AN ANALYSIS OF FACTORS INFLUENCING RAILWAY FREIGHT RATES

by

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ABSTRACT

The level of any particular railway freight rate is a function of the interaction between cost and demand factors for the movement of the commodity from one location to another. The purpose of this thesis is to analyse cost and demand factors influencing railway freight rates. The study focuses on three areas: 1) the determination of the joint effect of a number of factors on the rate; 2) three rate issues; and 3) the strength and weaknesses of the CTC Waybill Analysis to explain trends in rates.

The analysis ranges in scope from a description of cost and demand factors affecting rates to a statistical analysis. The subjective nature of rate-making, the polarized views concerning cost- or demand- based pricing, and the impact of public policy on rate-making are discussed in Chapter 2. The theoretical relationship between a factor and the rate is described for a large number of factors in this chapter as well. The third chapter describes six rate categories. Two of these rate categories are mode-competitive rates and one is based upon specific market competitive factors. Temporal changes in these rate categories are noted in an attempt to explain the relative importance of cost and demand factors over time. In the fourth chapter the available data are examined and two rate models are postulated. These rate models are used to assess some of the issues concerning rates. Chapter 5 presents the statistical results of the study. From these results, a proposal is made for explaining trends in rates by monitoring changes in identified, significant factors over time.

The study concludes that the joint effect of a number of factors is important in defining the level of a rate. All factors are not equally important and the significant factors vary for different regional movements.

The results of this study indicate that both cost and demand factors are significant for explaining differences in rates. Cost factors are more significant than demand factors in all movement models examined. The value of the commodity is significant in some cases, but intermodal competition and market competition are also significant.

The study concludes that the Waybill Analysis data are useful for making a detailed analysis of factors influencing rates. The analysis of a number of factors is considered to be a superior method to that of examining one aggregate measure, average revenue per ton-mile, for explaining trends in rates.

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CHAPTER 1

INTRODUCTION

1.1 Objective and Relevance of the Study

This study is concerned with an analysis of some of the cost and demand factors which influence railway freight rates. These factors are known to be significant in rate-making and should explain differences in existing rates.

Railway freight rates are a contentious and politically sensitive issue, particularly between the provinces and the federal government. [1] Concern is expressed that railway freight rates are based on the value of service rather than on the costs of providing the service. Another concern is that intermodal competition has been ineffectual in some parts of Canada; higher rail rates are attributed to this lack of intermodal competition. [2] This study addresses

(1) The Joint Submission on Transportation made by the four Western Premiers to the Prime Minister of Canada, Western Economic Opportunities Conference, Calgary, Alberta, July 1973.

(2) Government of Alberta, Department of Industry and Commerce, "The Equitable Pricing Policy: A New Method of Rail Rate Making", July 1973.

these issues by determining the significance of various factors.

The Canadian Transport Commission Waybill Analysis often is used as a source document for explaining temporal trends in rates.[(1)] There are three areas of concern in the use made of these Waybill Analysis data. First, often only one measure, average revenue per ton-mile, is used. Although weight and distance may be the most significant factors affecting rates, both their significance and the effect exerted by other factors should also be considered. Second, these data are highly aggregated. Average revenue and average variable values are analysed. The actual rates and actual variable values are not examined. Third, the data only represent cost factors. It is impossible to draw any conclusions about the relative importance of demand factors from data. Yet many issues remain concerned with the significance of value of the commodity, intermodal competition, and market competition. As noted above, this study deals directly with these issues. An alternative method of evaluating trends in the factors affecting differences in rates is postulated, given the results of this study.

(1) Morrish, J. H., and MacKinnon, D. P., An Address to the 18th Annual Traffic and Transportation Conference, Canadian Industrial Traffic League, Winnipeg, Manitoba, February 1974; and ________________ "Railroads' Waybill Analysis Explains Freight Rate Trends", Materials Management and Distribution, December 1974, pp. 26 - 29.

Differences in rates are relatively easy to understand when single factor/rate relationships are described. However, rates are the result of the joint affect of a number of factors. Understanding the nature of the joint affect and measuring it are more difficult to accomplish. Regression analysis and factor analysis are two statistical techniques employed in this study to determine what factors are significant and to measure this significance.

1.2 Methodology

The analysis proceeds in two stages. The first stage provides a theoretical and historical base from which the statistical evaluation may follow. The second stage, the statistical analysis, is an assessment of the data and the regression results.

The theoretical section deals with the expected relationship between each factor and the rate. Both cost and demand factors are treated in this manner. At this stage nothing is said about the importance of one factor in relation to other factors, nor is the absolute affect of the factor on the rate identified. This treatment serves two purposes, however. First, it sets the stage by identifying the many factors which are important in rate-making. Second, the prior knowledge of what the factor/rate relationship might be is a means of validating the statistical results.

There is a two-fold objective to the historical perspective. First, it indicates how rate-making theory has been made operational. Second, the temporal changes in the importance of the different rate categories is a measure of the changing rate-making environment. Some rate categories, for example Commodity Competitive rates, are an explicit recognition of the emerging importance of some factor. In this case, the rate category provides for mode-competitive rates.

The analysis of the data is directed to two ends. Those data derived from the Waybill Analysis are assessed for their suitability and their limitations are identified. As an adjunct, the variables extracted from the Waybill Analysis are related to the theoretical factor/rate relationships dealt with in the first stage of the analysis. At this stage, the necessity of obtaining additional data, notably demand data, is made clear. The data are examined prior to the definition of the rate models. In particular, any constraints imposed on the use of the models by the data limitations are identified.

Regression analysis is used to determine which cost and demand variables are significant for eight regional movements. A major consideration in this study is the potential problem of a high degree of correlation between any two cost and demand factors being evaluated. Such a condition has serious implications for assessing the regression results. The research design accounts for this by using factor analysis as an intermediate step prior to employing regression analysis. The merits of this two-stage approach versus the use of regression analysis alone are discussed.

1.3 Outline of the Succeeding Chapters

Each chapter is prefaced with an introductory section concerning the topic of the chapter.

The rate-making environment is discussed in the second section of Chapter 2. This includes a description of the impact of public policy in setting a structure within which rates are made. Public policy is characterized as havng a reactive role to play as well, in response to rate issues. The subjective nature of rate-making is emphasized in this section, and the fundamental controversy, cost versus demand-based pricing, is reviewed. The third section described the factors and the specific factor/ rate relationships.

Six freight rate categories are described and compared in Chapter 3. The implementation of these categories are related to evolutionary changes in public policy. A more recent comparison indicates the relative importance of each rate among the other rate categories and the apparent trends during the period 1970 to 1973. The last section of this chapter provides the rationale for the quantitative analysis. A framework for the analysis is given by postulating three hypotheses relating to rate issues.

Chapter 4 evaluates the data and describes two general rate models. In the second section, the Waybill data are described; particular attention is paid to the organization of these data. The limitations of these data are noted. In the third section, the factors in the models are related to the factors discussed in Chapter 2. Each factor is described and evaluated separately. The fourth section describes the organization of the data into eight movement models and the sampled commodities are noted. The last section describes the impact of the data limitations on the developed models which are descriptive (analytical) rather than predictive.

Chapter 5 presents the results of the statistical analysis. The second section outlines the research design and describes regression analysis and factor analysis in very general terms. The third section provides an overview of the results in terms of the significant variables and the relative ranking of significant variables within each of the eight movement models. The fourth section describes separately the results for each of the eight movement models. The use of factor analysis is noted in each case. A summary of the mathematical highlights of factor analysis is presented as an Appendix to Chapter 5. The fifth section is a summary of the statistical results. The last section presents a proposal for monitoring trends in factors affecting rates over time.

There are three sections to Chapter 6. The first is a brief summary of the study. The second deals with areas requiring further study. Particular attention is given to anomalies in the results. The last section presents the conclusions drawn from the study.

CHAPTER 2

FACTORS INFLUENCING DIFFERENCES IN THE LEVELS OF RATES

2.1 Introduction

The focus of this chapter is on the cost and demand factors that affect the level of railway freight rates. However, rate making is a complex subject and merely describing these factors may not be adequate for understanding the nature and level of rates. Rate-making is an art, not a science, and recognizing this may help in understanding the rate-making process. Public policy is important for two reasons. First, policy is instrumental in defining the environment in which rates are made. Second, public policy may be called upon in reaction to conditions created by the state of freight rates. The subjectivity of rate-making and public policy concerns, therefore, are relevant in any discussion about factors affecting differences in rates.

2.1.1 Rate Making - Art Not a Science

Notwithstanding the attempts to define "scientific" rate structures and indeed the attempt in this thesis to analyse factors influencing differences in rates in a quantitative fashion, rate-making is still largely a matter of judgement. The problems associated with determining costs associated with the movement of a specific commodity from a particular origin to a specific destination is part of the problem. The negotiations between shippers and carriers add a further judgemental dimension to the setting of rates. Considerations other than those purely cost- or demand-oriented may influence the rate-making process. For example, public policy both constrains the limits of the rates and the level of a rate may be questioned on the grounds of "public interest". (1)

2.1.2 Public Policy - Defining the rate-making environment

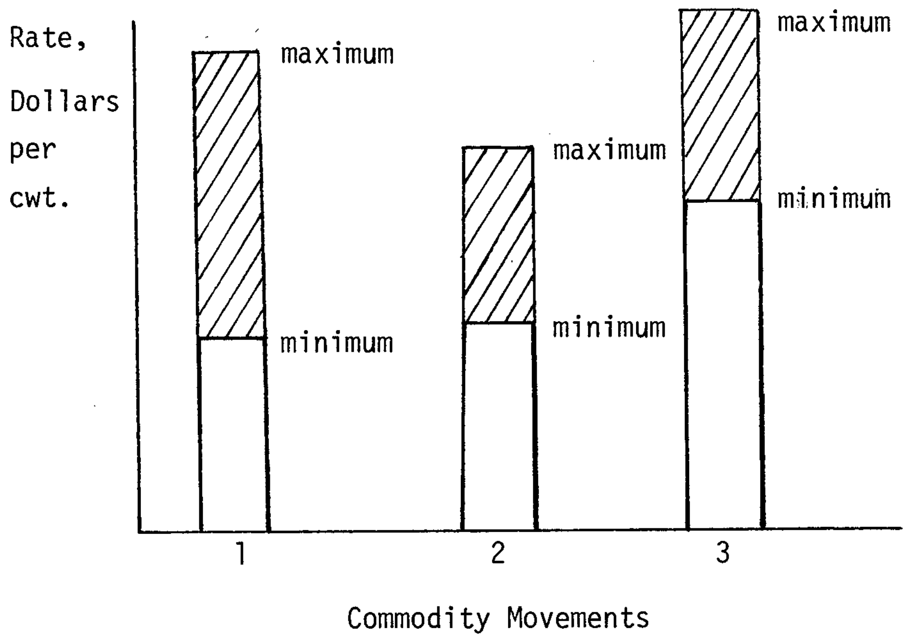
Railway pricing in Canada is predicated upon cost and demand factors constrained by a minimum of regulation. The creation of the rate-making environment as it exists today is a result of a gradual temporal shift in the emphasis of public policy which culminated in the National Transportation Act of 1967. The effect of public policy in defining the rate-making environment is that primary reliance is placed on market forces for determining the level of rates. That is, within the regulatory framework, the differences in the level of two or more rates at any time is based on cost and demand factors which are market-determined.

The minimum level for a rate is 100% of the variable (out-of-pocket) costs for the movement of the particular commodity. (2) The maximum level of the rate may be fixed by

(1) Section 334 and 336 of the Railway Act and Section 23 of the National Transportation Act, 1967 respectively.
(2) Section 334 of the Railway Act.

either the Canadian Transport Commission or by market forces. In the former case, if a shipper has a prima facie case that he is a "captive shipper" then the maximum rate may be defined as high as 2.5 times the variable costs for the movement of the commodity. (1) In the strictest sense, the maximum rate can be designated as that rate which, if exceeded, will result in a failure to move the traffic. However, there are many factors which the railways might consider before attempting to negotiate a rate as high as one which results in no movement of the traffic.

Figure 2.1 - The General Structure of Rates



In each of three cases, depicted in Figure 2.1, the minimum rate reflects the differences in the variable costs required for the movement of the commodity. For the first com-

(1) Section 336 of the Railway Act.

modity movement, the maximum rate is set at 2.5 times the variable cost, reflecting the maximum rate charged a "captive shipper". The second and third commodity movements reflect maximum rates set by market forces. In each case the area between the maximum and minimum rate levels represents potential rate levels for the movement of the commodity. Where the rate is finally established will depend on a number of factors. The availability of alternative transport modes and negotiating skills are among these factors.

A formal appeal mechanism exists whereby a shipper may ask for a reduction in rates in the "public interest" under Section 23 of the National Transportation Act. In the event that the Canadian Transportation Commission decides that a prima facie case has been made that a rate is not in the public interest, a formal hearing will be held. Should the CTC decide that the rate is high, the railways can be ordered to reduce the level of the rate. In spite of the existence of this mechanism and its importance, it is difficult to determine its effect as there has only been one decision by the CTC concerning rates. It may well be a factor in negotiations between shippers and carriers.

2.1.3 Public Policy - Reaction to freight rate issues

In an imperfect world, it is hardly surprising that reality differs from the perfection often assumed in formulating public policy. The impact of the National Transportation Act is that reliance is placed on market forces to determine the level of rates. Should these market forces fail to serve the policy requirements, policy reaction may be necessary. A concern of the western provinces, historically, is that transportation policy affects the regional economy. Although the emphasis of these concerns may have changed, it is alleged that the National Transportation Act as public policy has failed to deal with the regional economic requirements of western Canada.(1)

In general, the western provinces view current transportation policy as limiting economic expansion of the region.(2) Specific issues concerning railway freight rate cases were raised at the Western Economic Opportunities Conference in the summer of 1973.(3) The issues include the following:

1. Rail users pay approximately 80% of the fixed costs while air and water users pay approximately 20% of such costs;
2. Railways base many rates on the value of the products transported; therefore finished goods are charged higher rates than raw materials;

(1) Government of Alberta, Department of Industry and Commerce, Transport Research and Development Division, "The Equitable Pricing Policy: A New Method of Rail Rate Making", July 1973, p. 1.
(2) The Equitable Pricing Policy, op. cit., p. 5.
(3) Joint submission on Transportation by the Four Western Premiers to the Prime Minister of Canada, Western Economic Opportunities Conference, Calgary, Alberta, July 1973.

3. Rail rate groups exist in Central Canada, and large areas are considered one location for rate-making purposes; such a policy encourages development of the small communities covered by the area rate;
4. Horizontal percentage rate increases place a disproportionate burden on western non-competitive traffic; and;
5. In certain instances higher rail rates are charged for short hauls than for longer ones involving the same commodity.

2.1.4 Summary

Before discussing the general factors influencing the level of rates, it should be noted that railway pricing is a complex subject which has a long history of controversy. To some extent the views about railway rates and what they ought to be predicated upon are polarized. On one hand it is argued that freight rates should be based on costs; on the other it is argued that rates should be set on the basis of demand for the service. (1)

The Alberta government has taken the former position. (2) The railways would be expected to rationalize rate-making in the latter manner; that is, charge what the traffic will bear

(1) Davis, Grant M., Combs, Linda J., "Some Observations Regarding Value-of-Service Pricing in Transportation", Transportation Journal, Vol. 14, No. 3, Spring 1975, p. 49.
(2) The Alberta government's paper: "The Equitable Pricing Policy".

(demand-based pricing).[1] Current policy has created an environment in which both costs and demand factors may be relevant in determining the level of rates.

The discussion of cost and demand factors in the following two sections is simplified by necessity. In contrast, determining the equity of a particular rate level requires the identification of specific factors affecting the level of that rate. Thus a dicotomy exists between the general treatment given the theoretical relationship between factors and rates in this chapter, and the inherent specificity of any particular rate.

2.2 Railway Costs and Cost Factors

The rail mode is capital intensive and unlike other transport modes (except pipelines), the railway companies have a major investment in the infrastructure. Thus fixed costs are a significant component of the total cost. This factor seriously affects the ability of the railroad companies (or anybody else) to make rates purely on the basis of costs.

Although variable costs would increase as a proportion of total costs in the long-run, in the short-run most costs are fixed.[2] The problem of making rates on the basis of costs

(1) Alberta Government, op. cit., p. 5 and Railway Transport Committee Decision, Rapeseed Case, op. cit., p. 44.
(2) See Locklin, op. cit., p. 168, he references a study done in 1943, which found that in the long-run, 70 - 80 percent of U. S. railroad operating expenses are variable.

becomes one of allocating these fixed costs to the traffic which is moved. While both fixed and variable costs can be allocated by some means, the allocation may not be significant for the making of rates.

Differences in the level of rates can be influenced by cost factors related to different commodities moving between the same points, or by cost factors for the same commodity moving between different points.

2.2.1 Cost Factors Influencing Differences in Rates Between Commodities

The loading characteristics of different commodities can result in different costs. The weight per cubic foot is commonly used to define the loading characteristic of a commodity. In general, as weight per cubic foot increases, the rate decreases. This condition is reflected in different carload minima for different commodities. For example, commodities with low carload minima, say 25,000 pounds, will have a higher rate per hundredweight than will a commodity with a higher carload minima, say 80,000 pounds. Commodities may load lightly for other reasons besides weight density. Objects with large dimensions which cannot be "broken down" or with odd shapes will incur higher rates.

The liability of the carrier for the goods carried and the susceptibility of the goods to loss and damage may be instrumental in defining differences in rates. Commodities highly susceptible to damage will bear higher costs than those with low susceptiblity to damage, other things being equal.

Costs directly related to a particular commodity may decrease as a result of higher volumes of traffic moving over time. The utilization of unit coal trains represents the kind of cost efficiencies alluded to by this factor. In this case, cost efficiencies are achieved through increased handling efficiencies. Other things being equal, lower rates per transported unit would be expected.

Equipment requirements for two commodities may result in different costs and hence different rates. For example, frozen meat, requiring a refridgerated car would bear a higher rate that would canned meat which can be shipped in a standard box car.

2.2.2 Cost Factors Influencing Differences in Rates Between Particular Points

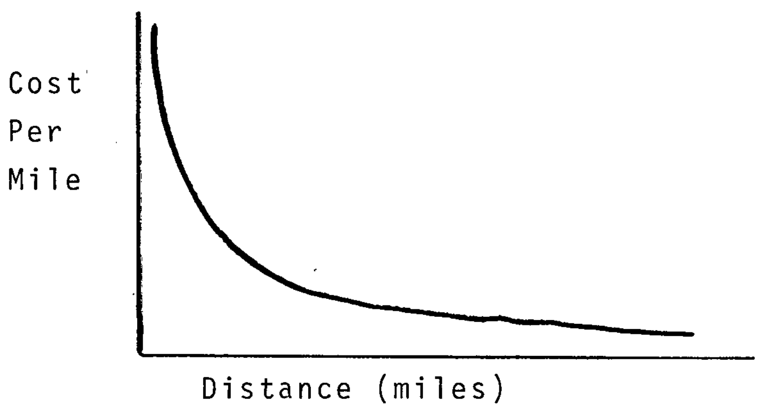
The cost-distance relationship is predicated on two types of costs, terminal costs and line haul costs. (1) Terminal costs can be viewed as a fixed amount per hundredweight. If intermediate-point costs are ignored, line haul costs can be expressed as a constant amount per mile. (2) Total cost for any movement is:

(1) Purdy, opt. cit. p. 101.
(2) op. cit.

(2.1) $TC = a + bD$ where a = the fixed terminal cost per hundredweight;
b = fixed cost per mile;
D = the distance of movement;
TC = Total cost

The cost per mile is non-linear and its slope is negative (Figure 2.2). This relationship results because the fixed terminal charges are spread over more miles as the distance increases. Total cost for long-hauls are greater than for short-hauls and the rates, other things being equal, will reflect these costs. (Table 2.1) The rate per mile/distance relationship is also non-linear; it declines as distance increases, (Table 2.1). [1]

Figure 2.2 - Cost Per Mile for the Same Commodity Moving Different Distances



(1) Interstate Commerce Commission, Bureau of Accounts, "Rail Carload Cost Scales by Territories for the Year 1959", Washington, D.C., November 1960, Table 2, p. 72.

Table 2.1 - The Rate-Distance Relationship

An Example: 100 Pounds Moving Different Distances

Distance (in miles)	Total Cost of the Movement (in dollars)	Rate per Mile (in cents)
50	.0797	.1596
100	.0924	.0924
500	.1935	.0387
1000	.3199	.0319
1500	.4463	.0297
2000	.5727	.0286
2500	.6991	.0279

Source: See footnote (1) below, adapted from Interstate Commission, Bureau of Accounts, Rail Carload Cost Scales by Territory, for the Year 1959, Washington, D. C., November 1960, Table 2, p. 72.

Operating conditions for two movements in different regions may be different even though the distance is the same for both movements. For example, differences in route profiles can result in different operating costs which the shipper may not be aware of. Some parts of the British Col-

(1) Out-of-pocket terminal costs, a, equal 6.714 cents per 100 pounds; out-of-pocket line haul cost, b, equal .02528 cents per hundredweight mile. Both of these costs are for a Western District, box car movement at 50 tons per car. Therefore, if rates are assumed to equal costs for a 100 pound shipment moving different distances, the total cost of the movement = a + bD when a and b are as defined above and D, is the distance travelled. The rate per mile in cents, $= \frac{(a + bD)}{D}$ See source Table 2.1.

umbia Railway system have maximum gradients of 2.2%. Heavily laden trains travelling on this part of the system may require the addition of an auxillary power unit. Thus all traffic moving over this part of the system bears this additional cost. In an opposite case, larger trains may be able to operate with fewer engines in certain Prairie sub-divisions. Rates in the former case would be higher, other things being equal, than in the latter case.

Multiple line hauls, for example from a branch line to a main line will incur switching costs. As the number of lines crossed increases, switching costs increase and rates will increase.

As traffic density increases, the unit cost of transportation decreases. Therefore, large volumes of traffic over a line, or portion of a line, may result in lower rates, other things being equal. The necessary qualification is that excess capacity exists on the line. At some point, the addition of traffic to a line may cause costs to increase as capital is expended to increase capacity.

If traffic is added to a system and it moves in the same direction as empty car movements, rates would be lower. This factor may become increasingly important in the future, insofar as the utilization of unit trains often results in backhauling empty cars. Although it could be important elsewhere in Canada, it would be expected to be more significant in Western Canada, given the potential for unit train movements of bulk commodities.

2.3 Demand Factors Affecting the Level of Rates

Demand for transport is a derived demand. It is the demand for a product which may result in that product being transported from one point to another. Thus there are two dimensions to consider: first are those factors which may affect the demand for the commodity, and second there are factors which may influence the demand for transport of the commodity.

Market competition is one factor which can affect the demand for the product. Demand for any one product may decrease if it is subjected to strong market competition. Thus, to ensure competitiveness, it would be expected that rates would decrease as market competition increases. Competition for carriage of the commodity may exist between transport modes, affecting the demand for transport. Other things being equal, rates would be expected to decrease when intermodal competition increases.

2.3.1 Demand Factors Affecting Differences in Rates Between Commodities

The value of the commodity is a major factor influencing differences in rates. In the past, it played a greater role in determining the level of rates than it does today. The diminishing role of this factor may be attributed to increasing competition from road and air modes for carriage of high-value goods. (1) In general, the higher the value of the commodity, the more likely it is that the rate will be higher than for a low-valued good. This is not meant to imply that high-valued goods will necessarily have a high rate relative to low-valued goods; it only means that the ability of high-valued goods to bear a higher rate is greater than for low-valued goods. (2)

In addition to the general condition, there are a number of specific issues which may be related to the value of the commodity. Thus rate differentials ~~between~~ among raw materials and finished products, and the use made of the commodity may be explained, in part, by the value of the commodity. The rate for raw products is generally lower than for finished products. The use made of a commodity may depend on its quality (grade or purity) which is reflected in differential values for different grades of a commodity. (3)

The economic condition of an industry may affect the level of rates. Other things being equal, in times of prosperity rates may be higher than those when the particular industry is suffering from depressed economic conditions.

(1) Although the discussion in this section is meant to deal with competition among commodities, among other things, it is important to note that in reality, it is difficult to differentiate between competition for the commodity and competition for carriage of the commodity vis-a-vis other factors.

(2) Locklin, ibid. p. 159.

(3) A different rate would be expected between sand for manufacturing glass and sand for construction, for example.

2.3.2 Demand Factors Affecting Differences in Rates Between Particular Points

In the transport of a good between particular points, competition may play an important role in explaining rate differentials.

The ability of a transported commodity to compete effectively in a market depends on the product price and, of course, the price is dependent upon the costs of production and distribution which include transportation costs. Other things being equal, lower rates would be expected for commodities subject to a high degree of competition and higher rates would be expected for commodities which bear little market competition.

Intermodal competition may influence the level of rates. The trade-off between modes is between the modes' service characteristics and the shippers' cost of using the mode. That is, if time in transit is an important factor for the shipper he will be willing to bear a higher transport cost for shipping by air than if he were to use a less speedy mode such as rail. Specific origins or destinations may have some inherent advantage for the shipping of some types of commodities. Other things being equal, a high degree of intermodal competition would mean lower rates, and higher rates would be expected when there is little or no intermodal competition.

It may be very difficult to separate the influence of market and intermodal competition. For example, the long-short haul discrimination charged for the movement of steel from eastern Canada to Alberta and British Columbia may be a function of both types of competition. An example of the long-short haul problem is portrayed in Table 2.2.

Table 2.2 - The Long-Short Haul Discrimination Problem - Alberta and British Columbia
(dollar transport cost per hundred pounds)

ORIGIN	DESTINATION		
	Vancouver	Edmonton	Saskatoon
Toronto (iron and steel)	$1.68	N/A	$2.47
Hamilton (skelp)	$1.35	$2.11	N/A

Source: Alberta Government, Equitable Pricing Policy, p. 5, compiled by author.

It may be argued that the lower costs in Vancouver are attributable to both market competition for steel in Vancouver and water competition via the Panama Canal. Vancouver has the advantage. It is closer to other sources, like Japan and South America, and a cheaper mode of transport - water, can be utilized. (1)

(1) Although this was the case in 1973, ocean freight rates and manufacturing costs in the Far East and South America may have increased substantially since 1973. If this is the case, a decrease in the total cost differential between domestic and foreign steel might result in higher railway freight rates at the present time.

2.4 Summary

Rate-making has been characterized as a less-than-exact phenomenon. Public policy in Canada has set a stage whereby both cost and demand factors may interact in defining the level of a rate.

The nature of railway costs limit the degree to which costs may be allocated in a significant manner. The subjective nature of demand factors in some cases makes it difficult to determine the equity of any particular rate.

Public policy has been characterized as having a second role to play in determining differences in rates. As economic and social goals change, public policy on transportation can be expected to change. For example, a great deal of concern has been expressed in some regions of Canada about the impact of railway freight rates on regional development.

In some cases there appears to be interdependence between or among the cost and demand factors discussed. In addition, the portrayal of a specific factors' influence on differences in rates is in general terms. There has been no discussion about the degree to which a factor affects a rate level, yet it may be assumed that this is an important dimension affecting differences in rates. Caution must be exercised in analysing specific freight rates in terms of the factors discussed in this chapter.

CHAPTER 3

RATE STRUCTURE AND CHANGES IN THE RATE STRUCTURE OVER TIME

3.1 Introduction

In the previous chapter, rates were characterized as being heterogeneous. The number of factors involved, their relationships with one another and the rate-making environment all contribute to the complexity of defining rate levels. As well, the thousands of commodities moving between thousands of pairs of points suggest that administering a published set of rates is a difficult task. Rate tariffs are a means of simply articulating and administering railway freight rates.

There are five main rate systems. A sixth rate system, although less important, is discussed to indicate the extent of rate regulation and control that exists in Canada. The first rate system, Class Rates, antedates railway rate systems but was readily adopted by the railways. The remaining rate systems were each initiated primarily to serve a specific purpose, as will become apparent.

The amount of traffic moving under each of these rate types has changed over time. Thus the temporal changes in the traffic moving under each rate type reflect the relative importance of cost, demand, and public policy factors over time.

3.2 Class Rates

The current Class Rate system applies only to carload traffic. In the Class Rate structure commodities are grouped in one of a number of classes. Each class rate is expressed as a percentage of the Class One rate. (1)

The carload minimum weight is provided, as is the state of the commodity packaging (for example, set up, knocked down, or owner's risk of breakage). The Class One rates are related to a distance scale which shows the "taper" phenomenon accorded long-distance movements.

Very little traffic tends to move under the Class rate system. Only .8% of the sampled ton-miles for all of Canada moved under Class rates in 1972. (2) The Class rates provide a higher average revenue per freight ton-mile to the railways, 4.71¢ in 1972, than do the other rate structures. (3)

3.3 Commodity Non-Competitive Rates

This rate system is non-competitive vis-a-vis intermodal competition. However, it does focus on those commodities which may be market-competitive. Perhaps more importantly, the Commodity Non-competitive rates were designed to ensure the movement of those commodities which would not, or could not move at the Class rates. Typically, the commodities are low-valued, bulk commodities such as coal, ores, concentrates,

(1) Purdy, ibid., p. 100, footnote 2 and Canadian Transport Commission, Waybill Analysis, 1972, Table 1, p. 3.
(2) CTC, Waybill Analysis, Table 1, p. 3, 1972
(3) op. cit., Table 3, p. 44.

cement, potash, and sulphur. [1] For such commodities, the transport costs are significantly high in relation to the market value of the good.

Cost factors contribute to the viability of this rate system as well. For example, handling cost efficiencies have been realized in the transport of bulk commodities by unit trains. In general it would be expected that bulk commodities would load to higher weights in railways cars and the volume of traffic may be relatively more constant.

In 1972, 29.6% of the total sampled ton-miles in the Waybill Analysis, moved under this rate system and the average revenue per freight ton-mile was 1.24¢.

3.4 Commodity Competitive Rates [2]

The impetus behind the development of this rate system is attributed to increasing intermodal competition, particularly highway competition. [3]

Bearing in mind the service characteristics-cost of service trade-off, higher-valued commodities will move subject to competition between the railways and the road air carriers. Low-valued goods may be the subject of competition between rail and water carriers.

(1) Purdy, ibid, pp. 102 - 103
(2) Approved in the Railway Act, S. 331, referenced in Purdy, op. cit. p. 103.
(3) CTC, Waybill Analysis, ibid. p. 3.

These rates are negotiable by the shipper and the carrier. The ability of the shipper to secure a mode-competitive rate depends upon the nature of the commodity being shipped, the location of origin and destination, and alternative transport means from the orgin to destination.

In 1972, 23.8% of the sampled ton-miles in the Waybill Analysis moved under Commodity Competitive Rates. (1) Average revenue per freight ton-mile in 1972 was 2.23¢. (2)

3.5 Agreed Charges (3)

Agreed Charges rates are negotiated. Like the Commodity Competitive rates, Agreed Charges are designed to meet intermodal competition. In contrast to Commodity Competitive rates, the shipper must commit to the railways some proportion (usually over 80%) of his total traffic for the period in which the Agreed Charges are negotiated (usually one year).

Of the total sampled ton-miles in 1972, 17.8% moved under Agreed Charges rates. (4) Average revenue per freight ton-mile that year was 2.01¢. (5)

3.6 Statutory Grain Rates

This rate applies to grain and grain products transported for export. The rate originated with the Crowsnest Pass

(1) CTC, Waybill Analysis, ibid, p. 3.
(2) op. cit. p. 44.
(3) Agreed Charges provided for in the Transport Act, 1938, S. 35, referenced in Purdy, op. cit., p. 104.
(4) CTC, Waybill Analysis, ibid, p. 3.
(5) op. cit., p. 44.

Agreement of 1896 and has remained in effect, other than for some short periods, since that time. (1)

The Statutory Grain rates are mentioned here as a particular anomaly. Their existence is a function of legislative action; cost factors are relatively important vis-a-vis the rate level, but they are a contentious issue from the railway companies standpoint.

However, a significant 28% of the sampled ton-miles in 1972 moved under these rates. Average revenue per freight ton-mile was .50¢, as it has been for a number of years. (2)

3.7 Fixed Rates

Fixed rates are not part of the formal rate structure; however, they provide a regulated alternative to the first four structures discussed above.

The Fixed Rate exists to protect those shippers who are dependent solely on rail carriers and who may be dissatisfied with the level of the negotiated rate. (3) The Fixed Rate is set equal to a minimum of 250% of the variable cost. In addition, should the shipper accept this rate in contract with the railways, he must ship all traffic affected by the agreement with the railways for at least one year. (4)

(1) Purdy, op. cit., pp. 175 - 182, discusses the statutory grain rates.
(2) CTC, Waybill Analysis, op. cit., p. 3 and p. 44.
(3) Amendment to Railway Act., S. 336, by National Transportation Act, 1967.
(4) Purdy, ibid., p. 105.

Purdy notes that the Fixed Rate is 75% over full cost, and hence it is not a particularly attractive alternative for a shipper.[1]

3.8 Temporal Changes in the Rate Categories

The sampled ton-miles for each rate category is used to measure the trends for each rate category during the period 1970 to 1973, Table 3.1.

In summary, the four year trends for each rate category are as follows:

1. Class Rates decline overall during the period;
2. Commodity Non-Competitive Rates show an upward trend;
3. Commodity Competitive Rates show a sustained upward trend;
4. In this short period there are no distinctive trends for Agreed Charges or Statutory grain rates.

The kinds of commodities moving under these different rates and the underlying rationale behind each one suggest the following conclusions.

(1) op. cit., p. 105

Table 3.1 - Comparison of Ton-Miles for Five Rate Categories, 1970 to 1973

Freight Rate Category	Ton-Miles 1970	Ton-Miles 1971	Percentage Change From 1970	Ton-Miles 1972	Percentage Change From 1971	Ton-Miles 1973	Percentage Change From 1972
Class Rates	7,484,943	6,556,833	-12%	6,215,764	-5%	7,025,418	+13%
Commodity Non-Competitive	239,004,717	243,523,257	+ 2%	237,867,695	-2%	283,602,101	+19%
Commodity Competitive	161,262,229	188,175,354	+17%	191,149,894	+2%	222,475,847	+16%
Agreed Charges	119,858,930	143,781,589	+20%	143,237,899	0	117,246,725	-18%
Statutory Grain Rates	197,881,812	220,603,818	+11%	225,281,175	+2%	188,970,641	-16%
Total	725,492,631	802,640,851		803,752,427		819,320,732	

Source: Canadian Transport Commission Waybill Analysis Carload All-Rail Traffic, 1970,1971, 1972, and 1973, Table 1.

First, the Class Rate structure is relatively unimportant, and there are no trends apparent that would suggest that these rates will increase in importance.

Second, the increasing relative share of traffic moving under Commodity Competitive Rates suggests that intermodal competition is an important factor in rate making.

Third, the decreasing share of traffic moving under Agreed Charges does not mean necessarily that intermodal competition is decreasing in importance. More likely, the reduction may be attributed to the reluctance of shippers to be committed to one mode as required under the Agreed Charges. In fact, if intermodal competition is increasing, then the Agreed Charges conditions could be perceived as less and less desirable by shippers. If this is the case, it could mean that traffic previously moving under Agreed Charges is now moving under the Commodity Competitive Rates.

Fourth, the traffic moving under Commodity Non-Competitive Rates would be expected to remain relatively stable, with any changes in relative volume being attributed to economic changes in the markets for these commodities. To some extent the railways enjoy a monopoly position for the carriage of these commodities, i.e. they are the most economical transport mode. Similarly, the relative volume of grain carried may reflect supply and demand changes over the short-run.

3.9 Summary

The theoretical foundation for rate levels was laid in Chapter 2. Public policy is instrumental in defining the rate-making environment in which cost and demand factors may influence the level of a particular rate. By necessity, the factor-rate relationship must be evaluated with all other factors, but one, held constant. Clearly, this sort of superficial analysis does nothing to illuminate the joint effects that a number of factors have on rate levels or on differences in rates.

In this Chapter, the types of rates are described briefly to indicate the relative importance of implicit factors in the different rate categories. Some rates reflect the increasing importance of intermodal competition, while still others are a reflection of the kinds of commodities moving under a particular rate structure.

Although the data utilized in this study do not conform to the rate types discussed in Chapter 3, these data do represent some of the variables discussed in Chapter 2. The hypotheses stated below reflect some of the concerns related to rate-making.

Hypotheses:

1. Rates are based on the value of the service (pricing based on demand) and not on the cost of providing the service.
2. Intermodal competition has had an effect in determining differences in railway freight rates.

3. Market competition for the transported commodities influences differences in railway freight rates.

The next two chapters are devoted to a more quantitative analysis of some of the factors thought to explain differences in rates. The cost factor data were taken from the Canadian Transport Commission Waybill Analysis, 1972. These highly aggregated data are often used to explain rate trends in terms of average revenue per ton-mile. (1) Whether or not this is a reasonable approach to take will be determined from the analysis. In addition, Chapter 4 will deal specifically with factors to be evaluated and will describe two hypothetical rate models. The results will be dealt with in Chapter 5, vis-a-vis the three hypotheses stated above.

(1) See for example, Morrish, J. H. and MacKinnon, D. P., An Address to the 18th Annual Traffic and Transportation Conference, Canadian Industrial Traffic League, Winnipeg, Manitoba, February 1974.

CHAPTER 4

TWO RATE MODELS AND DATA USED IN THE ANALYSIS

4.1 Introduction

The objective of the quantitative analysis is to measure the relative importance and joint effect of the variables discussed in Chapter 2. In this chapter two models are postulated and the data used in the analysis are evaluated. The data are evaluated in terms of problems with the data and their impact on the study.

Both the Canadian Transport Commission Waybill Analysis and Statistics Canada material provide data for analysis of rate factors. The Waybill Analysis presents data from a 1% sample of carload all-rail traffic waybills forwarded to the Canadian Transport Commission by the railway companies. The Statistics Canada data provides information for determining the value of commodities grown, processed or manufactured. Two variables measuring competition were defined subjectively and the data for these were obtained from the rates officers for the Canadian National and the Canadian Pacific Railways.

4.2 Nature of the Data Used in the Analysis

Commodity movement data from the 1972 Waybill Analysis are used in this study. These data reflect the movement of commodities by various intra- and inter- regional movements.

Three regions are defined in the Waybill Analysis, the Maritime, the Eastern, and the Western regions. The Maritime region consists of the Maritime provinces and that part of Quebec east of Levis and Diamond, Quebec. The Eastern Region consists of the remainder of Quebec and that part of Ontario, east of Thunder Bay and Armstrong, Ontario. The Western regions consists of all territory west of Thunder Bay and Armstrong, excluding the Yukon Territory. Thus nine movement combinations are possible.

Data are presented for approximately 300 commodity classes. Within each commodity class the data are further subdivided by some or all of the nine possible regional movements. The following Table, extracted from the Waybill Analysis, presents the data by commodity class and movement using nine measures.

Table 4.1 - Extract from the Annual Waybill Analysis, 1972

Class No.	Commodity Class	Region		No. of Carloads	Weight (Tons)	Revenue ($)	Ton-Miles	Car-Miles	Average			
											Revenue	
		From	To						Length of Haul (Miles)	Load Per Car (Tons)	Per Ton-Mile (¢)	Per Car-Mile ($)
124	Pre-cooked Frozen Food Preparations											
		Maritime	Maritime	2	65.0	931	8,395	247	130	32.5	11.09	3.77
		Maritime	Western	3	95.6	7,268	263,718	8,251	2,759	31.9	2.76	.88
		Eastern	Maritime	2	29.8	1,271	32,870	2,206	1.103	14.9	3.87	.58
		Eastern	Western	2	53.8	3,531	136,431	4,779	2,536	26.9	2.59	.74
		Western	Maritime	2	44.5	2,520	87,935	3,988	1,977	22.3	2.87	.63
		Western	Eastern	2	65.4	2,593	111,636	3,451	1,707	32.7	2.32	.75
		Western	Western	6	153.9	2,728	65,981	3,004	428	25.7	4.13	.91
				19	508.0	20,842	706,966	25,926	1,392	26.7	2.95	.80

The commodity classes defined by the Canadian Transport Commission are far broader in scope than the commodity classifications found in the rail freight tariffs. Therefore a waybill commodity class may include a number of commodities which are subject to different rates in a tariff or tariffs. Without the original waybills it is impossible to ascertain the extent to which commodities, subject to different tariffs, have been grouped in the various waybill commodity classes.

In a similar manner, the sub-grouping of commodities in a specific class by the regional origin and destination of the movement means that different rates may have been applied. For example, one carload of coal could move 100 miles and another may move 300 miles. The average haul distance, 200 miles, would be shown in the data, however, different rates would be applied on the basis of the different cost-distance relationships for these two movements. With only the Waybill Analysis data in their aggregate form it is impossible to determine the extent to which different rates applied.

The first five data elements, number of carloads, weight, revenues, ton-miles, and car-miles, are totals for the specific movement of each commodity. The last four data elements are averages. The use of the data in this form is limited by their degree of aggregation.

The nature of the Waybill Analysis does not preclude using it to analyse which cost and demand factors may be influencing differences in rates. It does point out, however, that the data in this form should be used with caution.

The Waybill Analysis does not contain data measuring the demand for transport or demand for the product. Commodity value, intermodal competition, and market competition data are derived from other sources to measure these two kinds of demand. In this study intermodal competition and market competition are measured on an ordinal scale and these scales are applied to each commodity movement. The questionnaire used by the railways' rates officers to estimate these two variables is found in Appendix 1 to this chapter.

Both intermodal competition and market competition are complex, multi-dimensional phenomena. Any in-depth quantitative analysis of these factors is restricted given the objective of this thesis. Two practical and less costly approaches are considered.

First, each variable could be estimated in one dimension. For example, the ton-miles of a commodity moving from one region to another could be expressed in terms of the proportion carried by rail versus other modes to measure the amount of intermodal competition. This may not provide a realistic measure. For example, it is possible that 100% of some commodity could travel by rail and using the measure described above it would be concluded that there is no intermodal competition. But the amount of traffic moved by rail could be explained by the rail rate having been lowered to ensure that all of that traffic moved by rail rather than some other mode. Thus the danger exists that over-simplification might result in a failure to capture all impacts of a particular variable.

The second approach involves the subjective estimation of these variables. The railways, trucking associations, and shippers' associations would be expected to have some knowledge of the degree of intermodal and market competition existing for a particular commodity movement. A Delphi-like method could be used, whereby estimates from each of these three sources could be obtained, information exchanged, and second and third estimates made until a consensus is reached.(1) This method is not used. The rates officers from the Canadian National and Canadian Pacific Railways independently estimate the two variables and the average value is used in this analysis.

The benefit of having railways' rates officers estimate the degree of intermodal and market competition is that these factors are considered by them in rate negotiations with shippers. Thus while they might lack detailed knowledge about specifics of intermodal and market competition, the rates officers would be expected to have a glob-

(1) MacCrimmon K. R., "Managerial Decision Making", Working Paper No. 117, Faculty of Commerce and Business Administration, University of British Columbia, February 1972, p. 32.

al appreciation of the relevance of these two variables for a particular commodity movement.

4.3 Factors to be Analysed

Clearly it would be desirable to analyse all of the factors which may be affecting differences in rates. For any one movement, depending on the commodity and its origin and destination, it would be expected that a different set of factors would play a dominant role in determining the rate. The limitation imposed by the availabilty of data, however, preclude evaluating all factors that might influence differences in rates.

The factors analysed in this study are included in two rate models described below.

The first model will be evaluated for five intra- and inter- regional movements. Equation (4.1) shows the factors included in this rate model.

(4.1) $Y = f(L,D,N,V)$ where Y = average revenue per hundredweight, in dollars;

f = an unspecified relationship;

L = load per car, in tons;

D = average haul distance, in miles;

N = number of carloads in the movement; and

V = dollar value of the commodity per ton.

The second model will be evaluated for three movements; Western - Eastern, Western - Western, and Eastern - Western (equation 4.2).

(4.2) $Y = f(L,D,N,V,\bar{C}_{MD},\bar{C}_{MT})$ where all terms are as defined above and:

$\bar{C}_{MD}$= average degree of intermodal competition; and

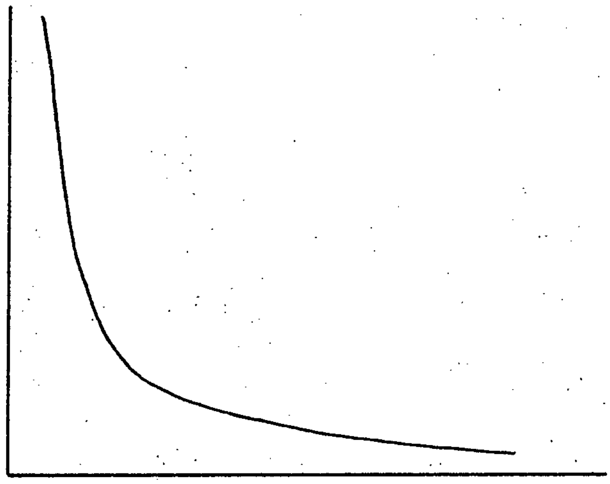
$\bar{C}_{MT}$= average degree of market competition.

The average revenue per hundredweight variable, will be referred to as the proxy rate variable. The remaining variables in these two models will be evaluated in Chapter 5 to determine the extent to which they explain differences in the proxy rate variable. Each of these variables are discussed below.

4.3.1 Load Per Car

Weight per car is an important cost factor for the carrier. To some extent it is a measure of utilization. Thus, as the weight per car increases, better utilization is achieved. The increasingly efficient utilization of the car results in lower unit costs and, hence, lower rates would be expected. Rate tariffs reflect this by quoting lower rates at different carload minima. These conditions are represented in Figure 4.1.

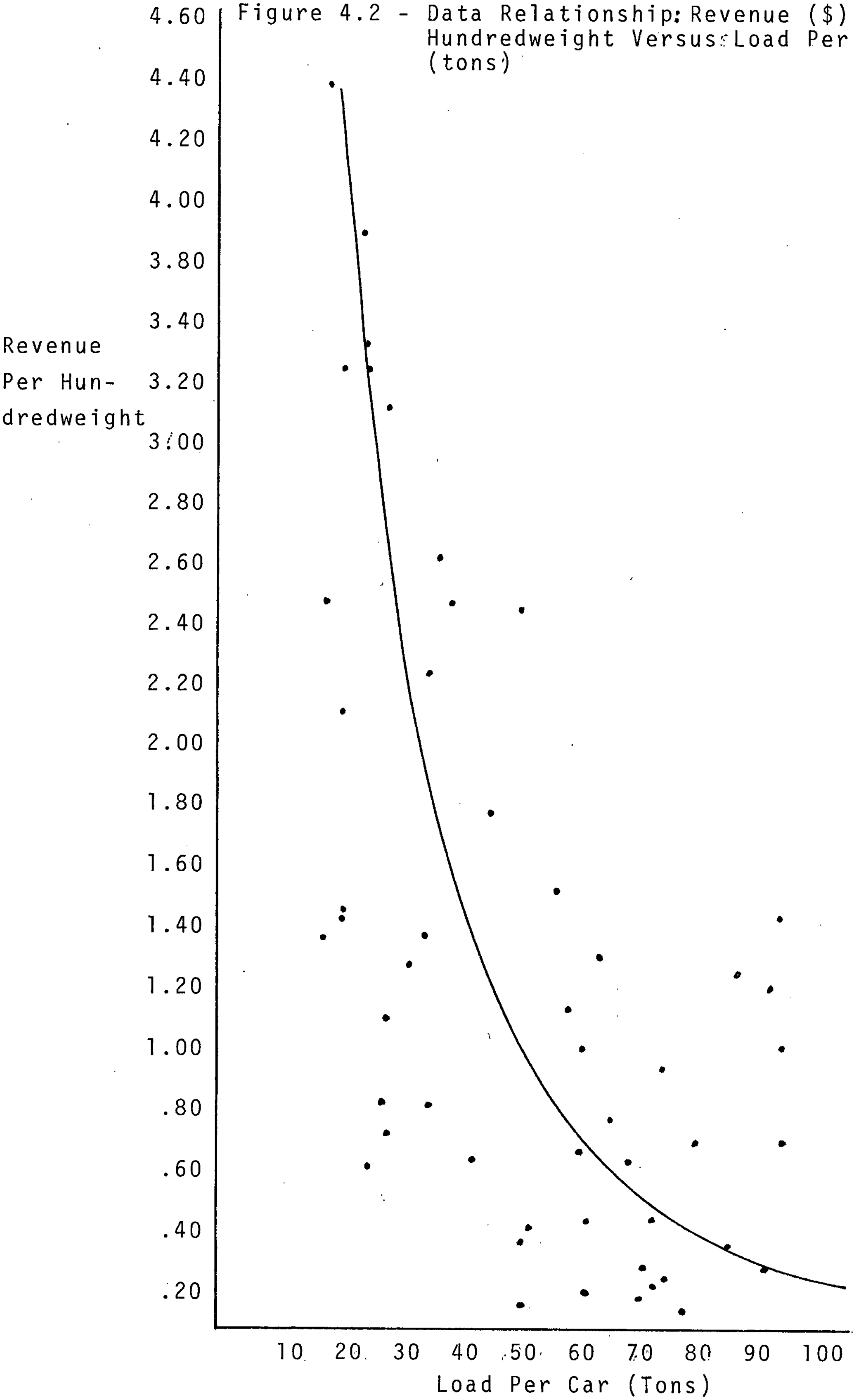
Figure 4.1 - The Expected Rate-Carload Minima Relation



A sub-sample of the Waybill Analysis data indicates that load per car is inversely related to the actual revenue dollars per hundredweight received by the railways. Further, the relationship is non-linear (Figure 4.2). The variations of the sample points about the fitted line are indicative of the effect that other variables exert on the proxy rate variable.

In addition, inspection of the data reveals a high degree of variability, as much as 100%, in the load per car reported for the same commodity moving between different regions. Given the broad commodity class definitions, it could be that the density is variable due to different forms of the commodity being transported or the load in the car is mixed, i.e. a number of different commodities are in the car.

Figure 4.2 - Data Relationship: Revenue ($) Per Hundredweight Versus Load Per Car (tons)



Source: CTC Waybill Analysis

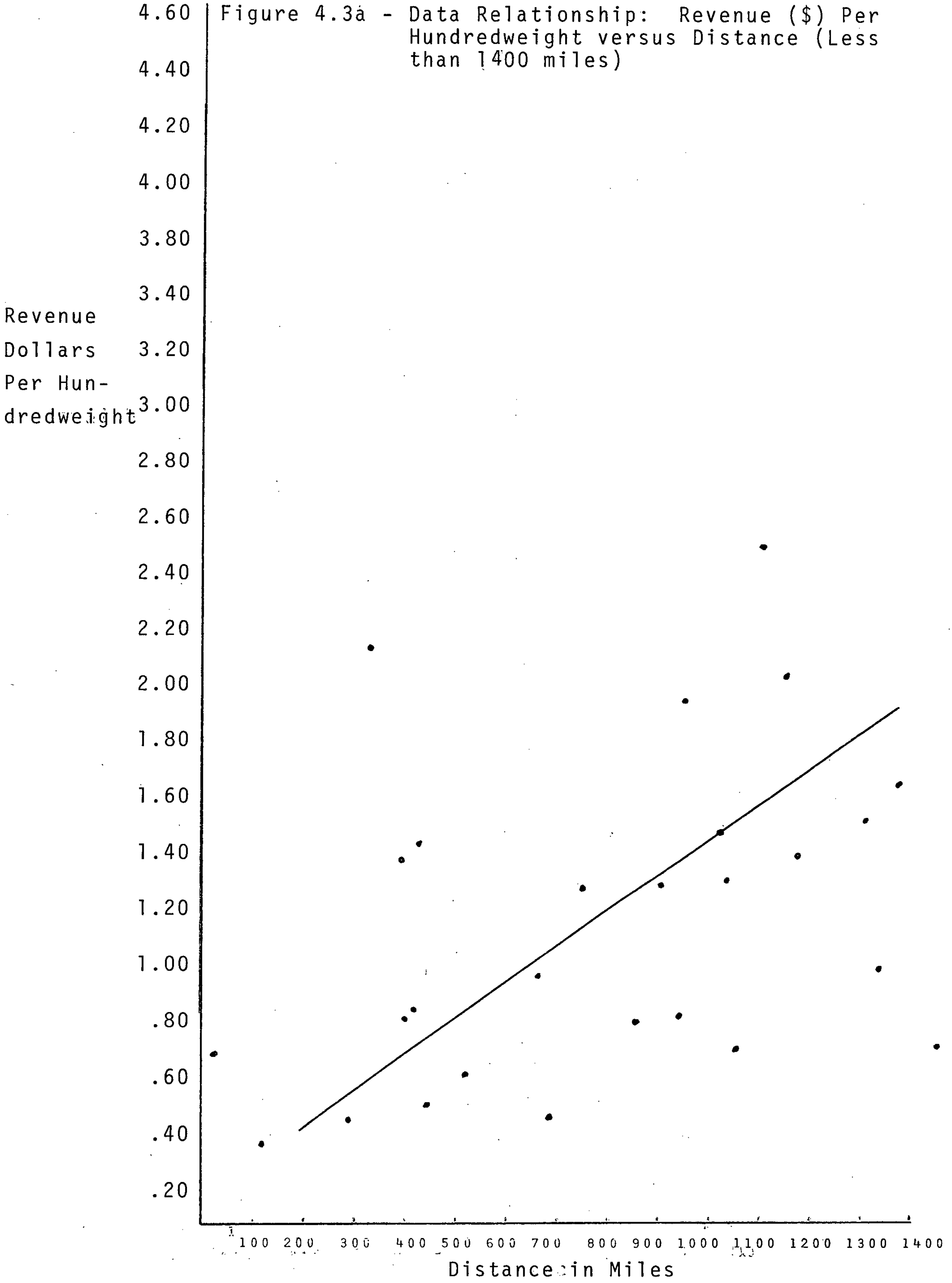
4.3.2 Distance

The length of haul for a particular shipment is also an important cost factor for the carrier. Other things being equal, the longer the distance, the higher will be the transport cost.

The average haul distance is used as a proxy variable to determine the influence that distance has on rates. The aggregation of the Waybill data limits the use of this variable; but where significant differences in average haul distance exist it would be expected that some variation in rates would be explained.

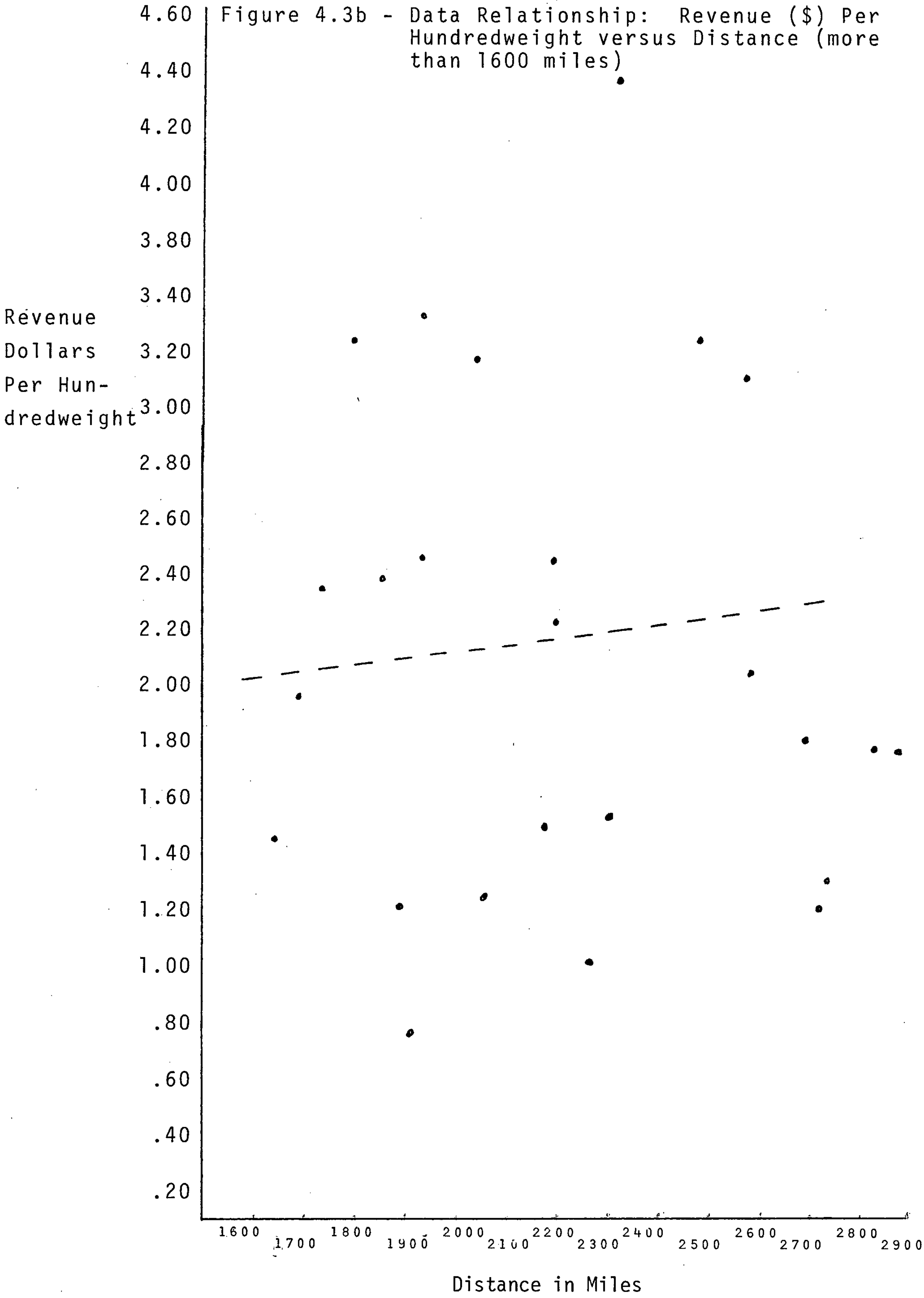
Inspection of the waybill data sub-sample shows a positive relationship (up to about 800 miles), between the proxy rate variable and distance. However, beyond 800 miles, it is not possible to discern what relationship exists. The variation about a fitted line is very high, suggesting that other factors are important for long distance movements (Figures 4.3a and 4.3b).

Figure 4.3a - Data Relationship: Revenue ($) Per Hundredweight versus Distance (Less than 1400 miles)



Source: CTC Waybill Analysis

Figure 4.3b - Data Relationship: Revenue ($) Per Hundredweight versus Distance (more than 1600 miles)



Source: CTC Waybill Analysis

4.3.3 Number of Carloads

The number of carloads constituting a particular commodity movement is used as a proxy measure for the volume of traffic. If the Waybill data constitute an unbiased random sample, then the number of carloads of a commodity is representative of the contribution of that commodity to the total regional traffic volume. If the volume of cars is high, it may be possible for a shipper to negotiate a more favourable rate with the carrier. The shippers' position would be enhanced, as well, if a constant volume of traffic is generated. It is not possible to determine from the data whether movement patterns, such as seasonal movements, exist.

The Waybill data sub-sample indicated a strong, inverse, non-linear relationship between the proxy rate variable and number of carloads (Figure 4.4). The variation in the proxy rate variable is very high for a low number of carloads and tends to decrease as the number of carloads increases. To some extent, this can be explained by the increasing significance of this variable, as the number of carloads increases. Presumably, other variables are more significant when the number of carloads in the movement is small, hence the high variation in the proxy rate variable.

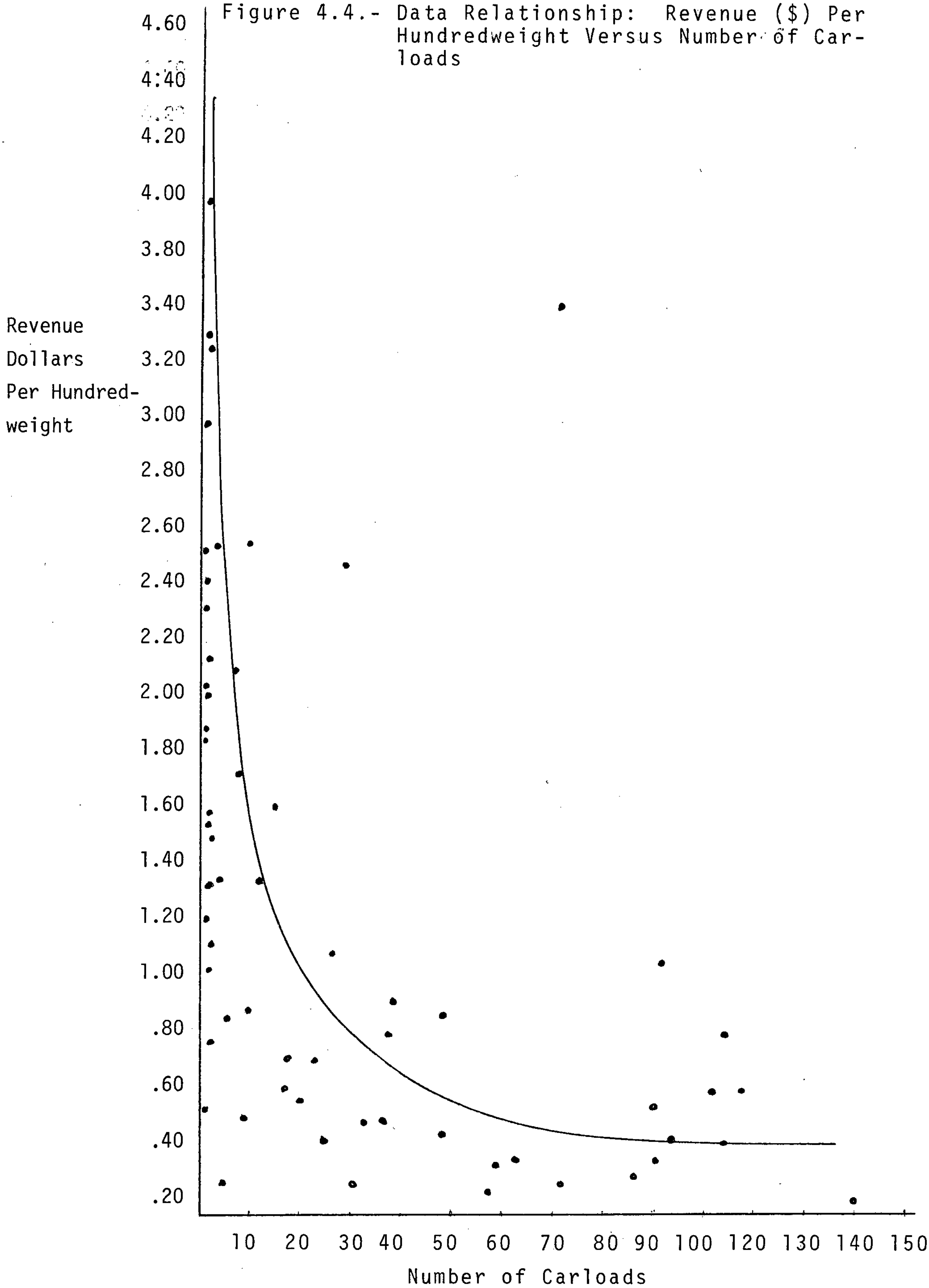


Figure 4.4.- Data Relationship: Revenue ($) Per Hundredweight Versus Number of Carloads

Source: CTC Waybill Analysis

4.3.4 Commodity Value

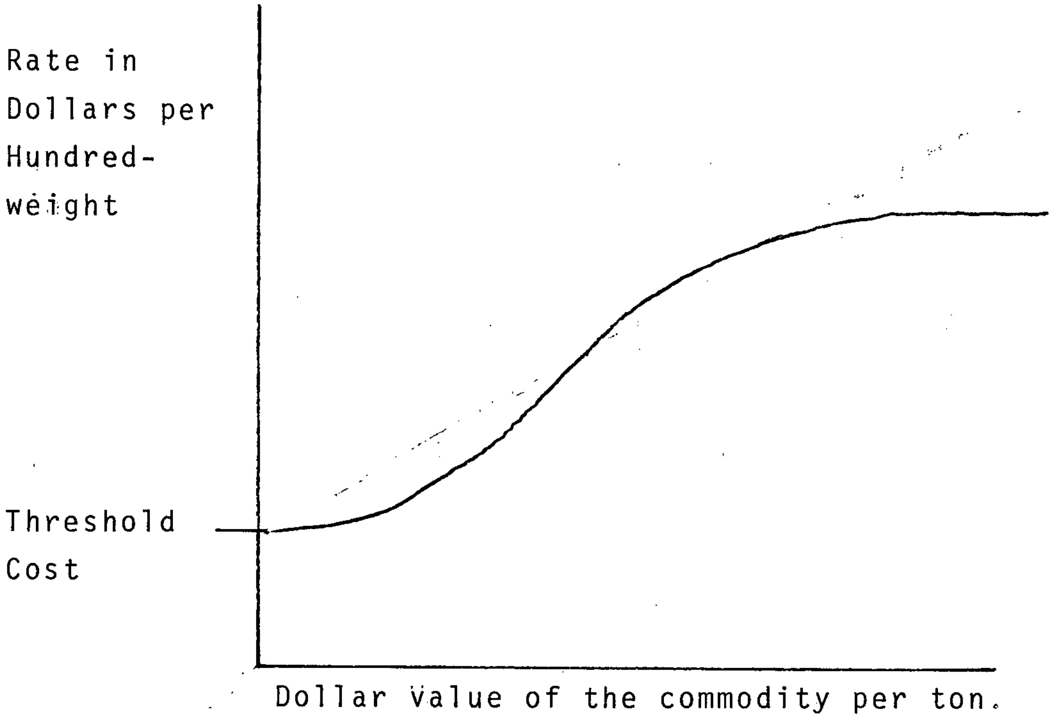
Dollar value of the commodity is used as a measure of the commodity's elasticity of demand for transport. The Waybill data does not include this information, however, Statistics Canada publishes commodity production information which includes the dollar value of various commodities. (1)

In general, high freight rates are usually associated with higher-valued goods. It is recognized by the railway companies that low-valued commodites will move often at only very low rates. The ability of a commodity to compete in a particular environment is associated with this factor. Goods shipped into an area will compete effectively in the market if the transportation costs and other production costs allow the goods to be competitively priced. For example, transportation costs can be looked at as a proportion of the total market value of the commodity. A four dollar rate on a ten dollar item is more significant than a four dollar rate on a one hundred dollar item, in terms of the effect on the commodity's ability to compete effectively.

The general relationship between rates and the value of the commodity is shown in Figure 4.5.

(1) Statistics Canada, 62-005, February 1974, Table 2.

Figure 4.5 - The Relationship Between Rate and Dollar Value of the Commodity



It should be noted that there are practical limits to this relationship, as portrayed in Figure 4.5. It is not reasonable to propose that very low-valued commodities move at rates close to zero. The rates on this low-valued traffic still must reflect the variable costs associated with this movement. There are also practical limits on the rate which can be charged against high-valued traffic. Competition by alternative modes is more important for high-valued goods and this will influence the level at which railway rates are set. For example, inventories for high-valued goods will be kept at a lower level than for low-valued goods, due to their relative inventory costs. Thus more frequent shipments rather than fewer bulk shipments will be made. Modal choice is more important under these circumstances and railway rates may reflect such intermodal competition by being lower than otherwise would be expected.

The value of some of the sampled commodities is related to the proxy rate variable in Figure 4.6. On the basis of this sample, it is concluded that there is no discernable relation between commodity value and the proxy rate variable. The variation is equally high for low-valued goods and high-valued goods.

4.3.5 Intermodal Competition

For each commodity movement, the rates officers for the Canadian National and Canadian Pacific Railways were asked to define the degree of intermodal competition.

As noted above, intermodal competition is hightly correlated with commodity value. The declining importance of the Class Rate category, essentially value of service pricing (based on commodity value), is ascribed to increasing highway competition. (1) In Chapter 3 it was noted that the traffic moving under the Commodity Competitive rate category was increasing during the period 1970 to 1973. In addition the railways have suggested that intermodal competition was the primary cause of an overal reduction in the average revenue per ton-mile from 1968 to 1972 for manufactured goods moving east to west. (2)

(1) Purdy, ibid., p. 110.
(2) Morrish and MacKinnon, ibid., p. 5.

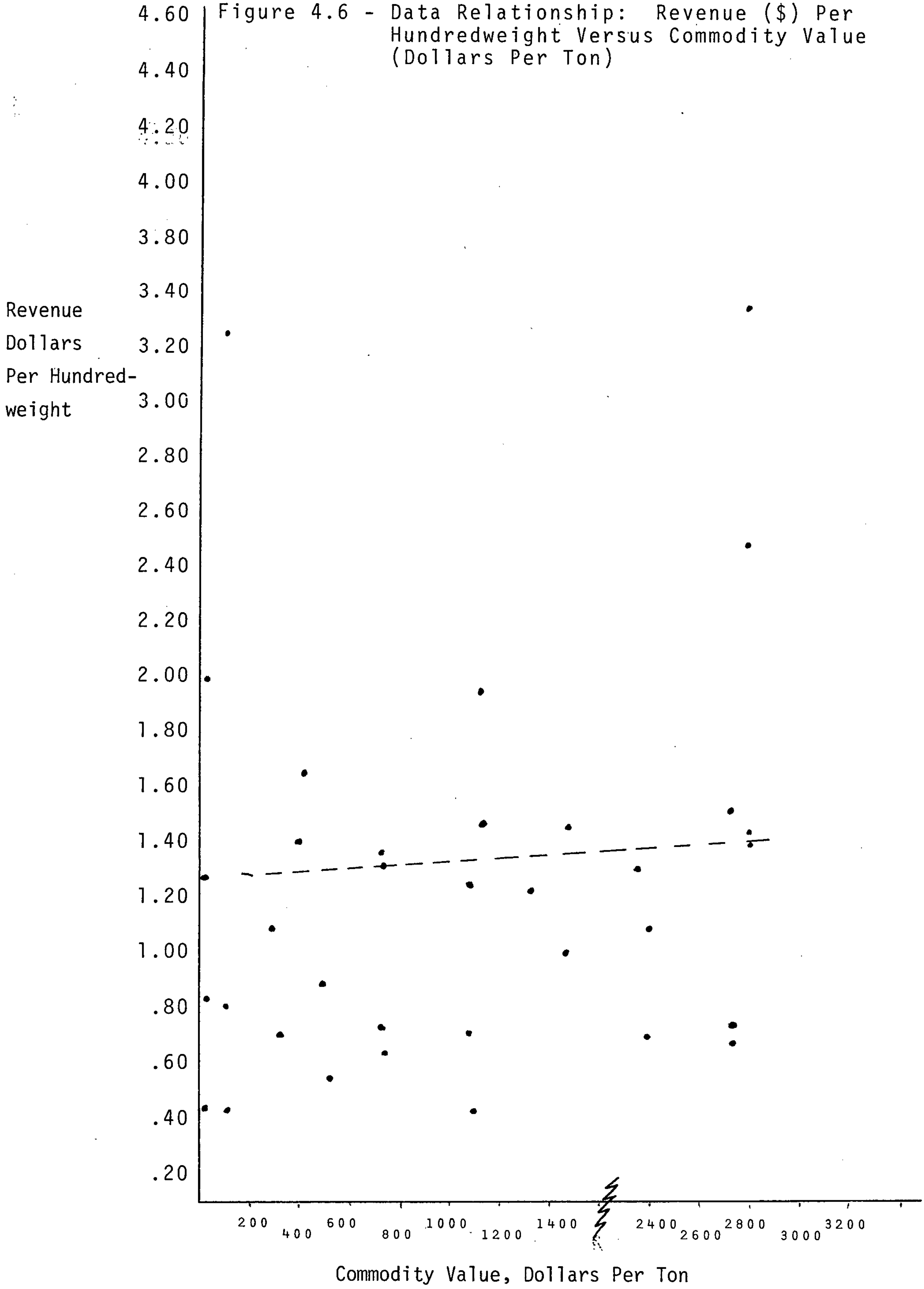


Figure 4.6 - Data Relationship: Revenue ($) Per Hundredweight Versus Commodity Value (Dollars Per Ton)

Source: CTC Waybill Analysis and Statistics Canada 62-005

Given the above considerations, it is reasonable to attempt to measure the significance of intermodal competition.

4.3.6 Market Competition

Like the previous variable, market competition was defined subjectively and data were obtained from the railway's rates officers.

Market competition has been included because it relates to the derived demand aspect of transportation. To some extent market competition is a more significant factor affecting differences in rates than is intermodal competition, because demand for transport is a derived demand. (1) For example steel rates, which were less to Vancouver than to Edmonton or Saskatoon, were rationalized on the basis of market competition. (2)

4.4 Organization of the Sample Data

The addition of dollar value of the commodity as a variable imposed a constraint on the selection of a set of sample data from the Waybill Analysis. The availability of the value information was instrumental in choosing among the various Waybill Analysis commodity classes. Given the above constraint, thirty-six commodities were chosen to constitute the sample data base. The class number and commodi-

(1) op. cit., p. 7
(2) cf. ante, p. 23

ty description, as they appear in the Waybill Analysis, are shown in Table 4.2.

Table 4.2 - Class Number and Commodity Description of the Sample Analysed

Class Number	Commodity
10	Meat, fresh or chilled
16	Fish and marine animals
18	Butter
20	Cheese
54	Apples
62	Grapes
70	Pears
78	Fruit juice and fruit juice concentrates
86	Sugar beets
88	Cabbage
94	Onions and shallots
108	Sugar
114	Coffee
120	Shortening and lard
122	Soups and infant foods
128	Hay, forage and straw
148	Ale, beer, stout and porter
150	Wines and fermented alcoholic beverages
156	Tobacco, unmanufactured
204	Copper ore and concentrates
208	Iron ore and Concentrates
210	Lead ore and concentrates
216	Nickel ore and concentrates
222	Zinc ore and concentrates
238	Bituminous coal
248	Asbestos, crude, unmanufactured
258	Sand, N.E.S.

Table 4.2 - Class Number and Commodity Description of the Sample Analysed (Continued)

Class Number	Commodity
274	Barytes, natural
276	Gypsum
280	Nepheline Syenite
288	Liquid sulphur
330	Woodpulp
516	Portland Cement
528	Lime, Hydrated and Quick
580	Toiletries

Source: CTC Waybill Analysis

The sample data were grouped according to regional movement as shown in Table 4.3. The number of commodities constituting the sample are also indicated.

Table 4.3 - Number of Commodities Included in a Specific Regional Movement

Movement		Number of Commodities
Origin	Destination	in the Movement
Maritime	Maritime	22
Maritime	Eastern	10
Maritime	Western (1)	0
Eastern	Maritime	16
Eastern	Eastern	27
Eastern	Western	12
Western	Maritime	12
Western	Eastern	16
Western	Western	23

(1) This movement was not evaluated due to lack of data.

4.5 Descriptive Rather than Predictive Models

The models, which are described in Chapter 5, are descriptive rather than predictive models. A number of considerations, most of them related to the nature of the data or to the variable being evaluated, are responsible for this limitation.

The following four reasons preclude using the developed models for predictive purposes.

1. A rate predicting model would require specific variable values. The models in Chapter 5 are not based on specific variable states but on highly aggregated data.
2. The proxy rate variable, average revenue per hundredweight, is an aggregate figure reflecting a number of rates in a tariff or tariffs. The actual values in the sample data are meaningless in an absolute sense, although they do have meaning in a relative sense.
3. The specificity of rates is a function of the commodity being moved (its characteristics), and the origin and destination of the movement. Thus adding commodities to those sampled would be expected to change the model results.
4. Cost and demand factors affecting a specific rate will change over time. The cost of providing different kinds of services will change at different

rates. The importance of various cost and demand factors in defining a rate level may change over time. These changes are difficult to measure; therefore, they constitute an effective barrier against developing predictive models.

4.6 Summary

Two rate models are described in this chapter. These models reflect a rate-making environment in which both cost and demand factors are expected to affect differences in rates. Some of these variables are proxies for factors which are either difficult to measure (elasticity of demand for transport), or were not available (original waybill data). Two factors, intermodal competition and market competition, were defined subjectively.

A number of conditions preclude using the models described in the following chapter for predictive purposes.

The statistical analysis dealt with in the following chapter is designed to provide concrete evidence about the relative importance of the factors discussed in this chapter. However, the most important aspect of the statistical analysis is that some understanding may be gained about the joint effect of these variables on the proxy rate variable. Clearly, the sample data shows a high variance when any one variable is related to the proxy rate variable. Thus, in most movements, a number of factors would be expected to have some joint effect in influencing differences in rates.

Appendix 1

The rates officers for Canadian National and Canadian Pacific Railways provided the data for the amount of inter-modal and market competition. The instructions are shown below, as are the commodities in the three regional movement samples.

MODAL COMPETITION

Group commodities in classes 1, 2, 3, and 4 according to the amount of modal competition.

Class 1	High level of modal competition
Class 2	Frequent modal competition
Class 3	Limited modal competition
Class 4	No significant modal competition

MARKET COMPETITION

Group commodities in Classes 1, 2, 3, and 4 according to the amount of competition for the commodity in the destination region.

Class 1	High level of market competition
Class 2	Significant market competition

Class 3 Limited market competition

Class 4 No significant market competition

Commodities from the four Western provinces to Ontario and Quebec

Commodity	Average Miles Travelled	Class of Competition
Meat, fresh or chilled	1917	
Fish & marine animals	2836	
Apples	2527	
Pears	2441	
Potatoes, other than sweet	2171	
Sugar	1637	
Shortening & lard	1678	
Ale, beer, stout & porter	575	
Copper ore & concentrates	2145	
Nickel ore & concentrates	1317	
Bituminous coal	1895	
Asbestos, crude unmfg.	2640	
Liquid sulphur	2232	
Woodpulp	2270	
Lime, hydrated and Quick	708	

Commodities moving within the four western provinces

Meat, fresh or chilled	534	
Butter	765	
Farinaceous substances & flour	915	
Fruit juice & concentrates	387	
Sugarbeets	30	
Sugar	217	
Coffee	821	
Soups & Infant Foods	497	
Ale, beer, stout & porter	283	

Commodities moving within the four western provinces

Commodity	Average Miles Travelled	Class of Competition
Wines & fermented alcoholic beverages	765	
Copper ore & concentrates	203	
Iron ore & concentrates	189	
Lead ore & concentrates	499	
Nickel ore & concentrates	820	
Zince ore & concentrates	939	
Bituminous coal	661	
Sand NES	220	
Barytes Natural	419	
Liquid Sulphur	585	
Woodpulp	457	
Portland Cement Standard	200	
Lime, Hydrated & Quick	457	
Toiletries, cleaning preparations, etc.	630	

Commodities moving from Ontario & Quebec to the four Western provinces

Farinaceous substances & flour	2165
Apples	1763
Grapes	2019
Coffee	1922
Shortening & Lard	1726
Soups and Infant Foods	1794
Ale, beer, stout & porter	1129
Iron ore & concentrates	2040
Zince ore & concentrates	1213
Asbestos, crude unmfg.	2537
Portland Cement Standard	2773
Toiletries, cleaning preparations, etc.	1838

CHAPTER 5

STATISTICAL ANALYSIS OF TWO RATE MODELS

5.1 Introduction

The objective of the statistical analysis is to determine whether the postulated models reflect differences in rates. The data are organized in such a manner that eight different regional movements can be evaluated separately.

In the next section, the research strategy is outlined and a brief review is made of the two analytical methods used. The third section will deal with an overview of the results obtained from these analyses. The fourth section is concerned with the results of the individual movement models. A summary of the results is presented in the fifth section. A proposal for monitoring trends in the factors affecting rates is described in the last section of the chapter.

5.2 Research Design

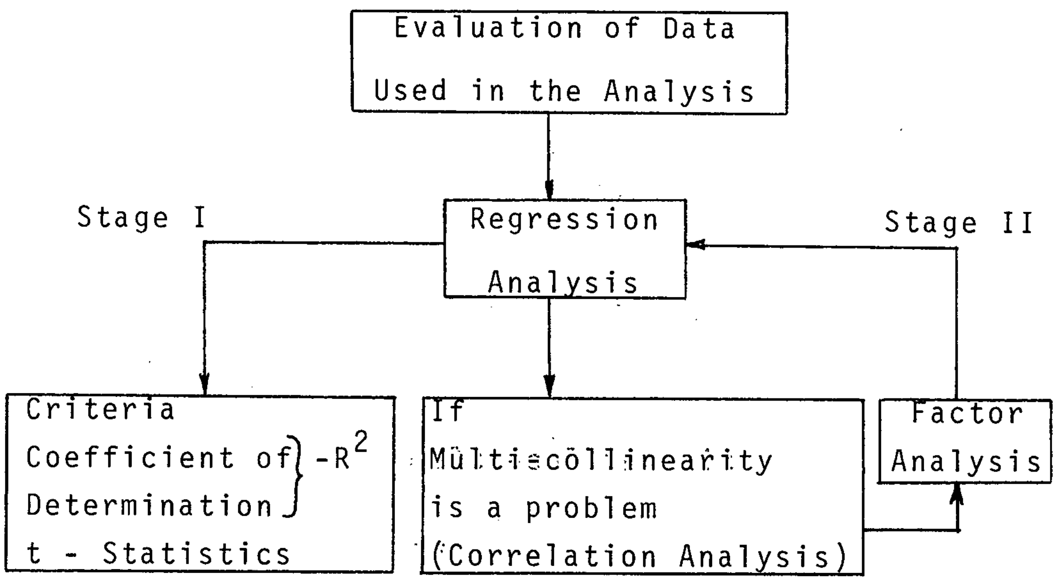
There are three major factors which affect the research strategy.

1. The number of movement models (8) and the number of variables in these models (4 variables for five movements and 6 variables for 3 movements), means a large number of combinations must be evaluated.

Factor analysis is used to produce a set of statistically independent variables from the original data.[1] These new data represent the original variables and they can be regressed against the proxy rate variable. The regression results of this two-stage approach do not reflect the multi-collinearity problem.

A schematic of the research process is shown in Figure 5.1.

Figure 5.1 - Schematic of the Research Process



The primary research tool is regression analysis. The technique involves explaining the variance of some specified

(1) For a very readable introduction to factor analysis, see Rummel R.J., "Understanding Factor Analysis", Journal of Conflict Resolution, Vol. XI No. 4, December, 1967.

variable (the dependent variable) by one or more explanatory variables (the independent variable(s)). The basic assumptions of regression analysis are:

1. the explanatory variables must be statistically independent;
2. the residuals (the unexplained variance in the dependent variable) must be statistically independent;
3. the variance of the residuals must be constant.

If multi-collinearity is a significant problem, it will be dealt with by using factor analysis as a preliminary step, prior to using regression analysis. (1)

Factor analysis has many applications; however, it has been used in a limited context in this study to create new variables, which satisfy the first assumption in regression analysis. The method is more difficult to understand conceptually then is regression analysis. The new variables are mathematical manipulations of the original variable values. They cannot be interpreted in their own right, nor can they be compared meaningfully. (2)

(1) The models described later in the chapter have been tested for autocorrelation (violation of assumption 2) and inspected for heteroschedasticity (violation of assumption 3.)

(2) See Appendix 1, Chapter 5-- Some details on the specific application of factor analysis.

5.3 General Observations of the Results (1)

This section will examine the analytical results in general terms; in effect it will bring together all of the models for comparative purposes. Three dimension are considered: 1) the significant variables in each model; 2) the relative importance of the significant variables in each model; and 3) the results vis-a-vis the expected outcome.

Except for one movement, the results indicate that several factors explain the variance observed in the proxy rate variable. (Table 5.1) Load per car is significant in all models. The remaining significant variables vary from model to model.

(1) Load per car and number of carloads were transformed to their inverse values and the eight movement models reflect these two changes.

Table 5.1 - Comparison of Significant Variables Among Eight Movement Models [1]

Movement From	Movement To	Load Per Car (L^{-1})	Significant Variables (t - Statistics) Distance (D)	Number of cars (N^{-1})	Dollar Value (V)	Intermodal Competition (C_{MD})	Market Competition (C_{MT})
Maritime	Maritime	5.57	8.59	3.93		N.E.	N.E.
Eastern	Maritime	5.67			2.50	N.E.	N.E.
Eastern	Eastern	3.95	3.03		2.41	N.E.	N.E.
Western	Maritime	2.23		3.04	1.71	N.E.	N.E.
Maritime	Eastern	5.00				N.E.	N.E.
Western	Eastern	4.71	3.29			1.83	
Western	Western	4.22	6.56				1.99
Eastern	Western	3.35			1.82		1.66

(1) The significance level is 10%.

N.E. - Not Evaluated.

At least one demand variable, either dollar value, intermodal competition, or market competition is significant in six of the eight movement models. Given these results, it is concluded that both cost and demand factors account for differences in rates among the commodities constituting six of the eight samples. Cost factors alone account for differences in rates for commodities in the Maritime - Maritime and Maritime - Eastern samples in Table 5.1.

The significant variables in a particular movement model explain the variance in the proxy rate variable to different degrees (Table 5.2). The relative importance of a variable in a particular model changes from model to model. In general, load per car is the most important variable in six of the eight models, and the second most important variable in the other two. In these two latter models, distance is the most important variable. Distance is not significant in all cases. However, where it is significant, it is either the most important or second most important variable. While Table 5.1 indicates that both cost and demand factors are significant, Table 5.2 indicates that cost factors are relatively more important than are demand factors in accounting for differences in rates.

Table 5.2 - Relative Ranking of Significant Variables for Different Movements

Movement From	To	Coefficient of Determination (R^2)	Load Per Car (L^{-1})	Distance (D)	$(\hat{b}_i S_i)$ (1) Number of cars (N^{-1})	Dollar Value (V)	Intermodal Competition (C_{MD})	Market Competition (C_{MT})
Maritime	Maritime	.9442	.22 (2)	.65 (1)	.15 (3)		N.E.	N.E.
Eastern	Maritime	.8004	.44 (1)			.19 (2)	N.E.	N.E.
Eastern	Eastern	.6761	.24 (1)	.18 (2)		.14 (3)	N.E.	N.E.
Western	Maritime	.8528	.63 (1)		.57 (2)	.50 (3)	N.E.	N.E.
Maritime	Eastern	.7579	.40 (1)				N.E.	N.E.
Western	Eastern	.8368	.57 (1)	.39 (2)			-.23 (3)	
Western	Western	.8073	.17 (2)	.27 (1)				.08 (3)
Eastern	Western	.7050	.55 (1)			.32 (2)		-.30 (3)

N.E. - Not Evaluated

(1) The relative importance of each significant variable i is approximated by $\hat{b}_i S_i$, where $\hat{b}_i$ is the estimated regression coefficients for the i'th variable and S_i is the calculated standard deviation of the i'th variable. The figure in brackets is the rank of the significant variable in the model.

Three general observations from the results are summarized below:

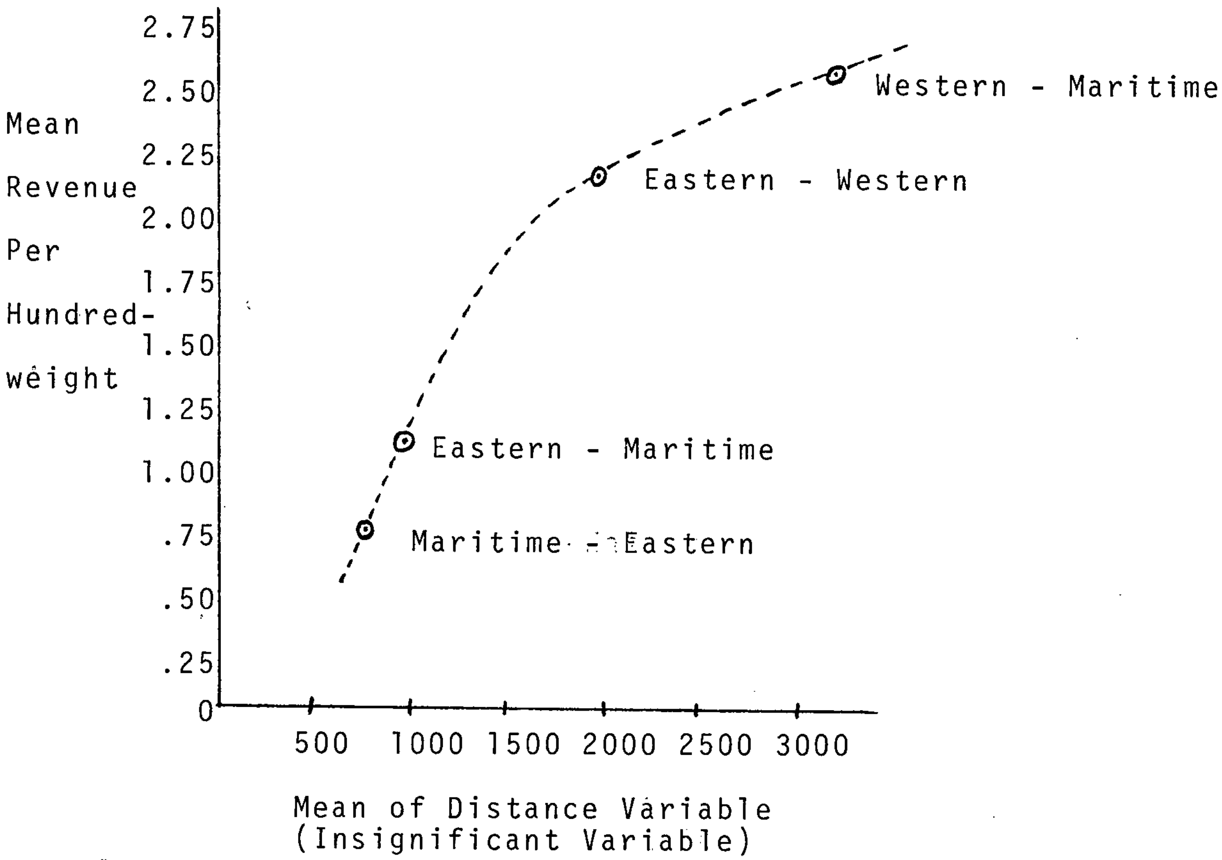
1. The postulated models do not account for all variables affecting differences in rates; however, they do appear to account for most of the variance in the proxy rate for the sampled commodities.
2. The amount of explained variance varies from model to model, as does the relative importance of the variables explaining differences in rates.
3. Both cost and demand factors are significant. Cost factors are more important than demand factors for explaining differences in the proxy rate given the sampled commodities.

The results do not completely meet with expectations. Both load per car and distance are explicitly treated in rail rate tariffs. Although load per car is significant, as noted above, distance is not significant in four of the eight movement models (Table 5.3). The significance of distance may be misleading even in those cases where distance is statistically significant. The rate-distance relationship may be spurious. That is, other factors such as intermodal competition or market competition may change as distance changes and it is these factors which may affect rates and not distance per se. This may also be the case where distance is not statistically significant but some relationship appears to exist (Figure 5.2).

Table 5.3 - Movement Models Excluding Distance as a Significant Variable

Movement From	Movement To	Average Value of Proxy Rate Variable	Mean for Movement	Standard Deviation for Movement	Distance Correlation of Distance With Significant Variables: L^{-1}	N^{-1}	γ	C_{MD}	C_{MT}
Eastern	Maritime	1.11	904.312	346.328	.3946		.3887	N.E.	N.E.
Western	Maritime	2.67	3081.58	652.988	-.2926	.3682	-.2449	N.E.	N.E.
Maritime	Eastern	.74	742.7	171.837	.0591			N.E.	N.E.
Eastern	Western	2.22	1909.92	467.267	-.0304		-.1065		-.4725

Figure 5.2 - Comparison of the Average Distance Moved With the Mean of the Proxy Rate Variable for Four Movements



5.4 Analysis of Results for Specific Movements

Each of the eight movement models is evaluated in this section. The following information is given for the regression results of the original variables:

1. regression equation;
2. coefficient of determination (R^2);
3. correlations between the significant variables;
4. rank order of the significant variables;
5. implications of the results for the three hypotheses reiterated below; and

6. specific observations about the model.

The impact of multi-collinearity often can not be determined by simple inspection of the correlations among the explanatory variables. To complete the evaluation for each movement, the regression results of the new variables produced by factor analysis are given. The coefficient of determination (R^2) and the statistically significant original variables will be noted for comparison purposes.

The three hypotheses are:

1. rates are based on the value of the service (pricing based on demand) and not on the cost of providing the service;
2. intermodal competition has had an effect in determining differences in railway freight rates; and
3. market competition for the transported commodities influences differences in railway freight rates.

5.4.1 <u>Model results testing the first hypothesis</u>

<u>Maritime - Maritime Movements</u>

(5.41) $Y = .1230 + 9.3756L^{-1} + .001032D + .3494N^{-1}$

$R^2 = .9442 \quad r_{DL^{-1}} = .4945 \quad r_{N^{-1}L^{-1}} = .4932$

$r_{N^{-1}D} = .3731$

The rank order of the significant variables is given below:

1. distance;
2. load per car; and
3. number of cars in the movement (Table 5.2)

Only the first hypothesis is tested by this model. The results suggest that the first hypothesis is incorrect, as cost factors alone are significant.

The positive regression coefficients reflect the expected relationships between each of the explanatory variables and the dependent variable. As distance increases, the rate increases. As the inverse of load per car increases (load per car decreases), the rate increases. Similarly, as the inverse of number of cars increases (number of cars decreases) the rate increases. Elasticity of demand for transport is not a significant variable for the commodities sampled.

Regressing the factor analysis variables does not significantly change the amount of explained variance in the proxy rate variable ($R^2 = .9437$). Three new variables were found to be significant: the first new variable is composed of the joint interaction of the inverse of load per car and distance; the second is number of carloads; and the third is dollar value. Although a demand variable is now significant, the first hypothesis would be rejected again; both cost and demand factors are significant.

Eastern - Maritime Movements

$$(5.42) \quad Y = .1738 + 24.9662L^{-1} + .0002312V$$

$$R^2 = .8004 \quad r_{VL^{-1}} = .3093$$

The load per car variable is the most significant of the two variables (Table 5.2). Thus the first hypothesis is rejected on the basis of these results.

The positive regression coefficient for the dollar value variable indicates that as the value of the commodity increases, the rate will increase. Therefore, high-valued goods will bear a higher rate than low-valued goods.

The amount of explained variance in the proxy rate variable does not change significantly when the new factor analysis variables are regressed against the dependent variable. (R^2 = .8036). The inverse of load per car and distance form one significant new variable. The number of carloads forms another significant variable, as does the dollar value. The results of either method means rejection of the first hypothesis, that rates are based on value of service alone.

Eastern - Eastern Movements

$$(5.43) \quad Y = -.1671 + 12.765L^{-1} + .0007746D + .0001717V$$

$$R^2 = .6761 \quad r_{DL}{-1} = .2731 \quad r_{VL}{-1} = .2847$$

$$r_{VD} = -.1114$$

Load per car is the most important variable, followed by distance and value of commodity. The first hypothesis would be rejected on the basis of these results; not only are cost factors significant, but they are relatively more important than the demand factor.

The relatively low level of explained variance (67.61%), suggests that other factors, not evaluated, may be significant. A test of autocorrelation was conducted to determine whether a major variable had been omitted. Although the test was inconclusive, it is doubtful that a major explanatory variable has been omitted. There are a number of potential variables that might increase the level of explanation, including: density of traffic in the eastern region; intermodal competition, and market competition. In some parts of the densely populated eastern region, trucking competition would be relatively intense for the movement of high-valued goods over short distances. Indeed average haul distance in the sample is the least of the eight movements and the average dollar value per ton is the second highest.

The correlations between the significant independent variables provide some insight into the nature of the commodities in the sample. The dependency between value and the inverse of load per car (.2847) suggests that as the load per car increases, the dollar value decreases. This is a direct reflection of the sampled commodities, i.e. high density bulk commodities would be expected to have a lower value per ton than lower density manufactured products.

The amount of explained variance does not change significantly when the new factor analysis variables are regressed against the proxy rate variable (R^2 = .6852). However, all four original variables are significant, given their association with the four significant new variables.(1) The first hypothesis is rejected as both cost and demand factors are significant.

Western - Maritime Movements

$$(5.34) \quad Y = .2619 + 42.2729L^{-1} + 1.3007N^{-1} + .0006245V$$

$$R^2 = .8528 \quad r_{N^{-1}L^{-1}} = .0411 \quad r_{VL^{-1}} = .7678$$

$$r_{VN^{-1}} = -.2217$$

Load per car is the most significant variable, followed by number of carloads and dollar value. This model suggests that the first hypothesis would be rejected; both cost and demand factors are significant.

The results of this evaluation may be questionable due to the high correlation between value and load per car. The high correlation may be due to the particular commodities constituting the sample. To some extent the value of the commodity is less a measure of the elasticity of demand for transport, and is more a measure of the kinds of commodities travelling between these two regions.

(1) The number of new variables produced by the factor analysis technique can be specified. In this, and the remaining movement models, the number of new variables exactly equals the number of original variables in the original rate models.

Regression of the factor analysis variables does not change the amount of explained variance in the proxy rate variable significantly (R^2 = .8595). The same significant variables have been included by using this technique. The first hypothesis is rejected again on the basis of these results.

Maritime - Eastern Movements

(5.45) $Y = .0719 + 23.5118L^{-1}$

$R^2 = .7579$

The only significant variable for the commodities sampled is the load per car variable; it accounts for 75.79% of the variation in the proxy rate variable. With the other variables being insignificant, it is clear in this case that factors, other than those evaluated, significantly affect differences in rates. Intermodal competition, primarily from water transport, would likely be a significant factor for commodities moving from the Maritimes to the Eastern region.

The variance of the proxy rate variable is explained completely by a cost factor. Although other factors have not been evaluated, it is apparent that the first hypothesis would be rejected, as a cost variable alone is significant.

By regressing the new factor analysis variables against the proxy rate variable, the amount of the explained variance increases by a significant 10% (R^2 = .8596). The increase may be attributed to the addition of number of carloads as a significant variable. These results mean that the first hypothesis is rejected; only cost factors are significant.

5.4.2 Model Results Testing All Three Hypotheses Western - Eastern Movements

$$(5.46)\quad Y = -.1889 + 49.5755L^{-1} + .0006043D - .1898C_{MD}$$

$$R^2 = .8368 \quad r_{DL^{-1}} = .2185 \quad r_{C_{MD}L^{-1}} = .3826$$

$$r_{C_{MD}D} = .2741$$

The load per car variable, distance and intermodal competition variables are significant in that order of importance. The excluded variables are all highly correlated with the significant variables.

The significance of these three variables would suggest rejection of the first hypothesis; the rates are not based solely on the value of the service. The second hypothesis, that intermodal competition has a significant effect on differences in rates, would be accepted. These results do not support the third hypothesis that market competition is a significant factor.

The positive correlation between intermodal competition and distance means that intermodal competition increases with distance. For the commodities in this sample, water competition may be particularly important, either because traffic is lost to the water route through the Panama Canal or because of water competition on the Great Lakes. The regional export of bulk commodities from the west via the Great Lakes would be particularly vulnerable to lower cost water competition and rates would be expected to be lower as a result. The negative regression coefficient reflects this logic: as intermodal competition increases, the rate decreases. The negative correlation between intermodal competition and the inverse of load per car is a more complex relation. This correlation indicates that as the load per car increases, intermodal competition increases. This explanation supports the previous conclusion that bulk commodities on this route are susceptible to lower rates due to intermodal competition.

The regression results of the new factor analysis variables indicate a significant reduction in the amount of explained variance in the proxy rate variable ($R^2 = .7822$). There is no change in the significant factors accounting for the variance of the proxy rate; the new significant variables are associated with load per car, distance, and intermodal competition. Thus the first and third hypotheses are rejected and the second one is accepted.

Western - Western Movements

$$(5.47) \quad Y = -.3308 + 11.0337L^{-1} + .0009762D + .0853C_{MT}$$

$$R^2 = .8073 \quad r_{DL^{-1}} = .1799 \quad r_{C_{MT}L^{-1}} = .1239$$

$$r_{C_{MT}D} = -.0085$$

Distance is the most significant of the three variables, followed by load per car and market competition (Table 5.2). The three variables account for 80.73% of the observed variation in the dependent variable. There is a relatively low degree of correlation among the three significant variables.

The results of this analysis indicate that both cost and demand factors are significant in defining differences in rates. Thus the first hypothesis would be rejected. Intermodal competition is not a significant variable, given the commodities included in the sample. Therefore the second hypothesis is rejected on the basis of these results. The third hypothesis, that rates are influenced by market competition, is accepted.

The correlations shown above indicate that market competition is almost completely independent of distance. The expected relationship exists, that is, as distance increases, market competition decreases. Market competition is correlated positively with the inverse of load per car. That is, as load per car decreases, market competition increases. Conversely, within the western region, market competition is low for commodities having high carload weights.

There is an anomaly in the results (equation 5.4 7). The positive regression coefficient for the market competition variable means that as market competition increases, the rate increases.[1] This, however, is contrary to what would be expected. A more intuitive argument would be that as market competition for a commodity increases, the rate decreases. This argument is based on the price competitiveness of the commodity. The railways stand to lose revenue if the commodity fails to move because it is not price competitive. The inverse relation argument, i.e. rates should decrease as market competition increases, would be expected as part of the rate negotiation process. Indeed, it has been used with some variation in formal hearings before the Railway Transport Committee of the Canadian Transport Commission.[2]

The amount of explained variance in the dependent variable increases when the new factor analysis variables are regressed against the proxy rate variable (R^2 = .8250). Two additional variables, number of carloads and dollar value, become significant using this technique. On the basis of these results, the first and second hypothesis are rejected, and the third hypothesis is accepted. The use of this technique does not solve the apparent anomaly noted above, between market competition and the rate. The regres-

(1) This result may be due to a limited sample or the relationship may indeed by true. The regression results of the new factor analysis variables indicate exactly the same relationship, i.e., as market competition increases the rate increases. This should be the subject of some future study.

(2) Rapeseed Case and Anglo-Canadian Pulp and Paper Mills Ltd. et. al.

sion of the new factor analysis variables results in the same market competition/rate relationship.

Eastern - Western Movements

$$(5.48)\quad Y = 1.5517 + 33.5483L^{-1} + .0004639V - .5242C_{MT}$$

$$R^2 = .7050 \quad r_{VL^{-1}} = -.0253 \quad r_{C_{MT}L^{-1}} = -.2331$$

$$r_{C_{MT}V} = .4134$$

Load per car is the most important variable in the equation, followed by dollar value and market competition. The first and second hypotheses are rejected and the third hypothesis is accepted, given these results.

The regression coefficients indicate the following relationships: 1) as load per car increases, the rate decreases; 2) as the value of the commodity increases, the rate increases; and 3) as market competition increases, the rate decreases. To some extent, these general relationships support some of the contentious issues raised by the western provinces. Market competition for steel in British Columbia was used to rationalize steel rates to B. C. that were lower than the rates for steel shipped to Alberta. Similarly westerners have suggested that value of the commodity is the basis for pricing. Although the latter hypothesis is not supported by these results (the most sigficicant factor is a cost variable), a comparison of the dollar value regression coefficients indicates larger regression coefficients for Western to Maritime and Eastern to Western movements than for Eastern to Maritime and Eastern to Eastern movements. (1) Thus there is some evidence that the value of the commodity has different levels of importance.

The explained variance in the dependent variable decreases a significant 23% when the new factor analysis variables are regressed against the proxy rate variable (R^2 = .4776). The reduction is explained by the reduction in significant variables; dollar value and market competition are excluded. The very significant difference in the amount of explained variance of the proxy rate variable emphasises the extent to which multi-collinearity may be a problem. In this case, factor analysis has served a distinctly useful purpose. The low degree of explained variance may be due to the small sample size and/or other factors may be significant. On the basis of these results, all three hypotheses are rejected.

5.5 Summary of the Statistical Analysis

The statistical analysis has two dimensions. The first dimension is concerned with the implications of the results vis-a-vis the stated hypothesis. The second dimension relates to the methodology and research strategy.

(1) The Western Maritime value coefficient is .0006245; however, there is sufficient evidence of multi-collinearity to render the regression coefficient questionable. The Eastern to Western value coefficient, however, is still higher than the other two quoted movement coefficients. These latter results are not as questionable.

The acceptance (A) or rejection (R) of the three hypotheses is portrayed for each movement model evaluated (Table 5.4).

Table 5.4 - Implications of the Model Results for the Three Hypotheses

Movement Model		Hypothesis		
From	To	1	2	3
Maritime	Maritime	R	N.E.	N.E.
Eastern	Maritime	R	N.E.	N.E.
Eastern	Eastern	R.	N.E.	N.E.
Western	Maritime	R	N.E.	N.E.
Maritime	Eastern	R	N.E.	N.E.
Western	Eastern	R	A	R
Western	Western	R	R	A*
Eastern	Western	R	R	A

R - Reject

A - Accept

N.E. Not Evaluated

* - Result is questionable

For the sampled commodities, rates are not based on the value of the service, but on a combination of cost and demand factors where the cost factors are the most significant element. Within the western region, intermodal competition is not a significant factor explaining differences in the proxy rate of the sampled commodities. Nor is intermodal competition significant for the sampled commodities moving from the eastern to the western region. [1] Market competition is significant both for shipments within the west as well as for shipments from the east to the west.

The use of factor analysis as an intermediate step resulted in a number of significant changes in the final movement models. In four cases, changes in the magnitude of explained variance were small, but additional variables were shown to account for that variance. The remaining four models showed significant departures in the amount of explained variance from regression results of the original variables. Again in some cases, variables were added or deleted. Given the often high degree of variable interdependency, factor analysis provides a feasible solution for overcoming one methodological problem, that of multicollinearity.

In the following section a process is described for monitoring trends in the factors affecting differences in rates. This process reflects many of the results described in the previous sections of this chapter; however, it is a proposal only and has not been tested.

(1) These results depart from the general statement made by Morrish and MacKinnon, that average revenue per ton-miles east to west has decreased primarily because of intermodal competition. Morrish and MacKinnon op. cit. p. 5. The departure may be accounted for by the small number of sampled commodities, or it could be that intermodal competition is indeed insignificant. This should be the subject of a future study.

5.6 A Proposal for Monitoring Trends of Rate Factors

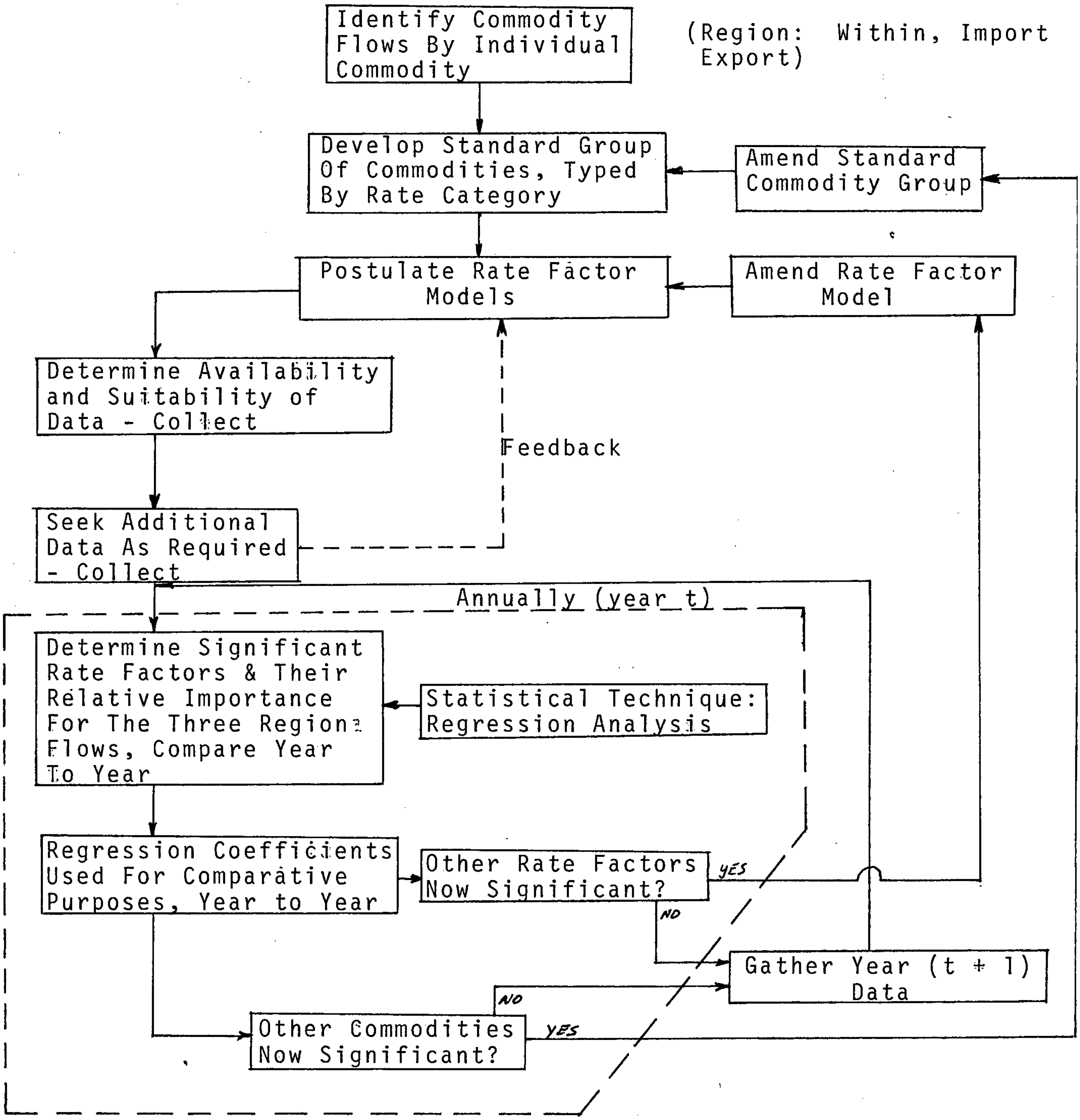
In this section an ex post analytic approach is postulated for monitoring trends in those factors affecting differences in rates. The proposed procedure is derived from the results in this study. Although there may be other reasons for monitoring the rate factors, two ar considered: 1) the technique would be useful for monitoring the effects of public policy or for determining what policy action is required; and 2) the impact of external influences on the rate factors could be evaluated. A schematic of the process is shown in Figure 5.3.

The procedure would be particularly appropriate at a regional level for an analysis of factors influencing rates in one time period or over several time periods. It should be clear that the procedure is relatively flexible. For example, the groupings of commodities by movements within, into, and out of the region could just as easily be movements within, into and from other specified regions. Each of the major process components is dealt with below.

Commodity Flows

The results of this study show that the direction of the movement is important. In most cases, the models described in the previous section of this chapter display different characteristics. The extent to which commodity flows will be disaggregated will depend upon considerations which are not studied in this thesis. For example, direc-

Figure 5.3 - A Schematic Of The Rate Factor Monitoring Process



tion of movement within a region may be relatively important, or some commodities may move to only one significant location.

Standard Group of Commodities

The commodities constituting the sample can influence which factors are significant; therefore, it is necessary to have a standardized sample for the analysis. For example, if all of the commodities in the sample are low-valued, bulk commodities, it is possible that only market competition will be a significant factor and intermodal competition will not. The commodities in the sample should reflect all factor possibilities. Although it is suggested that the standard commodity group could be amended from time to time, the full affect of this has not been evaluated. Changes would be expected and caution must be exercised in assessing the results if new commodities are added.

Rate Factor Models

The models could include any factors thought to be relevant to the particular movements being studied. It is recommended, however, that the factors used in this study be evaluated first, as they have been found significant in this analysis.

Data

Less highly aggregated data than were used in this study should be employed. The actual rate, rate category, load per car, distance, and number of carloads in the movement could be taken from the original waybill. In addition, more precise measures of commodity value should be sought. The measurement of intermodal and market competition probably would be subjective as in this study.

Statistical Methods

Regression analysis could be employed as the research tool. The results of this study show a high degree of correlation between the original explanatory variables. The use of factor analysis or transformations of the original data should be used to overcome this problem if it is significant.

Comparison from Period to Period

The parameters sought in each analysis are: 1) the extent to which the explanatory variables explain the variance of the rate; 2) the variables or factors which are significant; 3) the relative importance of each factor in the rate model; and 4) the regression coefficient for that variable. The monitoring of trends in rate factors from period to period is in terms of the above parameters.

The following aspects need emphasis.

1. The process described is an analytic method and not a predictive method.
2. The process has not been tested; it appears to be a feasible approach to the problem of evaluating time trends of factors affecting rates, given the results of this study.

3. Only the general procedure is outlined above; the details of the methodology are considered to be situation specific.

Appendix 1

Factor analysis may be used as an intermediate step, prior to using regression analysis. The factor scores are by definition independent of one another; therefore when the factor scores are regressed against the proxy rate variable, the first assumption required for the regression technique is satisfied.

Because all variables constituting the general models are evaluated, an attempt is made to load each of the original variables onto one factor space.[(1)] This proves to be feasible. Each original variable tends to load very highly on one factor space, usually showing a factor loading in the rotated factor space greater than .85. That is, each variable has at least $(.85)^2 \times 100$ or 72% of its variation in common with the variation in the factor space.

Factor analysis produces factor scores for each case variable, utilizing an internal regression routine.

The entire process is outlined in summary mathematical form below.[(2)]

(1) This method represents a considerable departure from the more usual use of factor analysis, in which the number of factors resulting are based upon some significance criterion. The initial use made of factor analysis using the internal significance criterion resulted in fewer factor spaces than original variables. This only served to confirm that the variables were to varying degrees related to one another.

(2) These equations only focus on the highlights of the process and do not deal with the entire process.

1) Standardize each case variable

(5.49) $Z_{ij} = (X_{ij} - \bar{X}_j)/s_j$ where Z_{ij} = the standardized value for the i^{th} case and the j^{th} variable;

X_{ij} = the original j^{th} variable for the i^{th} case;

$\bar{X}_j$ = the mean of the j^{th} variable for all cases in the sample; and

s_j = the standard deviation for the j^{th} variable.

2) Determine the factor score, a_{ij} for the i^{th} case and j^{th} variable (example, the first variable)

(5.50) $a_{i1} = c_1 Z_{i1} + c_2 Z_{i2} + \ldots\ldots\ldots + c_n Z_{in}$

where Z_{ij}, $j = 1 \ldots\ldots\ldots n$ are the standardized variables; and

c_j, $j = 1 \ldots\ldots\ldots n$ are regression coefficients determined within the factor analysis program.

3) Regress the factor scores against the proxy rate variable

(5.51) $Y = a + b_1 F_1 + b_2 F_2 + \ldots\ldots\ldots b_n F_n$

where Y = proxy rate variable

a and b_k, $k = 1 \ldots\ldots\ldots n$ are calculated regression coefficients; and

F_k, k = 1 .... n are the specific factors, each representing one of the original variables.

CHAPTER 6

SUMMARY, AREAS OF FURTHER RESEARCH, AND CONCLUSIONS

6.1 Summary

This thesis evaluates the significance of a limited number of cost and demand factors which are expected to explain differences in railway freight rates. There are two areas in which this topic is relevant. First, it addresses directly some specific issues concerning railway freight rates. Second, the problem of assessing trends in rates over time is examined. A process is postulated for assessing temporal changes in the factors that have a significant influence on rates. A number of considerations influence the approach taken in this study. In particular, the availability and nature of data are relevant considerations, as are the characteristics and capability of the various analytical methods employed. To some extent, the availability of data is a constraint affecting the factors that are evaluated.

6.1.1 Rate Issues

Among the many specific concerns expressed about rates three issues are postulated in the form of hypotheses and examined in this study.

1. Rates are based on the value of the service (pricing based on demand) and not on the cost of providing the service.
2. Intermodal competition has had an effect in determining differences in railway freight rates.
3. Market competition for the transported commodities influences differences in railway freight rates.

If the first hypothesis is true, only demand factors would be significant and cost factors would be insignificant. Cost factors, load per car, distance, and number of carloads in the movement are examined. The data for these variables are extracted from the CTC Waybill Analysis, 1972. A fourth variable, commodity value is used as a proxy for the elasticity of demand for transport. These data are extracted from a Statistics Canada publication. The hypothesis is tested by analysing which of the four variables are significant for eight movement models. The hypothesis can be accepted as true only if all cost factors in a model are statistically insignificant.

The second and third hypotheses are tested for three regional movements by adding subjectively defined variables, intermodal competition and market competition, to the four variables described above. These hypotheses are accepted for a particular movement model if the relevant variable is significant and rejected otherwise.

6.1.2 The Use of the Waybill Analysis Data and Their Limitations

The CTC Waybill Analysis data often are used to measure trends in rates. Usually the trend is explained by some factor or factors which have not been measured explicitly. Thus assessing trends in rates and evaluating the significance of factors affecting differences in rates are part of the same concern. The results of this study indicate that measuring the changing significance of rate factors and their joint effect over time may be a better measure of temporal trends in rates than is some aggregate measure, such as average revenue per ton-mile. The use of the Waybill Analysis commodity data and average revenue per ton-mile data suffer from the weaknesses described below.

1. These data are highly aggregated; revenues are the result of rates which may be found in one or more tariffs; distance is an average figure, as is load per car. These aggregate measures do not accurately reflect the real cost relationships.
2. Given current public policy, both cost and demand factors would be expected to be important; however, only cost variables are contained in the Waybill data. Thus the data are of limited value for evaluating the affect of public policy.
3. Although weight and distance are found to be the most significant factors in this study, there is no

guarantee that the ton-miles measure explains differences in rates to the same degree for different movements. A higher degree of explanation is achieved by evaluating all feasible factors. From the discussion in Chapter 2 it is clear that many factors might be significant as determinants of a particular rate.

6.1.3 The Research Design and Its Implications for Future Analysis

The impact of the research design is two-fold. First, the thesis objective and the characteristics of the data require a relatively sophisticated analytic method. The objective requires the identification of significant factors that can be used to replicate, as nearly as possible, the level of an existing rate. The examination of the data shows that there is a high degree of correlation among the explanatory factors. Together, these two aspects dictate which statistical technique is used and potential problems that may be encountered. Regression analysis is used as the primary statistical method. Factor analysis is used to produce new, statistically independent variables from the original variables. This procedure overcomes the problem of high correlation among the explanatory variables which affects the use of regression analysis; however, it also complicates the analysis considerably.

The second impact of the research design is that it provides a base from which future analytical studies may be made. An approach is postulated for monitoring trends over time of significant rate factors. The process has not been tested; however, it is considered feasible given the results of this study. The process may be characterized as having three components.

1. Identify significant commodities and incorporate these into a standard commodity group. Significant movement patterns may be identified through a separate analysis.
2. Postulate rate models, incorporating cost and demand factors thought to be significant. Which factors are significant will be related to the particular region of interest. The commodities chosen and the organization of the data by movement patterns may be determinants of potential factors.
3. Use regression analysis to produce statistical measure for the significant variables. These measures will be compared from year to year to evaluate changes in the significant variables. A high degree of correlation between factors may be expected, and this phenomenon must be accounted for.

6.2 Areas of Further Research

There are two categories of further research. The first is concerned with continuing the research started in this study by employing a larger sample of commodities and using disaggregated rather than aggregated data. The second category of research reflects concern for some of the results obtained in this study.

6.2.1 Continuing the Research

The proposed process described in section 5.6, Chapter 5, would serve as the research design for a continuing study of the significance of rate factors. A number of changes could be made, including:

1. the use of original disaggregated waybill data;
2. the use of a more sophisticated means for defining the degree of intermodal competition and market competition;
3. the use of preliminary analysis to broaden the scope of sampled commodities;
4. the use of prior analysis to determine what factors may affect organization of the commodities by movement pattern; and
5. the use of additional data to measure factors which are not evaluated in this study.

A discussion of the number of possible applications of this approach would be speculative at this point, although many come to mind. The method has not been tested to determine its feasibility and testing of the method is one possible objective, however academic it appears to be.

6.2.2 Further Research Stemming from the Statistical Results

The use of factor analysis to solve the multi-collinearity problem increased the complexity of the analysis. In four of the eight movement models, this technique made a relatively insignificant contribution to the results. Although factor analysis could be used to validate the regression results, other techniques, such as mathematical transformation of the variables should be evaluated for eliminating multi-collinearity. Retention of the explanatory power of the transformed variable and a consequent reduction of multi-collinearity are the objectives of any transformation.

Two anomalies in the movement models should be the subject of further study.

The Eastern - Western movement model shows a reasonable coefficient of determination (R^2) when the original explanatory variables are regressed against the dependent variable. However, the use of factor analysis prior to regression analysis resulted in two significant changes: 1) there is a 23% reduction in the explained variation of the dependent variable; and 2) only one variable, load per car is retained as being significant. Two steps may be taken to explain differences in rates for this model. First other factors could be examined, *ex ante*, and included in the rate model if they appear to be significant. Second, the sample size could be increased to include a larger cross-section of commodities. For example, some commodities might reflect a mode competitive rate and intermodal competition could become a significant variable. Furthermore, merely increasing the sample size, including more of the same commodity types, could make dollar value and market competition significant variables again.

Morrish and MacKinnon have suggested that intermodal competition is a factor affecting a reduction in average revenue per ton-mile, 1968 to 1972, for Eastern - Western movements. This is contrary to the results of this study. The hypothesis that intermodal competition is significant in explaining differences in rates should be tested by increasing the number and kinds of commodities constituting the sample for this movement.

Both the regression results of the original variables and the regression results of the new factor analysis variables for the Western - Western movement model show a positive relationship between the rate and market competition. That is, as market competition increases, the rate increases; this is contrary to the expected relationship. The following hypothesis should be tested utilizing a larger sample of commodities.

Null Hypothesis: Market competition is a significant factor influencing higher rates.

Alternative Hypothesis: Market competition is a significant factor influencing lower rates, i.e. market competition is inversely related to the rate.

6.3 Conclusions

Five conclusions are drawn from the results of this study.

1. Both cost and demand factors are significant in explaining differences in railway freight rates where rates are represented by an aggregate measure, average revenue per hundredweight. Given this assumption, there is no evidence that rates are based solely on the value of service. Indeed, the study indicates that cost factors are relatively more important than are demand factors in all movement models.
2. The significant variables affecting differences in the proxy rate vary from movement model to movement model. In some cases, insignificant variables identified in this study for a particular movement might be significant given a wider range of sampled commodities. In other cases, the nature of the regional commodity movements and transport technology might preclude the variable from being significant, particularly if differences in rates among commodities are being evaluated. Given these considerations, and bearing in mind the limited number of commodities sampled, the following specific conclusions are drawn:

   1) intermodal competition is significant for

Eastern - Western movements; and 2) market competition is significant for Eastern - Western movements, insignificant for Western - Eastern movements, and highly questionable for Western - Western movements.

3. The extent to which the Waybill Analysis data is aggregated affects any use made of these data. Although general conclusions may be drawn about the explained variance of average revenue per hundredweight from the results of this study, it is not possible to relate these results to any specific rate. However, this is the case with the average revenue per ton-mile measure as well.
4. On the basis of these study results, it is concluded that a feasible methodology exists for analysing the relative importance of a set of identified significant factors from year to year. The proposal outlined in Chapter 5, and summarized in the previous sections of this chapter, has not been tested but should be considered in any future examination of trends in railway freight rates
5. The variables evaluated in this study show a variable, but usually high degree of correlation between one another. The extent to which multi-collinearity may be a problem is shown by the results obtained for the Eastern - Western movements. The

use of factor analysis in this case clearly aided the analysis. Conclusions based on the original regression results would be in error due to the magnitude of the variable correlations.

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