t	$/t	000 t	$/t
C_{OC_AR}	0	$247,293	0	$277,404	0	$276,616	0	$278,270
C_{OC_AU}	418	$256,747	462	$246,855	502	$247,136	441	$246,970
C_{OC_CN}	16	$306,274	9	$324,494	2	$323,289	12	$326,386
C_{OC_EU}	22	$256,807	6	$282,806	-9	$281,556	14	$283,954

Continued . . .

Model PARAMETERS	Base Elasticities t= 0 %		Base Elasticities T= 50%		High BoundElasticities T= 50%		Low Bound Elasticities T=50%	
C_{OC_US}	23	$299,412	8	$326,157	-5	$324,932	15	$327,963
C_{OC_CIS}	1	$258,485	0	$276,331	0	$275,322	1	$277,470
C_{OC_ROW}	9	$255,326	9	$250,394	9	$250,385	9	$250,766
Domestic Supply	000 t	$/t	000 t	$/t	000 t	$/t	000 t	$/t
Q_{oc}	11,152	$256,747	10,937	$246,855	10,943	$247,136	10,940	$246,970

Scenario C: The Impact of the Freight Rate Changesto or from aSpecific Region:

Two different hypothetical situations are examined in this scenario:

i. The impact of the changes to a specific importing regions

ii. The impact of the changes from a specific exporting region

From time to time there is a peak in ocean freight rates to one or from some regions. For instance in the 1990s, Japan was importing lots of raw material due to their increasing industrial productions. This increased the demand for seaborne bulk transportation and consequently increased the freight rates to and from Japan. In the recent years, there has been an increase in bulk services along the routes to and from China. In the first hypothetical situation of this section, it is assumed that there is an increase in the demand for bulk shipment due to increase of demand for another bulk cargo, like increasing demand for iron in China (Pacific Asia).Therefore, we assume the freight rates from other regions to Pacific Asia increase by 50 %. This change of demand is being investigated during the short term before the vessels from other routes can enter the new high demand routes and adjust the prices. Therefore, in a short period the freight rates to Pacific Asia increases, while freight rate in other directions stays the same. Table 4-8 summarize the impact of this change on bulk flow to Pacific Asia. In this analysis, we assumed that the ROW will be the countries with shortest or no seaborne distance to the importing region. With such an increased freight rates, the import price of different regions varies. The Wheat imported from EU region shows the highest price change, followed by AR and CIS. Except the import from US and CN, the wheat originated from all other regions in PA drops down. The total import drops by 14.4% and the use of domestic wheat increases by 4%. Again, this drop varies from region to region and the amount of drop depends on a number of parameters and cannot be only related to the geographical distance.

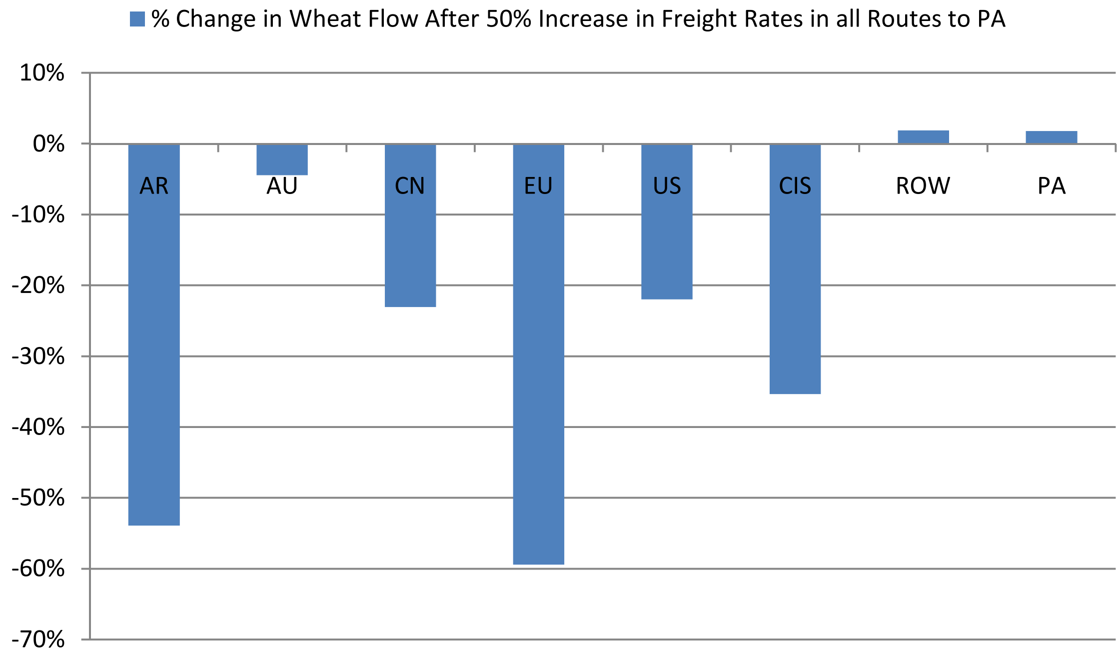


Figure 4-8 Impact of 50% Increase in Freight Rates of the Routes to Pacific Asia in Flow of Wheat to Pacific Asia
Source: Simulation Results

Table 4-8 Impact of a 50%Increase in Freight Rate in all Routes to Pacific Asia on Wheat Import and Price

	Quantity 000t	**Price $/000t**	**% Δ Q**	**% Δ P**
$C_{PA\text{-}AR}$	138	$303,277	-54%	13%
$C_{PA\text{-}AU}$	6,476	$306,379	-4%	5%
$C_{PA\text{-}CN}$	3,203	$317,079	-23%	8%
$C_{PA\text{-}EU}$	9	$318,752	-59%	14%
$C_{PA\text{-}US}$	6,625	$299,332	-22%	8%
$C_{PA\text{-}CIS}$	272	$297,679	-35%	10%
$C_{PA\text{-}ROW}$	3,486	$287,077	2%	4%
$C_{PA\text{-}PA}$	111,792	$293,748	2%	4%

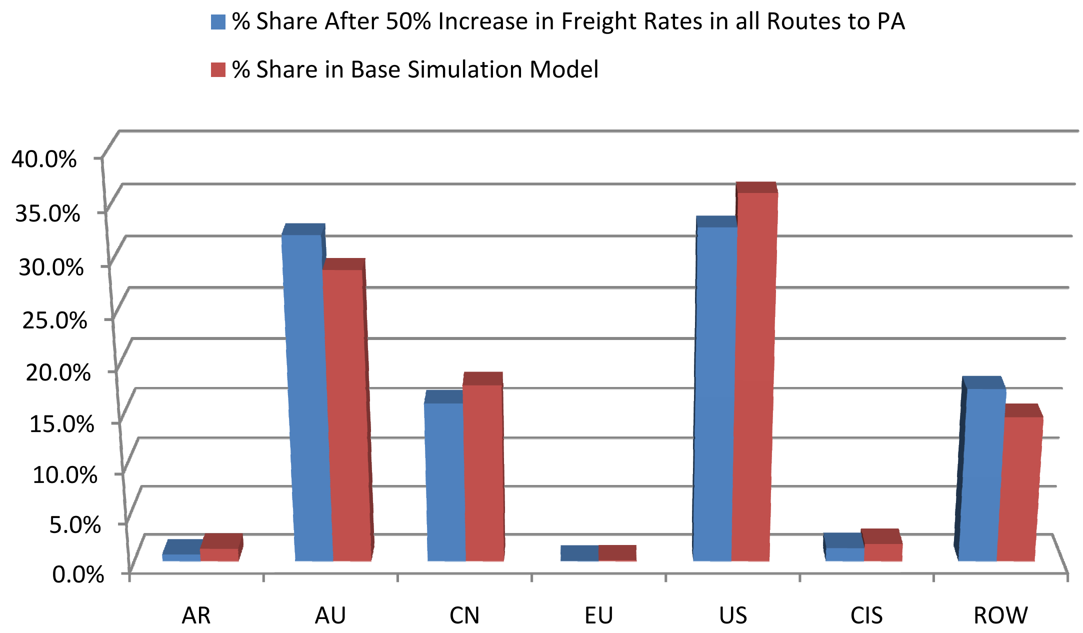


Figure 4- 9 Comparison of the % Share of Wheat from Different Regions to PA before and after 50% Increase in Freight Rates of all Routes to PA Using the Base model Parameters (Sigma=6, Eta=-0.15)
Source: Simulation Results

In the second hypothetical situation, it is assumed that because of the increasing demand for the bulk shipping services from a specific origin, in this example Canada, the freight rates from Canada to different destinations increase. Again we assume that it is short term and entrance of the new vessels to the area cannot affect the peak in freight rates.

As per the result of the simulation, this change in freight rates reduces the total amount of wheat exported from Canada by 5%. It also changes the distribution of wheat exported to different regions. After a 50% increase in freight rates from Canada, Oceania (OC) followed by Pacific Asia (PA) and North Africa (NA) have the most increased prices. The wheat shipped to the Other European Countries (OE), Latin America (LA), Near East (NE), Pacific Asia (PA), North Africa (NA), Sub Saharan Africa (SS), and Oceania OC fall while the amount shipped to

European Union (EU), and United States (US), and the Canadian Domestic consumption increased.

Table 4-9 Impact of a 50% Increase in Freight Rates on Price and Quantity in all Routes from Canada
(Base Model Elasticities : Sigma= 6, Eta=-0.15)

	Quantity 000 t	**Price $/000 t**	**ΔQ%**	**ΔP%**
C_{EU-CN}	2,045	$266,225	5%	-1%
C_{OE-CN}	3	$281,135	-5%	1%
C_{CN-CN}	6,025	$220,475	1%	-7%
C_{US-CN}	3,090	$262,535	8%	-1%
C_{LA-CN}	3,801	$277,325	-2%	0%
C_{NE-CN}	869	$282,736	-6%	1%
C_{PA-CN}	3,403	$305,075	-18%	4%
C_{SA-CN}	2,240	$284,718	-8%	1%
C_{NA-CN}	1,612	$296,225	-14%	3%
C_{SS-CN}	1,232	$275,332	-1%	0%
C_{OC-CN}	11	$322,763	-29%	5%

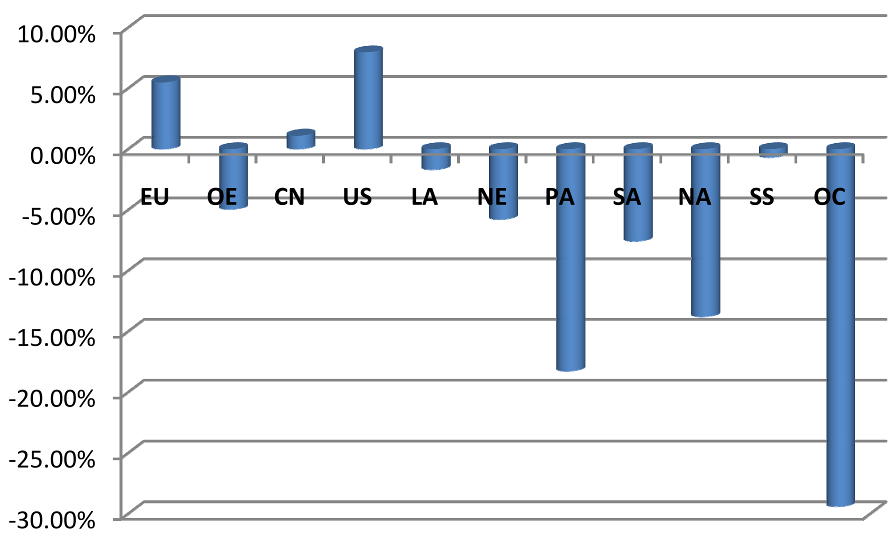


Figure 4- 10 Impact of 50% Increase in Freight Rates of all Routes from Canada on Wheat Export from Canada by Regions

The export to Oceania shows the largest percentage decrease followed by Pacific Asia. However this can be analysed and used further if combined by the role of the importing region in total Canadian wheat market. Figure 4-11 compares the portion of the export share to each region including Canadian domestic consumption from Canadian wheat before and after regional increase in freight rates.

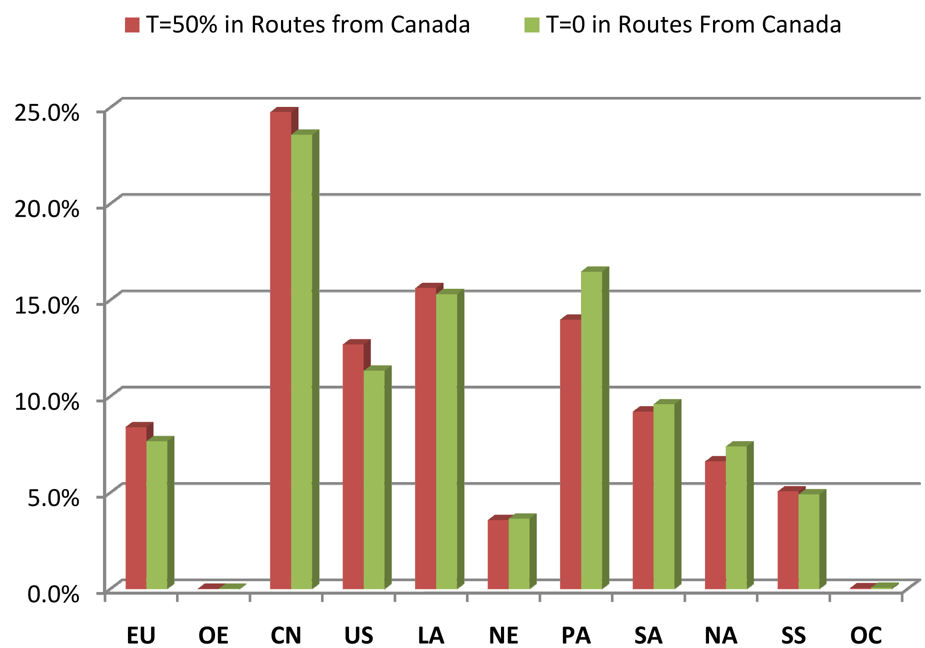


Figure 4- 11 Comparison of the Canadian Wheat Exports to Different Regions before and after 50% Increase in Freight Rates of all Routes from Canada Using the Base model Parameters (Sigma=6, Eta=-0.15)

Source: Simulation Results

Based on the results of the simulation developed in this research, and shown in above diagram, PA is among the big importers of the Canadian wheat, while Oceania is not a significant importer. After a 50% increase in freight rates, Canada has decreased thexport to PA region, while increasing the export to EU, US, and LA.

4.5. Summary

This chapter developed the empirical trade model to simulate the global wheat market. Using Armington framework, it allowed the two way trade and differentiation between different originated wheat. The world was divided into eleven consuming and seven producing regions in a way that while covering all the wheat consuming regions, none of the main players in the wheat market get neglected. A vertical model considering ocean transportation as the major transporting mode was established.

In order to examine the impact of variation in various parameters on the results of this study a sensitivity analysis was carried out. The overall elasticity of demand for wheat, and elasticity of substitution for different types of wheat were changed to a lower bound and an upper bound and the model was re-solved each time to obtain the market clearing solution. As per the results obtained from this analysis, the endogenous variables vary as predicted in the theoretical framework. With decreasing overall elasticity of demand and elasticity of substitution of variety of wheat originated in different regions, the model shows less change in flow of wheat from region to regions, while increasing the elasticities and elasticity of substitution show larger replacements of different type of wheat in different regions. This proves that the results obtained through this model are sensitive to this variation.

The impact of the changes in freight rate on global wheat flow was examined. As per the result in Chapter 3 the sign and direction of the changes on freight rate depends on a series of variables and cannot be predicted. The model should be solved each time for the new set of equilibrium quantities and prices.

Chapter 5 will summarise the overall conclusion, the limitations of this study, and future research possibilities.

CHAPTER 5

SUMMARY AND CONCLUSIONS

5.1. Summary and Conclusions

Ocean transportation is and always has been the dominant method of wheat movement across the world. According to trade literature, historical changes in transportation rates and descending freight rates as a result of technological changes have significantly increased global trade; during the past decade, however, the trend has changed. From 1997 to 2007, the average per-unit ocean freight rate increased along various routes by more than 200%. Despite the increasing transportation costs, trade of all types of wheat has increased from a total of 99 million tons to 110 million tons. This is an approximate 11% increase in wheat exports during the past 10 years, while total wheat production across the world has gone from 610 million tons in 1997 to 597 million tons in 2007, showing a total reduction of -0.02%. Considering the fact that more than 80% of the wheat produced in various regions has been shipped via ocean shipping and the fact that ocean transportation accounts for almost one fifth of the average wheat price in some places, the question is whether the changes in ocean freight rates have affected wheat flow globally, and, if so, how.

To answer the above question, this study realizes the need for a model that is appropriate for illustrating the wheat global trade model considering the vertical connections of the supply chain in a way that also values and entails the spatial characteristic of the global trade model, as well as the product differentiation, and allows for two-way trades. Moreover, such a model needs to be general enough to consider all producing and consuming regions and their interactions and reactions caused by shocks to ocean transportation costs. Familiarization with the ocean transportation market, the intermediate production level, and the wheat market and players was necessary. Chapter 2 of this thesis summarized the main characteristics, ongoing changes, and market structure of the ocean freight market and concluded that bulk movement is the main mode of ocean transportation. The results of this chapter indicate that although bulk shipping seems the most economical way of transporting such a bulky product like wheat across the globe, wheat movers also have the option of using containerized carriers. However despite of the recent trend toward more specialized services and containerized shipment, bulk movement is still the dominant ocean shipping method. Regardless of the type of services being chosen, grain movers are price takers in the ocean transportation market. These findings became the main structural assumptions from which to build a vertical trade model in the rest of this thesis. The model was based on using bulk carriers, the freight rates were assumed to be exogenous, and service users were assumed to be price takers.

Spatial trade models were reviewed in Chapter 3 and the Armington framework was selected as the appropriate framework as it can accommodate the spatial characteristics of this model, the heterogeneity of wheat originating from different regions, and two-way trade. One of the main findings of this chapter was that in such a model the changes in the price of wheat originating from region i in region j is a function of a variety of factors. These include all the own price effects and cross price effects of wheat originating from different regions; therefore, to determine the magnitude of the change and the sign and direction of it is impossible unless solving the market clearing condition for all the markets.

In Chapter 4, a global simulation model for wheat trade was constructed based on the Armington framework described in Chapter 3, with the intention of investigating the impact of changes in the freight rate on the world wheat market. The global wheat-consuming countries were divided into eleven main regions according to geographic distances and availability of data: European Union, other European countries, Canada, United States, Latin America, Near East Asia, Pacific Asia, South Asia, North Africa, Sub Saharan Africa, and Oceania. The producing regions were divided into six major regions: Argentina, Australia, Canada, European Union, United States, and CIS region. The rest of the world's exports fell under the category entitled "Rest of the World (ROW)." The ROW exporting region to each consuming region was assumed to be a different region due to the different average wheat price and distances. The price and freight rates associated with each of the ROW countries were calculated based on the weighted average price of wheat and the freight rates to each specific consuming region. However, due to the small fraction of wheat exported from ROW countries, a more simplified model with unified ROW will not impact the outcome of the model in a drastic way. To maintain the consistency in the model, the data set was used from one source. All of the initial base quantities, prices, and available freight rates were borrowed from the World Grain Statistics, International Grain Council 2008. The year 2006-2007 was selected as the base year and all further calculations were based on the base year prices and quantities. If the freight rate along a specific route was not available through this source, it was calculated based on the geographic distance between the ports and relative prices along other routes. This model treated wheat prices and ocean freight rates as exogenous variables.

The elasticities to build the demand and supply parameters were borrowed from the available wheat trade model literature and the market clearing conditions were determined by incorporating freight rates into the exporting region (Free On Board) FOB prices.

Several scenarios were examined to verify the functionality, validation of the model, and the impact of the freight rate on wheat flow across the world. The first scenarios included a 10%, 50% and 100% increase in freight rates with demand elasticity of -0.15 and elasticity of substitution equal to 6 (base model elasticities), which captured the changes in flow of wheat to and from different regions. After a 50% increase in freight rates of all routes, the export from Canada, Australia, and Rest of the world to Sub Saharan Africa increased, but the export to most of the regions decreased. The model is a tool to compare the price and quantity changes and compare the comparative advantages and disadvantages that are created by changes in wedges due to freight rate fluctuation. For instance, based on the model, Canada has the opportunity to export more to Near East Asia and Sub Saharan Africa. The major exporters to this region are CIS region, United States, followed by Canada and Australia. After this change in freight rates all other regions have decreased the export to NE except Canada. The result implied that shorter geographical distances and lower freight rates do not necessarily result in increasing export to the regions with lower per unit freight rates. This is why before any decision making, it is reasonable to adopt such a tool that is capable of measuring the reactions to price changes that are associated with freight rates considering different demand and supply parameters.

Another result from this section showed that regional wheat prices changes varied from -2.5% to 30.2%. Although this decrease in price is mainly associated with region supply price, but in some occasions it is associated with adjusting the FOB (Free on Board) price, it means that despite of the increase in freight rates, some regions were forced to reduce the premium price to stay in business (e.g. after a 50% increase in freight rates in base model, the price of Canadian wheat in United States dropped by -1.4%). It also showed that low premium prices did not necessarily contributed to maintain or increase the market share associated with each exporting region. For instance, although the price of wheat produced in European Union and Argentina initially were lower than the price of some other regions like Canada, the results showed an export share loss after increasing freight rates for them in some regions. In some regions, the percentage of this loss was even larger than regions with more expensive premium prices like Canada. It may be due to varying preferences and a low sensitivity on the part of the consuming region toward the price of wheat from certain origins.

The overall increase in freight rates showed changes in trade patterns, and the magnitude of these changes varied from region to region. The tool developed based on Armington model in this thesis is capable of capturing the fluctuations, measuring changes and the competitive advantages that are created because of the freight rate changes.

Sensitivity analysis was carried out to examine the robustness of the model in terms of the borrowed elasticity parameters from the literature. The results confirmed that the simulation results were robust in terms of demand own price elasticity and elasticity of substitution. As the elasticity and elasticity of substitution increased, the model showed less sensitivity to freight rate changes and vice versa.

In the last scenario, regional shocks were examined. First the freight rates to a specific destination were increased. Pacific Asia was the selected region. A 50% increase in freight rates of the route to PA intensified the wedges between the FOB prices and import price of the wheat from Argentina and CIS. But the import price of Canada and United states showed the smaller change (8%) and therefore the wheat imported from these two regions to PA increased. The result indicated that Australia, originally the largest market share holder in this region, had to decrease the amount of wheat exported to this region.

The second hypothetical situation examined the increase in freight rates from a specific region. The freight rate from Canada to all destinations was increased by 50%. This resulted in a redistribution of the wheat exported from Canada to all the other regions. The export to Oceania showed the largest percentage decrease followed by Pacific Asia. Based on the results of the simulation developed in this research, and shown in above diagram, after a 50% increase in freight rates, Canada has decreased the export to PA region, while increasing the export to EU, US, and LA.

The model in this research was developed and used to verify the impact of changes in freight rates under described scenarios. As per explained in Chapter 4 and implied here these freight rate fluctuations may be an overall change along all routes or a change along a specific route. The major implication of this study is to use the developed model as a tool to be used for wheat exporter and importers to measure the price changes that are associated with the changes in freight rates. As explained earlier, even if there is a change in the freight rate of a specific route, it affects all of the players and the flow of wheat along different routes across the world. Although the change may be minor, the model has the capacity of reflecting that impact. The market clearing condition solve for each scenario indicates that after each shock in freight market, the prices adjust such that the markets clears again and new quantities that are the outcome of the new solutions, reflect these changes. However it should be considered that wheat is a major product used in all regions of the world, and not all regions have the opportunity to produce the quality and quantity of wheat demanded in the region. The sensitivity toward transportation costs is only one of the causes of the price and quantity changes. Also one should note that all generally all dominant wheat exporters in the world are scattered across the globe. Therefore, regardless of the magnitude of the change in freight rates, the consumer region has no choice but to adapt or revise its strategic planning in regard to long run changes.

5.2. Study Limitations

This study developed a Market Simulation Model of the global wheat market and established a vertical link between wheat in consumer and producer ports, and considered wheat from different origins differentiated products. However, due to the large number of variables and the need to simplify, all wheat types produced in a specific region were aggregated under one category. This simplification helped to reduce the number of parameters and variables, and did not harm the study. However, the model has the capacity to expand and consider this type of differentiation. The other problem arising from the same aggregation was in deciding the prices of different types of wheat. A weighted average of the prices of different types of milling wheat was used in regions in which data was available.

Another limitation of the study was in using base year prices and quantities and borrowed elasticities from the literature to estimate the intercepts and coefficients. The calculated intercepts and coefficients were highly dependent on base year data and elasticity assumptions. However, a sensitivity analysis was carried out to address this issue. Using fixed elasticities of demand and supply was other limitation of this study, which mostly used the estimations suggested by Alston et al. (1990). However, the sensitivity analysis carried out later showed that the results were robust to the elasticities and variations in these elasticities did not result in drastic changes in the endogenous variables.

Another limitation of this study was in the availability of freight rates along all routes, and the availability of two or more routes to some destinations. To stay consistent, if there were two routes and therefore different freight rates available from an origin to a destination, the route with the lower freight rate was used in the model. This eliminated the risk of choosing one route over the other by this model. This was left as a suggestion for further studies. In addition, there were no data available for some routes and the author had to do some calculations and make judgments based on the prices of other routes to get estimations that closely approximated reality.

5.3. Need for Further Research

The model developed in this thesis served as a preliminary model to capture the impact of freight rates on wheat flow. Some major assumptions were made to build the model and the relaxation of some of those assumptions would open up new research options that would benefit stakeholders in the wheat and grain industries through maintaining their market shares and minimizing their transportation costs.

There has been an increase in wheat prices and freight rates during the past few years, and also an increase in demand for wheat. This study has displayed the basics for developing a tool that measures the changes that arise from freight rate fluctuations. However, to come up with a more applicable tool, a model that calculates the willingness to pay in each region may help to improve the applicability of this model.

As mentioned in the limitations of the study, the model did not incorporate different route selections. Developing this work with more powerful software would help to increase the number of variables. In addition, the increasing popularity of containerized services, and associated economic and logistical ramifications, cannot be fully evaluated with the numerous simplifying assumptions employed in this research. Future research that incorporates different shipping options, and considers port facilities, product differentiation, and consumer preferences, is a primary recommendation following from the results of this thesis.

The wheat reallocation and simulation model developed in this thesis has significant potential to be further developed for related studies that focus on wheat and grain transportation.

One of the major assumptions in constructing the market clearing conditions of this thesis is the assumption of perfect competition on the wheat exporter side. This is a simplifying assumption, but further investigation is warranted through setting one by one market clearing condition and bringing the market power of some of the wheat producers like CWB to the table with more powerful data analysis software.

This study looked into annual data sets. Developing a month-to-month or seasonal model for wheat flow with different port options may be of interest to stakeholders.

REFRENCES

Alaouze, C. M., A. S. Watson, H. N. Sturgess (1978). An Oligopoly Pricing in the World Wheat Market. *American Journal of Agricultural Economics, 60*, 173-85.

Alston, J. M., C. A. Carter, R. Gray, D. A. Sumner (1997).Third-Country Effects and Second-Best Grain Trade Policies: Export Subsidies and Bilateral Liberalization. *American Journal of Agricultural Economics,* 79, 1300-10.

Alston, J. M., C. A. Carter, R. Green, D. Pick (1990).Whither Armington Trade Models*.* *American Journal of Agriculture Economics, 72, 455-67.*

Alston, J. M., R. S. Gray, et al. (1999).The Wheat War of 1994: Reply. *Canadian Journal of Agricultural Economics,* 47, 99-104.

Armington, P. S. (1969). A Theory of Demand for Products Distinguished by Place of Production. *International Monetary Fund Staff Papers,* 159-78.

Babula, R. A. (1987). An Armington Model of U.S. Cotton Exports*. Journal of Agricultural Economics,* 39, 12-22.

Baughman, L. (2004). Shrimp Antidumping Petition Would Jack Up Prices to Shrimp-Consuming Industries. Trade Partnership report Retrieved September, 2004, from *http://www.citac.info/shrimp/new_releases/ShrimpPrices_6_10_04.pdf.*

Baumol, W. J. (1961). What Can Economic Theory Contribute to Managerial Economics*? American Economic Review,* 51, 142-146.

Baylis, K. (1998). The Economics of Grain Handling and Transportation under Deregulation. *Department of Agricultural Economics*. Saskatoon, Saskatchewan. M.Sc.

Bennathan, E. and A. A. Walters (1969).*The economics of ocean freight rates*, Praeger.

Blandford, D. (1988). Market Share Models and the Elasticity of Demand for U.S. Agricultural Exports. *Elasticities in International Agricultural Trade*. C. A. Carter and W. H. Gardiner. Boulder, Colo, Westview Press.

Blejer, M.I. and A.L. Hillman (1982). A Proposition on Short-Run Departures from the Law-of-one-price. *European Economic Review*17, 51-60.

Canadian Wheat Board (2010), Grain Trade Forecast 2011-12, from: *http://www.cwb.ca/public/en/farmers/forecasts/pdf/long-term_forcast-2011-12.pdf.*

Bon, R. (1984). Comparative stability analysis of multiregional input-output models, column, row, and Leontief-Strout gravity coefficient models. *The Quarterly journal of Economics,* 4, 212-235.

Carlton, D.W. and J. M. Perloff (2004). *Modern Industrial Organization*, Addison Wesley.

Celik, H. M. (2004). Modeling freight distribution using artificial neural networks. *Journal of Transport Geography,* 2, 141-148.

Celik, H. M. a. J. M. Guldmann. (2002). Spatial interaction modeling of interregional commodity flows. *European Congress of the Regional Science Association*. Dortmund, Germany.

Chami Batista, J. and N. I. A. Junior (2005). Aggregation Problems in Estimates of Armington Elasticities and Pass-Through Effects. *Economia,* 6, 329-355.

Clyde, P. S. and J. D. Reitzes (1995). The Effectiveness of Collusion under Antitrust Immunity, the Case of Liner Shipping Conferences. *Bureau of Economics Staff Report.* Washington, DC, Federal Trade Commission**,** 1-56.

Clyde, P. S. and J. D. Reitzes (1998). Market Power and Collusion in the Ocean Shipping Industry: Is a Bigger Cartel a Better Cartel? *Economic Inquiry,* 36, 292-304.

Corden, W. M. (1984). The Normative Theory of International. *Trade Handbook of International Economics.* P. B. Kenen and R. W. Jones. Amsterdam, North Holland.

International Grain Council (2003-2009). *World Grain Statistics Handbook*. London.

Cox, T. L., J. R. Coleman, J.P Chavas, and Y. Zhu (1999). An Economic Analysis of the Effects on the World Dairy Sector of Extending Uruguay Round Agreement to 2005. *Canadian Journal of Agricultural Economics* 47, 169-184.

Csaki, C. (1985). *Simulation and System Analysis in Agriculture*. New York. USA.

Davis, G. C., N. C. Kruse (1993). Consistent Estimation of Armington Demand Models. *American Journal of Agricultural Economics*75 (3), 719-723.

Dick, A. R. (1996). When Are Cartels Stable Contracts? *Journal of Law and Economics, 39*, 241-283.

Dixit, A. (1983). International Trade Policy for Oligopolistic Industries. *The Economic Journal,* 94, 1-16.

Dougherty, M. S. (1995). A Review of Neural Networks Applied to Transport. *Transportation Research Part C: Emerging Technologies,* 3(4), 247-260.

Enke, S. (1951). Equilibrium among Spatially Separated Markets: Solution by Electric Analogue. *Econometrica,* 19**,** 40-47.

Fayle, C. E. (1933). *A Short History of the World's Shipping Industry*. New York, Dial Press.

Fox, K. A. (1953). A Spatial Equilibrium Model of the Livestock-Feed Economy in the United States. *Econometrica,* 21, 547-566.

Fox, N. R. (1992). An Empirical Analysis of Ocean Liner Shipping. *International Journal of Transport Economics,* 19, 205-225.

Fox, N. R. (1994). An Oligopoly Model of Ocean Liner Service. *Review of Industrial Organization,* 9, 343-355.

Fox, N. R. (1995). Some Effects of the U.S. Shipping Act of 1984 on Ocean Liner Shipping Conferences. *Journal of Maritime Law and Commerce,* 26, 531-544.

Frankel, J. A., S. J. Wei (1998).*The Role of History in Bilateral Trade Flow*, *The Regionalization of the World Economy.* Chicago, The University of Chicago press.

Fujita, M., P. Krugman, A. J. Venables (1999). *The Spatial Economy: Cities, Regions, and International Trade*, MIT Press.

Gregory, K. V. (2000). Economies of Scale in International Liner Shipping and Ongoing Industry Consolidation: An Application of Stigler's Survivorship Principle. *Department of Economics.* Virginia, Virginia Polytechnic Institute and State University, M.A.

Grennes, T., P. R. Johnson, M. Thursby (1978). *The Economics of World Grain Trade*.New York, Praeger Publishers.

Clarkson Research group, C. R. (2004). The Tramp Shipping Market., Clarkson Research Studies.*URL: http://www.pfri.uniri.hr/~bopri/documents/Unit26-TRAMPSHIPPINGMARKET_000.pdf*

Guldmann, J. M. (1999). Competing Destinations and Intervening Opportunities Interaction Models of Inter-City Telecommunication Flows. *Regional Science, 78*, 179-194.

Haigh, M. S., H. L. Bryant (2001).The Effect of Barge and Ocean Freight Price Volatility in International Grain Markets. *Agricultural Economics, 25*, 41-59.

Harley, C. K., D. N. McCloskey (1971). The Shift from Sailing Ships to Steamships, 1850-1890: A Study in Technological Change and its Diffusion. *Essays on a Mature Economy: Britain after 1840.* Princeton, Princeton University Press.

Heads, J. (1994).The international competitiveness of Western Canadian Transportation. *A report for Western Economic Diversification Canada*. Winnipeg.

Helpman, E. (1984). Increasing Returns, Imperfect Markets, and Trade Theory. *Handbook of International Economics.*R. W. Jones and R. B.Kenen.Amsterdam, North Holland.

Herman, A. (1983). *Shipping conferences*. Boston, Kluwer Law and Taxation Publishers.

Hotelling, H. (1929). Stability in competition. *The Economic Journal*, 13, 41-57.

Hummels, D. (2007). Transportation Costs and International Trade in the Second Era of Globalization. *Journal of Economic Perspective* 21(3), 131-154.

Isard, P. (1977). How Far Can We Push the Law-of-one-price? *American Economic Review* 67, 942-948.

Israd, W. (1951). Inter Regional and Regional Input-Output Analysis, a Model of Space Commodity. *The Review of Economics and Statistics,* 33, 157-169.

Jonnala, S., Fuller, S. and Bessler, D. (2002). A GARCH Approach to Modeling Ocean Grain Freight Rates. *International Journal of Maritime Economics* 4, 103-125.

Koo, W. W. (1987). A Role of Transportation Costs in Agricultural Product Trade. *Journal of the Transportation Research Forum* 28, 132-139.

Kosior, J. (2002). Containerization of Grain: An emerging Trend or Wishful Thinking? *7th Annual Fields on Wheels Conference*. Transport Institute, University of Manitoba.

Krugman, P. (1980). Scale Economies, Product Differentiation, and the Pattern of Trade. *American Economic Review,* 70 (5), 950-959.

Lancaster, K. (1966). A New Approach to Consumer Theory. *Journal of Political Economy, 74*(2), 132.

Lancaster, K. (1979). *Variety, Equity, and Efficiency*. New York, Columbia University Press.

Laure, B. (1991). Is Wheat a Homogeneous Product? *Canadian Journal of Agricultural Economics,* 39, 103-117.

Letwin, W. (1965). *Law and Economic Policy in America: The Evolution of the Sherman Antitrust Act.* Chicago, University of Chicago Press.

Lewis, I., D. B. Vellenga (2000). The Ocean Shipping Reform Act of 1998. *Transportation Journal, 39*: 27-34.

Lloyd, P. J., X. G. Zhang (2006). The Armington Model. *Productivity Commission Staff Working Paper.* Melbourne, Commonwealth of Australia.

Marshall, A. (1921). *Industry and Trade: A Study of Industrial Technique and Business Organization,* London: Macmillan.

Marx, D. (1953). *International Shipping Cartels: A Study of Industrial Self-regulation by Shipping Conferences*. Princeton, Princeton University Press.

McCalla, A. F. (1966). A Duopoly Model of World Wheat Pricing. *American Journal of Agricultural Economics* 48, 711-727.

McGee, J. S. (1960). Ocean Freight Conferences and American Merchant Marine. *University of Chicago Law Review*, 27, 191-314.

McGee, J. S. (1960). Ocean Freight Rate Conferences and the American Merchant Marine. *The University of Chicago Law Review,* 27, 191-314.

McNulty, P. J. (1968). Economic Theory and the Meaning of Competition. *Quarterly Journal of Economics*, 82(4), 639-656.

OECD (2001). Regulatory Issues in International Maritime Transport. Paris, Organization for Economic Co-operation and Development.

OECD (2002). Competition Policy in Liner Shipping. Paris, Organization for Economic Co-operation and Development.

Park, J. J., W.W. Koo (2004). An Econometric Analysis of Ocean Freight Rates for Grain Shipments from the United States to Major Importing Countries. *Journal of the Transportation Research Forum, 43*(2).

Podolny, J. M., S. Morton (1999). Social Status, Entry and Predation: The Case of British Shipping Cartels 1879-1929. *Journal of Industrial Economics,* 47, 41-67.

Prentice, B. E. (1998). Re-Engineering Grain Logistics: Bulk Handling versus Containerization. *40th Annual Transportation Research Forum Meeting Proceedings,* 1, 339-352.

Reichert, H. and K. Vachal (2003). Identity Preserved Grain – Logistical Overview. *Product Differentiation and Market Segmentation in Grains and Oilseeds: Implications for Industry in Transition*. Washington.

Reitzes, J. D., K. L. Sheran (2002). Rolling Seas in Liner Shipping. *Review of Industrial Organization, 20: 51-59*.

Rodrigue, J. P., C. Comtois, B. Slack (2009). *The Geography of Transport System.* The Routltgde.

Samuelson, P. A. (1952). Spatial Price Equilibrium and Linear Programming. *American Economic Review*, 42, 283-303.

Schmalensee, R. (1992). Sunk Cost and Market Structure: A Review Article. Journal of Industrial Economics, 40, 125-134.

Shneerson, D. (1976). The Structure of Liner Freight Rates. *Journal of Transport Economics and Policy* 10 (1), 52-67.

Shy, O. (1996). *Industrial Organization Theory and Applications*, MIT Press.

Sjostrom, W. (1989). Collusion in Ocean Shipping: A Test of Monopoly and Empty Core Models. *The Journal of Political Economy,* 97(5), 1160-1179.

Sjostrom, W. (2004). Ocean Shipping Cartels: A Survey. *Review of Network Economics,* 3(2), 107-134.

Srivastava, R. K. (1997). A Vertical Trade Model of the International Pork Industry. *Agriculture Economics*. Saskatoon, Saskatchewan. PhD Thesis.

Stigler, G. J. (1983). *The Organization of Industry*. Chicago and London, University Of Chicago Press.

Stopford, M. (1997).*Maritime Economics*. London, Routledge.

Sumner, D., R. Boltuck (2001). *Anatomy of the Global Wheat Market and the Role of the Canadian Wheat Board*. Winnipeg, Canadian Wheat Board.

Sumner, D. A., J. M. Alston, et al. (1994).*A Quantities Analysis of the Effects of Wheat Imports on the U.S. Market for Wheat Including the Impact on Deficiency Payments*. Winnipeg, Canadian Wheat Board.

Sussman, J. (2000). *Introduction to Transportation System*. Artech House Publishers.

Takayama, T., G. G. Judge (1971). *Spatial and Temporal Price Allocation Models.* Amsterdam, North Holland.

TEFO. International Trade Finance Terms .*Trade & Export Finance Online Retrieved* July 2011, from *http://tefo.com/trade-finance-glossary/o.html*.

Vachal, K. , H. Reichert. (2000). Identity Preserved Grain. *Logistic Overview,* Retrieved January 2006, from http://www.ugpti.org/pubs/pdf/SP143.pdf.

Vercammen, J. (1996). An Overview of Changes in Western Grain Transportation Policy. *Canadian Journal of Agricultural Economics* 44, 397-402.

Vocke, G, O. Liefert (2011). Wheat Outlook. *United States Department of Agriculture* Retrieved July 2011, from http://usda.mannlib.cornell.edu/usda/ers/WHS/2010s/2011/WHS-07-14-2011.pdf

Wilson, W. W. and K. L. Casavant (1991). Some Market Power Implications of the Shipping Act of 1984: A Case Study of the U.S. to Pacific Rim Transportation Markets. *Western Journal of Agricultural Economics, 16* (2): 427-434.

Wilson, W. W., W. W. Koo, A. Carter (1990). Importer Loyalty in the International Wheat Market."*Journal of Agricultural Economics* 41 (1), 94-102.

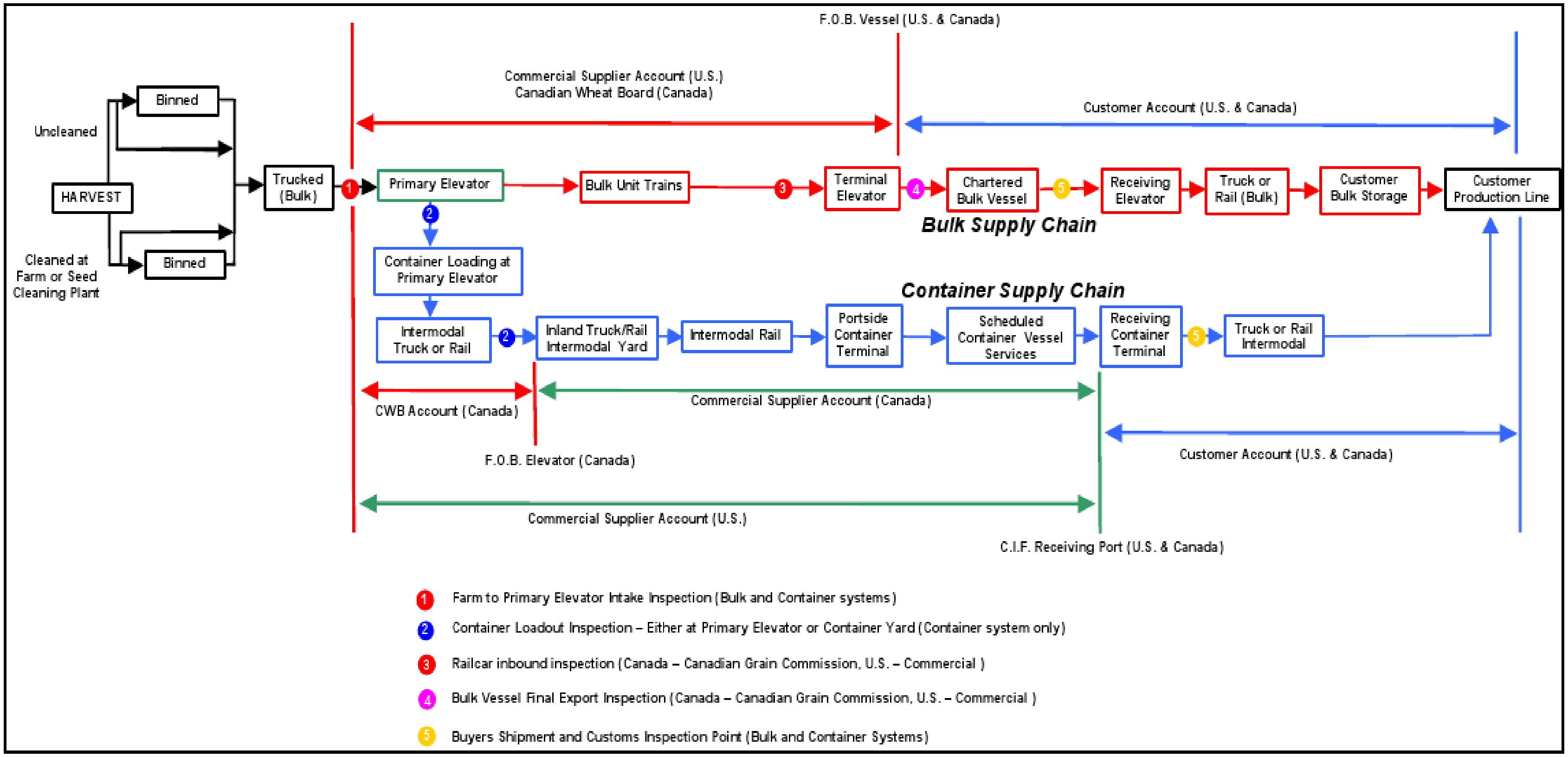
Wilson, W. W. K., Won W. Taylor, Richard D., B. L. Dahl (2005). Fundamental Factors Affecting World Grain Trade in the Next Two Decades. *Agribusiness & Applied Economics Report*. North Dakota, North Dakota State University.

Winston, C. (1981). A Multinomial Probit Prediction of the Demand for Domestic Ocean Container Service. *Journal of Transport Economics and Policy,* 15(5), 243-252.

Yamey, B. S. (1972). Predatory Price Cutting: Notes and Comments. *Journal of Law and Economics,* 15, 129-42.

Zimmer, Y.. (2006). *Agri Benchmark Cash Crop Report.* Braunschweig.

APPENDIX A- Logistics Flow map: Bulk vs. Container from Primary Elevator to Customer Plant



Source: Kosior 2002, 7th Annual Fields on Wheels Conference, URL last accessed on July 2011: http://umanitoba.ca/faculties/management/ti/media/docs/7th_annual_FOW_02.pdf

APPENDIX B- Empirical Model Simulations

Table A-1 Equilibrium Quantity Demanded, Supplied, and Prices for all Regions under the Base Assumptions for 10%, 50%, and 100% Increase in Freight Rates

ELASTICITY OF SUBSTITUTION	**6**		**6**		**6**	
DEMAND ELASTICITY	**-0.15**		**-0.15**		**-0.15**	
SUPPLY ELASTICITY	**0.5**		**0.5**		**0.5**	
%Freight Rate Increase	**10%**		**50%**		**100%**	
EU Markets	**Quantities**	**PEUi**	**Quantities**	**PEUi**	**Quantities**	**PEUi**
Domestic demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{EU_AR}	12.14	$238,116.76	5	$256,775	0	$280,099
C_{EU_AU}	146.63	$319,016.38	93	$334,539	26	$353,942
C_{EU_CN}	1919.88	$268,491.39	1,847	$268,127	1,756	$267,671
C_{EU_EU}	112,567.97	$197,820.26	113,746	$195,426	115,218	$192,434
C_{EU_US}	623.19	$255,048.61	540	$258,488	436	$262,787
C_{EU_CIS}	1966.98	$246,566.34	1,407	$255,350	706	$266,331
C_{EU_ROW}	387.57	$199,738.18	386	$197,849	383	$195,487
	Quantities	Pcd	Quantities	Pcd	Quantities	Pcd
Supply	**000 t**	$/000t	**000 t**	**$/000t**	**000 t**	**$/000t**
Q_{EU}	124,906.89	197,820.26	124,152	$195,426	123,209	$192,434
OE Market	**Quantities**	POEi	**Quantities**	**POEi**	**Quantities**	**POEi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{OE_AR}	0.84	$246,731.15	0	$268,522	0	$295,761
C_{OE_AU}	0.00	$304,822.98	0	$315,184	0	$328,135
C_{OE_CN}	2.88	$279,425.39	2	$283,037	2	$287,551
C_{OE_EU}	684.25	$232,327.26	417	$242,481	84	$255,174
C_{OE_US}	43.98	$267,148.61	32	$274,988	17	$284,787
C_{OE_CIS}	73859.55	$212,059.34	74,350	$208,295	74,962	$203,591

Continued….

C_{OE_ROW}	58.89	$212,389.15	58	$209,132	58	$205,061
	Quantities	Pus	Quantities	Pus	Quantities	Pus
Supply	**000 t**	$/000t	**000 t**	**$/000t**	**000 t**	**$/000t**
Q_{OE}	89,711.47	$212,059.34	88,917	$208,295	87,924	$203,591
CA Market	**Quantities**	PEUi	**Quantities**	**PEUi**	**Quantities**	**PEUi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{CA_AR}	0.00	$229,624.76	0	$245,195	0	$264,659
C_{CA_AU}	0.00	$329,799.89	0	$349,243	0	$373,548
C_{CA_CN}	5970.79	$234,941.39	6,018	$222,377	6,077	$206,671
C_{CA_EU}	0.00	$231,370.26	0	$241,176	0	$253,434
C_{CA_US}	0.00	$250,483.61	0	$252,263	0	$254,487
C_{CA_CIS}	0.00	$256,543.34	0	$268,955	0	$284,471
C_{CA_ROW}	0.00	$238,083.00	0	$238,083	0	$238,083
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{CA}	25,098.31	$234,941.39	24,432	$222,377	23,598	$206,671
US Market	**Quantities**	POEi	**Quantities**	**POEi**	**Quantities**	**POEi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{US_AR}	19.81	$218,778.76	7	$230,405	0	$244,939
C_{US_AU}	0.00	$331,741.72	0	$351,891	0	$377,079
C_{US_CN}	2749.02	$265,785.39	2,298	$264,437	1,733	$262,751
C_{US_EU}	3.51	$233,229.26	2	$243,711	0	$256,814
C_{US_US}	24842.24	$219,639.61	25,570	$210,203	26,479	$198,407
C_{US_CIS}	14.82	$259,568.34	6	$273,080	0	$289,971
C_{US_ROW}	98.35	$223,573.53	97	$215,880	95	$206,264
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{US}	49,053.83	$219,639.61	48,006	$210,203	46,695	$198,407
LA Market	**Quantities**	PLAi	**Quantities**	**PLAi**	**Quantities**	**PLAi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{LA_AR}	20193.25	$187,934.76	20,690	$188,345	21,312	$188,859
C_{LA_AU}	0.95	$308,332.96	1	$319,970	0	$334,517
C_{LA_CN}	3837.34	$276,631.39	3,719	$279,227	3,571	$282,471

Continued….

C_{LA_EU}	317.51	$248,002.26	192	$263,856	34	$283,674
C_{LA_US}	6733.99	$250,483.61	6,638	$252,263	6,518	$254,487
C_{LA_CIS}	110.71	$270,855.74	66	$288,472	9	$310,493
C_{LA_ROW}	664.53	$209,020.71	666	$210,116	668	$211,484
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{LA}	22,641	$187,935	22,628.03	$187,717.32	22,631.50	$187,774.94
NE Market	**Quantities**	PAUi	**Quantities**	**PAUi**	**Quantities**	**PAUi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{NE_AR}	372	243,976	235	$264,765	64	$290,751
C_{NE_AU}	1,192	303,024	1,136	$312,731	1,067	$324,865
C_{NE_CN}	939	280,599	1,006	$284,638	1,089	$289,685
C_{NE_EU}	1,150	249,947	877	$266,509	537	$287,211
C_{NE_US}	1,873	270,252	1,807	$279,219	1,724	$290,429
C_{NE_CIS}	3,939	253,854	3,549	$265,289	3,063	$279,582
C_{NE_ROW}	1,805	225,915	1,832	$232,744	1,867	$241,280
C_{NE_NE}	42,730	226,870	43,376	$233,701	44,183	$242,241
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{NE}	42,730	$226,870	43,376	$233,701	44,183	$242,241
PA Market	**Quantities**	PPAi	**Quantities**	**PPAi**	**Quantities**	**PPAi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{PA_AR}	256	$276,034	80	$308,481	0	$349,040
C_{PA_AU}	6,766	$294,576	6,712	$301,211	6,645	$309,505
C_{PA_CN}	4,083	$296,981	3,766	$306,977	3,368	$319,471
C_{PA_EU}	19	$287,308	8	$317,455	0	$355,139
C_{PA_US}	8,187	$281,097	6,965	$294,008	5,438	$310,147
C_{PA_CIS}	391	$275,265	270	$294,485	118	$318,511
C_{PA_ROW}	3,431	$278,107	3,467	$283,874	3,511	$291,084
C_{PA_PA}	110,095	$284,986	111,189	$290,636	112,557	$297,700
	Quantities	Prd	Quantities	Prd	Quantities	Prd

Continued….

Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{PA}	110,095	$284,986	111,189	$290,636	112,557	$297,700
SA Market	**Quantities**	PSAi	**Quantities**	**PSAi**	**Quantities**	**PSAi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{SA_AR}	146	$253,224	67	$277,376	0	$307,566
C_{SA_AU}	1,543	$301,748	1,395	$310,991	1,209	$322,545
C_{SA_CN}	2,424	$282,053	2,423	$286,619	2,423	$292,328
C_{SA_EU}	1,041	$251,973	693	$269,271	258	$290,894
C_{SA_US}	289	$282,846	231	$296,393	157	$313,327
C_{SA_CIS}	4,039	$253,369	3,364	$264,626	2,521	$278,698
C_{SA_ROW}	567	$240,961	572	$245,169	578	$250,430
C_{SA_SA}	97,539	$239,764	98,379	$243,882	99,428	$249,029
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{SA}	97,539	$239,764	98,379	$243,882	99,428	$249,029
NA Market	**Quantities**	**PNAi**	**Quantities**	**NAi**	**Quantities**	**PNAi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{NA_AR}	114	$238,264	73	$256,880	22	$280,149
C_{NA_AU}	277	$303,862	254	$313,800	224	$326,222
C_{NA_CN}	1,853	$290,457	1,785	$297,957	1,701	$307,331
C_{NA_EU}	5,742	$229,844	5,225	$238,948	4,579	$250,328
C_{NA_US}	2,805	$271,328	2,584	$280,568	2,306	$292,117
C_{NA_CIS}	4,422	$224,792	4,998	$225,518	5,717	$226,426
C_{NA_ROW}	937	$236,488	947	$241,812	960	$248,467
C_{NA_NA}	19,049	$241,094	19,260	$246,414	19,523	$253,063
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
	19,049	$241,094	19,260	$246,414	19,523	$253,063
SS Market	**Quantities**	**PSSi**	**Quantities**	**PSSi**	**Quantities**	**PSSi**

Continued….

Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{SS_AR}	1,527	**$217,555**	1,506	$228,736	1,480	$242,713
C_{SS_AU}	756	**$283,276**	882	$285,802	1,039	$288,959
C_{SS_CN}	1,300	**$275,170**	1,534	$277,233	1,826	$279,813
C_{SS_EU}	3,344	**$248,486**	2,891	$264,516	2,325	$284,554
C_{SS_US}	3,627	**$276,279**	3,590	$287,438	3,543	$301,387
C_{SS_CIS}	954	**$266,212**	836	$282,140	689	$302,051
C_{SS_ROW}	441	**$248,706**	450	$258,579	461	$270,920
C_{SS_SS}	5,254	$245,972	5,360	$255,844	5,493	$268,184
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{SS}	5,254	**$245,972**	5,360	$255,844	5,493	$268,184
OC Market	**Quantities**	**POCi**	**Quantities**	**POCi**	**Quantities**	**POCi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{OC_AR}	0	**$253,342**	0	$277,538	0	$307,782
C_{OC_AU}	427	**$254,789**	462	$246,956	507	$237,165
C_{OC_CN}	15	**$309,952**	9	$324,664	1	$343,054
C_{OC_EU}	19	**$262,048**	6	$283,009	0	$309,211
C_{OC_US}	20	**$304,794**	8	$326,322	0	$353,233
C_{OC_CIS}	1	**$262,093**	0	$276,523	0	$294,561
C_{OC_ROW}	9	**$254,359**	9	$250,494	9	$245,662
	Quantities		Quantities		Quantities	
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{OC}	11,109	**$254,789**	10,939	$246,956	11,150.88	$256,698.32

Table A-2 Implied Demand Elasticities, Base year Quantity and Prices, Lower Bound Over all Demand Elasticity and Elasticity of Substitution

Implied Demand Elasticities									
Eta= -0.1 **Sigma=3**									
EUROPEAN UNION DOMESTIC MARKET									
Demand Elasticities in EU Domestic Market with Respect to the Price of									
Source	Share								
AR	0.000	**-3.000**	0.004	0.048	2.770	0.016	0.052	0.010	
AU	0.001	0.000	**-2.996**	0.048	2.770	0.016	0.052	0.010	
CN	0.016	0.000	0.004	**-2.952**	2.770	0.016	0.052	0.010	
EU	0.955	0.000	0.004	0.048	**-0.230**	0.016	0.052	0.010	
US	0.005	0.000	0.004	0.048	2.770	**-2.984**	0.052	0.010	
CIS	0.018	0.000	0.004	0.048	2.770	0.016	**-2.948**	0.010	
ROW	0.003	0.000	0.004	0.048	2.770	0.016	0.052	**-2.990**	
OTHER EUROPEAN COUNTRIES DOMESTIC MARKET									
Demand Elasticities in OE Domestic Market with Respect to the Price of									
AR	0.000	**-3.000**	0.000	0.000	0.029	0.002	2.869	0.002	
AU	0.000	0.000	**-3.000**	0.000	0.029	0.002	2.869	0.002	
CN	0.000	0.000	0.000	**-3.000**	0.029	0.002	2.869	0.002	
EU	0.010	0.000	0.000	0.000	**-2.971**	0.029	2.869	0.002	
US	0.001	0.000	0.000	0.000	0.029	**-2.998**	2.869	0.002	
CIS	0.989	0.000	0.000	0.000	0.029	0.002	**-0.131**	0.002	
ROW	0.001	0.000	0.000	0.000	0.029	0.002	2.869	**-2.998**	
CANADA DOMESTIC MARKET									
Demand Elasticities in CN Domestic Market with Respect to the Price of									
AR	0.000	**-3.000**	0.000	2.900	0.000	0.000	0.000	0.000	
AU	0.000	0.000	**-3.000**	2.900	0.000	0.000	0.000	0.000	
CN	1.000	0.000	0.000	**-0.100**	0.000	0.000	0.000	0.000	
EU	0.000	0.000	0.000	2.900	**-3.000**	0.000	0.000	0.000	
US	0.000	0.000	0.000	2.900	0.000	**-3.000**	0.000	0.000	
CIS	0.000	0.000	0.000	2.900	0.000	0.000	**-3.000**	0.000	
ROW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**-3.000**	

Continued….

Implied Demand Elasticities								
Eta= -0.1 Sigma=3								
UNITED STATES OF AMERICA DOMESTIC MARKET								
Demand Elasticities in US Domestic Market with Respect to the Price of								
Source	**Share**							
AR	0.001	**-2.998**	0.000	0.300	0.000	2.585	0.002	0.010	
AU	0.000	0.002	**-3.000**	0.300	0.000	2.585	0.002	0.010	
CN	0.103	0.002	0.000	**-2.700**	0.000	2.585	0.002	0.010	
EU	0.000	0.002	0.000	0.300	**-3.000**	2.585	0.002	0.010	
US	0.891	0.002	0.000	0.300	0.000	**-0.415**	0.002	0.010	
CIS	0.001	0.002	0.000	0.300	0.000	2.585	**-2.998**	0.010	
ROW	0.004	0.002	0.000	0.300	0.000	2.585	0.002	**-2.990**	
LATIN AMERICA DOMESTIC MARKET									
Demand Elasticities in LA Domestic Market with Respect to the Price of									
AR	0.631	**-1.172**	0.000	0.352	0.032	0.616	0.011	0.060	
AU	0.000	1.828	**-3.000**	0.352	0.032	0.616	0.011	0.060	
CN	0.121	1.828	0.000	**-2.648**	0.032	0.616	0.011	0.060	
EU	0.011	1.828	0.000	0.352	**-2.968**	0.616	0.011	0.060	
US	0.212	1.828	0.000	0.352	0.032	**-2.384**	0.011	0.060	
CIS	0.004	1.828	0.000	0.352	0.032	0.616	**-2.989**	0.060	
ROW	0.021	1.828	0.000	0.352	0.032	0.616	0.011	**-2.940**	
NEAR EAST ASIA DOMESTIC MARKET									
Demand Elasticities in NE Domestic Market with Respect to the Price of									
AR	0.008	**-2.978**	0.065	0.050	0.065	0.101	0.217	0.096	2.284
AU	0.022	0.022	**-2.935**	0.050	0.065	0.101	0.217	0.096	2.284
CN	0.017	0.022	0.065	**-2.950**	0.065	0.101	0.217	0.096	2.284
EU	0.023	0.022	0.065	0.050	**-2.935**	0.101	0.217	0.096	2.284
US	0.035	0.022	0.065	0.050	0.065	**-2.899**	0.217	0.096	2.284
CIS	0.075	0.022	0.065	0.050	0.065	0.101	**-2.783**	0.096	2.284
ROW	0.033	0.022	0.065	0.050	0.065	0.101	0.217	**-2.904**	2.284
NE	0.788	0.022	0.065	0.050	0.065	0.101	0.217	0.096	**-0.716**

Continued….

Implied Demand Elasticities									
Eta= -0.1 **Sigma=3**									
PACFIC ASIA DOMESTIC MARKET									
Source	**Share**	**Demand Elasticities in PA Domestic Market with Respect to the Price of**							
AR	0.002	**-2.993**	0.147	0.090	0.000	0.185	0.009	0.074	2.387
AU	0.051	0.007	**-2.853**	0.090	0.000	0.185	0.009	0.074	2.387
CN	0.031	0.007	0.147	**-2.910**	0.000	0.185	0.009	0.074	2.387
EU	0.000	0.007	0.147	0.090	**-3.000**	0.185	0.009	0.074	2.387
US	0.064	0.007	0.147	0.090	0.000	**-2.815**	0.009	0.074	2.387
CIS	0.003	0.007	0.147	0.090	0.000	0.185	**-2.991**	0.074	2.387
ROW	0.026	0.007	0.147	0.090	0.000	0.185	0.009	**-2.926**	2.387
PA	0.823	0.007	0.090	0.090	0.000	0.185	0.009	0.074	**-0.613**
SOUTH ASIA DOMESTIC MARKET									
Demand Elasticities in SA Domestic Market with Respect to the Price of									
AR	0.002	**-2.996**	0.043	0.065	0.030	0.008	0.113	0.015	2.621
AU	0.015	0.004	**-2.957**	0.065	0.030	0.008	0.113	0.015	2.621
CN	0.023	0.004	0.043	**-2.935**	0.030	0.008	0.113	0.015	2.621
EU	0.010	0.004	0.043	0.065	**-2.970**	0.008	0.113	0.015	2.621
US	0.003	0.004	0.043	0.065	0.030	**-2.992**	0.113	0.015	2.621
CIS	0.039	0.004	0.043	0.065	0.030	0.008	**-2.887**	0.015	2.621
ROW	0.005	0.004	0.043	0.065	0.030	0.008	0.113	**-2.985**	2.621
SA	0.904	0.004	0.043	0.065	0.030	0.008	0.113	0.015	**-0.379**
NORTH AFRICA DOMESTIC MARKET									
Demand Elasticities in NA Domestic Market with Respect to the Price of									
AR	0.004	**-2.990**	0.023	0.154	0.483	0.236	0.352	0.077	1.564
AU	0.008	0.010	**-2.977**	0.154	0.483	0.236	0.352	0.077	1.564
CN	0.053	0.010	0.023	**-2.846**	0.483	0.236	0.352	0.077	1.564
EU	0.167	0.010	0.023	0.154	**-2.517**	0.236	0.352	0.077	1.564
US	0.081	0.010	0.023	0.154	0.483	**-2.764**	0.352	0.077	1.564
CIS	0.121	0.010	0.023	0.154	0.483	0.236	**-2.648**	0.077	1.564
ROW	0.027	0.010	0.023	0.154	0.483	0.236	0.352	**-2.923**	1.564
NA	0.539	0.010	0.023	0.154	0.483	0.236	0.352	0.077	**-1.436**

Continued….

Implied Demand Elasticities									
Eta= -0.1 Sigma=3									
SUB SAHARAN AFRICA DOMESTIC MARKET									
Source	**Share**	**Demand Elasticities in SS Domestic Market with Respect to the Price of**							
AR	0.089	**-2.742**	0.122	0.209	0.581	0.612	0.165	0.074	0.879
AU	0.042	0.258	**-2.878**	0.209	0.581	0.612	0.165	0.074	0.879
CN	0.072	0.258	0.122	**-2.791**	0.581	0.612	0.165	0.074	0.879
EU	0.201	0.258	0.122	0.209	**-2.419**	0.612	0.165	0.074	0.879
US	0.211	0.258	0.122	0.209	0.581	**-2.388**	0.165	0.074	0.879
CIS	0.057	0.258	0.122	0.209	0.581	0.612	**-2.835**	0.074	0.879
ROW	0.025	0.258	0.122	0.209	0.581	0.612	0.165	**-2.926**	0.879
SS	0.303	0.258	0.122	0.209	0.581	0.612	0.165	0.074	**-2.121**
OCEANIA DOMESTIC MARKET									
Demand Elasticities in OC Domestic Market with Respect to the Price of									
AR	0.000	**-3.000**	2.479	0.095	0.130	0.136	0.006	0.053	
AU	0.855	0.000	**-0.521**	0.095	0.130	0.136	0.006	0.053	
CN	0.033	0.000	2.479	**-2.905**	0.130	0.136	0.006	0.053	
EU	0.045	0.000	2.479	0.095	**-2.870**	0.136	0.006	0.053	
US	0.047	0.000	2.479	0.095	0.130	**-2.864**	0.006	0.053	
CIS	0.002	0.000	2.479	0.095	0.130	0.136	**-2.994**	0.053	
ROW	0.018	0.000	2.479	0.095	0.130	0.136	0.006	**-2.947**	

Table A-3 Implied Demand Elasticities, Base year Quantity and Prices, Higher Bound Over all demand elasticity and Elasticity of substitution

Implied Demand Elasticities									
Eta= -0.2 Sigma=12									
EUROPEAN UNION DOMESTIC MARKET									
Demand Elasticities in EU Domestic Market with Respect to the Price of									
Source	Share								
AR	0.000	**-11.999**	0.016	0.195	11.273	0.065	0.212	0.039	
AU	0.001	0.001	**-11.984**	0.195	11.273	0.065	0.212	0.039	
CN	0.016	0.001	0.016	**-11.805**	11.273	0.065	0.212	0.039	
EU	0.955	0.001	0.016	0.195	**-0.727**	0.065	0.212	0.039	
US	0.005	0.001	0.016	0.195	11.273	**-11.935**	0.212	0.039	
CIS	0.018	0.001	0.016	0.195	11.273	0.065	**-11.788**	0.039	
ROW	0.003	0.001	0.016	0.195	11.273	0.065	0.212	**-11.961**	
OTHER EUROPEAN COUNTRIES DOMESTIC MARKET									
Demand Elasticities in OE Domestic Market with Respect to the Price of									
AR	0.000	**-12.000**	0.000	0.000	0.119	0.007	11.673	0.009	
AU	0.000	0.000	**-12.000**	0.000	0.119	0.007	11.673	0.009	
CN	0.000	0.000	0.000	**-12.000**	0.119	0.007	11.673	0.009	
EU	0.010	0.000	0.000	0.000	**-11.881**	0.119	11.673	0.009	
US	0.001	0.000	0.000	0.000	0.119	**-11.993**	11.673	0.009	
CIS	0.989	0.000	0.000	0.000	0.119	0.007	**-0.327**	0.009	
ROW	0.001	0.000	0.000	0.000	0.119	0.007	11.673	**-11.991**	
CANADA DOMESTIC MARKET									
Demand Elasticities in CN Domestic Market with Respect to the Price of									
AR	0.000	**-12.000**	0.000	11.800	0.000	0.000	0.000	0.000	
AU	0.000	0.000	**-12.000**	11.800	0.000	0.000	0.000	0.000	
CN	1.000	0.000	0.000	**-0.200**	0.000	0.000	0.000	0.000	
EU	0.000	0.000	0.000	11.800	**-12.000**	0.000	0.000	0.000	
US	0.000	0.000	0.000	11.800	0.000	**-12.000**	0.000	0.000	
CIS	0.000	0.000	0.000	11.800	0.000	0.000	**-12.000**	0.000	
ROW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**-12.000**	

Continued….

Implied Demand Elasticities Eta= -0.1 Sigma=3									
UNITED STATES OF AMERICA DOMESTIC MARKET									
Demand Elasticities in US Domestic Market with Respect to the Price of									
Source	**Share**								
AR	0.001	**-11.990**	0.000	1.221	0.002	10.519	0.007	0.042	
AU	0.000	0.010	**-12.000**	1.221	0.002	10.519	0.007	0.042	
CN	0.103	0.010	0.000	**-10.779**	0.002	10.519	0.007	0.042	
EU	0.000	0.010	0.000	1.221	**-11.998**	10.519	0.007	0.042	
US	0.891	0.010	0.000	1.221	0.002	**-1.481**	0.007	0.042	
CIS	0.001	0.010	0.000	1.221	0.002	10.519	**-11.993**	0.042	
ROW	0.004	0.010	0.000	1.221	0.002	10.519	0.007	**-11.958**	
LATIN AMERICA DOMESTIC MARKET									
Demand Elasticities in LA Domestic Market with Respect to the Price of									
AR	0.631	**-4.560**	0.000	1.434	0.129	2.505	0.045	0.246	
AU	0.000	7.440	**-12.000**	1.434	0.129	2.505	0.045	0.246	
CN	0.121	7.440	0.000	**-10.566**	0.129	2.505	0.045	0.246	
EU	0.011	7.440	0.000	1.434	**-11.871**	2.505	0.045	0.246	
US	0.212	7.440	0.000	1.434	0.129	**-9.495**	0.045	0.246	
CIS	0.004	7.440	0.000	1.434	0.129	2.505	**-11.955**	0.246	
ROW	0.021	7.440	0.000	1.434	0.129	2.505	0.045	**-11.754**	
NEAR EAST ASIA DOMESTIC MARKET									
Demand Elasticities in NE Domestic Market with Respect to the Price of									
AR	0.008	**-11.911**	0.263	0.202	0.266	0.413	0.881	0.392	9.295
AU	0.022	0.089	**-11.737**	0.202	0.266	0.413	0.881	0.392	9.295
CN	0.017	0.089	0.263	**-11.798**	0.266	0.413	0.881	0.392	9.295
EU	0.023	0.089	0.263	0.202	**-11.734**	0.413	0.881	0.392	9.295
US	0.035	0.089	0.263	0.202	0.266	**-11.587**	0.881	0.392	9.295
CIS	0.075	0.089	0.263	0.202	0.266	0.413	**-11.119**	0.392	9.295
ROW	0.033	0.089	0.263	0.202	0.266	0.413	0.881	**-11.608**	9.295
NE	0.788	0.089	0.263	0.202	0.266	0.413	0.881	0.392	**-2.705**

Continued….

Implied Demand Elasticities									
Eta= -0.1 **Sigma=3**									
PACFIC ASIA DOMESTIC MARKET									
Source	**Share**	**Demand Elasticities in PA Domestic Market with Respect to the Price of**							
AR	0.002	**-11.973**	0.600	0.368	0.002	0.751	0.037	0.303	9.713
AU	0.051	0.027	**-11.400**	0.368	0.002	0.751	0.037	0.303	9.713
CN	0.031	0.027	0.600	**-11.632**	0.002	0.751	0.037	0.303	9.713
EU	0.000	0.027	0.600	0.368	**-11.998**	0.751	0.037	0.303	9.713
US	0.064	0.027	0.600	0.368	0.002	**-11.249**	0.037	0.303	9.713
CIS	0.003	0.027	0.600	0.368	0.002	0.751	**-11.963**	0.303	9.713
ROW	0.026	0.027	0.600	0.368	0.002	0.751	0.037	**-11.697**	9.713
PA	0.823	0.027	0.368	0.368	0.002	0.751	0.037	0.303	**-2.287**
SOUTH ASIA DOMESTIC MARKET									
Demand Elasticities in SA Domestic Market with Respect to the Price of									
AR	0.002	**-11.982**	0.173	0.266	0.124	0.033	0.461	0.062	10.663
AU	0.015	0.018	**-11.827**	0.266	0.124	0.033	0.461	0.062	10.663
CN	0.023	0.018	0.173	**-11.734**	0.124	0.033	0.461	0.062	10.663
EU	0.010	0.018	0.173	0.266	**-11.876**	0.033	0.461	0.062	10.663
US	0.003	0.018	0.173	0.266	0.124	**-11.967**	0.461	0.062	10.663
CIS	0.039	0.018	0.173	0.266	0.124	0.033	**-11.539**	0.062	10.663
ROW	0.005	0.018	0.173	0.266	0.124	0.033	0.461	**-11.938**	10.663
SA	0.904	0.018	0.173	0.266	0.124	0.033	0.461	0.062	**-1.337**
NORTH AFRICA DOMESTIC MARKET									
Demand Elasticities in NA Domestic Market with Respect to the Price of									
AR	0.004	**-11.958**	0.095	0.626	1.967	0.958	1.433	0.315	6.365
AU	0.008	0.042	**-11.905**	0.626	1.967	0.958	1.433	0.315	6.365
CN	0.053	0.042	0.095	**-11.374**	1.967	0.958	1.433	0.315	6.365
EU	0.167	0.042	0.095	0.626	**-10.033**	0.958	1.433	0.315	6.365
US	0.081	0.042	0.095	0.626	1.967	**-11.042**	1.433	0.315	6.365
CIS	0.121	0.042	0.095	0.626	1.967	0.958	**-10.567**	0.315	6.365
ROW	0.027	0.042	0.095	0.626	1.967	0.958	1.433	**-11.685**	6.365
NA	0.539	0.042	0.095	0.626	1.967	0.958	1.433	0.315	**-5.635**

Continued….

Implied Demand Elasticities									
Eta= -0.1 Sigma=3									
SUB SAHARAN AFRICA DOMESTIC MARKET									
Source	**Share**	**Demand Elasticities in SS Domestic Market with Respect to the Price of**							
AR	0.089	**-10.951**	0.496	0.849	2.366	2.489	0.673	0.300	3.578
AU	0.042	1.049	**-11.504**	0.849	2.366	2.489	0.673	0.300	3.578
CN	0.072	1.049	0.496	**-11.151**	2.366	2.489	0.673	0.300	3.578
EU	0.201	1.049	0.496	0.849	**-9.634**	2.489	0.673	0.300	3.578
US	0.211	1.049	0.496	0.849	2.366	**-9.511**	0.673	0.300	3.578
CIS	0.057	1.049	0.496	0.849	2.366	2.489	**-11.327**	0.300	3.578
ROW	0.025	1.049	0.496	0.849	2.366	2.489	0.673	**-11.700**	3.578
SS	0.303	1.049	0.496	0.849	2.366	2.489	0.673	0.300	**-8.422**
OCEANIA DOMESTIC MARKET									
Demand Elasticities in OC Domestic Market with Respect to the Price of									
AR	0.000	**-12.000**	10.087	0.386	0.531	0.555	0.024	0.217	
AU	0.855	0.000	**-1.913**	0.386	0.531	0.555	0.024	0.217	
CN	0.033	0.000	10.087	**-11.614**	0.531	0.555	0.024	0.217	
EU	0.045	0.000	10.087	0.386	**-11.469**	0.555	0.024	0.217	
US	0.047	0.000	10.087	0.386	0.531	**-11.445**	0.024	0.217	
CIS	0.002	0.000	10.087	0.386	0.531	0.555	**-11.976**	0.217	
ROW	0.018	0.000	10.087	0.386	0.531	0.555	0.024	**-11.783**	

Table A-4 Equilibrium Quantity Demanded, Supplied, and Prices for all Regions under the Higher Bound Demand Elasticity and Elasticity of Substitution Assumptions for 50%, and 100% Increase in Freight Rates

ELASTICITY OF SUBSTITUTION	**12**		**12**		**12**	
DEMAND ELASTICITY	**-0.2**		**-0.2**		**-0.2**	
SUPPLY ELASTICITY	**0.5**		**0.5**		**0.5**	
%Freight Rate Increase	**0%**		**50%**		**100%**	
EU Markets	**Quantities**	**PEUi**	**Quantities**	**PEUi**	**Quantities**	**PEUi**
Domestic demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{EU_AR}	14	$233,452	0	$278,255	0	$255,854
C_{EU_AU}	160	$315,136	0	$354,300	16	$334,718
C_{EU_CN}	1,938	$268,582	1,562	$264,921	1,750	$266,751
C_{EU_EU}	112,273	$198,418	118,304	$189,529	115,289	$193,974
C_{EU_US}	644	$254,189	224	$260,007	434	$257,098
C_{EU_CIS}	2,107	$244,370	0	$263,928	681	$254,149
C_{EU_ROW}	388	$200,211	381	$192,531	384	$196,371
	Quantities	**PEU**	**Quantities**	**PEU**	**Quantities**	**PEU**
Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{EU}	125,095	$198,418	122,293	$189,529	123,694	$193,974
OE Market	**Quantities**	**POEi**	**Quantities**	**POEi**	**Quantities**	**POEi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{OE_AR}	1	$241,283	0	$293,918	0	$267,601
C_{OE_AU}	0	$302,233	0	$328,494	0	$315,364
C_{OE_CN}	3	$278,522	1	$284,801	2	$281,661
C_{OE_EU}	751	$229,788	0	$252,269	92	$241,029
C_{OE_US}	47	$265,189	0	$282,007	17	$273,598
C_{OE_CIS}	73,737	$213,000	76,011	$201,188	74,874	$207,094
C_{OE_ROW}	59	$213,203	58	$202,388	58	$207,795

Continued….

	Quantities	Pus	Quantities	Pus	Quantities	Pus
Supply	**000 t**	**$/000t**	**000 t**	**$/000t**	**000 t**	**$/000t**
Q_{OE}	89,910	$213,000	87,417	$201,188	88,663	$207,094
CN Market						
Domestic Demand	**Quantities**	**PCNi**	**Quantities**	**PCNi**	**Quantities**	**PCNi**
C_{CA_AR}	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{CA_AU}	0	$225,732	0	$262,815	0	$244,274
C_{CA_CN}	0	$324,940	0	$373,907	0	$349,423
C_{CA_EU}	5,959	$238,082	6,130	$203,921	6,045	$221,001
C_{CA_US}	0	$228,918	0	$250,529	0	$239,724
C_{CA_CIS}	0	$250,039	0	$251,707	0	$250,873
C_{CA_ROW}	0	$253,440	0	$282,068	0	$267,754
	0	$238,083	0	$238,083	0	$238,083
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{CA}	25,265	$238,082	23,452	$203,921	24,359	$221,001
US Market	**Quantities**	**PUSi**	**Quantities**	**PUSi**	**Quantities**	**PUSi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{US_AR}	23	$215,872	0	$243,095	0	$229,484
C_{US_AU}	0	$326,705	0	$377,437	0	$352,071
C_{US_CN}	2,862	$266,122	584	$260,001	1,723	$263,061
C_{US_EU}	4	$230,608	0	$253,909	0	$242,259
C_{US_US}	24,660	$221,999	28,123	$195,627	26,392	$208,813
C_{US_CIS}	17	$256,190	0	$287,568	0	$271,879
C_{US_ROW}	99	$225,639	94	$202,832	96	$214,236
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{US}	49,316	$221,999	46,387	$195,627	47,851	$208,813

Continued….

LA Market	Quantities	PLAi	Quantities	PLAi	Quantities	PLAi
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{LA_AR}	20,069	$187,832	22,218	$187,015	21,143	$187,424
C_{LA_AU}	1	$305,424	0	$334,876	0	$320,150
C_{LA_CN}	3,867	$275,982	3,383	$279,721	3,625	$277,851
C_{LA_EU}	349	$244,038	0	$280,769	41	$262,404
C_{LA_US}	6,758	$250,039	6,496	$251,707	6,627	$250,873
C_{LA_CIS}	122	$266,451	0	$308,090	10	$287,271
C_{LA_ROW}	664	$208,749	665	$209,574	665	$209,162
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{LA}	22,635	$187,832	22,586	$187,015	22,610	$187,424
NE Market	**Quantities**	**PNEi**	**Quantities**	**PNEi**	**Quantities**	**PNEi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{NE_AR}	406	$238,778	0	$288,908	98	$263,843
C_{NE_AU}	1,206	$300,598	980	$325,224	1,093	$312,911
C_{NE_CN}	923	$279,590	1,421	$286,935	1,172	$283,262
C_{NE_EU}	1,218	$245,806	113	$284,306	665	$265,056
C_{NE_US}	1,890	$268,010	1,914	$287,648	1,902	$277,829
C_{NE_CIS}	4,036	$250,995	2,829	$277,179	3,432	$264,087
C_{NE_ROW}	1,798	$224,253	1,875	$243,381	1,837	$233,817
C_{NE_NE}	42,569	$225,165	44,378	$244,298	43,474	$234,732
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{NE}	42,569	$225,165	44,378	$244,298	43,474	$234,732
PA Market	**Quantities**	**PPAi**	**Quantities**	**PPAi**	**Quantities**	**PPAi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{PA_AR}	300	$267,922	0	$347,196	0	$307,559
C_{PA_AU}	6,779	$292,918	6,894	$309,864	6,837	$301,391
PA Market	**Quantities**	**PPAi**	**Quantities**	**PPAi**	**Quantities**	**PPAi**

Continued….

C_{PA_CN}	4,163	$294,482	3,335	$316,721	3,749	$305,601
C_{PA_EU}	22	$279,770	0	$352,235	0	$316,002
C_{PA_US}	8,493	$277,869	4,041	$307,367	6,267	$292,618
C_{PA_CIS}	421	$270,460	0	$316,108	157	$293,284
C_{PA_ROW}	3,422	$276,672	3,525	$293,336	3,474	$285,004
C_{PA_PA}	109,822	$283,573	112,988	$299,925	111,405	$291,749
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{PA}	109,822	$283,573	112,988	$299,925	111,405	$291,749
SA Market	**Quantities**	**PNEi**	**Quantities**	**PNEi**	**Quantities**	**PNEi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{SA_AR}	166	$247,185	0	$305,722	0	$276,454
C_{SA_AU}	1,580	$299,438	962	$322,904	1,271	$311,171
C_{SA_CN}	2,424	$280,911	2,946	$289,578	2,685	$285,244
C_{SA_EU}	1,128	$247,648	0	$287,989	400	$267,819
C_{SA_US}	304	$279,459	77	$310,547	191	$295,003
C_{SA_CIS}	4,208	$250,554	1,782	$276,295	2,995	$263,424
C_{SA_ROW}	565	$239,957	581	$253,112	573	$246,534
C_{SA_SA}	97,330	$238,735	99,974	$251,710	98,652	$245,223
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{SA}	97,330	$238,735	99,974	$251,710	98,652	$245,223
NA Market	**Quantities**	**PNAi**	**Quantities**	**PNAi**	**Quantities**	**PNAi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{NA_AR}	124	$233,610	0	$278,572	23	$256,091
C_{NA_AU}	283	$301,378	146	$326,784	214	$314,081
C_{NA_CN}	1,870	$288,582	1,627	$304,921	1,748	$296,751
C_{NA_EU}	5,872	$227,568	3,691	$247,829	4,781	$237,699
C_{NA_US}	2,861	$269,019	1,913	$289,667	2,387	$279,343
C_{NA_CIS}	4,278	$224,610	7,345	$224,409	5,812	$224,509
C_{NA_ROW}	934	$235,049	959	$247,744	946	$241,397

Continued….

C_{NA_NA}	18,996	$239,760	19,499	$252,449	19,248	$246,104
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{NA}	18,996	$239,760	19,499	$252,449	19,248	$246,104
SS Market	**Quantities**	**PSSi**	**Quantities**	**PSSi**	**Quantities**	**PSSi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{SS_AR}	1,532	$214,759	1,452	$240,870	1,492	$227,814
C_{SS_AU}	725	$282,645	1,295	$289,318	1,010	$285,981
C_{SS_CN}	1,241	$274,653	2,475	$277,063	1,858	$275,858
C_{SS_EU}	3,457	$244,478	1,421	$281,649	2,439	$263,064
C_{SS_US}	3,636	$273,489	3,645	$298,607	3,641	$286,048
C_{SS_CIS}	983	$262,230	432	$299,648	708	$280,939
C_{SS_ROW}	439	$246,231	460	$270,400	450	$258,316
C_{SS_SS}	5,228	$243,503	5,487	$267,672	5,358	$255,587
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{SS}	5,228	$243,503	5,487	$267,672	5,358	$255,587
OC Market	**Quantities**	**POCi**	**Quantities**	**POCi**	**Quantities**	**POCi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{OC_AR}	0	$247,293	0	$305,938	0	$276,616
C_{OC_AU}	418	$256,748	586	$237,524	502	$247,136
C_{OC_CN}	16	$306,274	0	$340,304	2	$323,289
C_{OC_EU}	22	$256,806	0	$306,306	0	$281,556
C_{OC_US}	23	$299,412	0	$350,453	0	$324,932
C_{OC_CIS}	1	$258,485	0	$292,158	0	$275,322
C_{OC_ROW}	9	$255,484	9	$245,285	9	$250,385
	Quantities		Quantities		Quantities	
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{OC}	11,152	$256,748	10,734	$237,524	10,943	$247,136

Table A-5 Equilibrium Quantity Demanded, Supplied, and Prices for all Regions under the Lower Bound Demand Elasticity and Elasticity of Substitution Assumptions for 50%, and 100% Increase in Freight Rates

ELASTICITY OF SUBSTITUTION	**3**		**3**		**3**	
DEMAND ELASTICITY	**-0.1**		**-0.1**		**-0.1**	
SUPPLY ELASTICITY	**0.5**		**0.5**		**0.5**	
%Freight Rate Increase	**0%**		**100%**		**50%**	
EU Markets	**Quantities**	**PEUi**	**Quantities**	**PEUi**	**Quantities**	**PEUi**
Domestic demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{EU_AR}	14	$233,452	5	$281,564	9	$257,508
C_{EU_AU}	160	$315,135	96	$353,970	128	$334,552
C_{EU_CN}	1,938	$268,583	1,814	$271,114	1,876	$269,848
C_{EU_EU}	112,274	$198,419	113,764	$194,323	113,019	$196,371
C_{EU_US}	644	$254,188	529	$266,068	587	$260,128
C_{EU_CIS}	2,107	$244,370	1,407	$268,224	1,757	$256,297
C_{EU_ROW}	388	$200,209	385	$197,450	387	$198,829
	Quantities	Pcd	Quantities	Pcd	Quantities	Pcd
Supply	**000 t**	**$/000t**	**000 t**	**$/000t**	**000 t**	**$/000t**
Q_{EU}	125,096	$198,419	123,804	$194,323	124,450	$196,371
OE Market	**Quantities**	**POEi**	**Quantities**	**POEi**	**Quantities**	**POEi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{OE_AR}	1	$241,283	0	$297,227	1	$269,255
C_{OE_AU}	0	$302,232	0	$328,164	0	$315,198
C_{OE_CN}	3	$278,523	2	$290,994	3	$284,758
C_{OE_EU}	751	$229,789	418	$257,063	584	$243,426
C_{OE_US}	47	$265,188	31	$288,068	39	$276,628
C_{OE_CIS}	73,737	$213,000	74,365	$205,484	74,051	$209,242
C_{OE_ROW}	59	$213,203	58	$207,279	59	$210,241
	Quantities	Pus	Quantities	Pus	Quantities	Pus
Supply	**000 t**	**$/000t**	**000 t**	**$/000t**	**000 t**	**$/000t**
Q_{OE}	89,910	$213,000	88,324	$205,484	89,117	$209,242

Continued….

CA Market	**Quantities**	**PCNi**	**Quantities**	**PCNi**	**Quantities**	**PCNi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{CA_AR}	0	$225,732	0	$266,124	0	$245,928
C_{CA_AU}	0	$324,938	0	$373,576	0	$349,257
C_{CA_CN}	5,959	$238,083	6,029	$210,114	5,994	$224,098
C_{CA_EU}	0	$228,919	0	$255,323	0	$242,121
C_{CA_US}	0	$250,038	0	$257,768	0	$253,903
C_{CA_CIS}	0	$253,440	0	$286,364	0	$269,902
C_{CA_ROW}	0	$238,083	0	$238,083	0	$238,083
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{CA}	25,265	$238,083	23,781	$210,114	24,523	$224,098
US Market	**Quantities**	**PUSi**	**Quantities**	**PUSi**	**Quantities**	**PUSi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{US_AR}	23	$215,872	8	$246,404	15	$231,138
C_{US_AU}	0	$326,703	0	$377,107	0	$351,905
C_{US_CN}	2,862	$266,123	2,295	$266,194	2,579	$266,158
C_{US_EU}	4	$230,609	2	$258,703	3	$244,656
C_{US_US}	24,660	$221,998	25,598	$201,688	25,129	$211,843
C_{US_CIS}	17	$256,190	6	$291,864	12	$274,027
C_{US_ROW}	99	$225,242	95	$210,282	97	$217,762
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{US}	49,316	$221,998	47,060	$201,688	48,188	$211,843
LA Market	**Quantities**	**PLAi**	**Quantities**	**PLAi**	**Quantities**	**PLAi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{LA_AR}	20,069	$187,832	20,863	$190,324	20,466	$189,078
C_{LA_AU}	1	$305,423	1	$334,545	1	$319,984
C_{LA_CN}	3,867	$275,983	3,658	$285,914	3,763	$280,948
C_{LA_EU}	349	$244,039	192	$285,563	271	$264,801
C_{LA_US}	6,758	$250,038	6,534	$257,768	6,646	$253,903

Continued….

LA Market	**Quantities**	**PLAi**	**Quantities**	**PLAi**	**Quantities**	**PLAi**
C_{LA_CIS}	122	$266,452	66	$312,387	94	$289,419
C_{LA_ROW}	664	$208,743	671	$213,002	667	$210,872
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{LA}	22,635	$187,832	22,785	$190,324	22,710	$189,078
NE Market	**Quantities**	**PNEi**	**Quantities**	**PNEi**	**Quantities**	**PNEi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{NE_AR}	406	$238,778	215	$292,217	311	$265,498
C_{NE_AU}	1,206	$300,597	1,107	$324,893	1,156	$312,745
C_{NE_CN}	923	$279,590	948	$293,128	936	$286,359
C_{NE_EU}	1,218	$245,807	813	$289,100	1,016	$267,453
C_{NE_US}	1,890	$268,009	1,687	$293,709	1,788	$280,859
C_{NE_CIS}	4,036	$250,996	3,342	$281,475	3,689	$266,236
C_{NE_ROW}	1,798	$224,130	1,853	$237,917	1,826	$231,023
C_{NE_NE}	42,569	$225,158	43,873	$238,955	43,221	$232,057
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{NE}	42,569	$225,158	43,873	$238,955	43,221	$232,057
PA Market	**Quantities**	**PPAi**	**Quantities**	**PPAi**	**Quantities**	**PPAi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{PA_AR}	300	$267,922	68	$350,505	184	$309,214
C_{PA_AU}	6,779	$292,917	6,559	$309,533	6,669	$301,225
C_{PA_CN}	4,163	$294,483	3,528	$322,914	3,845	$308,698
C_{PA_EU}	22	$279,772	7	$357,028	14	$318,400
C_{PA_US}	8,493	$277,868	6,466	$313,428	7,479	$295,648
C_{PA_CIS}	421	$270,460	251	$320,404	336	$295,432
C_{PA_ROW}	3,422	$276,652	3,493	$288,181	3,458	$282,417
C_{PA_PA}	109,822	$283,572	112,002	$294,832	110,912	$289,202
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{PA}	109,822	$283,572	112,002	$294,832	110,912	$289,202

Continued….

SA Market	Quantities	PSAi	Quantities	PSAi	Quantities	PSAi
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{SA_AR}	166	$247,185	59	$309,031	113	$278,108
C_{SA_AU}	1,580	$299,437	1,354	$322,573	1,467	$311,005
C_{SA_CN}	2,424	$280,911	2,269	$295,771	2,347	$288,341
C_{SA_EU}	1,128	$247,649	633	$292,783	880	$270,216
C_{SA_US}	304	$279,458	212	$316,608	258	$298,033
C_{SA_CIS}	4,208	$250,554	3,142	$280,592	3,675	$265,573
C_{SA_ROW}	565	$239,824	574	$247,436	570	$243,630
C_{SA_SA}	97,329	$238,734	98,826	$246,075	98,077	$242,404
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{SA}	97,329	$238,734	98,826	$246,075	98,077	$242,404
NA Market	**Quantities**	**PNAi**	**Quantities**	**PNAi**	**Quantities**	**PNAi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{NA_AR}	124	$233,610	72	$281,881	98	$257,746
C_{NA_AU}	283	$301,377	256	$326,453	269	$313,915
C_{NA_CN}	1,869	$288,583	1,729	$311,114	1,799	$299,848
C_{NA_EU}	5,871	$227,569	5,117	$252,623	5,494	$240,096
C_{NA_US}	2,861	$269,018	2,497	$295,728	2,679	$282,373
C_{NA_CIS}	4,278	$224,611	4,919	$228,705	4,598	$226,658
C_{NA_ROW}	934	$235,346	960	$248,491	947	$241,918
C_{NA_NA}	18,997	$239,771	19,517	$252,894	19,257	$246,332
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{NA}	18,997	$239,771	19,517	$252,894	19,257	$246,332
SS Market	**Quantities**	**PSSi**	**Quantities**	**PSSi**	**Quantities**	**PSSi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{SS_AR}	1,532	$214,759	1,496	$244,179	1,514	$229,469
C_{SS_AU}	725	$282,644	890	$288,987	807	$285,815
C_{SS_CN}	1,241	$274,654	1,500	$283,256	1,371	$278,955
C_{SS_EU}	3,457	$244,479	2,853	$286,443	3,155	$265,461

Continued….

SS Market	Quantities	PSSi	Quantities	PSSi	Quantities	PSSi
C_{SS_US}	3,636	$273,488	3,498	$304,668	3,567	$289,078
C_{SS_CIS}	983	$262,230	826	$303,944	904	$283,087
C_{SS_ROW}	439	$246,250	460	$270,015	449	$258,132
C_{SS_SS}	5,228	$243,504	5,483	$267,266	5,356	$255,385
	Quantities	Prd	Quantities	Prd	Quantities	Prd
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{SS}	5,228	$243,504	5,483	$267,266	5,356	$255,385
OC Market	**Quantities**	**POCi**	**Quantities**	**POCi**	**Quantities**	**POCi**
Domestic Demand	000 t	$/000t	000 t	$/000t	000 t	$/000t
C_{OC_AR}	0	$247,293	0	$309,247	0	$278,270
C_{OC_AU}	418	$256,747	465	$237,193	441	$246,970
C_{OC_CN}	16	$306,274	8	$346,497	12	$326,386
C_{OC_EU}	22	$256,807	5	$311,100	14	$283,954
C_{OC_US}	23	$299,411	8	$356,514	15	$327,963
C_{OC_CIS}	1	$258,486	0	$296,455	1	$277,470
C_{OC_ROW}	9	$255,044	9	$246,488	9	$250,766
	Quantities		Quantities		Quantities	
Domestic Supply	000 t	$/000t	000 t	$/000t	000 t	$/000t
Q_{OC}	11,152	$256,747	10,727	$237,193	10,940	$246,970