AN ECONOMETRIC MODEL OF DEMAND AND PRODUCTION IN THE CANADIAN RAILWAY TRANSPORTATION INDUSTRY

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ABSTRACT

An Econometric Model of Demand and Production in the Canadian Railway Transportation Industry.

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This thesis constitutes an econometric examination of demand and production relationships in the Canadian railway transportation industry for the period 1952-70. A general theoretical model is first formulated which includes all major functional variables in the industry. Two of these are then examined in some depth, namely demand and production. The former is separated into groups by the nature of the railways' output, and demand functions are estimated by means of multiple regression. The latter is formulated as an industry production function, and this too is estimated statistically. The model is a yearly one, and its main purposes are to describe quantitatively the principal economic relationships in the industry, and to serve in some capacity as a predictive tool.

ACKNOWLEDGMENTS

I wish to express here my gratitude to all those who were, by their help, instrumental in the completion of this thesis. A few deserve special mention. I would like to offer my thanks to the Canadian National Railways, for whom I was an employee in the department of Research and Development during the period of preparation of this thesis. Their many forms of direct and indirect assistance, and the attitude of encouragement enjoyed there were most helpful. I would like to make special reference to Mr. R.W. Warren, Senior Economist for the Canadian National, who gave much willing and helpful advice. Mme Luce Bourgeois and Mlle Linda Trubiano were most cheerful and conscientious typists and their work is greatly appreciated. Doctor Vittorio Corbo acted as my advisor, and enabled me to draw the greatest educational benefit from the process. Finally, I would like to mention the unceasing encouragement, assistance, and support of my wife, Deb.

In spite of all the contributions of others, of course, I accept responsibility for any errors which may remain.

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LIST OF SYMBOLS

Symbol	Meaning
*	Multiplication
$\sum$	Summation
$<$	Less than
$>$	Greater than
$\hat{a}$	A statistical estimator for some variable, a.
R^2	The coefficient of determination for a regression, adjusted for degrees of freedom.
t-value	The value of the t-ratio under the hypothesis that a coefficient is zero.
F	The Fisher F-ratio for the hypothesis that all coefficients are zero.
D-W	The Durbin-Watson d statistic.

LIST OF TERMS

Term	Meaning
AMTRAK	The National Railroad Passenger Corporation (U.S.A.).
n.o.s.	Net otherwise specified.
net-ton-miles	The product of a payload, or net, weight and the number of miles travelled.
passenger-miles	The number of miles travelled by each passenger, times a given number of passengers.

INTRODUCTION

The following paper represents the results of a rather detailed, although beginning, inquiry into some of the quantitative relationships influencing the Canadian railway industry over the past twenty or so years. The study is part of a larger theoretical model of the complete industry. Although a number of such studies involving industry-level econometric models have been developed[1], this one seems to be an initial application of econometric tools to the particular industry involved. The Canadian railway industry is one of the largest, oldest, and most important industries in the economy which, however, has been and is continuing to be subject to a number of fundamental changes.

Part I begins with a description of the railway industry, its historical development, and the nature of its operation. Part II describes the complete industry model in its theoretical form. Part III consists of an investigation into the nature of demand in the industry in a disaggregated form. Part IV is a discussion of the nature of the

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[1]A.R. Dobell *et al*, "Telephone Communications in Canada: Demand, Production and Investment Decisions", *The Bell Journal of Economics and Management Science*, Vol. 3, No. 1 (Lancaster: Lancaster Press Inc., 1972); K.J. Cohen, *Computer Models of the Shoe, Leather, Hide Sequence* (Englewood Cliffs: Prentice-Hall, 1960); T.H. Naylor *et al* "A Computer Simulation Model of the Textile Industry", *Journal of the American Statistical Association LXII* (December 1967).

industry production function; and Part V offers a number of general conclusions.

Although the sectors of the model presented here are only a beginning, it is felt that econometric modelling at the level of the individual industry or firm is a powerful tool in the decision-making process. Developments along these lines promise to add a considerable amount of power to companies' abilities to predict and influence the future.

PART I

THE INDUSTRY

CHAPTER I

THE CANADIAN RAIL INDUSTRY

The companies which comprise the Canadian railway transportation industry currently account for approximately forty percent of the intercity freight traffic handled in Canada, and about three percent of intercity passenger travel[1]. Statistics Canada[2] reports data for common carrier railways in Canada on the basis of four classes, as follows: Class I consists of the Canadian National Railways (C.N.R.) and Canadian Pacific Rail (C.P.R.); Class II consists of some twenty-three other carriers earning annual gross operating revenues of more than $500,000.; Class III consists of carriers earning revenues below that limit annually; and Class IV consists of "other railways of a special nature such as terminal, bridge and tunnel companies". Table 1 gives an indication of the relative magnitudes of the firms which made up the industry in 1970.

The two class I roads are by far the largest firms in the industry; a good indication of their size is the fact that they accounted for more than eighty-seven percent of the industry's operating revenues in 1970. Canadian National and Canadian Pacific are transcontinental systems with

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[1]DBS, Transportation Service Bulletin (Catalogue No. 50-001)

[2]Note that the names "Statistics Canada" and "Dominion Bureau of Statistics" (DBS) refer to the same organization. The former name shall be used throughout, except for publications produced before 1970, when the name was officially changed.

terminals, main lines and branch lines covering virtually every geographical area of any economic importance in the country. The other roads fall into two broad categories: those which are Canadian extensions of American railroads, and which largely exist to provide connecting services with the larger roads; and railroads which serve particular natural resource areas, such as areas which produce lumber and iron ore.

The types of service offered by Canadian railway firms are numerous, although for the purposes of this study we shall consider them as belonging to two principal groups: freight and passenger transportation. The former is characterized by a considerable degree of product differentiation, the service provided ranging from the carriage of large volumes of rough commodities like stone and ore to the movement of live animals and small express freight shipments. Passenger services of course, encompass the carriage of, feeding of, and provision of sleeping accommodation for people travelling on trains. Freight operations are by far the most important from a revenue standpoint to the railway industry, accounting for more than ninety-two percent of the gross operating revenue arising from the two types of service in 1970[1]. Canadian railway companies are also involved in many other aspects of economic activity, some of which are: shipping and ferry services, hotels and restaurants; telecommunications; trucking; real

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[1]Statistics Canada, Railway Transport, Part I: Comparative Summary Statistics (Catalogue No. 52-207), 1970.

TABLE 1

TRACK AND REVENUE STATISTICS FOR CANADIAN RAILWAYS IN 1970

Railways		Average Miles of Track Operated	Total Rail Operating Revenue ($ Millions)
Class 1:	Canadian National	23,143	852.2
	Canadian Pacific	16,601	616.8
Class 2:	Algoma Central	322	11.7
	Canada Southern	280	16.1
	Chesapeake and Ohio	339	16.2
	Northern Alberta	923	11.6
	Ontario Northland	532	19.2
	Pacific Great Eastern	862	31.0
	Quebec, North Shore and Labrador	358	56.0
	All other[a]	1,290	47.5
Classes 3 and 4:		46	1.4
	Total:	44,696	1,679.8

[a]Data is shown separately only for those railways earning gross operating revenues above $8 million annually. These companies account for more than 96 percent of the total Canadian gross operating rail revenues.

Source: Statistics Canada, Railway Transport, Part II: Financial Statistics (Catalogue No. 52-208), 1970; and Railway Transport, Part III: Equipment, Track and Fuel Statistics (Catalogue No. 52-209), 1970.

estate; air transport, provision of storage space; and consulting. For this study, however, we shall consider only rail freight and passenger services.

The Market

We will describe here quite briefly the sources of demand for railway transportation in Canada. Since the basic output units of the productive process are point-to-point traffic movements, it is necessary to consider the market in terms of originating locations for commodities or passengers and corresponding terminating locations. Treating the movement of goods first, then, sources of freight car loadings in Canada are principally the following: import products entering Canada from the east coast; raw materials produced in the Maritimes, such as forest products, coal and other mine products; iron and other ores from Northern Quebec; forest and mine products from Quebec and northern Ontario; manufactured articles produced in the Quebec City-Windsor "corridor"; imported goods from the United States which enter Canada via this corridor; northern Manitoba mine products; grain from the three Prairie provinces; potash and fertilizers from Saskatchewan; livestock and petroleum from Alberta; and forest products, coal and other mine products from British Columbia. On the other hand, the principal destinations for these products correspond to the population centres in Canada, with a considerable amount of exports flowing out of the country via "gateways" at Halifax, St. John, Churchill, Vancouver, Duluth, and the corridor mentioned above. The list is by no means exhaustive, but indicates the major part of the market for Canadian railway output. Turning to passengers, the principal components of the market are to be found in the higher-density population centres of eastern Canada (especially the "corridor") and in transcontinental services.

The Development of the Industry

Railroads have formed the foundation of the Canadian transport industry[1] since the mid-nineteenth century. The history of their development is the history of Canada itself, since railroads provided the means by which the nation's resources were first opened up, and by which most of its commerce was conducted up until the advent of the highway motor vehicle[2].

The first rail lines were opened in what is now eastern Canada beginning in the late 1830's. The lines were at first quite short and construction proceeded at a relatively slow pace until Confederation. At that time, however, the importance of an integrated transportation network became more apparent, for both political and economic reasons. As a result, and with government help, the Canadian Pacific and Inter-colonial Railways were created to provide links between central Canada, and British Columbia and the Maritime provinces, respectively. Although most of the railway companies operating in Canada during the late nineteenth century were privately owned, government support for the construction and maintenance of new lines was a necessity.

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[1]Some ambiguity is regrettably unavoidable by the use of the term "industry" to refer to both the railways and the set of all transportation companies.

[2]Excellent references, as well as brief histories of railroads in Canada, can be found in A.W. Currie, Canadian Transportation Economics (Toronto: University of Toronto Press, 1967) and H.L. Purdy, Transport Competition and Public Policy in Canada (Vancouver: University of British Columbia Press, 1972).

The vast distances to be spanned and the low population density of the Canadian nation were major problems to the commercial viability of new transport enterprises, especially the railway.

A further burst of railway construction activity took place at ther turn of the century,and during the two decades immediately following. This period was one of optimism for Canada, a time of high immigration and a growing population. Spurred by plans for developing the rich resources of the West, the federal government and different private companies pushed lines across northern Ontario to the Prairies and eastward from central Canada to New Brunswick. Thus were born the Canadian Northern, National Transcontinental and Grand Trunk Pacific railways, giving the young nation three transcontinental lines.

Unfortunately, the economy found itself unable to sustain such a wealth of railway capacity. Much of the commerce of western Canada was (and, to a great degree is still) based on natural resources. Thus freight rates had to be maintained at fairly low levels to allow sufficient volumes of traffic to move over the great distances to the markets and, as a result, many of the railway lines and operations were unable to make a profit. In addition, the great surge of building had created over-capacity and duplication of facilities in many cases. Purdy (in Transport) offers the information in table 2 as an illustration of the growth in Canada's rail network over the above-mentioned period.

TABLE 2

MAIN-TRACK MILEAGE IN CANADA

Year	Miles in Operation
1850	66
1860	2,065
1870	2,617
1880	7,194
1890	13,151
1900	17,657
1910	24,731
1920	38,805

Faced with such a bleak situation, the government of Canada settled on amalgamation as the solution to the problems of the troubled lines. Thus during the period from 1917 to 1923 the Canadian National Railways came into being, formed from the Canadian Northern, the Grand Trunk, the Grand Trunk Pacific, and the Canadian Government Railways (including the National Transcontinental and Intercolonial). The Canadian National was created with the intention that it function as an independent business enterprise, even though it was a government-owned system. From the start, however, it was saddled with three huge and continuing problems: a heavy structure of debt; a high degree of redundancy of its physical plant; and an enforced responsibility to maintain a great number of uneconomic services which were felt to be in the public interest. These problems linger on to this day, in greater or lesser measure.

The railways' story from the nineteen-twenties to the present falls under five principal headings: the advent of competition from other modes; the heavy use of plant and equipment during the Second World War; the running down of that plant in the absence of sufficient investment; the technological improvements of the last two decades; and the development of a more permissive attitude towards railway competition in the transport industry since the beginning of the nineteen-sixties. In the nineteen-twenties and thirties the railways encountered increasing competition from highway carriers. The latter were most effective competitors to the heavily-capitalized railroad companies, what with their easy market entry, low fixed costs, and availability of a ready-maintained highway network. The highway carriers were generally faster and more flexible and were regulated to a lesser extent in the area of rates than their rail counterparts. Later on, the technology developed during the war helped to create better airplanes and led to the development of petroleum pipelines--both of these modes cut into the railways' once-monopoly position in land transport. At the same time, national defense considerations and the nature of railways as the backbone of Canada's transportation system inflicted heavy utilization of their physical plant during the war. Rates, frozen in wartime and always slow to change in any case, did not generate enough revenue to maintain or expand that plant, however. Thus by the late nineteen-forties and early fifties the quality of the railways' capital goods and equipment was considerably run-down. Of course, this situation had an adverse effect on the firms' ability to withstand competition from other modes.

The other main features of the railway industry's history--those which have the greatest importance for the period covered by this study--were the large changes in technology and competitive climate which took place during the nineteen-fifties and sixties. Dieselization was accomplished during the decade of the fifties, which changed the nature of production radically. No longer constrained to stop every hundred or so miles for coal and water as they had been with steam power, trains could be scheduled over much greater distances and at much higher average speeds than before. Also, repairs diminished in importance due to the relative reliability and durability of the diesel locomotive. Together, these two factors allowed a reduction in the number of divisional points, maintenance shops, marshalling yards, and employees across the rail system. Less important than dieselization but still worthy of note were the design of larger and more efficient hump marshalling yards, the introduction of centralized traffic control systems, and the computerization of office procedures and traffic movement reporting. At the same time as these technical innovations were being introduced, negotiations with the government were being held which led to the MacPherson Royal Commission on transportation of 1959-61, and culminated in the National Transportation Act of 1967. The upshot of this was that the railways--traditionally the providers of many services that were uneconomic but which were justified as being in the public interest--were allowed to stand more solidly on their own feet in the competitive transportation market. This new permissiveness took the form of freedom to abandon uneconomic services (such as low-density branch-line traffic) where that was deemed reasonable; and to obtain subsidy payments from the government where it was not, but where revenues did not cover the long-run variable costs of operation.

CHAPTER II

THE POSITION OF RAILWAYS IN THE TRANSPORTATION INDUSTRY

Competition

Canadian railways, for a long time the holders of a monopoly position with respect to land transportation in Canada, have been recently engaged in a vigorous struggle for a share of the market. Table 3 gives an indication of the decline of the railways' importance in the overall industry through the past two decades, and the ascendance of other modes, notably the petroleum pipeline.

TABLE 3

FREIGHT TRANSPORTATION IN CANADA BY
COMMERCIAL CARRIERS
(Billions of ton-miles)

Year	Rail(%)	Road(%)	Water(%)	Air(%)	Pipe(%)	Total
1952	68.4(61)	8.9(8)	30.9(27)	0.02(-)	4.7(4)	112.9
1956	78.8(54)	10.6(7)	39.4(27)	0.04(-)	16.2(12)	145.1
1960	65.5(47)	13.8(10)	36.9(26)	0.04(-)	23.6(16)	139.8
1964	85.0(41)	17.5(9)	59.2(29)	0.06(-)	43.3(21)	205.1
1967	94.1(41)	19.5(9)	57.2(25)	0.10(-)	56.2(24)	227.1

Source: DBS, Transportation Service Bulletin (Catalogue No. 50-001), November 1969.

Although the table shows a decreasing percentage of the market for rail carriers, one significant detail is not shown by the data. That is the changing mix of commodities which make up the ton-mile totals. Railways have faced an increasing degree of competition in recent years from highway motor carriers, particularly in the area of high-value, low-density commodities--hence, ton-mile figures do not reflect this competition well. High-value commodities have normally been relied on by rail carriers not only to meet the short-run variable costs of carriage, but to contribute significant amounts of revenue to the typically high fixed costs[1] faced by rail firms. Thus competition in this area is particularly damaging to the railroads. The same argument can be applied to air carriers, although with less emphasis. In spite of the relative decline in railway transportation output, table 3 shows that the absolute amount of traffic carried has actually increased.

Output

The basic unit of output in the railway industry is the car trip for freight movements and the passenger trip for passenger movements. Considering the former for now, a car movement consists of a number of component parts: retrieval of an empty car from the system inventory (normally a yard--the inventory of a railroad is almost continuously moving); placing of that car for loading at a siding; loading of the car; terminal operations necessary to release the loaded car from the siding and place it on a train; a multi-segment train journey with marshalling en route; terminal operations at the destination point; unloading of the car; return of the car to the empty inventory; and disposition of the empty in a return direction, or to some other location. Passenger trips are similar in many ways, except that

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[1]That is, fixed in the short run.

passengers "unload" themselves at stations, and trains are not usually marshalled en route. Since weight characteristics are important, however, freight output is normally measured in net-ton-miles. By the same token, passenger output is measured in terms of passenger-miles. Combining these two measures of output in constant dollar units gives the level of Canadian railway output, which is shown in figure 1 for the period 1956-70. The most obvious features are the decline in output over the years 1956-61 and the ensuing upswing after 1962.

Table 4 illustrates a number of characteristics of the railways' output over the period 1952-68.

TABLE 4

SELECTED RAILWAY OUTPUT STATISTICS (1952-68)

Year	Average Tons Per Loaded Car Mile	Average Passenger Journey (Miles)	Average Revenue per Net-ton-mile(¢)	Average Miles per Ton
1952	31.6	104.5	1.377	422
1954	30.3	100.8	1.517	402
1956	33.1	111.5	1.409	416
1958	32.4	116.3	1.501	432
1960	33.1	116.1	1.517	413
1962	34.7	104.8	1.501	422
1964	38.4	117.0	1.345	435
1966	40.7	111.6	1.365	451
1968	42.5	128.0	1.433	439

Source: Statistics Canada, Railway Transport, Part I: Comparative Summary Statistics (Catalogue No. 52-207), for selected years.

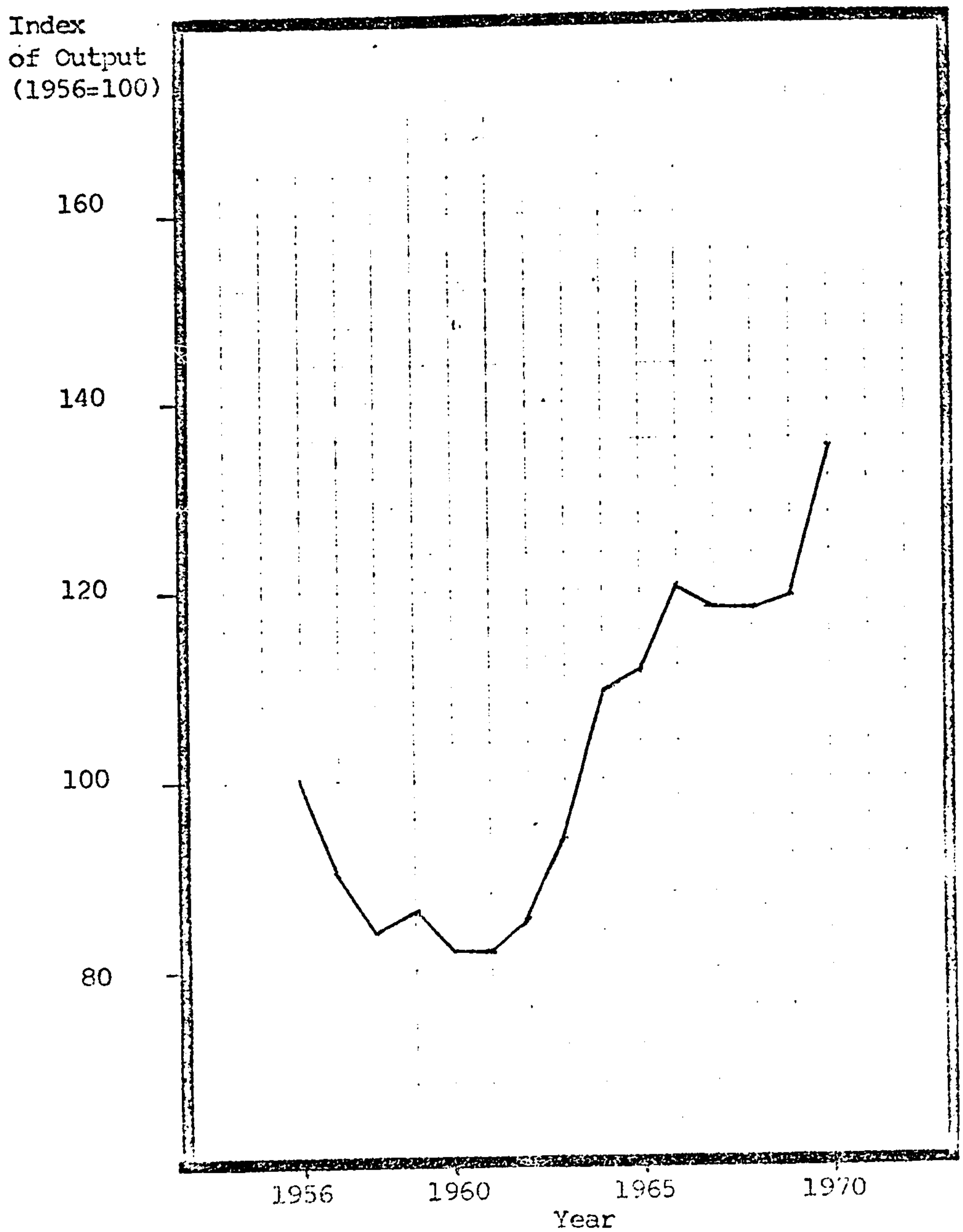

Figure 1.--Combined total passenger and freight output in the Canadian railway industry (1956-70), in constant 1956 dollars.

Average tons per loaded car mile is an estimator of the average load carried by freight cars. Average miles per ton is likewise an estimator of the average length of haul for each revenue freight car movement. Clearly, the trend established in this table indicates that output increases are outstripping increases in revenue--the average revenue per net-ton-mile is approximately the same for 1968 as it is for 1952. This is a rather singular instance in a period of high inflation such as Canada has experienced since the Korean War. S.E. Peterson has argued that rising levels of production and corresponding fixed levels of average revenue are signs that the railway industry is in a "cost-price squeeze".[1] Moreover, one of the ways out of this squeeze--technological improvements--seems, he adds, to provide more potential to the railways' competitors, trucks and pipelines. The railways are quite possibly in a situation of diminishing returns, he observes, heavier utilization of rolling stock and roadbed giving rise to progressively smaller increments of revenue.

Many of the features of railway operations in Canada are better understood in the light of their high degree of capital investment. Purdy writes: "By their very nature railways are capital intensive, but the Canadian carriers show extremely high capital investment". "In the United States, railway services...absorb almost thirty-five percent less of the country's Gross National Product than is the case

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[1] S.E. Peterson, "Monitoring and Control Processes in Relation to Corporate Forecasting--A Report to Canadian National Railways" (Unpublished) Montreal, 1972.

in Canada"[1]. The chief contributing factors to this are the unwarranted early expansion of the industry, the large distances spanned by the rail systems, and the low population density of the nation. Two other factors are of importance to the industry output. One is the great dependence of Canada's economy on natural resources, of which the rail companies are prime carriers. The emphasis of activity on this type of shipment condemns the railways to a situation of heavy one-way shipments and correspondingly heavy empty car flows. Another factor is the railways' position as a common carrier, which binds them to accept any shipments which are demanded at a given (administered) price.

Railway Rates

A brief note will be made here about railway prices, one of the most controversial and important variables to influence the rail firms' total revenues. Owing partly to the vital nature of transportation in the economy and partly to the extreme complexity of transport pricing, railway rates are administered prices. The subject of rates is a topic of considerable dimensions in itself, and will not be examined here[2]. For the purposes of this study it is sufficient to remember that the prices of rail services are fixed by means of collusion between the rail companies under regulated ceilings, which are maintained by the federal government. This aspect of pricing is relevant to the discussion of demand in Chapter IV.

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[1] H.L. Purdy, Transport, p.8.

[2] A.W. Currie and H.L. Purdy give excellent treatments of the Canadian rail rate picture.

PART II

THE MODEL

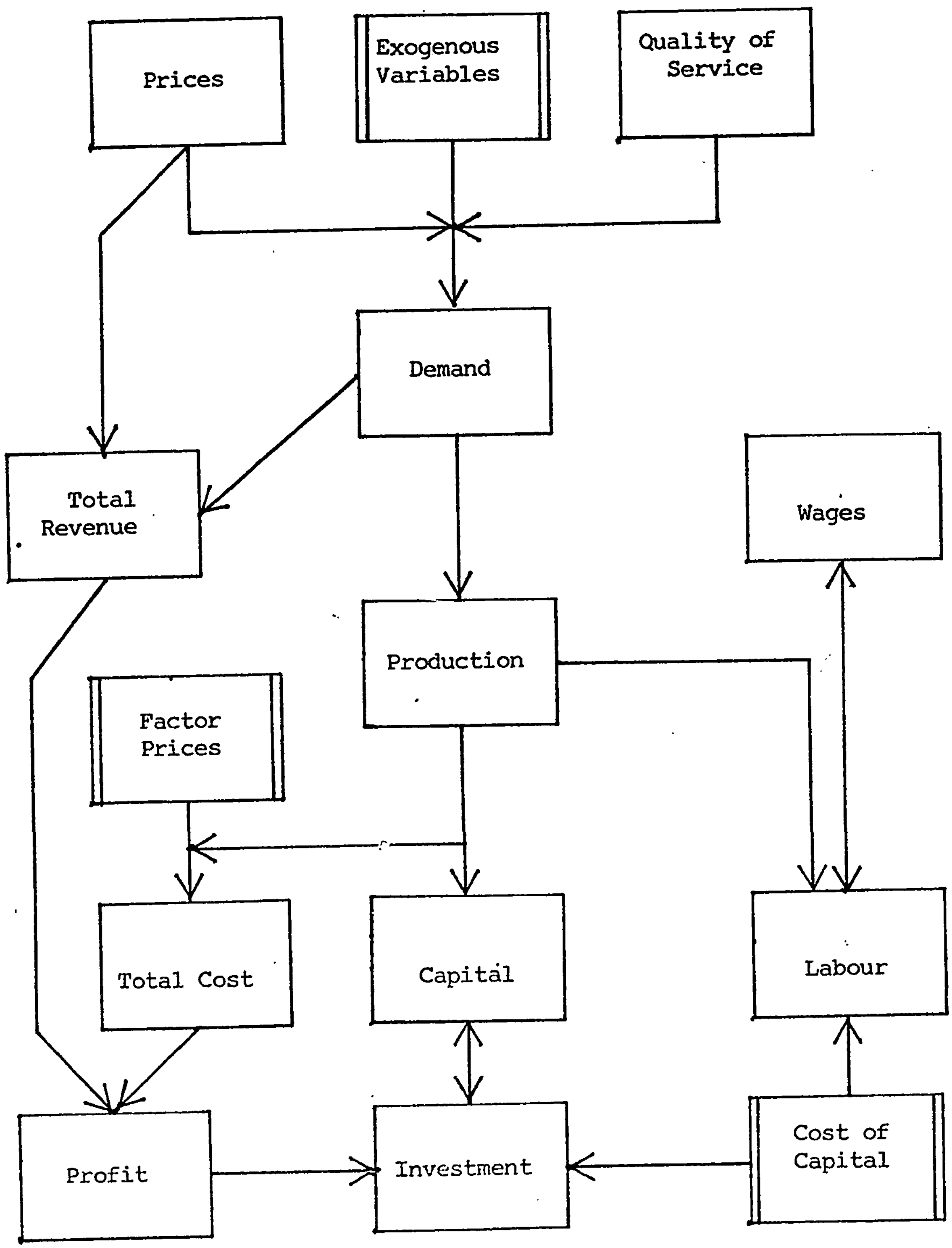
CHAPTER III

OVERVIEW OF THE MODEL

The present study constitutes an examination of two sectors of a complete model of the railway industry. Thus it is really only a beginning step into a more comprehensive treatment of the subject. Figure 2 represents the entire theoretical model and its functional relationships, including the relationships of demand and production to the whole.

It is important to remember at the outset that the model is static in nature. Thus all lagged adjustments and functional relationships are omitted. Clearly, the block diagram could become hopelessly complex with the inclusion of all intertemporal relationships. Exogenous variables to the model are represented by double-bordered blocks. The group referred to in the block at the top of the figure represents income variables which determine the level of railway transportation service output that the economy would support under given conditions. "Prices" and "quality of service" are two general classes of endogenous variables which define the conventional demand relationship, and which are subject to industry policy. The flow lines from these three blocks enter the "demand" block, showing a direct functional and causal relationship. "Demand" represents a series of specific equations which correspond to the different products and product groups produced by the industry. Summing the dependent variables of the demand equations, of course, gives the

Figure 2.--The Complete Industry Model.
(Double-line blocks represent exogenous variables)



total amount of output demanded per time period (however it is measured--usually it is in constant dollars). This variable is translated, via the industry production function, into a "capital" and a "labour" component. The "production" block thus determines the desired level of capital stock and of employment which will produce the required output, according to the technical nature of the productive process. In addition the production relationship, combined with exogenous factor prices (including "wages" which are shown separately) determines a total cost variable. Considering only the left-hand-side of the diagram for a moment, we notice that prices and the amount of output demanded determine "total revenue" via an identity. Taking the difference between total revenue and total cost gives "profit", which is a significant determinant of the "investment" block. We note here again that any dynamic properties of the model are suppressed in this representation, such as the effects of investment on total cost over time (and the effects of demand shifts on prices). These are, of course, quite important in reality. Considering now the right-hand-side of the diagram, we notice that "wages" (which is a factor price) and the level of employment ("labour") simultaneously affect each other. The relative "cost of capital" variable partially determines both investment and labour employment. Finally, the endogenous investment variable influences the capital stock (via new capital purchases) and is itself influenced by capital i.e. investment is a function of the desired level of capital stock (actually the difference between the desired and actual levels.)

This, in brief summary, is the essence of the complete model. We mention here a number of purposes which the model is intended to serve:

1. To illustrate the exact functional nature of the relationships faced by the railway industry.
2. To predict future levels of employment, capital stock, traffic volumes, revenue, profit, cost, and investment for the industry.
3. To investigate the results of shifts in different parameters of the model, either endogenously or exogenously introduced, including: changes in prices; changes in factor prices; changes in the cost of capital; changes in productivity; and changes in different aspects of the quality of service.

The model as treated in this study is a yearly one, covering the period 1952-70. Detailed discussions of the individual sectors of the model are presented in the following sections, along with empirical results.

PART III

DEMAND

CHAPTER IV

THE THEORETICAL FRAMEWORK FOR DEMAND ANALYSIS

Part III constitutes an investigation into the nature of and principal economic variables affecting the demand for rail transportation services. Historical data is subject to econometric analysis in order to achieve estimates of the various relationships shaping this demand.

General Form of the Model

We employ the general form

$$q = f(y_1, y_2, \ldots y_i, p_1, p_2, \ldots p_j)$$

of demand relationship in the ensuing analysis, where q represents quantity of rail service demanded, y_i represents any one of i income-type variables and p_j represents any one of j price-type variables. The variables are drawn from different time series and each represent values for a period t; the subscripts have been omitted for simplicity, however.

Two important characteristics of the demand relationship will be mentioned here. One is the fact that, since transportation is a service, it is impossible to stockpile the output or redistribute it over time (since we assume the existence of a horizontal supply curve--see page 32):

transportation which is foregone in a period (t) cannot be carried over as a residue into period (t + 1) by consumers. The upshot of this is that there is no direct relationship between the amount demanded in one period and amounts demanded in previous periods. A second major characteristic is the derived nature of the demand for rail (indeed, any) transport. That is, with some notable exceptions in the passenger area, rail transport is neither demanded nor consumed for its own sake --it is desired as a part of the larger process by which other goods or services are produced, or by which other aspects of consumer demand are satisfied. Thus there is an important intermediate connector in the relationship between income per time period and the consumption or utilization of rail transport in the same period. At the level of the household or firm in the economy an increase in income can be expected, ceteris paribus, to induce a corresponding increase in the amount of goods and services demanded. As was said above, the major part of rail transport (freight movement) will not be influenced directly in this fashion. However, the increase in amount of goods and services demanded will normally induce industry to expand production in the aggregate, and this will normally carry with it an increase in the amount of rail transport demanded, since railway freight service is an important productive factor in the economy. This is as true of cattle transport for final steak consumption and iron ore transport for automobile production as it is for the travel of administrative personnel to branch offices. The meaning of this special characteristic of transport demand is that two stages of relationships can be identified: the first relates the demand for different commodities to their determining variable (income); the second relates the demand for transportation of those commodities to the demand for the commodities themselves. Thus the income-type variables of the demand function influence the consumption, or demand, variable in a two-stage manner. Since good estimators for the first of these two stages are already in existence, we shall treat demand for transported products as exogenous to our model and concentrate on the second stage. The income variable, then, will be represented most often in our demand relationships by terms in the demand for transported goods.

Whereas the income variable reflects the (two-stage) relationship between income and rail transport demand, the price variable reflects conditions which shape the division of the transport market between railways and their competitors or substitutes--that is, the modal split.[1] It is important that "price" not be considered in a narrow fashion in the analysis of modal splits of demand. Equally as important

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[1]Since there is no good substitute for transportation in general --at least in the short run--its price elasticity of demand may be assumed to be rather low. This is not so, however, with respect to relative prices between modes. On the subject of the long-run price elasticity of demand for transportation, S.E. Peterson ("Monitoring and Control Processes") feels that it is high. Since transportation is a form of tax on the productive process, he says, firms will attempt to minimize this "tax" in the long run by means of decentralization and relocation according to the distribution of population. Thus the transport industry's share of GNP will decline in a nature economy. See Appendix V.

as relative prices between substitutable transport modes as measured by rates and fares are the "prices" measured in terms of relative speeds of movement, relative reliability and the relative comprehensiveness of the service being sold. Many modern studies of transport demand centre around this broader concept of "price".[1] As Purdy points out,[2] these additional characteristics of the different modes contribute to the imperfection of competition in the transportation industry, and what at first blush might appear to be a perfectly competitive situation is anything but, the seemingly homogeneous product of ton-miles of freight hauled being differentiated by the above variables and others. Mallen and Pernotte, from their study of Canadian transportation buyers, pointed out quite a number of additional important criteria, among them: the total cost of service, including rates, inventory costs, and costs of loading, unloading, loss and damage; convenience; punctuality; distance (quite often a rule of thumb is applied by shippers to select a mode); personal contact; the carrier's flexibility; the availability of high-class equipment; and the opportunities of reciprocal business.

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[1]See, for example: R.E. Quandt, ed., The Demand for Travel: Theory and Measurement (Lexington: D.C. Heath and Co., 1970); E. Culley, "Forecasting Intercity Travel", Papers--Eleventh Annual Meeting of the Transportation Research Forum (Oxford: R.B. Cross Co., 1970); and B. Mallen and J.F. Pernotte, Decision Making and Attitudes of Canadian Freight and Cargo Transportation Buyers (Montreal: Sir George Williams University, 1972).

[2]H.L. Purdy, Transport, Chapter 5.

Following from this theoretical approach, we arrive at the indicated general estimating form for our demand equations:

$$q = c + (a_1x_1 + \dots + a_ix_i) + (b_1p_1 + \dots + b_jp_j)$$

where q is the quantity of rail transport service demanded per time period, x_i are (income-type) variables representing demand for transported commodities, p_j are (price-type) variables representing "price", however it is defined, and the a_i, b_j and c are coefficients.

Rationale for the Estimation of Demand Relationships

As E.J. Working pointed out in an early paper,[1] and as has subsequently become a well-known part of econometric theory, attempts at estimating a demand relationship can be doomed by a situation of contemporaneously shifting demand and supply functions.[2] In short, industry supply and demand functions can both be shifting over time and, since our only observations are values which are equilibruim points, these observations may trace out a "function" (or, more properly, a locus) which is neither a supply nor a demand curve. Alternatively, it is possible that neither curve shifts. This creates an even worse situation, since estimation is impossible from a series of observations that differ from one another only by random errors. We will see in later sections that the second barrier to identification is not fulfilled. Furthermore, we will argue below that the demand functions is a

[1]E.J. Working, "What Do Statistical 'Demand Curves' show?" Quarterly Journal of Economics, Volume 41 (1927).

[2]See W.J. Baumol, Economic Theory and Operations Analysis (3rd ed.; Englewood Cliffs: Prentice-Hall, 1972), Chapter 10, for a lucid explanation of this problem.

stable one over the sample period, and that the supply function is variable because of a special characteristic of the Canadian railway industry: thus the former cause of non-identification is avoided.

A second impediment to the estimation of an industry demand function is the existence of queuing in the industry. This may be the result of insufficient capacity or the exercise of monopoly powers. In any case, it gives rise to excess demand in the industry which, in the present instance, would mean that observations on the amount of rail transport service purchased per time period do not represent the amount demanded, but only the amount supplied. However, it is argued that the nature of the railway industry in Canada today preludes a condition of tight capacity.[1] The historically heavy capitalization of Canada's railways, the large degree of duplication of facilities, and their position as a backbone of the economy have contributed to this position --the railways must have the ability to provide service whenever it is required through a wide variance in economic conditions. Moreover, their position as common carriers under government regulation forces them to accept all traffic within certain administered price limits.

[1]Although this is becoming less the case as the railway companies rationalize their physical plants to a greater extent.

Thus we may expect the industry supply curve to be of the shape shown in figure 3.

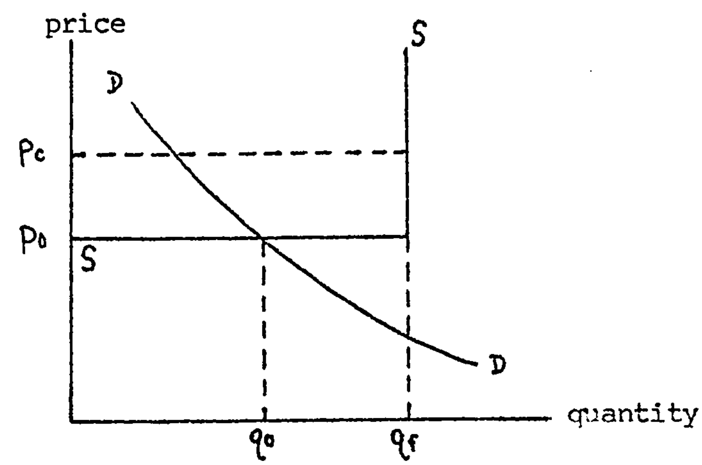

Fig. 3.--Industry supply and demand curves

Here we show a negatively-shoped demand curve for railway transportation, DD, in (price, quantity)-space, and a discontinuous industry supply curve, SS. The curve SS is horizontal (perfectly elastic) at the current price level, p_o, up to an output level which is equal to capacity output, q_f. At that point the curve becomes inelastic. The administered price ceiling is represented by price level p_c. It can be seen that the equilibrium quantity supplied and demanded will be q_o. In figure 4 we see what happens when the price level changes.

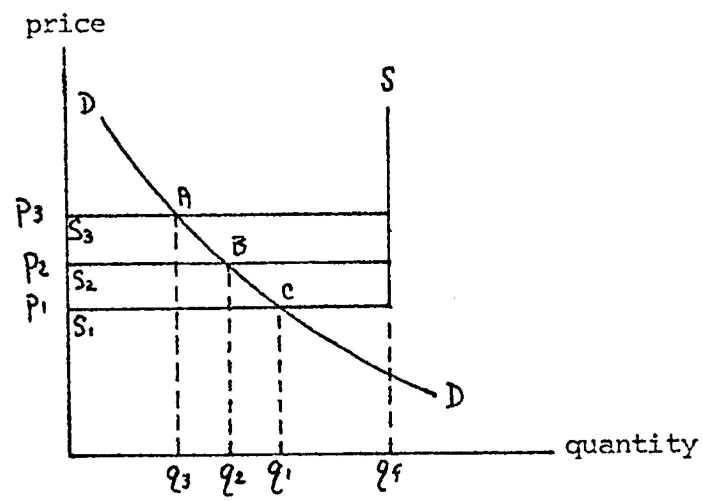

Fig. 4.--Shifts in the supply curve

For prices p^1, p_2, and p_3 the supply curve will shift upwards from S_1S to S_2S and S_3S, resulting in equilibrium levels of output of q_1, q_2, and q_3, respectively. This diagram embodies our assumptions about industry behaviour, mentioned above. Within the range of plant capacity the supply curve is horizontal and shifts in response to changes in prices. We have a basis, therefore, for estimating the curve DD by means of observations corresponding to points A, B, and C in figure 4. Our assumption of plentiful capacity is reflected in the way that curve DD never intersects the (shifting) supply curve at levels of output greater than q_f.

CHAPTER V

DEMAND CHARACTERISTICS OF THE CANADIAN RAILWAY INDUSTRY

Segregation of Demand by Commodity Group

Clearly, the concept of "quantity of rail service demanded" is not very meaningful as an aggregate amount. Railroads carry virtually every commodity which it is possible to carry in the economy, over a wide variety of distances. The range of transported objects covers everything from gravel, stone and ore all the way up the productive scale to automobiles and television sets, and also includes passengers. Shipments range from less-than-carload or express to unit train loads. Moreover, service characteristics and rate structures vary widely between groups of commodities. Some rough commodities require little or no extra service; some dimensional (outsize), piggyback (trailer-on-flat-car), or refrigerated loads require a great deal. Rates are perhaps most heterogeneous. They must cover the possible movement of some 25,000 commodities between pairs of upwards of approximately 10,000 stations in Canada and are based on four structures[1].

Quite probably, a priori reasoning could support any number of different partitionings of the spectrum of rail transport output. Too, with railway car loadings in Canada reaching 3.7 million in

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[1] These are: the Class Rate structure; the Commodity-non-competitive structure; the Competitive structure; and the Agreed Charges structure. For an excellent description of these, see H.L. Purdy, Transport.

1970[1] statistical convenience is the most powerful judge of each grouping. In any case, the following groups have been identified as significant for the purposes of this study:

1. grain and flour;
2. agricultural products (other than grain);
3. animals and animal products;
4. iron ore;
5. coal products;
6. mine products (excluding coal and iron ore);
7. forest products;
8. manufactured and miscellaneous products
9. passengers (Canadian National Railways);
10. passengers (all railways but the C.N.R.);
11. less-than-carload (l.c.l.) freight.[2]

Justification for this partioning lies partly in the requirement for a manageable number of groups and partly in the different characteristics with respect to intermodal competition which may be found in different

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[1] Source: Statistics Canada, Railway Transport, Part V: Freight Carried by Principal Commodity Classes (Catalogue No. 52-211), 1970.

[2] Refer to Appendix I for a more detailed description of these groups.

commodities. Grains, for example, represent commodities which move in large volumes over relatively long distances and under rates which are, for the most part, fixed. Price elasticities of demand should logically be quite low, and the rail companies have a comparative advantage, by virtue of their well-developed branch line networks in the grain-growing areas and their greater carrying capacities, which precludes intermodal competition[1]. Two other characteristics of this group are its dependence on international demand for the commodities, and the relative unimportance of speed of haulage. "Other agricultural products" is separated as a group for similar reasons of intermodal competition, price-sensitivity and markets served. This group includes all unprocessed agricultural products (except grains and flour), such as mill products, fruits, vegetables and seeds. Demand for this group lies largely in domestic markets and is served to a great extent by imports. Truck competition is a strong factor in this group since trucking's greater speed and flexibility of pick-up and delivery are important to commodities which are perishable and tend to move in smaller volumes. The same holds true for animals and animal products, which group includes live animals, meats, fats and oils, wool, and hides. Iron ore is treated separately for two reasons: its large size relative to the total tonnage carried; and the tremendous shift in demand for its haulage over the sample period--iron ore's share of total tonnage

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[1]With the exception of water competition on the Great Lakes, and the advantage of cheaper capacity applies to an even greater extent to water carriers.

has increased from five percent in 1952 to forty-nine percent in 1970. Coal products are separated for a similar reason: their percentage share of the total has decreased from thirty-five (1954) to nine (1969). The remaining mine products group encompasses all ores except iron ore; all gravel, sand, and stone; crude petroleum; and other mineral raw materials for industry. Demand for carriage of these commodities may be expected to rest more heavily on Canadian (and American) industrial production than the foodstuffs. This group, as well as the two preceeding it, tend to be made up of high-volume, low-value materials. The mode which has impacted the railways most heavily with respect to movement of this group of commodities is the petroleum pipeline. Forest products are more subject to truck competition than mine products. They are grouped for this reason, for the different characteristics and origins of the shipments, and for the reasonable expectation of a counter-cyclical demand for the commodities, for residential construction. The group consists of pulpwood, lumber, plywood, logs, and other commodities. Manufactures and miscellaneous represents all end products, from paper and steel to automobiles and processed foods. Here is where intermodal competition is strongest, movements travel the shortest distances, and total service considerations are most important. This is even more important for the less-than-carload group. This group has been dropped from consideration by this study, however, due to a scarcity of data about its handling. Passengers, of course, are completely dissimilar to freight with respect to almost every criterion metnioned above. The Canadian National is separated because of a distinctive corporate policy, and the fact that it carries well over half of the industry's passengers.

The Data

The principal sources of data for the study have been publications of Statistics Canada (DBS). These are of such great number that they will be mentioned only under the relevant sections of this essay. In addition, much valuable information has been obtained from the Canadian Transport Commission's yearly publication, Waybill Analysis: Carload All-Rail Traffic.[1]

In principle, all dependent variables of the demand functions to be estimated should be measured in terms of carloads, where each carload is weighted by the distance travelled and the payload (net) weight of the shipment. This statement applies, of course, only to freight; for passengers the relevant value would be the number of passengers, weighted by the distance travelled. Hence, the appropriate units of measurement for each dependent variable are, respectively, net-ton-miles and passenger-miles. Unfortunately, the required data are not readily available in the former units for the eight commodity groups, but only for all commodities as an aggregate figure. Recourse was necessary, therefore, to the Waybill Analysis in order to obtain yearly figures for freight net-ton-miles. This

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[1]Canadian Transport Commission, Railway Transport Committee, Waybill Analysis: Carload All-Rail Traffic, 1952-70 reports (Ottawa: Information Canada).

report consists of an approximate one-percent sample of all carload all-rail freight movements between Canadian stations, for a year at a time. Data is presented for each of 267 commodities (see Appendix I) and is broken down by weight (tons), revenue, and net-ton-miles. The procedure followed, then, was to compute the average length of haul, in miles, from the ratio of net-ton-miles to net tons, and to apply the results to the yearly total of tons for each commodity group, taken from Statistics Canada data[1]. That is, for each commodity group:

$$ntm = tons * \frac{sntm}{stons}$$

where:

ntm = estimated total net-ton-miles;

tons = total net tons ;

sntm = sample net-ton-miles ;

stons = sample net tons.

The values for ntm were treated as observations on the dependent variable for each equation. The validity of this approach rests on two main assumptions: that the Canadian Transport Commission (CTC) sample is representative of the population; and that each commodity group used in this study contains items which are homogeneous--in other words, that aggregation into groups does not destroy any properties of commodities within a group. Although it is probable that these assumptions are not completely justified, it is difficult to tell how far off the mark they are. In any case, this alternative was the best available.

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[1]Statistics Canada, <u>Railway Transport: Part I</u>

Turning to the independent variables, we consider the two types mentioned earlier, income variables and price variables. For the former, indices of real domestic product for Canada were used most often.[1] For the latter, data is very poor and different approximations were required. Appendix II describes the approach used to estimate a price index series for rail freight rates. Ideally, the relevant price variable for a demand function should be the relative price of one transportation mode (that is, rail) to its competitors. The serious dearth of any historical statistics on the different modes, however, made this impossible for this study. The price variable used for estimation, except where noted below, was simply the price series for railway rates. Of course, most of the discussion about the less restrictive definition of "price", given in the last chapter, is not yet capable of statistical analysis for this very reason of data scarcity.

Trucking Rates

An excellent example of the shortage of price data is the trucking sector of the transportation industry. Ideally, trucking rates should be reflected in the price variable of the agricultural goods,

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[1]The sources for these are: Statistics Canada, Index of Industrial Production, System of National Accounts, Domestic Product by Industry, January 1971 (Catalogue No. 61-005); DBS, Real Domestic Product by Industry 1961 Base (Catalogue No. 61-506); and DBS, Indexes of Real Domestic Product by Industry: 1961-69, 1961 = 100 (Catalogue No. 61-510). Subsequent references to this material will be to Statistics Canada, Real Domestic Product by Industry.

forest products, and manufactured/miscellaneous equations in particular. They would enter in the way of relative prices or indices thus:

$\frac{\text{rail prices}}{\text{trucking prices}}$.

The ideal quite often does not exist in real life, however, and trucking companies display little of the ideal in the way that their statistics are retained, organized, and made available. Historically, Canada's trucking rirms have been small (relative to the total industry), decentralized and have had operations characterized by heavy competition. Clearly, research and the accumulation of a central statistical base have suffered. In the course of research for this thesis, a number of authorities were examined for the availability of suitable data for the estimation of price-demand relationships. Among these were: Statistics Canada (Ottawa), The Canadian Trucking Association (Ottawa), The Canadian Transport Tariff Bureau (Toronto), The Quebec Tariff Bureau (Montreal), The Motor Transport Industrial Relations Bureau of Ontario (Toronto), and Smith Transport Company (Montreal and Toronto). The best that could be obtained were a single comprehensive one-year study (by Statistics Canada for 1970), and many helpful (sometimes-contradictory) qualitative descriptions of price behaviour in the industry over the sample period (1952-1970). Perhaps the only strong conclusions that could be reached were two: thattruck rates have tended to follow closely behind the railways' rate movements--that is, that service criteria are more important than prices in intermodal competition; and that statistical data is not available--not in exact form nor through any good proxy (such as factor costs)--short of by compiling some hundreds of thousands of historical tariff records into indices.

CHAPTER VI

EMPIRICAL RESULTS--FREIGHT

Grain Products

Grains have been treated separately, as we mentioned earlier, because of (among other things) the heavy influence of exports on the demand for the transportation of grain products. This group accounted for approximately nine percent, by weight, of all freight carried by Canadian railways in 1969. Historically, Canada has been a leading producer and exporter of wheat and other grains, just as the railroads have traditionally taken a large part in the movement of grain to the seaports. Grain and flour account for over fifty percent, by value, of the "food, feed, beverages, and tobacco" category of Canada's exports in 1970.[1]

The nature of traffic for the grains commodity group for the sample period 1954-70 is illustrated in figure 5. Net tons and net-ton-miles are both represented as indices, based on the year 1954. Net tons are actual values; net-ton-miles were estimated by the approach described in Chapter V Clearly, the relationship between the two quantities is very stable, as we would expect for this type of shipment. Geographical

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[1]Statistics Canada, Trade of Canada, Volume I: Summary and Analytical Tables (Catalogue No. 65-201), 1970.

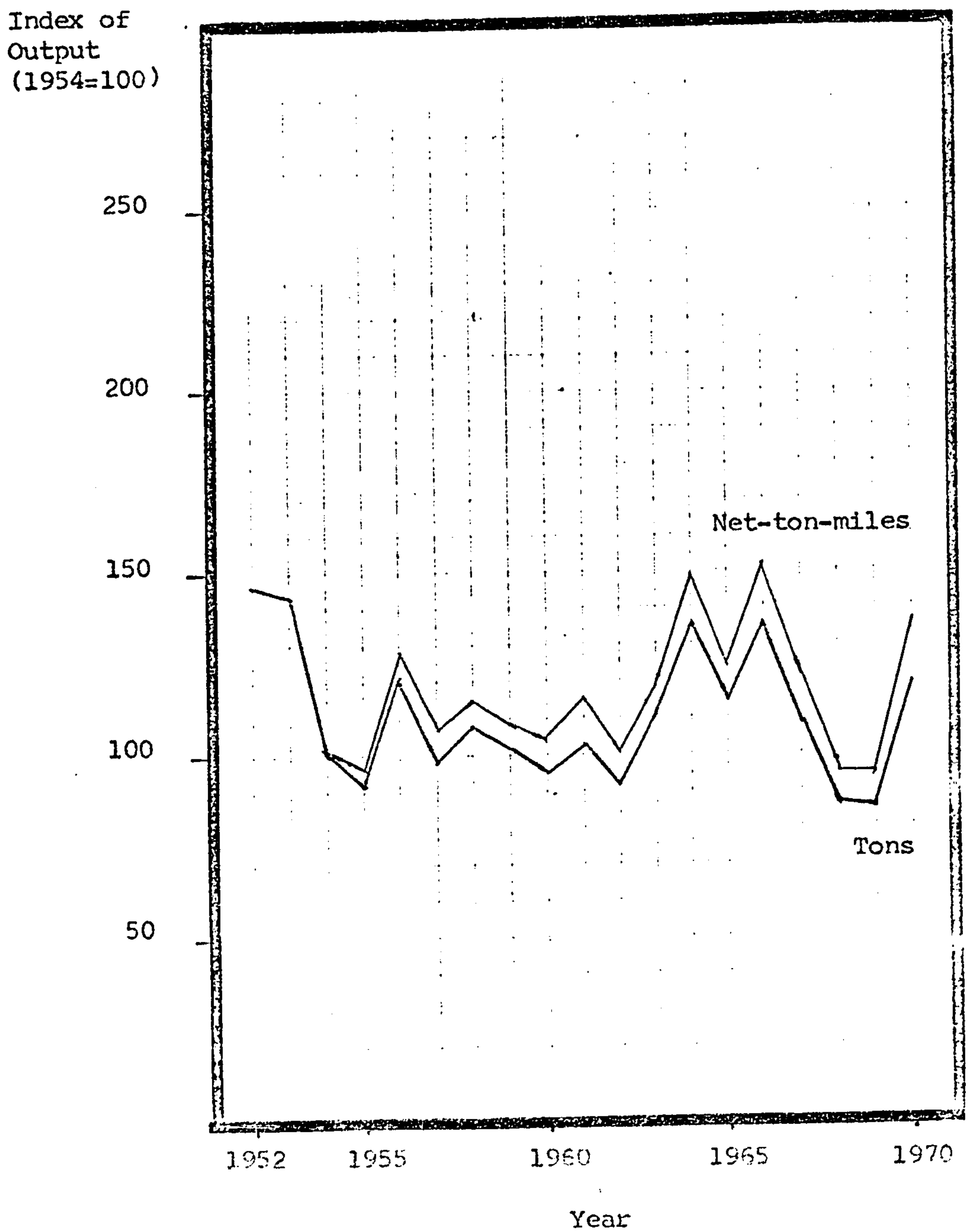

Figure 5.--Graph of tons (1952-70) and net-ton-miles (1954-70) versus time for grain products.

production areas and the location of major population centres and seaports do not change quickly, if at all. Thus it is quite reasonable that the average length of haul should remain fairly constant over the seventeen-year period, a fact which is apparent from the graph.

Estimation of the demand for grain transport equation was done using net-ton-miles as a dependent variable, and price, a domestic consumption variable, and exports as independents. The first two were obtained by the methods described in chapter V and Appendix II, respectively. The third was a real domestic product index (from Statistics Canada, Real Domestic Product by Industry). Observations on the export variable were obtained by combining amounts for different commodities to reach a total, measured in tons.[1] This proved especially interesting for two reasons: the published data on shipments by rail (Waybill Analysis and Statistics Canada, Railway Transport, Part I) and exports do not coincide over the sample period for all commodities which would logically fall under the heading of "grain and grain products"; and export figures have a very low degree of consistency in their units of measurement over the sample period. The former problem was solved by considering only a major subset of the logical grouping, i.e. the one described in Appendix I. The latter problem was solved by converting bushels, pounds, barrels, and hundredweights to tons, then summing all commodities for each year. The equation

[1]Source: Statistics Canada, Trade of Canada, Volume II: Exports (Catalogue No. 65-202), 1954-70.

was estimated, as were all equations in this paper, using the method of ordinary least-squares (OLS). The data are annual and cover the period 1954-70.

The equation estimated is as follows (t-values are included in parentheses):

$$\begin{aligned} NTM = \underset{(2.76)}{23049.2} + \underset{(10.09)}{0.8678}\ EXPOR - \underset{(1.43)}{16592.1}\ PRICE \\ -\underset{(-2.93)}{63.756}\ XBAKE \end{aligned} \tag{1}$$

$R^2 = 0.90$ $\qquad F(3,13) = 46.58$ $\qquad D\text{-}W = 2.43$

where:

NTM = total yearly net-ton-miles, in millions;

EXPOR = total yearly exports of commodities which match those of NTM, in thousands of tons;

PRICE = revenue per net-ton-mile, in cents;

XBAKE = index of real domestic product of bakeries in Canada.

The elasticities computed at 1970 levels are 0.46 and 0.68 for price and exports, respectively.

A number of things can be noticed in the above results, among them a fairly high R^2, a significant F-value, and the absence of any autocorrelation of residuals, as indicated by the Durbin-Watson test. All coefficients test to be significantly different from zero by their t-values, the price coefficient at the eighty percent confidence level and all others at the ninety-nine percent level. The unusual sign on the proxy variable for domestic consumption (XBAKE) is probably due to mis-specification in some degree; a possibility is that the mix of domestic and export traffic shifted in a way that was not identifiable from the available data. Removing XBAKE from the regression resulted in an R^2 of 0.84, an export coefficient of 0.8194, and a reduced significance for the price variable. Clearly, exports are very important in determining the level of demand for grain haulage. The price elasticity is perhaps a bit higher than would be expected, however. Quite possibly this is due to the insufficiency of revenue per ton-mile as a proxy for prices.

The equation was also estimated using yearly tons hauled as the dependent variable--that is, distance was ignored. As we would expect from the close relationship between tons and net-ton-miles for grain, this did not change the results much. The main difference was a shift in emphasis from price to exports: the price elasticity of demand became 0.065 and the export elasticity is intuitively more appealing. Railways have virtual monopolies in the land transport of grain, by virtue of their highly-developed branch line networks and their large fleets of rolling stock. Furthermore, the high degree of rate regulation for grain would also tend to reduce the influence of prices on demand.

Further estimation was tried using the level of grain production in Canada as a regressor. This variable was rejected, however, on both a priori and statistical grounds. Grain transport, for storage or whatever reason, is not strongly related to supply factors. The index of production of grain miles was also tried, but was found to the highly collinear with XBAKE.

Agricultural Products, Except Grain

The agricultural products group, less grain (or simply "agricultural products"), is of relatively little importance to the railways, having represented only about three percent, by weight, of all freight traffic moved in 1969. Furthermore, the historical outline of the group in figure 6 shows a fairly constant, or even declining, contribution of these commodities to the total. As in the case of grain, tons and net-ton-miles are very closely related, showing a rather constant average length of haul. The principal reason for the declining share of the railways in carriage of this group of commodities is, most probably, the increased competition of trucking firms. The greater speed of trucks and their greater flexibility have given them a relative advantage in this area, where shipments are typically small and perishable.

In estimating this equation it was necessary, therefore, to employ some good proxy variable to represent the impact of the highway carriers. Ideally, this would take the form of some measure of relative speed and convenience. The insufficiency of data on trucking has already been alluded to, however; thus it was necessary to resort to data which was a less direct representation of the competitive factors. In addition to the usual regressors of price and a domestic product index then, a variable was introduced to represent the increasing capacity of the truck carriers in Canada-- this being the result of their competitive advantage in certain areas. The series chosen was

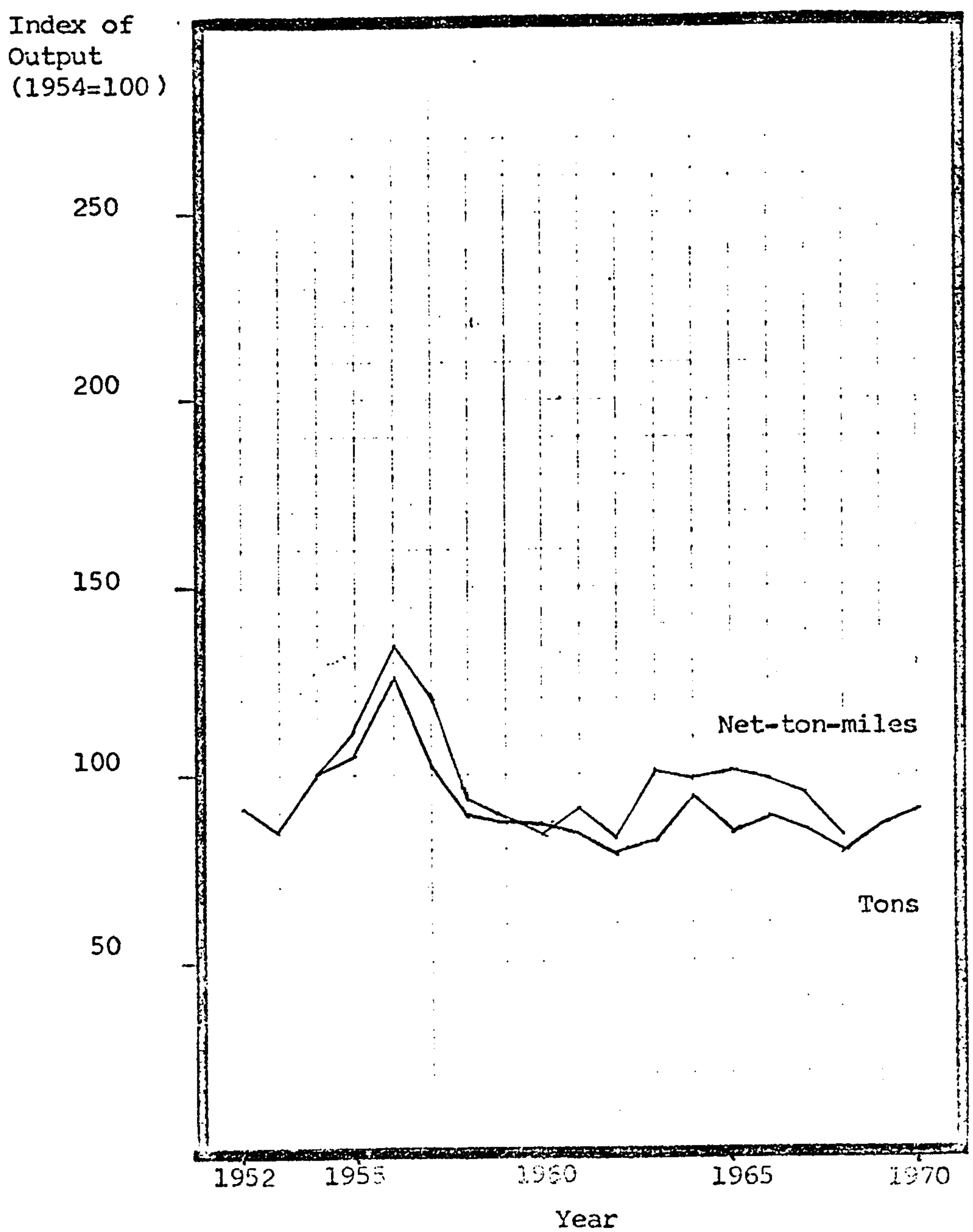

Figure 6.--Graph of tons (1952-70) and net-ton-miles (1954-68) versus time for agricultural products, less grains.

the number of semi-trailers in use by common carriers per year,[1] deflated by the index of real domestic product for the transport industry as a whole (Statistics Canada, Real Domestic Product by Industry). In effect, this series gives the relative importance of highway carriers to the total transport industry and their relative popularity as a mode. Common carriers were selected instead of contract carriers (who operate under continuing contracts) because of their greater numbers (the former are about three to four times as large as the latter in terms of plant and equipment). In any case, there is a good deal of collinearity between series for each category, and their total. The number of semi-trailers was selected, rather than, say, the number of tractors, because the former measure abstracts most strongly from technological change.

The agricultural products equation was estimated by OLS for the period 1954-68. The results are as follows (again, t-values are in brackets):

$$\underset{}{NTM} = \underset{(5.23)}{11208.7} + \underset{(0.54)}{4.8309}\ XPROD - \underset{(-1.93)}{2951.5}\ PRICE - \underset{(-2.73)}{25.024}\ TRUCK \qquad (2)$$

[1]From D.B.S., Motor Carriers--Freight (Catalogue No. 53-205) 1954-60, and D.B.S., Motor Carriers--Freight (Common and Contract), Part II (Catalogue No. 53-223) 1961-68.

$R^2 = 0.61$ $F(3,11) = 8.20$ $D\text{-}W = 1.98$

where:

NTM = net-ton-miles, in millions;

XPROD = index of real domestic product for agriculture;

PRICE = revenue per net-ton-mile

TRUCK = semi-trailers of common carriers, deflated by real domestic product for transport.

The elasticities computed at 1968 levels are:

e(XPROD) = 1.44; e(PRICE) = 1.11; e(TRUCK) = 0.90.

The R^2-value and F-value are rather unsatisfactory here, as is the significance of the coefficient of XPROD. Also, the coefficient of PRICE is significantly different from zero only at the ninety percent confidence level. All coefficients, however, have the "right" sign--the truck competition variable in particular is quite significant, as is the constant term. Referring to figure 6, it seems quite plausible that the constant term is the most significant. In fact, re-estimation of the equation after removal of XPROD actually increased R^2 to 0.63 (R^2 is adjusted for degrees of freedom). Substitution of an index of real domestic product for the food-producing industries (Statistics Canada) did very little to change the results--this is due in large measure to the correlation (0.64) between the two variables. Finally, net tons was tied as the dependent variable. No combination of the variables could improve on the above results, however.

Animals and Animal Products

The animal and animal products group (or "animals") exhibits a great many characteristics of the agricultural products group. It is even less significant to the railways, comprising but one-half a percent of the total yearly tonnage output. Like the previous group, the net tonnage hauled has been decreasing over the sample period (refer to figure 7). On the other hand, the average length of haul has risen considerably and has resulted in an increasing level of net-ton-miles. Such service characteristics as refrigeration, gentle handling, speed, and in-transit care are important to this group. Hence, it is reasonable to assume that the highway carriers also compete strongly in this area. For this reason the same trucking capacity variable was included in this equation as the one for agricultural products. In addition, a real domestic product index for the meat packing industry was included[1], this sector being responsible for the bulk of the demand for shipments in this group. A price variable was also included. Estimation was done for the period 1954-68.

The estimated equation is as follows:

$$\underset{}{NTM} = \underset{(7.10)}{3779.3} + \underset{(1.13)}{1.5077}\ XMEAT - \underset{(-4.60)}{721.35}\ PRICE \qquad (3)$$

$R^2 = 0.64$ $\qquad$ $F(2,12) = 13.11$ $\qquad$ D-W = 2.25

[1] Statistics Canada, Real Domestic Product by Industry.

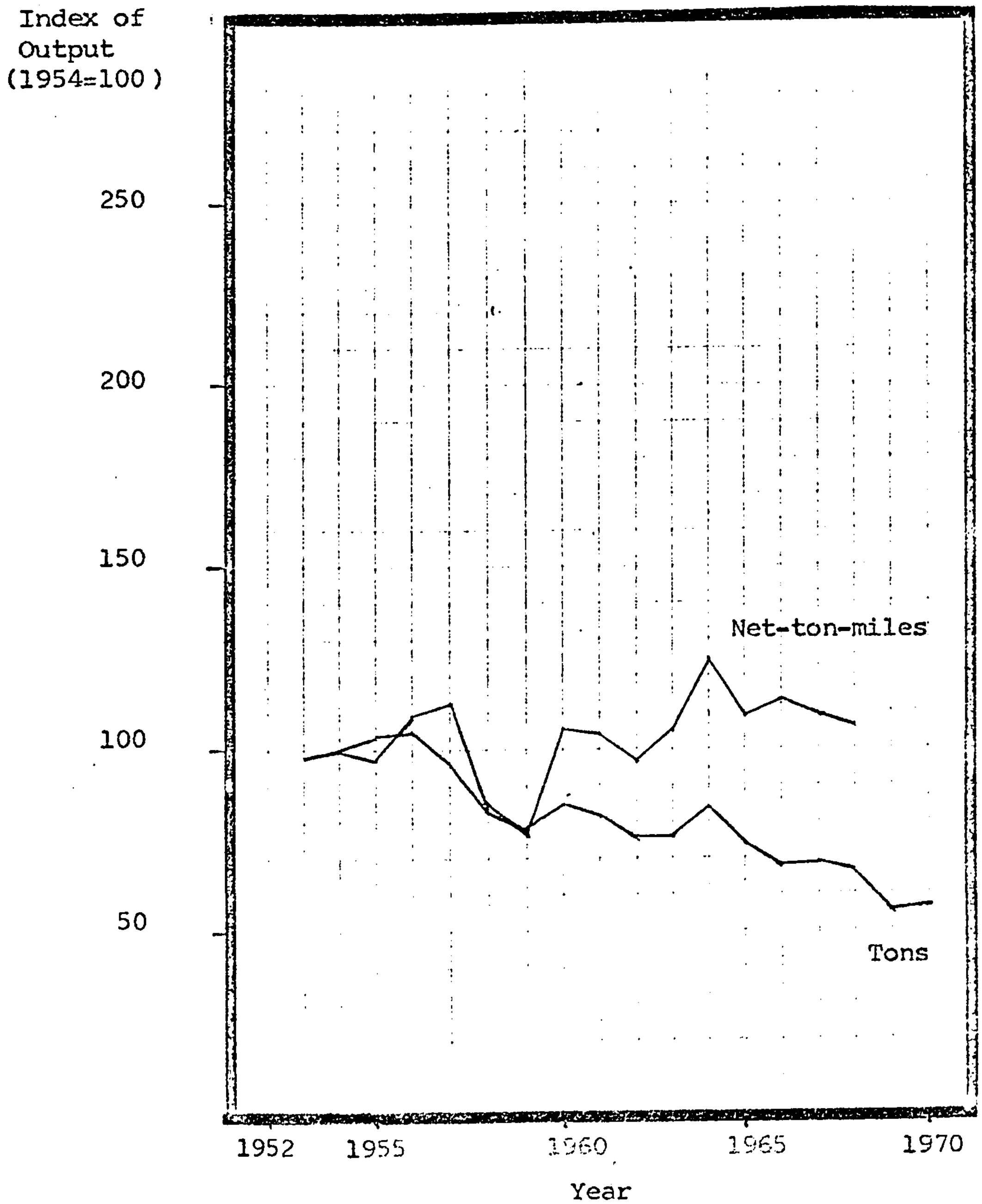

Figure 7.--Graph of tons (1953-70) and net-ton-miles (1954-68) versus time for animals and animal products.

where:

NTM = net-ton-miles, in millions;

XMEAT = index of real domestic product in the meat-packing industry;

PRICE = revenue per net-ton-mile, in cents.

The price elasticity is 1.16, computed at the 1968 level.

As in the previous equation, we have a rather loose fit, as indicated by the R^2-value. The F-statistic, while not spectacular, is significant. Once again the most significant coefficient is the constant term. The Durbin-Watson statistic indicates the absence of any positive or negative autocorrelation. The price coefficient is quite significant, as we might expect from the opportunities for competition in the carriage of animals and products; the "income-type" demand variable is not statistically significant, however. Re-estimation of the equation using the trucking capacity variable improved the fit not at all--in addition, its t-value was not significant. Using net tons as the dependent improved the R^2-value to 0.77. However, tons and XMEAT were very highly negatively correlated (-0.86). If any meaning can be attached to that, perhaps it is that the railways during the sample period were standby transportation; whenever demand went up, trucks absorbed the majority of the market.

Iron Ore

As opposed to the more perishable foodstuffs, the mine products groups of commodities have been steadily increasing areas of operation for the railroads. Iron ore transport is the most striking of the three groups considered in this study. Opening up of new mines in the Canadian Shield during the last twenty years and a growing level of industrial production in both Canada and the United States have given rise to the near-explosive expansion indicated in figure 8. Iron ore carriage accounted for over eighteen percent, by weight, of the railways freight business in 1969. Being a heavy, large-volume commodity, iron ore is particularly appropriate for railway carriage on land. This characteristic, the development of unit ore trains, and the construction of many small resource railways in inaccessible localities have meant the absence of any real competition from highway carriers.

The estimation of the demand equation for iron ore was carried out with just two independent variables: prices; and the index of real domestic product for iron and steel mills (Statistics Canada, Real Domestic Product by Industry). Although iron ore exports are considerable, they are sold predominantly to the United States, whose economy largely matches strides with Canada's (or perhaps the reverse?): thus collinearity between Canada's product index and any export series is virtually assured. The estimation was done with data for the period 1954-70.

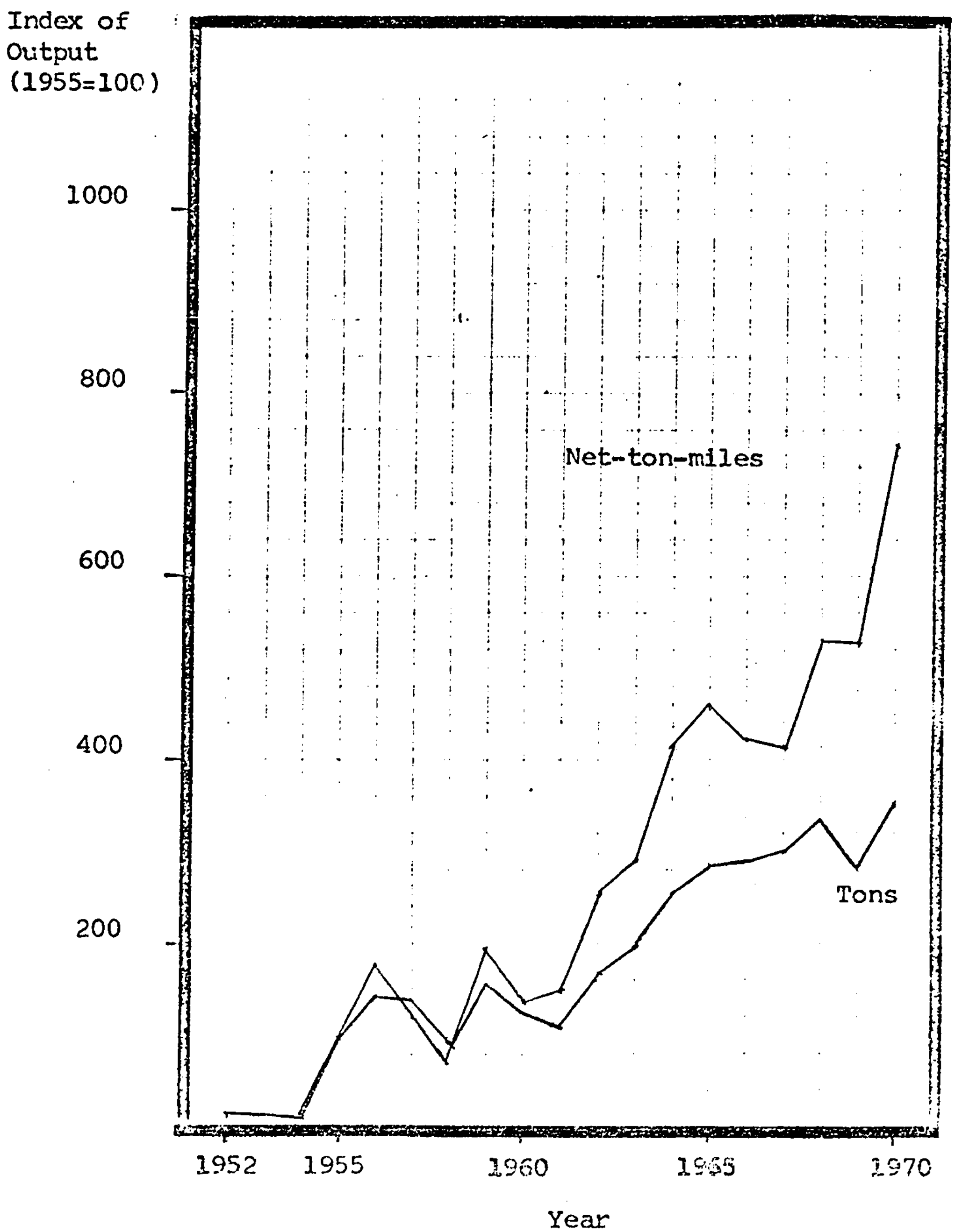

Figure 8.--Graph of tons (1952-70) and net-ton-miles (1954-70) versus time for iron ore.

The estimated equation is as follows:

$$NTM = \underset{(-1.51)}{-3379.5} + \underset{(17.36)}{73.322\ XISTL} - \underset{(-0.56)}{1125.7\ PRICE} \quad (4)$$

$$R^2 = 0.95 \qquad F(2,14) = 152.58 \qquad D\text{-}W = 1.25$$

where:

NTM = net-ton-miles, in millions;

XISTL = index of real domestic production for iron and steel mills;

PRICE = revenue per net-ton-mile

The elasticities calculated at 1970 levels are:

e(XISTL) = 1.3; e(PRICE) = 0.12.

The worthwhile fit is largely due to the influence of production in the iron and steel industry. Rail transport prices are only significant at the sixty percent level of confidence, and the constant term's coefficient is significantly different from zero only at the eighty percent level. The negativity of the constant term is a reflection of the rapid growth of iron ore transportation. The Durbin-Watson statistic is in the "inconclusive region", $d_L < d < d_u$; hence, the existence of autocorrelation is neither confirmed nor rejected. Finally, the signs of the coefficients of the two explanatory variables are as expected. Too, on the basis of the above discussion the low price elasticity of demand is intuitively quite acceptable.

Even though figure 8 shows the average length of haul to be increasing--that is, that net-ton-miles are increasing more rapidly than net tons--rerunning the regression with tons as the dependent variable did not materially affect the fit. The only changes of note were in the Durbin-Watson statistic (which became 2.07) and the price elasticity (which became 0.41). The former is no longer in the "inconclusive region", but indicates the absence of both positive and negative autocorrelation.

Coal Products

Whereas iron ore transport was increasing over the sample period, the haulage of coal and associated products was behaving irregularly. Figure 9 shows coal traffic to be on a more or less continuous decline, measured in tons. When net-ton-miles are considered, however, an increasing length of haul is seen to be generating an irregularly increasing series. Quite probably this was due to a shift in the composition of demand, from heating uses and transportation to industrial uses and exports. Coal products accounted for approximately five percent of all freight handled by Canadian railways in 1969.

Estimation of the coal transport demand equation was done for both net tons and net-ton-miles, using a price variable and the index of real domestic product in the coal industry. The results for

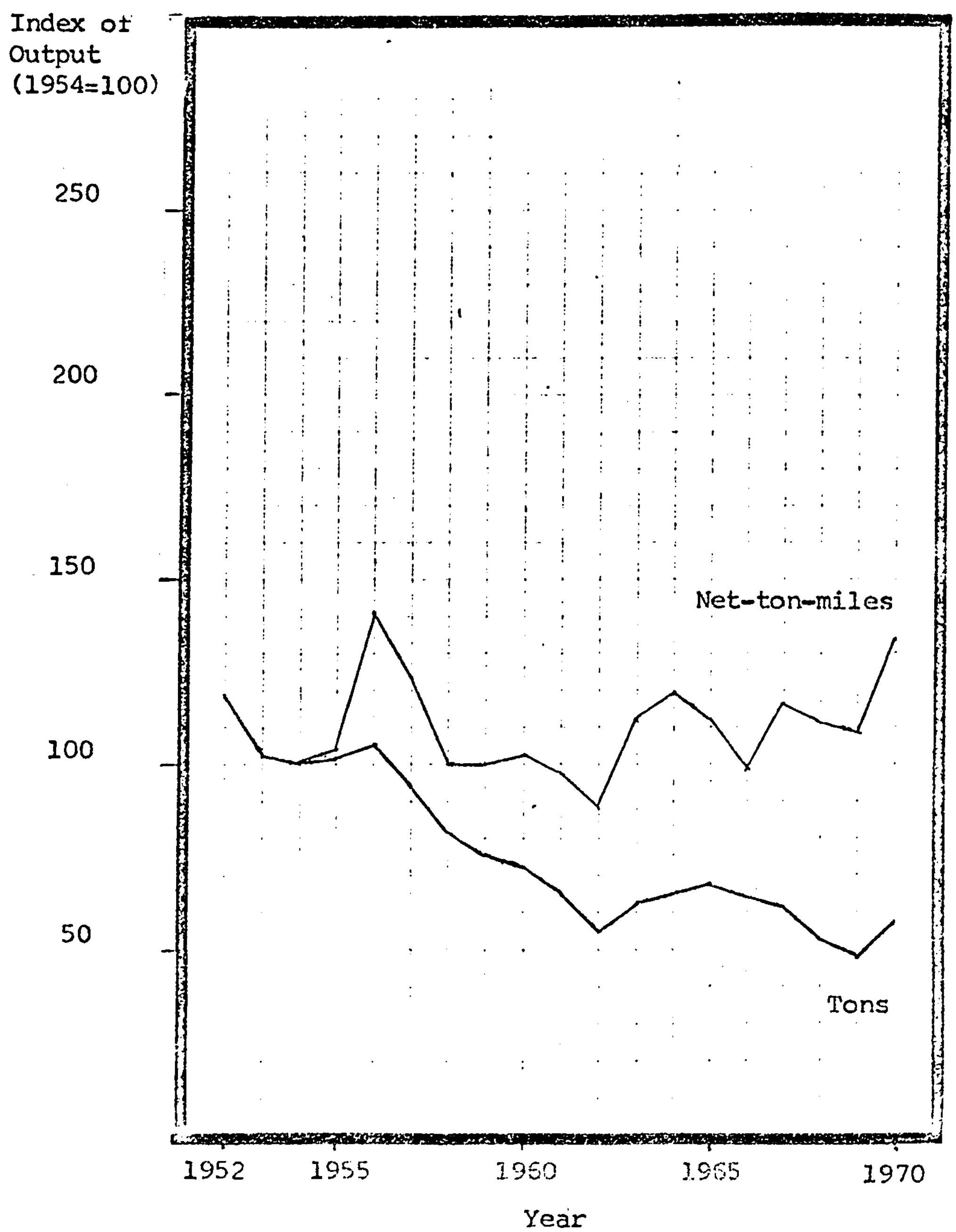

Figure 9.--Graph of tons (1952-70) and net-ton-miles (1954-70) versus time for coal products.

1954-70 were:

$$NTM = \underset{(5.57)}{6569.2} + \underset{(3.31)}{22.246}\ XCOAL - \underset{(-2.98)}{3905.0}\ PRICE \qquad (5)$$

$R^2 = 0.45$ $\qquad$ $F(2,14) = 7.53$ $\qquad$ D-W = 1.38

$$TONS = \underset{(-7.50)}{-14.930} + \underset{(9.66)}{0.10958}\ XCOAL + \underset{(8.51)}{18.843}\ PRICE \qquad (6)$$

$R^2 = 0.94$ $\qquad$ $F(2,14) = 121.25$ $\qquad$ D-W = 1.44

where:

NTM	= net-ton-miles, in millions;
TONS	= net tons, in millions;
XCOAL	= index of real domestic product in the coal industry;
PRICE	= revenue per net-ton-mile, in cents.

The elasticities calculated at 1970 levels are:

	PRICE	XCOAL
equation (5):	0.37	0.45
equation (6):	1.09	1.35

The second equation is offered because of the relatively poor fit of (5). As Theil points out, however[1], it is not valid to compare the fit of two equations by the R^2 coefficients when the dependent variables are not the same. Note that the price coefficient of (6) would be expected to be negative. Autocorrelation is not indicated in either equation and all coefficients are significant. We note that, as in the case of iron ore

[1] H. Theil, Principles of Econometrics (Wiley and Sons, 1972), p. 544.

transport, the elasticities are higher for a dependent variable which is measured in tons, rather than ton-miles. This is hardly surprising, due to the nature of the relationship between the two variables. The coal equation was also estimated with the index of real domestic product in the durable goods-producing industries as a regressor (Statistics Canada, Real Domestic Product by Industry); no significant change in results was achieved.

Products of Mines, Except Iron Ore and Coal

Mine products, excluding iron ore and coal, made up the third-largest of our commodity groups, by weight, for 1969. Much of what was said about iron ore--the density of shipments, the railways inherent advantages, and the importance of American exports--also holds true for this group. Figure 10 shows the changing nature of the traffic for the years 1954-68. Although the total weight of commodities in this group has increased only slightly, the average length of haul and total net-ton-miles have grown very noticeably. One possible explanation for this can be found in the opening of many new mines in the North, further away from industry and shipping.

Estimation was done using different domestic product variables and a price variable. The results for the period 1954-68 were:

$$\underset{}{NTM} = \underset{(2.11)}{3630.8} + \underset{(1.50)}{16.060}\ XDUR + \underset{(1.89)}{28.757}\ XCONS \underset{(-2.96)}{-2254.8}\ PRICE \qquad (7)$$

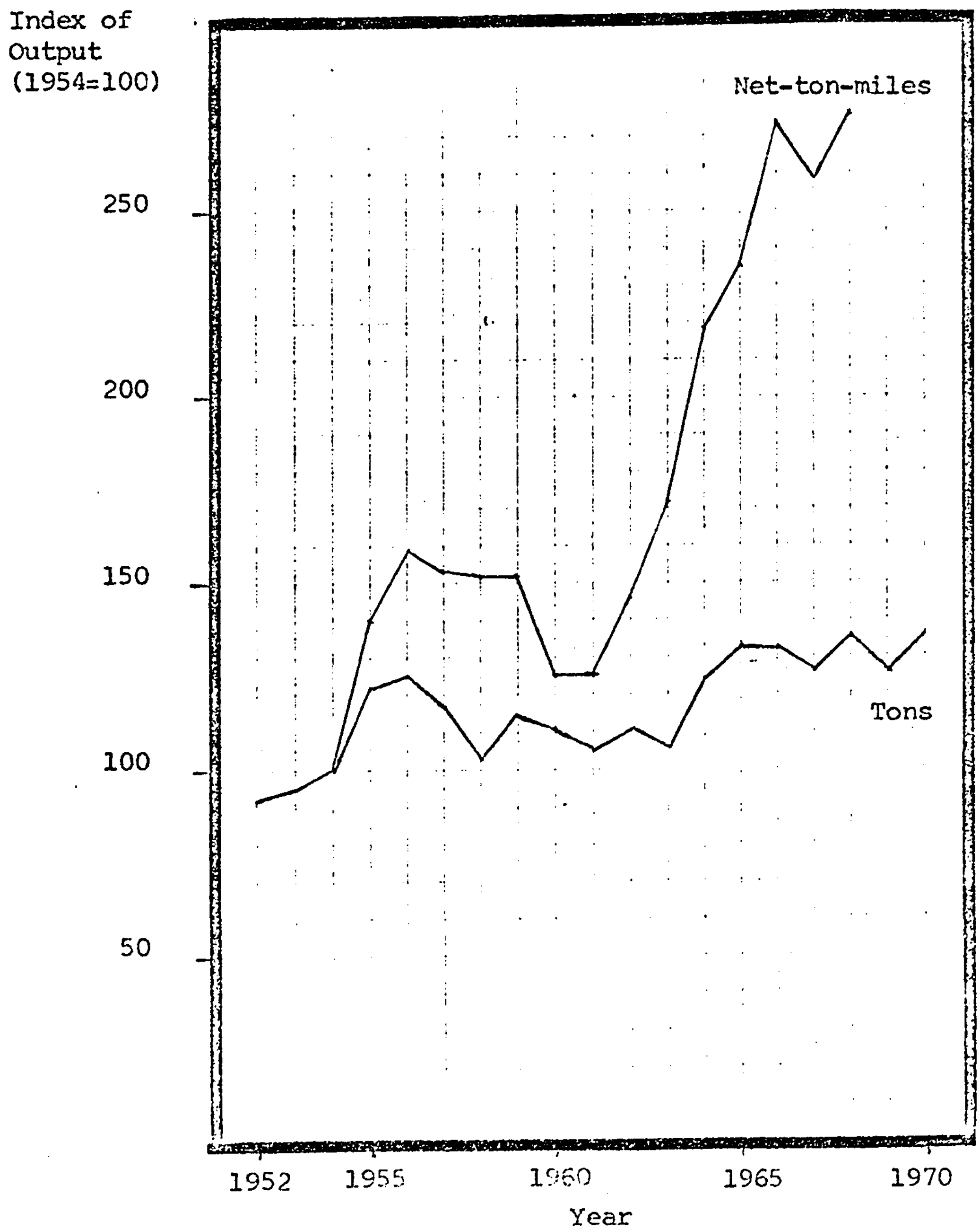

Figure 10.--Graph of tons (1952-70) and net-ton-miles (1954-68) versus time for mine products, less iron ore and coal.

$R^2 = 0.96$ $F(3,11) = 111.35$ $D\text{-}W = 1.36$

where:

NTM = net-ton-miles, in millions;

XDUR = index of real domestic product for durable goods industries;

XCONS = index of real domestic product for construction;

PRICE = revenue per net-ton-mile, in cents.

The elasticities computed at the 1968 level are:

e(XDUR) = 0.39; e(XCONS) = 0.56; e(PRICE) = 0.44

A number of things are apparent in this equation, among them: the fairly tight fit; the lack of any conclusive indication of the presence or absence of positive autocorrelation; and the marginal significance of the coefficients of the product indices. This latter result is more than likely a reflection of collinearity. The two product index variables, plus an index of product in the mining industry, were tried in various combinations and singly--all estimations gave similar results. The correlation coefficients between pairs of the variables are:

XDUR/XMINE = 0.94
XMINE/XCONS = 0.96
XDUR/XCONS = 0.97

where XMINE is the product index for mining. The indication is, then, that the two principal sectors which use mine products-- durable goods manufacturers and the construction industry--and the mining industry itself all tend to move in phase quite strongly with respect to the level of activity; and that variations in this level explain a great deal of the variance in the rail carriage of mine products. Finally, we may remark on the closeness of the price elasticity to the other two, and the fact that all are fairly low.

Forest Products

In considering forest products, we again met an area where competition from highway carriers is relatively stronger, since shipments are of a much lower density than those of mine products. The traffic levels of this group have been quite irregular over the sample period, as figure 11 shows. Total traffic is up slightly for both tons and ton-miles at the end of the period. The forest products group is a fairly large portion of the total of freight traffic (by tons), accounting for eleven percent of that total in 1969.

Estimation of this equation was a fairly troublesome affair, as the results below show. None of the usual demand variables--indices of real domestic product in the user industries--seemed to explain the level of demand, although the endogenous variable seemed to respond better when measured in tons than in ton-miles. The results for the period 1954-68 are:

$$NTM = \underset{(3.41)}{15140.3} + \underset{(0.22)}{1.6185}\, XDUR - \underset{(-2.22)}{5309.8}\, PRICE \qquad (8)$$

$R^2 = 0.38$ $\qquad F(2,12) = 5.31$ $\qquad D\text{-}W = 1.04$

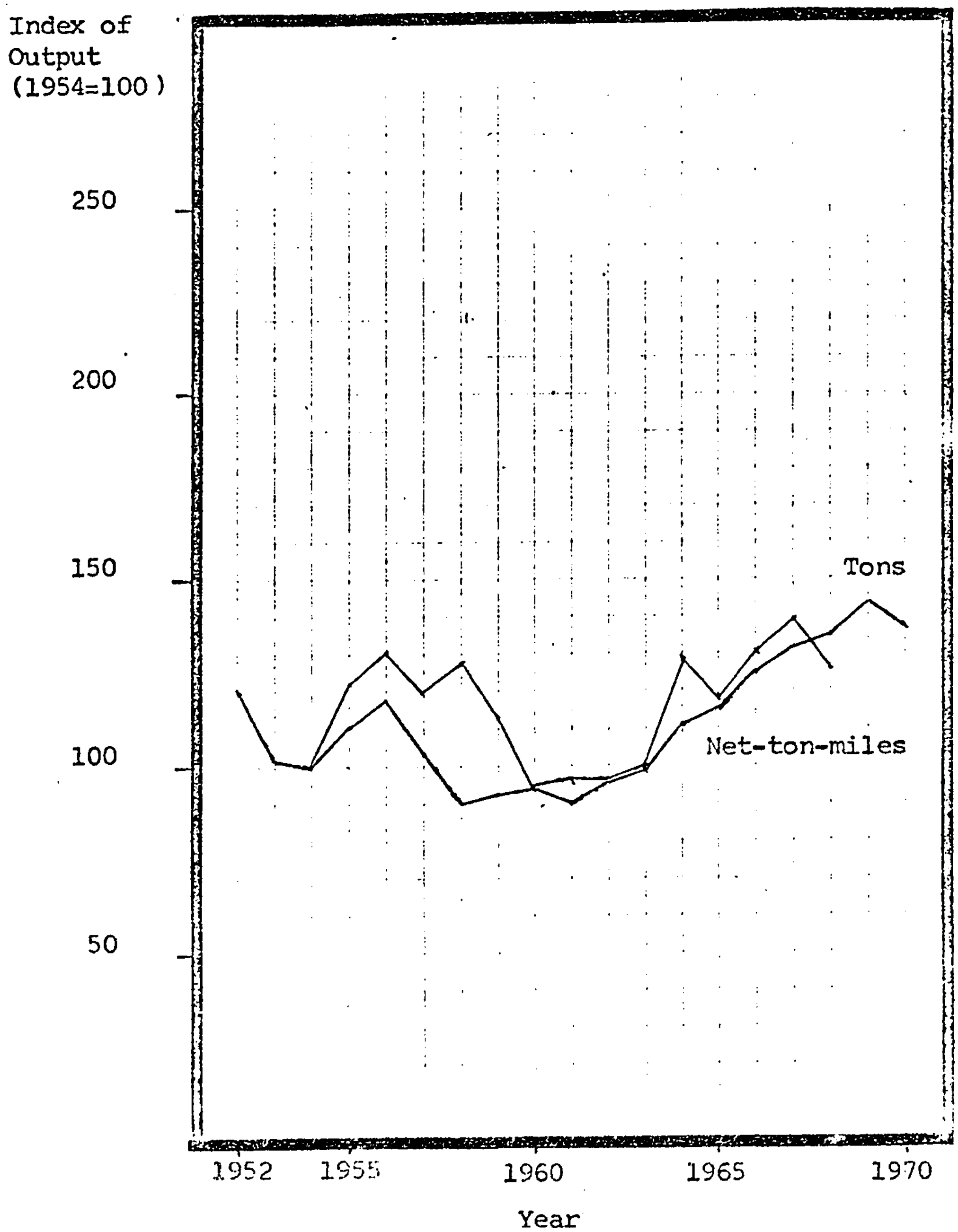

Figure 11.--Graph of tons (1952-70) and net-ton-miles (1954-68) versus time for forest products.

$$\text{TONS} = \underset{(4.40)}{31.759} + \underset{(2.50)}{0.03027}\ \text{XDUR} - \underset{(-2.96)}{11.524}\ \text{PRICE} \tag{9}$$

$R^2 = 0.76$ $F(2,12) = 23.62$ D-W = 0.94

where:

NTM = net-ton-miles, in millions;

TONS = net tons, in millions;

XDUR = index of real domestic product in the durable goods industries;

PRICE = revenue per net-ton-mile, in cents.

The elasticities calculated at 1968 levels are:

	XDUR	PRICE
equation (8):	0.04	1.04
equation (9):	0.26	0.79

Equation (8) shows a poor statistical fit, as well as a very insignificant coefficient for XDUR. Equation (9) gave a moderately better fit, with all coefficients significant: XDUR at the ninety-five percent level of confidence, PRICE at the ninety-eight percent level, and the constant term at the ninety-nine percent level. Both equations exhibit signs of positive autocorrelation. Application of other product indices, for the paper and forest industries, provided no cure for the problem; as with the other cases above, they were found to be highly correlated with each other and with XDUR. Nor did adding exports improve matters. The price elasticities of the equations are both moderately large; the "income" elasticities, however, are small. This latter result seems to lend some support to the theory of an anti-cyclical nature of demand for forest products, mentioned in Chapter 5.

Manufactured and Miscellaneous Products

"Manufactured and miscellaneous" commodities make up by far the largest and most diverse of the different groups considered in this study. This group alone accounted for over thirty-five percent of all freight (in tons) carried by Canadian railways in 1969. Moreover, it has undergone rapid growth since 1961, as figure 12 indicates; length of journey, tons, and net-ton-miles have all risen. Competition from highway carriers is very strong in this area. In fact it is likely this competition for shorter hauls that has driven up the railways' average length of trip.

Because of the diversity of the commodities and the importance of this group to the economy, less specific variables were chosen for estimation of the demand equation. Prices, an economy-wide product index, and the same trucking variable used for agricultural products[1] were all used, with satisfactory results. The estimated equation is:

$$\underset{}{NTM} = \underset{(3.92)}{10849.2} + \underset{(20.43)}{343.87}\, RDPMA - \underset{(-5.91)}{158.37}\, TRUCK \qquad (10)$$

$R^2 = 0.97$ $\qquad F(2,12) = 239.93$ $\qquad$ D-W = 1.38

where:

NTM = net-ton-miles, in millions;

RDPMA = index of real domestic product, all sectors but agriculture;

TRUCK = the number of common carrier semi-trailers, deplated by the real domestic product of the total transport industry.

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[1] See above, under "Agricultural Products".

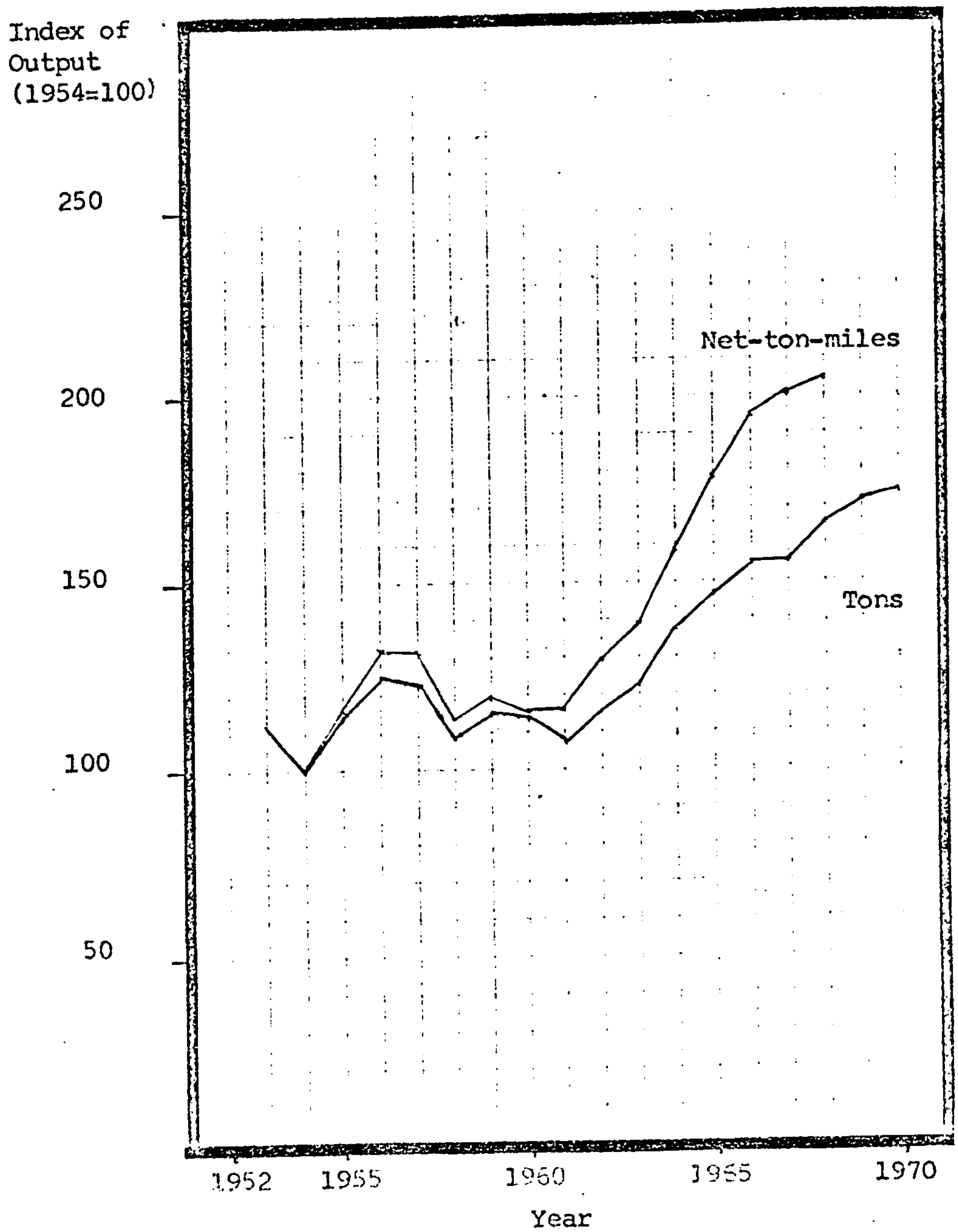

Figure 12.--Graph of tons (1952-70) and net-ton-miles (1954-68) versus time for manufactured and miscellaneous products.

The 1968-level elasticities for RDPMA and TRUCK are 1.22 and 0.51, respectively.

All coefficients are satisfactory in equation (10), with the possible exception of the Durbin-Watson statistic (which is marginal). The trucking variable was finally settled on after price proved to be insignificantly different from zero in other tests; the two variables show very little correlation with each other (-0.11). On the basis of these results it is quite clear that the level of freight traffic for this commodity group is very closely tied to the level of activity in the economy; in fact the elasticity of 1.22 suggests that fluctuations in general economic activity produce even greater fluctuations in railway operations. Truck competition, as we mentioned, is very important: prices seem to take a back seat to other competitive criteria.

CHAPTER VII

THE DEMAND FOR PASSENGER TRANSPORTATION

Competition for Passenger Traffic

From the railroads' point of view, competition in this sector of their operations has been the most severe of all. As the results in tables 5 and 6 show, the rail firms' relative share of the market has dropped continuously over the past two decades, with respect to both commercial carriers' passenger miles and the total of all carriers.

TABLE 5

INTERCITY PASSENGER-MILES, BY COMMERCIAL CARRIERS
(Mileage in Billions)

Year	Bus	Air	Rail	Total
1949	3.33 (48%)	0.39 (6%)	3.19 (46%)	6.91
1950	3.39 (51%)	0.45 (7%)	2.82 (42%)	6.66
1951	3.46 (48%)	0.56 (8%)	3.11 (44%)	7.13
1966	4.32 (39%)	4.26 (38%)	2.59 (23%)	11.17
1967	5.12 (38%)	5.26 (39%)	3.14 (23%)	13.62
1968	4.41 (40%)	4.20 (38%)	2.51 (22%)	11.12

Source: H. L. Purdy, Transport, P. 74.

TABLE 6

INTERCITY PASSENGER-MILES, BY RAIL AND PRIVATE AUTOMOBILE
(Mileage in Billions)

Year	Passenger Cars	Commercial Rail Services
1952	33.4	2.9
1956	44.8	2.7
1960	58.3	2.1
1964	73.3	2.6
1967	83.3	3.1

Source: DBS, Transportation Service Bulletin (Catalogue No. 50-001), November, 1969.

In the former area the air carriers have been the railways' greatest competitors. Over the total picture, the private automobile has made the greatest dent in the rail share.

The explanation for the ascendance of other modes relative to rail in the passenger business will not be found in relative prices of the services (that is, "prices" in the narrow sense), as we shall see later, but in the characteristics of the services and the competitive position of the railways with respect to these characteristics. In concurrence, Purdy quotes J.C. Lessard:

> Speed and convenience would appear to be the most important attraction to passengers with comfort ranking third. This is patently clear from the predominance of the private car for short distance travel and the growing attraction of the airplane

> for long distance movements both of which are high-cost carriers.[1]

In analysing this theory, we could probably be quite safe in segregating passengers into three groups: those who travel for business reasons, those who travel on vacations, and those who travel on short-term personal trips. For the first group speed and convenience would appear to be of overriding importance--the fare for any mode is likely to constitute only a small portion of the total cost of any business trip once wages and accomodation for a traveller are considered. This goes far to explain the increasing popularity of the airplane. For the second group freedom is an important service characteristic--the freedom to depart from a fixed schedule or route; hence, a reason for the popularity of the private automobile. For the third group convenience is a major factor; again, this constitutes a vote in favour of the automobile. Other, exogenous, factors have contributed to the decline in the railways' share of passengers. Examples of these would be: the large investment by governments in highways and airports which has occurred during the past two decades and which has added appeal to automobile and air travel, respectively; the continuing increase in the ownership of private automobiles and in the opulence and improved performance of this means; and the positive attitudes towards air and auto travel which have been inculcated in travellers' minds by the efforts of groups not directly connected with the provision of transportation, such as automobile manufacturers and travel agencies.

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[1] H.L. Purdy, Transport, P. 75

Lest the picture be painted too black for the railways, the great volume of thought and opinion must be mentioned which supports the rail position and its continuing viability as a competitive passenger-carrying mode. One spokesman for the railways is G.C. Campbell, a former General Manager of Passenger Services for the Canadian National Railways. In a presentation to the Transportation Research Forum[1] Campbell argues convincingly in favour of the greater development of rail passenger transport. His reasons range from the feasibility of achieving positive net revenues to such externalities as lower air and noise pollution, a more efficient allocation of the totality of economic resources devoted to passenger transportation, and the many possible beneficial effects on urban development which a shift from highway to rail travel would bring.

At the present time, however, such discussion is academic--unfortunate as that may be. As was pointed out in Chapter I, freight revenues by far outweigh passenger revenues. Hence it is freight considerations which determine, and shall continue to determine, the policy of Canadian railway companies--at least until that time that a special group or commission is charged with the operation of rail passenger services, much like AMTRAK, in the United States. It is well to note here one

[1] G.C. Campbell, "Opportunities for Railroads in Transportation of People", Papers - Eleventh Annual Meeting of the Transportation Research Forum (Oxford: The Richard B. Cross Co., 1970)

argument which is often offered in favour of the development of rail passenger services in higher density population areas, or "corridors". That argument is that, since good rail networks already exist in most of these areas, high-speed intercity trains can be initiated with a minimum of social cost and a maximum of social benefit. This view tends to forget, however, that these rail networks--especially in high-density areas--are maintained because of a high volume of freight traffic. It would simply be impossible to add passenger trains, especially ones with speeds radically different from the usual mix of traffic, without severely impacting the normal trains' operation.

Canadian National Passenger Operations

For the purposes of this study, rail passenger operations have been separated into two categories: the Canadian National Railways' operations, and all other railways. Figure 13 gives a good indication of why this has been done: the C.N.R. has clearly differed from the other railway companies in the pattern of its operations over the sample period 1952-70, quite apart from the fact that it has produced over half of the railways' output each year, by passenger miles.[1]

Estimating a demand function for passenger travel on an aggregate scale involves making some strong assumptions at best. Not only do demand characteristics change by geographical area, but also according to weather, the time of year, the number of airplane crashes in the

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[1]Statistics Canada, Railway Transport, Part IV (Catalogue No. 52-210) for selected years.

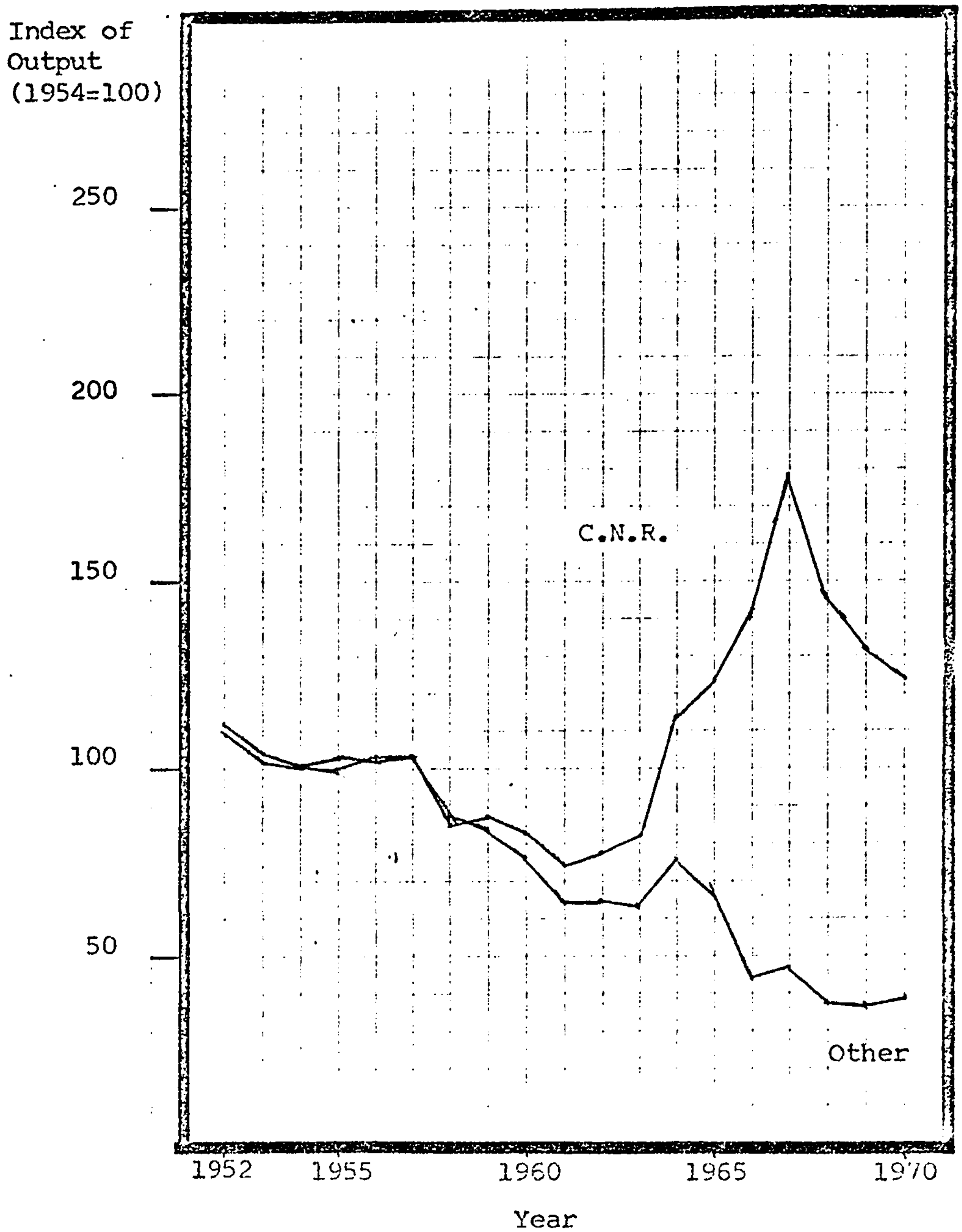

Figure 13.--Graph of passenger-miles of the C.N.R. and all other railway companies, versus time for the period 1952-70.

previous time period, and many other subjective criteria. At best, however, we would expect to achieve reasonable results for predictive purposes if we had accurate or approximate data on the relative speeds, availabilities, comforts, cost to consumers, conveniences, or dependabilities of different competing modes. Not unexpectedly, very little of this list is readily available. As far as speed[1], convenience, availability, and dependability are concerned little enough is known in a systematic way about individual origin-destination pairs, let alone the entire industry. Thus, for estimation of our firm and rest-of-the industry functions, it has been necessary to concentrate on price and comfort (in some sense) to identify the relationships.

With reference to figure 14, it is clear that the C.N.R. underwent a fundamental change in its passenger policy during the years 1960-63. Purdy describes the new policy as a "three-phased attack" "... on the passenger front".[2] The three phases referred to were: management reorganization; improvement in service and equipment where the market warranted; and the initiation of fares which were flexible upwards and downwards according to daily and seasonal demand. The effects of this new approach were striking, on the number of passengers carried, and even moreso on the average length of journey (hence, passenger-miles). Increasing competition from air carriers and the private

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[1] "Speed" includes terminal delays to passengers.

[2] H.L. Purdy, Transport, P. 75

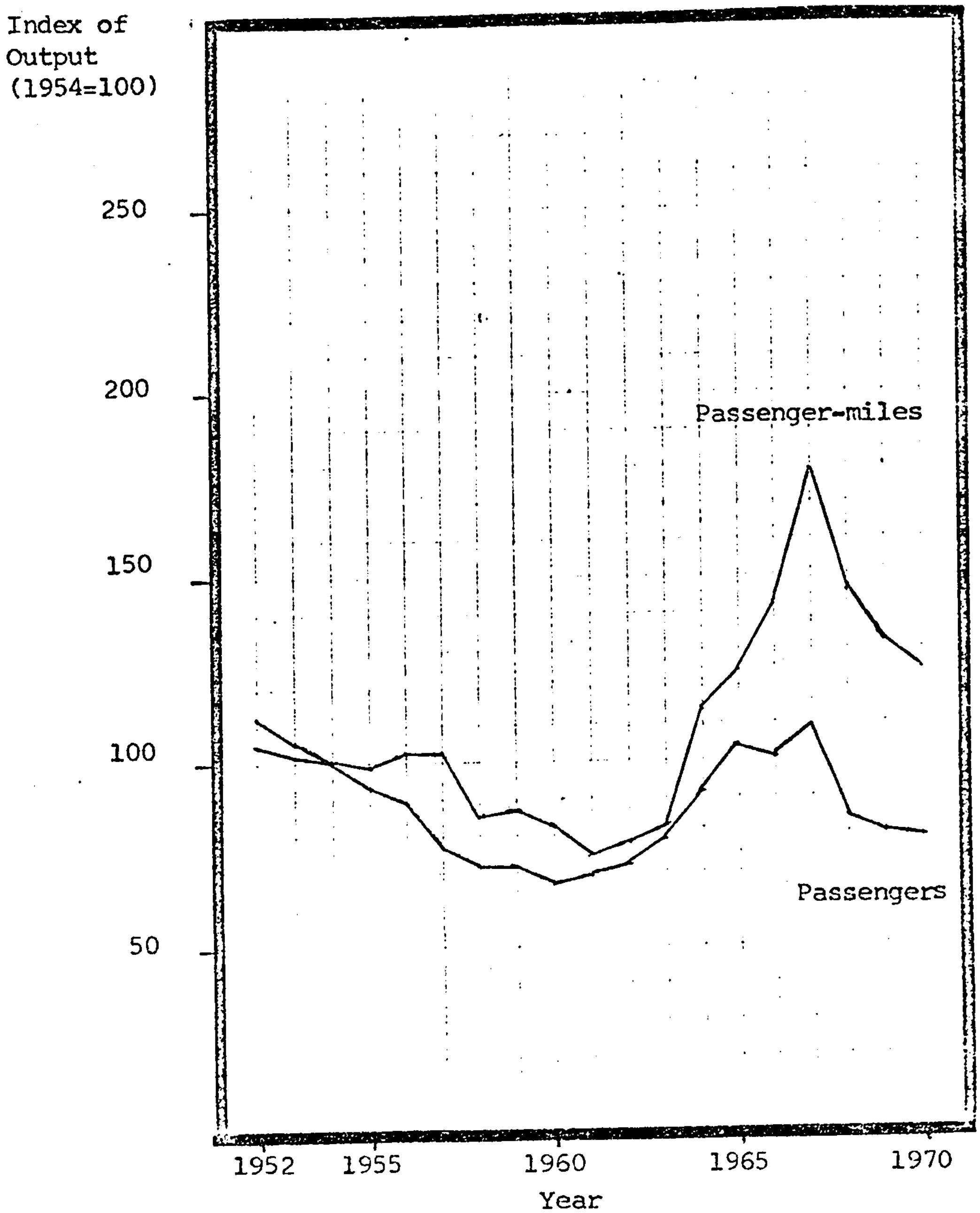

Figure 14.--Graph of passengers and passenger-miles for the C.N.R., versus time for the period 1952-70.

automobile reversed the upward trend after the peak in 1967, however.

In estimating the demand equation it was necessary to obtain a good proxy variable to reflect the C.N.R.'s more agressive marketing effort over the years 1961-67. This task proved more successful in the conception than the delivery, however, and recourse was taken to a variable which is not entirely satisfactory. Neither Statistics Canada, nor the Canadian National's Annual Report, nor any other source which comes to mind publishes figures about the yearly expenditure of C.N.R. on the passenger marketing effort or about new net investment in passenger rolling stock. The proxy selected, then, was the yearly equipment maintenance expense for "passenger train cars", deflated by the number of passenger cars in use.[1] On the one hand this value is appropriate, since a large fraction of the C.N.R.'s improvements in its rolling stock (hence, passenger comfort and marketability) were and are made in the company's own repair shops. On the other it is difficult, if not impossible, to determine how much of this expense was incurred in <u>advance</u> of the sale of the service, and can therefore be considered as exogenous; and how much was incurred as a <u>result</u> of the other (unknown) expenditures and resulting demand, and must therefore be treated as endogenous--that is, being explained by, rather than explaining, demand. It is quite logical that equipment maintenance expense should be directly related to use. Having offered this caveat, we will proceed

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[1] Statistics Canada, <u>Railway Transport, Part II</u> (Catalogue No. 52-208) 1954-70, and <u>Railway Transport, Part III</u> (Catalogue No. 52-209) 1954-70

to the other variables. A price series was included in the regression, representing the relative prices of C.N.R. passenger travel to other modes. This was computed by forming the ratio of elements of an average-revenue-per-passenger-mile series to elements of the consumer price index, passenger transport component.[1] The latter series covers all modes, including the cost of private automobile operation. Also employed in the regression was an (income-type) variable giving the number of automobile registrations per capita. Estimation of the equation was done for the period 1954-70.

The estimated equation is as follows:

$$\underset{}{PASMI} = \underset{(0.06)}{73.951} + \underset{(6.23)}{0.33127}\,MAINT + \underset{(1.17)}{13.050}\,RELPR \underset{(-3.38)}{-8016.9}\,AUTOS \qquad (11)$$

$R^2 = 0.83$ $\qquad$ F(3,13) $\qquad$ D-W = 1.51

where

PASMI = passenger miles, in millions;

MAINT = expenses for maintenance of passenger cars, in dollars per car;

RELPR = a revenue per passenger-mile index deflated by the consumer price index for transport;

AUTOS = auto registrations per capita.

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[1] Statistics Canada, Prices and Price Indexes (Catalogue No. 62-002), selected months 1954-70.

The elasticities computed at 1970 levels are:

e(MAINT) = 1.88; e(RELPR) = 0.67; e(AUTOS) = 1.43

Quite noticeable are the fairly good fit, as evidenced by the R^2 and F statistics; the absence of autocorrelation; and the lack of significance of the constant term. The relative price coefficient is not as significant as one would like; moreover, it has the "wrong" sign. The coefficients of MAINT and AUTOS both are significant and have the expected signs. The result for AUTOS was amplified, with an interesting connotation, when the equation was re-estimated with personal disposable income as a variable. The correlation between these two variables is 0.97--the alternative form, then, gave a negative sign to disposable income as well. This result is a necessary condition (but not a sufficient one, however) for the definition of rail passenger travel as an <u>inferior</u> good--one for which demand is inversely related to income. Rerunning the regression with price (revenue per passenger-mile) as an independent variable resulted in the proper (negative) sign; however, the coefficient was not significantly different from zero.

<u>Passenger Operations--All Companies but C.N.R.</u>

Much of what has been said above applies to the remainder of railway companies and their involvement in passenger operations; hence, much the same procedure was used to estimate this demand equation as the previous one. One or two differences in this sector of the industry are evident from figure 15, however. One is the steady decrease in demand over the sample period. Another is the decreasing average length of trip, reflecting the heightened importance of commuter trains. Still

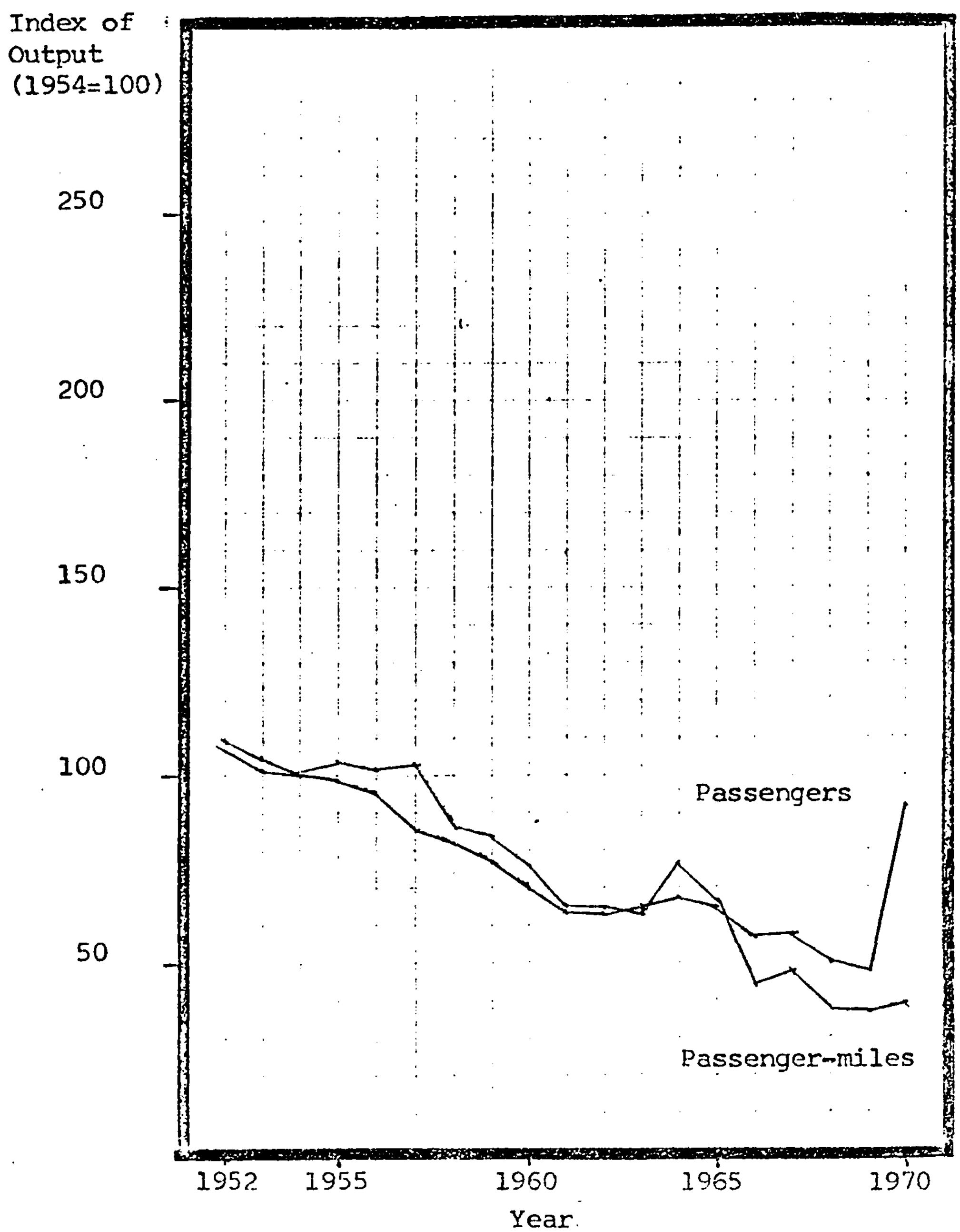

Figure 15.--Graph of passengers and passenger-miles for all railway companies except C.N.R., versus time for the period 1952-70.

another is the introduction of the GO (Government of Ontario) Transit System, which carries commuters in the Toronto area and which began reporting data in 1970.[1]

Estimation was carried out with the same variables as for the C.N.R. equation, with the exception of the maintenance expenses variable. It was felt that this (or proxy) did not apply, since the other firms did not seem to be taking an aggressive part in the struggle to maintain passenger revenues. In addition, prices for the C.P.R. were substituted for C.N.R. prices, the former railway accounting for over eighty-five percent of the "other" passenger-miles. Once more, estimation was done for 1954-70.

The resulting equation is:

$$\begin{aligned} \text{PASMI} = \underset{(6.24)}{5406.0}\ \text{DNOGO} &+ \underset{(6.19)}{5446.5}\ \text{DGO} \\ &+ \underset{(5.94)}{5263.1}\ \text{DSTRK} - \underset{(-7.60)}{12244.5}\ \text{AUTOS} \\ &- \underset{(-2.74)}{15.415}\ \text{RELPR} \end{aligned} \tag{12}$$

where

PASMI = passenger-miles, in millions;

DNOGO = a dummy variable, equal to one for every year but 1966 and 1970;

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[1] Statistics Canada Railway Transport, Part I (Catalogue No. 52-207)

DGO = a dummy variable representing the reporting of GO Transit, equal to one in 1970 and zero for other years;

DSTRK = a dummy variable representing the Canadian railway strike of 1966, equal to one in 1966 and zero for other years;

AUTOS = automobile registrations per capita;

RELPR = an index of C.P.R. revenue per passenger-mile, deflated by the consumer price index for passenger transport.

The elasticities calculated at 1970 levels are 6.4 and 1.85 for AUTOS and PRICE, respectively.

We see again, as for C.N.R. passenger demand, that AUTOS is very significant and has a negative sign. Disposable income was also tried as a regressor and the same result was repeated--thus again a necessity condition is fulfilled for the definition of rail passenger travel as an inferior good. All coefficients in the above equation are significant and have the expected signs. Autocorrelation is not ruled out by the Durbin-Watson test, however. Applying the following test for equality between any two coefficients of the dummy variables:[1]

$$t = \frac{\hat{a}_1 - \hat{a}_2}{\hat{var}\ (a_1 - a_2)}$$

where $\hat{a}_1$ and $\hat{a}_2$ are estimated coefficients of any two of the dummies, it was found that none of the $\hat{a}_1$ was significantly different from any of the others.

[1]This test is described in Appendix III

PART IV

PRODUCTION

CHAPTER VIII

PRODUCTION--THE THEORETICAL FRAMEWORK

Part IV consists of an investigation into the contribution made by different factor inputs to the output of the Canadian railway industry, and the estimation of an <u>industry production</u> function which relates the level of output to the inputs.

General Form of the Model

The production function is a technical or engineering relationship of the general form:

$$Q = f(K, L, t)$$

where Q represents output, K represents the service from capital goods, L represents the service from labour inputs, and t represents technological change. All variables are measured in real terms. The precise form of the production function chosen for this study was the Cobb-Douglas function, which has the form:

$$Q = aK^{b}L^{c}e^{dt+\epsilon} \qquad (1)$$

where Q, K, L and t are as above; e denotes exponentiation (i.e. e is the basis of the natural logarithms); a to d inclusive are coefficients; and ϵ is a random error term. As in the case of the demand function, all subscripts representing a particular time period have been dropped--there are no lags.

The measurement of each variable is a fairly complex matter. Output must be measured in real terms, as a flow--hence, constant dollars per time period, or net-ton-miles per time period. Likewise, capital must be measured in real terms as a stock; normally this is done in constant dollars. Labour is measured in man-hours per time period, as a flow--preferably weighted to indicate the heterogeneous composition of an industry's labour force. Technology may be measured as a trend, or an index of technological change may be developed and employed as an independent variable.

Output

Although output, or operating revenue, is readily avaivable in current dollars for the Canadian railways,[1] conversion of these values to real (constant-dollar) terms provides a severe problem. This is because the realm of railway operations is so vast, covering many kinds of freight movement, passengers, switching, and other areas, and because Statistics Canada does not publish a deflator for its railway output statistics. Three approaches suggested themselves for this study: however, none was without its shortcomings. One was simply to ignore the possible effects of prices, and to obtain observations on output in current dollar terms. Another was to consider only freight and passenger operations, for which deflators were available, and to construct an output series in constant dollars based on these two categories. Although the approach ignored some information, it covered more than

[1] Statistics Canada, Railway Transport, Part I

ninety percent of the toal industry output. A third approach was to compute deflators for each sub-category of freight and passenger traffic (as in Appendix II), plus the other categories of revenue to the extent that was possible: then to apply the deflators to each category in order to arrive at total output in real dollars. Something like this approach was attempted in a study by M. Mendelsohn.[1] This alternative was not chosen in the present study, however, for two good reasons: the resources available to duplicate Mendelsohn's (unpublished) deflators in their entirety were not equal to his own; and the change in data reporting by Statistics Canada and the C.T.C. for 1969-70 (see Appendix I) caused a break in continuity of the data during the sample period. Consequently, each of the first two above-mentioned approaches was tried.

Capital

The problems associated with the measurement of service from a capital stock are legion. It is virtually impossible to estimate how much plant and equipment are "used up" or made obsolescent by the productive process in any given time period. The usual procedure, and the one followed here, is, therefore, to assume that the service from the capital stock is closely related to the stock itself, and to use the stock as a proxy for the service.

Mendelsohn (in Productivity Trends)has followed a rather different

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[1] M. Mendelsohn, Productivity Trends in the Canadian Railways, 1956-1968, Report 27, CTC Economics Branch, January, 1972.

approach. He estimated the capital input to the productive process as the amount of capital "used up" each year, K_u. His procedure was to treat the values K_u as observations of capital input (although he did not estimate a function), where:

$$K_u = D + (I*d*r)$$

and where D = the depreciation charged each year, in constant dollars; I = the addition to net capital stock per year, in constant dollars; d = an imputed depreciation rate per year (e.g. one-fifteenth) for new equipment; and r = the estimated cost of capital to the railways. This approach, although interesting, relies on the very strong assumption of a close connection between accounting depreciation rates and the service derived from a given capital stock. This is simply not justifiable on intuitive or statistical grounds--one can think of many examples (especially in the railway industry) of amortized capital goods which nevertheless constitute worthwhile inputs into the productive process.

Briefly then, what was done in the current study was to compute the proxy for capital input as the constant-dollar value of the net capital stock of all railways. The procedure was to compute accumulated investment, less retirements and depreciation, deflated by an implicit price index of capital goods. In addition a capacity utilization factor was applied to the capital input to deflate it for under-utilization. The derivation of this factor is described in detail in Appendix IV.

Labour

Labour was included in the production function as the sum of man-hours input to the productive process per year, each man-hour being weighted by its real wage. This weighting removed the assumption of the homogeneity of the industry's labour force which is implicit in the use of labour measured in men or man-hours. Thus the increasing (or decreasing) quality and education of the members of the railways' labour force was accounted for.

Estimating Form of the Equation

In its standard form (see above) the Cobb-Douglas function is nonlinear. For OLS estimation, therefore, a transormation to a linear form is accomplished by taking logarithms. Thus equation (1) of Chapter VIII becomes:

$$\log Q = \log a + b \log K + c \log L + dt \qquad (2)$$

which is linear in the logs of all variables (log e disappears since it is identical to 1). This form was used in estimation of the results shown in the next chapter.

CHAPTER IX

EMPIRICAL RESULTS FOR PRODUCTION

Output in the rail industry is represented in figure 1 of Chapter II, in constant 1956 dollars. The production relationship was estimated for the period beginning in 1956 because data prior to that year were not reported by Statistics Canada in a format compatible with succeeding years.[1] The graph indicates only that portion of output which consists of freight and passenger car movements (i.e. over ninety percent of total rail operations). Quite obvious are the years of decreasing production (1956-61) and the following recovery of the industry from a low point in 1961. It should be noted here that both of these measures--i.e. ton-miles and passenger-miles--constitute an aggregation which glosses over the different components of the productive process: car loadings and unloadings, terminal switching, car maintenance, and line-haul.

As we indicated in the last chapter, two methods were employed for obtaining observations on output, neither of them completely satisfactory. For one the values for total rail operating revenue were used,

[1]In 1956 there occurred a substantial change in reporting, by which a large body of expenses previously reported under the operating account were changed to fall under the capital account.

measured in current dollars.[1] For the other, net-ton-miles and passenger -miles were combined into one value, weighted respectively by the 1956 dollar value for each unit of measurement.[2]

The value for capital stock was taken in current dollars from Statistics Canada's report on railway financial statistics (Rail Transport, Part II), being the total accumulated investment in rail properties, less accrued depreciation on road and equipment. This series of figures was transformed into constant 1956 dollars by deflation with an implicit price index for gross fixed capital formation of business machinery and equipment.[3] Finally, the observations were converted to "utilized capital" by application of the capacity utilization index series as developed in Appendix IV. Two methods of such conversion were tested: one using a utilization index derived from peaks in 1956 and 1970; the other using an index derived from peaks in 1956, 1959 and 1970. Symbolically, the capital series K_u is defined as:

$$K_u = \frac{(I - D) * U}{p}$$

for each observation, where I = accumulated investment, D = accrued

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[1]Statistics Canada, Rail Transport, Part I

[2]Statistics Canada, Rail Transport, Part I In effect, this amounts to using a base-weighted deflator.

[3]Statistics Canada, "National Income and Expenditures, Historical Revision: 1947-1972," July 10, 1972 (Unpublished data series).

depreciation, U is a utilization percentage, and p is an implicit deflator. We will make a note here of the inadequacy of the deflator used; being a general index, it can be expected to apply to many goods which have no relevance to railway operations. Mendelsohn developed a specific deflator for his study; it was not available, however, and covered only the period 1956-68 in any case.

Labour input was obtained from the general, maintenance, and operations groups of employee statistics published by Statistics Canada[1]. These figures were in current dollar-weighted man-hours and were subsequently deflated by an implicit price index for consumption expenditure.[2] The resulting variable is L where:

$$L = \frac{\sum (n * w)}{p}$$

and where n = the number of man-hours worked per year per employee, w = that employee's money wage per hour, p = a wage deflator, and the summation sign indicates a summation over all employees in the industry.

The equation was estimated for the period 1956-70. Results are as follows:

$$\log Q_1 = \underset{(-3.07)}{-2.8737} + \underset{(1.96)}{0.4316 \log K_1} + \underset{(3.63)}{0.8090 \log L} + \underset{(4.43)}{0.01370\, t} \qquad (1)$$

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[1]Statistics Canada, Railway Transport, Part VI: Employment Statistics (Catalogue No. 52-212), selected years.

[2]Statistics Canada, "Historical Revision".

$R^2 = 0.99$ $\quad F(3,11) = 318.08$ $\quad D\text{-}W = 1.99$

$$\underset{}{\log Q_2} = \underset{(0.09)}{0.3572} - \underset{(-1.36)}{0.5625 \log K_2} + \underset{(5.31)}{1.6695 \log L} + \underset{(5.97)}{0.0324\, t} \qquad (2)$$

$R^2 = 0.91$ $\quad F(3,11) = 45.54$ $\quad D\text{-}W = 1.75$

where

Q_1 = output, measured in current dollars;

Q_2 = output, measured in 1956 constant dollars;

K_1 = utilized capital, measured in terms of two capacity peaks, in constant 1956 dollars;

K = utilized capital, measured in terms of three capacity peaks, in constant 1956 dollars;

L = labour, measured in constant 1956 dollar-weighted man-hours;

t = a time trend

Although the tight fit is quite encouraging, a problem which is widespread in the estimation of production functions is painfully obvious --that is the irregularity of the coefficients of capital and labour. The high correlations of L to K_1 and K_2 (0.77 and 0.59 are the correlation coefficients for each respective pair), which are quite common in Cobb-Douglas functions, have caused the estimation of rather meaningless coefficients of these variables in both equations. The sum of the two coefficients can be relied on, however. This is the returns-to-scale parameter which indicates conditions of constant, decreasing, or increasing returns to scale in the industry by taking on the value one, a value less than one, or a value greater than one, respectively.[1] Applying the test described in Appendix III, it was found that this returns-to-scale parameter was significantly different from one in equation (1) but not significantly different from one in equation (2). That is, equation (1) indicates a situation of increasing returns to scale in the railway industry, whereas equation (2) does not. The only real conclusion that can be derived from these results is that it is vital to have a satisfactory deflator for output in the industry--without that no substantive results can be reached, since the definition of output must remain ambiguous. Moreover, the lack of any single correct measure of output makes it impossible to know which capital series is more relevant for the railways. Finally, we can draw attention to the different weights placed on technological change by the two equations. Equation (1) gives the rate of change of technology as being equal to 1.4 percent, while equation (2) gives it as 3.2 percent. Both coefficients are statistically significant.

Recognizing that the correlation between labour and capital had caused spurious coefficients to be estimated for these two variables, an attempt was made to re-estimate them by placing a constraint on their sum (i.e. the returns-to-scale parameter)--this procedure should normally fix the exact proportions of the two variables in exchange for sacrificing

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[1]The elasticity of substitution is trivial in the case of Cobb-Douglas functions, being implicitly assumed equal to one.

power in estimating their sum, since that sum is itself fixed. The procedure is as follows:

We have: $$Q = aK^{b}L^{c}e^{dt} + \epsilon$$

After estimation of this equation we have reason to believe that $(a + b) > 1$. There exists collinearity, however, so restrict $(b + c) = 1 + g$ where g is some number greater than zero. That is, restrict

$$c = 1 + g - b$$

We then get: $$Q = aK^{b}L^{1+g-b}e^{dt} + \epsilon$$

Or: $$Q = aK^{b}L^{1+g}L^{-b}e^{dt+\epsilon}$$

Or: $$\frac{Q}{L^{1+g}} = a\left(\frac{K^{b}}{L^{b}}\right) e^{dt+\epsilon}$$

Or, taking logs:

$$\log\left(\frac{Q}{L^{1+g}}\right) = \log a + b \log\left(\frac{K}{L}\right) + dt \qquad (3)$$

We then estimate this equation for various values of g and select the one which minimizes the sum of the squares of residuals--that result should give better estimates of b and, hence, c (since $c = 1 + g - b$)

To try this test, the data for equation (2) were transformed. Re-estimation was then done for equation (3) above, using the values $g = 0.1$, $g = 0.2$, and $g = 0.3$. The results, unfortunately, were again such that one of the coefficients was negative. This can only be attributed to the poorness of the measurement of the output variable.

Capital-Labour-Output Ratios

Table 7, below, gives some indication of the relative importance of the two major factors of production to Canadian railways. All data have been taken from the sources mentioned above, and are measured in 1956 constant dollars. "Capital" refers to the total capital stock, not the total deflated by a utilization index. The capital-output ratio series shows an increasing trend from 1956 to 1961, which is a reflection of both the high degree of capacity under-utilization in the industry for those years, and the completion of the changeover from steam locomotion to diesel, with its corresponding high investment levels. The series shows diminishing values for the remaining years, indicating the fall-off in investment spending and the rise in capacity utilization. The capital-labour series displays similar behaviour, increasing over the period up to 1963. A decreasing trend is evident for the remaining years, again showing the reduction of investment spending and also rising labour costs. Figure 16 shows the level of labour input in the industry for the same period, both in man-hours and constant dollar-weighted man-hours. It is quite clear from the graph that labour's real wage rate has been rising considerably over the sample period. The labour-output ratio exhibits different behaviour from the other two, however. This series is almost continuously decreasing over the entire period. Quite probably on account of the increasingly greater degree of capacity utilization, the productivity of labour is seen to be rising noticeably. One other feature which is apparent is the relatively rapid adjustment of labour to output, compared with the adjustment of

TABLE 7

THE RELATIONSHIPS BETWEEN CAPITAL, LABOUR, AND OUTPUT
(Constant 1956 dollars)

Year	Capital/Output	Capital/Labour	Labour/Output
1956	3.689	6.478	0.570
1957	4.290	7.034	0.610
1958	4.851	7.931	0.612
1959	4.898	8.062	0.608
1960	5.150	8.697	0.592
1961	5.186	8.717	0.595
1962	5.030	8.886	0.566
1963	4.536	8.926	0.508
1964	3.930	8.343	0.471
1965	3.871	8.137	0.476
1966	3.617	8.182	0.442
1967	3.726	7.833	0.476
1968	3.783	8.277	0.457
1969	3.796	8.198	0.463
1970	3.388	8.120	0.417

capital to output. It is upon this characteristic that the deflation of the capital stock by a capacity utilization index depends.

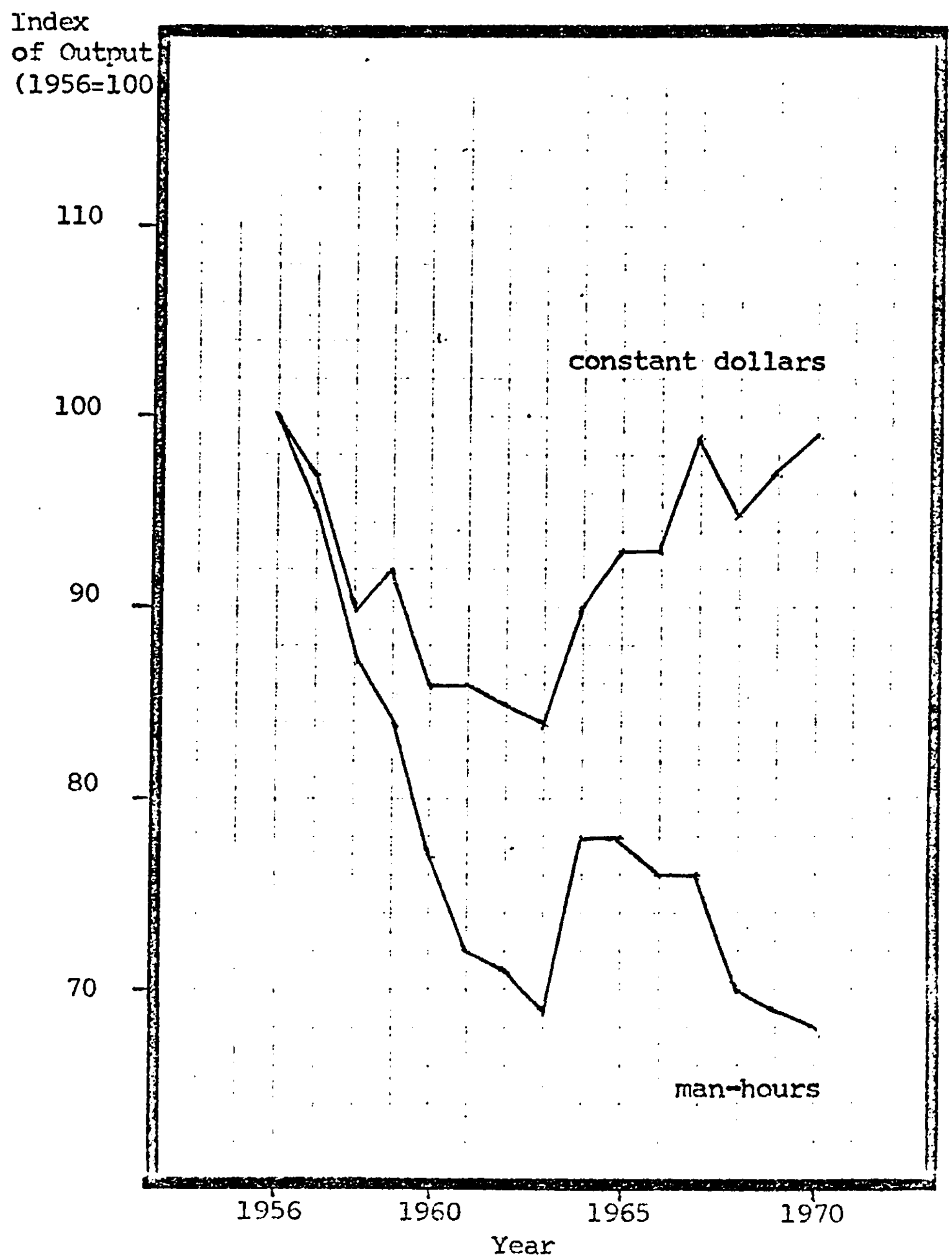

Figure 16.--Labour employment in the Canadian railway industry (1956-70), measured in constant (1956) dollar value and man-hours.

PART V

CONCLUSIONS

CHAPTER X

CONCLUSIONS

The specific conclusions of this study have been set down in each relevant section, and there is no need to reiterate them here. A number of general points seem worth mentioning in retrospect, however.

This study has been restricted in many ways by the lack of data availabilitv. In large measure, this is due to the large number of member firms in the transportation industry. Although the railways may be thought of as an "industry" in their own right, their behaviour depends to a great extent on the behaviour of other modes. It is certainly of prime importance, therefore, to accumulate a far better data base from which to launch quantitative studies such as this one. Most important are the areas of prices and quality-of-service. Information on the first category could hardly be much worse at the present, considering its importance to competition and the rational allocation of economic resources. The second category is, of course, a relatively new area for study and much emphasis should be given to it.

Application of the approach put forward in this paper seems to be of most use to individual firms--although necessarily those large enough to have sufficient resources to devote to the corporate planning effort. At the level of the firm, computer-aided systems can remove a great deal of the problems associated with a poor industry-wide body of information. This is true, of course, only for the variables which are endogenous to the firm.

APPENDIXES

APPENDIX I

COMMODITY DEMAND GROUPS

The following groupings describe in detail the dependent variables of each of the demand relationships of Section III. Each group has been designed with a strong dependence on the DBS classification by 267 commodities, which was in effect from 1956 to 1969. For those years of the sample period when data for this classification was not available, a conversion has been made and the details have been given below. Reference should be made to the relevant issues of DBS, Railway Transport, Part I: Comparative Summary Statistics Catalogue Number 52-207.

Commodity Groups

1. Grains and Products

Under the 267-commodity grouping, this group consist of:

- wheat
- corn
- sorghum grains
- oats
- barley
- rye
- rice
- grain, n.o.s.
- flour, wheat

Under the more recent Standard Commodity Classification, or SCC (refer to Statistics Canada, Catalogue Number 52-207 for 1970), this group consists of commodity code numbers:

- 024 to 034
- 044

2. <u>Other Agricultural Products (Except Grains)</u>

Under the DBS 267-commodity grouping, this group consists of the entire major section "Products of Agriculture" with the commodities of group 1, above, excluded. Under the SCC this group consists of commodity codes:

- 036
- 038
- 042
- 052 to 076
- 082 to 104
- 114
- 128 to 136
- 156
- 166 to 174
- 178
- 180
- 198

3. <u>Animals and Animal Products</u>

Under the DBS 267-commodity grouping, this group corresponds exactly with the major section "Animals and Products". Under the SCC, the group consists of these codes:

- 002 to 022
- 118 to 120

- 160
- 164
- 196
- 362 to 364

4. Iron Ore

Under the DBS 267-commodity grouping, this group consists of the one member "Iron Ore". Under the SCC, it consists of only code 208.

5. Coal Products

Under the DBS 267-commodity classification, this group consists of the commodities:

- anthracite coal, n.o.s.
- anthracite coal to breakers and washeries
- bituminous coal
- coke

Under the SCC, the group consists of commodity codes:

- 236 to 242
- 448

6. Other Mine Products (Except iron ore and coal)

Under the DBS 267-commodity classification, this group consists of the entire major section "Products of Mines", with the members of groups 4 and 5, above, excluded. Under the SCC, the group consists of codes:

- 202 to 204
- 210 to 216
- 220 to 226
- 244 to 262
- 266 to 292
- 452
- 508

7. Forest Products

Under the DBS 267-commodity classification, this group corresponds exactly to the major section " Products of Forests". Under the SCC, it consists of the commodity codes:

- 182 to 194
- 300
- 308 to 328

8. Manufactured and Miscellaneous Products

Under the DBS 267-commodity classification, this group corresponds exactly to the major section "Manufactures and Miscellaneous".

Under the SCC, the group consists of the following codes:

- 040
- 046 to 050
- 078 to 080
- 106 to 112
- 116
- 122 to 126
- 138 to 154
- 158
- 162
- 200
- 206
- 218
- 228 to 232
- 264
- 294 to 298
- 304 to 306
- 330 to 360
- 366 to 372

- 450
- 454 to 506
- 510 to 640

For completeness, the following two groups are included here.

9. Passengers Carried by Canadian National Railways

This group consists of all passengers carried on Canadian lines by CN as reported in Statistics Canada, Railway Transport, Part IV: Operating and Traffic Statistics (Catalogue No. 52-210).

10. Passengers Carried on All Railways Except CNR

This group consists of all passengers carried on Canadian rail lines (from Statistics Canada, 52-210) with the exception of those of group 9, above.

Conversion From the 267-Commodity Classification to the SCC

Some note will be made here on the conversion of 1970 data to the groupings used in this study. Data from 1954 to 1969, of course, required no conversion as it was available directly from the DBS. This was true of published data for the period 1952 to 1956 as well, even though the breakdown by commodity within the major sections was not to the 267 commodity level.

Using the descriptions of the commodities as a basis, a conversion of data from the SCC to the 267-commodity classification was affected. Fortunately, Statistics Canada published data for the year 1969 under both classifications, and so a test for the conversion was possible.

The results were:

Group	Per Cent Difference, Converted versus Actual	Per Cent of All Commodities, by Tons
grain	0.3	8.5
other agricultural	4	3.2
animals	14	0.5
iron ore	0.02	18.6
coal	4	4.6
other mine	0.8	18.2
forest	0.8	11.0
manuf. and misc.	1.5	35.3
	Total:	100.0

The discrepancies (that is, the existence of non-zero values in the "per cent difference" column) are due to non-comparability between commodity data as reported under the two classifications. Unfortunately, it is impossible to make the two sets of data correspond exactly (without having recourse to the original base data--the waybills). The procedure followed, then, was to estimate the 1970 levels by applying the formula:

1970 statistic (by group) = K times 1969 statistic (from the 267-commodity classification)

$$\text{where } K = \frac{\text{1970 statistic converted from SCC}}{\text{1969 statistic converted from SCC}}$$

It is felt that the results thus arrived at are a good approximation to the actual-yet-unattainable ones in three cases: grain products, iron ore and coal products. In these three cases the modified data were used in estimation. As for the others, the probable influence of errors appeared too great and the samples were cut off at 1969, or, in the case of the Waybill Analysis data (which unfortunately did not provide the duplicate groupings for 1969, but only the SCC groupings), at 1968.

APPENDIX II

INDICES OF RAILWAY FREIGHT RATES BY MAJOR COMMODITY GROUPINGS, 1952-1970

In order to measure the effects of price changes on the demand for different rail services, it is first necessary to have an accurate series of price data. In view of the fact that rail freight rates must cover some 25,000 commodities travelling under four different rate structures between any of some 10,000 separate stations,[1] the acquisition of such a series is no small matter. The procedure followed for this study parallels, and is in some respects an extension of the work of N.T. Jazairi.[2] It will be described briefly below.

The basis for Jazairi's study, and this extension, is data contained in the Canadian Transport Commission's annual Waybill Analysis. This information contains weight, distance and revenue information for all Canadian, all-rail, carload movements, derived from an approximate one percent sample of all yearly traffic. The format of the data consists of tons, ton-miles, and revenue for a number of commodities and commodity groups. The first step in deriving a freight rate index is to partition

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[1]See Chapter 6.

[2]N.T. Jazairi, An Index of Railway Freight Rates by Region and Rate Categories: 1954-1968, Research Report No. 1, University of Toronto/York University Joint Program in Transportation (Toronto, 1971).

the set of all items in the sample into subsets, each with a high degree of homogeneity among its elements. For the purposes of this study, we shall deal only with partitionings based on commodity divisions, rather than on geographical, rate-structure or other criteria (the former of which the data base does not support).

Next we calculate the average yearly change in prices by subset, using revenue per ton-mile as a proxy for the actual price levels. Jazairi used the method of a chain link index in calculating his results. Thus, the index of prices for year 2 relative to year 1, I_{12}, is equal to:

$$I_{12} = \frac{p_2\ (q_1 + q_2)}{p_1\ (q_1 + q_2)} \qquad \text{.................} \ (1)$$

where p_i is the price of each commodity in the subset for year i and q_i is the quantity of that commodity for year i. The numerator gives total revenue at year 2 price levels for all commodities in both years shipped according to year 2 prices; the denominator gives total revenue for all commodities of both years shipped according to year 1 prices. Successive indices are computed for years 3, 4, and the rest by repeated applications of this formula. Thus is derived Jazairi's so-called "chain index (binary comparison)". From this series of indices a "chain link" can be calculated; for example:

$$I_{13} = I_{12} * I_{23} \qquad \text{.................} \ (2)$$

Of course, the result in equation (1) is exactly equivalent to that obtained from:

$$I_{12} = \frac{ar_2}{ar} \qquad \text{.................} \ (3)$$

where ar_i is the average revenue per ton-mile for year i for a subset, since this value will be an average price for the subset, weighted by the amount of each commodity carried.

Formula (3) was the one used in estimating the results in the tables which follow.

Jazairi makes note of four variables which give use to differentiation among transport services with respect to pricing:

1. mode.
2. commodity.
3. distance.
4. geographic location.

The mode under consideration is rail only; distance and location enter the picture via the rules of rate structures. Commodity is important for reasons of the amount and kind of service required, besides mere haulage; examples are refrigeration, special packing, and handling of very large or heavy objects. We may add to these:

5. time or season.
6. competitive criteria.

Seasonality in rates is widespread for passengers, although less so for freight. Competitive criteria, such as intermodal competition, or intermodal competition in a customer's industry, are also important parameters in the pricing mechanism.

The extensions to Jazairi's work here are principally three. One is the extension of his study to a longer period, covering the years from 1952 or 1954 to 1970 instead of 1954 to 1968. Although this means analysing a discontinuous data base, it is felt that the new information gained is still useful.[1] A second enlargement on the original study is the greater degree of separation by commodity group. Results are presented for all freight commodity groups represented in Appendix I of this paper, plus passengers[2], whereas the original contains only five groups. A third extension is the greater degree of computational precision maintained for intermediate results, which produced indices which differ by up to one percentage point. Moreover, the series for coal disagrees considerably with Jazairi's (for whatever reason) and no definition of that author's subset seems to reconcile the differences.

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[1]The C.T.C. changed its sampling procedure with the 1954 Waybill Analysis, from a procedure by which all traffic was recorded for four separate days of the year, to one in which approximately one percent of all traffic was recorded for every day of the year. Also, the method of reporting and grouping commodities was changed in the 1969 Analysis to correspond to Statistics Canada's revised reporting (see Appendix I).

[2]Data for passengers is from Statistics Canada, Railway Transport, Part I (Catalogue No. 52-207).

TABLE 8

INDEX OF AVERAGE FREIGHT RATES OF GRAINS
ALL CANADA (1952-1970)

Year	Chain Index (Binary Comparison)	Chain Link 1954 = 100
1952	100.00	89.82
1953	99.66	89.51
1954	111.71	100.00
1955	91.64	91.64
1956	96.85	88.75
1957	96.85	88.75
1958	91.64	91.64
1959	102.49	93.92
1960	94.17	88.45
1961	97.25	86.02
1962	99.82	85.87
1963	103.54	88.91
1964	98.80	87.84
1965	99.13	87.08
1966	97.38	84.80
1967	102.69	87.08
1968	103.49	90.12
1969	99.33	89.51
1970	96.60	86.47

1954 = \$0.00658 per net-ton mile

TABLE 9

INDEX OF AVERAGE FREIGHT RATES OF AGRICULTURAL PRODUCTS, LESS GRAIN ALL CANADA (1952-1968)

Year	Chain Index (Binary Comparison)	Chain Link 1954 = 100
1952	100.00	88.81
1953	113.58	100.87
1954	99.14	100.00
1955	94.30	94.30
1956	99.23	93.57
1957	95.37	89.24
1958	111.73	99.71
1959	111.88	111.55
1960	100.58	112.20
1961	88.74	99.57
1962	99.06	98.63
1963	101.98	100.58
1964	95.26	95.81
1965	99.70	95.52
1966	98.94	94.51
1967	108.02	102.09
1968	101.41	103.54

1954 = $0.01385 per net-ton-mile

TABLE 10

INDEX OF AVERAGE FREIGHT RATES OF ANIMAL PRODUCTS
ALL CANADA (1952-1968)

Year	Chain Index (Binary Comparison)	Chain Link 1954 = 100
1952	100.00	115.48
1953	91.24	105.36
1954	94.91	100.00
1955	99.97	99.97
195	102.19	102.16
1957	99.97	102.12
1958	108.15	110.45
1959	111.60	123.26
1960	83.40	102.80
1961	102.07	104.92
1962	99.84	104.75
1963	99.32	104.05
1964	93.20	96.97
1965	101.88	98.79
1966	96.52	95.35
1967	111.63	106.44
1968	91.48	97.37

1954 = $0.02966 per net-ton-mile

TABLE 11

INDEX OF AVERAGE FREIGHT RATES OF IRON ORE
ALL CANADA (1954-1970)

Year	Chain Index (Binary Comparison)	Chain Link 1954 = 100
1954	100.00	100.00
1955	105.78	105.78
1956	92.29	97.63
1957	125.90	122.91
1958	103.36	127.04
1959	82.53	104.85
1960	102.26	107.22
1961	106.06	113.73
1962	95.19	108.26
1963	104.48	113.11
1964	96.17	108.77
1965	100.57	109.39
1966	102.55	112.18
1967	105.98	118.89
1968	93.14	110.73
1969	92.54	102.48
1970	103.12	105.68

1954 = $0.00969 per net-ton-mile

TABLE 12

INDEX OF AVERAGE FREIGHT RATES OF COAL
ALL CANADA (1952-1970)

Year	Chain Index (Binary Comparison)	Chain Link 1954 = 100
1952	100.00	90.22
1953	120.02	108.28
1954	92.35	100.00
1955	100.20	100.20
1956	93.73	93.91
1957	106.59	100.10
1958	99.80	99.90
1959	101.00	100.90
1960	92.68	93.51
1961	99.36	92.91
1962	95.27	88.52
1963	90.64	80.24
1964	97.64	78.34
1965	105.86	82.93
1966	104.09	86.33
1967	93.53	80.74
1968	98.64	79.64
1969	96.49	76.85
1970	85.97	66.07

1954 = $0.01002 per net-ton-mile

TABLE 13

INDEX OF AVERAGE FREIGHT RATES OF ALL MINE PRODUCTS, LESS COAL AND IRON ORE ALL CANADA (1952-1968)

Year	Chain Index (Binary Comparison)	Chain Link 1954 = 100
1952	100.00	95.19
1953	111.39	106.03
1954	94.31	100.00
1955	87.89	87.89
1956	101.56	89.26
1957	103.67	92.54
1958	98.57	91.22
1959	114.14	104.12
1960	98.12	102.17
1961	98.81	100.95
1962	91.67	92.54
1963	89.60	82.92
1964	93.81	77.79
1965	97.62	75.94
1966	94.64	71.87
1967	112.14	80.59
1968	97.38	78.48

TABLE 14

INDEX OF AVERAGE FREIGHT RATES OF FOREST PRODUCTS
ALL CANADA (1952-1968)

Year	Chain Index (Binary Comparison)	Chain Link 1954 = 100
1952	100.00	90.36
1953	113.21	102.30
1954	97.75	100.00
1955	94.40	94.40
1956	100.33	94.71
1957	106.96	101.31
1958	99.32	100.62
1959	111.68	112.38
1960	95.90	107.77
1961	97.29	104.85
1962	94.96	99.56
1963	99.81	99.38
1964	92.05	91.48
1965	99.32	90.86
1966	99.59	90.49
1967	99.79	90.30
1968	102.20	92.29

1954 = $0.01608 per net-ton-mile

TABLE 15

INDEX OF FREIGHT RATES OF MANUFACTURED
AND MISCELLANEOUS PRODUCTS
ALL CANADA (1952-1968)

Year	Chain Index (Binary Comparison)	Chain Link 1954 = 100
1952	100.00	97.20
1953	113.47	110.29
1954	90.67	100.00
1955	97.24	97.24
1956	99.67	96.92
1957	102.55	99.39
1958	99.21	98.60
1959	115.90	114.28
1960	97.21	111.08
1961	90.35	100.36
1962	97.14	97.49
1963	92.86	90.53
1964	98.69	89.35
1965	97.55	87.16
1966	95.76	83.46
1967	101.76	84.94
1968	93.12	79.09

1954 = $0.02788 per net-ton-mile

TABLE 16

INDEX OF PASSENGER FARES
ALL CANADA (1952-1970)

Year	Chain Index (Binary Comparison)	Chain Link 1954 = 100
1952	100.00	100.35
1953	100.00	100.35
1954	99.65	100.00
1955	100.00	100.00
1956	102.09	102.09
1957	101.37	103.48
1958	104.71	108.36
1959	96.78	104.88
1960	101.33	106.27
1961	102.30	108.71
1962	96.15	104.53
1963	96.00	100.35
1964	82.64	82.93
1965	103.78	86.06
1966	98.38	84.67
1967	103.29	87.46
1968	100.00	87.46
1969	107.57	94.08
1970	104.07	97.91

1954 = $0.287 per passenger-mile

APPENDIX III

A TEST OF SIGNIFICANCE FOR A LINEAR COMBINATION OF REGRESSION COEFFICIENTS

The following is a description of a statistical test of significance for a linear combination of coefficients of a regression: $a_1, a_2, \ldots, a_n$. I am indebted to Doctor Vittorio Corbo of Sir George Williams University for the approach. Examples of it can be found in this paper, in chapters VII and IX.

The test is built around the t-distribution. We will consider below a case involving two coefficients: call them a and b. We desire to test the two coefficients for mutual equality by employing the unbiased OLS estimators, $\hat{a}$ and $\hat{b}$ of a and b, respectively. That is, we wish to determine whether

$$a - b = 0$$

$$\text{or} \qquad r'A = 0$$

where A is the column vector of coefficients $\begin{pmatrix} a \\ b \end{pmatrix}$ and r is the row vector which defines the particular linear combination of regression coefficients: in our case $r = (1, -1)$. Defining $\hat{A}$ as the OLS estimator of A, we then form the ratio:

$$\hat{t} = \frac{r'\hat{A} - r'A}{\hat{var}\,(r'A)}$$

which ratio should be distributed as t, if our hypothesis is correct. Simplifying for our example, the hypothesis is:

$$H_0: \; r'A = 0$$

Therefore:

$$\hat{t} = \frac{r'\hat{A} - 0}{\hat{var}\,(r'A)}$$

Or:

$$\hat{t} = \frac{\hat{a} - \hat{b}}{\hat{var}\,(a-b)}$$

We can rewrite the denominator as:

$$\frac{\sum\left[(\hat{a} - \hat{b}) - (a - b)\right]^2}{N}$$

where N = the number of observations. Rewriting, we get:

$$\frac{\sum\left[(\hat{a} - a) - (\hat{b} - b)\right]^2}{N}$$

or, developing the square in the numerator, we get:

$$\frac{\sum(\hat{a}-a)^2}{N} \quad + \quad \frac{\sum(\hat{b}-b)^2}{N} \quad \frac{-2\sum(\hat{a}-a)\,(\hat{b}-b)}{N}$$

Which is equal to:

$$\hat{var}\,(a) \quad + \quad \hat{var}\,(b) \quad -2\,\hat{cov}\,(a,b)$$

Note that the formula for the variance in terms of deviations from the mean relies on the assumption that $\hat{a}$ and $\hat{b}$ are unbiased estimators of a and b. Note also that if we let r = (1,1), as in Chapter IX we get the alternative result for the denominator:

$$\hat{var}\,(a) \quad + \quad \hat{var}\,(b) \quad +2\,\hat{cov}\,(a,b)$$

In summary, our test is thus:

$$\hat{t} = \frac{\hat{a} - \hat{b}}{\hat{var}(a) + \hat{var}(b) - 2\,\hat{cov}(a,b)}$$

which can be evaluated by using the computer-generated results for $\hat{a}$, $\hat{b}$, $\hat{var}$ (a), $\hat{var}$ (b), and $\hat{cov}$ (a,b).

APPENDIX IV

DERIVATION OF A CAPACITY UTILIZATION SERIES FOR CANADIAN RAILWAYS

The derivation of a capacity utilization index for this study was accomplished by the use of L.R. Klein's "trend-through-peaks" method of estimation.[1] The method consists of the following: examining an output (total revenue) series for an industry; identifying certain observations as being "peaks";[2] establishing a (linear) trend line of this peak output by means of linear interpolation; then finally comparing the historical output levels with points on this trend line, to arrive at a series of percentages of utilization.

This capacity utilization series is used as a deflator for the observations on the level of the railways' capital stock for the estimation of a production function. The application of the capacity utilization rate to capital only, ignoring labour, is based on the assumption that output and labour input are sufficiently flexible to adjust quickly to fluctuations in demand, whereas the stock of capital

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[1] Department of Industry, Trade and Commerce, Rate of Capacity Utilization, Canada--Third Quarter, 1972 (Ottawa, 1972)

[2] That is, representative of capacity output.

is fixed in the short run. That is, variations in output are assumed to correspond to variations in the degree of use of the industry's physical plant.

Table 17 gives the results of the derivation procedure as applied to this study. Two methods were followed in computing the utilization rates. The first employed a trend line of peak output which was based on the years 1956 and 1970 as peaks. The second used an additional peak, 1959, in estimation of this trend line. The validity of using 1959 is in some doubt since it is a local, rather than a global, peak. Justification for its inclusion would have to be found in some strong indication that the railway industry's capacity, did in fact, decrease in the late 1950's. For a discussion of these two methods, see Chapter IX.

TABLE 17

RATES OF CAPACITY UTILIZATION--CANADIAN RAILWAYS

Year	Method 1: Rate of Utilization (%)	Method 2: Rate of Utilization (%)
1956[a]	100.000	100.000
1957	95.134	99.043
1958	85.895	93.103
1959[b]	88.617	100.000
1960	81.745	90.972
1961	80.536	88.458
1962	79.646	86.402
1963	81.211	87.059
1964	87.287	92.518
1965	88.857	93.170
1966	94.228	97.788
1967	95.052	97.667
1968	94.058	95.742
1969	95.831	96.668
1970[a]	100.000	100.000

[a] are defined as "peaks" for methods 1 and 2.

[b] is also defined as a "peak" for method 2.

APPENDIX V

TRANSPORT'S SHARE OF GNP IN A MATURE ECONOMY

In an unpublished paper, S.E. Peterson[1] argues that transportation's share of Gross National Product will logically decline in a mature economy. Although his remarks are addressed particularly to the rail industry, he supports them by reference to conditions in the transport industry as a whole. He gives three principal reasons for his contention. One is that, in a mature and developing economy, population density is higher--at least in the particular areas where most economic activity occurs. A second is that transportation expense, which includes money, time and inconvenience, is of the nature of a tax on production and economic man will seek to minimize this tax by means of industrial location optimization with respect to the ever-more-densely-populated areas of the country. Finally, he argues that the fastest growing elements of a mature economy are the service industries and these, he says, require less transportation inputs than the goods-oriented industries.

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[1] S.E. Peterson, "Monitoring and Control Processes In Relation to Corporate Forecasting--A report to Canadian National Railways", Montreal 1972. (Mimeographed)

On a priori grounds, these arguments may be met by others which are equally valid. First, it is not intuitively clear why increased population density should decrease transportation's share of GNP; whereas distances would likely be smaller, the number of movements and the quality of transportation service may both be expected to increase. Second, although transportation cost is a form of tax, it will be minimized only in conjunction with other production costs and, if it is relatively "cheaper" (in terms of time, money and convenience) than, say, property taxes or labour costs, then the mentioned minimizing behaviour will have less effect on whether transport's importance improves or deteriorates. Finally, there is no intuitive reason why a shift towards service-oriented industries would cause a shift in emphasis away from the transport industry, although this might be the case for rail carriers.

In any case, the dispute must be fought on empirical grounds since both sides of the question can be supported by theory. In this respect the following reflection of the Canadian experience is illuminating. Regressing the yearly index of total output of the Canadian transport industry versus the corresponding index of real domestic output, minus agriculture, we find the following results:[1]

$$\text{transport} = \underset{(-2.7)}{-8.0} + \underset{(40.6)}{1.087}\ \text{domestic output}$$

$R^2 = 0.99$ where the bracketed values are t-statistics.

[1] Statistics Canada, Real Domestic Product by Industry.

Clearly, the Canadian data shows the reverse to Peterson's expectations. For every percentage point increase in real domestic output in Canada over time, the transportation industry enjoys a 1.09 per cent increase.

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