AN APPLICATION OF A GRAVITY MODEL TO AIR CARGO AT VANCOUVER INTERNATIONAL AIRPORT

by

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ABSTRACT

There has been very little research in the area of air cargo demand analysis and forecasting. This thesis attempts to investigate the application of gravity models to air cargo. Using international export volumes from Vancouver International Airport in 1998, a gravity model was built. The inclusion of tariffs as an impedance factor allowed testing of the effect of tariffs as predicted by gravity models. The results were consistent with international trade theory that tariffs provide a barrier to international trade. Further, a comparison is made between aggregate and disaggregate models (across commodities). It was found that aggregation eliminates commodity specific characteristics.

In using the gravity model, there are two adjustments which need to be made to reduce the bias in the model: firstly, adjustment is necessary to the bias inherent in the constant term of a log-linear model; and a further adjustment is required when forecasting actual levels rather than log levels. Even after adjustments for both types of bias, the gravity model did not produce accurate forecasts. The aggregate model produced better forecasts than the disaggregate model, but both sets of forecasts did not accurately predict the actual volumes transported. This could be as a result of the stable nature of the variables included in the model, which tend to change very slowly over time. Further, it is apparent that other additional explanatory variables should be included in the models to better capture the short-term changes in air cargo.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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1. INTRODUCTION

Air cargo has evolved substantially since the first cargo was flown in the 1940's. No longer merely an isolated form of transportation, the air transportation industry has become a link in the chain of global logistics. This change in the nature of air transportation has accompanied the changing business environment. With the world becoming smaller on a daily basis, and international transactions being carried out as effortlessly as local transactions, the logistics industry has bloomed. It is providing smooth intermodal transitions, and is connecting businesses worldwide in an efficient, cost effective manner.

Despite the merging of different modes of transportation, each mode still has its own niche in the logistics environment. In particular, air transport is still able to provide the fastest transportation time between intercontinental cities, and the increasing volume of global air cargo is testament to the fact that it remains an indispensable part of the logistics industry. Growth in international air cargo in 2000 was up 8% from 1999, with 18.8 million tonnes of cargo being carried (Folley).

However, the fragility of the air transportation industry has once again been highlighted by the terrorist attack on New York and Washington on September 11th, 2001. The general economic downturn, together with the terrorist attack have resulted in a sharp decline in cargo volumes in an already depressed industry. Second quarter showed a decline of almost 6%, and the third quarter is expected to show an even more substantial decline (Folley).

Since the air transport industry changed on September 11th, gaining an understanding of the demand for air cargo is vital to stimulate the industry and restore consumer confidence in the industry. Insight into the nature of air cargo can assist air transportation carriers in providing the best, most competitive services. Furthermore, forecasting air cargo will also assist cargo transportation providers in providing the necessary infrastructure (from aircraft to storage facilities) to match the changes in the air transportation industry, and continued smooth operation of the global logistics flow.

Combining these issues, this research undertakes to examine the international demand for air cargo. Vancouver International Airport (YVR) was chosen as the reference point, with the analysis of international goods flowing between YVR and its trading partner countries.

Knowledge of the characteristics of air cargo is important to provide the correct air cargo services. The types of commodities typical in air cargo, and how these commodities are carried is addressed in section 2.

In order to provide a competitive, efficient transport process, it is vital that the factors affecting the demand for transportation are recognised and considered. Section 3 addresses factors such as time, price and service which may influence decisions on transportation mode.

Turning attention to Vancouver International Airport, section 4 analyses international air cargo exports from YVR. This includes analysis of the specific commodities which are transported, as well as the primary destinations of the air cargo leaving the airport.

Before building any forecasting models, a review of past forecasting methodologies is undertaken. Section 5 discusses the roles played by different forecasting methods.

In order to examine the demand for air cargo, a gravity model has been applied to the international air cargo export data. This model has been used in the demand for many forms of urban travel of passengers, but has not been used in air cargo. The model is discussed in section 6, and the results and findings are discussed in section 7. Section 8 uses the estimated model to forecast air cargo exports.

The future drivers of air cargo will provide a further indication of potential growth prospects. With the global economy becoming more integrated, and consumers demanding customised goods and services, the nature of air cargo is changing dramatically. These, and other factors, are discussed in section 9.

The findings of this research have highlighted some areas of further investigation. The area of air cargo demand analysis has received limited attention in the past, and as such provides significant opportunities for research in the future. Some ideas are addressed in section 10.

The paper concludes with section 11, a brief summary and conclusion of the current research.

2. AIR CARGO

2.1 Classification of Air Freight and Air Cargo

Air freight consists of shipped goods, mail and separate paid passenger luggage. Paid passenger luggage consists of excess luggage a passenger may wish to take, above and beyond the normal allocated luggage. This luggage takes first priority on a passenger aircraft after normal passenger luggage is included. Mail consists of all letters, parcels and other containers that are sent via the postal system from a sender to a receiver. Mail is prioritised next, receiving space allocation after all passenger luggage has been loaded onto the aircraft. Shipped goods are goods that are sent from a shipper to a consignee via a transportation provider. These goods vary in size and value from machine parts to electronic components, clothing to toys. On passenger aircraft, shipped goods receive last priority, and are allocated the remaining space and weight after all other freight is loaded. Thus, capacity is stochastic in nature.

In general, the types of goods that are shipped can be classified into five broad categories:

i. *High degree of obsolescence*, for example computer equipment and electronics
ii. *Short lived life cycle*, for example apparel and clothing
iii. *Perishable*, for example seafood, fruits and vegetables, and flowers
iv. *Time sensitive*, for example newspapers and magazines
v. *Valuable products*, for example jewellery and pharmaceutical products

Each of these commodity categories has different processing and storage requirements, and consequently may have different infrastructure needs.

For the purposes of further discussion, air cargo will refer to shipped goods only, excluding mail and separate paid passenger luggage.

2.2 Origin/Destination of Air Cargo

Air cargo in Canada is classified according to the origin (for imported cargo) or the final destination (for exported cargo). There are three sectors that have been defined:

i. *Domestic*: this includes all air cargo that is transported within Canada

ii. *Transborder*: this includes all air cargo that is transported between Canada and the United States

iii. *International*: this includes all air cargo that is transported between Canada and other countries (excluding the United States)

2.3 How Air Cargo is Carried

Air cargo carriers transport air cargo from the origin to destination airports, which may form a part of the total transportation process from shipper to consignee. The cargo may be packed into containers or onto pallets, or it may be bulk loaded. Containers and pallets are packed and secured before loading onto the aircraft, while bulk loading involves the loading of individual pieces of cargo.

The most common form of transportation is belly hold cargo. In Canada, more than half of all air cargo is carried in this manner. Belly hold cargo is containerised or bulk loaded, depending on the size of the aircraft and the loading facilities loaded into the bellies of passenger aircraft, filling any available space. Due to the extensive passenger networks already in existence, this is a convenient means of transporting air cargo. A significant disadvantage with this means of transportation is that air cargo has the lowest priority in the loading and unloading of the aircraft: passenger luggage is loaded and unloaded first, followed by mail. This may delay the processing of air cargo.

Air cargo may also be transported by all-cargo aircraft, also known as freighters. All air cargo is containerised and loaded on the main deck of the aircraft. These freighters may be operated as independent airlines, or in conjunction with a passenger airline. The benefit of using this form of transportation is that there is no priority restriction in the loading and unloading of the cargo. Thus, freighters offer an improvement over belly hold cargo in terms of processing time of cargo. Airlines have different options in the ownership and operation of freighters. They may be owned and operated by the airline themselves; they may be "wet leased" from a third party company who operates the aircraft; or they may be leased from a third party but self operated. The advantage of leasing aircraft, particularly freighters, is that it provides flexibility in responding to changing demands, without the significant capital investments that are necessary in the ownership of aircraft. Aircraft can be added or removed from the fleet more easily.

A very important player in cargo transportation is integrated carriers. Integrated carriers, or integrators, specialise in time definite and express shipment of parcels and packages, typically smaller in size and weight than normal cargo. The cargo is containerised and loaded on the main deck of the aircraft, in the same manner as freighters. An important difference between integrators and other airlines is that integrators operate all components of the transportation service: from ground handling of the aircraft, to loading and unloading the aircraft, to final delivery. This ensures a smooth transition from one mode of transport to another, and an efficient service from shipper to consignee.

2.4 Modal Competition

Air transportation is not the only form of transport available to shippers in Canada. In most cases, there are other competing modes of transport between the shipper and consignee, dependant on the location of the shipper and consignee. The primary competitors are rail, trucking and marine shipping.

For domestic cargo, competition arises from trucking and rail. With the lower costs involved with trucking and rail transportation, planning can save significant costs on transportation.

Transborder cargo also faces competition from trucking, and to a much lesser degree, rail. Trucking in particular is a significant form of competition for destinations that are within a two-day truck drive away. In these cases, the simplicity of not having to wait for a specific flight, or for less physical handling of the cargo may result in trucking being a faster form of transport. This, together with the lower cost associated with trucking, makes it a strong competitor to air transportation.

International cargo only faces competition from marine shipping. For some commodities, the large difference in transit time between air and marine shipping tends to carry more importance than the difference in shipping rates. One disadvantage of the lack of competition is that international markets may be inaccessible to some lower valued goods: it may be too expensive to send relatively lower valued goods by air, but the goods may perish or become obsolete if sent by sea.

Competition from various modes of transport may be more applicable to certain commodities than others. Perishables, such as fresh vegetables and cut flowers, are less likely to consider marine shipping a viable alternative for long distances. Similarly, raw materials, such as lumber and coal, are unlikely to consider air transport a viable alternative to rail or marine shipping.

3. UNDERSTANDING TRANSPORTATION DEMAND

It is vital to know and understand the characteristics that are incorporated in decisions regarding modal choice. These characteristics may be classified as either endogenous or exogenous, depending on the amount of control transportation firms have over them.

This section will attempt to identify some endogenous factors of the firms both demanding and supplying transportation; exogenous variables beyond the influence of these firms are given somewhat less attention. Some differences between demand for passenger transportation, and demand for cargo transportation will also be discussed.

There are some broad general categories of variables affecting the demand for transportation. These categories are by no means exhaustive, but give an idea of considerations taken when considering different transportation modes.

i. *Time* – this includes both the time horizon and time cycles in demand;

ii. *Price* – the freight rate charged by different modes of transport for transportation of goods;

iii. *Quality of Service variables* – these include a variety of variables such as damage rates and journey time which may affect the goods being transported;

iv. *Exogenous variables* – typically these variables are exogenous to the suppliers and demanders of transport, but will still have an effect on decisions made with respect to transportation, although they may be subject to influence by other agencies, such as governments. Examples are income levels, location of population and business centres;

v. *Other Exogenous factors* – these are variables exogenous to all decision makers which are still influential in the demand for different transportation modes, such as historical and geographic influences.

3.1 The Influence of Time on the Demand for Transport

The time horizon under consideration is one of the most important factors influencing both the demand for transportation, and the effect other factors will have. The time horizon can be divided into 2 periods: the short-term and the long-term.

In the short-term, the reaction to changes in other factors may be strongly inelastic. The relative unresponsiveness to price changes, for example, may be due to a belief that the changes are not of a permanent nature, or technical considerations may constrain an immediate reaction. In the short-term, it is unlikely that shippers of cargo will search for transportation mode substitutes in the face of increasing prices. They may rather wait to see if the price change is permanent, or may not want to be inconvenienced by the search for a new mode of transport.

In the long-term, however, there are numerous possibilities for the firm facing rising prices, making the price elasticity once again more elastic. These options include switching to alternative modes of transport, or relocation of the firm closer to the retail markets. Thus, as the time horizon under consideration starts to lengthen, the demand for transportation becomes more elastic. The high costs involved in switching from one alternative to another – be it another mode of transportation or relocation of the firm – are too high to allow potential temporary changes in the short term, but can be incorporated into the long term strategy of the firm, and thus could be considered as viable alternatives in the long term. Similar arguments apply to other factors.

One of the most pronounced characteristics of the demand for transportation is the fluctuation over time – sometimes more than doubling from a "*trough*" to a "*peak*" in the cycles. These cycles may be short (such as passenger demand for daily urban transportation) to very long cycles (such as international freight transportation). There is a very limited capability of transportation operators to control these cycles in demand, and yet they must ensure that sufficient capacity exists to accommodate the peaks. Daily passengers commuting will place a high demand on transport systems during mornings and evenings, with relatively lower demand during the remainder of the day. For international cargo transportation, there is a strong peak during the summer months, a smaller peak in November (in anticipation of Christmas consumer demand) and a low trough in the early months of the year.

3.2 Price as an Influence on Demand for Transport

The price referred to is the freight rate that is charged by the supplier of the transportation mode (or carrier) to the shipper of the goods. There are a number of ways that this price may influence the decisions that the shipper makes with respect to choice of transportation mode. This sensitivity of the shipper to price is captured in the price elasticity of the demand for transportation.

3.2.1 Transportation Demand as a Derived Demand

One of the major differences between the economic demand for transportation and the economic demand for normal economic goods is that the demand for transportation is a derived demand, and is thus dependant on the underlying commodity. Demand for transportation is usually not a demand for movement for its own sake, particularly in the case of transportation of freight.

The presence of price differentials for the same good at different locations, or the existence of different goods at different locations, indicates the potential demand for movement of goods, and hence a demand for transportation. Differing relative prices for goods at different locations enables these locations to achieve higher consumption levels through trade of goods. However, trade in goods will only occur if the price differentials exceed the cost of transporting the goods.

3.2.2 The Effect of Price

Since the demand for transportation is a derived demand, the demand for transportation of freight is related to the final demand for the goods being transported and existing price differentials. Consequently, changes in the price of the transported good, as well as the price of transporting the goods, will affect the potential for transportation. Thus, the elasticity for transport demand is influenced by the elasticity of demand for the final product. In general, the elasticity of demand for transport is more elastic than the elasticity for the demand of the final product transported.

Another important factor in the sensitivity of shippers to the freight rate is the relationship between the freight rate and the value of the product being shipped. In cases where the freight rate is very high in comparison to the value of the product (such as for grain and vegetables) the shipper is more sensitive to changes in the freight rate, and thus the elasticity of demand is very elastic. Conversely, in the case of shipping high value products (such as for jewellery and electronic components) the freight cost is a relatively small fraction of the total cost of placing the product on the market, and thus the shipper will be less sensitive to changes in the freight rate. Hence, the elasticity of demand is more inelastic for higher valued products.

The price and availability of viable transportation alternatives will also affect the demand for any particular mode. If alternative transport modes are highly substitutable for the particular goods being shipped, a shipper will be more sensitive to changes in freight rate, and thus demand for a particular mode of transportation will be more elastic. If there are no viable alternative transportation modes, then changes in the freight rate will not drive the shipper to seek another transportation mode. Thus the elasticity of demand is relatively more inelastic. As mentioned earlier, this should be viewed in conjunction with the time horizon under consideration – it may not be a strategic move to change transportation modes if the freight rate increases are merely temporary and expected to return to original levels in the short term.

The size of the shipper could influence the impact price has on the demand for transportation. Larger shippers who tend to have larger shipments and tend to utilise transportation more frequently can afford to seek out better transportation alternatives. Due to the larger volumes of cargo, there are more alternatives with respect to routes, transport modes and frequency of shipping available to the shippers. Thus, larger shippers are more sensitive to price fluctuations, and the elasticity of demand is more elastic. Small shippers are somewhat constrained by lot sizing required for some transport modes. They may not have sufficient volumes of cargo to make other transport modes more cost effective, and are thus limited to a few routes and transport modes. Thus, smaller shippers are less sensitive to price fluctuations, and consequently their elasticity of demand is more inelastic than for larger shippers.

3.3 Quality of Service and Demand for Transport

In addition to price, service quality also affects demand for transport. These relate to the service and care taken of the cargo both while the cargo is in transit, and while the cargo is waiting at the origin and destination points awaiting transfer from one mode to another. It is sufficient that the quality of care at only one of the abovementioned locations is sub-standard for that mode of transport to be disregarded as a potential choice. In some cases, these service variables may be more important than price or shipment time in explaining the behaviour of shippers and their choice of transportation mode.

One of the most important service variables is the time taken for goods to be transported from origin to destination. The journey time or average speed of shipment affects the decision of transport mode for a number of reasons. Goods-in-transit represent a capital investment which cannot be invested elsewhere in the firm. Further, these goods do not form part of inventory or buffer stock for the firm's operations, and thus can not be utilised when needed.

The length of journey time is closely related to damage and pilferage. These can vary dramatically between modes of transport, and also among carriers within the same mode of transport. It seems likely that the longer the journey time, the longer the time the goods are out of the control of the owner, and thus the higher the potential for deterioration. In the case of perishable goods requiring refrigeration, the carriers may pay less attention to controlling the environment than the owner would, and consequently there is a higher probability of damage to the transported cargo. Similarly, the longer the journey time, the more opportunity there is for pilferage of the goods to occur.

Reliability of the transportation service provided is another important consideration. As more companies continue to move towards "*just-in-time*" production processes (with inventories kept at a minimum) the ability of a carrier to deliver goods within the stated time becomes critical. To optimise such processes, it is vital that carriers are reliable, and often firms are willing to pay additional costs to ensure this service.

Related to reliability is the convenience of service. Aspects of convenience refer to the pickup and delivery of goods, as well as special handling, customs clearance and storage. Door-to-door service offered by motor carriers and integrators has long been recognised as an important service advantage, despite the higher cost associated. The frequency of transportation is a related convenience factor. As can be expected, the more frequently the goods can be transported, the more likely the shipper is to utilise the particular mode of transport.

Frequency of service is also related to convenience: a more frequent service is more convenient, and is more likely to be utilised by shippers of goods. The option of sending shipments more than once a day means that goods do not need to wait long for the next service time, but can be sent more frequently and reach the market earlier.

The minimum shipment size is a further service factor. Smaller lot sizes reduce the firm's inventory requirements since smaller, more frequent shipments can be utilised in the managing of inventory. Smaller lot sizes also result in a smaller amount of capital being tied up in goods-in-transit.

3.4 Exogenous Variables affecting Demand for Transport

In addition to the above mentioned endogenous factors (price, time and quality of service), there are numerous exogenous factors influencing the demand decisions faced by shippers. Not all of these factors are completely exogenous, random or accidental, but may be influenced either directly or indirectly by governments or other organisations.

One factor regarded as being exogenous is consumer tastes. Tastes are not completely exogenous, since firms can advertise differentiated products in order to attempt to alter the tastes and preferences of consumers. This is true not only for consumer products, but for transportation as well. Large transportation companies can use advertising in an attempt to lure shippers to alter their choice for mode of transportation.

The income level of consumers is influenced by various forces, but is an exogenous factor as far as individual firms are concerned. Income levels affect both the types and quantities of goods consumed. Per capita income can be influenced by the government through tax and employment policies, and also by general economic conditions and price levels. These all ultimately affect the demand for transportation, but are beyond the control of carriers and shippers.

The industrial structure of the economy influences transportation demand. Through the promotion of various secondary industries, tax incentives and infrastructure investments, governments may introduce public policies which affect industrial composition. These decisions are frequently made without a direct understanding of the impact on the transportation system. For example, promotion of the lumber industry will have a vastly different impact on transportation than incentives for the electronics industry. However, these policies are not implemented by the transportation sector, and thus are treated as exogenous influences on carriers and shippers.

3.5 Other Exogenous Factors

Lastly, there are some variables affecting the demand for transportation which are purely exogenous. These are factors which are a result of the geography of the region, a result of historical events or a result of natural resources within the area. The position of a natural harbour and the occurrence of mineral deposits are such examples. Since these factors affect the location of people and industries, they too will affect the demand for transportation. Although their truly exogenous nature may seem to imply that they are of little interest to the demand for transportation, they may indeed provide explanation for particular demand patterns for transportation.

3.6 Comparison between Passengers and Cargo

The above discussion does not distinguish between the demand for passenger transportation, and the demand for cargo transportation. Instead, it is of a more general nature, and deals primarily with the similarities between passenger demand and cargo demand. There are, however, characteristics specific to each which provide additional understanding of transport demand.

In general, passengers are more sensitive to the time of day they travel than cargo. Passengers prefer to travel at convenient times of the day, and may require substantial incentives to travel either very early in the morning or very late at night. On the other hand, cargo is more insensitive to the time of day. Cargo is more concerned with reaching the final destination, and not as concerned with the time of day the transportation occurs.

A very significant difference between passengers and cargo is in the routing. Passengers generally will not tolerate very circuitous routing, and prefer a more direct routing with as few stops and detours as possible. Cargo, on the other hand, has no preference for direct or circuitous routing; it is more concerned with reaching the final destination by the time required. This allows more flexibility on the part of the shipper, as consolidation of smaller shipments for parts of the route may realise cost savings.

Another important factor to consider in transport demand is the demand for one-way transport versus return transport. Typically, passengers require return travel, as trips are usually between residence and work, between home and vacation or a business trip. In contrast, cargo seldom requires a return trip – once the goods have reached the final destination, they generally will be employed for their intended purpose. Thus, cargo carriers may be faced with potentially empty backhaul, and charge higher rates to compensate.

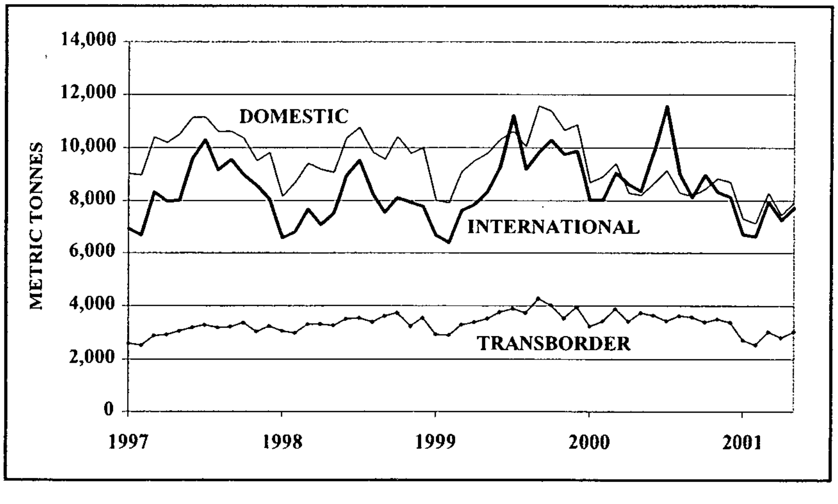
4. ANALYSIS OF INTERNATIONAL EXPORTS VIA AIR FROM VANCOUVER INTERNATIONAL AIRPORT (YVR)

Having gained an understanding of how choices are made between transport modes, the focus is now on the transportation of cargo via air through Vancouver International Airport. As is typical of other trade, Canada's air cargo industry is tied very strongly with the economic health of both Canada and her trading partners. With the Asian Crisis in 1998, and the corresponding economic slump in Asia, international air cargo volumes, especially export volumes, were depressed. The economic recovery starting in 1999, resulted in a similar recovery in international air cargo volumes. As from the end of 2000 and into 2001, North America has experienced a dramatic economic slowdown. With both Canada and the United States similarly affected, an impact is being felt on both transborder and domestic air cargo volumes.

Vancouver International Airport (YVR) has experienced a similar pattern in its air cargo. The high dominance of Asia as an international export region resulted in YVR experiencing a much larger drop in international export volumes than was evident at other airports during the 1998 crisis. The dramatic effect of the North American slowdown is having a direct effect on both transborder and domestic export cargo volumes for all Canadian airports, including YVR. International exports are also experiencing a decline as a result of the slowdown. This is a more indirect effect, as the North American economic slowdown overflows into the global market, causing a global slowing.

The following figure shows a breakdown of total air cargo traffic at YVR by sector.

FIGURE 4.1: TOTAL AIR CARGO BY SECTOR



Total domestic air cargo, as a percentage of total air cargo, processed by Vancouver has been declining steadily from a high of 49.3% in 1997 to current level of 42%.

Furthermore, the actual volumes of domestic air cargo passing through Vancouver Airport have also seen a decline, even after accounting for seasonality.

Transborder air cargo has seen the opposite pattern to that displayed by domestic air cargo, with an increase in both volumes and percentage of total air cargo. There appears to have been a stabilisation of transborder air cargo at 16% of total air cargo, but this is an increase from 13.3% of total air cargo in 1997. The strong decline in export volumes from the latter part of 2000 through into 2001 is as a result of the economic slowdown mentioned above.

International air cargo has seen an increase since 1997. As a percentage of total air cargo, international air cargo has increased from a low of 36.2% to a peak of 47.9%, but is stabilising around 40%. However, the effect of the North American slowdown has resulted in a strong decline in international export volumes from the latter part of 2000 into 2001.

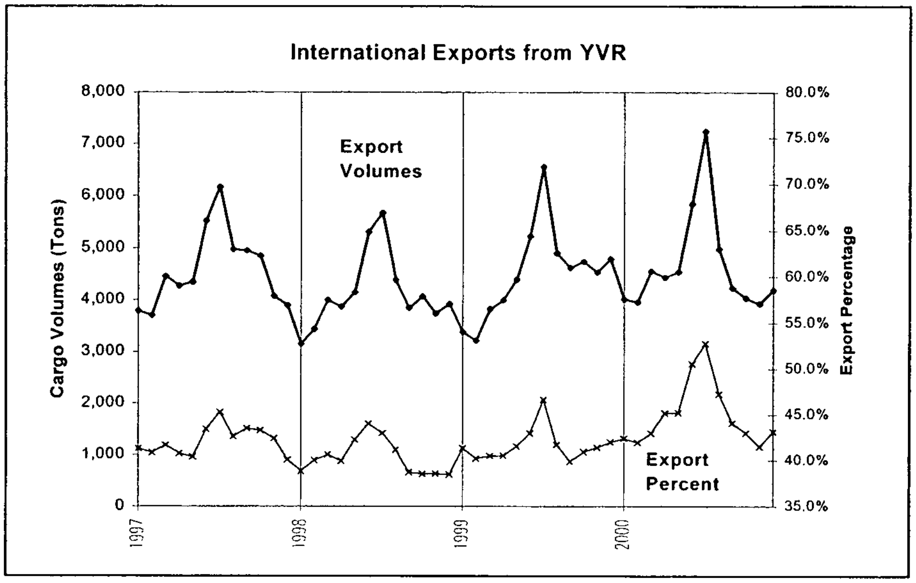
4.1 International Exports from YVR

The concentration of this research is on International export volumes, and will be the centre of discussion for the remainder of the section. International exports do not include exports to the United States, only exports to other international destinations. International exports from YVR have averaged a little over 40% of total exports from YVR over the last 4 years. There is great fluctuation, however, from lows in the winter months of 38% to highs in the summer months of 50%. In 2000, 56,000 tonnes of cargo from YVR were destined for international markets, out of a total of 123,300 tonnes of export goods from YVR. This is declining sharply in 2001, and is not expected to show recovery until late in 2002 and early 2003.

International exports from YVR display seasonal patterns in volumes. The highest peak is in July, with lowest volumes in December / January. The summer peak is primarily as a result of the large volume of fresh fruit and vegetables destined for Asian markets. The winter lows are typical for post-holiday period and the start of the new year (machinery and instrument exports are low), as well as mid-winter period (perishable exports are low).

This can be seen in the following figure. The actual volume of international air cargo exports is shown together with the percentage of total exports that international exports comprises.

<u>**FIGURE 4.2: INTERNATIONAL EXPORT VOLUMES**</u>

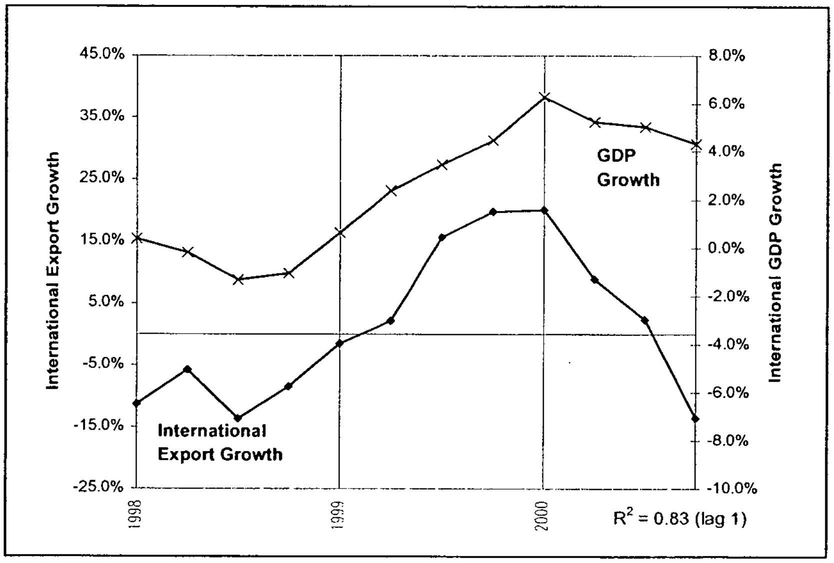


There appears to have been consistent growth in international export volumes, with higher and higher peaks being reached in the summer months. The exception is 1998, which had lower volumes due to the Asian crisis that impacted most Asian countries. However, 1999 and 2000 continues an upward trend from 1997.

Another noticeable trend is the increasing share of total exports that international exports are capturing, particularly in 2000 with the slowdown in the US economy reducing the transborder exports from YVR.

The figure below shows the annual GDP growth for international export partners[1] (quarter over same quarter in previous year), together with international export cargo growth at YVR (quarter of same quarter of previous year).

FIGURE 4.3: INTERNATIONAL GROWTH COMPARISON



Growth in exports is expected to be more reliant on the economic growth of the receiving country than the exporting country. A comparison between economic growth data for Canada and international export partners with international export growth at YVR confirms this.

There appears to be a strong relationship between the GDP growth of international partners, and the growth in international exports from YVR. The high R^2 value of 0.83 between lagged International GDP growth and international export growth indicates the strength of this relationship.

Thus, it is apparent that the strongest force driving international export growth is the economic growth of the receiving country. This further indicates that other factors may have a smaller impact on affecting international air cargo exports.

[1] The GDP of international export partners was created by weighting the GDP growth of individual export partners by their contribution to international exports to YVR. Only the largest 15 countries were used, accounting for 79.1 % of exports from YVR.

4.2 Cargo by Destination

The figure below indicates the primary international export countries, based on the volumes of air cargo from YVR. This shows the dominant destinations which YVR exports air cargo to.

FIGURE 4.4: INTERNATIONAL EXPORT PARTNERS BY VOLUME (IN TONNES)

The largest 12 international export partners, together with the export volumes received are shown in the table below.

TABLE 4.1: LARGEST INTERNATIONAL EXPORT PARTNERS BY VOLUME (IN TONNES)

COUNTRY	AIR CARGO VOLUME (TONNES)	PERCENTAGE OF TOTAL
Japan	10,049	23.1%
Hong Kong	8,015	18.4%
Taiwan	2,888	6.6%
Germany	2,606	6.0%
Australia	1,944	4.5%
United Kingdom	1,784	4.1%
China	1,615	3.7%
Singapore	1,548	3.6%
Netherlands	1,216	2.8%
France	824	1.9%
Thailand	773	1.8%
Other	10,207	23.5%
TOTAL	**43,469**	**100.0%**

The largest international export partners are Japan and Hong Kong, which together comprise 41.5% of the total International export volumes. There are many other important trading partners in Asia, which highlights the reliance on the region. In total, Asia receives over 60% of international exports. The remaining export partners are very small in comparison. Germany and the United Kingdom, the dominant European partners, comprise a smaller part of exports. Europe in total receives approximately one quarter of all international exports.

4.3 Cargo by Commodity

The primary commodity groups exported internationally from YVR are listed in the following table.

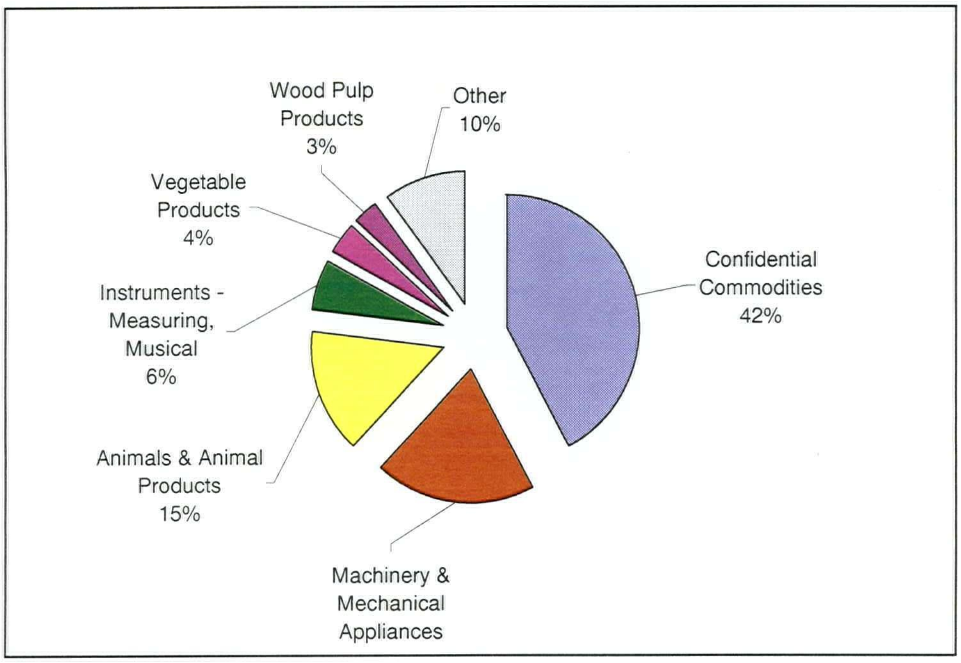
TABLE 4.2: INTERNATIONAL EXPORT COMMODITIES BY VOLUME (IN TONNES)

COMMODITY GROUP	AIR CARGO VOLUME (TONNES)	PERCENTAGE OF TOTAL
Confidential Commodities	18,400	42.3%
Machinery & Mechanical Appliances	8,554	19.7%
Animals & Animal Products	6,511	15.0%
Instruments - Measuring, Musical	2,631	6.1%
Vegetable Products	1,640	3.8%
Wood Pulp Products	1,343	3.1%
Base Metals & Articles Thereof	594	1.4%
Miscellaneous	589	1.4%
Chemical Products	563	1.3%
Transportation Equipment	479	1.1%
Prepared Foodstuffs	416	1.0%
Mineral Products	312	0.7%
Plastics & Rubber	299	0.7%
Wood & Wood Products	226	0.5%
Articles of Stone, Plaster, Cement, Asbestos	218	0.5%
Textiles & Textile Articles	198	0.5%
Animal or Vegetable Fats	165	0.4%
Pearls, Precious or Semi-Precious Stones, Metals	148	0.3%
Hides & Skins	137	0.3%
Works of Art	23	0.1%
Arms & Ammunition	20	0.0%
Footwear, Headgear	3	0.0%
TOTAL	43,469	100.0%

The large volume of *confidential commodities* influences the distribution of the internationally exported commodities. *Confidential commodities* do not have any additional detailed information as to the nature of the commodities it comprises, and thus no further breakdown can be obtained. Furthermore, it does not seem reasonable to assume that the *confidential commodities* follow the same commodity structure as the rest of international exports and thus cannot merely be divided proportionally among the other commodity groups.

This data is depicted graphically in the following figure:

FIGURE 4.5: INTERNATIONAL EXPORT COMMODITIES BY VOLUME (IN TONNES)



* *Other includes all groups not explicitly indicated*

This data reveals that, aside from confidential commodities, machinery and instruments form the largest portion of international exports, followed by perishable products – animal products and vegetable products.

Combining the information on international export partners and export commodities allows an analysis and understanding of the demand for particular commodities by specific countries.

4.4 Preparing for the Future

The different commodities may require different handling and thus different infrastructure for processing. Whereas perishable products require refrigeration, machinery and instruments may require larger storage and packing areas.

Understanding the volumes of cargo flowing, as well as the commodity breakdown, can assist in the planning of future infrastructure requirements. As such, forecasting of air cargo plays a very important role in supporting capital investment decisions at YVR.

5. APPROACHING AIR CARGO FORECASTING

The forecasting of air cargo has been an area of aviation forecasting that appears to have received the least amount of research attention, in spite of its growing importance in the twentieth and twenty first century. Most research has been more focussed on the forecasting of passengers or overall aviation demand. As such, investigation into forecasting models from a variety of areas has been necessary in order to identify potential models that could be applied to air cargo forecasting.

The types of models that have been used to forecast aviation trends are varied in nature, depending ultimately on the desired usage of the forecasts. The models developed and used range from forecasting using growth rates to using historical data and cross-sectional data. The models range from relatively simple exponential smoothing methods, to more complex abstract and gravity models. Despite the wide range of models, however, it appears that there is still no reliable means of forecasting air transportation data, and thus the research into the field for improved forecasting methods is continuing.

Interestingly, the early research in the field of transportation forecasting with gravity models, particularly during the late 1960's and 1970's, has provided a solid backbone to much of the research and developments during the late 1990's. It is likely that these methods will remain the backbone as further research occurs in the twenty first century.

5.1 Forecasting using Growth Rates

Logit models are one method used in the forecasting of the growth in data. Vedantham and Oppenheimer (1998) present a model used by the Environmental Defense Fund which uses a long-term non-linear dynamic systems approach to forecast the demand growth in aviation. This model breaks the demand for aviation into different sectors (personal travel, business travel and freight, military and general) and analyses the differing underlying dynamics of each sector. When looking at the market evolution in each sector, a logit model is used to capture the changes in the growth rates as eventual saturation is reached. In this research, the growth of aviation demand is forecast under different scenarios.

An innovative forecasting model was developed by Ashley and Hanson (1995) to forecast (amongst others) the demand of passengers and air cargo at Schiphol Airport. Once again, the developed models forecast the growth in the data. For passenger demand, the growth rate was related to various economic variables, levels of air fares and demand elasticities. Incorporating competition from other airports and other modes of transport extended this model further. A hierarchical logit model was based on information on passengers' air route choices and preferences for air over other transport modes. It was used to forecast how passengers were likely to choose between modes and between alternative air routes via competing airports. The forecasting process for air cargo followed a similar process.

This process of forecasting growth rates seems to have been adopted by Boeing (1999). Although the details of the forecasting process are difficult to obtain, growth rates were forecast for both mail and air freight.

5.2 Forecasting using Historical Data

Most of aviation forecasting has been undertaken on historical data rather than using growth rates. One of the earliest methods used by forecasters in the air transportation industry was regression analysis. Taneja (1978) provides an in depth discussion on the building and fitting of regression models to air transport data. His discussion starts with simple regression, and is extended into a multiple regression equation. Taneja also discusses typical model assumption violations that frequently occur in air transportation data, the potential effects on both fitting and forecasting, and the possible remedies to eliminate the violations. Taneja extends the single equation model to a multi-equation model, with the introduction of two-stage least squares, three-stage least squares and simultaneous equation systems. These more complex systems allow the analysis of both demand and supply in forecasting.

Econometric methods have been employed by Sletmo (1971). In the estimation of various elasticities of demand for air cargo, he used econometric techniques for the estimation of air cargo demand. These demand functions depend on underlying economic demand theory. Sletmo investigated both the use of a basic static demand equation and also dynamic competitive models. He concluded that the dynamic competitive models were more suited to explaining the demand for air cargo than the static model. Further, he concluded that dynamic models provided insights that went beyond the basic static model.

Another of the simplest methods employed in forecasting is that of exponential smoothing. This was the approach taken by Kasilingam (1996). In developing a cargo revenue management model, the capacity available for air cargo was forecast. Air cargo capacity was calculated as the residual capacity after passenger luggage and mail were accounted for. Exponential smoothing models on historical mail data forecast the volume of mail. Using the expected number of passengers, the expected number of bags was calculated. From these forecasts, the available capacity for air cargo was calculated. Kasilingam also used exponential smoothing to forecast different cargo products at the market level.

5.3 Forecasting between Two Nodes

Some of the oldest models that have been used in the field of forecasting travel demand are those which look at flows between two points – an origin and a destination. These models may include both cross-sectional as well as time series data – adding additional information to the model. Models that fall into this category include abstract models and gravity models.

5.3.1 Abstract Models

Abstract models formulate the demand for a particular mode of transport between an origin and a destination not in terms of demand for the mode itself, but in terms of an abstract mode with a specific set of attributes or characteristics. Each mode is characterised only in terms of features. In specifying the demand equation of a basic abstract model, Quandt and Baumol (1966) postulated that the demand for travel along an arc utilising a particular mode of transport depends on the characteristics of the mode, and on a set of exogenous variables. These exogenous variables include socio-economic, geographic and demographic characteristics of the origin and destination nodes. In their paper, Quandt and Baumol conclude that the abstract model draws satisfactory explanation of the current situation and is able to draw strong inferences about the future. One strength of this model is the ability to evaluate future modes of transport merely on their characteristics, without defining the mode itself. Another strength of the abstract model is the ability to estimate the future demand for each mode and also the total demand for travel.

This basic abstract model received much attention, and a large number of variants of the basic mode have been formulated and estimated subsequently, all in the interest of improving the basic theory. Quandt and Young (1969) researched the inclusion of different formulations of the basic abstract model with the inclusion of different explanatory variables, different model formulations and different estimation methods. However, in attempting to narrow the choice of models, it appeared that city pairs might have intrinsic characteristics that may cause travel on some arcs to be different to what might be predicted.

5.3.2 Gravity Models

Gravity models forecast demand purely on empirical grounds, rather than based on economic theory of choice, as indicated by Oum (1980). The various forms of these models have essentially the same basic characteristics: the volume of traffic between an origin and a destination is an increasing function of trip generating factors at the origin, trip attraction factors at the destination and a decreasing function of the impedance factors between the origin and destination. Quandt and Baumol (1969) used the populations at the two nodes as generation and attraction factors, and the distance between the nodes as the impedance factor. However, as Oum (1980) indicates, other variables that could be included are production (generation), consumption (attraction) and impedance factors such as cost of transportation and travel time.

Alcady (1967) uses a simple form of the gravity model to test whether aggregation across different modes of transportation provides better performances by the gravity model. His analysis is based on 16 city-pair routes of the California city-pair grid. He uses air, rail and highway as the three modes of transport. Based on his results, he concludes that aggregation does provide more consistent results.

Gravity-type models appear to have been used in the air industry itself. Airbus (2000), in their forecasting for future freighters, forecast the demand of air cargo flow in 120 submarkets. The precise details of the model developed are not readily available.

However, the model used has the same generation and attraction characteristics that are typical in gravity models.

With the development of more sophisticated models – in the areas of both abstract and gravity – Howrey (1969) researched which models were preferable for the prediction of air travel. In his paper, he compared predictions of the various models, based on a set of empirical data. He concluded that it was difficult to improve dramatically on the predictions of the simple gravity model. Another interesting conclusion was that the model that fits the sample data best may not necessarily be the best model to use for forecasting and prediction.

5.3.3 Inventory Approach

Developing out of the abstract model was an inventory approach to freight transport demand. Baumol and Vinod (1970) extend the idea that modes of transport can be represented by a set of attributes. In making the choice between different modes of transport, indifference curves are constructed in modal space. This involves understanding the trade-off between various attributes of the different modes. In particular, when looking at the speed and economy of a mode, inventory plays a role in that different combinations of speed and economy necessitate different amounts of in-transit inventory, and different levels of safety stock. Thus, in minimising the total cost of shipping, the inventory costs should also be included as relevant to the decision.

5.3.4 Disaggregate Demand Forecasting

The field of urban transportation has approached the problem of forecasting demand for trips between two nodes using disaggregated demand forecasting. McFadden (1978) explains the need for more flexible demand forecasting methods, particularly those which are able to incorporate behavioural decisions that individuals make in transportation choices. The disaggregate model has a unified concept, in which a trip generation model and the modal split model are dependant on each other. This is different from conventional models in which they are treated independently of each other. The advantages of disaggregate forecasting is the flexibility in modelling: it is not based on one model, but is rather a concept or method which can be used in different contexts.

5.4 Comparison between Cargo and Passenger forecasting

In an attempt to forecast both air cargo and passengers, an understanding of the available capacity may be necessary.

Defining air cargo capacity differs from passenger capacity in numerous aspects. One of the most critical aspects for air cargo is that the available capacity in belly load aircraft is uncertain, and tends to be stochastic in nature. This is in sharp contrast to passenger capacity, where there is a fixed and known seat capacity on any given aircraft. Firstly, air cargo depends on the expected number of passengers on the flight, in addition to the accompanying passenger baggage. This introduces significant variability into the available space for cargo, as the exact number of passengers and volume and weight of baggage are unknown until shortly before the aircraft departs. A second source of variability is the payload of the aircraft. The payload depends on several factors such as weather, fuel weight and season (Kasilingam 37). Since the payload differs for different flights and different aircraft, the remaining available capacity – assuming passenger and baggage information is known – will still tend to be uncertain and stochastic in nature.

Another critical aspect of forecasting air cargo is that cargo capacity is 3-dimensional in nature: volume, weight and number of container positions all play a role in the available cargo carrying capacity (Kasilingam 38). This is in stark contrast to the 1-dimensional nature of passenger forecasting. In the latter case, the only factor to consider is the number of seats on the aircraft. The arising issue for air cargo is that the factor constraining the available capacity may be different for each flight. In the case of high-density shipments, capacity in terms of weight may be the constraining factor. Additional volume may still be available for cargo, although no additional weight may be lifted. In other cases, the weight and volume may be available for a given shipment, but the necessary shaped container may not have a position in the aircraft.

Thus, the relative simplicity of the passenger forecasting becomes more complex in the case of air cargo.

6. GRAVITY MODEL

The gravity model used in transportation is based on Newton's Law of Universal Gravitation as is used in Physics. Newton's Law postulates that the force of gravitational attraction between any two massive bodies is proportional to their masses and inversely proportional to the square of the distance between their centres (Pogge). Mathematically this can be expressed as follows:

$$F = G\frac{M_1 M_2}{d^2}$$

where F = the force exerted between the two masses;

G = the Gravitational Force Constant;

M_1 = the mass of the first object;

M_2 = the mass of the second object;

d = distance between the objects' centres.

This model has been modified for use in transportation research, and primarily for urban transportation research. In the modification, the model attempts to explain that the volume of traffic (force exerted) between two areas (two bodies) is proportional to generation and attraction factors (factors equivalent to mass) and inversely proportional to impedance factors (factors equivalent to distance).

Thus, the gravity model can be formulated in transportation as follows (Alcady 1967):

$$T_{ij} = K\frac{G_i^{\alpha} A_j^{\beta}}{I_{ij}^{\gamma}}$$

where T_{ij} = the traffic volume from i to j;

G_i = the forces of generation in i;

A_j = the forces of attraction in j;

I_{ij} = impedance factors between i and j;

and K, α, β, γ = constants to be estimated.

In the most "naïve" model, the populations of the two cities (P_i and P_j) are used as forces of generation and attraction, and the distance between the two cities (D_{ij}) is representative of the impedance factor.

Thus, the model becomes

$$T_{ij} = K\frac{P_i^{\alpha}P_j^{\beta}}{D_{ij}^{\gamma}}$$

However, there are numerous other factors that can be used as factors in the model. Generation factors can include the personal disposable income of the people living in the area, the gross domestic product of the area, or the level of business activity. Attraction factors can include the number of tourists to the region, the gross domestic product of the area, or the level of business activity. Impedance factors could include the cost of travel, the time taken to travel, and regulatory issues. Any of these additional factors could be included easily in the model through the inclusion of additional terms, provided there is no strong correlation between the factors in the model. Specifically, both distance and cost are important determinants of travel, but since they are likely to be highly correlated, only one can be included in the model (Howrey p218).

6.1 Examining the Role of Tariffs

One factor that has not been examined as an impedance factor in gravity models is that of tariffs. There are two main reasons for this, both factors somewhat related to the other. Firstly, there seems to be limited existing research on the application of gravity models to the transportation of cargo – most research has been in the application of transportation of passengers, whose personal travel decisions are not in any way affected by the presence of tariffs. Secondly, most of the existing literature examines domestic transportation patterns – very little research appears to have been undertaken across borders, where tariffs would start to play a role. Alcady (1967) used 16 city-pair routes from a cross-section of the California city-pair grid, with passenger traffic across 4 transportation modes. Howrey used 30 of the most heavily travelled passenger routes by air emanating from Cleveland, Ohio in his study.

Thus, it is evident that the effect of tariffs has not been examined in the context of the gravity model. International economics focuses on the role of tariffs in international trade, and highlights the negative effect tariffs have on the volume of imports. This paper will attempt to examine the effects of tariffs in the gravity model through the use of tariffs as an impedance factor in this model.

6.2 Aggregate versus Disaggregated Models

Another interesting application of the model is that the model can be applied to both aggregated and disaggregated data. This is due to the formulation of the gravity model, which does not include variables reflecting the specific characteristics of the disaggregated data. For example, in the disaggregation of data according to transportation mode, Alcady (1967) noted that no variables are included which reflect modal peculiarities. Only variables which represent more general factors are included.

Alcady (1967) further hypothesized that aggregation over different transportation modes tends to eliminate some of the peculiar characteristics of travel which are evident in the individual modes. Thus, the aggregated model provides better performances of the gravity model. The reasoning is that individual modes are less stable, and less responsive to the variables that are included in the model, and more sensitive to those variables that have been excluded from the model.

Studies such as Alcady's have focussed on the disaggregation over transportation mode. This paper will address the issue of disaggregation across commodity types. The working hypothesis here is similar to the hypothesis which Alcady proposed: that aggregation across commodities tends to eliminate some of the specific characteristics of each commodity type.

6.3 Estimating the Model

For the purposes of this research, the basic gravity model was extended in some ways to include other economic variables which were believed to have a significant effect on the demand for air cargo.

The model used is as follows:

$$E_{ij} = K \frac{P_i^{\alpha_1} P_j^{\alpha_2} I_i^{\alpha_3} I_j^{\alpha_4}}{D_{ij}^{\alpha_5} C_{ij}^{\alpha_6} T_j^{\alpha_7}} \varepsilon_{ij}$$

where E_{ij} = the volume of exports (in tonnes) exported from i to j;

P_i = the population of exporting region i;

P_j = the population of receiving region j;

I_i = the per capita GDP of exporting region i;

I_j = the per capita GDP of receiving region j;

D_{ij} = the distance between i and j.

C_{ij} = the consumer price inflation differential between i and j.

T_j = the tariff barriers in receiving region j;

and K, α_1, α_2, α_3, α_4, α_5, α_6, α_7 = constants to be estimated.

The current model is non-linear, and so natural logarithms are taken of both sides to transform to a linear model that can be estimated by ordinary least squares. This gives the following model for estimation:

$$lnE_{ij} = K' + \alpha_1 ln(P_i) + \alpha_2 ln(P_j) + \alpha_3 ln(I_i) + \alpha_4 ln(I_j) + \alpha_5 ln(D_{ij}) + \alpha_6 ln(C_{ij}) + \alpha_7 ln(T_j) + \varepsilon'_{ij}$$

As discussed earlier, the model is concerned with the volume of air cargo exports from Vancouver International Airport to other countries in the world. So, let i represent

Vancouver International Airport, and j represent the export receiving country. Thus, since i remains unchanged for all observations, the subscript can be dropped, and the model rewritten as follows:

$$lnE_{ij} = K' + \alpha_1 ln(P) + \alpha_2 ln(P_j) + \alpha_3 ln(I) + \alpha_4 ln(I_j) + \alpha_5 ln(D_j) + \alpha_6 ln(C_j) + \alpha_7 ln(T_j) + \varepsilon'_j$$

Since $ln(P)$ and $ln(I)$ are constants, this model can again be rewritten as follows:

$$ln\ E_j = K'' + \alpha_2 ln(P_j) + \alpha_4 ln(I_j) + \alpha_5 ln(D_j) + \alpha_6 ln(C_j) + \alpha_7 ln(T_j) + \varepsilon'_j$$

For ease and without loss of generality, this is rewritten as follows:

$$ln\ E_j = K'' + \beta_1 ln(P_j) + \beta_2 ln(I_j) + \beta_3 ln(D_j) + \beta_4 ln(C_j) + \beta_5 ln(T_j) + \varepsilon'_j$$

In this estimation, the coefficients can be interpreted as elasticity coefficients of cargo volume with respect to each of the variables.

This final form of the model is that which has been used for estimation and analysis in the following sections.

6.4 Implications of Logarithmic Transformations

Goldberger (1968) has indicated that in the estimation of log-linear functions there is no bias with respect to the estimation of the elasticities of the original function: the estimates of $\beta_1, \ldots, \beta_5$ in the log-linear function are the same as the estimations of the elasticities in the non-linear function. However, he points out that is some bias in the estimation of the constant term, K, in the original formulation.

Although it seems intuitive that

$$E(K) = e^{E(K^*)},$$

this is incorrect. For a random variable $u \sim N(\mu, \sigma^2)$, the variable $U = e^u$ has a lognormal distribution with mean

$$E(U) = e^{E(u)+\frac{1}{2}V(u)} = e^{\mu+\frac{1}{2}\sigma^2}$$

Thus, $e^{E(K^*)}$ is a biased estimator of K, and should be adjusted in order to obtain the correct level of the original function.

6.5 Data

By far the most challenging part of this research was the collection of sufficient, accurate data. Access to traffic volume data was extremely difficult, especially pooled data, which was the "ideal" data set required for the building of the above model.

The export data was based on the volume of air cargo data that was exported from Vancouver International Airport to its various international[2] destination countries during 1998, as supplied by Statistics Canada. The data is measured in tonnes of air cargo transported, and is further broken down by HS04 codes[3]. This gives the volume of air cargo by commodity for each destination country during 1998.

The original number of partner countries included in the sample set was 127 countries and territories. This was the total number of countries for which Statistics Canada had data. This number was reduced to 116 countries with the elimination of countries for which no volume of exports was recorded. Finally, the explanatory variables under consideration were collected for as many countries as possible, with countries eliminated where data was not available. This reduced the original sample size to 61 countries[4] in the final sample size.

This reduction in sample size is not desirable. However, upon closer examination, the majority of the countries that were eliminated from the original sample were mainly smaller trading partners, and the remaining countries comprised 89.4% of total international export trade volumes. For this reason, the sample has been deemed sufficient for the purposes of this research.

6.5.1 Cargo Volume: E_j

The cargo volume, E_j, is the aggregate volume of data that is transported from Vancouver International Airport to each receiving country j. This is measured in tonnes.

Volumes were chosen rather than the dollar value of the exports since over time the "real" measurement of exports is more desirable (measured in tonnes) than the nominal measurement of exports, which is prone to changes in valuation. Furthermore, since previous models have been based on number of trips, or number of passengers, both of which are "real" measures, measuring air cargo in tonnes is consistent with previous models and research.

For the disaggregate model, the commodities were broadly categorised into 5 groups, as shown in the table below.

[2] Excluding the US

[3] The HS04 codes are a part of the Harmonization Code System, a multipurpose international product nomenclature developed by the World Customs Organization (WCO). It comprises about 5,000 commodity groups, each identified by a unique six digit code. More than 177 countries and economies use the system as a basis for their Customs tariffs and for the collection of international trade statistics.

[4] All export data is shown in Appendix 1.

TABLE 6.1: DISAGGREGATE COMMODITY GROUPS

GROUP NUMBER	DESCRIPTION	COMMODITIES INCLUDED
1	Confidential Commodities	Confidential Commodities
2	Machinery & Instruments	XVI: Machinery & Mechanical Appliances XVII: Transport Equipment XVIII: Instruments – Measuring, Musical
3	Perishable Products	I: Animals & Animal Products II: Vegetable Products III: Animal or Vegetable Fats IV: Prepared Foodstuffs
4	Mineral, Metal & Wood Products	V: Mineral Products IX: Wood & Wood Products X: Wood Pulp Products XIII: Articles of Stone, Plaster, Cement, Plaster XIV: Pearls, Precious or Semi-Precious Stones, Metals XV: Base Metals and Articles thereof
5	Other	VI: Chemical Products VII: Plastics & Rubber VIII: Hides & Skins XI: Textiles & Textile Articles XII: Footwear, Headgear XIX: Arms & Ammunition XX: Miscellaneous XXI: Works of Art

The disaggregate dependant variables, Ek_j, are the volume of exports of commodity group k (for $k = 1,2...5$) exported to receiving country j. It is also measured in tonnes. There is a level of aggregation taking place even at this disaggregate level. This was necessary particularly where the data was sparse, and the analysis less meaningful.

6.5.2 Cargo Volume: P_j

The population of the receiving country, P_j, measured in millions of people, was obtained from the World Bank's World Development Indicators 2001.

Population is seen as an attraction factor in the gravity model. As in many of the previous gravity models, it is assumed that as the size of the population in the destination region increases, the demand for goods and services by the country will also increase. Thus, as the general level of demand within the country increases, it is assumed that there is a parallel increase in the demand for air transported commodities.

6.5.3 Per Capita GDP: I_j

The per capita GDP of the export receiving country was also obtained from the World Bank's World Development Indicators. Per capita GDP has been reported in constant 1995 US dollars for all countries.

The conversion to US dollars ensures comparison between countries. Although the country of origin is Canada, and thus it would appear that a base currency of Canadian dollars would be preferable, converting the values from US dollars to Canadian dollars requires the same operation on all figures, and thus has no effect on the estimated coefficients, only on the constant term.

Similar to the population, per capita GDP is seen as an attraction variable in the gravity model. The rationale is that a population with a higher per capita GDP is associated with higher personal disposable income. A higher income is related to higher demand for goods and services by the country, and thus a higher demand for air transported goods.

A better measure of income would be personal disposable income. This takes into account both personal and corporate taxation, and gives a better indication of the spending power of the individuals within the region. This data, however, was difficult to find, and as such per capita GDP was used.

Finally, converting all values to a common currency, whichever base currency is chosen, is performed using a currency exchange rate. This adjustment methodology does not account for the relative price levels between countries, which may also affect the purchasing power of consumers in different countries. A better variable would be one that adjusts by a purchasing power parity (PPP) measure, instead of merely a currency exchange. Once again, this data was not easily available.

6.5.4 Distance: D_j

The distance is taken as the straight line distance between Vancouver and the city with the largest international airport in the receiving country. These distances were obtained from Indo.com, and are measured in kilometres.

There is some debate as to the relationship between distance and volume of travel. Alcady (1976) indicates that the relationship is likely to be different for air travel than for other modes. He indicates that for passengers, the proportion of trips taken by air is an increasing function of distance. This research will decide whether the same relationship is true for air cargo. If the relationship is indeed an increasing function, then distance will no longer serve as a force of impedance.

A better distance measure would be one that measures the actual flying distance between airports, since this value is more accurate. Firstly, this was difficult to define for non-direct routes. Secondly, this data was not readily available for all countries included in the sample.

6.5.5 Consumer Price Inflation Differential: C_j

The consumer price inflation is taken as the annual percentage change in Consumer Price Index (CPI) for each of the countries. The data is taken from the World Bank's World Development Indicators 2001. The differential is taken as the difference in consumer inflation between the receiving country and Canada.

Consumer inflation influences consumer demand for products: higher inflation tends to erode the purchasing power of consumers, and thus reduces the demand for products.

This lower demand for goods translates into lower demand for imported goods, including those received by air.

The inclusion of the consumer inflation differential attempts to take into account the purchasing power of consumers that was missing from the per capita GDP.

6.5.6 Tariff: T_j

The tariff is the simple average tariff across all goods and services. It is expressed as a percentage, and is taken from the World Bank's World Development Indicators.

Two measures of average tariff are conventionally used: the simple mean and the weighted mean tariff. The weighted mean tariffs are weighted by the value of the countries trade with each of its trading partners. As indicated by the World Bank, the simple averages are a better indicator of tariff protection than the weighted average. Weighted averages are typically biased downward because higher tariffs discourage trade and thus reduce the weights applied to these tariffs.

As is consistent with economic trade theory, higher tariffs tend to reduce the volume of exports into the country. Thus, tariffs represent a force of impedance between Vancouver and its trading partners.

6.5.7 Other variables considered

At this point, it is worth mentioning other variables that were considered for the current research. Some were unavailable, and others were tested but discarded. Both could provide ideas for future investigation.

There were a few variables that were sought but were not available. The cost of travel and the time for travel were two such variables. The cost data was unavailable for the current research for a few main reasons. Firstly, the rates charged by different carriers vary widely, and so a true value would require a significant data collection effort. Secondly, the characteristics of a "typical" parcel are very difficult to define, due to the wide variety of commodities transported. Thus, defining the cost for a "typical" parcel is challenging. Thirdly, the fierce competition between cargo agents has resulted in the cost data being treated as extremely confidential, and is not shared very readily.

The travel time was also unavailable for a few reasons. Firstly, it was difficult to find time data in appropriate units: although time was available in days, finer units (such as hours) would be more useful. Secondly, there are not always direct flights between the origin and destination airports. There are many different possible routes, each with a different flight time and transfer time. This complicates the collection of data.

There were two other variables that were initially tested, but were discarded due to insignificance. The percentage of urbanisation of the receiving country was originally included in the model. It was hypothesized that the percentage urbanisation would change the types of commodities demanded: highly urbanised countries would have a higher demand for electronics, machinery and instruments. However, urbanisation was not significant in any of the models.

The currency exchange rate was also included in an earlier model. Although it is still maintained that the exchange rate is important in affecting the demand for traded goods, the model did not find significance in a static, one period model. Perhaps with the incorporation of time series data, exchange rates would play a more significant role.

6.6 Transforming the Variables

Variable transformation through the natural log function was straight forward for most variables. Some variables (consumer inflation differential, tariffs and disaggregate exports) were more difficult due to the occurrence of non-positive values.

There seems to be no standard methodology for dealing with this problem. One method involves truncating the data and removing non-positive values. In this research, truncation of the data would introduce bias into the data. Firstly, removing all non-negative values would significantly reduce the sample size, which is undesirable. Secondly, removing non-positive variable values would remove countries with inflation rates lower than Canada, as well as countries with no tariff barriers, which would bias the sample.

As such, transformations have been used which do not reduce the sample size, but do linearly map the data into the positive real numbers. The transformations discussed below are by no means perfect, but provided a potential solution to the problem.

6.5.1 Consumer Price Inflation Differential: C_j

Due to taking the consumer price differential between the receiving country and Canada, there are instances of negative values of the variable. This was evident in 13 out of the 61 countries.

Since this research is addressing the differential between two countries, and thus is more of an ordinal measure than a cardinal measure, the proposition is to add K_C to all C_j's, where

$$K_c > \left| \underset{j}{Min}\{C_j\} \right|$$

This transformation preserves the ordinal nature of the variables, while ensuring all instances of the variable are positive.

6.5.2 Tariff: T_j

In the case of tariff data, three countries out of the sample of 61 countries had no tariff barriers, and so had 0 for tariff rate. Due to the absence of negative numbers, the transformation used for consumer inflation differential was not applicable in this case. Instead, the following transformation was used:

$$T_j' = T_j + 0.01$$

The intention was to preserve the ordinality, while adjusting the values as little as possible.

6.5.3 Disaggregate Exports: Ek_j

Disaggregate exports had occurrences of 0 values. Again, due to the absence of negative numbers, the transformation used for consumer inflation differential was not applicable. Instead, a transformation similar to that used for tariffs was used:

$$Ek_j' = Ek_j + 1$$

Again, this preserves ordinality with minimum disturbance to the values.

7. RESULTS AND FINDINGS

All model estimations were carried out using ordinary least squares in NCSS. The full results of the regressions are included in Appendix 2. The results of the aggregate and disaggregate models were compared with each other. The standard criteria were used in evaluating the performances of the models. In particular, the agreement of the signs with the results expected on the basis of *a priori* knowledge, the statistical significance of the coefficients, the explanatory power (R^2) and significance of the entire relationship were all considered in judging the estimated equations.

7.1 Data Analysis

Descriptive statistics for each of the variables was calculated. These are shown in table 7.1.

TABLE 7.1: DESCRIPTIVE STATISTICS OF NATURAL LOGS OF DATA

	MEAN	STANDARD DEVIATION	MEDIAN	MINIMUM	MAXIMUM
Exports (Total)	4.7303	2.0414	4.8283	0.0000	9.2152
Exports (Model 1)	2.9854	2.8040	4.0775	0.0000	8.4194
Exports (Model 2)	3.5894	1.9926	4.0604	0.0000	8.1047
Exports (Model 3)	1.6111	2.2308	0.0000	0.0000	8.0196
Exports (Model 4)	1.9067	1.8947	1.3863	0.0000	6.5820
Exports (Model 5)	1.8295	1.7763	1.6094	0.0000	5.7777
Population	3.0235	1.5409	2.9806	-0.9163	7.1246
Income	8.4414	1.5459	8.2744	5.2149	10.8122
Distance	9.1370	0.2893	9.0821	8.2774	9.7220
Tariff	1.8221	1.6499	2.1412	-4.6052	3.8397
Consumer inflation differential	1.6844	1.1970	1.7285	-1.8618	4.4502

The descriptive statistics reveal a few interesting points. In terms of the dependant variables, the aggregate volumes displayed symmetric behaviour, with the mean and median very close. The other dependant variables displayed more asymmetric characteristics, with the medians for models 1 and 2 larger than the mean (negatively skewed) and the medians for models 3, 4 and 5 smaller than the mean (positively skewed). This is reasonable, since the disaggregate models were more sparse than the aggregate model. In particular, the median of 0 indicates very sparse data in the model. The standard errors are larger for models 1 and 3, and fairly consistent for the remaining models.

The explanatory variables were more consistent, with lower standard deviations. There was also more symmetry evident, with the means and medians much closer in value. In particular, distance seemed to have a very narrow range, and very small standard error. This is intuitively correct, since the international trade partners have to be at least a continent away[5], and can be no further than half a globe away.

7.2 Testing of Assumptions

In the estimation of linear regression models, there are some assumptions that are made in order to ensure that the estimated coefficients are BLUE – best linear unbiased estimates. This is necessary for both hypothesis testing and model fit.

7.2.1 Normality Assumptions

In all linear regression models, it is assumed that normality exists in the errors, ε_j. Although the normality assumption is not required to perform the least squares regression itself, the least squares estimators perform better under normality than under conditions of non-normality on the ε_j. However, the assumption of normality is required for the validity of hypothesis testing, and confidence interval estimation. Thus, the regression residuals in each estimation were tested for normality. Testing, residual plots and normality plots are used to determine whether the residuals are indeed normal. Details of the tests and plots are provided in Appendix 2.

Initial expectations were that the transformed data would violate the assumptions of normality in some, if not all, of the models. Analysis of residuals in all estimated models indicated that most models displayed normal residuals. Two of the disaggregate models did reject normality in the residuals – Perishable Products and Other Products. There was no discernable pattern in the residuals to indicate a standard transformation. These models need to be viewed more cautiously.

7.2.2 Multicollinearity

Multicollinearity occurs when there are near linear dependencies between the explanatory variables. Under multicollinearity, the influence of individual explanatory variables on the dependant variable is difficult to isolate, and the coefficients are biased.

The pair-wise correlations between the explanatory variables are shown in the following table.

[5] US not included in the sample.

TABLE 7.2: CORRELATION MATRIX OF EXPLANATORY VARIABLES

	POPULATION	INCOME	DISTANCE	TARIFF	CONSUMER INFLATION
POPULATION	1.0000	-0.4067	0.1422	0.3586	0.1388
INCOME	-0.4067	1.0000	-0.3521	-0.6137	-0.4719
DISTANCE	0.1422	-0.3521	1.0000	0.0689	0.0303
TARIFF	0.3586	-0.6137	0.0689	1.0000	0.3831
CONSUMER INFLATION	0.1388	-0.4719	0.0303	0.3831	1.0000

From the table it is evident that some correlations exist between some of the variables, particularly tariff and income. Although the pair-wise correlations are not extremely strong, it is still necessary to ensure there are no linear relationships between multiple explanatory variables.

The eigenvalues and eigenvectors of the correlation matrix are important in the detection of multicollinearity. The nearness to zero of the smallest eigenvalue is a measure of the strength of a linear dependency. Multicollinearity can be measured in terms of the ratio of the largest to the smallest eigenvalue. This is called the condition number of the correlation matrix. When a condition number exceeds 100, multicollinearity exists.

The eigenvalues are shown in the following table, together with the condition numbers.

TABLE 7.3: EIGENVALUES OF CENTRED CORRELATIONS

NO. OF VARIABLES	EIGENVALUE	CONDITION NUMBER
1	2.2997	1.00
2	1.0231	2.25
3	0.8339	2.76
4	0.5484	4.19
5	0.2949	7.80

Since the largest condition number of 7.80 is significantly smaller than 100, the conclusion is drawn that multicollinearity is not present in the current data set.

7.2.3 Influential Observations

The existence of outliers in a data set could be problematic in regression analysis, as the outlying data point could exert an undue amount of counterproductive influence on the regression results. It is vital to be able to identify these "influential" observations and determine the extent to which the estimated coefficients and predicted values are influenced by them.

A standard measure to test the presence of influential observations is the calculation of a DFBETA for each regression coefficient. This measure indicates the number of standard errors that the coefficient changes if the *i*th observation were excluded from the data set. If the coefficient would change by more than 2 standard errors, the data point is influential and should be investigated further for possible exclusion from the model.

Considering the wide range of countries included in the data set, it was expected that some countries would indeed be influential observations. However, the DFBETA's for each of the regression coefficients were small (|DFBETA| <1 for most observations and models) and thus it was concluded that there were no influential observations in the data set.

7.3 Estimating the Model

Since all models displayed no multicollinearity and had no influential data points, the analysis of the regression models could proceed. The evidence of normality violation in two models (Perishable Products and Other) was kept in mind when analysing the results.

All explanatory variables were included in the original model. Using a backward selection process, variables were removed from the model until a parsimonious model was obtained: one achieving a balance between simplicity (as few explanatory variables as possible) and fit (as many explanatory variables as needed). The results of the initial models are included in table 7.4, and the results of the final model (after insignificant variables were removed) are included in table 7.5.

TABLE 7.4: RESULTS OF INITIAL AGGREGATE AND DISAGGREGATE GRAVITY MODELS

Dependent Variable	*K''*	*Pj*	*Ij*	*Dj*	*Tj*	*Cj*	R^2
E (Total)	-14.4514 (-2.3504)**	0.9055 (8.1116)***	0.7619 (5.0256)***	1.2033 (2.0427)**	-0.3159 (-2.5578)**	-0.2421 (-1.6146)	0.6840
E1 (Confidential Commodities)	-21.5888 (-2.5535)***	0.8770 (5.7130)***	1.1106 (5.3269)***	1.5540 (1.9184)*	-0.3162 (-1.8614)*	-0.6387 (-3.0965)***	0.6833
E2 (Machinery & Instruments)	-13.7005 (-2.4783)***	0.9956 (9.9190)***	0.8425 (6.1800)***	0.8487 (1.6023)	-0.3317 (-2.9869)***	0.0103 (0.0765)	0.7319
E3 (Perishable Products)	6.6063 (0.7800)	0.4817 (3.1323)***	0.4814 (2.3048)**	-0.9836 (-1.2121)	-0.4417 (-2.5962)**	-0.4295 (-2.0785)**	0.4980
E4 (Mineral, Metal & Wood)	-19.5269 (-2.4045)**	0.5193 (3.5216)***	0.7113 (3.5519)***	1.5099 (1.9406)*	-0.2585 (-1.5843)	0.3168 (1.5991)	0.3602
E5 (Other)	-10.4773 (-1.7683)*	0.6838 (6.3559)***	0.7409 (5.0707)***	0.5032 (0.8864)	-0.2230 (-1.8733)*	-0.1227 (-0.8489)	0.6125

Notes: *regression coefficients shown with t-values in parenthesis*
*** *denotes significance at 1% level*
** *denotes significance at 5% level*
* *denotes significance at 10% level*

TABLE 7.5: RESULTS OF FINAL AGGREGATE AND DISAGGREGATE GRAVITY MODEL ESTIMATION

Dependent Variable	*K''*	*Pj*	*Ij*	*Dj*	*Tj*	*Cj*	*R²*
E *(Total)*	-16.8229 (-2.7781)***	0.9208 (8.1617)***	0.8501 (5.9257)***	1.3364 (2.2589)**	-0.3393 (-2.7271)***		0.6691
E1 *(Confidential Commodities)*	-21.5888 (-2.5535)***	0.8770 (5.7130)***	1.1106 (5.3269)***	1.5540 (1.9184)*	-0.3162 (-1.8614)*	-0.6387 (-3.0965)***	0.6833
E2 *(Machinery & Instruments)*	-5.1961 (-4.2387)***	0.9998 (9.9493)***	0.7617 (6.4323)***		-0.3664 (-3.3742)***		0.7193
E3 *(Perishable Products)*	-3.3488 (-1.6138)***	0.4784 (3.0985)***	0.5822 (3.0263)***		-0.4043 (-2.4062)**	-0.3944 (-1.9198)*	0.4846
E4 *(Mineral, Metal & Wood)*	-20.0100 (-2.6236)**	0.4675 (3.1509)***	0.7468 (4.7746)***	1.5541 (2.0149)**			0.3075
E5 *(Other)*	-5.9907 (-4.5930)**	0.6948 (6.4983)***	0.7334 (5.8210)***		-0.2590 (-2.2414)*		0.6001

Notes: *regression coefficients shown with t-values in parenthesis*
*** *denotes significance at 1% level*
** *denotes significance at 5% level*
* *denotes significance at 10% level*

7.4 Results for the Aggregate Model

The first model estimated was the aggregate model. The model was estimated initially with all variables included.

In the initial regression, only the consumer inflation differential was not significant (even at the 0.10 level) and so was removed from the subsequent model. The re-estimated model showed significance in all its independent variables.

The aggregate estimated equation had the expected signs on the coefficients in the final model; namely positive for population and income, and negative for tariffs. The sign on the distance coefficient was positive. This provides an answer to the earlier discussion of whether cargo models would provide the same positive sign that passenger models provided. The significance of the coefficients in the aggregate model is very high, with 4 of the 5 coefficients significant at the 1% level.

The population elasticity of the aggregate model is close to unity, implying the volume of exports is proportional to the size of the population of the receiving population. The income elasticity is also high, implying again a strong relationship between the income of the population and the demand for air cargo. The coefficient of distance is higher than unity, implying a strong propensity to consume exports via air the further the country is from Vancouver. This could be as a result of the limited modal competition for these commodities, the greater the distance from Vancouver. Possibly in the case of perishable products with potentially high obsolescence, the further the receiving market is from Vancouver, the more necessary it becomes to use air transportation.

Tariff had a relatively low elasticity, implying that large changes in the tariff rates are accompanied by only small changes in the volume of air exports. Thus, for commodities transported by air, the level of tariffs are not a high deterrent – consumers clearly have a demand for the commodities typically transported by air, and are willing to pay the additional price as a result of the tariffs.

Finally, consumer inflation differential was excluded from the initial model due to insignificance. However, the p-value of 0.1121 shows only slight insignificance, and thus consumer inflation differential was still included in the disaggregate models. The small negative elasticity of the consumer inflation differential indicated that although a higher differential imposes a small impedance effect on the volume of air cargo transported, the low elasticity implies a small sensitivity to the differential.

The explanatory power of the model is fairly good, with an R^2 of 0.6691. However, although two thirds of the variation in the total volume of exports by air is explained, there are other unidentified explanatory variables which account for approximately one third of the variation.

7.5 Results of the Disaggregate Models

The five models used in the disaggregate model were estimated individually, and initially included all explanatory variables. It is interesting to note the different models had different significant variables in the final equation: all models included both population and income, but the inclusion of distance, tariffs and consumer inflation differential differed. This highlights some of the commodity specific characteristics referred to by Alcady.

7.5.1 Confidential Commodities: $E1_j$

The model for confidential commodities was the only model that included all of the original variables, although distance and tariffs were only significant at the 10% level.

As discussed earlier, confidential commodities provide no detail as to the actual types of commodities included. Thus, it is difficult to analyse the consumer behaviour associated with these commodities.

The signs of all the coefficients were consistent with *a priori* beliefs. The population coefficient was a little lower than in the aggregate model, but still elastic enough to suggest a strong relationship between the size of the population and demand for Confidential Commodities. Income elasticity is highly elastic in this model, greater than unity. This implies a great sensitivity of air export volumes to changes in income. Distance again provided the expected positive sign, with a very elastic coefficient of 1.55. This implies the demand for these commodities is very sensitive to the distance: the further the country from Vancouver, the higher the volumes of confidential commodities consumed. Despite the large elasticity associated with the distance variable, it is only significant at the 10% level, indicating that distance is not a strongly significant variable.

The influence of tariffs is very close to that seen in the aggregate model: a relatively low elasticity, with the expected negative sign. Finally, consumer inflation differential was a very significant variable in the model, in sharp contrast to the insignificance evident in the aggregate model. The explanatory power of the model is slightly stronger than the aggregate model, with an R^2 of 0.6833.

7.5.2 Machinery & Instruments: $E2_j$

The final Machinery & Instruments model only contained three of the original variables, but the included variables were all significant at the 0.01 level. All the variables displayed the expected signs in the final model. In the initial model, however, consumer inflation had a marginally positive coefficient. Due to the high p-value of 0.94, the variable was removed.

The population elasticity was almost unitary, similar to the aggregate model. This implies a proportional relationship between the volume of machinery and instruments exported by air, and the size of the population. The income elasticity is lower than that in the aggregate model. Lastly, the tariff coefficient is similar to the aggregate model, with a relatively more inelastic behaviour. Consequently, a large decrease in tariffs is associated with only a small increase in demand for machinery and instruments.

Distance and consumer inflation were excluded from the final model. It appears that the volume of machinery and instruments exported is not influenced by the distance of the receiving country from Vancouver, nor by the inflation differential between the countries.

The explanatory power of the Machinery & Instrument model is higher than in the aggregate model. The R^2 is 0.7193, indicating that the 3 variables discussed above account for over 70% of the variation in the volume of machinery and instrument exports. Although distance and consumer inflation differential are not significant explanatory variables, there may exist other commodity specific variables that would explain some of the remaining variation in Machinery & Instrument export volumes.

7.5.3 Perishable Products: $E3_j$

The Perishable Products model excluded the distance variable in its final form, and included consumer inflation differential at only a 0.10 significance level. The signs of the coefficients in the final model all agreed with prior beliefs. In the initial mode, however, distance displayed a negative coefficient. This high p-value of 0.23 resulted in it being removed from the model.

The population coefficient was highly significant, but the elasticity was much lower than seen in all previous models. One explanation is that countries with larger populations tend to rely more on self-provided perishable products.

The income coefficient was likewise lower than the aggregate model: although highly significant, the elasticity was only 0.5822. This lower elasticity, however, is consistent with the relatively inelastic demand for essential economic goods.

The impact of tariffs is more pronounced in the Perishable Products model than was evident in any previous models. It is still inelastic, indicating changes in the tariff rates has a very small impact on the volumes of perishables that are received by air.

A disturbing element to the model is the very low explanatory power – an R^2 of 0.4846. It seems that there should be numerous other commodity specific variables which can explain the variation in export volumes of perishables. These may relate to weather conditions, or percentage of land under cultivation.

7.5.4 Mineral, Metal & Wood: $E4_j$

The Mineral, Metal & Wood model also included only three of the five variables, with tariff and consumer inflation differential being insignificant. All included variables displayed signs consistent with *a priori* beliefs. Population and income continue to display the very high significant levels.

Similar to the Perishable Products model, the population variable in this model shows a much lower coefficient value than in other previous models. This implies that increases in population are associated with much smaller percentage increases in demand for minerals, metals and wood from air cargo. It seems that these commodities are obtained by other means: by marine shipping, or self produced.

The income coefficient in this model is similar to the Confidential Commodities model. It is more elastic, at 0.7468. Distance is the other significant variable in this model, and is highly elastic at 1.55.

The explanatory power of this model is very low, with an R^2 of only 0.3075. This is not a very good model, and there certainly must exist other variables which could better explain the demand for minerals, metals and wood transported by air.

7.5.5 Other: $E5_j$

Rather than continue estimating models with weaker and weaker explanatory powers, the remaining commodities were included together in the final model: Other. This included a very diverse range of commodities, from works of art, to textiles, to arms and ammunition. Not all of the initial variables were significant in the Other model: distance and the consumer inflation differential were insignificant. However, all variables displayed the expected signs.

Population continued to be a very significant variable (at 1%) but the coefficient is markedly lower than in the aggregate model. There is a less elastic response in Other volumes to changes in population.

The income coefficient is fairly similar in magnitude to many of the other models. The value of 0.7334 indicates a relatively elastic response to changes in income. Tariffs are the last significant variable included in the Other model. The value was similar to previous models, at an inelastic level of –0.2590. Although significant in the model, large changes in the tariff rate are only associated with small changes in volumes exported.

The Other model has a slightly higher explanatory power than the previous two models, with an R^2 of 0.6001. This may be in part due to the aggregation over smaller commodity groups. There are still other variables which could be included in the model to explain the remaining variation in Other export volumes.

7.6 Empirical Results Comparison

The six models examined have given an array of values for the variable coefficients. Further, different combinations of variables are found to be significant in different models. The range of values of variables in the various models indicates varying levels of stability.

TABLE 7.6: COEFFICIENTS OF GRAVITY MODEL ESTIMATION

	P_j	I_j	D_j	T_j	C_j	Adjusted R^2
Disaggregate Range:						
Min	0.6948	0.5822	1.5540	-0.4043	-3.0965	0.3075
Max	0.9998	1.1106	1.5541	-0.2590	-0.3944	0.7193
Aggregate Value	0.9208	0.8501	1.3364	-0.3162	-	0.6691
Models Included in:						
Confidential Commodities	✓	✓	✓	✓	✓	
Machinery & Instruments	✓	✓		✓		
Perishable Products	✓	✓		✓	✓	
Minerals, Metal & Wood	✓	✓	✓			
Other	✓	✓		✓		

7.6.1 Population: P_j

The coefficients of population were highly significant in all models, with *p=0.0000* in most models. This indicates the high explanatory power of population in the gravity model and the valuable force of attraction population provides. The range of elasticities can be seen in table 7.6. The range is wide, indicating a less stable influence of the variables on different commodity groups.

7.6.2 Income: I_j

Similar to population, income was included in all models at a very high significance level (*p=0.0000* in most models). Income is thus another important variable in the gravity model, serving as a strong force of attraction. The range of elasticities is very wide (as seen in table 7.6), indicating a less stable influence of income on the demand for different commodity groups.

7.6.3 Distance: D_j

The distance variable was only included in three of the six models estimated. This is interesting in that it indicates that only certain commodities consider the distance between Vancouver and the receiving country. In the models where distance was included, it displayed a very narrow, very elastic range (table 7.6). This implies that distance is stable in its effect on demand, but only for the commodities where it is significant.

Most importantly, though, is the sign of the coefficient. Although intuitively contradictory, the positive sign supports findings of research in passenger models that air transport distance is positively correlated with traffic volume. This is important in the understanding of the possible destinations for air cargo, in that further destinations may provide higher volumes in the future.

7.6.4 Tariffs: T_j

Only one model – Mineral, Metal & Wood – did not include tariffs in the final model. In the other five models, tariffs displayed different levels of significance: from $p=0.0194$ to $p=0.0680$ depending on the commodity. The range of elasticities of tariffs is very narrow, and rather inelastic. This very narrow range is testimony to the stability of tariffs in influencing the demand for commodities. It was interesting, however, to note the inelastic nature of exports to tariffs. This implies that large decreases in the tariffs would only result in small increases in export volumes.

7.6.5 Consumer Price Inflation Differential: C_j

Consumer inflation differential was only significant in two of the five disaggregate models, and not in the aggregate models. While it was very significant in the Machinery & Instruments model ($p = 0.003$), it was less significant in the Perishable Products model ($p=0.060$). The two values were quite different, again indicating the instability of consumer inflation. It is also not very strong in providing an overall understanding of demand.

7.6.6 Explanatory Power: R^2

The aggregate model displayed a fairly strong explanatory power. The disaggregate models, however, had a very wide range in the R^2 values, as can be seen in table 6.6. Although the first two disaggregate models had better fitting models than the aggregate model (with higher R^2 values), the remaining three models had a lower explanatory power. Thus, although the included variables perform well in some models, the other models would need to include more explanatory variables in order to perform better.

7.7 Discussion of Objective Findings

The results have been discussed extensively above. The discussion concludes with a discussion of the objectives of the research.

This research had two main objectives: (1) to examine the impacts of tariffs in the context of gravity models; (2) to examine whether aggregation over commodities tends to eliminate commodity specific characteristics.

In the analysis of tariffs, it is apparent that tariffs have a significant influence on both the aggregate and the disaggregate models. Although the coefficients indicate a relatively inelastic response of air cargo volumes to changes in the tariff rate, the variable is still significant as an impedance factor in the gravity model. Moreover, the small range of the tariff coefficient indicates stability of the variable in influencing the demand for various commodities. The only concern is that tariff was not significant in one model, Metals Minerals & Wood. For a truly stable variable, it should be significant in all models.

In analysing the types of commodities in Metals Minerals & Wood, it seems that these goods may not utilise air transport as the primary means of transport. Thus, only a small portion of the total Metals Minerals & Wood destined for the receiving country are sent via air. The demand for air transportation of these goods may indicate they are more essential in nature, and hence do not consider tariffs as a relevant barrier.

It is important to note that the gravity model performs according to international trade theory: that tariffs do indeed provide a barrier to international trade.

In deciding whether aggregation eliminates some commodity specific characteristics, there are a few aspects to consider. Firstly, the disaggregate models have different significant explanatory variables in the final model. This indicates that different models react to different included variables, and certainly to specific variables which are not included.

Secondly, the wide range of variable coefficients in the disaggregate models indicates the instability of the variable in response to the commodity being exported. The various commodities clearly display different sensitivities to changes in the explanatory variables. These provide evidence of commodity specific characteristics emerging in the disaggregate models.

The benefit of the aggregate model is exactly that the commodity specific characteristics are eliminated. The model fits better than most of the disaggregate models, and the coefficients provide a measure of an "average" effect of each of the variables.

7.8 Criticisms of the Model

Despite the widespread and growing use of gravity models for analysis of transportation, it is not without criticism. Not always detrimental, the criticisms provide direction for further research, and hopefully the development of better models in the future.

One of the recurrent criticisms of the model is that the model is not based on the theoretical foundation of standard microeconomic models of consumer behaviour (Oum). The model is based almost entirely on the idea that the traffic flow is directly related to the size of the two areas under consideration and inversely related to impedance factors – which represent friction, inconvenience and cost of transportation.

Another significant problem is the measurement of the variables. The "mass" variable is conventionally explained as population. However, other variables could be used which would provide better "mass" properties. These could be total economic activity, investment in infrastructure, value added in manufacturing. Similarly for the "impedance" factors: different measures may provide better estimates in the model. Other variables such as travel time (including loading and unloading) and travel cost could be used.

A basic issue in the model relates to weights being applied to the masses. (Isard 506). Isard argues that different kinds of people may contribute differently to the economy, and the population should be weighted accordingly. However, this raises the question of what weights would be applicable.

Furthermore, there is a lack of theory to explain the values estimated for the exponents (Isard 515). Initial gravity models assumed values for the exponents, based on the assumptions of impacts of population and distance on the dependant variable. Later models (including this research) estimated the exponents.

Finally, the air cargo forecasting model does not take into account the derived nature of the air cargo industry. Since the majority of international export cargo from YVR is transported in passenger aircraft, cargo is restricted to the routes and flights that are available to passengers. Cargo may thus be restricted by the available capacity in the passenger flights. This is not adequately dealt with in this forecasting model, since the data may be truncated.

8. Forecasting using Gravity Models

Understanding the demand for air transportation of cargo provides insight into the determining factors and significant contributors. However, the real benefit of these models is derived from harnessing these factors and using them to forecast air cargo flows in the future. Understanding the possible future volumes assists in the strategic planning of infrastructure and other service provision.

8.1 Forecasts using Aggregate and Disaggregate Models

Having analysed the aggregate and disaggregate models, both models will be used to forecast the data. As has been discussed earlier, the aggregate model eliminates commodity specific characteristics. Thus, for more accurate forecasts, it is expected that the disaggregate models together will better predict the individual commodities, and hence provide a more accurate forecast.

The base period was taken as 1998. First, the estimated model was used to predict total exports for 1998. Then exports for 1999 were forecast. This year was chosen as the aggregate data was available for 1999, and thus the predictions of the model could be compared. Exports for each commodity group were unavailable for 1999.

There has not been much literature on the accuracy of the forecasts obtained from the gravity model. For this reason, there has been some apprehension in forecasting of international exports.

The desire is to forecast

$$\hat{E} = \sum_j \hat{E}_j$$

However, since the model is in terms of logs, there is some bias when taking exponentials of the estimates. In particular, although

$$\sum_j \widehat{\ln E_j} = \sum_j \ln E_j$$

it is not true that

$$\sum_j \hat{E}_j = \sum_j E_j$$

There is an element of bias that is introduced, which should be adjusted for in the forecasts. Specifically, the expected bias of each observation is defined as

$$E(Bias) = E\left(e^{\widehat{\ln E_j}} - E_j\right) = E\left(e^{\widehat{\ln E_j}} - e^{\ln E_j}\right)$$

The expansion of e^u is as follows:

$$e^u = \sum_{i=0}^{\infty} \frac{u^i}{i!}$$

For simplicity, the second order approximation is used.

$$e^u = 1 + u + \frac{u^2}{2}$$

For a simple model, with a single explanatory variable, the equation can be expressed as follows:

$$Y_i = KX_i^{\alpha} \varepsilon_i$$

Taking natural logarithms:

$$\ln Y_i = K' + \alpha \ln X_i + \varepsilon_i'$$

Without loss of generality, this can be expressed as:

$$W_i = \alpha + \beta V_i + \varepsilon_i$$

Now,

$$E(Bias) = E(e^{\hat{W}_i} - e^{W_i})$$

$$= E(e^{\hat{\alpha} + \hat{\beta} V_i} - e^{\alpha + \beta V_i + \varepsilon_i})$$

By using the second order approximation for e^u, this can be expressed as:

$$= E[1 + \hat{\alpha} + \hat{\beta} V_i + \frac{1}{2}(\hat{\alpha} + \hat{\beta} V_i)^2 - \{1 + \alpha + \beta V_i + \varepsilon_i + \frac{1}{2}(\alpha + \beta V_i + \varepsilon_i)^2\}]$$

By expanding and taking expectations of the terms, this simplifies to

$$= \frac{1}{2} Var(\alpha) + V_i Cov(\alpha, \beta) + \frac{X_i^2}{2} Var(\beta) - \frac{1}{2} Var(\varepsilon_i)$$

Thus, after forecasting, the adjusted forecast is obtained as follows:

bias factor = naïve prediction – corrected prediction

Thus,

$$corrected\ prediction = naïve\ prediction - bias\ factor$$

This methodology can be followed for models with the necessary number of explanatory variables, and the corresponding bias factor can be calculated.

Using the equations, the exports for 1998 are forecast using both the aggregate and disaggregate models. Three scenarios are used:

i. *Naïve (biased unadjusted) forecast* which uses the biased constant and does not adjust for the bias factor;

ii. *Adjusted forecast* which uses the biased constant and adjusts for the bias factor;

iii. *Unbiased forecast* which uses the unbiased constant term and adjusts for the bias factor.

The aggregate results of the three methods are shown in the table below. The percentage of actual exports is shown in parentheses. Full forecasts are shown in Appendix 3.

TABLE 8.1: GRAVITY MODEL PREDICTIONS - 1998

	ACTUAL	NAÏVE FORECAST	ADJUSTED FORECAST	UNBIASED FORECAST
AGGREGATE	38,840	22,998 (59.2%)	23,045 (59.3%)	47,118 (121.3%)
DISAGGREGATE	38,840	21,065 (54.2%)	21,342 (54.9%)	64,260 (165.4%)
Model 1	16,686	10,768 (64.5%)	10,842 (65.0%)	41,871 (250.9%)
Model 2	10,381	7,580 (73.0%)	7,611 (73.3%)	13,627 (131.3%)
Model 3	7,377	1,151 (15.6%)	1,228 (16.6%)	4,549 (61.7%)
Model 4	2,699	667 (24.7%)	726 (27.2%)	2,467 (91.4%)
Model 5	1,697	899 (53.0%)	935 (55.1%)	1,746 (102.9%)

From the table above it is clear that the gravity models estimated in this research do not perform very well as a forecasting tool. Even after adjusting for the bias factor and the bias in the constant term, the forecasts do not provide satisfactory predictions. The naïve and adjusted forecasts both underperform significantly, while the unbiased forecast overpredicts. This may indeed be a characteristic of logarithmic models in general.

Furthermore, the aggregate model slightly outperforms the disaggregate models (-21.3% vs. -65.4%). Viewed in conjunction with previous findings, the elimination of commodity specific characteristics in the aggregate model seemed to provide a better overall estimate. This is not consistent with prior beliefs.

Using data for 1999, the exports are forecast for 1999. The results are shown in table 7.2, with full forecasts available in Appendix 3.

TABLE 8.2: GRAVITY MODEL PREDICTIONS - 1999

	ACTUAL	NAIVE FORECAST	ADJUSTED FORECAST	UNBIASED FORECAST
AGGREGATE	54,133	22,998 (24.5%)	23,045 (42.6%)	48,145 (88.9%)
DISAGGREGATE	54,133	18,150 (33.5%)	18,429 (34.0%)	48,003 (88.7%)
Model 1		6,749	6,824	26,244
Model 2		7,730	7,761	13,898
Model 3		2,078	2,155	3,575
Model 4		678	738	2,509
Model 5		915	951	1,777

Forecasting for 1999 performed surprisingly better than for 1998. The discrepancy between the aggregate and disaggregate forecasts has decreased (88.9% vs. 88.7%). This seems to indicate that the commodity specific factors are not that instrumental in forecasting exports. The strength of the forecasts has improved (from 121.3% in 1998 to 88.9% in 1999).

Thus, it seems that the biased gravity model estimated has not performed well when compared to actual volumes in the forecast period. The adjustment for the bias factor also does not seem to provide a significant improvement in the forecasts. The unbiased model (correction of the constant term) seems to perform much better.

The dramatic improvement in the forecasting should be viewed cautiously. The improvement is more a result of increases in actual volumes, which rose sharply to more closely match the forecast, rather than the forecast adjusting to forecast the actual volumes more accurately.

It appears that there are other explanatory variables which should be included to more accurately capture short term changes in export volumes.

8.2 Problems in Forecasting Demand

It is apparent in the above discussion that the forecasts are problematic. The most severe problem is the adjustment for bias that is necessary. The adjustment factor that was used in this research did not seem to adjust the forecasts sufficiently, and the adjusted forecasts were still inaccurate. The unbiased forecasts (adjusting the constant term) performed significantly better, but there is still room for improvement.

Further, the model does not seem to be capturing the changes in the environment affecting the volumes of air cargo exported. The most obvious shortcoming is that the variables included in the model are stable over time, or only changing at a very slow rate. This makes the gravity model unsuitable for short-term forecasting, and apparently more suitable for long-term forecasting. Thus, explanatory variables should be included which have more fluctuations in the short term.

However, in long-term forecasting the assumption of a stable model structure and constant parameter estimates seems unreasonable. It is more likely that the model structure will also change over time, than the elasticities of variables will remain unaltered over time. Ultimately, as Quandt indicates, the long run the model should incorporate changes in the exponents over time.

Model specification also affects the accuracy of forecasts. The inclusion of behavioural characteristics, such as consumer tastes and lifestyle changes, has been overlooked. It can not be denied that these factors do change over the long-term, and would alter the demand for commodities. This in turn would alter the demand for air transportation.

Attention also should be given to the interdependence of the demand and supply for air transportation. It may be necessary to model this relationship by a system of simultaneous equations.

Forecasting error can have significant impacts, and there is concern over whether it is better to overestimate or underestimate. Both occurrences can have dramatic impacts, particularly where infrastructure investments are concerned. The preferable case may depend ultimately on the symmetry of the costs of the error. A case of over-estimation may result in the development of a half-empty airport; under-estimation may result in an airport with insufficient capacity which could lead carriers to seek other airports.

9. FUTURE IMPACTS ON AIR CARGO

Air cargo has shown remarkable growth in the past years, both within Canada and globally. With continuing changes in the global economy, rapid expansion of the Internet and its capabilities, and developments within the airline industry regulation, this growth could potentially continue, given the right circumstances. Unfortunately, not all global influences are positive, and the recent terrorist attack in New York is likely to have a dampening effect on the growth in air cargo. This section will go into further detail on some of these aspects.

9.1 Canada's International Air Policy

The Canadian government, as with governments of other countries, has a regulatory policy governing the operation of air transportation services between Canada and other countries.

Any airline that would like to provide international air services between Canada and another country needs to obtain the approval of both governments prior to beginning scheduled flights. For these scheduled air services, the approval takes the form of a "*bilateral trade agreement*" between Canada and the applicable country. These agreements include numerous provisions such as the cities to be served, number of carriers that can fly the routes, and the flight frequency. Canada currently has 70 such bilateral agreements.

The current international air policy was introduced in December 1994 and completed in March 1995. The only change since March 1995 was made in December 1999.

The current international air policy is under discussion and review. The new policy is intended to take into account a wider spectrum of Canadian stakeholders, including air carriers, airports, communities, travellers and the trade and tourism sectors. However, this may be challenging, given the potential conflicts of interest that may arise between different stakeholders.

The following possible changes to the current policy could increase the volumes of air cargo in Canada:

i. Canada's negotiating position with its major bilateral trading partners is one of searching for more open agreements. This could result in an increased number of cities to be served within the foreign country, and an increase in the flight frequency to the country. This potential increase in the market size within the bilateral trading country could result in an increase in air cargo transported.

ii. Air relations between countries have historically tended to focus on passengers services, and, as such, most bilateral agreements to date have not distinguished between passenger and all-cargo services. As all-cargo services continue to grow in importance, it appears important to distinguish between passenger and all-cargo services. Further, there has been an interest from some stakeholders to negotiate open all-cargo agreements in an attempt to encourage foreign carriers to serve Canadian markets. The introduction of additional freighters would provide new capacity for products which can only be carried by freighters.

iii. Fifth freedom rights provide for a carrier to transport goods and passengers between two countries outside of the home country. By allowing carriers fifth freedom rights, a foreign carrier could combine different markets on a single flight. This is particularly advantageous in cases where a market is inaccessible on a non-stop flight, but may be accessible if fifth freedom rights are allowed in an intermediary country. For example, an Asian carrier could combine Canada and South American in a single flight.

In the past Canadian carriers have opposed the granting of fifth freedom rights, as it is viewed as diverting traffic from Canadian carriers. However, fifth freedom rights could make some routes more competitive and provide additional air cargo capacity, and for this reason more liberal fifth freedom rights are being investigated.

iv. Canadian bilateral agreements typically contain various provisions regarding the ownership and control of foreign carriers serving Canada. The standard provision requires that carriers should be "*substantially owned and effectively controlled*" by nationals of the countries designating them. The primary reason for this stipulation is to have some element of control over who receives the economic benefits from the service. If this becomes a more negotiable point, it is likely that additional foreign carriers may have access to the Canadian markets, bringing with them additional cargo.

The revisions to Canadian International Air Policy could have major impacts on air cargo. With a move towards more liberal policies and the consequential opening of markets, additional markets would become more accessible, and additional flights would provide additional air cargo capacity. These revisions together could provide additional air cargo for Canada.

9.2 The Internet

The growth of the Internet and e-commerce is likely to have the most significant impact on air cargo. Due to the continuous rapid expansion of the Internet and its capabilities, predicting the actual effect is challenging at best.

There has been an unprecedented increase of Internet transactions, particularly in the area of business-to-business (B2B). This growth is expected to continue in the future, as is a smaller growth in the smaller business-to-customer (B2C) sector. The growth will increase the demand from both businesses and customers for time-definite delivery of ordered goods. For businesses, the Internet provides a greater transparency in markets.

This enables them to dramatically reduce the cost of inventories with a concurrent increase in frequency of procurement.

Internet consumers are, however, sensitive to price and this may favour the use of ground transportation within North America. As intercontinental Internet transactions become more common, it can be expected that there will be an increase in air cargo.

Document transmission remains an uncertain area when trying to understand its effect on air cargo. It is expected that there will be some movement away from paper transmission of documents towards Internet transmission. However, there are still some obstacles to be overcome, including security issues and dependability factors. Until these issues are fully resolved, it is not expected that significant document volumes will be diverted from air express to the Internet in the immediate future.

9.3 Electronic Data Interchange

The increased use and development of electronic data interchange (EDI) will also impact air cargo volumes. EDI should allow improved inventory handling by businesses, and thus drive businesses towards "just-in-time" inventory control. By managing inventory on a "just-in-time" basis, minimal inventory is held by businesses, and better integration of data transfer, ordering and payment systems into one management system can occur. As a result, there may be a more frequent demand for goods, with a smoother ordering and payment system.

Electronic Data Interchange is also used by Customs, although currently in a very limited capacity. "Wheels up" clearance involves the electronic submission of cargo air waybills from the aircraft to Customs at the destination airport for processing while the aircraft is still en route. Customs "wheels up" clearance has a great impact on the processing of air cargo once it arrives at its destination airport.

With the wider use of the "wheels up" clearance process, the customs clearance process is simplified significantly, and is hence faster. This shorted processing time of air cargo reduces potential delays at airports, and can make air transportation a more attractive transportation option for shorter distance shipments.

9.4 Electronics Industry Growth

One of the major commodities transported world wide by air is electronics. The electronics industry has seen substantial growth in the past few years, and this growth is expected to continue in the future. Researchers in the supply chain of electronics have identified changes in the electronics industry that may have impacts on the need for transportation of electronic components. In particular, the coming years are expected to see product lifecycles becoming shorter and shorter: products will be reaching obsolescence much faster and will be requiring replacement more frequently. Mass customisation of products, similar to the way that Dell operates, is expected to become more common. As a result, companies are more inclined to perform more frequent, smaller shipments, than larger less frequent shipments.

In addition, the low cost barrier to entry is bringing heavy competition from numerous smaller start-up companies. A trend towards manufacturing and logistics outsourcing is driving significant growth in the electronics manufacturing service and third party logistics providers. Outsourcing requires additional transportation for components prior to assembly, followed by transportation of the final product to its market.

These factors all translate into increases in air transportation of electronic components, and hence total air freight.

9.5 Impact of September 11th 2001 Terrorist Attack

Unfortunately, despite the potentially positive growth influences discussed above, the impact of the terrorism attack on the World Trade Centre in New York is having a very dramatic negative effect on the economy and the airline industry, including air cargo.

The overall economic impact of the attack is spreading much further than the airline industry. There has been a sharp drop in consumer spending, and a loss in consumer confidence. This is predicted to translate into an economic contraction in the US particularly, and worldwide potentially, in both the third and fourth quarters of 2001. The close relationship between air cargo and economic growth could result in a decline in air cargo volumes over the same period.

The heightened awareness of airline security issues will impact both passengers and cargo. Within countries, as well as across borders, the increased security precautions could raise business costs and lower productivity. Further, it is expected that aircraft will no longer be able to turn around in under 45 minutes, as has been possible in the past. This will lengthen the processing time of air cargo, and may make other modes of transport more attractive for short haul carriage. Further, these slower transfer times may drive airlines towards larger aircraft and lower flight frequency, reducing cargo carrying capacity.

The impact of the terrorist attack on the airline industry itself will be devastating in both the short-term and long-term. The industry has lost in excess of $650 million as a result of closed air space in the US alone. The total is expected to rise to $2 billion for the third quarter. Analysts expected further losses of $3 billion for the fourth quarter. Canada and European countries have also experienced significant losses. Within the US, the airline industry has shed more than 100,000 jobs. Internationally, the job losses have been on a smaller scale. All this does not bode well for economic growth in the short term.

One of the most significant effects on the airline industry has been the increased cost of insurance. Airline underwriters lowered the coverage limit from $700 million to $50 million for damages to third parties in the event of attacks on airliners. Most airports and aircraft leasing contracts stipulate minimum coverage of $750 million to $1 billion. As airlines have been hard pressed to cover the additional insurance costs, many have grounded their aircraft, or sought government assistance to provide emergency insurance coverage. This has resulted in increased insurance costs for airlines, and reduced cargo carrying capacity from grounded aircraft.

The additional costs incurred by the airlines, including cargo airlines, can be expected to filter through to the end users in the form of higher prices. Northwest Cargo was the first cargo airline to alter its pricing policies to compensate for additional aircraft hull insurance and new security procedures.

In the US, cargo airlines will receive approximately 10% of the $5 billion financial aid package offered by the US government, which should compensate them for some of the additional costs. Despite the financial aid packages and government assistance with insurance, many airlines still face the threat of bankruptcy. As a result, many airlines have been cutting routes, reducing flight frequency on certain routes, and reducing their fleet size. Fleet size reduction has been either through grounding of aircraft, or the sale of aircraft. Airlines facing these problems include Swissair, Varig, Continental and Virgin Atlantic. This will reduce the worldwide carrying capacity of cargo both as belly hold in passenger aircraft, and in freighters.

10. DIRECTIONS FOR FURTHER RESEARCH

This research is part of a limited literature into the application of gravity models to air cargo. The main limiting factor in this is the lack of accurate data. However, should data become available in the future, there is a wealth of opportunities for future research.

10.1 Time Series

The form of the "ideal" data set would be pooled data. Pooled data would include the volume of exports *and* imports per country by commodity by volume (in tonnes) for a range of years. This would allow analysis of the changes of trading partners over the years, as well as changes in the commodities consumed. Further, changes in consumer tastes could be identified, and possibly included in future models.

By using pooled data, exponent adjustments discussed by Quandt could be included. The model suggested is as follows:

$$E_{ij} = K^{\alpha_0(t)} \frac{P_{it}^{\alpha_1(t)} P_{jt}^{\alpha_2(t)} I_{it}^{\alpha_3(t)} I_{jt}^{\alpha_4(t)}}{D_{ij}^{\alpha_5(t)} C_{ijt}^{\alpha_6(t)} T_{jt}^{\alpha_7(t)}}$$

As a first approximation, the functions $\alpha_i(t)$ may either be expressed as linear or quadratic functions of time.

10.2 Other Variables

There are variables in the model which could be altered in favour of better measures. Although it is not expected that the improved measures would dramatically change the results, more accurate measures may introduce more stability in the models.

As mentioned earlier, a measure of per capita income instead of per capita GDP would give an indication of the purchasing power of the consumers, after the effects of taxes. This should also be measured in terms of PPP and not in terms of a fixed currency. The distance between cities should be measured in terms of actual flying distance, and not the straight-line distance.

Other variables that could be included as impedance factors are the cost of transport, and the time for travel. Research exists on the testing of various travel related variables as impedance factors, but there is inconclusive evidence as to which of distance, cost or time is the best measure.

As has been discussed earlier, service level also impacts the demand for transportation. Variables such as number of flights per day and reliability of service can capture an element of service quality, and could be included in further models.

With the inclusion of time series data through the use of pooled data, currency exchange rates could be included in future models. The changes in currency value over time influences the volume of trade between countries. This could be not investigated in a one period model, but should be considered in a multi-period model.

Another important aspect to measure is the structure of the economy. An economy that is more focussed in primary industries will demand different commodities than an economy that is more focussed in secondary and tertiary industries. Furthermore, the secondary and tertiary industries dominant in the economy will alter the nature of commodities demanded. Although percentage urbanisation was used to attempt to capture this, it did not perform well, and another measure should be sought.

10.3 Transformations on the Data

Log-linear models require all data to have positive values. In the current context, this was not possible for all variables. Crude data transformations were used to ensure all data was positive, but there may be better ways to achieve this. Either truncated distributions should be used, or better transformation should be used in the future.

10.4 Inclusion of other Origin Points

The current research used a single origin point. As such, all explanatory variables relating to the origin city were absorbed in the constant term, and no specific analysis relating to the origin could be included. Thus, no generation factors could be included in the models. By incorporating numerous origin points, generation factors could be included in the model. Factors such as population and income at the origin could also influence the volume of exports.

10.5 Air Cargo as a Derived Industry

As has been mentioned earlier, air cargo in Canada is a derived industry, since it relies on passenger flights. Thus, the truncated nature of the data could play a vital role in the construction of the model. In order to understand whether the data is truncated, it may be necessary to undertake a capacity study of the passenger flight network, and determine whether there is excess demand or excess supply. In the case of excess demand, the data may be truncated and modelling should take this into account.

10.6 Bias Estimation

The current method of bias estimation and adjustment could be improved upon. Although the theoretical approach behind the adjustment seemed good, the adjustment factors calculated did not seem to provide significant adjustments, and the forecasts were not improved much by the adjustment factor. This aspect of the forecasting requires substantial attention.

10.7 Non-Linear Estimation

Although theory indicates that the estimation of the log-linear model is equivalent to that of the log-linear model, it may not indeed be the case. For this reason, future research could be pursued in the area of estimation of a non-linear gravity model.

11. CONCLUSION

The undertaking in this research was to investigate the application of the gravity model to air cargo and forecast future international export volumes. Previous applications of the gravity model have focussed primarily on passenger transport and interurban travel. There has been very little research in the area of air cargo.

Before analysing air cargo, it is important to understand how different factors impact the choice of transportation mode. The underlying price of the transported goods, as well as the cost of transportation, impact the choice of transportation mode. Furthermore, shippers will frequently trade off the cost of transport against the time taken to transport to the goods. The additional services provided by transport carriers may favour one transport mode over another. These and other factors are considered when selecting the transportation mode.

Vancouver International Airport (YVR) was the focus of the research, with international air cargo exports providing the data for air cargo flows. YVR has shown substantial growth in air cargo volumes since 1994, and processes a wide range of commodities annually. The primary trade partners are Asian, receiving more than 60% of international air cargo exports from YVR. It was also evident that the growth in air cargo is closely related to economic growth. In order for YVR to provide the necessary facilities and infrastructure in the future to assist in the transportation of cargo, they need to understand the potential growth of air cargo.

The gravity models were estimated both on an aggregate and a disaggregate level (by commodity type). There were two main objectives in the analysis of the model performance: (1) to examine the effects of tariffs in the context of gravity models, and (2) to examine whether aggregation eliminated some commodity specific characteristics in the disaggregate models. The results indicated that tariffs performed well as an impedance factor, with high levels of significance. This is consistent with international trade theory. Further, the aggregation of export data across commodities seemed to eliminate some of the commodity specific characteristics in the disaggregate models. The preference for one over the other rests on which provides more accurate forecasts.

Forecasting of air cargo is essential, and may be used in support of strategic planning and investment. The forecasting ability of the estimated gravity model was tested by predicting 1998 (the year of fitting) and forecasting for 1999. Overall, the forecasts did not perform well. After adjusting for expected bias, the forecasts were not significantly improved beyond the naïve forecasts. The unbiased forecasts were an improvement, but still do not account for all the exports. Further, it is apparent that the model does not fit the data well, and that there are explanatory variables which should be included to improve model fit and forecasting ability. The aggregate model performed better than the disaggregate model, although the prior belief was that the commodity specific disaggregate models would capture changes better.

It is evident in both the fitting of the model and the forecasting that there are still many problems that require attention. The inclusion of additional explanatory variables should assist both the fit of the model, as well as the accuracy of forecasts.

The future of air cargo is dependant on many factors. The characteristics of both air transportation and competitor transport modes may result in switching from one mode to another. In addition, the changing nature of international business, and the manner in which business is conducted, could see further changes in the entire logistics industry as consumers' demand for time-definite delivery of goods. In the short-term, the impact of the economic downturn and terrorist attack in New York and Washington needs to be worked through before recovery of the air transport industry can be expected. However, once recovery has occurred, it is expected that the air transport industry will again fulfil a vital role in international logistics, and show strong growth again.

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APPENDIX 1: DATA

TABLE A1.1: AGGREGATE AND DISAGGREGATE EXPORT DATA (IN TONNES)

COUNTRY	TOTAL EXPORTS	MODEL 1 EXPORTS	MODEL 2 EXPORTS	MODEL 3 EXPORTS	MODEL 4 EXPORTS	MODEL 5 EXPORTS
Japan	10,049	3,296	3,309	3,039	83	322
Hong Kong	8,015	4,533	600	1,890	780	212
Germany	2,606	690	1,197	563	88	68
Australia	1,944	935	521	21	381	86
United Kingdom	1,784	683	405	360	162	174
China	1,615	736	236	616	0	27
Singapore	1,548	763	640	45	64	36
Netherlands	1,216	504	226	352	90	44
France	824	432	134	120	111	27
Thailand	773	498	123	3	144	5
Belgium	724	195	310	40	40	139
South Korea	658	388	183	12	33	42
Switzerland	623	259	250	94	2	18
Italy	598	209	240	35	86	28
Spain	593	253	44	2	206	88
South Africa	471	350	101	0	15	5
Malaysia	462	190	115	21	7	129
Sweden	445	228	185	2	9	21
Norway	425	260	124	33	4	4
New Zealand	314	236	60	0	9	9
Brazil	251	156	71	0	1	23
India	236	100	121	0	0	15
Austria	195	114	61	14	3	3
Finland	195	78	108	0	2	7
Egypt	194	83	103	0	4	4
Turkey	165	0	67	0	89	9
Denmark	161	115	11	9	2	24
Mexico	157	81	64	0	7	5
Sri Lanka	139	0	0	0	139	0
Chile	137	82	31	2	22	0
Ireland	125	58	19	36	10	2
Poland	108	0	30	0	0	78
Philippines	107	0	104	0	3	0
Czech Republic	103	59	24	7	11	2
Mozambique	98	98	0	0	0	0
Russia	91	0	80	0	4	7
Indonesia	76	3	73	0	0	0

COUNTRY	TOTAL EXPORTS	MODEL 1 EXPORTS	MODEL 2 EXPORTS	MODEL 3 EXPORTS	MODEL 4 EXPORTS	MODEL 5 EXPORTS
Pakistan	63	0	62	0	0	1
Saudi Arabia	61	4	57	0	0	0
Bangladesh	51	0	43	0	8	0
Lithuania	51	0	51	0	0	0
Venezuela	47	0	47	0	0	0
Greece	40	4	30	1	0	5
Nigeria	40	0	0	0	40	0
Colombia	32	2	20	0	10	0
Tunisia	29	0	29	0	0	0
Jamaica	28	0	0	28	0	0
Trinidad and Tobago	28	0	1	26	0	1
Romania	28	0	10	4	14	0
Tanzania	22	0	13	0	1	8
Peru	21	2	8	0	9	2
Zimbabwe	20	0	20	0	0	0
Morocco	17	0	3	0	0	14
Portugal	10	0	7	0	0	3
Luxembourg	10	9	0	0	1	0
Algeria	8	0	5	0	3	0
Uruguay	2	0	2	0	0	0
Botswana	2	0	0	0	2	0
El Salvador	2	0	2	0	0	0
Latvia	2	0	0	2	0	0
Ecuador	1	0	1	0	0	0
Total for modelling	**38,840**	**16,686**	**10,381**	**7,377**	**2,699**	**1,697**
Residual*	4,629	1,714	1,283	1,355	142	135
Total	**43,469**	**18,400**	**11,664**	**8,732**	**2,841**	**1,832**

* *residual includes all countries not included in the model*

Table A1.2: Explanatory Variable Data

Country	Population (mil)	Income (US$)	Distance (km)	Tariff (%)	Consumer Inflation Differential (%)
Japan	126.4	42,285	7,573	4.8	-0.34
Hong Kong	6.6	21,801	10,279	0.0	1.85
Germany	82.0	31,285	8,078	3.5	-0.06
Australia	18.8	22,821	13,638	5.7	-0.13
United Kingdom	59.3	20,718	7,604	3.5	2.43
China	1,242.2	725	8,796	16.8	-1.83
Singapore	3.9	25,297	12,837	0.0	-1.25
Netherlands	15.7	29,293	7,722	3.5	1.00
France	58.4	28,243	7,946	3.5	-0.31
Thailand	59.8	2,629	11,819	21.6	7.08
Belgium	10.2	29,016	7,842	3.5	-0.03
South Korea	46.4	11,022	8,179	8.7	6.53
Switzerland	7.1	44,988	8,343	0.0	-0.88
Italy	57.6	19,911	9,023	3.5	0.97
Spain	39.4	16,391	8,436	3.5	0.85
South Africa	41.4	3,922	16,431	8.5	5.90
Malaysia	22.2	4,380	12,788	7.1	4.28
Sweden	8.9	28,796	7,456	3.5	-1.12
Norway	4.4	37,053	7,203	2.9	1.27
New Zealand	3.8	16,564	11,336	2.8	0.30
Brazil	165.8	4,501	11,200	13.6	2.21
India	979.7	430	11,118	32.2	12.24
Austria	8.1	30,962	8,525	3.5	-0.08
Finland	5.2	29,257	7,536	3.5	0.41
Egypt	61.5	1,144	10,867	20.5	3.19
Turkey	63.4	3,175	9,636	8.2	83.65
Denmark	5.3	36,864	7,661	3.5	0.86
Mexico	95.3	3,540	3,934	10.1	14.94
Sri Lanka	18.8	789	13,391	20.1	8.38
Chile	14.8	5,247	10,523	10.0	4.12
Ireland	3.7	23,154	7,178	3.5	1.44
Poland	38.7	3,396	8,224	13.1	10.74
Philippines	72.9	1,124	10,563	10.0	8.73
Czech Republic	10.3	5,129	8,277	6.8	9.69
Mozambique	17.0	188	16,680	16.9	-0.43
Russia	146.8	2,134	8,229	13.9	26.68

Country	Population (Mil)	Income (US$)	Distance (KM)	Tariff (%)	Consumer Inflation Differential (%)
Indonesia	203.7	975	13,340	10.9	56.66
Pakistan	131.6	500	11,729	46.5	5.24
Saudi Arabia	19.7	6,866	11,993	12.6	-1.59
Bangladesh	125.6	350	11,366	22.0	7.30
Lithuania	3.7	2,055	8,114	3.9	4.09
Venezuela	23.2	3,531	6,701	12.6	34.80
Greece	10.5	12,269	9,801	3.5	3.77
Nigeria	120.8	254	11,929	21.8	9.33
Colombia	40.8	2,404	6,752	11.8	19.37
Tunisia	9.3	2,279	9,418	18.4	2.14
Jamaica	2.6	1,712	5,393	17.9	7.64
Trinidad and Tobago	1.3	4,651	7,083	18.4	4.63
Romania	22.5	1,309	9,209	13.1	58.11
Tanzania	32.1	184	15,018	21.0	11.81
Peru	24.8	2,354	8,160	13.0	6.26
Zimbabwe	11.7	715	15,822	22.2	30.83
Morocco	27.8	1,392	8,848	22.1	1.92
Portugal	10.0	11,976	8,311	3.5	1.79
Luxembourg	0.4	49,620	8,028	3.5	-0.03
Algeria	29.5	1,542	9,117	25.0	1.32
Uruguay	3.3	6,461	11,414	4.6	9.82
Botswana	1.6	3,611	16,182	8.5	5.67
El Salvador	6.0	1,727	5,014	6.7	1.56
Latvia	2.4	2,335	7,851	5.6	3.65
Ecuador	12.2	1,560	7,053	12.9	35.11

APPENDIX 2: REGRESSION RESULTS

Aggregate Model:Total Exports

Regression Equation Section

Independent Variable	Regression Coefficient	Standard Error	T-Value (Ho: B=0)	Prob Level	Decision (10%)	Power (10%)
Intercept	-16.82293	6.055529	-2.7781	0.007426	Reject Ho	0.864218
Lpopulation	0.9208361	0.1128238	8.1617	0.000000	Reject Ho	1.000000
Lincome	0.8501331	0.1434657	5.9257	0.000000	Reject Ho	0.999987
Ldistance	1.336442	0.5916226	2.2589	0.027799	Reject Ho	0.721337
Ltariff	-0.3392972	0.1244191	-2.7271	0.008517	Reject Ho	0.852921
R-Squared	0.669067					

Regression Coefficient Section

Independent Variable	Regression Coefficient	Standard Error	Lower 90% C.L.	Upper 90% C.L.	Standardized Coefficient
Intercept	-16.82293	6.055529	-26.95094	-6.694925	0.0000
Lpopulation	0.9208361	0.1128238	0.7321357	1.109536	0.6951
Lincome	0.8501331	0.1434657	0.6101836	1.090083	0.6438
Ldistance	1.336442	0.5916226	0.3469396	2.325943	0.1894
Ltariff	-0.3392972	0.1244191	-0.5473909	-0.1312035	-0.2742
T-Critical	1.672522				

Analysis of Variance Section

Source	DF	Sum of Squares	Mean Square	F-Ratio	Prob Level	Power (10%)
Intercept	1	1364.922	1364.922			
Model	4	167.2981	41.82454	28.3046	0.000000	1.000000
Error	56	82.74875	1.477656			
Total(Adjusted)	60	250.0469	4.167448			

Root Mean Square Error	1.215589	R-Squared	0.6691
Mean of Dependent	4.730304	Adj R-Squared	0.6454
Coefficient of Variation	0.256979	Press Value	102.6971
Sum |Press Residuals|	61.30065	Press R-Squared	0.5893

Normality Tests Section

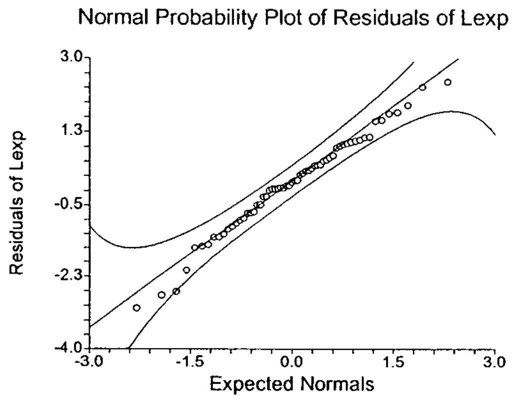
Assumption	Value	Probability	Decision(10%)
Skewness	-1.2573	0.208653	Accepted
Kurtosis	0.4990	0.617802	Accepted
Omnibus	1.8297	0.400573	Accepted

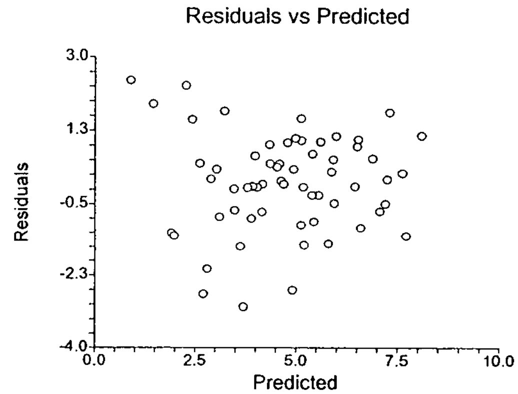
Multicollinearity Section
Eigenvalues of Centered Correlations

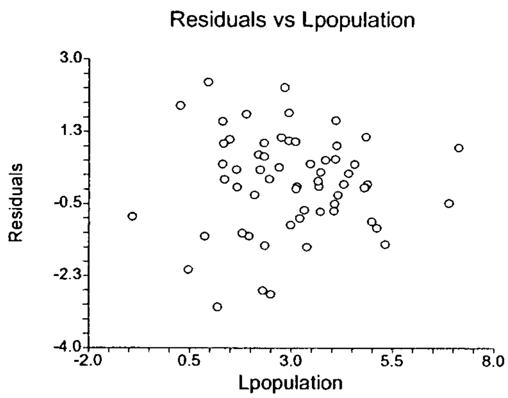
No.	Eigenvalue	Incremental Percent	Cumulative Percent	Condition Number
1	2.037217	50.93	50.93	1.00
2	0.956257	23.91	74.84	2.13
3	0.687455	17.19	92.02	2.96
4	0.319072	7.98	100.00	6.38

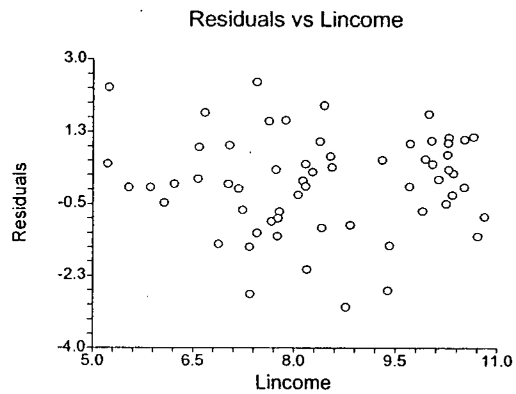
All Condition Numbers less than 100. Multicollinearity is NOT a problem.

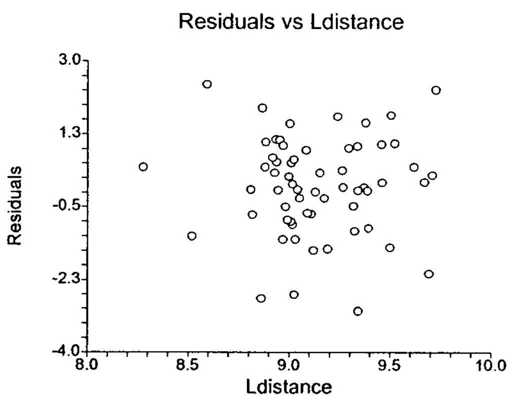
Plots Section

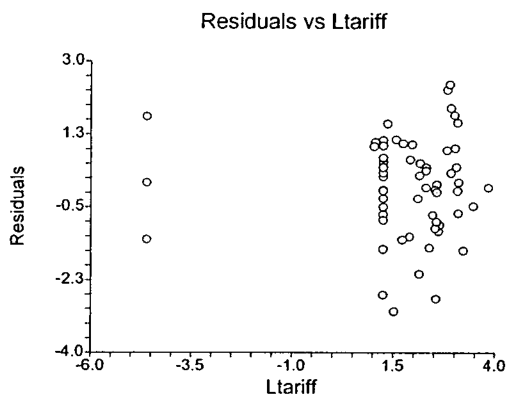












Disaggregate Model 1: Confidential Commodities

Regression Equation Section

Independent Variable	Regression Coefficient	Standard Error	T-Value (Ho: B=0)	Prob Level	Decision (10%)	Power (10%)
Intercept	-21.58878	8.454693	-2.5535	0.013468	Reject Ho	0.809771
Lpopulation	0.8770252	0.1535141	5.7130	0.000000	Reject Ho	0.999968
Lincome	1.110614	0.2084918	5.3269	0.000002	Reject Ho	0.999850
Ldistance	1.554051	0.8100709	1.9184	0.060255	Reject Ho	0.598860
Ltariff	-0.3161702	0.1698519	-1.8614	0.068028	Reject Ho	0.577012
Linflation_diff	-0.6387044	0.2062693	-3.0965	0.003080	Reject Ho	0.921197
R-Squared	0.683338					

Regression Coefficient Section

Independent Variable	Regression Coefficient	Standard Error	Lower 90% C.L.	Upper 90% C.L.	Standardized Coefficient
Intercept	-21.58878	8.454693	-35.73377	-7.443794	0.0000
Lpopulation	0.8770252	0.1535141	0.6201909	1.13386	0.4820
Lincome	1.110614	0.2084918	0.7618	1.459428	0.6123
Ldistance	1.554051	0.8100709	0.1987749	2.909327	0.1604
Ltariff	-0.3161702	0.1698519	-0.6003382	-3.200215E-02	-0.1860
Linflation_diff	-0.6387044	0.2062693	-0.9837999	-0.2936088	-0.2727
T-Critical	1.673034				

Analysis of Variance Section

Source	DF	Sum of Squares	Mean Square	F-Ratio	Prob Level	Power (10%)
Intercept	1	543.6776	543.6776			
Model	5	322.3651	64.47303	23.7374	0.000000	1.000000
Error	55	149.3852	2.716094			
Total(Adjusted)	60	471.7503	7.862505			

Root Mean Square Error	1.648058	R-Squared	0.6833
Mean of Dependent	2.985423	Adj R-Squared	0.6546
Coefficient of Variation	0.552035	Press Value	192.6827
Sum |Press Residuals|	84.21948	Press R-Squared	0.5916

Normality Tests Section

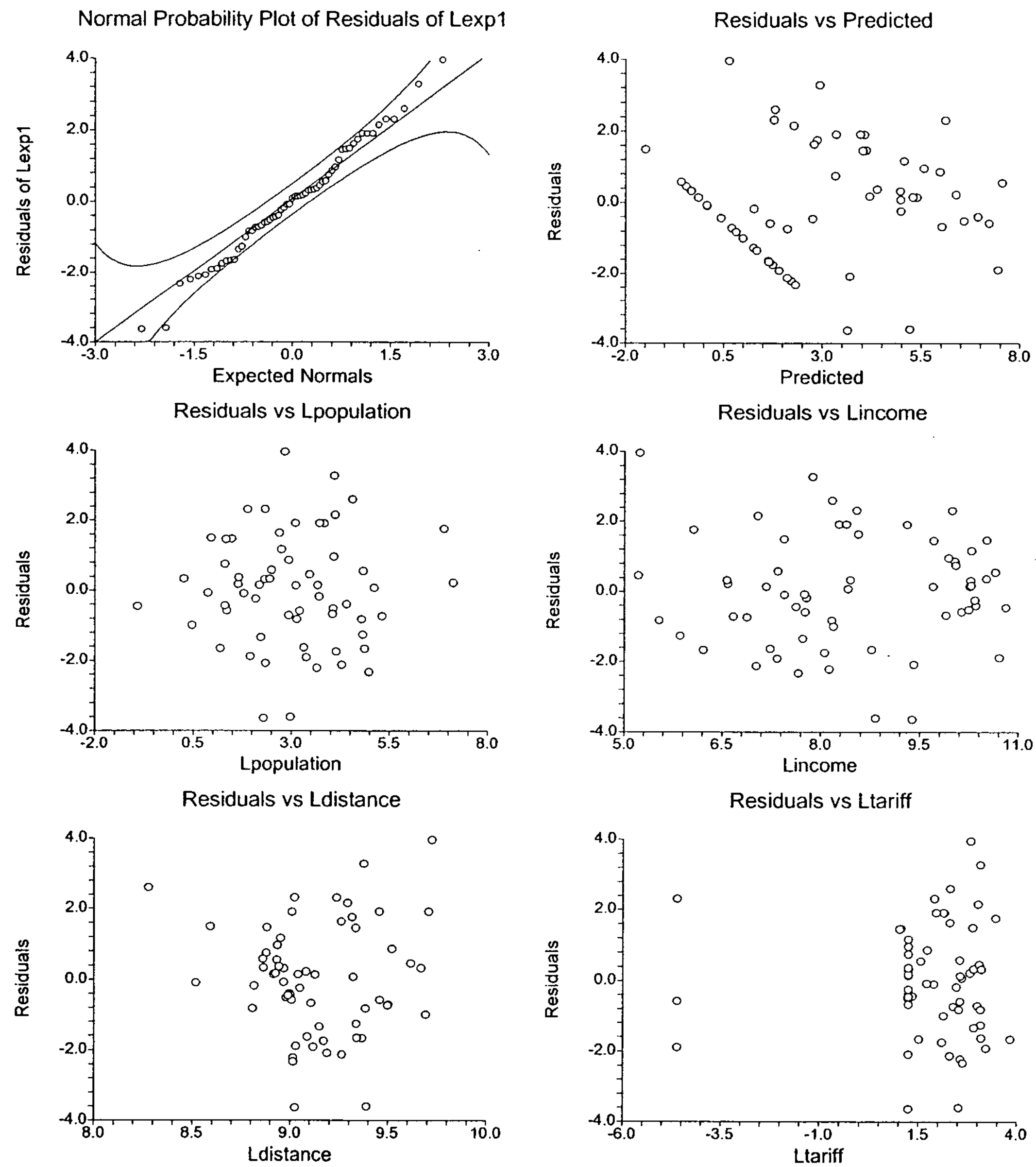
Assumption	Value	Probability	Decision(10%)
Skewness	0.2037	0.838566	Accepted
Kurtosis	0.2100	0.833691	Accepted
Omnibus	0.0856	0.958106	Accepted

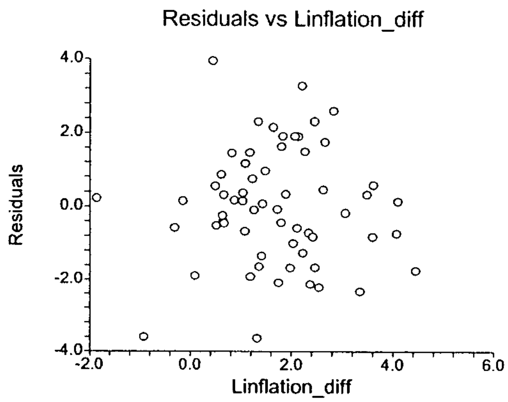
Multicollinearity Section
Eigenvalues of Centered Correlations

No.	Eigenvalue	Incremental Percent	Cumulative Percent	Condition Number
1	2.299673	45.99	45.99	1.00
2	1.023070	20.46	66.45	2.25
3	0.833934	16.68	83.13	2.76
4	0.548442	10.97	94.10	4.19
5	0.294882	5.90	100.00	7.80

All Condition Numbers less than 100. Multicollinearity is NOT a problem.

Plots Section




Residuals vs Linflation_diff
Residuals
4.0
2.0
0.0
-2.0
-4.0
-2.0
0.0
2.0
4.0
6.0
Linflation_diff

Disaggregate Model: Machinery & Instruments

Regression Equation Section

Independent Variable	Regression Coefficient	Standard Error	T-Value (Ho: B=0)	Prob Level	Decision (10%)	Power (10%)
Intercept	-5.196062	1.22586	-4.2387	0.000083	Reject Ho	0.994502
Lpopulation	0.9997922	0.1004883	9.9493	0.000000	Reject Ho	1.000000
Lincome	0.7617486	0.1184249	6.4323	0.000000	Reject Ho	0.999999
Ltariff	-0.3664224	0.108595	-3.3742	0.001337	Reject Ho	0.954381
R-Squared	0.719278					

Regression Coefficient Section

Independent Variable	Regression Coefficient	Standard Error	Lower 90% C.L.	Upper 90% C.L.	Standardized Coefficient
Intercept	-5.196062	1.22586	-7.245735	-3.146388	0.0000
Lpopulation	0.9997922	0.1004883	0.8317729	1.167812	0.7732
Lincome	0.7617486	0.1184249	0.5637388	0.9597584	0.5910
Ltariff	-0.3664224	0.108595	-0.5479963	-0.1848484	-0.3034
T-Critical	1.672029				

Analysis of Variance Section

Source	DF	Sum of Squares	Mean Square	F-Ratio	Prob Level	Power (10%)
Intercept	1	785.896	785.896			
Model	3	171.3506	57.11685	48.6827	0.000000	1.000000
Error	57	66.87513	1.173248			
Total(Adjusted)	60	238.2257	3.970428			

Root Mean Square Error	1.083166	R-Squared	0.7193
Mean of Dependent	3.589365	Adj R-Squared	0.7045
Coefficient of Variation	0.3017708	Press Value	77.56827
Sum |Press Residuals|	57.15238	Press R-Squared	0.6744

Normality Tests Section

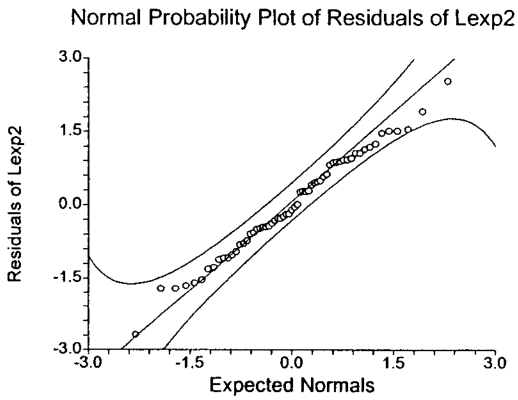
Assumption	Value	Probability	Decision(10%)
Skewness	-0.2185	0.827020	Accepted
Kurtosis	-0.4352	0.663413	Accepted
Omnibus	0.2372	0.888182	Accepted

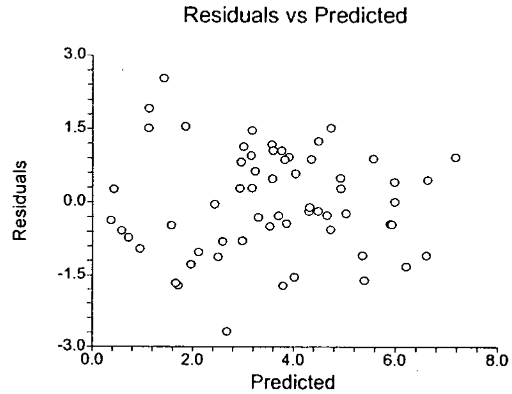
Multicollinearity Section
Eigenvalues of Centered Correlations

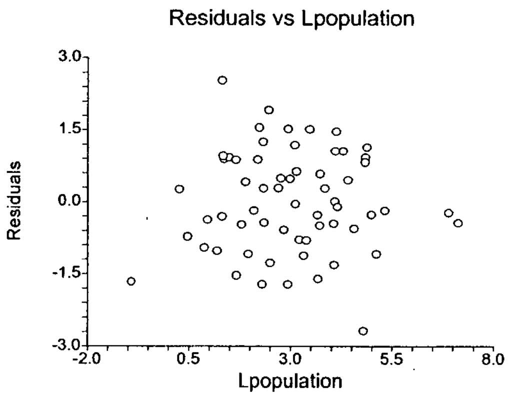
No.	Eigenvalue	Incremental Percent	Cumulative Percent	Condition Number
1	1.929113	64.30	64.30	1.00
2	0.687630	22.92	87.22	2.81
3	0.383257	12.78	100.00	5.03

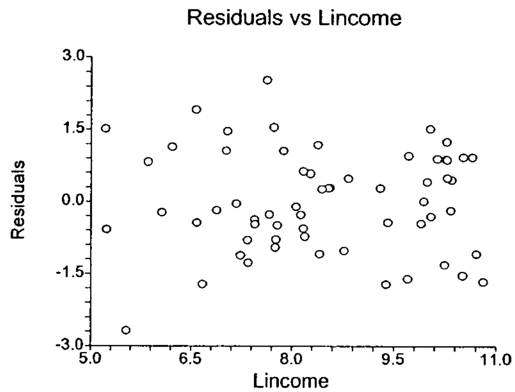
All Condition Numbers less than 100. Multicollinearity is NOT a problem.

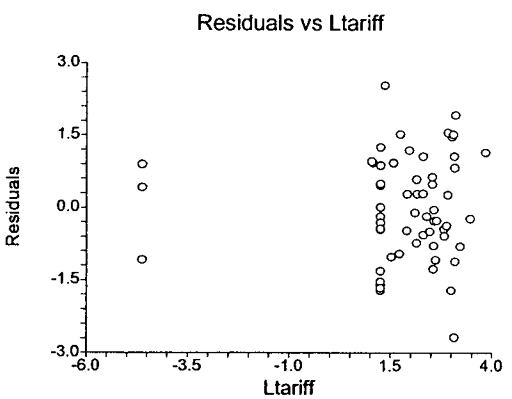
Plots Section











Disaggregate Model 3: Perishable Products

Regression Equation Section

Independent Variable	Regression Coefficient	Standard Error	T-Value (Ho: B=0)	Prob Level	Decision (10%)	Power (10%)
Intercept	-3.348776	2.075079	-1.6138	0.112191	Accept Ho	0.480429
Lpopulation	0.4784038	0.1543967	3.0985	0.003039	Reject Ho	0.921600
Lincome	0.582179	0.1923727	3.0263	0.003736	Reject Ho	0.910620
Ltariff	-0.404278	0.1680139	-2.4062	0.019444	Reject Ho	0.767984
Linflation_diff	-0.3944186	0.2054465	-1.9198	0.059981	Reject Ho	0.599557
R-Squared	0.484561					

Regression Coefficient Section

Independent Variable	Regression Coefficient	Standard Error	Lower 90% C.L.	Upper 90% C.L.	Standardized Coefficient
Intercept	-3.348776	2.075079	-6.819392	0.12184	0.0000
Lpopulation	0.4784038	0.1543967	0.2201719	0.7366356	0.3305
Lincome	0.582179	0.1923727	0.2604313	0.9039266	0.4034
Ltariff	-0.404278	0.1680139	-0.685285	-0.1232711	-0.2990
Linflation_diff	-0.3944186	0.2054465	-0.7380325	-5.080468E-02	-0.2116
T-Critical	1.672522				

Analysis of Variance Section

Source	DF	Sum of Squares	Mean Square	F-Ratio	Prob Level	Power (10%)
Intercept	1	158.3307	158.3307			
Model	4	144.6831	36.17078	13.1613	0.000000	0.999997
Error	56	153.9027	2.748263			
Total(Adjusted)	60	298.5858	4.97643			

Root Mean Square Error	1.657789	R-Squared	0.4846
Mean of Dependent	1.611082	Adj R-Squared	0.4477
Coefficient of Variation	1.028991	Press Value	204.2388
Sum |Press Residuals|	85.5655	Press R-Squared	0.3160

Normality Tests Section

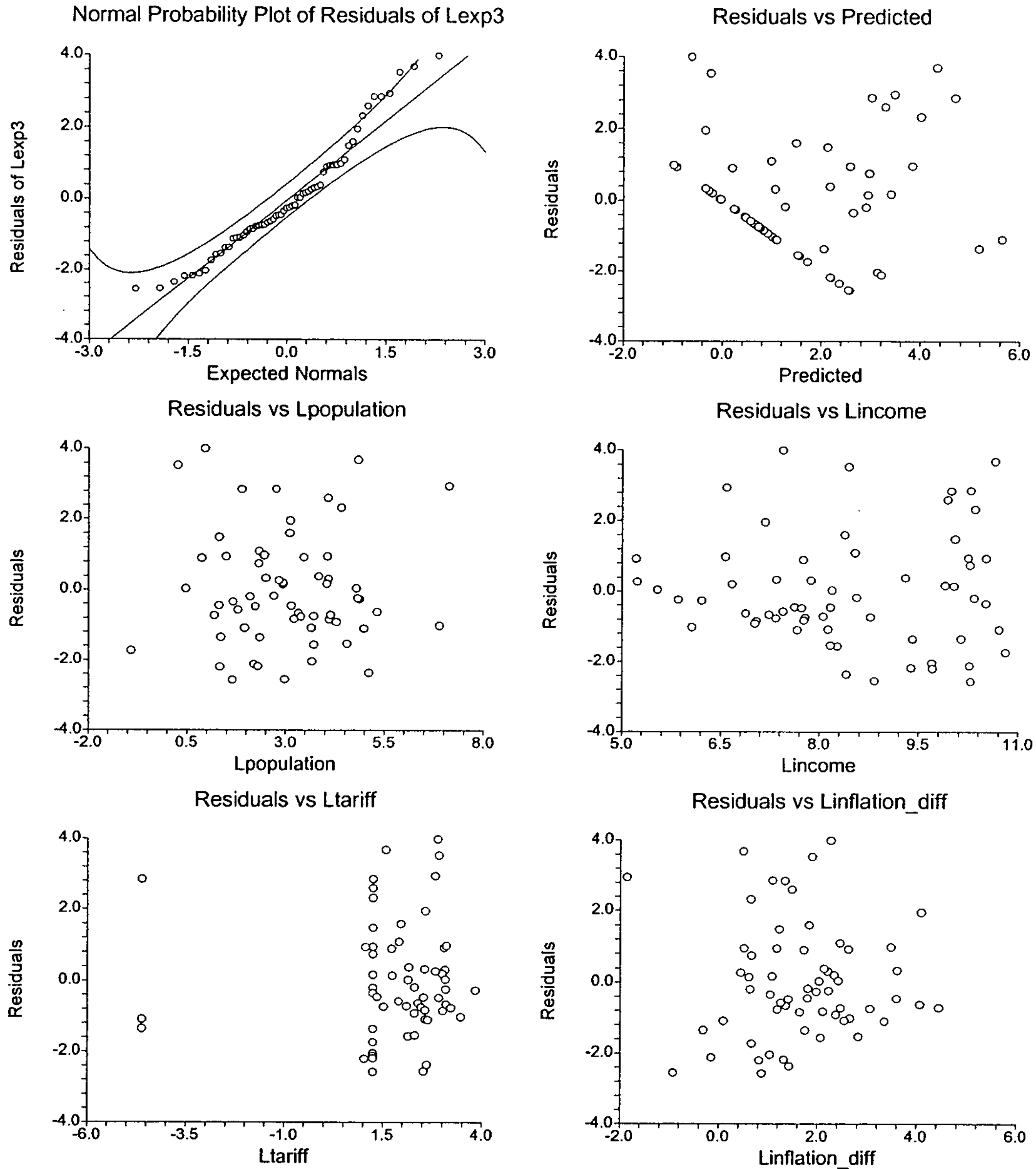
Assumption	Value	Probability	Decision(10%)
Skewness	2.2007	0.027754	Rejected
Kurtosis	0.2754	0.783040	Accepted
Omnibus	4.9191	0.085473	Rejected

Multicollinearity Section
Eigenvalues of Centered Correlations

No.	Eigenvalue	Incremental Percent	Cumulative Percent	Condition Number
1	2.222362	55.56	55.56	1.00
2	0.862866	21.57	77.13	2.58
3	0.549041	13.73	90.86	4.05
4	0.365732	9.14	100.00	6.08

All Condition Numbers less than 100. Multicollinearity is NOT a problem.

Plots Section



Disaggregate Model 4: Metals, Minerals & Wood

Regression Equation Section

Independent Variable	Regression Coefficient	Standard Error	T-Value (Ho: B=0)	Prob Level	Decision (10%)	Power (10%)
Intercept	-20.01001	7.626818	-2.6236	0.011143	Reject Ho	0.828303
Lpopulation	0.4674986	0.1483685	3.1509	0.002593	Reject Ho	0.928994
Lincome	0.746758	0.1564027	4.7746	0.000013	Reject Ho	0.998937
Ldistance	1.554074	0.7712751	2.0149	0.048636	Reject Ho	0.635497
R-Squared	0.307464					

Regression Coefficient Section

Independent Variable	Regression Coefficient	Standard Error	Lower 90% C.L.	Upper 90% C.L.	Standardized Coefficient
Intercept	-20.01001	7.626818	-32.76228	-7.257755	0.0000
Lpopulation	0.4674986	0.1483685	0.2194222	0.7155751	0.3802
Lincome	0.746758	0.1564027	0.4852482	1.008268	0.6092
Ldistance	1.554074	0.7712751	0.2644793	2.843668	0.2373
T-Critical	1.672029				

Analysis of Variance Section

Source	DF	Sum of Squares	Mean Square	F-Ratio	Prob Level	Power (10%)
Intercept	1	221.7576	221.7576			
Model	3	66.23692	22.07897	8.4354	0.000099	0.996292
Error	57	149.1929	2.61742			
Total(Adjusted)	60	215.4299	3.590497			

Root Mean Square Error	1.617844	R-Squared	0.3075
Mean of Dependent	1.906665	Adj R-Squared	0.2710
Coefficient of Variation	0.8485205	Press Value	168.5895
Sum |Press Residuals|	81.81243	Press R-Squared	0.2174

Normality Tests Section

Assumption	Value	Probability	Decision(10%)
Skewness	1.1033	0.269918	Accepted
Kurtosis	-0.3080	0.758057	Accepted
Omnibus	1.3120	0.518910	Accepted

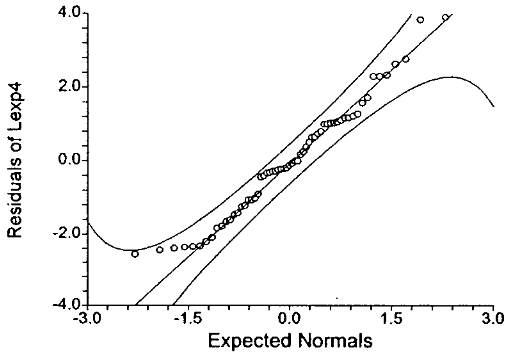
Multicollinearity Section
Eigenvalues of Centered Correlations

No.	Eigenvalue	Incremental Percent	Cumulative Percent	Condition Number
1	1.613196	53.77	53.77	1.00
2	0.859518	28.65	82.42	1.88
3	0.527285	17.58	100.00	3.06

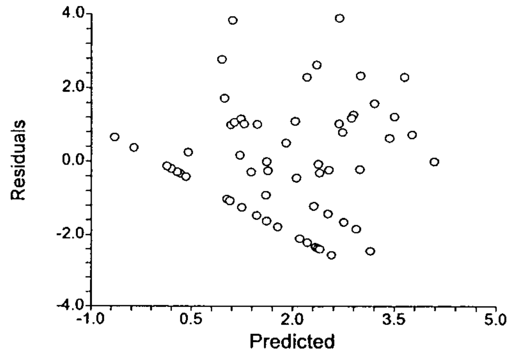
All Condition Numbers less than 100. Multicollinearity is NOT a problem.

Plots Section

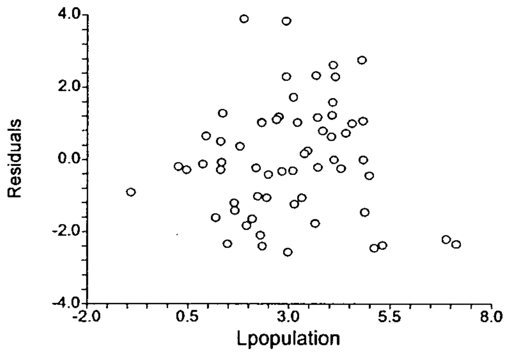
Normal Probability Plot of Residuals of Lexp4



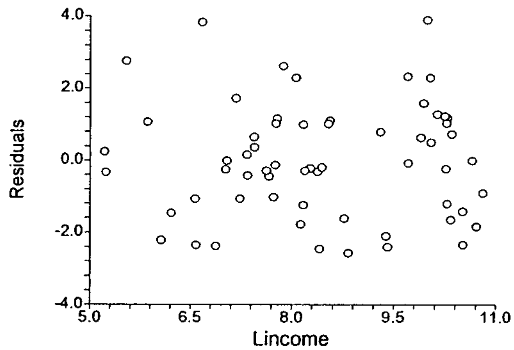
Residuals vs Predicted



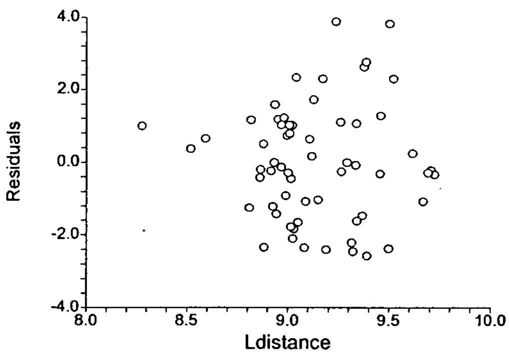
Residuals vs Lpopulation



Residuals vs Lincome



Residuals vs Ldistance



Disaggregate Model 5: Other Products

Regression Equation Section

Independent Variable	Regression Coefficient	Standard Error	T-Value (Ho: B=0)	Prob Level	Decision (10%)	Power (10%)
Intercept	-5.990654	1.304287	-4.5930	0.000025	Reject Ho	0.998091
Lpopulation	0.6947826	0.1069173	6.4983	0.000000	Reject Ho	0.999999
Lincome	0.7334482	0.1260014	5.8210	0.000000	Reject Ho	0.999980
Ltariff	-0.2589814	0.1155426	-2.2414	0.028908	Reject Ho	0.715667
R-Squared	0.600116					

Regression Coefficient Section

Independent Variable	Regression Coefficient	Standard Error	Lower 90% C.L.	Upper 90% C.L.	Standardized Coefficient
Intercept	-5.990654	1.304287	-8.17146	-3.809848	0.0000
Lpopulation	0.6947826	0.1069173	0.5160138	0.8735514	0.6027
Lincome	0.7334482	0.1260014	0.5227703	0.9441261	0.6383
Ltariff	-0.2589814	0.1155426	-0.452172	-6.579084E-02	-0.2405
T-Critical	1.672029				

Analysis of Variance Section

Source	DF	Sum of Squares	Mean Square	F-Ratio	Prob Level	Power (10%)
Intercept	1	204.1601	204.1601			
Model	3	113.6138	37.87128	28.5138	0.000000	1.000000
Error	57	75.70583	1.328173			
Total(Adjusted)	60	189.3197	3.155328			

Root Mean Square Error	1.152464	R-Squared	0.6001
Mean of Dependent	1.82945	Adj R-Squared	0.5791
Coefficient of Variation	0.6299509	Press Value	88.01733
Sum |Press Residuals|	56.63306	Press R-Squared	0.5351

Normality Tests Section

Assumption	Value	Probability	Decision(10%)
Skewness	2.0445	0.040906	Rejected
Kurtosis	0.8556	0.392222	Accepted
Omnibus	4.9119	0.085780	Rejected

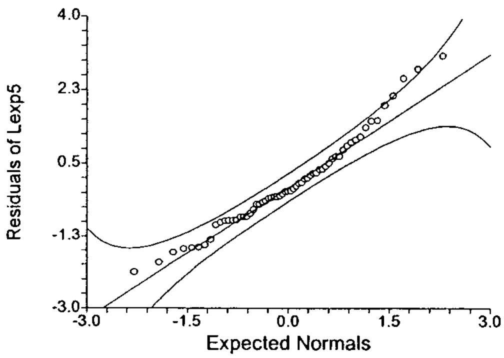
Multicollinearity Section
Eigenvalues of Centered Correlations

No.	Eigenvalue	Incremental Percent	Cumulative Percent	Condition Number
1	1.929113	64.30	64.30	1.00
2	0.687630	22.92	87.22	2.81
3	0.383257	12.78	100.00	5.03

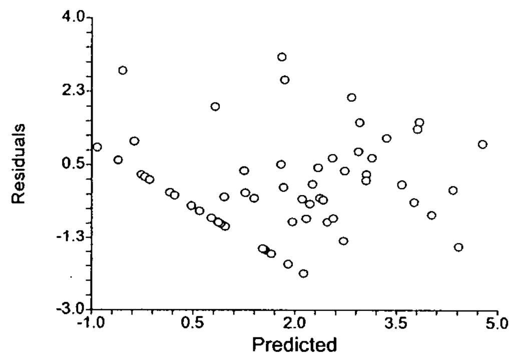
All Condition Numbers less than 100. Multicollinearity is NOT a problem.

Plots Section

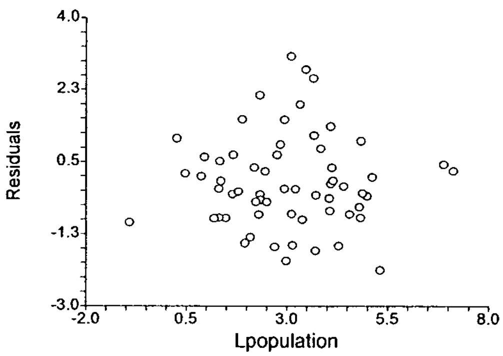
Normal Probability Plot of Residuals of Lexp5



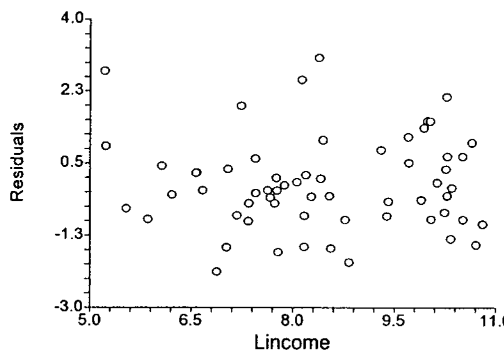
Residuals vs Predicted



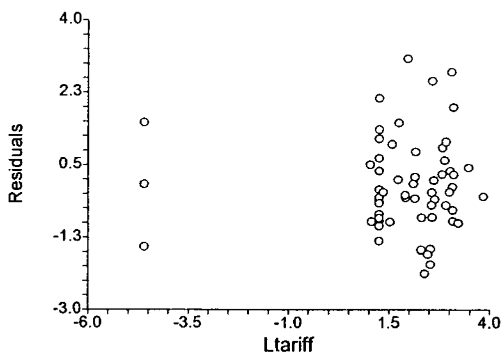
Residuals vs Lpopulation



Residuals vs Lincome



Residuals vs Ltariff



APPENDIX 3: FORECASTS

TABLE A3.1: FORECASTS FOR 1998

COUNTRY	AGGREGATE MODEL			MODEL 1 EXPORTS		
	NAIVE	ADJUSTED	UNBIASED	NAIVE	ADJUSTED	UNBIASED
Japan	3,271	3,272	6,848	1,904	1,905	7,402
Hong Kong	1,503	1,503	3,146	452	453	1,758
Germany	2,062	2,063	4,317	1,029	1,031	4,003
Australia	694	694	1,452	395	396	1,537
United Kingdom	994	995	2,081	263	264	1,021
China	676	677	1,415	593	593	2,304
Singapore	1,414	1,414	2,959	1,367	1,368	5,317
Netherlands	401	402	839	158	160	616
France	1,353	1,354	2,832	728	729	2,831
Thailand	169	169	353	19	20	73
Belgium	273	274	571	144	145	560
South Korea	376	376	786	58	59	226
Switzerland	2,251	2,252	4,713	1,728	1,729	6,720
Italy	1,176	1,177	2,462	413	414	1,606
Spain	642	643	1,345	221	222	858
South Africa	360	360	753	52	53	203
Malaysia	169	170	354	28	30	110
Sweden	223	224	468	197	199	767
Norway	147	148	308	61	62	236
New Zealand	120	121	252	56	57	217
Brazil	741	742	1,552	146	147	567
India	382	383	800	18	19	69
Austria	261	261	546	146	148	569
Finland	140	141	293	66	68	258
Egypt	78	78	162	10	11	38
Turkey	221	222	462	6	7	22
Denmark	177	178	371	80	82	312
Mexico	99	100	208	6	7	24
Sri Lanka	25	26	53	2	3	8
Chile	93	94	195	16	18	64
Ireland	79	79	165	28	29	109
Poland	102	103	214	9	11	36
Philippines	110	111	230	8	10	33
Czech Republic	54	55	113	6	7	23
Mozambique	10	10	20	2	3	7
Russia	231	232	484	10	12	40
Indonesia	332	333	696	8	10	32
Pakistan	65	66	136	5	7	21

Country	Aggregate Model			Model 1 Exports		
	Naive	Adjusted	Unbiased	Naive	Adjusted	Unbiased
Saudi Arabia	168	169	351	184	185	716
Bangladesh	57	57	119	4	5	14
Lithuania	11	12	24	2	3	6
Venezuela	51	52	107	2	4	9
Greece	182	182	380	40	42	157
Nigeria	45	45	93	2	4	9
Colombia	64	65	134	4	5	14
Tunisia	21	22	44	4	5	15
Jamaica	2	3	5	0	1	1
Trinidad and Tobago	4	5	9	1	2	3
Romania	32	33	67	1	2	3
Tanzania	14	14	29	1	2	2
Peru	49	50	103	5	7	21
Zimbabwe	18	19	38	1	2	3
Morocco	33	33	68	5	6	20
Portugal	136	137	286	38	39	148
Luxembourg	23	23	47	16	17	61
Algeria	38	38	79	7	8	27
Uruguay	41	41	85	5	7	20
Botswana	16	17	34	3	4	11
El Salvador	7	7	14	1	2	4
Latvia	7	8	15	1	2	4
Ecuador	15	16	31	1	2	2
Forecast	**22,507**	**22,554**	**47,118**	**10,768**	**10,842**	**41,871**

TABLE A3.2: FORECASTS FOR 1998

COUNTRY	MODEL 2 EXPORTS			MODEL 3 EXPORTS		
	NAÏVE	ADJUSTED	UNBIASED	NAÏVE	ADJUSTED	UNBIASED
Japan	1,314	1,314	2,362	76	78	302
Hong Kong	398	399	716	110	111	435
Germany	761	761	1,367	56	57	220
Australia	115	115	206	19	20	75
United Kingdom	402	402	722	27	28	107
China	369	369	663	33	34	129
Singapore	264	264	474	179	180	709
Netherlands	139	139	249	20	22	81
France	501	502	901	47	48	186
Thailand	43	44	78	3	4	12
Belgium	89	90	161	20	21	77
South Korea	139	140	251	9	10	35
Switzerland	744	744	1,338	284	285	1,124
Italy	379	379	681	31	32	121
Spain	223	224	402	23	24	91
South Africa	57	58	103	5	6	19
Malaysia	36	36	64	4	6	18
Sweden	78	78	139	25	26	99
Norway	50	50	89	13	15	53
New Zealand	24	24	42	9	10	36
Brazil	214	214	384	11	12	42
India	154	154	277	3	4	11
Austria	75	75	134	18	20	73
Finland	46	46	82	13	14	52
Egypt	24	25	43	2	4	9
Turkey	75	76	136	2	3	8
Denmark	56	56	100	14	15	56
Mexico	114	115	205	5	6	18
Sri Lanka	6	6	10	1	2	3
Chile	24	25	43	4	5	14
Ireland	27	28	49	8	10	33
Poland	41	41	73	3	4	12
Philippines	37	37	66	3	4	10
Czech Republic	19	19	34	3	4	11
Mozambique	2	2	3	1	2	3
Russia	106	107	191	3	4	12
Indonesia	89	89	160	2	3	7
Pakistan	20	21	36	1	3	5
Saudi Arabia	36	37	65	13	14	51
Bangladesh	19	20	35	1	3	5
Lithuania	4	5	7	2	3	6
Venezuela	26	26	46	2	3	6

Country	Model 2 Exports			Model 3 Exports		
	Naive	Adjusted	Unbiased	Naive	Adjusted	Unbiased
Greece	48	48	86	8	9	31
Nigeria	15	15	26	1	2	4
Colombia	34	35	62	2	3	8
Tunisia	6	7	11	2	3	6
Jamaica	1	2	3	1	2	2
Trinidad and Tobago	2	2	3	1	2	3
Romania	11	12	21	1	2	3
Tanzania	3	4	6	0	2	2
Peru	20	20	36	2	4	9
Zimbabwe	3	4	6	0	2	1
Morocco	12	13	22	2	3	8
Portugal	45	45	80	9	10	35
Luxembourg	5	6	9	6	7	22
Algeria	13	14	24	2	3	9
Uruguay	8	9	15	2	3	8
Botswana	2	3	4	1	2	4
El Salvador	5	5	9	2	3	7
Latvia	3	3	5	1	3	5
Ecuador	7	8	13	1	2	3
Forecast	**7,580**	**7,611**	**13,627**	**1,151**	**1,228**	**4,549**

TABLE A3.3: FORECASTS FOR 1998

COUNTRY	MODEL 4 EXPORTS			MODEL 5 EXPORTS		
	NAIVE	ADJUSTED	UNBIASED	NAIVE	ADJUSTED	UNBIASED
Japan	60	60	221	119	119	231
Hong Kong	15	16	54	47	47	90
Germany	43	44	159	76	77	149
Australia	39	39	143	19	20	37
United Kingdom	25	26	92	45	46	88
China	11	11	39	21	22	41
Singapore	18	19	67	36	36	70
Netherlands	18	19	65	23	24	45
France	33	34	123	56	57	109
Thailand	11	11	39	6	7	12
Belgium	15	16	54	17	18	33
South Korea	15	16	57	19	20	37
Switzerland	19	20	70	83	84	162
Italy	31	32	114	43	44	83
Spain	20	21	75	29	29	56
South Africa	20	21	74	8	9	16
Malaysia	11	12	41	6	7	12
Sweden	13	14	47	15	16	30
Norway	10	12	39	12	13	23
New Zealand	11	12	40	6	7	12
Brazil	23	24	86	21	22	41
India	9	10	34	10	11	20
Austria	16	17	58	15	16	30
Finland	10	11	37	11	11	21
Egypt	5	6	19	4	4	7
Turkey	9	10	34	10	10	19
Denmark	12	14	46	13	13	25
Mexico	3	4	11	13	14	25
Sri Lanka	3	4	11	1	2	2
Chile	8	9	28	5	5	9
Ireland	7	8	25	7	8	14
Poland	6	7	22	6	7	12
Philippines	5	6	19	5	5	9
Czech Republic	4	5	16	4	5	8
Mozambique	1	2	5	0	1	1
Russia	8	9	29	11	12	22
Indonesia	11	12	40	8	9	16
Pakistan	4	5	16	3	3	5
Saudi Arabia	13	14	49	7	7	13
Bangladesh	3	4	12	2	3	5
Lithuania	1	2	5	1	2	2
Venezuela	3	5	13	5	5	9

Country	Model 4 Exports			Model 5 Exports		
	Naive	Adjusted	Unbiased	Naive	Adjusted	Unbiased
Greece	11	12	41	9	10	18
Nigeria	3	3	10	2	2	4
Colombia	3	4	13	5	6	10
Tunisia	3	4	10	2	2	3
Jamaica	1	2	2	1	1	1
Trinidad and Tobago	1	2	5	1	1	1
Romania	3	4	10	2	3	4
Tanzania	2	2	6	1	1	1
Peru	4	5	13	4	4	7
Zimbabwe	3	4	11	1	1	1
Morocco	3	4	11	2	3	4
Portugal	8	9	30	9	9	17
Luxembourg	5	6	18	3	3	5
Algeria	3	4	13	2	3	5
Uruguay	5	6	19	2	3	5
Botswana	4	5	15	1	1	2
El Salvador	1	2	3	1	2	2
Latvia	1	2	4	1	1	2
Ecuador	2	3	6	2	2	3
Forecast	**667**	**726**	**2,467**	**899**	**935**	**1,746**

TABLE A3.4: FORECASTS FOR 1998

COUNTRY	DISAGGREGATE MODEL		
	NAIVE	ADJUSTED	UNBIASED
Japan	3,472	3,477	10,518
Hong Kong	1,022	1,026	3,055
Germany	1,965	1,969	5,898
Australia	587	592	1,999
United Kingdom	761	766	2,030
China	1,026	1,029	3,177
Singapore	1,864	1,868	6,637
Netherlands	358	363	1,056
France	1,366	1,370	4,150
Thailand	82	86	214
Belgium	285	290	886
South Korea	241	245	605
Switzerland	2,859	2,863	9,413
Italy	896	901	2,605
Spain	516	521	1,482
South Africa	142	147	414
Malaysia	85	90	244
Sweden	328	333	1,083
Norway	146	151	440
New Zealand	105	110	347
Brazil	415	419	1,121
India	194	198	410
Austria	270	275	864
Finland	146	151	451
Egypt	45	49	116
Turkey	102	106	218
Denmark	176	180	540
Mexico	141	145	284
Sri Lanka	13	17	35
Chile	56	61	159
Ireland	78	83	230
Poland	65	70	155
Philippines	57	62	137
Czech Republic	36	41	92
Mozambique	6	10	20
Russia	139	143	294
Indonesia	118	122	256
Pakistan	34	38	84
Saudi Arabia	253	257	893
Bangladesh	30	34	70
Lithuania	10	15	27
Venezuela	38	42	83

Country	Disaggregate Model		
	Naive	Adjusted	Unbiased
Greece	116	121	332
Nigeria	22	27	52
Colombia	49	53	107
Tunisia	16	21	46
Jamaica	3	8	9
Trinidad and Tobago	5	10	15
Romania	18	23	41
Tanzania	6	11	17
Peru	35	40	86
Zimbabwe	8	12	22
Morocco	25	29	65
Portugal	109	114	311
Luxembourg	34	39	117
Algeria	28	33	77
Uruguay	23	28	67
Botswana	11	15	35
El Salvador	10	14	25
Latvia	7	12	20
Ecuador	12	16	27
Forecast	**21,064**	**21,342**	**64,260**

TABLE A3.5: FORECASTS FOR 1999

COUNTRY	AGGREGATE MODEL			MODEL 1 EXPORTS		
	NAIVE	ADJUSTED	UNBIASED	NAIVE	ADJUSTED	UNBIASED
Japan	3,277	3,278	6,861	1,150	1,151	4,470
Hong Kong	1,551	1,551	3,246	1,321	1,322	5,136
Germany	2,089	2,090	4,373	604	605	2,349
Australia	718	719	1,504	207	209	807
United Kingdom	1,012	1,012	2,118	233	234	905
China	716	717	1,500	106	108	414
Singapore	1,487	1,487	3,112	493	493	1,915
Netherlands	413	414	865	103	104	401
France	1,387	1,388	2,903	399	400	1,551
Thailand	175	175	365	32	33	124
Belgium	279	280	584	80	82	312
South Korea	410	411	858	94	95	365
Switzerland	2,283	2,284	4,780	695	696	2,703
Italy	1,190	1,191	2,492	278	279	1,081
Spain	662	663	1,387	138	140	537
South Africa	364	365	762	48	49	186
Malaysia	178	179	372	29	30	112
Sweden	229	230	480	72	73	279
Norway	149	150	313	40	42	157
New Zealand	125	126	261	42	43	163
Brazil	747	748	1,564	91	93	355
India	404	405	846	26	27	101
Austria	265	265	554	86	87	334
Finland	144	145	301	42	44	165
Egypt	82	82	171	9	10	33
Turkey	211	212	442	6	7	24
Denmark	180	181	377	48	50	188
Mexico	102	103	214	6	7	22
Sri Lanka	26	27	55	2	4	9
Chile	93	93	194	14	16	56
Ireland	85	86	179	23	24	88
Poland	106	107	222	10	12	40
Philippines	113	114	236	9	10	34
Czech Republic	54	55	113	9	10	35
Mozambique	10	11	21	1	2	3
Russia	237	238	497	5	6	20
Indonesia	334	334	698	15	16	57
Pakistan	67	68	141	5	6	20
Saudi Arabia	169	169	353	56	57	217
Bangladesh	59	60	124	4	5	14
Lithuania	11	12	23	2	3	7
Venezuela	48	49	100	3	4	10

Country	Aggregate Model			Model 1 Exports		
	Naïve	Adjusted	Unbiased	Naïve	Adjusted	Unbiased
Greece	187	188	391	38	40	149
Nigeria	45	46	94	2	4	9
Colombia	62	62	129	4	6	16
Tunisia	22	23	46	3	4	12
Jamaica	2	3	5	0	1	1
Trinidad and Tobago	4	5	9	1	2	3
Romania	31	32	65	1	2	4
Tanzania	14	15	30	1	2	3
Peru	50	51	105	6	7	23
Zimbabwe	18	19	38	1	2	3
Morocco	32	33	68	5	6	18
Portugal	139	140	292	28	30	110
Luxembourg	25	26	53	10	11	39
Algeria	39	39	81	5	6	18
Uruguay	39	40	82	6	7	22
Botswana	17	17	35	2	3	9
El Salvador	7	8	15	1	2	4
Latvia	7	8	15	1	2	4
Ecuador	14	15	29	0	2	2
Forecast	**22,998**	**23,045**	**48,145**	**6,749**	**6,824**	**26,244**

TABLE A3.6: FORECASTS FOR 1999

COUNTRY	MODEL 2 EXPORTS			MODEL 3 EXPORTS		
	NAIVE	ADJUSTED	UNBIASED	NAIVE	ADJUSTED	UNBIASED
Japan	1,316	1,317	2,367	56	57	221
Hong Kong	411	411	739	1,386	1,386	841
Germany	770	770	1,384	40	41	158
Australia	119	119	213	13	14	51
United Kingdom	408	409	734	25	26	99
China	389	389	699	11	12	44
Singapore	276	277	497	95	96	375
Netherlands	143	143	256	16	17	62
France	513	513	922	32	34	128
Thailand	45	45	80	4	5	16
Belgium	91	92	164	14	15	54
South Korea	151	151	271	12	13	47
Switzerland	754	755	1,356	162	163	639
Italy	383	383	688	24	25	94
Spain	230	230	413	17	19	68
South Africa	58	58	104	5	6	18
Malaysia	37	38	67	4	6	18
Sweden	79	80	143	13	15	53
Norway	51	51	91	10	12	41
New Zealand	24	25	44	8	9	30
Brazil	216	216	388	8	9	32
India	162	163	292	4	5	14
Austria	76	76	136	13	14	52
Finland	47	47	84	10	11	39
Egypt	25	26	45	2	3	8
Turkey	73	73	131	2	3	9
Denmark	57	57	102	10	12	41
Mexico	117	118	211	4	6	17
Sri Lanka	6	6	10	1	2	4
Chile	24	24	43	3	5	13
Ireland	29	30	53	7	9	29
Poland	42	43	76	3	5	13
Philippines	38	38	68	3	4	10
Czech Republic	19	19	34	3	5	14
Mozambique	2	2	3	0	2	2
Russia	109	109	196	2	3	8
Indonesia	89	90	161	3	4	10
Pakistan	21	21	38	1	3	5
Saudi Arabia	36	37	65	6	7	24
Bangladesh	20	21	36	1	3	5
Lithuania	4	5	7	2	3	7
Venezuela	24	25	44	2	3	7

COUNTRY	MODEL 2 EXPORTS			MODEL 3 EXPORTS		
	NAIVE	ADJUSTED	UNBIASED	NAIVE	ADJUSTED	UNBIASED
Greece	49	50	88	8	9	30
Nigeria	15	15	27	1	2	4
Colombia	33	34	60	2	4	9
Tunisia	7	7	12	1	3	5
Jamaica	1	2	3	1	2	2
Trinidad and Tobago	2	2	3	1	2	3
Romania	11	12	20	1	2	3
Tanzania	3	4	6	0	2	2
Peru	20	21	36	2	4	10
Zimbabwe	3	4	6	0	2	1
Morocco	12	13	22	2	3	7
Portugal	46	46	82	7	9	29
Luxembourg	6	6	11	4	5	17
Algeria	14	14	25	2	3	7
Uruguay	8	9	15	2	4	9
Botswana	2	3	4	1	2	3
El Salvador	5	6	9	2	3	7
Latvia	3	3	5	1	2	5
Ecuador	7	7	12	1	2	2
Forecast	**7,730**	**7,761**	**13,898**	**2,078**	**2,155**	**3,575**

TABLE A3.7: FORECASTS FOR 1999

COUNTRY	MODEL 4 EXPORTS			MODEL 5 EXPORTS		
	NAIVE	ADJUSTED	UNBIASED	NAIVE	ADJUSTED	UNBIASED
Japan	60	61	221	119	120	231
Hong Kong	15	16	56	48	48	93
Germany	44	44	161	77	78	150
Australia	40	41	147	20	20	38
United Kingdom	25	26	93	46	46	89
China	11	12	41	22	23	43
Singapore	19	20	70	38	38	73
Netherlands	18	19	67	24	24	46
France	34	35	125	57	58	111
Thailand	11	12	40	6	7	12
Belgium	15	16	55	17	18	34
South Korea	17	18	61	20	21	40
Switzerland	19	20	71	84	85	164
Italy	31	32	116	43	44	84
Spain	21	22	77	29	30	57
South Africa	20	21	74	8	9	16
Malaysia	11	12	42	6	7	12
Sweden	13	14	48	16	16	31
Norway	10	12	39	12	13	23
New Zealand	11	12	41	6	7	12
Brazil	23	24	87	21	22	41
India	10	10	35	11	11	21
Austria	16	17	59	15	16	30
Finland	10	11	38	11	12	21
Egypt	5	6	19	4	4	7
Turkey	9	10	32	9	10	18
Denmark	13	14	47	13	14	25
Mexico	3	4	11	13	14	26
Sri Lanka	3	4	12	1	2	2
Chile	8	9	28	5	5	9
Ireland	7	8	27	8	8	15
Poland	6	7	23	7	7	13
Philippines	5	6	19	5	5	9
Czech Republic	4	5	16	4	5	8
Mozambique	1	2	5	0	1	1
Russia	8	9	30	11	12	22
Indonesia	11	12	40	8	9	16
Pakistan	4	5	17	3	3	5
Saudi Arabia	13	14	48	7	7	13
Bangladesh	3	4	12	2	3	5
Lithuania	1	2	5	1	2	2
Venezuela	3	4	12	4	5	8

Country	Model 4 Exports			Model 5 Exports		
	Naive	Adjusted	Unbiased	Naive	Adjusted	Unbiased
Greece	11	12	42	9	10	18
Nigeria	3	3	10	2	2	4
Colombia	3	4	12	5	6	10
Tunisia	3	4	11	2	2	3
Jamaica	1	2	2	1	1	1
Trinidad and Tobago	1	2	5	1	1	1
Romania	3	4	10	2	3	4
Tanzania	2	2	6	1	1	1
Peru	4	5	13	4	4	7
Zimbabwe	3	4	11	1	1	1
Morocco	3	4	11	2	3	4
Portugal	8	9	31	9	10	17
Luxembourg	5	7	20	3	3	6
Algeria	3	4	13	3	3	5
Uruguay	5	6	18	2	3	5
Botswana	4	5	15	1	1	2
El Salvador	1	2	3	1	2	3
Latvia	1	2	4	1	1	2
Ecuador	1	2	5	2	2	3
Forecast	**678**	**738**	**2,509**	**915**	**951**	**1,777**

TABLE A3.8: FORECASTS FOR 1999

COUNTRY	DISAGGREGATE MODEL		
	NAIVE	ADJUSTED	UNBIASED
Japan	2,701	2,705	7,510
Hong Kong	3,181	3,184	6,865
Germany	1,535	1,539	4,202
Australia	398	403	1,256
United Kingdom	737	742	1,920
China	540	544	1,242
Singapore	920	924	2,931
Netherlands	303	308	832
France	1,035	1,040	2,837
Thailand	98	102	273
Belgium	217	222	619
South Korea	294	298	784
Switzerland	1,714	1,718	4,932
Italy	759	764	2,063
Spain	435	440	1,152
South Africa	139	143	399
Malaysia	88	93	251
Sweden	193	198	553
Norway	124	129	351
New Zealand	91	96	290
Brazil	360	364	902
India	212	216	463
Austria	206	211	611
Finland	120	125	348
Egypt	45	49	114
Turkey	99	103	214
Denmark	141	146	402
Mexico	144	148	287
Sri Lanka	13	18	37
Chile	54	59	149
Ireland	74	79	212
Poland	68	73	164
Philippines	59	64	140
Czech Republic	40	45	107
Mozambique	5	9	15
Russia	135	140	275
Indonesia	126	130	284
Pakistan	35	39	85
Saudi Arabia	118	123	368
Bangladesh	31	35	72
Lithuania	10	15	28
Venezuela	36	41	81

Country	Disaggregate Model		
	Naïve	Adjusted	Unbiased
Greece	116	121	327
Nigeria	23	27	53
Colombia	48	53	108
Tunisia	16	21	43
Jamaica	3	8	8
Trinidad and Tobago	5	10	15
Romania	18	22	41
Tanzania	7	11	18
Peru	36	40	89
Zimbabwe	8	12	22
Morocco	24	29	62
Portugal	99	103	269
Luxembourg	28	33	92
Algeria	26	31	67
Uruguay	23	28	68
Botswana	10	15	32
El Salvador	10	14	25
Latvia	7	12	19
Ecuador	11	15	24
Forecast	**18,149**	**18,428**	**48,003**