Elasticity of Demand for Red Meat Transportation:

A Gravity Model Analysis of Western Canadian Pork Exports

By:

HÉCTOR J. URBINA-OLANA

A thesis
presented to the University of Manitoba in
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ABSTRACT

Canadian pork production exceeds its domestic demand and further increases can be only be sustained by successfully expanding export markets. Language, purchasing power, health awareness, proximity, values, and business relationships and NAFTA make the United States a target market for increasing Canadian pork exports. However, the flow of pork from Canada to the United States is affected positively and negatively by micro and macro factors. The major objective of this thesis is to estimate empirically the effects on Western Canadian pork exports of changes in income, hog production in the U.S. (by state) and the transport costs (truck). The goal of this study is to identify regional markets within the United States where further market penetration may be possible.

The theoretical foundation of the analysis is the interregional trade model. The concepts of excess supply and demand can be utilized to derive the demand for transportation. The derived demand for transport can be estimated as a gravity model within the context of the interregional trade framework. A pooled cross-section time series technique as described by Kmenta (1986), was used to estimate the gravity model. The empirical model employs annual data for the period of 1989 to 1992.

The parameters of the derived demand for transport are income, an index of production and transportation freight rates. The results show that the derived demand for the transport of pork is highly elastic and that the cost of transport is the most important factor affecting trade flows. Of the three Western Provinces taken into account in this study, Manitoba and Saskatchewan are more responsive to changes in transport cost. The

lower transport costs elasticity for Alberta may be explained by the larger gross margins and/or the lower backhaul freight rates.

A change in the specialization in hog production in a U.S. state has a negative effect on Western Canadian pork exports, but perhaps less than might be expected. U.S. pork does not appear to be a perfect substitute for pork imports.

The study findings suggest that Manitoba marketing efforts should concentrate in the Mid-Atlantic and West South centre states. The Alberta hog industry should focus its marketing strategy in selling on Mountain and South Atlantic states. The Saskatchewan hog industry should focus in the Mountain and Mid-Atlantic states.

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My thesis is dedicated to my parents, Julio Cesar, and Andrea, who are living in El Salvador; my sister, Sandra Julieta; my lovely wife and my son, Pablito Ignacio.

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Héctor J. Urbina

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Chapter I

Introduction

1.0 Problem Setting

Profit incentives have encouraged countries, like Canada, to specialize in producing certain commodities (i.e. pork) and to trade with countries specializing in other commodities. The incentive for specialization and trade lies in the economies of producing commodities that are, relatively speaking, best suited to each country's resource endowment. Western Canada is endowed with considerable land base for an expansion of the hog industry, and has ample technology, capital, and individual managerial skills suitable for pork production.

The recent end of freight subsidies under the Western Grain Transportation Act (WGTA) means that prairie farmers have a greater incentive to sell their grain closer to home rather than pay much higher shipping costs. Consequently, more grain (barley) is likely to be sold to hog producers in Western Canada rather than to export markets. There is widespread opinion that the hog industry in Manitoba could easily double in size within a decade because of available feed supplies.

Changes are occurring in the structure of the Western Canada hog industry. Hog producers across Western Canada are building larger hog barns that take advantage of sophisticated mechanical feeding systems and computerized controls[1]. In many cases, these new ventures are tied in with disease-free, genetically advanced

[1] For example, the Taiwanese are considering the development of four operations in Saskatchewan and Puratone Corp. and Elite Swine Inc. are considering to double the current production in Manitoba.

breeding stock suppliers and feed company contracts. Specialization and integration together with economies of size creates productivity gains in the use of human and nonhuman capital. As a result, the pork industry of Western Canada is competitive with all other major producing sectors in North America.

Pork products form a substantial share of farm cash receipts in Alberta, Saskatchewan and Manitoba. With a small consumer population and extensive agricultural resources, Western Canada's pork production exceeds its local food requirements. Thus, Western Canada relies on shipping the surplus production to other regions of Canada, and exporting to the U.S.A., Mexico, and overseas markets.

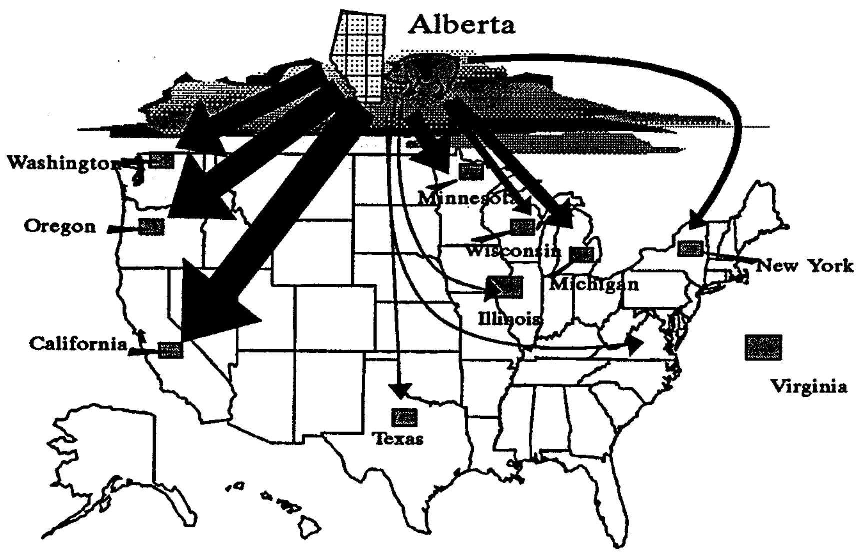
Western Canada is a large exporter of pork product at the present time, and the potential exists for a considerable expansion. Increased pork trade will not take place however, if the cost and effort of movement is too great. Transportation costs play an important role in determining the trade flow of pork between Canada and United States and deserve to be studied.

1.1 Statement of the Problem

Western Canada is a surplus-producing region in Canada and its population is not growing as fast as its hog production. Roughly speaking for every 3 hogs produced only one is for local consumption, the other two have to be exported. Thus, the critical need to develop new international markets for the increasing pork production in Western Canada[2].

[2] For a complete description of pork in this category, the reader is refer to Appendix I.

(a) Main Pork State-Importers in the U.S. from Alberta,1992



(b) Main Pork State-Importers in the U.S. from Manitoba, 1992

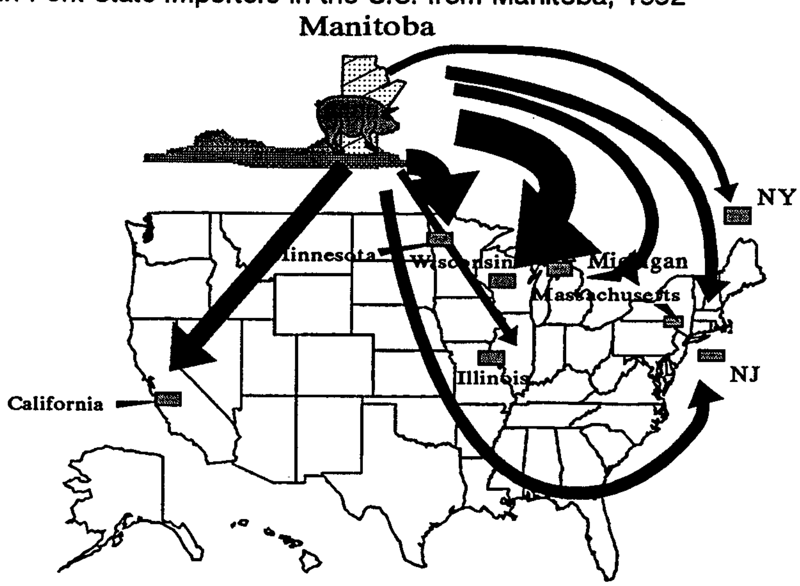


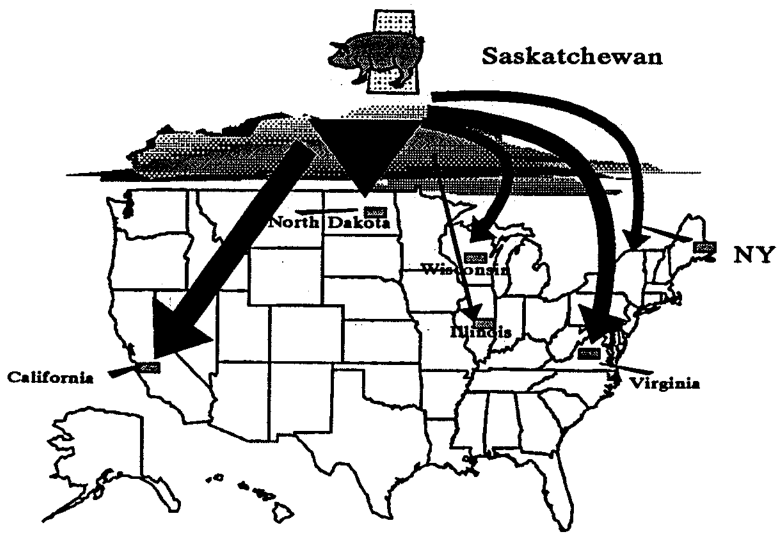
Figure 1. Prairie Provinces pork exports to the U.S. 1992

Figure 1 (a), (b) and (c) maps the main pork flows from the Western provinces to U.S. The figure presents the tonnage of outflow of pork represented by the width of the arrow. From this figure, we can pinpoint the deficit-producing areas served by exports of Western Canadian pork. Notice the concentration of pork sales around very closed geographic regions. For example, Alberta sells most of its product to California, Oregon and Washington. On the other hand, Wisconsin and Minnesota are major markets for Manitoba. In the case of Manitoba however, the states of California, Kansas, Texas have developed as export markets in spite of the long distance.

Figure 1 indicates where there is little Canadian pork export market penetration. For instance, the north east, south east, and central part of the U.S. are less attended by Western Canadian pork exporters. This lack of balance between high level and low level of sale volumes can be explained competing supplies in the United States.

There is an increasing geographic specialization of farm production in the U.S. as well as in Canada. Figure 2 illuminates the strategic connection between the Western Canadian provinces and the U.S. Pacific Western regions. The region known as the "corn belt" has specialized in livestock and feed grains. The region is also where the top ten hog producers are concentrated. Iowa, Illinois, Minnesota, Indiana, and Nebraska had average pig crops over 7 million in the 1988-1992 period. Exports from Western Canadian provinces tend to border the corn belt surplus region and reach those deficit regions that are closer to the former, and the most distant from the

(c) Main Pork State-Importers in the U.S. from Saskatchewan, 1992



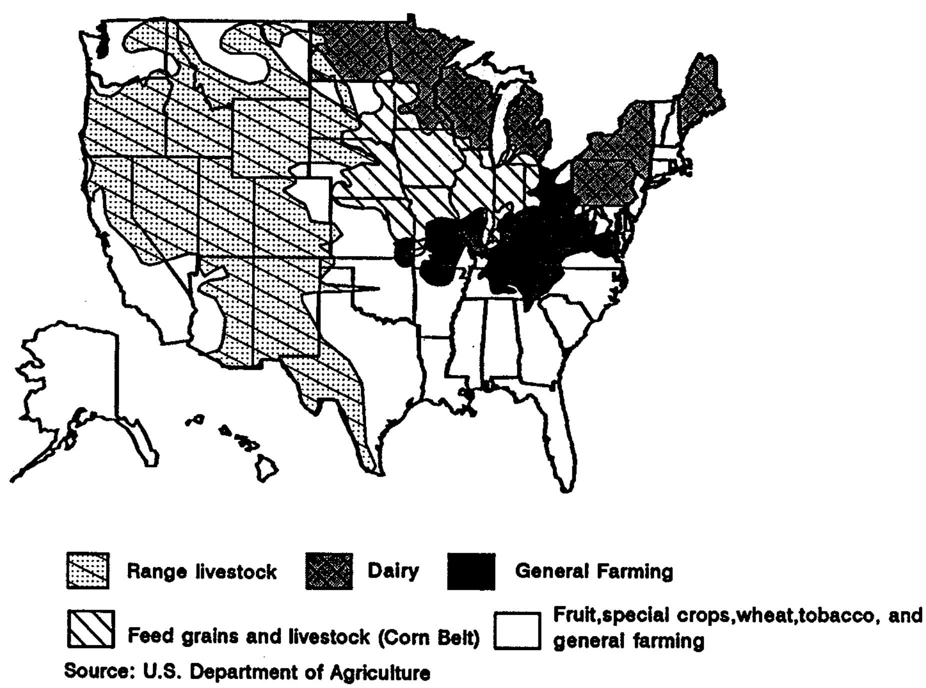


Figure 2. Major types of farming throughout the United States

latter. The corn belt surplus region would appear to be in a better strategic position supply pork to the Atlantic east coast and the southern U.S. A simple map technique reveals the uneven distribution of sales from the Western provinces, but does not reveal the opportunities for expansion.

The problem is to identify the particular region of the U.S. where Canadian pork exports can be most easily expanded. The present study examines the geographical regions of the United States in an attempt to provides insight in market penetration. The commodity nature of pork makes the industry very sensitive to relatively small changes in prices. The value-to-weight ratio of the product implies that transportation cost changes can influence market penetration and market share. The focus of this study is the role of transportation costs, and the guide they can give us in identifying potential markets.

1.2 Specification of Objectives

The general objective of this thesis is to study the potential for increasing Manitoba, Saskatchewan and Alberta pork exports to US.

The specific objectives are:

a) to develop a conceptual model that relates interregional theory and gravity models;

b) to empirically estimate the effects of transport cost on the opportunities for marketing unprocessed pork from Western Canada to the U.S..;

c) to identify potential individual or regional markets in the U.S. where exports could be increased.

1.3 Scope of the Study

The interregional model to be considered is one of the simplest of those falling within the general category of a standard, partial equilibrium, spatial formulation. Samuelson (1952) who, introducing the concept of net social payoff, first cast it mathematically into a maximum problem and then related it to a minimum transport-cost problem. Takayama and Judge (1964) formulated an interregional equilibrium model. Their model, a spatial, partial equilibrium formulation, allows for interaction among both countries and commodities under the assumption of free trade and a perfectly competitive market. Takayama and Judge have developed a model capable of solving for partial equilibrium conditions involving several interrelated commodities among many trading regions.

Takayama and Judge (1964), Bawden (1966) and Koo (1994) have used spatial equilibrium models on the basis of a mathematical programming algorithm to analyze the effects of comprehensive trade policies used by exporting and importing countries on the world trade. In these studies, trade flows are explained by the prices of commodities in importing and exporting countries and transportation costs between countries. Mathematical programming models can be used to measure the impact upon prices, production, consumption and trade flows resulting from a change in the trade policy of one country. These results can be used to draw conclusions concerning the desirability from a national viewpoint of adopting alternative trade policies.

However, we are not interested in formulating a model in which we can analyze policy problems in interregional trade or find the cheapest transport routes from each origin to each destination. The objectives of this study are to evaluate factors affecting trade flows of pork and to examine the sensitivity of export sales to changes in the freight rates. Based on an interregional trade framework together with a gravity model, we can trace out a derived demand curve for transportation[3]. The gravity model has been used to evaluate bilateral trade flows of commodity aggregates between pairs of countries. Unlike traditional gravity models of aggregate trade, in this study a commodity-specific gravity model is developed. We assume two regions, each having a separate supply and demand schedule for a single commodity, and then investigate the trade possibilities between the two regions of this commodity at alternative freight rates.

The movements of agricultural products between Canada and the United States is primarily by truck (Prentice et al, 1992). Truck shipment of live animals and meat accounted for 99 percent of all Canadian exports to U.S. in 1985. Therefore, we only consider the freight rates for truck transport in this study.

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[3] Transportation is classified as a derived demand because the demand for freight movements is derived from the demand for the consumption of a product at a location that is removed from the source of supply. Wilson (1980) suggests that freight movements result from decisions made in other sections of the economy concerning production, consumption, and sales that have little to do with transport per se. Therefore, the demand for intercity commodity movement is a derived demand.

From Western Canada, only British Columbia is considered a pork production deficit area, therefore, it is excluded from the model. The analysis does not take interprovincial trade into account because there are no data available of interprovincial trade in Canada. The market penetration analysis is based on the implied demand for transport from Western Canada to specific U.S. points.

The data set consist of exports from each of the Prairie Provinces (Alberta, Saskatchewan, and Manitoba) to each of the 38 states in U.S. To limit the scope of the study, it was decided to include 38 states, defined as the states with the largest population. These 38 states accounted for more than 95 percent of Western Canada-U.S. pork traded from 1989 to 1992. The data is for 1989-1992, which are the latest year for which the numbers are available, at least for one source: Agricultural Statistics U.S.D.A.

1.4 Organization of the Study

Chapter II reviews empirical studies that have used gravity models to examine trade flows. The theoretical link between the gravity model and the interregional trade model is presented, and the gravity model is identified as a derived demand for transportation. In Chapter III the gravity model theory is discussed with regard to the forecasting of trade volumes from Canada to U.S. and Mexico. An econometric model is developed following the conceptual model.

Chapter IV estimates the model developed in Chapter III. Tests indicating the relevance of using transport cost instead of distances are performed to estimate the effects on trade volume. Potential market niches are identified and the impacts of changing transport costs are examined.

Chapter V summarizes the results and presents the conclusions of the thesis. Some recommendations for further research are provided.

Chapter II

Literature Review

2.0 Introduction

The historical development of the gravity model was inspired by parallels in physical sciences. In the physical sciences, the laws of gravity govern the interaction of mass based on distance separation and mutual attraction. Spatial interaction models in the social sciences have tried to apply those "physical laws" to explain human travel patterns and interregional trade flows.

The problem with gravity models is not with the statistical significance of their coefficients or the reasonableness of their results, but in reconciling their specification with economic theory. The results are usually plausible, but models based on physical phenomena, like gravity have no economic meaning. According to Deardoff (1984), gravity models have been extremely successful empirically, and tell us something important about what happens in international or interregional trade, but it do not tell us why. This has certainly not inhibited geographers from applying gravity models, nor economists from trying to fit them into the accepted theory.

2.1 Review of Gravity Models

In this chapter, we explore different approaches that try to explain the gravity models. The review considers three groups: geographers, regional economists and trade economists.

2.1.1 From the Geographer Stand Point

The gravity models have been used by geographers for transport planning and retailing as well as transactions modelling.

Retail Market Models

Barke (1986) presented four models of the family of gravity models. The first model, called Reilly's law of retail gravitation, calculates the attraction of retail trade from a town in its surrounding territory. The calculation is based on the direct proportion to the population size of the city and the inverse proportion to the square of the distance from the city. There is no explanation for why the distance is squared, it is just assumed to be power of two.

$$R_i = \frac{P_i}{d_{ki}^2} \qquad (1)$$

where P_i is the population of city i
d_{ki}^2 the square of distance city i to city k

R_i calculates the attraction of a shopping centre, i to residents of another city, k. The number obtained from this formula has no units and it is usually compared with another number (obtained in similar way from another city) and whichever is higher gets more customer. Reilly's work has been used to determined the breaking point between two centres. In other words, it has been used to determine the influence of the dominant sphere of one shopping centre relative to another.

Extensions of Reilly Model

The second gravity model is an extension of the Reilly model. Instead of using population, this model uses the area of the retail floor space as a measure of attraction. Presumably, consumers are attracted to a shopping centre in direct proportion to the amount of shop floor space and in inverse proportion to their distance of travel as follow:

$$attractiveness = \frac{F_j}{d_{ij}^{\gamma}} \qquad (2)$$

Where

F_j represents floorspace of shopping centre j

The actual linear distance may not be very satisfactory guide for travel time or cost. Therefore, it may be necessary to weight the linear distance by a function γ. It is obvious that the accuracy of the model will be affected by the weighting applied to the distance factor γ[4]. The concept of attractiveness was used to define the floorspace of the shopping centre or the attraction of customers to a shopping centre given by equation number 2. The formula gives a number, but it does not have any units.

To show the effect of other competing centre's regions the last equation is modified as:

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[4] **Reilly assumed a value of gamma equal to 2**

$$Pr\begin{bmatrix}\textit{probability of a resident of}\\ \textit{zone } i \textit{ shopping in zone } j\end{bmatrix} = \frac{\dfrac{F_j}{d_{ij}^{\gamma}}}{\dfrac{\sum_j F_j}{d_{ij}^{\gamma}}} \qquad (3)$$

Where:

$0 < Pr < 1$

In other words, the probability of people from a region or a residential zone going to a particular shopping region, or shopping centre, is related to the overall attractiveness of that shopping centre compared to the overall attractiveness of all shopping centres in the region. Once the probability is estimated, the number of persons going to the shopping centres can be predicted.

Flows, nodes and regionalisation

Barke (1986) outlines the gravity model technique devised by Nystuen and Dacey, where flows of goods can be traced and understood. Nystuen and Dacey use an input/output flow matrix to determine the way in which flows are organised. The input/output matrix is complicated, but it simplifies these flows in order to distinguish the major pattern. To fully comprehend the spatial organization of a particular area, we must investigate the way in which such flows are organised around nodes to form regions. If we create a matrix, it will show that some nodal points stand out as being more important than others. The Nystuen and Dacey technique, enables us to simplify these flows in order to pick out the major patterns of flow. For each destination, the sum of all incoming flows (i.e. freights, trips, etc) is found. The sum of the flows (i.e. trips) into each region suggests the relative attractiveness of each place which can be arranged in a rank order.

For each region, the largest outward number of trips is also found. If these trips are to a location ranked higher than the location of origin, then the location of origin is considered to be subordinate of the location of destination. Those locations with largest flows to a smaller ranked location are considered to be dominant. Once the subordinate and dominant locations have been determined the pattern of movements with a defined geographical region can be identified.

Transaction flow analysis

By using a similar input/output flow matrix to the one created above, the total in flows (for example, the value of trade to a particular region) can be calculated. Then, the proportion of the value of that region can be calculated with respect to total "in" of all the regions in a country (i.e. 20 percent). If it is assumed that this particular region (i.e. Ontario) traded with all other regions on an equal basis, then the value of all the incoming trade to that region (i.e. Ontario) from each region in Canada should be the same amount in percentage terms (i.e. 20 percent) of each region's trade value. However, the amount traded to this particular region may be greater or lower than actual trade from other regions. Comparing the expected flows to the actual has two purposes: it enables one to pick out the major flows, that is, those flows that are considerably greater than expected. The technique draws attention to particularly interesting deviations from the expected, whether of a positive or negative nature, and suggests possible lines for further research.

2.1.2 Gravity Models from the Regional Economists' View Point

Isard (1960) introduced the concept of the region as a mass. This mass is composed of particles that in turn are governed by certain principles. These principles are supposed to constrain, or initiate, the action of particles and control their behaviour. However, he never defined the concept of region as a mass.

Assuming homogeneity among sub-areas (no significant differences in taste, incomes, and age distributions, etc) and using a simple probability principle, Isard derived and developed a gravity model. This particular gravity model depicts the interaction of people within a metropolitan region as a function of the populations of sub-areas and the distance variable when the interaction is reflected in trips.

$$I_{ij} = G\frac{P_i P_j}{d_{ij}^b} \qquad (4)$$

Where $$G = \frac{ck}{P}$$

In this equation I_{ij} is the actual trip volume between two regions and c and b are constants, P is the metropolitan population, P_i and P_j is the population of sub-area i and j respectively and d_{ij} is the distance between these two sub-areas. Isard also assumed that the total number of internal trips by the inhabitants of this metropolitan region be known and denoted by T. Based on the homogeneity assumption, he estimated that the number of trips that a representative individual undertakes to any area is defined as the average number of trips per capita for the entire metropolitan region. This average is equal to T/P and it was designated by the letter k in equation 4. Isard also found a straight-line relationship between the log of the ratio of actual (I_{ij}) to expected trip (T_{ij}) volume, and distance when plotted on a logarithmic scale. This relation is shown as follow:

$$\log\frac{I_{ij}}{T_{ij}} = a - b \log d_{ij} \qquad (5)$$

a is the intercept of equation and b is the slope of the line (5)

By taking antilog of equation (5) we get

$$\frac{I_{ij}}{T_{ij}} = \frac{c}{d_{ij}^{b}} \qquad (6)$$

c is the antilog of a (see also equation 4) and G in equation 4 is just a constant.

Isard develops a second concept corresponding to potential at sub-area i. Equation (4) was converted into another form by summing up the interaction of a single sub-area with all areas. Then, the sum was divided by the single population to yield the interaction with all areas on a per capita basis. This has been designated as potential at i for which he employed the following symbol (see equation 7).

$$_iV = G\sum_{j=1}^{n} \frac{P_j}{d_{ij}^b} \qquad (7)$$

The interpretation given to the concept of potential at sub-area i is not entirely clear. Depending on the problem, available data, and related considerations, Isard suggested that the measurement of mass as well as distance should be selected accordingly. For example, if industry location is being studied then transport cost distance is much more significant than physical distance. Another important issue is that masses are not the same or equal to unity. Applying weights to masses implies different contributions to explain the dependent variable. Isard also mentions that there are numerous empirical studies that report different exponents for both distance and population variables. Spatial interaction models used by Isard and other location theorists (economists, demographers, geographers, sociologists, planners and others) describe social phenomena in space, such as population migration, flows of goods, money and information, traffic movement and tourist travel.

2.1.3 Transport Demand Models

Transportation demand models have been estimated that resemble gravity models, but are not identified as such. Wilson (1980) estimated aggregated demand for transport in tonnage terms and found that it is closely related to real GNP or some index of real output. In other words, tonnage shipped depends on production and consumption levels, but it does not depend on the freight rate at least in the short run. However in the long run, one would expect demand to be more sensitive to freight rates.

According to Wilson, demand relations by mode would not be expected to follow real GNP or some other index of goods production so closely. To calculate demand equations by mode, most of the studies that Wilson found follow a general form like this:

$$T = a_1 \, R_1^{a_2} \, (GNP)^{a_3} \, R_2^{a_4} \qquad (8)$$

Where:
T refers to volume of traffic by rail for all commodities or one commodity class
R_1 refers to the rail rate
GNP is gross national product in real terms
R_2 is truck rate

Wilson suggests that data on each of these variables (or proxies of) are developed and values of a_i's are deduced using standard regression techniques. Since the variables are in logarithmic form, the coefficients represent elasticities.

2.1.4 Gravity models from the Trade Economist's Point of View

Linnemann's gravity model

Linnemann (1966) used a gravity model to explain the factors affecting and governing foreign trade between countries. He classified the factors in three types:

a) factors contributing to total potential supply of country A

b) factors contributing to total potential demand of country B

c) factors resisting to trade flow from potential supplier A to potential buyer B.

Linnemann defined total potential supply as the total production minus the production for home market under conditions of perfect mobility of products between countries. However, there is no such thing as perfect mobility because of the existence of trade impediments. Consequently, he introduced a potential foreign trade concept which means that the incidence of all trade obstacles together should be the same for all countries, per unit of supply. Hence, the size of a country's national or domestic product, and the size of a country's population are the factors that determine the potential supply and demand in the world market.

Linnemann argued that both potential demand and supply have to be realized at an equilibrium situation. He extended the gravity model equation by including population to internalize economies of scale. He explained this concept (economies of scale) by comparing two countries with similar incomes per capita, but different population sizes, Linnemann concludes that production for the home market and foreign demand ratio will be higher for the country with a larger population than the smaller nation. The bigger country will reach or surpass a minimum market size for efficient domestic production in more lines of production than the smaller country does.

The economic reasoning behind Linnemann's conclusion is the existence of economies of scale. Below a minimum output, the production process is inefficient and hence not competitive. The smaller country is limited by the size of the domestic market, which might be too small for certain production processes, and the impossibility of finding a substitute for certain factors that are absent. As a result of the limiting factors, every single country is going to have a peculiar domestic market-foreign market production ratio.

When examining the differences in income per capita between two countries with a given population size, Linnemann explained that the domestic market and foreign market production ratio will not change for both countries. The higher income per capita implies demand for new products that cannot be made economically in the importing country. The market of the supplier is not large enough for local production of the product to be cost competitive.

Natural trade obstacles and artificial trade impediments are only part of the general factors governing a country's participation in foreign trade. Linnemann concluded that the greater the cost of transportation between two countries, the smaller the trade flows. Transport cost, time and psychic (different languages, cultural differences and political hostilities) distance are the most importance natural trade obstacles. Artificial trade impediments include tariffs, quantitative restrictions, exchange controls, or a combination of these.

Linnemann can also be credited for being the first to assume different demand relationships for imports from different sources and to conjecture that the gravity equation was the reduced form of a partial equilibrium model.

Linnemann's reduced form equation[5] is based on the potential supply of country i and potential demand of country j.

$$X_{ij} = \delta_0 \frac{Y_i^{\delta_1} Y_j^{\delta_3} P_{ij}^{\delta_6}}{N_i^{\delta_2} N_j^{\delta_4} D_{ij}^{\delta_6}} \qquad (9)$$

Where

X_{ij} = trade flows between two countries

$Y_{i(j)}$ = gross national product of country i (country j)

$N_{i(j)}$ = population size of country i (country j)

D_{ij} = geographical distance between i and j countries

P_{ij} = preferential-trade factor between i and j countries

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[5] **A reduced form estimation can be explained with an example.**
Market Model. First let us consider a simple one-commodity model that can be written in the form of two equations:

Q = a-bP (a,b >0) Demand
Q = -c+dP (c,d >0) Supply

By solving these equations simultaneously, we solve for P and Q

P = (a+c)/(b+d) and Q = (ad-bc)/(b+d)

These solutions will be referred to as being in the reduced form: the two endogenous variables have been reduced to explicit expressions of the four mutually independent parameters a, b, c and d.

Units of the above variables varies depending on the nature of the study that he tried to accomplish.

Although Linnemann constructs a convincing theoretical framework, he could not provide a satisfactory explanation for the multiplicative functional form of the gravity equation. This gap tends to undermine an otherwise impressive economic construct.

Trade Flows Model

Leamer and Stern (1970) explained that the size of the foreign sector in a general equilibrium context will be determined by GNP, resource endowment, utility structure, and resistance factors. They suggested that population and income can be used as proxies for resource endowment and utility structure. Another factor affecting the trade sector is the cost of international trade. Transport costs and tariffs are natural candidates to be included.

Leamer and Stern used three models to describe trade flows. The first one is based on physical laws of gravitation, in which the gravity model has no economic meaning. The second model is based on a Walrasian general-equilibrium model, with each country having its own supply and a set of demands for the goods of all other countries. The flow is explained based on export-supply factors in the exporting country and import-demand factors in country j. The third description of trade flows is based on a probability model in which demanders are assigned to suppliers in a random fashion. Leamer and Stern gave us a theoretical foundation on how trade flows should work, but they did not work empirically to verify their theory.

Bilateral trade flows and transport costs

Geraci and Prewo, (1977) examined the direction and the level of aggregate bilateral trade flows in a multi-country trade network. Their concerns were with an explanation of the geographical pattern of a country's total imports from among its trading partners. They estimated elasticities of supply, demand, and trade resistance factors in a bilateral trade flows. They used distance as a proxy for transport costs, but found that it may result in a serious underestimate of the sensitivity of bilateral trade flows to transport costs. An interesting result of the Geraci-Prewo model is that the elasticity of exports with respect to the transport costs was nearly double the distance elasticity.

Anderson (1979) based his gravity model on the properties of expenditures systems. In his article, he developed four models: 1) the pure expenditure system model, 2) the trade-share-expenditure system model, 3) estimation efficiency and 4) many goods, tariffs and distance.

Anderson's first model explains the multiplicative form of the gravity model equation. It is based on the assumption of identical expenditures shares and income elasticities of unity. In this model there are no tariffs or transport costs.

In the second and third models, Anderson assumed that there is a variation of shares of total expenditures on tradeable goods across regions or countries. However, with identical homothetic preferences in each country within the class of tradeable goods, expenditures shares are identical for any good. By maximizing the preferences function of traded goods, subject to level of expenditure on traded goods, he derives individual traded-goods demands. These individual demands, M_{ij}, are a function of the GDP in country j (Y_j) for commodity i from country i, the share of expenditure on all traded goods in total expenditure in country j, denoted by φ_j, which is itself a function on GDP and population of country j. Finally, the share of expenditure of country i's tradeable good on total expenditure in j on tradeables is represented by θ_i.

$$M_{ij} = \theta_i \varphi_j Y_j \qquad (10)$$

The balance of trade relation, which states that value of imports of country i is equal to its exports, is combined with the individual demand equations to obtain a gravity model.

$$M_{ij} = \frac{\varphi_i Y_i \varphi_j Y_j}{\sum_j \varphi_j Y_j} \qquad (11)$$

The gravity model equation depends on country j's total expenditure on traded goods, country i's total expenditure on traded goods, and total expenditures of country j.

The fourth model considers many commodity classes of goods and a set of tariffs for each country, and transport cost proxied by distance. When Anderson extends the model to include transport cost, one assumption is necessary: whether or not the transport cost add one. A gravity model as a function of the same variables mentioned above is obtained by aggregating the commodity classes and assuming transit cost equal to one. When transit cost differs from one, a gravity model is produced with unknown bias. When transit cost is assumed to be an increasing function of distance and the same across commodities, a new aggregate-gravity equation is produced rather than a commodity-specific. This new gravity equation says that the flow from i to j is a function of capital account scale factor, total expenditure on traded goods, and transport cost, the economic distance.

2.2 Demand for Transport and Interregional Trade Models

The impact of transport cost on the domestic price level and on exports of a traded commodity are analyzed by using a simple two-region, one-commodity trade model. A derived demand curve for transportation is constructed based on the interregional trade potential. Finally, the derived demand for transport is related to the gravity model.

The following section has been based on the original Enke-Samuelson's Price Equilibrium Model. Samuelson (1952) who, introducing the concept of net social payoff, first cast it mathematically into a maximum problem and then related it to a minimum transport-cost problem. Samuelson has examined this problem diagrammatically for a two-variable case. Our discussion depends primarily on Samuelson's formulation.

2.2.1 Supply and Demand in Interregional Trade

An interregional commodity market is in equilibrium when at the prevailing price, the sales (volume) of exports exactly match the quantities demanded (volume of imports) by purchasers. In order to fully understand how equilibrium is established in interregional commodity markets, it is useful to derive the demand for imports schedule and the supply of exports schedule.

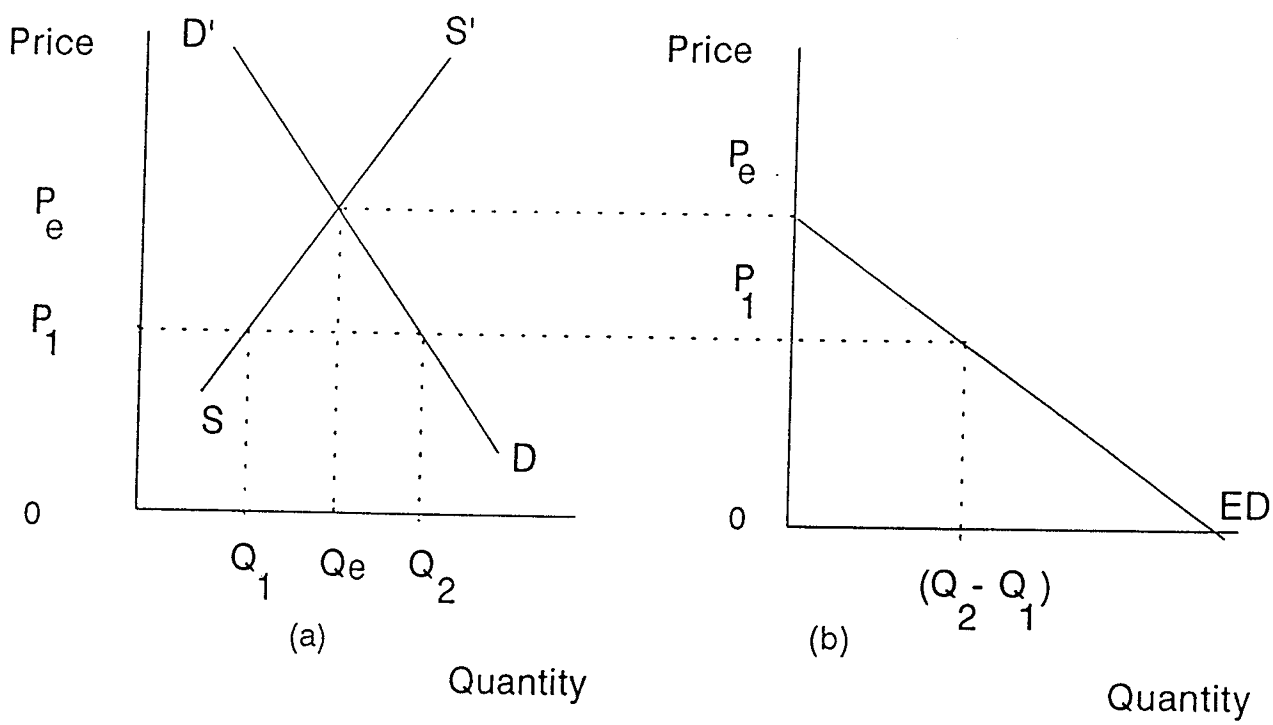
2.2.2 The Import Demand and Excess Supply Schedules

In price theory, the import demand schedule, also called the excess demand curve, gives the quantities of a commodity that a particular country is willing to import at alternative prices expressed in the country's own domestic currency (Chacholiades,1981).

Figure 2.1 illustrates the domestic demand curve (DD') and the domestic supply curve (SS') of a commodity (i.e. pork) in a particular region. Figure 2.1 (b) plots an excess demand for the region B, showing the quantity demanded exceeds the quantity supplied.

When market equilibrium is achieved quantity supplied and demanded equal to Q_e at price P_e. The demand and supply curve intersect at point Q_e with price P_e with quantity offered equal to quantity demanded. When there is neither a shortage, nor a surplus of the commodity in the market, an equilibrium situation or market clearing situation has been reached. At equilibrium price P_e, the excess demand is zero. If the price in the market were higher than this level, the quantity offered would exceed the quantity supplied. At prices above P_e there would be an excess supply (not shown).

Figure 2.1
Derivation of an Excess Demand Schedule



Competition among sellers would make this an unstable situation and force the price down. In a similar way, prices below the equilibrium level are unstable and are forced up by the bidding of prospective buyers. If the price drops below the equilibrium market price, then a supply shortage of the commodity is created. The supply shortage is the amount of imports that the region needs to restore domestic equilibrium. For example, if the price fell from P_e to P_1, consumers would want the quantity Q_2 but domestic production would supply only Q_1. The quantity Q_2-Q_1 would represent the demand for imports.

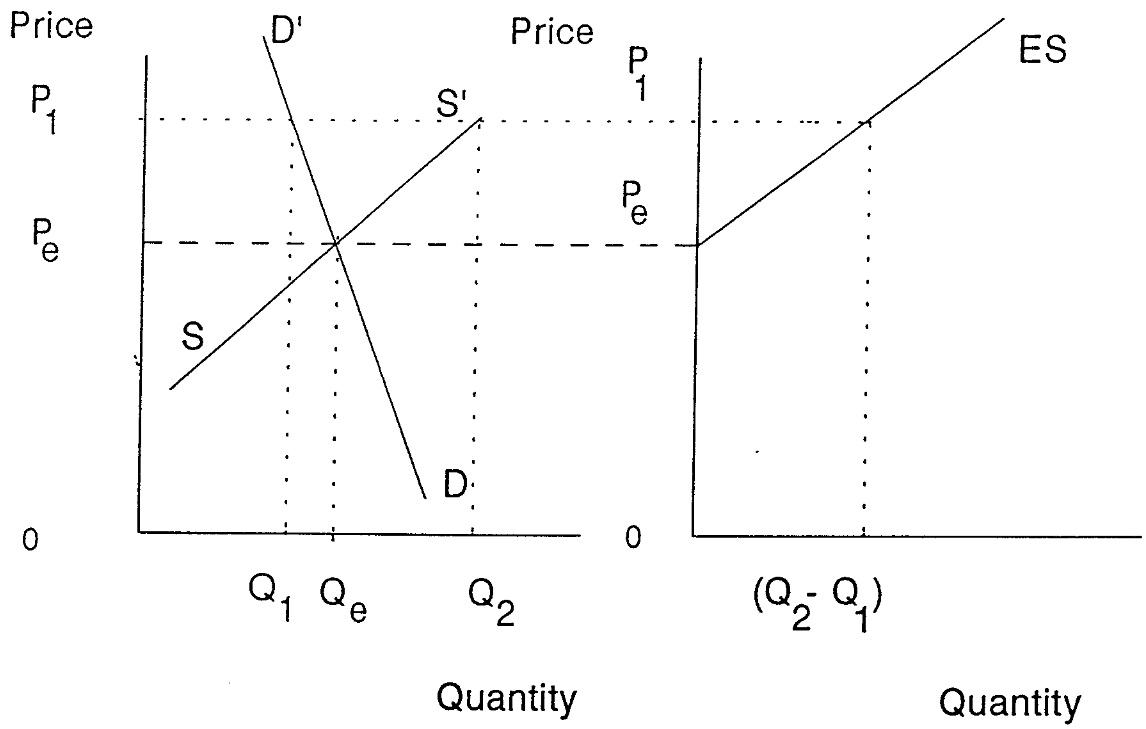
The excess demand curve (ED) equals the horizontal difference between the domestic demand and supply curves for all possible prices below the equilibrium price level. The excess demand curve depends on all properties and parameters that lie behind the domestic demand and supply schedules.

Now an opposite situation is developed, region Y, an exporting region, is able to provide the commodity to other regions that pay higher prices for the domestic product.

The export supply schedule shows the quantities of a commodity that a particular region is willing to export at alternative prices expressed in the country's own domestic currency. As shown in Figure 2.2, the excess supply curve is derived. Panel (a) shows the equilibrium price represented by the intersection of demand and supply curves. Panel (b) shows the resulting export supply curve (ES).
The derivation of the excess supply is the horizontal difference between the supply and demand curves, except that in the present case, the exporting region has a surplus

production at the prevailing market price P_1 that is above the equilibrium market price P_e. Hence, for every price level above P_e, a corresponding excess supply exists and by plotting the horizontal differences between the domestic demand and supply curves for all possible prices above the equilibrium price P_e, the excess supply curve can be derived for the commodity. At the price P_1, domestic consumers only demand the quantity Q_1. This bares the quantity Q_2-Q_1 available for export.

Figure 2.2
Derivation of an Excess Supply Shedule



2.2.3 Equilibrium in the Interregional Commodity Market

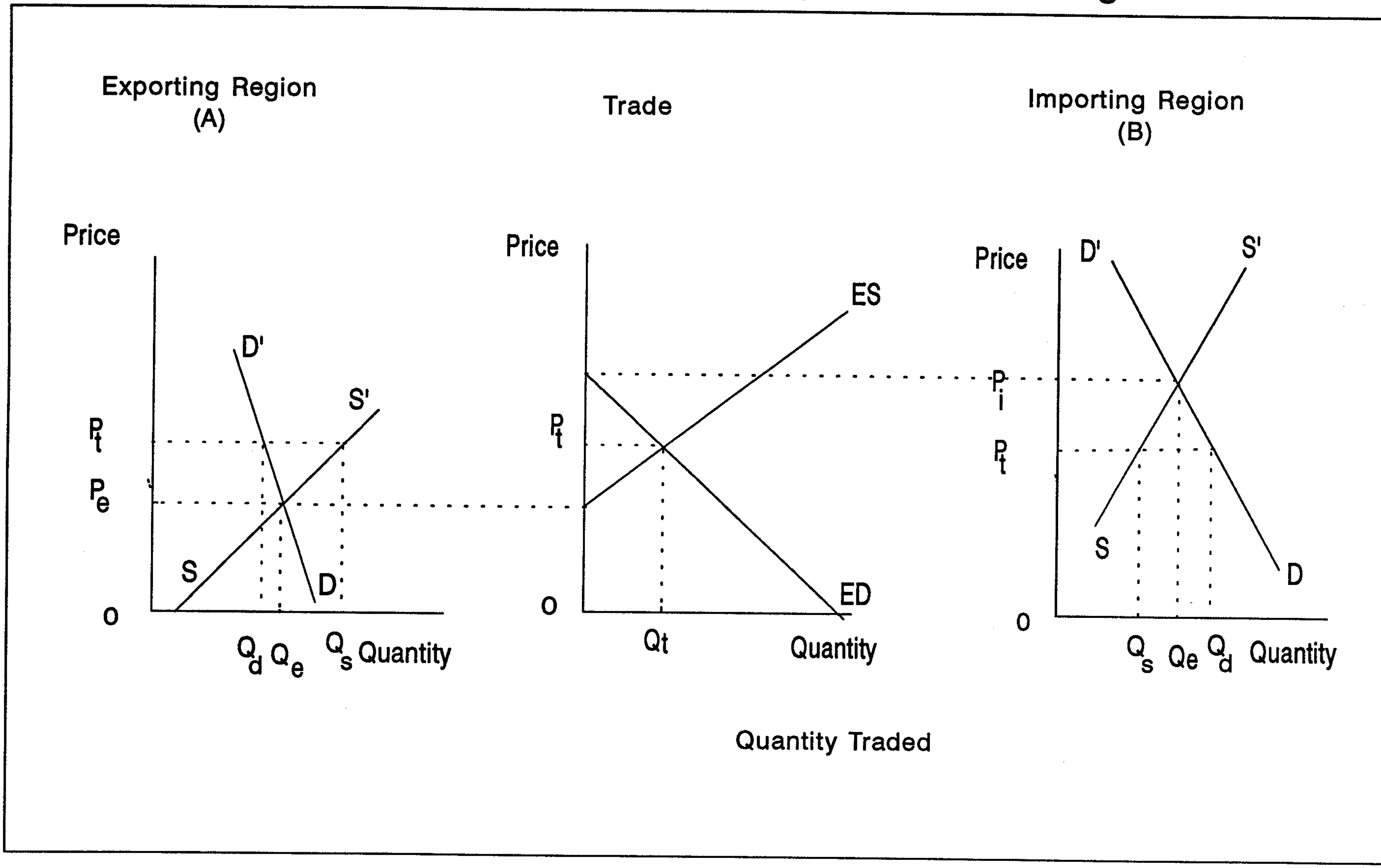
Equilibrium in the interregional commodity market can now be determined by combining the excess supply and excess demand schedule of two regions. If two regions have different prices in the absence of trade, this difference would give rise to trade flows from region A, where prices were low, to region B, where prices are high (Bressler and King, 1970). Assuming zero transportation costs traders in the two markets will arbitrage goods until the prices in the exporting and importing regions are equal. By superimposing one region's excess demand curve over another region's excess supply curve, an equilibrium trade flow can be determined graphically.

2.2.4 A Simple Two-Region Model

This model assumes the world to consist of two regions, A and B, with only one commodity being traded. To keep the model simple, it is further assumed that the currencies used in both regions are of equal value (i.e., one $C= one $US) and that transport cost is zero between the two regions.

The trade equilibrium of a simplistic model such as this one is illustrated graphically in Figure 2.3. Panel (a) and (b) of Figure 2.3 show the domestic demand (DD′) and domestic supply (SS′) curves of region A and region B respectively. The corresponding excess supply curve (ES) and excess demand (ED) curves are shown in panel (c). Panel (c) also shows the equilibrium trade model with equilibrium quantity Q_t being traded at equilibrium price P_t.

Figure 2.3 Determination of Interregional Equilibrium, Two-Region Model



Prior to trade the export region had a lower price (P_e) than the import price (P_i). After trade, the same price (P_t) applies everywhere. After trade occurs, prices rise in the export region (P_t-P_e), demand falls to Q_d and supply increases to Q_s. The opposite occurs in the importing region where prices drop (P_i-P_t), supply drops (Q_i-Q_s) and demand increases (Q_d-Q_i). The equilibrium requires the transfer of the quantity Q_t from the exporting region to the importing region.

2.2.5 Effects of Transport Costs in Interregional Trade

The model developed in section 2.2.4 can be used to analyze the effects of transport cost on the price level and quantity traded on the exportable good. This can be done by relaxing the previous assumption that transport costs were unimportant. Subsequently, a derived demand for transport can be constructed.

The following assumptions are necessary:

a) B is the Importing Region

b) A is the Exporting Region

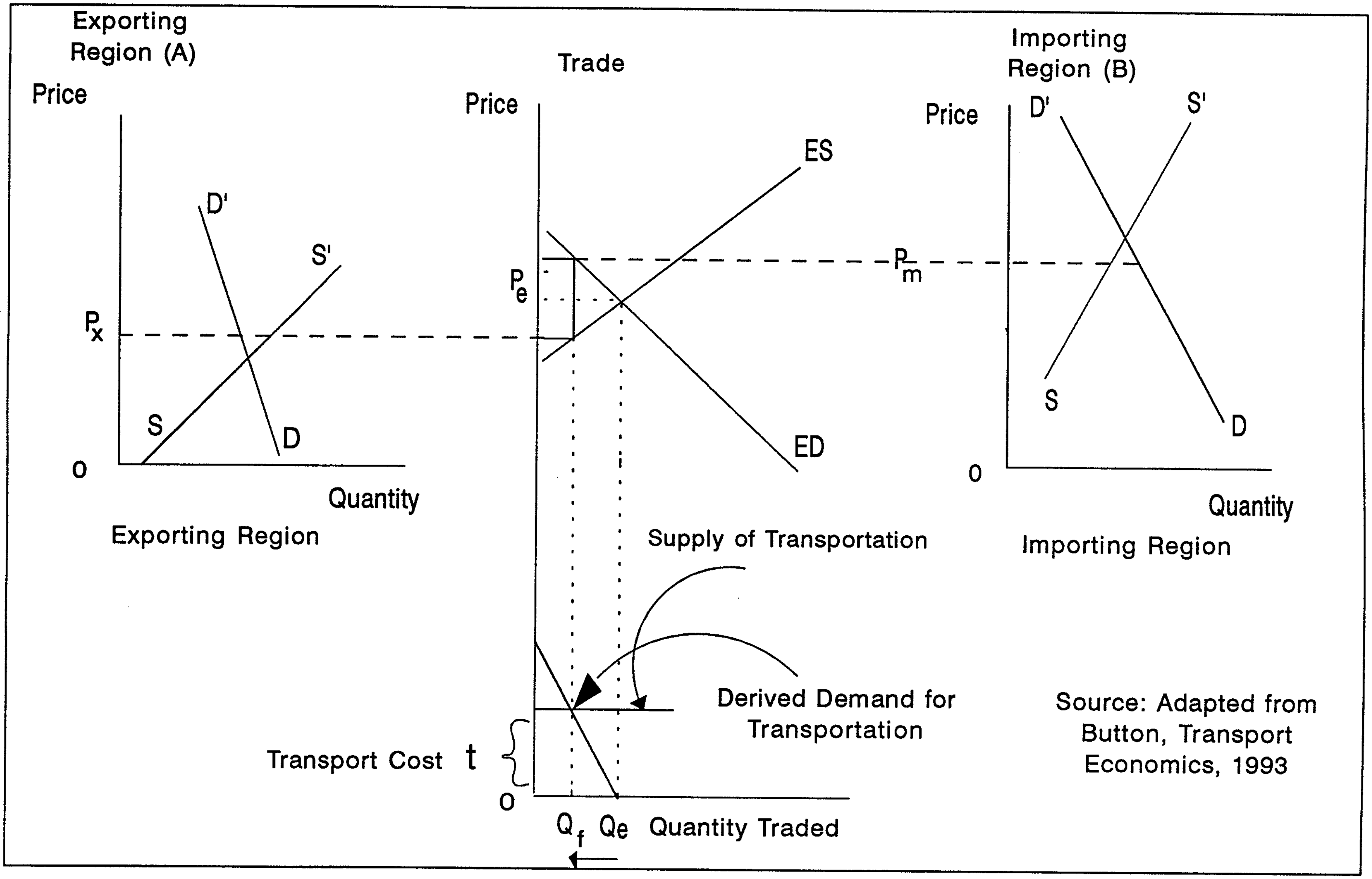
c) exchange rate is fixed

d) there exists free trade between the two regions

By introducing transport costs into the model, it follows that trade will not completely equalize commodity prices. Instead, the prices in the two regions will move toward each other until they differ exactly by the cost of transfer.

Figure 2.4 shows the importing and exporting regions and the interregional trade equilibrium. Bressler and King (1970) explain that in the absence of transfer

Figure 2.4 Derivation of Transport Demand Schedule, Two-Region Model



Source: Adapted from Button, Transport Economics, 1993 costs, both exporting and importing region will engage in trade because the difference in prices, traders buy the commodity in A and sell it in B. Traders will engage in such arbitrage as long as the price in B exceeds that in A.

The total volume of trade is reduced from Q_e (when transport costs are zero) to Q_f when transport cost are greater than zero. In summary, some regions are connected by trade only if the costs of transportation and handling do not exceed the price differences that exits in the absence of trade. Quoting Bressler and King (1970, pp. 90):

> It should be clear that trade will take place between two regions only if the prices in isolation differ by more than transfer costs, and that prices in one region can differ from the ones in another by any amount within the range of plus or minus transfer costs without giving rise to commodity movement.

The potential for product movements between two regions creates a derived demand for transport services. The derived demand for transport cost can be constructed from the interregional trade model (Button, 1987). If the excess demand curved is subtracted vertically from the excess supply curve, the derived demand[6] for transportation can be plotted. The vertical axis represents the freight rates and the horizontal axis represents the traded quantity of transport services in terms of the commodity between regions . The supply of transport is assumed to be perfectly

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[6] **Tomek and Robinson (1990) define primary and derived demands as follows: The ultimate consumer is the one who determines the shape and position of the demand function. For this reason, consumer demand relationships are often referred as primary demand. The term derived demand is used to denote demand schedules for inputs that are used to produce final products. The term derived demand also may be extended to most wholesale-or-farm-level demand functions. Derived demand differs from primary demand by the amount of marketing, transportation, and processing charges per unit of product.**

elastic at freight rate of t per unit. The price of imports P_m in the importing region B, and the price of export is P_x in region A, differ by the freight rate t.

To our knowledge, no one has ever attempted to estimate a derived demand for transport based on this interregional trade model. Observation reveals that the derived demand for transport is essentially a gravity model. This opens a new approach to the analysis of trade policy and commodity marketing. Unlike most efforts to model interregional trade, the gravity model approach does not require any assumptions regarding market price levels. Instead the price differences between markets are assumed to equal the freight rate. In turn the derived demand for transportation expresses the interaction of all market intermediaries.

2.3 Reconciling Gravity Models with Interregional Trade Models

After reviewing gravity models, interregional trade, and demand for transport, we are in a position to apply the theoretical concepts.

Gravity models are important because they estimate the flows of goods between regions and they usually assume that there is a general equilibrium indicating that value of exports of country i and the value of imports equal of foreign sector (It should be noted that gravity models deal with total exports and total imports, but the present model deals with a single commodity). There are many reasons why this assumption may not hold. On the supply side, all countries are not endowed with roughly the same distribution of resources. Resource endowment will have an increasing effect on the size of the foreign sector according to the following classification: balanced endowment, skewed to the production of domestic goods, skewed toward the production of international goods. A similar statement can be made to the demand side. That is, the demand characteristics can be ranked in the order of increasing stimulus to the size of the foreign sector: demand for home goods, demand for own international goods, demand for importables. A third influence why the general equilibrium is disturbed is the cost of international trade. Clearly a country that must incur unusually heavy costs to engage in international trade will have a correspondingly reduced foreign sector. Most of the studies estimate a single gravity equation for a group of countries to explain world trade. As might be expected, the above variables might not be as powerful explanatory variables of the trade in many commodity classes as they are for total trade of all commodities. However, they are fundamental variables that explain the level of imports or exports and the level of trade flows.

Gravity models have been a good predictor of trade flows (Deardorff ,1984)[7], but causal effects have not been explained in microeconomics. In addition, the problem of disequilibrium has been ignored, and value of exports as well as of imports

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[7] According to Deardorff the reason for the empirical success of the gravity models is their ability to incorporate some empirical phenomena not explained by traditional theories. For example, a good deal of trade, especially among the industrialized countries, seems to take place within industries rather than between them. He also mentioned that the proportion of intra-industry trade has grown significantly over time. The factor proportions theory can explain this relative growth of intra-industry trade over time only if factor endowments among the industrialized countries that engage in this trade have become less similar over time. But this seems to be quite the opposite of what has happened in the post-war period. He concluded that intra-industry trade is an empirical phenomenon that is not fully explained by traditional theories. However, he explained that the success of the gravity model is that it applies directly to intra-industry trade, since the dependant variable is gross trade in one direction rather than net trade. Deardorff (1984).

have been set equal to value of the foreign sector. It is worth noting that gravity models rely more heavily on data than on theory for their support.

On the other hand, regional trade models explain why trade occurs and the role of transport costs. Natural endowments contribute to increase the degree of specialisation and develop the comparative advantage. Because a region has specialized in a commodity with lower costs of production, relative to other places, the former has developed a comparative advantage. Producers can exchange their surplus of these products for other commodities they require, but which other areas are better suited to produce. Ullman (1956) says that before one place can supply a particular commodity there must be a demand for that commodity from another place, so that the two places complement each other.

Interregional trade theory posits that, a country will specialise in the export of those products that it can produce at the lowest relative cost, whether this comes from resource endowments, labour or other production costs. On the other hand, gravity models assume that an area has a capacity of supply, but fails to take into account the degree of specialisation. It has been represented by GNP rather than the supply of the commodity itself. Both theories agree that for interaction to take place between two places they must be complementary to each other and that transportation costs are an important determinate of trade.

Interaction between places depends on the presence or absence of intervening opportunities, but gravity models do not consider intervening opportunities that may prevent significant interaction from taking place. Finally, as transport economics suggest, interaction will not take place if cost and effort of movement is too great even if complementarity exists between two places and there are no intervening opportunities. Both gravity models and interregional trade models consider factors that prevent the interactions to take place.

The gravity model and the interregional trade model are two sides of the same coin. Both models assume that transportation costs are the primary determinant of trade flows. The interregional trade models are focused on regional price differences. These models determine commodity flows based on the difference between interregional prices and transportation costs. The traditional gravity models ignores regional price differences and focus on the commodity flows[8]. It is assumed that regional prices have to differ by the value of transportation costs.

The significance of this observation is important. The gravity model gives trade economists a new method for studying interregional commodity flows. The gravity model can be used to estimate the demand for interregional trade of commodities. In essence, it is the reduced form equivalent of the interregional trade models excess supply and excess demand curves.

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8 **This point can clarified by considering demand and supply schedules as follows:**

$$q^d = f(p, D_1, D_2, ...D_n)$$
$$q^s = g(p, S_1, S_2, ...S_m)$$

Which indicate that the quantity demanded depends on the price and a set of demand factor D_i, and that supply behaves similarly. We can solve these equations for the market-clearing quantity :

$$q = q^d = q^s = h(D_1, D_2, ..D_n, S_1, S_2, ..S_m)$$

That is, the observed quantity depends on the demand and supply factors but not on the price variable. Those readers familiar with simultaneous equation methods will recognize this is a reduced-form estimation.

2.4 Conclusions

The review in this chapter has suggested a number of factors determining the level and flow pattern of a country's commodity trade. The starting point was gravity models from the geographers point of view. Spatial interaction models used by Isard and other theorist describe social phenomena in space such as flows of goods. Economist like Linnemann explained that the factors affecting both demand and supply of traded goods are similar, so gravity models are reduced form equations.

Leamer and Stern explained that gravity equations assumed a general equilibrium but they ignored certain factors which disturb this equilibrium. Factors determining flow of goods can summarized by factors contributing to total supply, to total demand and factor resisting trade flows.

The use of distance instead of transport costs may result in an underestimate of the sensitivity of bilateral trade flows. Finally, Anderson derived the multiplicative form of the gravity equation by assuming identical expenditures shares. Anderson has also suggested a theoretical foundation for the equation in terms of a Cobb-Douglas expenditure system with goods differentiated by country of origin.

One of the most important concepts in the traditional interregional theory of trade is that of comparative advantage. Geographic specialization occurs because regions, like individuals are endowed differently with basic resources such as soil, climate, mineral deposits and with human resources that differ in quantity and quality.

Regions can exchange their surplus home products for other commodities they require, but which other people and other areas are better suited to produce.

The interregional trade models are focussed on regional price differences. The direct causes of interregional trade are interregional differences in commodity prices, although the fundamental causes are differences in consumer demands and preferences relative to resource endowments. The direct effects of trade are the equalization of commodity prices among the regions and, under restricted conditions, the equalization of factor prices. Given the realistic facts that resources are not homogeneous among regions, the technology is not identical, and that some regions may be completely specialized as far as some commodities are concerned, a more generally applicable conclusion is that trade transfers demands from resources scarce in a region to the ones that are abundant and relatively cheap in another region and, hence reduces (but normally will not completely eliminate) disparities in factor prices among regions. Thus, the interregional trade will permit increases in production and in productive efficiency and that this, plus the better adjustment of consumption patterns to tastes and preferences, will result in a general improvement in satisfactions and welfare.

Transportation costs act like a wedge to separate prices in different regions. If the prices in the separate markets differ by more than the cost of transportation, trade will occur until the prices differ by no more than the cost of transportation.

There is no literature reporting the estimation of a derived demand for transport, although it has been recognized in interregional trade theory. We propose that the derived demand for transport can be used to estimate the equilibrium of demand and supply for interregional trade flows.

An important feature of the gravity model derived from interregional trade theory assumptions is the explicit introduction of transport cost as an explanatory variable. It is important to note that assumptions required for trade theory equilibrium we required for the gravity model specification (see equation 3.17).

Chapter III

Theoretical Framework

3.1 Introduction

Freight demand analysis has been given scant attention in inter and intra-regional trade studies. First, there are serious practical difficulties associated with the required collection of large quantities of transportation data necessary for freight demand analysis. Freight rates are not readily available from published sources, and every traffic lane has different freight rates. Second, there seems to be a lack of research efforts in the modelling of inter-regional freight transport demand. Most studies of inter-regional trade have been content to make naive assumptions about freight rates. As Ferguson (1972) points out however, such assumptions help explain why econometric trade models often perform so poorly.

Inter-regional freight transport analysis must take into account two distinct, though related problems. The first, concerns the conditions of the supply of transport services while the second concerns the demand for freight transport services. A considerable amount of work has been carried out on the supply side of the freight transport problem, but the demand side of the system has been neglected. The relatively limited amount of detailed work that has been done on freight demand models no doubt reflects the theoretical and practical difficulties.

An interregional framework is used to define the derived demand for transport. In this chapter, a gravity model is derived algebraically within the interregional trade theory framework. Finally, the econometric specification of gravity model is presented.

3.2 Microfoundations of the gravity model using an interregional framework

We start this section by developing a general mathematical model based on the interregional trade theory presented in the last section of the previous chapter. In the next section, we developed a specific econometric model that will be used for empirical analysis in Chapter 4. The one-commodity, two region model can be represented algebraically as follows:

$QS_1 = S_1 (P_1, V_1)$	Exporter's Supply	(3.1)
$QD_1 = D_1 (P_1, V_1)$	Exporter's Demand	(3.2)
$QS_2 = S_2 (P_2, V_2)$	Importer's Supply	(3.3)
$QD_2 = D_2 (P_2, V_2)$	Importer's Demand	(3.4)
$QM_2 = QD_2 - QS_2$	Excess Demand	(3.5)
$QX_1 = QS_1 - QD_1$	Excess Supply	(3.6)
$QM_2 = QX_1$	Market Clearing Condition	(3.7)

If this assumes transport cost, then the equilibrium is

$QM_2 = QX_1$ is equal to 0 if $P_2 - P_1 \leq F_{12}$;

or greater than 0 if P_2-P_1 is $\rangle$ F_{12} meaning that trade will take place between region one and two only if prices in isolation differ by more than transfer costs. Otherwise, the trade is equal to zero.

Where

QS_i = represent the quantities supplied of the commodity in region i...(i=1,2)

QD_i = represent the quantities demanded of the commodity in region i...(i=1,2)

V_i = are vectors of exogenous supply and demand shifters on region i..(i=1,2)

QM_2 = represent the import quantities

QX_1 = represent the export quantities

F_{12} = transport costs to move one unit from region 1 to region 2

P_i = is the commodity's price in region i..(i = 1,2)

In order to keep the model uncomplicated there are assumed to be no significant currency exchange rate differences, tariffs or inventory holding policies in the two countries (e.g. Canada, and U.S.)[9]. The exchange rate can be taken into account when total income and transport costs are exchanged into common currency.

The pre-trade price gap measures the difference between the price of a commodity in the importing region (2) and the price of the same commodity in the exporting region (1), when no trade takes place between those two regions.

In the pre-trade situation, the price of the commodity of region 1, P_1, is determined by the intersection of the local supply curve (equation 3.1) of the region 1

[9] These assumptions are logical since we want to quantify the changes on transport cost on the trade of pork. There is no stock in these models since we deal with annual commodity flows only. Second, tariffs on pork are practically nil and NAFTA promises to make it easier for Canadians, Americans and Mexicans to do business by removing barriers and clarifying the rules of commerce

and the curve for the total demand, local and foreign, with the exception of the region 2 (equation 3.2).

Similarly, in the pre-trade situation the price of the commodity in the region 2, P_2 is determined by the intersection of the local demand curve (equation 3.4) for the region 2 and the curve for the total supply from domestic as well as foreign sources (equation 3.3), except for region 1.

The excess supply and demand curves depend on the reactions of consumers and producers in response to higher prices, plus the vector of supply and demand shifters. The excess supply is affected by the price of the commodity (P^{es}), disposable income (Y_1), the production specialization index (Ind_1) for the region 1. A general form of the excess supply can be represented by equation 3.8 as follows:

$$QX_1 = qx_1\ (P_{es}\ ,\ Y_1\ ,\ Ind_1) \qquad (3.8)$$

Where:

P_{es} *exporting price (f.o.b.)*
Y_1 *is the disposable income in the exporting region* 1
Ind_1 *is the self-sufficiency index in region* 1

The production specialization index is a per capita measure. Those regions with excess capacity (high production per capita) will export their excess to other areas with low capacity (low production per capita). The index is based on production and the population of the state; if the state has a higher ratio of production-population it is more self sufficient. Depending on the level of consumption the region will be an exporter or an importer of product.

The local demand shifter is assumed to be income, while the shifter of production capacity of the region is captured by an index of production specialization. A specific form of equation 3.8 can be written as:

$$QX_1 = a + \alpha_0 P_{es} - \alpha_1 Y_1 + \alpha_2 Ind_1 \qquad (3.9)$$

The excess supply curve for export of the commodity (3.9) from the exporting region to the importing region denoted QX_1 can be rewritten as (this can be easily done by the reader by taking the inverse function of 3.9):

$$P_{es} = P_1 + \beta QX_1 + \gamma_1 Y_1 - \gamma_2 Ind_1 \qquad (3.10)$$

This inverse demand function equation is represented in logarithm form with the coefficients as elasticities.

For example P_{es} = ln P_{es}; P_1 = ln P_1; QX_1 = ln QX_1; Y_1 = lnY_1; Ind_1 = lnInd$_1$.

The importing region is assumed to be affected by similar variables as the exporting region. Demand is influenced principally by prices and income, while supply is affected by prices and the specialization of production in this commodity.

The excess demand curve is shifted by factors like disposable income (Y_i), and the index of production specialization (Ind), while its slope is determined by the local supply and demand responses to changes in the importing price ($P^2{}_m$) of the commodity in that region. As is well known, the change in income will shift the local demand and therefore will shift the excess demand equation. On the other hand, the supply of commodity is determined by the price of the commodity (i.e. price of pork as well as the price of hogs). A decrease in factor costs increases (shifts) the supply of pork which in turn decreases (shift up) the excess demand for pork in the importing region.

$$QM_2 = QM_2 \ (P_{ed}, \ Y_2 \ , \ Ind_2) \qquad (3.11)$$

where:

P_{ed} is the importing price (c.i.f.)
Y_2 is the disposable income in the importing region 2
Ind_2 is the index of specialization in region 2

A specific form of equation 3.11 can be written as :

$$QM_2 = b - \phi_0 \ P_{ed} + \phi_1 \ Y_2 - \phi_2 \ Ind_2 \qquad (3.12)$$

The excess demand curve for imports denoted QM_2 can be written as:

$$P_{ed} = P_2 - \alpha QM_2 + \gamma_3 Y_2 - \gamma_4 Ind_2 \qquad (3.13)$$

The maximum freight rate F equals the difference between P_{ed} and P_{es}. The demand for trade can be represented by this relationship between F and Q (at equilibrium Q = QX_1 = QM_2). Equation (3.14) gives the derived demand for transport, F, as a function of P_2, P_1, Y_1, Y_2, Ind_1 and Ind_2 as defined in (3.10) and (3.13).

$$F = P_2 - P_1 - (\alpha + \beta)Q - \gamma_1 Y_1 + \gamma_2 Ind_1 + \gamma_3 Y_2 - \gamma_4 Ind_2 \qquad (3.14)$$

In equation 3.12 the derived demand for transport is represented as:

$$F = G - (\alpha + \beta)Q - \gamma_1 Y_1 + \gamma_3 Y_2 + \gamma_2 Ind_1 - \gamma_4 Ind_2 \qquad (3.15)$$

Where G denotes the pre-trade gap (P_2 - P_1).

Solving for Q, equation 3.15 becomes:

$$Q = \frac{G}{\alpha+\beta} - \frac{F}{\alpha+\beta} - \frac{\gamma_1 Y_1}{\alpha+\beta} + \frac{\gamma_3 Y_2}{\alpha+\beta} + \frac{\gamma_2 Ind_1}{\alpha+\beta} - \frac{\gamma_4 Ind_2}{\alpha+\beta} \qquad (3.16)$$

Rearranging equation 3.13 as a function of the freight rate and taking the anti-logarithm of both sides of the equation, we obtain a gravity model equation:

$$Q_{12} = \frac{G^{\frac{1}{\alpha+\beta}} Y_2^{\frac{\gamma_3}{\alpha+\beta}} Ind_2^{-\frac{\gamma_4}{\alpha+\beta}} Y_1^{-\frac{\gamma_1}{\alpha+\beta}} Ind_1^{\frac{\gamma_2}{\alpha+\beta}}}{F_{12}^{\frac{1}{\alpha+\beta}}} \qquad (3.17)$$

This equation represents a version of the gravity model based on the interregional framework. An increase of one percent of income in the exporting region, Y_1 negatively affects the quantity interchanged by $(-\gamma_1/\alpha+\beta)$ because it increases (shifts up) the local demand. Higher consumption in the surplus region, diminishes the quantity available for trade. The index of production specialization has the similar effect in the importing region. The greater the local production of the commodity, the less they need to import. More specifically, an increase of one percent of production of pork in the importing region, Ind_2, decreases quantity imported by $(-\gamma_4/\alpha+\beta)$ percent. On the other hand, an increase in the income of importing region and an increase in the specialization of production in the exporting region (one percent increase in Y_2 or Ind_1), leads to higher trade levels (an increase of $\gamma_3/(\alpha+\beta$ or $\gamma_2/\alpha+\beta$ percent respectively). It should be noted that the coefficients in equation 3.16 represent elasticities. As with prices, it is not absolute levels that matter, but the relative levels of income and production in the two regions that determine the potential increase or decrease in the flow of trade.

As implied in equation 3.15, the slope of the derived demand for transport depends on the slope of both excess supply and demand equations $(\alpha + \beta)$, and is more elastic relative to excess supply and demand curves. For simplicity, it is assumed that transport costs account for all the difference between the prices of the two regions.

With zero transport cost the quantity demanded in the market is:

$$\ln Q = \frac{\ln G}{\alpha + \beta} + \frac{\gamma_3}{\alpha + \beta} \ln Y_2 - \frac{\gamma_1}{\alpha + \beta} \ln Y_1 + \frac{\gamma_2}{\alpha + \beta} \ln Ind_1 - \frac{\gamma_4}{\alpha + \beta} \ln Ind_2 \quad (3.18)$$

When transport cost differ from zero, the equilibrium market will be:

$$Q = \frac{G - F}{(\alpha + \beta)} + \frac{\gamma_3}{\alpha + \beta} Y_2 - \frac{\gamma_1}{\alpha + \beta} Y_1 + \frac{\gamma_2}{\alpha + \beta} Ind_1 - \frac{\gamma_4}{\alpha + \beta} Ind_2 \quad (3.19)$$

Where

Q = Ln Q; F = Ln F; Y_2 = Ln Y_2 ; Y_1 = Ln Y_1 ; Ind_1 = Ln Ind_1 ;

Ind_2 = Ln Ind_2

The effect of a change in the transport cost F on the volume traded can be determined by taking the total derivative of the above equation:

$$dQ = -\frac{1}{(\alpha + \beta)} dF + \frac{\gamma_3}{\alpha + \beta} dY_2 - \frac{\gamma_1}{\alpha + \beta} dY_1 + \frac{\gamma_2}{\alpha + \beta} dInd_1 - \frac{\gamma_4}{\alpha + \beta} dInd_2 \quad (3.20)$$

A unit change in freight cost changes the volume traded by the factor $-1/(\alpha+\beta)$. Assuming a perfectly competitive transport market, the freight rate equals the long run marginal cost. The marginal freight revenue is obtained by taking the derivative of the product FQ with respect to Q

$$\frac{\partial(FQ)}{\partial q} = G - 2(\alpha + \beta)Q \qquad (3.21)$$

Profit maximization requires that the marginal freight revenue equals the marginal costs, MC:

$$\frac{\partial(FQ)}{\partial Q} = MC \qquad (3.22)$$

This condition can be expressed in terms of the optimal freight rate, F^*

$$\textit{When } MC = G\text{-}2(\alpha+\beta)Q, \qquad (3.23)$$

then the trade flows between region 1 *and* 2 *will be stable*

If conditions in the two markets cause Q to increase, then more transport services will be added, until the relationship MC=G-2(α + β) is returned. Conversely, if for some reason MC increases, then the quantity traded, Q, must decline, ceteris paribus.

This section demonstrates the linkage between commodity trade and transport cost algebraically in the form of a derived demand for transport (equation 3.14). It also demonstrates that the gravity model equation (3.17) is consistent with the inter-regional trade framework. It is important to note that the gravity model (3.17) requires equilibrium in all regional markets and demand and supply of transport consistent with (3.14).

3.3 Inter-regional Gravity Trade Econometric Model

This section of the thesis, specifies an econometric model for pork exports for Western Canada to the U.S.. The purpose of the model is to test the significance of transport costs in explaining the variation in the quantities of Western Canadian pork exports to different states in a period of time (1989, 1990, 1991, 1992). British Columbia is considered as a pork production deficit area within Western Canada. Manitoba, Saskatchewan and Alberta are the only provinces included in the model because they not only supplied and fulfil the local provincial demand but they also export the excess to deficit production areas. Final destinations and quantities of pork traded from Manitoba to the U.S. differ from Saskatchewan's and Alberta's exports.

The point of departure is the general gravity equation model (equation 3.17) developed in the previous section. The empirical model is just a specific application of that model (equation 3.17). Deriving the empirical model means repeating the same procedure as in the previous section with identical results except that the sub-indicies are different. Flows along a link of a transport system are explained by structural variables indicating: (i) the factors responsible for export of the commodity in question from the region of origin i (i.e. Ind_1, Y_1); (ii) the factors leading to import of the commodity in question to the region destination j (i.e. Y_2, Ind_2); (iii) the factors tending to impede the flows of traffic along a given link. These are called friction variables (i.e. F).

In the empirical model, we use the gravity model developed in equation 3.17 except that instead of using two regions, we apply this model to multi-regional pork trade between the Western Canadian Provinces and the individual states of the United States. Equation 3.17 is linearized by taking the natural logarithm, as was presented in equation 3.19. When natural logs are applied to equation 3.17 the exponents can be interpreted as elasticities. Also it should be noticed that when natural logs are applied to equation 3.17, the equation can be expressed in an additive form. Since one of the objectives of this study is to estimate transport cost elasticities, that conversion simplifies the calculation. The specific model for the analysis of a single country's (Canada's) export of pork is presented:

$$Q_{ij} = f(\underset{(-)}{F_{ip}}, \underset{(+)}{Y_p}, \underset{(-)}{Ind_j}) \qquad (3.24)$$

$$i = 1..3$$
$$j = 1..n$$

where

Q_{ij} = is the dependent variable and represents the total exports of Manitoba, Alberta and Saskatchewan (i=1,2,3) pork in truck load units (40,000 lbs) to each individual U.S. state j[10].

[10] Note that the number of importing states varies by year and by exporting province.

F_{ij} = truck load freight rate for pork from Manitoba, Saskatchewan and Alberta to each individual U.S. state j, expressed in American dollars per load truck. The negative sign in the equation means that freight rates and quantity exported are negatively related.

Y_j = is the real total disposable income in state j in U.S. in American dollars. The positive sign means that real income and quantity exported are positively related.

Ind = is the per capita pork production in region j in U.S. (number of hogs divided by state population). The negative sign means that per capita pork production in the U.S. region is negatively related to quantity exported.

Income affects pork consumption, but not likely as strongly the prices of other foods such as beef, chicken, etc. However, there are no data available for the retail prices of substitutes at the state level in the U.S..

Because the origin is fixed, the relative income and production specialization index are represented by only the income and the production specialization index of the importing state.

Since the one of the objectives of this study is to measure the effects of freight rate changes on the exports of pork from the prairie provinces, the explanatory variable that is of major importance in equation (3.23) is the freight cost variable F. Based on a *priori* economic reasoning, this is expected to be negatively related to the dependent variable Q_{ij}, (i.e.,$\partial Q_{ij}/\partial F < 0$). Also, exports are affected in a negative direction by specialization production of the commodity by the importing state (i.e. $\partial Q_{ij}/\partial Ind < 0$).

The model postulates that an increase in total disposable income in the importing state, leads to a rise of Canadian exports (i.e. $\partial Q_{ij}/\partial Y_j > 0$). This variable is expressed in American dollars. The model assumes that there are no basic differences in tastes between regions.

Finally the construction of the specialization index (Ind) of pork production indicates that if the state is capable of supplying more than its own domestic market, the excess production is shipped to the other deficit production states within the U.S.. Consequently, the specialization variable works as a repulsion or a pull variable. It is a repulsion variable if the state is a surplus area and highly specialized in pork production, or a pull variable is the state is a deficit area.

This section specified the econometric model for pork from Western Canada to the U.S.. The following section describes the techniques used to estimate the model.

3.4 Estimation Procedure

The choice of a proper estimation technique for the gravity econometric model depends on the nature of the problem and the objectives to be achieved. Since one of the major objectives in this thesis is to estimate the freight rate elasticities of pork exports, consistency of the estimates is of major importance.

Kmenta (1986) has pointed out that when we are dealing with microeconomic data over the cross sectional units, the values of the explanatory variable are not typically of a similar order of magnitude. The same is true of the values of the dependant variable as, for example, in the case of data on income and expenditure of individual families or when dealing with observations in geographic divisions as countries, states or cities, etc. Here the assumption of homoscedasticity is not very plausible. The appropriate model in this case may be one with heteroscedastic disturbances.

If the assumption of homoscedastic disturbance is not fulfilled we have the following consequences:

1) we cannot apply the formulae of the variances of the coefficients to conduct test of significance and construct confidence intervals. The tests are inapplicable.

2) if μ is heteroscedastic, the OLS estimators do not have the minimum variance property in the class of unbiased estimators; that is, they are inefficient in small samples.

3) the coefficient estimates would still be statistically unbiased; that it, even if the μ's are heteroscedastic, the $\bar{b}$ will have no statistical bias; their expected value will be equal to the true parameter,

$$E\ (\bar{b}) = b_i$$

4) The prediction (of Y for a given value of X) based on the estimates b_i's from the original data, would have a high variance, that is the prediction would be inefficient. Because the variance of the prediction includes the variances of mu and the parameter estimates, which are not minimal due to the incidence of heteroscedasticity.[11]

When we are dealing with cross-section and time series data there are a number of techniques suggested by Kmenta to estimate the econometric model. Here the behaviour of the disturbances over the cross-sectional units (households, states, countries, etc) is likely to be different from the behaviour of the disturbances of a given cross-sectional unit over time. Further, it is frequently assumed that the regression disturbances are mutually independent but heteroscedastic. Concerning the time series data, one usually suspects that disturbances are autoregressive.

Kmenta (1986) has also pointed out that when the cross sectional units are geographical regions with arbitrarily drawn boundaries --such as the states of the United States-- we would not expect that the cross-sectional are mutually independent. Thus, when we drop the assumption of mutual independence, we have what may be termed a cross-sectionally correlated and time-wise autoregressive model. With this in mind, the present analysis is extended to that technique.

The technique involves the application of OLS to all pooled observations to eliminate the autocorrelated disturbances. Second, we apply the OLS method to the transformed variables to obtain an asymptotically efficient estimator of the regression

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[11] For a detailed explanation of these consequences of heteroscedasticity, the reader is referred to Kmenta, J., Elements of Econometrics, MacMillan Publishing Company, 1986, pp. 270-289

coefficients and their variances. The specification of the behaviour of the disturbances in this model is as follows:

1) the variance of the disturbance is not constant for all observations

2) the disturbances are not mutually independent

3) the disturbances are autorregressive

Because one of objectives of this study is to estimate elasticities, each equation is estimated in the log-linear form. Each exporting province has different markets. The log-linear model, also called the double log model, is of the following form:

Consider our model:

$$Q_{ij} = \frac{G^{\frac{1}{\alpha+\beta}} \; Y_j^{\frac{\gamma_1}{\alpha+\beta}} \; Ind_j^{-\frac{\gamma_2}{\alpha+\beta}}}{F^{\frac{1}{\alpha+\beta}}} \qquad (3.25)$$

Which may be expressed alternatively as:

$$Ln\ Q_{ij} = \frac{1}{\alpha+\beta}\ Ln\ G + \frac{\gamma_1}{\alpha+\beta}\ Ln\ Y_j - \frac{\gamma_2}{\alpha+\beta}\ Ln\ Ind_j - \frac{1}{\alpha+\beta}\ Ln\ F \quad (3.26)$$

The above equation can be rewritten (see equation 3.16) as:

$$\overline{Q} = \Gamma + \beta_1 \overline{Y}_j - \beta_2 \overline{Ind}_j - \beta_3 \overline{F} + U_i \quad (3.27)$$

where:

$$\overline{Q} = Ln\ Q, \overline{Y}_j = \ln\ Y, \overline{Ind}_j = Ln\ Ind, \overline{F} = Ln\ F$$

Where α = (Ln $G/\alpha+\beta$) and β_i parameters correspond to the parameters in equation 3.22. The use of the log-linear model greatly simplifies the estimation process and subsequent analysis. For instance, this model is linear in the parameters α and β_i and linear in the logarithms of the dependent and independent variables. One attractive feature of the log-linear model of the type described in equation 3.23 above is the slope coefficient β_i measures the elasticity of Q with respect to Y, Ind and F. Since heteroscedasticity is a major concern an added advantage of the log-linear form is that a log arithmetic transformation very often reduces heteroscedasticity. This is because a logarithmic transformation compress the scales in which the variables are measured (Gujarati, D., 1978, pp. 210)

3.5 Conclusions

The interregional trade theory explained in Chapter 2 was used to develop the mathematical model in this chapter. We start from an equilibrium market in the two regions scenario for a single commodity traded. Since the exporting region has comparative advantage with respect to the importing region for the commodity produced, the exporting region ships its excess production to the deficit areas. We then derived excess supply and excess demand equations from the market equilibrium in the respective regions. By subtracting the excess demand from the excess supply equations, we derived the demand for transportation equation, or the gravity equation in the international trade literature. In this way the microfoundations of the gravity model have been established within an interregional trade framework. This version of the gravity equation represents the linkage between two distinct but related theories (inter-regional and international trade theories).

The effect of transport costs on the quantity of the commodity traded is also estimated and the maximum freight rate determined base on a perfectly competitive transport market.

An inter-regional gravity trade econometric model was developed to explained the trade flows of pork from Western Canada to the U.S.. Three variables chosen were those considered to be the most important : disposable income, the specialization production index and freight costs. Finally, the econometric techniques and the procedure to estimate the gravity equation were discussed.

Chapter IV

Empirical Model

4.1 Introduction

This chapter presents the estimation of the derived transport demand model equation (3.23) described in the previous chapter. The pooled cross-section time series technique is used to estimate the present model as described in Kmenta (1986). The pooling technique employs a set of assumptions on the disturbance covariance matrix that gives a cross-sectionally heteroscedastic and timewise autoregressive model[12].

Koo and Karemera (1991) parameterized their econometric model over time and cross-section units. According to them, this is especially needed for agricultural commodities because weather conditions make trade flows highly volatile in importing and/or exporting countries. A particular year may not provide accurate information to evaluate trade-flows of a commodity with cross-section data only. Therefore, a pooling technique that combines the cross-section and time series data was considered appropriate to estimate the parameters for each province.

The results obtained with the gravity model of the derived demand for transport are discussed in this chapter. Inferences are made regarding the effects of transport cost on the trade of Western Canadian Pork to the U.S. Finally, the model is used to

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[12] For a detailed description of the model the reader is suggested to refer to Kmenta (1986), Section 12.2, pp. 616-622.

examine the penetration of Western Canadian pork exports in specific U.S. state markets.

4.2 Economic Analysis

As explained previously, the model is intended to determine the main factors explaining the trade flows for pork from Western Canada to U.S., as well as to quantify (in terms of elasticities) the impact of transport cost. The model is not expected to have the same explanatory power for each of the western provinces because of their export diversity. For example, the greater dependence of Saskatchewan on a single market (California) tends to make the results of its estimation less reliable than the equations for Alberta or Manitoba, which have more diverse export patterns.

4.2.1 The Manitoba, Saskatchewan and Alberta Transport Derived Demand Equations

The empirical results show that the transport demand for pork is directly related to income and is inversely related to the specialization index and freight cost variables. The model behaved reasonably well. All the explanatory variables have the hypothesized sign and are statistically significant.

Tables 4.1 and 4.2 set out alternative regression specifications. The simplest version of the model (Equation 1) follows directly from the theoretical specification of the gravity model. The results of this model are shown in Table 4.1. Table 4.2

Table 4.1 Summary of Cross-Section Time Series results for the Transport Derived Demand Model by Province

Province / Variable Manitoba	Parameter Estimate	Standard Error	T Ratio 116 D.F.	R-Square 0.5955
Dependent Variable :LQ				
Intercept	2.567	5.902	0.435	
Income Elasticities	0.917	0.174	5.285	
Specialization Index Elasticities	-0.450	0.135	-3.334	
Transport Costs Elasticities	-3.329	0.769	-4.331	

Province / Variable Saskatchewan	Parameter Estimate	Standard Error	T Ratio 72 D.F.	R-Square 0.2931
Dependent Variable :LQ				
Intercept	15.324	4.709	3.254	
Income Elasticities	0.199	0.111	1.793	
Specialization Index Elasticities	-0.252	0.064	-3.939	
Transport Costs Elasticities	-2.632	0.544	-4.840	

Province / Variable Alberta	Parameter Estimate	Standard Error	T Ratio 104 D.F.	R-Square 0.5735
Dependent Variable :LQ				
Intercept	0.541	4.079	0.133	
Income Elasticities	0.324	0.110	2.953	
Specialization Index Elasticities	-0.205	0.068	-3.012	
Transport Costs Elasticities	-0.997	0.418	-2.386	

Table 4.2 Summary of Cross-Section Time Series results for the Transport Using a Dummy Variable Derived Demand Model by Province

Province / Variable Manitoba	Parameter Estimate	Standard Error	T Ratio 115 D.F.	R-Square 0.7797
Dependent Variable :LQ				
Intercept	0.120	4.656	0.026	
Income Elasticities	0.623	0.164	3.803	
Specialization Index Elasticities	-0.276	0.116	-2.373	
Transport Costs Elasticities	-2.0189	0.641	-3.151	
Dummy	2.299	0.354	6.493	

Province / Variable Saskatchewan	Parameter Estimate	Standard Error	T Ratio 71 D.F.	R-Square 0.7473
Dependent Variable :LQ				
Intercept	14.001	2.937	4.774	
Income Elasticities	0.171	0.117	1.462	
Specialization Index Elasticities	-0.202	0.058	-4.002	
Transport Costs Elasticities	-2.392	0.472	-5.069	
Dummy	3.091	0.354	8.720	

Province / Variable Alberta	Parameter Estimate	Standard Error	T Ratio 103 D.F.	R-Square 0.9525
Dependent Variable :LQ				
Intercept	4.373	2.407	1.816	
Income Elasticities	0.265	0.100	2.644	
Specialization Index Elasticities	-0.204	0.035	-5.757	
Transport Costs Elasticities	-1.353	0.265	-5.110	
Dummy	3.487	0.186	18.769	

presents results for a modified version of the model that includes a dummy variable (Equation 2) that distinguishes high volume from low volume importer states. The dummy variable was set to 1 if the state imported more that 500,000 kg of pork per year, 0 otherwise. The dummy variable was added because the original equation specification under-estimated trade flows. The economic logic of the dummy variable lies in the difference between relational trade linkages and spot market trade flows. Discussions with Canadian pork exporters revealed that they enjoy long term relations with some import markets, like California, North Dakota and Minnesota. These markets have disproportionably large volumes, and are consistent importers. The "spot market states" have relatively small volumes and do not import in every year. As a result, the gravity model without the dummy variable produces an average that does not represent either type of market (i.e. the spot markets are over-estimated, and the relational markets are under-estimated). The remainder of the analysis is based on the second specification of the model (Equation 2).

The magnitude of the income coefficients are smaller than one for all provinces. The quantities of pork traded are less sensitive to total income in importing states for Saskatchewan and Alberta than they are for Manitoba. The income coefficient may be interpreted as the percentage change in quantity of pork exported corresponding to a one percent change in income, other factors held constant. This is consistent with the idea that as income increases, a consumer buys more of most products. The results suggest that Manitoba pork exports may be more responsive to changes in U.S. income than Alberta and Saskatchewan exports. This may be because of the greater proportion of mid-western and eastern U.S. markets that Manitoba serves. It is also worth noting that currency exchange rate changes are captured by the income variable. If the value of the Canadian dollar declines relative to the U.S. dollar, the income in the U.S. rises.

Elasticity of pork demand with respect to the specialization index tends to be low for each province and all elasticities fall between a narrow range (from -0.201 to -0.276). The higher elasticity of pork demand with respect to the specialization index in Manitoba and Alberta relative to Saskatchewan might be due to volatile movements of pork to certain marginal markets. The highly inelastic nature of this variable is interesting. It suggests that U.S. pork is not a perfect substitute for Canadian pork. A rise in U.S. pork production has a relatively small impact on the volume of Canadian pork exports, at least under the conditions that prevailed during this time period.

Although the United States is the biggest pork export market for the Western Provinces, large quantities are shipped interprovincially. For instance, an estimated 167 million kg of pork (carcass weight) was produced in Manitoba, of which 33 million was consumed within the province, 110 million kg were sold to other provinces, and 34 million were exported[13]. Pork traded between Manitoba and the rest of Canada is 5 times (110 million kg) larger than pork traded between Manitoba and the United States (24 million kg) in 1994[14]. Although, an increase in the pork

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[13] This information was provided in a personal interview with Janet Honey from Manitoba Agriculture. There are no data available in interprovincial pork trade within Canada.

[14] In 1992, Canada's GDP was $687 billion Canadian dollars and Population was 27.3 million and U.S.A.'s Population was 253 million and GDP was 7194.4 billion Canadian dollars. Population in the U.S.A. is almost 10 times Canada's population and almost 11 times its GDP. McCallum (1995), reported that total trade between two

production in the U.S. increases the specialization index (which in turn affect negatively the demand for Western Canadian pork imports). The decrease in demand for Western Canadian pork will be slight because the provinces depend heavily on interregional trade within Canada. This model fails to take into account the interprovincial trade because there are no data available of interprovincial trade in Canada.

In the theoretical derivation of the derived demand for transport in chapters 2 and 3, the quantity imported and freight rate were found to be inversely related. The freight rate variable (F) which is of major importance here, has the hypothesized sign for the period analyzed (1989-1992). The Manitoba and Saskatchewan freight variables are more elastic than Alberta's freight elasticity. This suggests that Manitoba and Saskatchewan pork exports are more sensitive to changes in transport costs. If transport costs are important in determining the structure of Manitoba and Saskatchewan pork exports, so are the delivered prices.

As in the theoretical model, the transportation costs represent the difference between the import and export prices. One explanation for the elastic demand for transportation is that Manitoba and Saskatchewan encounter particularly strong price competition in the group of U.S. importing states that form their markets. The model implies that a one percent change in the freight rate in Manitoba and Saskatchewan is likely to result in an inverse change of 2.01 and 2.39 percent in the demand for pork respectively in the United States.

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provinces can be 20 times larger than between a province and a state.

On the other hand, Alberta pork exports appear to be less sensitive to transport cost than the other Western provinces. A one percent increase in transport costs in Alberta causes only a 1.35 percent decrease in exports and viceversa. One possible explanation is that Alberta hog processors have larger gross margins that enable them to absorb a narrowing of the import/export price difference. There are some indirect evidence to support this contention. Prices of hogs dropped as a result of a countervail duty (CVD $4.39 Cdn on live hogs) imposed in live hogs in Canada by the U.S. Department of Commerce in June 1985. However, the resulting prices changes was not uniform across Canada. Alberta registered the lowest selling prices in Western Canada (A complete price analysis of hog before and after the countervail duty can be found in Benson, Bruce L. et al). Lowest slaughter hog prices (which persisted in 1989 to 1992) along with lower labour cost in Alberta might have resulted in relative higher gross margins for Alberta pork processors (assuming similar slaughtering-processing costs across Western Canada). Consequently, Alberta hog processors can ship to distant points to eastern region of the U.S. despite the narrowing of price differences.

The lower freight rate elasticity for Alberta might also be explained by the backhaul freight rates out in Alberta. Prentice et al (1992) report Western Canada's trade deficit in southbound refrigerated freight was estimated in more than 500 thousand tonnes in 1989. As could be expected, imbalances in product movements cause backhaul freight rate opportunities. Carriers adjust their rates down to the southern regions to attract freight and obtain a better balance. To show this with an example, Prentice et al (1992) compared fronthaul and backhaul rates for 6 major Canadian cities and two cities in the U.S.. An average lower southbound (backhaul) freight rates of 1.14, 0.84, 1.02, and 1.06 $US/mile for British Columbia, Alberta, Saskatchewan and Manitoba were associated with higher northbound (fronthaul) freight rates (1.44, 1.45, 1.30 and 1.15 respectively). If freight rates out of Alberta are lower than out of the other Western provinces, then a percentage change will give a lower absolute price change. Consequently, the Alberta exporters would be less affected and the elasticities of transport demand could be expected to be lower.

The estimated transport cost elasticities for Western Canadian pork exports are relatively high compared to the coefficients of transport demand reported in the literature. One reason might be that most of these other studies used distance as a proxy for transport costs, which may result in a serious underestimate of the sensitivity of trade flows to transport costs (as reported by Geraci and Prewo (1977)). The second reason might be the nature of the data set (cross sectional/time series). Estimates obtained from time series analysis are viewed as short time responses, while cross sectional estimates are assumed to approximate long run responses. The third reason is that most of the published transport demand elasticities refer to ocean borne trade because most global trade is transported by water. The movement of agricultural products between Canada and U.S.A. is primarily by truck. Water transport is much cheaper than other modes of transport so the demand elasticities could be lower.

According to Wilson (1980), demand elasticities for transport also tend to be greater the lower the level of aggregation, and the higher the ratio of freight changes to the delivered price of the commodity. In the case of this analysis, the aggregation is minimal because only pork is considered. With respect to the ratio of freight costs to product price, the value is generally low[15]. Consequently, the freight rate elasticities calculated in this model seem plausible.

As derived in Chapter 3 (Equation 3.15), the derived demand for transport can be represented for each province using the results and coefficients from the gravity model as follow:

$$F_{Mb\text{-}USA} = 0.0594 + 0.308\,Y_i - 0.137\,Ind_i - 0.495\,Q_{Mb\text{-}USA} + 1.139\,Dummy$$

$$F_{Sk\text{-}USA} = 5.853 + 0.071\,Y_i - 0.084\,Ind_i - 0.4180\,Q_{Sk\text{-}USA} + 1.292\,Dummy$$

$$F_{Al\text{-}USA} = 3.232 + 0.195\,Y_i - 0.150\,Ind_i - 0.739\,Q_{Al\text{-}USA} + 2.577\,Dummy$$

Transportation costs represent the difference between the import and export prices and is denoted by the intercept of the above equations. As implied in the above equations, the slope (elasticity) of the derived demand for transport depend on the slope of both excess supply and demand equations.

Test for Heteroscedasticity

As suggested by the theory when we are dealing with microeconomic data, the observations may involve substantial differences in magnitude. Therefore, we performed and carried out several heteroscedasticity tests.

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[15] Assuming a freight rate of $4,000 on a 20 ton shipment, the cost would be $0.10 per pound. On pork, this would be less than 10 percent of the product price, or a ratio of 1:10. In contrast, grain shipments could have a ratio of 1:3

The null hypothesis is that the variance of the disturbance term is the same across states in the U.S.A.. As can be seen in the following Table 4.3 heteroscedasticity is no longer a problem with the modifications made to the equation.

Table 4.3 Heteroscedasticity Tests for Manitoba, Alberta and Saskatchewan demand for transport.

$H_o = \sigma_1^2 = \sigma_2^2 = \sigma_3^2 = ...\sigma_m^2$				
H_A is not true				
Variance σ_i^2 of the disturbance	X^2 Calc.	D. F.	Conf Inter Equat 1	X^2 Test
Manitoba				
E**2 on YHAT	0.868	1	3E-5 to 7.879	Accepted
E**2 on YHAT**2	0.552	1	"	Accepted
E**2 on LOG(YHAT**2)	5.902	1	"	Accepted
E**2 on LAG(E**2) ARCH Test	0.330	1	"	Accepted
E**2 on X (B-P-G)	8.799	3	7.17E-2 to 12.838	Accepted
Alberta				
E**2 on YHAT	6.948	1	3E-5 to	Accepted

$H_o = \sigma_1^2 = \sigma_2^2 = \sigma_3^2 = ...\sigma_m^2$				
H_A is not true				
E**2 on	8.635	1	"	Rejected
E**2 on LOG(YHAT**2)	5.945	1	"	Accepted
E**2 on LAG(E**2) ARCH Test	11.904	1	"	Rejected
E**2 on X (B-P-G)	7.856	3	7.17E-2 to 12.838	Accepted
Saskatchewan				
E**2 on YHAT	7.084	1	3E-5 to	Accepted
E**2 on	4.625	1	"	Accepted
E**2 on LOG(YHAT**2)	4.655	1	"	Accepted
E**2 on LAG(E**2) ARCH Test	12.212	1	"	Rejected
E**2 on X (B-P-G)	9.858	3	7.17E-2 to 12.838	Accepted[16]

[16] Heteroscedasticity tests for equation 2 are shown in the Appendix II

A Lagrange multiplier test for heteroscedasticity developed by Breusch and Pagan (1979) suggests that the error term has no serious heteroscedasticity with cross-section time series data. Most of the tests carried out to each province indicate that heteroscedasticity is not longer a problem.

4.3 Market Penetration Analysis

The gravity model provides a general guide to the relationship between income of the importing region and the cost of moving supplies from the origin to destination. One use of this information is to explore the issue of market penetration. The model yields expected volumes of exports to each destination. These data can be compared to actual shipments. States that are consistently importing less than expected may be identified as promising targets for export market development[17].

Tables 4.4, 4.5 and 4.6 present the current imports (by volume) for the most important importing states in the U.S. from Manitoba, Saskatchewan and Alberta. These tables also present the below-average importer-states and their respective difference in truck load units (a truck load unit is equivalent to 40,000 lbs) between the expected and the actual imports from the same states predicted by the gravity model.

The three provinces present similar characteristics, those importer states that import frequently (each year) and regular quantities (almost the same quantities each

[17] The definition of "promising" is somewhat arbitrary. In this analysis, a state with less than expected imports for three of the four years is judged as promisisng. Those states with greater than 10 truckloads in 1992 are classed as the most promising.

Table 4.4 (a) **Actual and Expected Imports of Pork from Manitoba, by U.S. states, 1989 - 1992**

Manitoba State Destination	Actual Imports of Pork (Truck Load Units) 1989	1990	1991	1992	Expected Imports of Pork (Truck Load Units) 1989	1990	1991	1992
Alabama	9.45	0.00	0.00	1.05	1.55	1.55	1.59	1.82
California	23.99	6.08	5.46	27.24	9.43	8.67	8.39	9.03
Colorado	0.60	0.00	9.86	1.05	3.00	2.82	2.61	3.01
Connecticut	6.56	0.00	0.00	2.06	4.45	4.35	4.27	4.98
Dist of Columbi	0.00	0.00	0.00	0.00	2.62	0.87	0.86	1.05
Florida	0.00	0.56	4.21	0.00	3.16	3.28	3.23	3.79
Georgia	1.05	4.22	0.00	0.00	1.84	1.92	1.90	2.19
Idaho	0.00	0.00	0.00	0.00	0.31	0.34	0.36	0.40
Illinois	29.27	19.02	0.00	20.30	6.62	6.69	6.62	7.41
Iowa	23.87	0.00	1.10	1.05	2.65	2.67	2.62	2.88
Kansas	0.00	5.10	0.00	0.00	2.46	2.49	2.54	2.85
Kentucky	1.28	0.00	0.00	0.00	1.87	1.94	1.94	2.24
Louisiana	0.00	2.10	0.00	0.00	2.72	2.84	2.74	3.17
Maine	5.16	0.41	0.00	0.00	0.96	4.03	0.96	1.08
Maryland	0.00	0.00	0.00	0.00	41.01	1.41	1.37	1.53
Massachusetts	59.78	22.51	9.55	23.86	1.35	40.89	41.66	47.00
Michiga	41.45	11.08	11.38	23.48	4.75	4.78	4.70	5.27
Minnesota	161.38	60.12	63.50	143.40	82.05	82.65	80.57	93.02
Missouri	0.00	0.00	0.00	0.00	0.99	0.98	1.00	1.10
Montana	0.00	0.00	0.00	0.00	1.31	1.35	1.33	1.51
Nebraska	17.86	1.97	13.82	0.00	1.60	1.62	1.62	1.80
Nevada	0.00	0.00	0.00	0.00	1.61	1.71	1.74	2.20
New Jersey	139.38	8.05	30.85	26.97	70.06	74.54	74.49	78.78
New Mexico	0.00	0.00	0.00	0.00	1.11	1.11	1.16	1.34
New York	115.45	62.94	31.96	21.30	93.41	99.21	99.27	110.74
North Dakota	2.87	0.00	2.13	0.49	4.93	5.05	5.03	5.84
Ohio	5.93	2.06	2.19	2.20	4.09	4.18	4.22	4.86
Oklahoma	0.00	1.05	6.31	5.04	2.09	2.15	2.21	2.35
Oregon	0.45	0.00	1.15	4.05	1.95	2.06	2.11	2.45
Pennsylvania	177.52	14.68	21.83	7.70	32.71	33.78	33.59	37.85
Rhode Island	74.32	26.29	11.41	3.52	1.17	1.21	1.16	1.30
South Dakota	19.27	2.15	0.75	2.35	1.52	1.50	1.48	1.72
Tennesse	0.00	0.00	0.00	0.00	0.94	0.99	0.98	1.15
Texas	49.48	132.59	8.05	13.32	71.05	70.84	73.28	82.36
Utah	0.00	0.00	0.00	0.00	2.65	2.57	2.52	2.77
Virginia	55.40	4.05	7.27	14.90	2.26	2.31	2.32	11.12
Washington	112.92	1.04	1.05	11.01	36.18	37.29	37.39	46.53
Wisconsin	41.52	41.76	57.71	182.76	48.09	48.74	48.85	54.96
Total	1,176	430	302	539	553	567	565	645

Actual less Expected Imports

Truck Load Units	1989	1990	1991	1992	Promising
Alabama	7.90	-1.55	-1.59	-0.77	*
California	14.56	-2.60	-2.92	18.21	
Colorado	-2.40	-2.82	7.25	-1.96	*
Connecticut	2.11	-4.35	-4.27	-2.92	*
Dist of Columbia	-2.62	-0.87	-0.86	-1.05	*
Florida	-3.16	-2.71	0.98	-3.79	*
Georgia	-0.78	2.30	-1.90	-2.19	*
Idaho	-0.31	-0.34	-0.36	-0.40	*
Illinois	22.65	12.34	-6.62	12.90	
Iowa	21.22	-2.67	-1.52	-1.83	*
Kansas	-2.46	2.61	-2.54	-2.85	*
Kentucky	-0.58	-1.94	-1.94	-2.24	*
Louisiana	-2.72	-0.74	-2.74	-3.17	*
Maine	4.19	-3.63	-0.96	-1.08	*
Maryland	-41.01	-1.41	-1.37	-1.53	*
Massachusetts	58.43	-18.39	-32.11	-23.13	**
Michigan	36.70	6.30	6.68	18.21	
Minnesota	79.33	-22.53	-17.07	50.38	
Missouri	-0.99	-0.98	-1.00	-1.10	*
Montana	-1.31	-1.35	-1.33	-1.51	*
Nebraska	16.27	0.35	12.20	-1.80	
Nevada	-1.61	-1.71	-1.74	-2.20	*
New Jersey	69.32	-66.48	-43.64	-51.80	**
New Mexico	-1.11	-1.11	-1.16	-1.34	*
New York	22.04	-36.27	-67.31	-89.44	**
North Dakota	-2.06	-5.05	-2.90	-5.35	*
Ohio	1.84	-2.12	-2.03	-2.66	*
Oklahoma	-2.09	-1.10	4.10	2.68	
Oregon	-1.50	-2.06	-0.96	1.60	*
Pennsylvania	144.81	-19.09	-11.76	-30.15	**
Rhode Island	73.15	25.08	10.25	2.22	
South Dakota	17.75	0.65	-0.72	0.63	
Tennesse	-0.94	-0.99	-0.98	-1.15	*
Texas	-21.58	61.75	-65.23	-69.03	**
Utah	-2.65	-2.57	-2.52	-2.77	*
Virginia	53.14	1.74	4.95	3.78	
Washington	76.74	-36.24	-36.34	-35.53	**
Wisconsin	-6.57	-6.97	8.85	127.60	
	624	(138)	(263)	(106)	

Table 4.5 Actual and Expected Imports of Pork from Saskatchewan, by U.S. states, 1989 - 1992

Saskatchewan Actual Imports of Pork

State Destination	Truck Load Units 1989	1990	1991	1992
Arizona	0.00	0.00	0.00	0.00
California	1077.89	136.75	109.98	160.78
Colorado	0.00	0.00	0.00	0.00
Connecticut	0.00	0.00	0.00	0.00
Dist of Columbia	0.00	0.00	0.00	0.00
Florida	0.00	0.00	0.10	0.00
Goergia	0.00	0.00	0.00	0.00
Idaho	0.00	0.00	0.00	0.00
Illinois	0.00	1.88	5.05	20.99
Iowa	1.29	0.00	0.00	2.95
Kansas	0.00	0.00	0.00	0.00
Kentucky	0.00	0.00	0.00	0.00
Lousiana	0.00	0.00	0.00	0.00
Maine	0.00	0.00	0.00	0.00
Massachusetts	5.62	3.19	0.00	0.00
Maryland	0.00	0.00	0.00	1.14
Michigan	0.00	0.00	0.00	0.00
Minnesota	15.07	0.00	0.59	1.08
Missouri	0.00	0.00	0.00	0.86
Montana	0.00	0.00	0.00	0.00
Nebraska	13.13	0.06	1.93	0.00
Nevada	0.00	0.00	0.00	0.00
NJ	0.00	0.00	0.00	0.98
New Mexico	0.00	0.00	0.00	0.00
NY	63.10	11.55	16.42	25.03
North Dakota	188.10	36.72	108.81	338.92
Ohio	0.00	0.00	0.00	0.00
Oklahoma	0.00	0.00	0.00	0.00
Oregon	0.00	0.00	0.00	0.00
Pensylvannia	0.00	0.60	0.00	0.00
Rhode Island	0.00	0.00	0.00	0.00
South Dakota	0.00	0.00	0.00	0.00
Tennesse	0.00	0.00	0.00	0.00
Texas	6.37	0.00	0.00	2.09
Utah	1.61	15.67	5.27	0.00
Virginia	6.38	0.00	0.92	80.22
Washington	8.89	0.74	0.00	0.00
Wisconsin	0.00	1.98	1.94	29.37
Total	1387	209	251	664

Expected Imports of Pork

State Destination	Truck Load Units 1989	1990	1991	1992
Arizona	2.10	1.35	1.34	1.47
California	49.84	44.97	43.24	46.32
Colorado	1.98	1.84	1.69	1.88
Connecticut	2.23	2.13	2.06	2.35
Dist of Columbia	3.22	0.87	0.84	0.98
Florida	0.71	0.70	0.68	0.78
Goergia	0.27	0.27	0.26	0.29
Idaho	0.41	0.42	0.42	0.46
Illinois	1.80	1.74	1.69	1.87
Iowa	1.73	1.66	1.61	1.75
Kansas	0.87	0.85	0.84	0.93
Kentucky	1.90	1.89	1.83	2.07
Lousiana	0.71	0.71	0.67	0.75
Maine	0.95	1.36	0.90	1.00
Massachusetts	1.07	1.09	1.10	1.22
Maryland	0.95	0.94	0.91	1.00
Michigan	0.91	0.89	0.86	0.96
Minnesota	2.52	2.42	2.34	2.62
Missouri	0.99	0.95	0.94	1.03
Montana	2.99	3.00	2.84	3.18
Nebraska	1.22	1.18	1.15	1.26
Nevada	1.77	1.76	1.73	2.05
NJ	1.61	1.62	1.60	1.70
New Mexico	1.24	1.20	1.20	1.35
NY	35.74	16.96	35.40	38.70
North Dakota	80.39	186.24	76.06	84.80
Ohio	0.85	0.84	0.82	0.92
Oklahoma	2.00	1.98	1.97	2.09
Oregon	1.64	0.40	0.39	0.44
Pensylvannia	0.89	0.87	0.86	0.69
Rhode Island	0.80	0.79	0.75	0.83
South Dakota	0.33	4.81	4.60	5.20
Tennesse	0.64	0.65	0.62	0.71
Texas	1.43	1.35	1.36	1.49
Utah	2.00	1.86	1.78	1.93
Virginia	17.47	17.02	16.84	18.82
Washington	3.95	3.83	3.75	4.39
Wisconsin	2.87	1.85	1.83	2.01
Total	233	314	218	241

Actual less Expected Imports

Truck Load Units	Act-Exp 1989	Act-Exp 1990	Act-Exp 1991	Act-Exp 1992	Promising
Arizona	-2.10	-1.35	-1.34	-1.47	*
California	1028.04	91.78	66.74	114.46	
Colorado	-1.98	-1.84	-1.69	-1.88	*
Connecticut	-2.23	-2.13	-2.06	-2.35	*
Dist of Columbi	-3.22	-0.87	-0.84	-0.98	*
Florida	-0.71	-0.70	-0.58	-0.78	*
Goergia	-0.27	-0.27	-0.26	-0.29	*
Idaho	-0.41	-0.42	-0.42	-0.46	*
Illinois	-1.80	0.15	3.36	19.12	
Iowa	-0.44	-1.66	-1.61	1.20	*
Kansas	-0.87	-0.85	-0.84	-0.93	*
Kentucky	-1.90	-1.89	-1.83	-2.07	*
Lousiana	-0.71	-0.71	-0.67	-0.75	*
Maine	-0.95	-1.36	-0.90	-1.00	*
Massachusetts	4.55	2.10	-1.10	-1.22	
Maryland	-0.95	-0.94	-0.91	0.15	*
Michigan	-0.91	-0.89	-0.86	-0.96	*
Minnesota	12.56	-2.42	-1.74	-1.53	*
Missouri	-0.99	-0.95	-0.94	-0.17	*
Montana	-2.99	-3.00	-2.84	-3.18	*
Nebraska	11.91	-1.12	0.78	-1.26	
Nevada	-1.77	-1.76	-1.73	-2.05	*
New Jersey	-1.61	-1.62	-1.60	-0.72	*
New Mexico	-1.24	-1.20	-1.20	-1.35	*
NY	27.36	-5.41	-18.97	-13.67	**
North Dakota	107.71	-149.53	32.75	254.11	
Ohio	-0.85	-0.84	-0.82	-0.92	*
Oklahoma	-2.00	-1.98	-1.97	-2.09	*
Oregon	-1.64	-0.40	-0.39	-0.44	*
Pensylvannia	-0.89	-0.27	-0.86	-0.69	*
Rhode Island	-0.80	-0.79	-0.75	-0.83	*
South Dakota	-0.33	-4.81	-4.60	-5.20	*
Tennesse	-0.64	-0.65	-0.62	-0.71	*
Texas	4.94	-1.35	-1.36	0.60	
Utah	-0.39	13.80	3.49	-1.93	
Virginia	-11.09	-17.02	-15.92	61.40	*
Washington	4.93	-3.10	-3.75	-4.39	*
Wisconsin	-2.87	0.13	0.11	27.36	
	1155	-105	33	424	

Table 4.6 Actual and Expected Imports of Pork from Alberta, by U.S. states, 1989 - 1992

Alberta State Destination	Actual Imports of Pork (Truck Load Units)				Expected Imports of Pork (Truck Load Units)				Actual less Expected Imports (Truck Load Units)				
	1989	1990	1991	1992	1989	1990	1991	1992	1989	1990	1991	1992	Promising
Arizona	6.17	3.34	5.51	2.26	5.03	2.65	2.70	2.87	1.14	0.69	2.81	-0.61	
California	279.34	276.82	761.61	524.68	129.71	222.30	216.73	225.06	149.63	54.52	544.88	299.62	
Colorado	2.36	0.00	0.00	5.17	3.04	2.88	2.70	2.93	-0.68	-2.88	-2.70	2.24	*
Connecticut	0.00	0.00	0.00	0.00	4.75	4.63	4.56	5.04	-4.75	-4.63	-4.56	-5.04	*
Dist of Columbi	0.00	0.00	0.00	0.00	4.34	2.06	2.04	2.31	-4.34	-2.06	-2.04	-2.31	*
Florida	0.00	0.00	1.04	2.15	3.14	2.22	2.19	2.43	-3.14	-2.22	-1.15	-0.27	*
Georgia	0.51	3.08	0.00	0.00	0.99	1.01	1.00	1.09	-0.48	2.06	-1.00	-1.09	*
Idaho	4.92	0.00	1.03	2.58	0.98	1.02	1.05	1.11	3.94	-1.02	-0.02	1.47	
Illinois	15.44	15.91	5.13	5.55	4.24	4.24	4.19	4.49	11.19	11.67	0.94	1.07	
Iowa	0.61	1.00	0.00	4.20	1.16	1.15	1.13	1.19	-0.55	-0.15	-1.13	3.01	*
Kansas	0.00	0.88	0.00	0.00	1.48	1.48	1.49	1.60	-1.48	-0.60	-1.49	-1.60	*
Kentucky	0.00	0.00	0.00	0.00	2.58	2.61	2.59	2.85	-2.58	-2.61	-2.59	-2.85	*
Louisiana	0.00	0.00	0.00	0.00	1.97	2.01	1.94	2.12	-1.97	-2.01	-1.94	-2.12	*
Maine	0.00	0.00	0.00	0.00	2.05	3.72	2.03	2.18	-2.05	-3.72	-2.03	-2.18	*
Maryland	0.00	0.00	0.00	0.00	1.95	1.99	1.95	2.08	-1.95	-1.99	-1.95	-2.08	*
Massachusetts	2.04	6.30	1.58	2.06	2.68	2.66	2.71	2.92	-0.64	3.63	-1.13	-0.86	*
Michigan	53.97	25.11	114.24	65.29	71.84	71.66	70.53	75.81	-17.87	-46.55	43.71	-10.52	**
Minnesota	96.56	19.78	137.22	89.31	67.50	67.22	65.83	71.63	29.07	-47.44	71.39	17.68	
Missouri	0.00	0.00	0.00	0.00	1.54	1.52	1.53	1.62	-1.54	-1.52	-1.53	-1.62	*
Montana	1.68	0.00	1.06	1.00	2.56	2.62	2.55	2.76	-0.88	-2.62	-1.49	-1.76	*
Nebraska	0.87	0.00	2.07	0.00	1.08	1.08	1.07	1.14	-0.21	-1.08	1.00	-1.14	*
Nevada	19.46	9.01	40.36	3.68	92.65	94.44	95.43	110.13	-73.18	-85.43	-55.07	-106.46	**
New Jersey	3.68	0.00	0.05	3.15	3.52	3.65	3.65	3.76	0.16	-3.65	-3.59	-0.61	*
New Mexico	0.12	1.05	0.00	0.00	2.22	2.19	2.25	2.45	-2.11	-1.14	-2.25	-2.45	*
New York	6.18	11.08	5.05	11.04	3.82	3.96	3.96	4.21	2.36	7.13	1.08	6.83	
North Dakota	1.04	0.00	1.00	0.00	1.61	1.63	1.60	1.74	-0.57	-1.63	-0.61	-1.74	*
Ohio	1.72	5.93	0.00	0.00	2.07	2.09	2.09	2.28	-0.35	3.84	-2.09	-2.28	*
Oklahoma	0.00	0.00	0.00	0.00	2.91	2.94	2.99	3.08	-2.91	-2.94	-2.99	-3.08	*
Oregon	118.41	36.89	115.89	302.37	41.09	42.26	42.80	46.81	77.31	-5.37	73.09	255.56	
Pensylvannia	3.65	0.00	0.00	4.10	1.97	1.99	1.98	2.12	1.68	-1.99	-1.98	1.97	*
Rhode Island	0.00	0.00	0.00	0.00	2.78	2.42	2.34	2.51	-2.78	-2.42	-2.34	-2.51	*
South Dakota	0.00	0.00	0.00	0.00	0.59	2.72	2.66	2.92	-0.59	-2.72	-2.66	-2.92	*
Tennesse	0.00	0.00	0.00	0.00	1.56	1.61	1.58	1.74	-1.56	-1.61	-1.58	-1.74	*
Texas	10.42	1.00	1.05	5.09	3.29	3.24	3.30	3.52	7.14	-2.24	-2.25	1.58	*
Utah	0.33	1.05	0.00	0.00	3.91	3.77	3.67	3.85	-3.58	-2.72	-3.67	-3.85	*
Virginia	21.10	0.00	201.70	5.23	49.18	49.57	49.74	53.97	-28.09	-49.57	151.96	-48.73	**
Washington	323.37	164.14	234.14	396.61	227.60	229.10	228.08	260.49	95.76	-64.96	6.06	136.12	
Wisconsin	3.29	5.71	1.03	25.62	2.05	2.04	2.04	2.18	1.25	3.68	-1.00	23.44	
Total	977	588	1,631	1,461	757	852	843	923	220	(264)	788	538	

year) are not signalled as promising markets. However, those markets with wide variations, large quantities one year and low quantities the following year are reported as potential markets. Western provinces also exported pork to some states only one year may be considered as marginal markets, but also signal potential markets.

Figure 4.1 (a) and (b) and 4.2(c) and (d) graphically present the more promising markets predicted by the gravity model for Manitoba, Saskatchewan and Alberta. These markets are serving the most populated and richest (in terms of total income) states in the U.S.. The number in each state indicates the number of truckloads by which shipments are short of expectations. Note that these markets are sensitive to transport cost. A small drop in the transport costs allow Western pork processors to penetrate new markets. For instance, by reducing transport cost by one percent, pork processors in Manitoba can penetrate markets in the south east, north east and south east regions as shown in Figure 4.1. However, many markets seem to be under served. The markets that are most under-served like Texas, in the case of Manitoba, could be target for development into "relational" markets rather than just "spot" markets.

As indicated in the previous section, Manitoba's export market is determined by transport cost. A change in transport cost can increase exports substantially in existing markets. Saskatchewan, on the other hand, presents a few markets where it can penetrate. Since the Alberta export market seems to be less sensitive to transport cost than the other two provinces, Alberta presents a more diversified market potential as seen in figure 4.2 (c). Alberta has assumed a steadily increasing share of Western

Figure 4.1 States receiving fewer shipments of pork from Manitoba and Saskatchewan in 1992 than expected using the gravity model Equation 2 (numbers indicate the number of truckloads by which shipments are short of expectations)

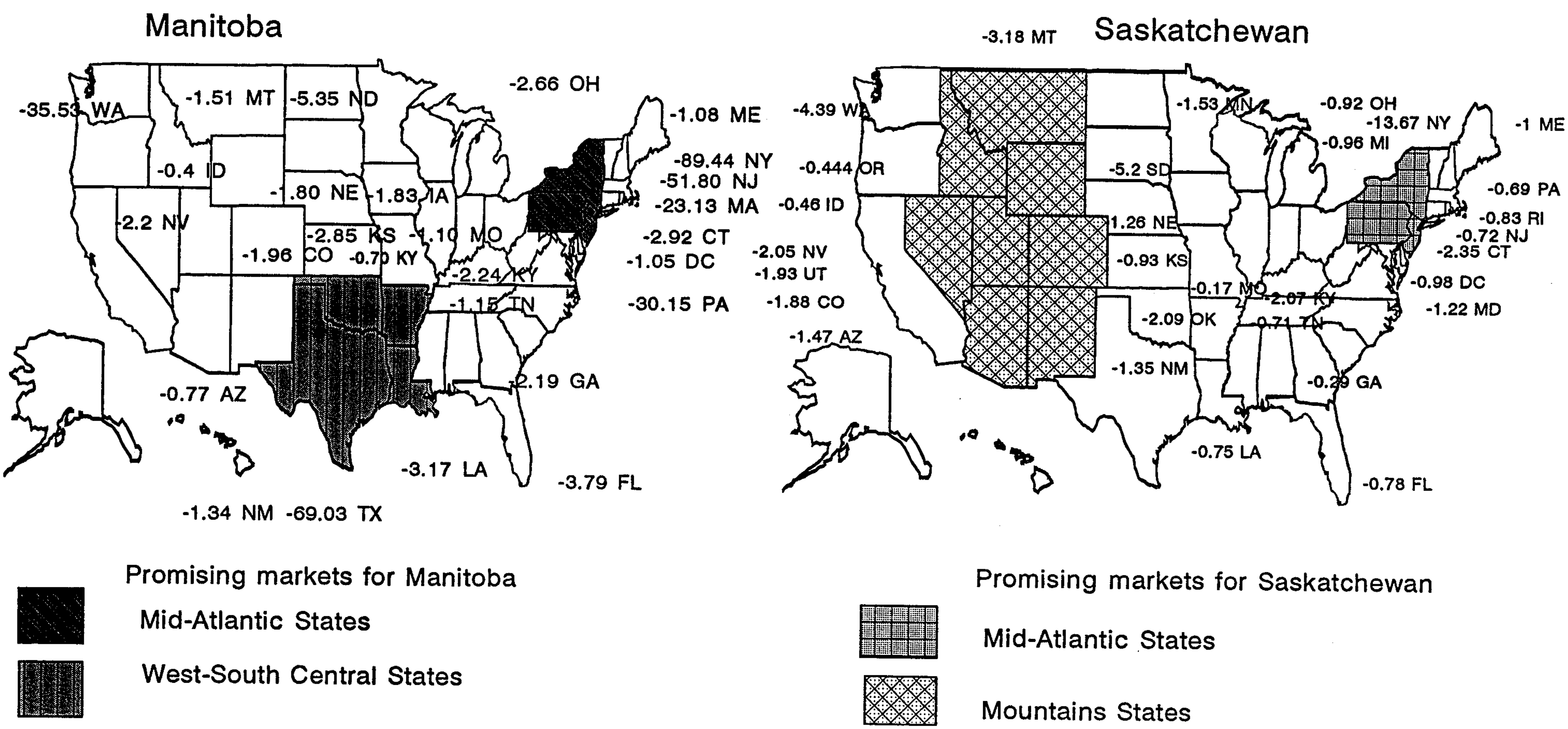


Figure 4.2 (c) States receiving fewer shipments of pork from Alberta from 1989 to 1992 than expected (numbers indicate the number of truckloads by which shipments are short of expectations)

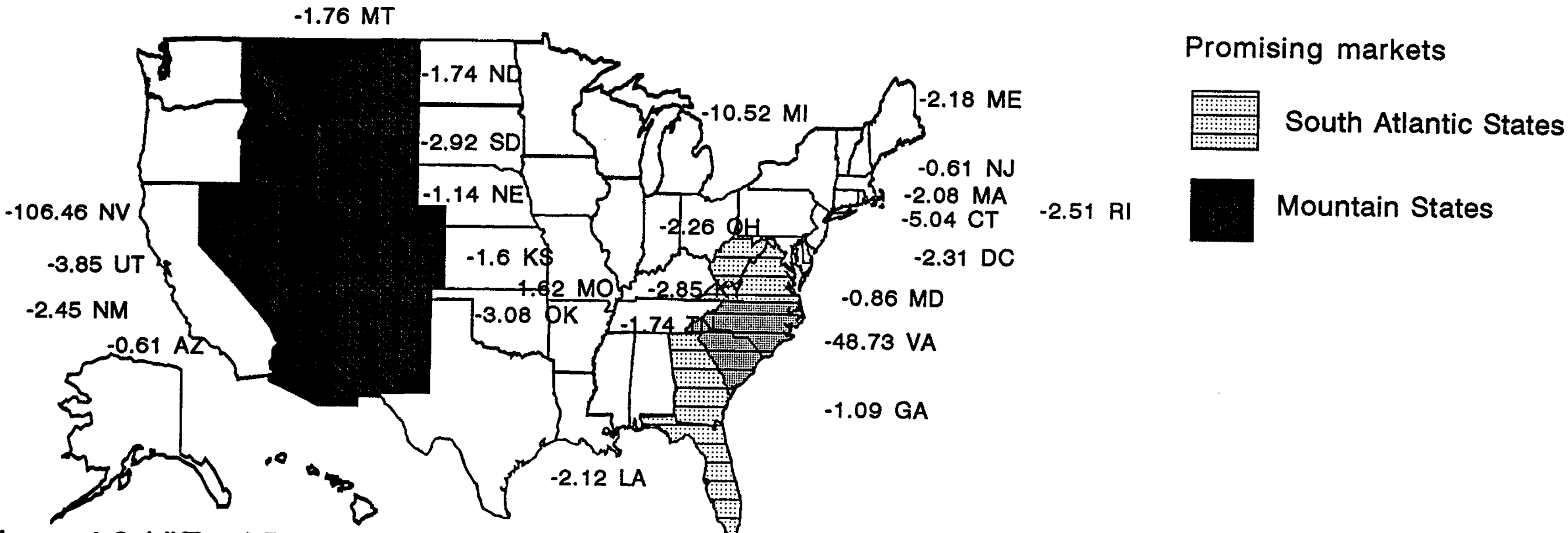
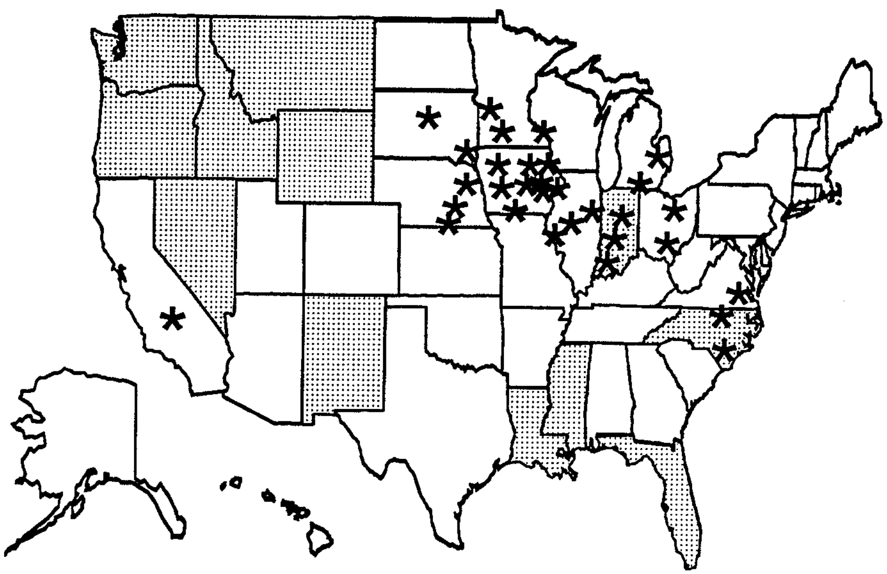
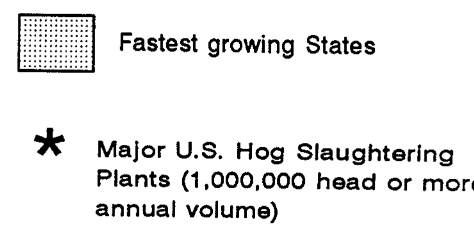


Figure 4.2 (d)Total Personal Income: Percent Change, 1989-92



	Percent Change	
	Personal Income	
States	Total	Population
Montana	9.0	2.1
Idaho	9.3	3.1
Florida	7.4	1.5
Mississippi	6.9	1.1
New Mexico	7.7	2.2
Nevada	9.1	3.9
Wyoming	6.1	1.2
North Carolina	6.4	1.6
Louisiana	5.0	0.4
Indiana	5.6	1.0
Oregon	6.6	2.0
Washington	5.1	2.2



Source: U.S. Department of Commerce, Bureau of Economic Analysis

Canadian pork exported to U.S. since 1990. This increased share is due to relatively flat levels of pork exported to U.S. by the other Western Provinces and substantial increase annual sales to the U.S. from Alberta. Alberta pork packers might have taken advantage of this situation by providing a regular supply of pork to these far away regions (see figure 4.2 (c)) which might become regular markets in the future.

Figure 4.2 (d) illustrates the fastest growing states for the period 1989 to 1992 in terms of percentage change in total personal income and population. Figure 4.2 (d) also maps the location of the major U.S. hog slaughtering plants. Thus, the potential markets for the prairie provinces in the U.S. tend to be where the fastest changes in total personal income are occurring and where the production of pork is generally low. These market potentials exist at current freight rates. A reduction in freight rates, or delivered prices to the region could create a large demand for pork.

4.4 Conclusions

The main factors included in the single commodity gravity inter-regional trade model (transport cost, index of specialization and total income) explain the pork traded from Western Canada to the U.S.. Saskatchewan seems to be the most sensitive to transport cost indicating that a reduction of freight rates can open new market opportunities in the U.S.. Saskatchewan has few market opportunities even if transport cost are reduced. Saskatchewan and Manitoba pork exports were determined by transport cost and delivered prices. Given that Manitoba and Saskatchewan transport cost elasticities are high, it was inferred that they encounter stronger competition in the U.S. importing states markets. As opposed to Manitoba's and Saskatchewan's market scenario, Alberta presents a very wide market potential. Since Alberta is less sensitive to transport cost than the other two provinces, Alberta might be able to penetrate a wider range of states. Higher gross margins might explain the insensitivity to transport cost in Alberta.

Total incomes in the importing states is an important factor explaining the trade pork flow. Manitoba pork exports were the most sensitive to changes in income in the importing areas.

The specialization index can slightly affect the quantity exported from Western Canada. Since pork exports from Western Canada also include interprovincial movements, an increase in the production of hogs in the U.S. will not affect substantially the quantity exported. All North American hog prices are linked through trade. If an increase in U.S. production caused their prices to drop, the same would occur in Western Canada and other parts of the country where pork is shipped.

Potential markets were predicted based on the gravity model. Using transport cost as a variable (instead of distance), the gravity model predicted a limited number of markets that can be penetrated. The most promising markets were located in the highest income and most densely populated states.

Chapter V

Summary, Conclusions and Recommendations

5.1 Summary

Inter-regional patterns are influenced by differences in natural endowments. In the case of Western Canada abundant feed supplies have encouraged the development of a well managed and technologically advanced hog industry. Larger processing plants, consolidation, and high capital investment in modern hog farms contribute to make the Western Canada pork industry competitive in North America. With a small consumer population and extensive agricultural resources, Western Canada's pork production exceeds its domestic food requirements. Thus, Western Canada relies on exporting its surplus to other regions.

The general objective of this study is to examine the potential to increase Manitoba, Saskatchewan and Alberta pork exports into individual states in the U.S.. Specifically the objectives were:

a) to develop a conceptual model that relates interregional theory and gravity models;

b) to empirically estimate the effects of transport cost on the opportunities for marketing unprocessed pork from Western Canada to some regions in the U.S.;

c) to identify potential individual or regional markets where exports could be increased.

Pork production in Canada and Western Canada is described, followed by an analysis of recent export trends to the U.S.. The major importing regions of Canadian pork include : Pacific, East-north central and West-north central markets in the U.S.. However, large quantities of pork have been exported to new potential markets such the Mid Atlantic and South Atlantic regions.

Chapter two reviewed, in the first section, the literature on gravity models from the point of view of geographers and economists as they relate to commodity flows. Subsequently, in the second section, interregional trade theory is discussed and the concepts of excess demand, excess supply and derived demand for transport are introduced. After that, we demonstrate graphically how a market equilibrium condition and quantity traded is affected by transport cost. Finally, a reconciliation of gravity models and interregional theory is discussed both theoretically and mathematically in chapter two and three, respectively.

In chapter three, the interregional general framework is reconciliated mathematically with the general form of the gravity model. Following this section, a specific econometric model for estimating the effects of transport cost, disposable income and the specialization index changes on pork exports are specified. The estimation procedure uses a pooled cross-section time series technique to calculate the derived demand equations as described by Kmenta (1986).

Chapter four presents the empirical and statistical results as well as an economic analysis. A dummy variable is included in the gravity model to separate the "relational market" exports from the "spot market" exports. The model conforms to the relationships expected by the theory, the coefficients are statistically significant, and the equations for the individual provinces are consistent.

5.2 Findings

The results indicate that the derived demand for the transport of pork is highly elastic. Consequently, the volume of pork exported is very sensitive to transport cost changes. The transport variable performed well for each province. The freight cost is inversely related to the import demand for pork as expected and the coefficients are statistically significant. Table 5.1 summarizes the estimated transport cost, income and specialization index elasticities of Manitoba, Saskatchewan and Alberta.

Table 5.1
Summary of Estimated Results

Using Equation 2	Manitoba	Saskatchewan	Alberta
Income Elasticities	0.6234	0.1711	0.2653
Specialization Index Elasticities	-0.2761	-0.2020	-0.2043
Transport Costs Elasticities	-2.0189	-2.3922	-1.3528
Dummy Variable	2.2992	3.0909	3.4873

Source: Table 4.2

Of the three provinces, Manitoba and Saskatchewan are more responsive to changes in transport costs (a one percent change in transport cost resulted in 2.01 and 2.39 percent changes in quantity traded, respectively). Alberta's lower transport cost elasticity may be explained by the larger gross margins that enable them to absorb a narrowing of the import/export difference. The lower freight rate elasticity might also be explained by the backhaul freight rates out in Alberta.

The transport elasticities estimated in this study are higher than the distance elasticities reported in the literature. Using distance instead of transport costs might result in underestimate of the sensitivity of trade flows to transport cost as found by Geraci and Prewo (1977). The nature of data set (cross sectional/time series) could also create more elastic transport cost elasticities because they are long run relationships. The third reason is that most transport demand elasticities refer to ocean borne trade because most global trade is transported by water. The gravity model in this study is more specific and refers only to refrigerated truck transport.

Saskatchewan and Alberta are less responsive to changes in the income of the importing states than is Manitoba. Specialization index has negative affect on Western Canadian pork exports, but perhaps less than might be expected.

With an elastic demand, a reduction in transport cost increases total revenue for transport companies in Western Canada. This suggests an interesting strategy that the carriers may wish to explore further. The gravity model for each province, can be used to estimate the expected amount of pork that each individual state should be importing. If the actual exported amount was more than the expected amount, then opportunities for increased pork sales will likely depend on developing specialized niches. However, if the actual exported amount was below the expected amount, then a general market expansion might be possible. Table 5.2 provides a summary of the potential regional markets in the U.S. by province. These results suggest that the

Manitoba hog industry should direct its most effort to the Mid-Atlantic and West-South Centre States. The Alberta hog industry should focus on the Mountain and South Atlantic States. The Saskatchewan hog industry has its best opportunity for expansion in the Mountains and Mid-Atlantic States.

Table 5.2
Potential Markets by Region and Province in Truck Load Quantities

Year 1992 U.S. Region	Manitoba Province TL units	Saskatchewan Province TL units	Alberta Province TL units
Pacific	(35.53)	(4.83)	------------
Mountain	(10.95)	(12.32)	(115.13)
East-north Central	(2.66)	(1.88)	(12.80)
East-south Central	(4.16)	(2.78)	(4.59)
West-north Central	(12.93)	(9.09)	(9.02)
West-south Central	(72.20)	(4.77)	(5.20)
New England	(27.13)	(5.40)	(10.51)
Mid Atlantic	(171.39)	(15.08)	(0.61)
South Atlantic	(8.56)	(2.03)	(54.48)

Note: the negative numbers in parenthesis mean that actual amount is less than the expected amount of pork imported

Potential Markets by Region and Province in Kilograms of Pork

Year 1992 U.S. Region	Manitoba Province kg	Saskatchewan Province kg	Alberta Province kg
Pacific	646,000	87,818	------------
Mountain	199,091	224,000	2,093,273
East-north Central	48,364	34,182	232,727
East-south Central	75,636	50,545	83,455
West-north Central	235,091	165,273	164,000
West-south Central	1,312,727	86,727	94,545
New England	493,273	98,182	191,091
Mid Atlantic	3,116,182	274,182	11,091
South Atlantic	155,636	36,909	990,545

Note: the negative numbers in parenthesis mean that actual amount is less than the expected amount of pork imported

5.3 Conclusions

This study has investigated the effects of transport cost changes on the export of Western Canadian pork to the U.S.. The general conclusion is that there is a potential to expand the market for Western Canadian pork in the various regions of the United States. Each province however, can maximize its potential by directing its efforts to different areas.

This study shows that transport costs are very important in determining pork traded from Western Canada. It was concluded that if transport cost are important in determining the structure of Western Canadian pork exports, so are the delivered prices. It was inferred based on the transport cost elasticities that strong price competition exists in the U.S. importing markets.

The gravity model shows that the more promising markets are the most populated and richest (in terms of total income) states of the U.S.. The common market places for Western Canada are: Pacific, South Atlantic, New England, Mid Atlantic and the Central regions.

Gravity models have a long history in modelling trade flows, but do not have strong economic foundation. The study demonstrate that gravity models can be reconciliated algebraically with existing economic theory using the economic framework for interregional trade. Essentially the gravity models represents the derived demand for transport. This finding could enable agricultural economist to examine interregional trade in a new light and provide an important test of the validity of traditional commodity price-based models of interregional trade.

One application of this model identify market potential model can be applied as a tool to provide insight on market penetration and focus export development strategies.

5.3 Limitations

The limitations of this study are related to the set of assumptions underlying the conceptual model, which is a partial equilibrium analysis. In a partial equilibrium model, there are certain factors held constant and others that are allowed to change in order to measure the effects over the variables of interest. Ideally, we would like to let all the variable change and measure the effects of only the causal variables. Such a model can be difficult to build and can become so cumbersome that it fails to capture the most important and relevant factors. Changes in transport cost could induce changes in both the retail and producer prices. This in turn can shift the position of the derived demand at the farm level and the primary supply at the retail level. As a result, one could expect an ongoing process of price changing that is not captured by the model.

Given the lack of interprovincial trade flows data in Canada, the model can only partially simulate the complex reality of trade flows between provinces and states. One potential problem is that the model can incorrectly identify potential markets and can underestimate or overestimate elasticities.

The data series for this analysis is adequate, but does not capture recent events. If the length of time series can be extended for a greater number of years, the model and thus results might improve significantly. By increasing the number of years of annual data the model will be able to capture recent trends as well as reflect reality more accurately.

In the model the supply of trucking was assumed to be perfectly elastic. This is reasonable given the large numbers of trucks and their ability to migrate to different geographical markets if freight rates change. However, this is an untested assumption, and may not hold for some "thin" markets.

5.5 Recommendation for Further Research

It is recommended to test for the significance among the differences in the provincial coefficients estimated in this thesis. We want to make sure that differences in the provincial coefficients are real and not simply speculations.

Further investigation should be done to know more of the other factors affecting the derived demand for transport in pork. Traditional gravity models simulate total trade among countries and require a general formulation. Single commodity gravity models could include variables that are more specific to the commodity's market. There is a need to further explore the potential of other variables in the commodity specific gravity model formulation.

This model can be easily applied to other regions in North America and other commodities such as: lumber, beef, and forages. For example this model could be used to examined flows between the NAFTA countries by various modes of transport and to develop transport demand models for sector, like grain. As a practical tool for identifying markets and estimating potential demand, we encourage researchers to use this type of gravity model.

Finally, it is recommended that the supply equation transport be linked to this model This will require a more elaborated model since both supply and demand for transport will be interacting, but could yield valuable insights on the impact of transportation input price changes. For example, the trade impacts of changes in petroleum prices could be modelled using this framework.

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Data Appendix

Appendix I : Canadian Export commodity classification for Pork Commodities.

Export and imports of meat and other commodities from and to Canada, are classified according to the International Convention of the Harmonized Commodity and Description Coding System (HS). Canada and a number of other countries adopted the Harmonized System for custom tariffs and import and exports statistics in January of 1988.

The six digit HS code is the root digit. For exports, this root digit has been extended by two digits for Canadian statistical purposes. The pork data are given under one series, 0203, and two sub-categories:

0203.1 -meat of swine, fresh/chilled
0203.2 -meat of swine, frozen

with a number of categories under each of these as is described as follows:

Canadian Export Classification Commodity Code HS	SS	Description
02.03		Meat of swine, fresh, chilled or frozen
		-Fresh or chilled:
0203.11	00	--Carcasses and half-carcasses
0203.12		--Hams, shoulders and cuts thereof, with bone in
0203.19		---Other:
	10	----Spare ribs
	20	----Back ribs
	90	----Other
		-Frozen:
0203.21	00	--Carcasses and half-carcasses
0203.22	00	--Hams, shoulders and cuts thereof, with bone in
0203.29		--Other
	10	---Spare ribs
	20	---Back ribs
	90	---Other

U.S. tariff for these pork commodities is free

Canadian exports to overseas countries are valued F.O.B. port of exit.

Source : This information was provided by Industry Canada, Canada Business Service Centre.

Index of Specialization

In order to build the index of specialization, the number of pigs by states was used for 1989-1992.

Source : Agricultural Statistics 1992, United States Department of Agriculture (U.S.D.A.).

Transportation costs

The source of this information comes from Atomic Transport. In order to have a common currency, the transport cost were changed into American Dollars. For this, the exchange rates were used from 1989 to 1992.
Source : Bank of Canada, Review Winter 1992 - 1992.

Total Income Variable

This information was taken directly from the Survey of Current Business, Volume 73, and 74, Number 1. Total and Per Capita Personal Income by State and Region.

Appendix II. Heteroskedasticity Tests for Equation 2

$H_o = \sigma_1^2 = \sigma_2^2 = \sigma_3^2 = ...\sigma_m^2$				
H_A is not true				
Variance σ_t^2 of the disturbance	X^2 Calc.	D.F.	Conf Inter Equat 2	X^2 Test
Manitoba				
E**2 on YHAT	3.243	1	3E-5 to 7.879	Accepted
E**2 on YHAT**2	2.768	1	"	Accepted
E**2 on LOG(YHAT**2)	2.976	1	"	Accepted
E**2 on LAG(E**2) ARCH Test	1.074	1	"	Accepted
E**2 on X (B-P-G)	8.263	4	0.207 to 14.860	Accepted
Alberta				
E**2 on YHAT	0.434	1	3E-5 to 7.879	Accepted
E**2 on YHAT**2	0.009	1	"	Accepted

$H_o = \sigma_1^2 = \sigma_2^2 = \sigma_3^2 = ...\sigma_m^2$				
H_A is not true				
E**2 on LOG(YHAT**2)	1.755	1	"	Accepted
E**2 on LAG(E**2) ARCH Test	0.001	1	"	Accepted
E**2 on X (B-P-G)	5.706	4	0.207 to 14.860	Accepted
Saskatchewan				
E**2 on YHAT	4.828	1	3E-5 to 7.879	Accepted
E**2 on YHAT**2	2.701	1	"	Accepted
E**2 on LOG(YHAT**2)	6.181	1	"	Accepted
E**2 on LAG(E**2) ARCH Test	4.5820	1	"	Accepted
E**2 on X (B-P-G)	5.944	4	0.207 to 14.860	Accepted

Table 1. Saskatchewan's Pork Exports to the U.S., by Destination, 1989-1992

	Quantity In Kg (millions)				Avg
Mid Atlan	1.14	0.22	0.30	0.47	0.53
Pacific	19.71	2.49	1.99	2.92	6.78
New Eng	0.10	0.06	0.00	0.00	0.04
Enc	0.00	0.07	0.13	0.91	0.28
Wnc	3.95	0.67	2.02	6.24	3.22
S Atlan	0.12	0.00	0.02	1.48	0.40
Wsc	0.12	0.00	0.00	0.04	0.04
Mount	0.03	0.28	0.10	0.00	0.10
Esc	0.00	0.00	0.00	0.00	0.00
Total	25.17	3.79	4.55	12.05	11.39

Table 2. Alberta's Pork Exports to the U.S., by Destination, 1989-1992

	Quantity In Kg (millions)				Avg
	1989	1990	1991	1992	
Mid Atlan	0.25	0.20	0.09	0.33	0.22
Pacific	13.08	8.67	20.17	22.20	16.03
New England	0.04	0.11	0.03	0.04	0.05
Enc	1.35	0.96	2.18	1.75	1.56
Wnc	1.80	0.39	2.54	1.70	1.61
S Atlan	0.39	0.06	3.68	0.13	1.06
Wsc	0.19	0.02	0.02	0.09	0.08
Montana	0.64	0.26	0.87	0.27	0.51
Esc	0	0	0	0	0
Total	17.73	10.67	29.58	26.51	21.12

Table 3. Manitoba's Pork Exports to the U.S., by Destination, 1989-1992

	Quantity In Kg (millions)				Avg
	1989	1990	1991	1992	
Mid Atlan	7.84	1.55	1.54	1.02	2.99
Pacific	2.49	0.13	0.14	0.77	0.88
New England	2.65	0.89	0.38	0.53	1.11
Enc	2.14	1.34	1.29	4.15	2.23
Wnc	4.09	1.26	1.47	2.67	2.37
S Atlan	1.02	0.16	0.21	0.27	0.42
Wsc	0.90	2.46	0.26	0.33	0.99
Mount	0.01	0.00	0.18	0.02	0.05
Esc	0.19	0.00	0.00	0.02	0.05
Total	21.34	7.80	5.47	9.78	11.10

Table 4 Alberta Actual Quantities Exported to U.S., by State

State Destination	1989 Kg	1990 Kg	1991 Kg	1992 Kg
Arizona	111,925	60,646	99,896	41,085
California	5,067,224	5,021,434	13,815,526	9,517,736
Colorado	42,761	0	0	93,735
Connecticut	0	0	0	0
Dist of Columbia	0	0	0	0
Florida	0	0	18,928	39,064
Georgia	9,277	55,800	0	0
Idaho	89,234	0	18,741	46,779
Illinois	280,025	288,560	93,001	100,759
Iowa	11,020	18,173	0	76,201
Kansas	0	15,876	0	0
Kentucky	0	0	0	0
Louisiana	0	0	0	0
Maine	0	0	0	0
Maryland	0	0	0	0
Massachusetts	37,008	114,204	28,645	37,378
Michigan	979,075	455,492	2,072,374	1,184,437
Minnesota	1,751,685	358,759	2,489,224	1,620,065
Missouri	0	0	0	0
Montana	30,428	0	19,165	18,145
Nebraska	15,745	0	37,482	0
Nevada	353,046	163,511	732,137	66,684
New Jersey	66,784	0	978	57,150
New Mexico	2,090	19,000	0	0
New York	112,051	201,072	91,572	200,290
North Dakota	18,803	0	18,109	0
Ohio	31,256	107,543	0	0
Oklahoma	0	0	0	0
Oregon	2,147,898	669,161	2,102,309	5,484,948
Pensylvannia	66,172	0	0	74,298
Rhode Island	0	0	0	0
South Dakota	0	0	0	0
Tennesse	0	0	0	0
Texas	189,077	18,131	19,058	92,370
Utah	5,905	19,050	0	0
Virginia	382,698	0	3,658,749	94,892
Washington	5,865,877	2,977,489	4,247,347	7,194,478
Wisconsin	59,742	103,648	18,732	464,669
Total	17,726,806	10,667,549	29,581,973	26,505,163

Table 5 Manitoba Actual Quantities Exported to U.S., by State

State Destination	1989 Kg	1990 Kg	1991 Kg	1992 Kg
Alabama	171,425	0	0	19,051
California	435,163	110,245	99,110	494,144
Colorado	10,865	0	178,900	19,051
Connecticut	119,055	0	0	37,326
Dist of Columbia	0	0	0	0
Florida	0	10,206	76,285	0
Georgia	19,119	76,503	0	0
Idaho	0	0	0	0
Illinois	530,922	345,109	0	368,319
Iowa	433,068	0	19,970	19,051
Kansas	0	92,590	0	0
Kentucky	23,264	0	0	0
Louisiana	0	38,100	0	0
Maine	93,515	7,367	0	0
Maryland	0	0	0	0
Massachusetts	1,084,492	408,286	173,164	432,862
Michigan	751,916	201,050	206,393	425,911
Minnesota	2,927,466	1,090,659	1,151,885	2,601,280
Missouri	0	0	0	0
Montana	0	0	0	0
Nebraska	323,998	35,750	250,706	0
Nevada	0	0	0	0
New Jersey	2,528,363	146,082	559,677	489,311
New Mexico	0	0	0	0
New York	2,094,246	1,141,700	579,817	386,406
North Dakota	52,064	0	38,652	8,845
Ohio	107,557	37,351	39,811	39,985
Oklahoma	0	19,051	114,406	91,364
Oregon	8,185	0	20,862	73,440
Pennsylvania	3,220,176	266,384	395,999	139,651
Rhode Island	1,348,196	476,923	206,931	63,799
South Dakota	349,577	39,016	13,652	42,660
Tennesse	0	0	0	0
Texas	897,491	2,405,168	146,045	241,709
Utah	0	0	0	0
Virginia	1,004,891	73,458	131,940	270,298
Washington	2,048,366	18,876	19,051	199,665
Wisconsin	753,090	757,601	1,046,798	3,315,261
Total	21,336,470	7,797,475	5,470,054	9,779,389

Table 6 Saskatchewan Actual Quantities Exported to U.S.,by State

State Destination	1989 Kg	1990 Kg	1991 Kg	1992 Kg
Arizona	0	0	0	0
California	19,552,835	2,480,683	1,994,972	2,916,551
Colorado	0	0	0	0
Connecticut	0	0	0	0
Dist of Columb	0	0	0	0
Florida	0	0	1,795	0
Goergia	0	0	0	0
Idaho	0	0	0	0
Illinois	0	34,165	91,591	380,811
Iowa	23,424	0	0	53,458
Kansas	0	0	0	0
Kentucky	0	0	0	0
Lousiana	0	0	0	0
Maine	0	0	0	0
Massachusetts	101,929	57,863	0	0
Maryland	0	0	0	20,760
MIchigan	0	0	0	0
Minnesota	273,410	0	10,763	19,677
Missouri	0	0	0	15,675
Montana	0	0	0	0
Nebraska	238,144	1,040	35,059	0
Nevada	0	0	0	0
New Jersey	0	0	0	17,807
New Mexico	0	0	0	0
NY	1,144,604	209,460	297,931	453,980
North Dakota	3,412,133	666,078	1,973,782	6,147,940
Ohio	0	0	0	0
Oklahoma	0	0	0	0
Oregon	0	0	0	0
Pensylvannia	0	10,925	0	0
Rhode Island	0	0	0	0
South Dakota	0	0	0	0
Tennesse	0	0	0	0
Texas	115,469	0	0	37,930
Utah	29,243	284,192	95,594	0
Virginia	115,647	0	16,775	1,455,244
Washington	161,174	13,362	0	0
Wisconsin	0	35,997	35,210	532,785
Total	25,168,012	3,793,765	4,553,472	12,052,618