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SURVEY OF METHODOLOGY AND PRELIMINARY ESTIMATES OF FISCAL INCIDENCE ASSOCIATED WITH THE DIVERSION OF TRAFFIC FROM RAIL TO ROAD IN MANITOBA

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SURVEY OF METHODOLOGY AND PRELIMINARY ESTIMATES OF FISCAL INCIDENCE ASSOCIATED WITH THE DIVERSION OF TRAFFIC FROM RAIL TO ROAD IN MANITOBA

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I. INTRODUCTION:

In 1967 the National Transportation Act formally incorporated a procedure to abandon grain dependent lines in the some 6000 miles of the Prairie rail network. In addition, experience in the United States indicated that bulk commodities such as grain could be profitably shipped over increasing distances using truck. The traditional technological relationships which had limited truck movements of freight to less than 500 miles were giving way to an improved highway infrastructure and new technology of transport.

Basic issues in transportation on the prairies are: first, the extent to which this modal shift, from rail to truck, actually exists; second, is it likely to become more pronounced - and if so, the fiscal implications of such a shift. The maintenance of rail infrastructure is primarily a responsibility of the national railways, and in the case of grain dependent lines the federal government. In the case of highways, primary responsibility lies with the provinces. If there is a significant shift from rail to truck in freight movement, then there may also be significant shifts in fiscal responsibility with respect to maintenance of infrastructure. To the extent that this shift is provoked by federal procedures and policies allow abandonment of grain dependent branch lines, then a case can be constructed for compensation of provincial governments.

This paper reviews the available evidence with respect to modal shift, especially as it pertains to grain movements. Although other products such as potash and general freight are increasingly moved by truck, it is difficult to assign this modal shift to explicitly federal policies relating to rail line abandonment. In addition, the magnitude of movements are well below any threshold levels which could be expected to produce specific road damage and hence they have minimal fiscal implication for provincial expenditures on the road network. Therefore, this paper concentrates upon grain movements since these have the highest prospect for producing estimable road damage.

The first part of the paper overviews rail and road freight operations in Manitoba and presents a conceptual model of the grain transportation and handling system. This section provides a "systems" review of the grain transportation system and identifies the major components to the estimation exercise needed to develop measures of fiscal incidence resulting from a rail/road modal shift of grain transport.

The second part of the paper considers the questions of freight demand and modal shift estimation, as well as the methodologies employed to estimate the fiscal impact of increased truck traffic upon road expenditures. As shall be demonstrated, the engineering questions underlying the relation between truck traffic and road costs are very poorly understood, and at this moment are under revision and further research. This, more than the econometric difficulties in estimating freight demand or modal shift obscure estimates of the fiscal incidence of increased grain traffic on the provincial road system.

The third part of the paper considers a "stylized" model of the fiscal incidence resulting from truck traffic due to rail line abandonment in Manitoba. This represents the type of analysis typically prepared by provincial highway engineers. The model is critically evaluated and a revised methodology proposed.

The final part of the paper presents a "qualitative" set of scenarios to "bracket" estimates of road costs resulting from rail line abandonment. Most important, is the basic point that given rapid change in the farm trucking technology, the economies of scale in farming operations and uncertainties in the relation between truck traffic and road costs, in particular bridge costs, the ultimate fiscal impact of additional grain movement being diverted from rail to road could range from a relatively small negative number (in the order of \$5 - \$10 million) to a reasonably substantial increase in expenditures on road maintenance and construction (in the range of \$25 - \$35 million). Even in the worst case, where there is a substantial fiscal impact, this typically will be less than 20 - 30 percent of annual highway expenditures.

This final section of the paper also represents a number of recommendations for further research and summarizes the appropriate methodology which should be employed to resolve this question. Despite the relatively small fiscal impact resulting from diverted traffic, this issue can be expected to become more important in the protracted negotiations surrounding the Crow rates. An essential condition to the satisfactory resolution of the fiscal incidence of rail/road cost shifts is agreement by both the Federal and Provincial Governments on an appropriate methodology. This more than the crude "back of the envelope" estimates of fiscal incidence constitutes the contribution of this paper.

II. THE GRAIN HANDLING AND TRANSPORTATION SYSTEM:

The most important diversion of freight from rail to road over the next decade will be with respect to grain. While these movements will be dominated by the need to move grain to export delivery points (Vancouver, Prince Rupert, Thunder Bay), a growing proportion of Prairie crops are specialty crops, destined in large measure to domestic or continental delivery points. This section of the paper presents a systems view of the grain handling and transportation system, surveys the basic features of rail and trucking operations and reviews the structure of the Manitoba trucking industry. The purpose is to provide a conceptual and descriptive framework for the discussion and analysis which follows:

1.0 Grain Handling and Transportation: A Systems View:

Over the past decade, the Federal Government has commissioned several investigations into the grain handling and transportation system on the Prairies. Most important are the Grain Handling and Transportation Commission (Hall), Prairie Rail Action Committee (PRAC) and the recent investigation into the Crow Rate revisions (Gilson). Emerging from these studies is a consistent vision of transportation issues in the three prairie provinces, which is intimately related to agricultural production, most notably the need to move the grain harvest to shipping points at Vancouver, Churchill, Thunder Bay and soon Prince Rupert. The following major trends are well documented, although they continue to contradict popular myths about prairie life:

- since the second world war there has been a persistent decline in farm populations, especially at grain delivery points;
- public services, in response to demand, have tended to be consolidated and relocated to regional cities away from the smaller towns and villages;

- average farm size has increased, the number of permit holders (Wheat Board) has fallen (especially in the last decade), the number of implement dealers declined by over 50 percent since 1970 and the number of country elevators declined precipitously;
- road transport of grains has been stimulated by larger, more widely spaced "high throughput" elevators, economies of scale in custom trucking and a more diversified agriculture which operates outside the traditional cooperative or marketing board system.

These trends point to a dynamic economy, undergoing significant change in response to new technologies and international marketing imperatives. None-the-less, persistent beliefs continue to confront those who would promulgate major change to the institutional framework of grain transportation and production. Specifically these include:

- rail-line abandonment will accelerate the demise of the small community;
- the railway is just as important to prairie communities as it was 50 years ago;
- rail-line abandonment will produce dramatic increases in the use of the rural road system, and hence place a considerable fiscal burden on provincial treasuries.

It is this last point which forms the object of this study. The general concensus of previous work, both by the Hall Commission and PRAC is that the induced road costs resulting from rail-line abandonment are slight. In particular PRAC noted that:

> "Rail abandonment will not cause large scale new road ton miles to be created. Most grain moves to alternate lines with few extra road miles. The present rate of grain elevator closures, if continued over the next decade, will be a larger factor in increasing road hauling distances than PRAC abandonment recommendations."

In addition, PRAC noted that the major damage due to road haulage would be on the secondary road system, and not on farm access roads or the primary paved system. Despite these conclusions they recommend:

> "That the Federal Government approve as compensation to prairie governments a lump sum payment based upon the incremental road costs occasioned by increased grain traffic resulting from rail-line abandonments. Payments are to be made for specific roads identified by the Federal Government (emphasis added) as being affected by rail-line closures. The sum to be paid within twelve months of such closures."

Of course, provincial governments have begun to assess the damage by farm trucks and a controversy between the federal and provincial governments is emerging over the true extent of this incremental road cost which may be assigned as a result of rail-line closures in particular and modal shift in general. On the surface, this issue appears to be a straightforward problem in engineering economics to assess the increased cost; however this is far from the case. Transportation systems analysis interweaves with engineering considerations to produce a seamless web of complexity. For example, both PRAC and the Hall Commission make no mention of the incremental cost of bridge upgrading, yet this is a real basis for claims for compensation resulting from increased road haulage of grain. Also the issue is really more complex than merely associating increased costs with more grain movements. Environmental factors in particular intervene to complicate any simple relation.

To properly appreciate the nature of the prairie transportation system, it is essential to review the general nature of grain transportation. All else pales in importance. This conceptual model shown in Figure 1 is based upon the work of Manheim (1980) and is a useful "first-cut" into the issue.

A typical transportation system is composed of three basic subsystems:

a. Transportation Sub-System. (Supply).
   This sub-system has a number of important elements.
   In particular there is:
   - technology which provides new modes, products (e.g. containers) and services (e.g. piggy back)
   - networks composed of links and intermediate transshipment points or modes

- link characteristics, of which the most important is congestion, that have prime influence on service parameters such as time (cost).
- vehicles (except pipelines and conveyor modes) of which the most important aspects are numbers in the system and operating characteristics (comfort, security, etc.)
- system operating policies which define the broad spectrum of technical and economic choice by creating network configurations and selecting the appropriate vehicle technology
- organizational policies comprising the entire structure of public and private institutional features governing the transportation system. An example of this would be the set of collective agreements conditioning the operation of transportation.

b. Activity Sub-System (Demand)

This sub-system comprises the set of social, economic and political decisions influencing transactions in a given region. These interactions determine the demand for transportation, and in part, they are influenced by transportation operations. In turn, the activity sub-system is comprised of the following elements:

- travel options are conditioned both by the perceived characteristics of the transportation system, and the basic need to move people and commodities.
- locational options again are in part determined by perceived choice presented by the basic infrastructure and by the need of the population. An example of this simultaneous determination is demonstrated by the tangled debate on the relation between transportation and economic development.

c. Flows (Equilibrium)

The confluence of the transportation sub-system and activity system is the production of flows over a network. As shown in

Figure 1, below, these flows can feedback and condition the transportation and/or activity sub-system or particular elements therein.

The entire transportation system is embedded into a general socio-economic and physical environment. The elements of this wider environment include national and international world demand for a region's commodities.

The grain transportation system specifically consists of the following sub-systems and elements:

a. Transportation, Handling and Storage
   - infrastructure (rail beds, roads, elevators)
   - operations (industrial organization of rail and trucking operations)
   - equipment (rolling stock, vehicle fleets)
   - costs, price
   - regulations, policies

b. Activity Sub-System
   - production
   - marketing (marketing boards, competitive structures)
   - processing (milling, refining, crushing)
   - consumption (final end use, feed grains)
   - policies (quotas)
   - prices (initial prices, futures prices, spot prices, etc.)

c. Flows
   - volumes and levels of service

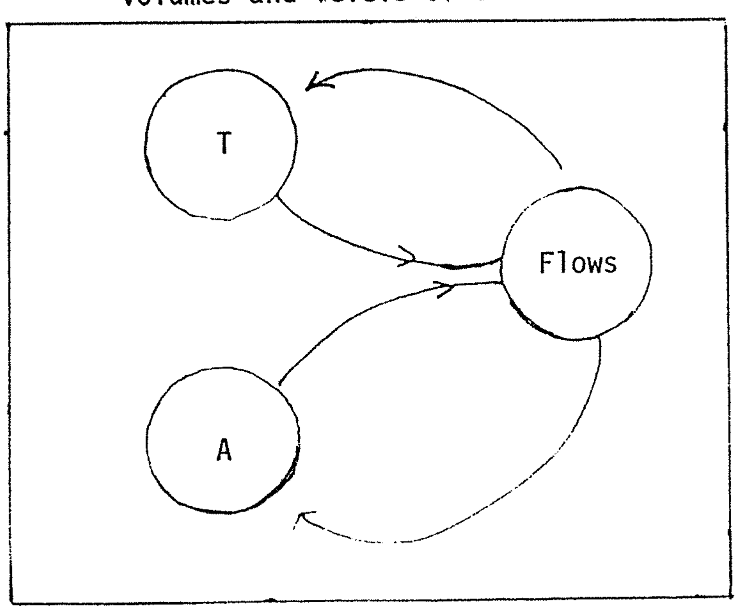


Figure 1.
A Systems Model of Grain Handling and Transportation

This simple description allows an identification and isolation of the specific issues underpinning the main question of the study. At the most general level is the fundamental demand for Canadian grain. Most discussion appears to assume that this will continue to grow, governed by the expanding human population and continued inability of many countries to produce sufficient food for their own needs. Two scenarios, one long term, the other short, could upset this assumption.

First, in the long term, there is the possibility that more countries will begin to solve their food problems. In the past, many developing nations, wishing to encourage much greater industrialization provided price support for their manufactured exports and let their agriculture falter. Now more are providing farm subsidies in an attempt to recover lost ground in domestic food production. For some, domestic food production is the essential first step toward internal social and political stability. An indication of this trend is that Bangladesh now faces problems in storing its grain surpluses, a dilemma completely unimaginable a decade ago.

In the short term, the increasing competition on international grain markets, and the potential subsidy war between the United States and the European Common Market countries could prolong the present soft prices for wheat and other grains. Already, low prices are producing important changes in the crops grown by farmers, the full effects of which are noted in more detail below. The overall framework for the activity system can be seen in the figure and tables below depicting recent trends in prairie and Manitoba grain farming.

In summary, the socio-economic environment in which the entire grain transport system is embedded could produce some important changes in the activity sub-system, and thereby influence the demand for transportation services. It is not inconceivable that past growth in export oriented grain production may taper in the future.

Another potentially important issue lies essentially within the activity sub-system. If wheat prices become weaker, more farmers may move into diversified crop production. Generally, these "specialty" crops are not marketed through a centralized agency (Canadian Wheat Board) or the cooperative movement (Wheat Pools), but rather, involve a direct and competitive relationship between the farmer and private processing companies. The implication of this increased diversity in agricultural products is that the spatial extent of production is wide, for two main reasons: First, as a risk minimizing strategy (with respect to dangers from drought and disease) the buyers (processing firms) would prefer to have the crop produced over a wide area. Second, the "market" or shipping points are not concentrated at one of four export shipping points. Whereas wheat and other export dominated crops are destined to these few shipping points, specialty crops tend to be shipped to buyers located throughout the prairie region. Consequently, trucks are predominant as the shipping mode. Of course a portion of the specialty crop is shipped abroad and to Eastern Canada, however, much less in proportion than the major grains.

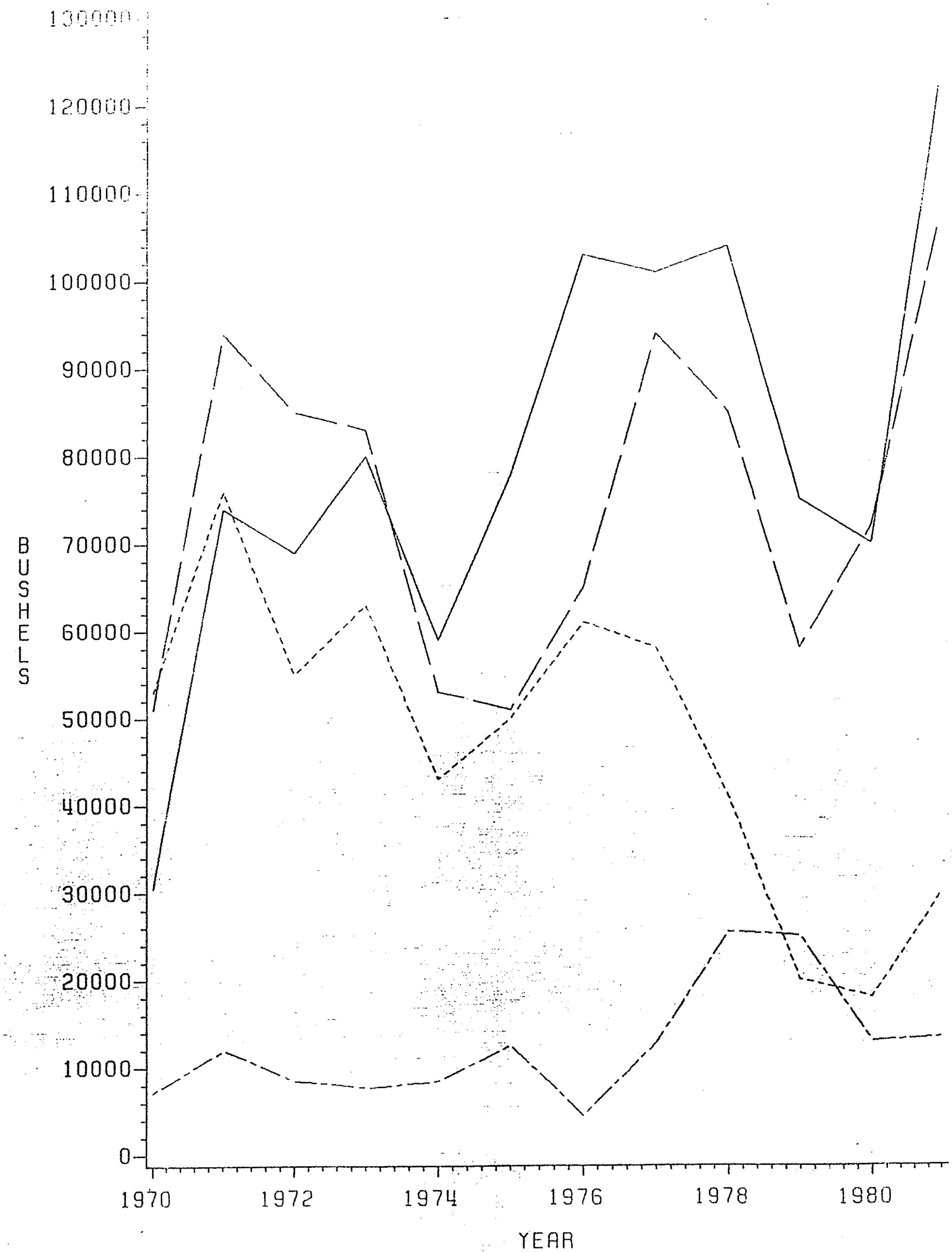
Table 1.
Major Grains and Specialty Crops
1981 - 1990

	Production in Millions of Tonnes	
	1981	1990*
Major grains and oilseeds	30.0	36.0
Specialty Crops	1.0	2.5

Finally, no overview of transportation in the West would be complete without a discussion of the Statutory Rate issue. It now appears possible that the Crow Rate in effect since 1897 (1925 in terms of Parliamentary legislation) may be significantly revised upward in the next several months. Actually, it is not correct to confine discussion solely to rate issues. Equally significant is the issue of rail-line abandonment which influences directly the shift of grain traffic from rail to road.

Since 1962, when the McPherson Royal Commission produced its findings,

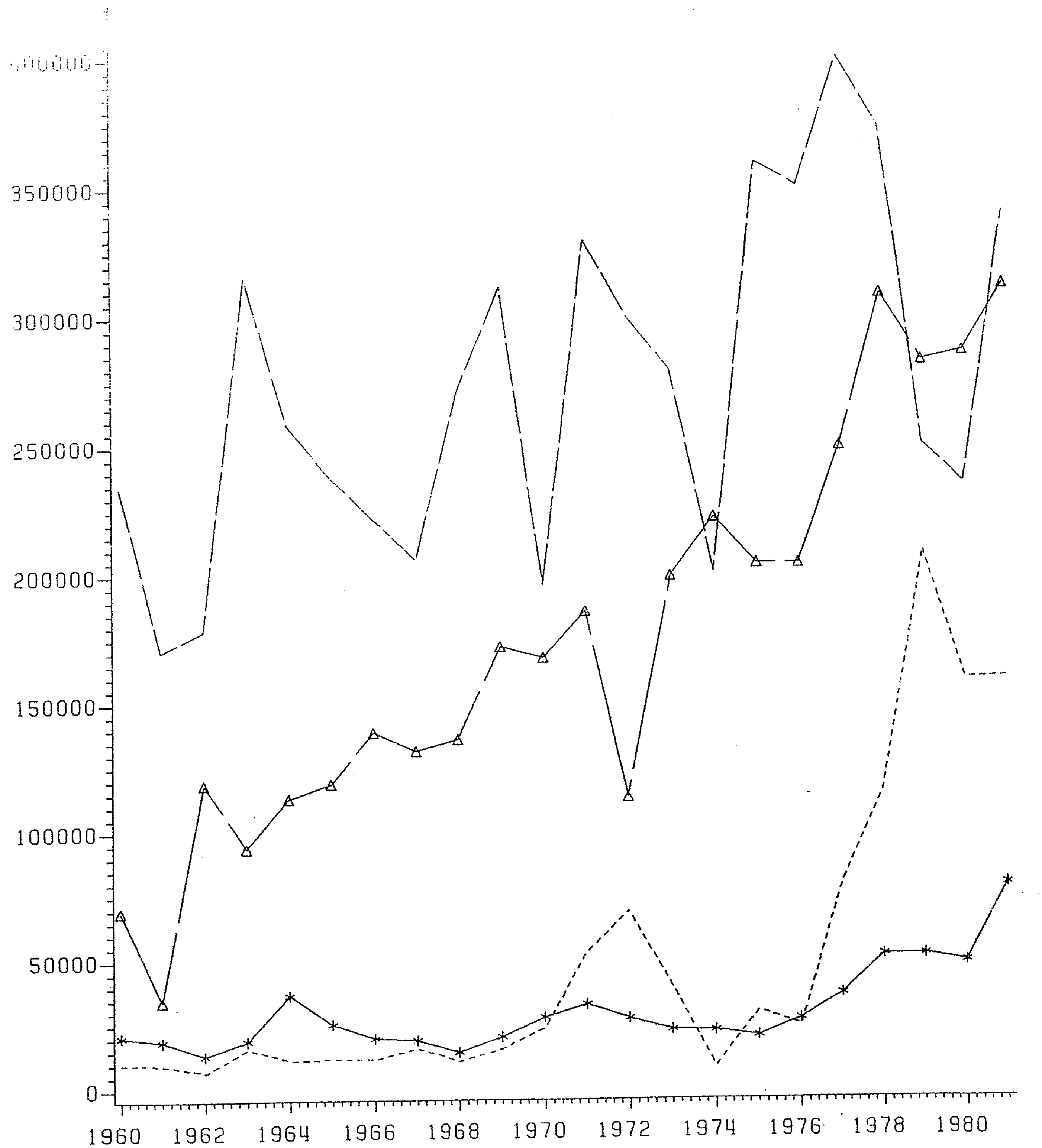
GRAIN PRODUCTION: MANITOBA



SOLID LINE IS WHEAT
DOTTED LINE IS OATS
DASHED LINE IS BARLEY
DOT-DASH LINE IS CANOLA

Figure 2.

TOP SPECIALTY CROP PRODUCTION 1960-81



STARRED LINE IS PEAS
TRIANGLED LINE IS POTATOES
SHORT DASHED LINE IS SUNFLOWERS
MEDIUM DASHED LINE IS SUGAR BEETS
ALL FIGURES ARE IN TONNES
DATA FROM MANITOBA DEPT OF AGRICULTURE YEARBOOK, 1981

Figure 3.

it has been generally conceded that the Crow Rate has been insufficient to provide revenue for that large component of the prairie rail network defined as "grain dependent". This grain dependency of large sub-sections of the rail network has evolved in the post war period as a result of a rapid expansion of the highway system, and the growing use of trucks to distribute most consumer and producer goods. The inability of the railway to recover sufficient revenue from these branch lines produced undermaintenance and serious deterioration in the rail beds. In 1967 the National Transportation Act permitted the Canadian Transportation Commission to accept and decide upon applications by the railway to abandon these uneconomic lines. The railway applied for massive abandonment, only a small portion of which was granted. To compensate the railways for upgrading of the branch lines retained in the system, a series of subsidies were authorized to retain these lines. The CN Rail will receive almost $300 million and the CP Rail almost $200 million dollars up to March of 1984 under this program. In 1977 the Hall Commission examined the entire network, and recommended 2,000 miles be abandoned with 1,800 miles to remain in the system until 2000.

The remaining 2,300 miles were proposed to be placed under a Prairie Rail Authority. In 1978 the Prairie Rail Action Committee considered these, and recommended 1,400 miles be abandoned with 1,000 added to the basic network. Another 600 miles have since been added to the guaranteed network. At the moment some 16,000 miles of rail line are guaranteed until 2000, much more than the railways desire. It should be noted that retentions of a line to 2000 effectively places it in limbo. No railway or handling company is willing to make substantial investment with only a 17 year planning horizon.

Associated with the proposed Crow Rate revisions is a massive investment in rail infrastructure (double tracking of the main lines, road development and purchase of hopper cars). In large part, these are the needed inducements to encourage the railways to continue maintaining the branch line network (since even a revised Crow may not cover costs) and to the farmer as assurance that the railways will provide higher levels of service than in the past. The recent purchase of 20 light diesels by CP is an indication however, of the railway's commitment to much of the present branch line structure.

In relation to the issue of road costs associated with increased use of trucking versus rail, the Crow package is fundamental. An efficient transport infrastructure is essential to grain movements and in turn, the nature of the transport development critical to the fiscal incidence of new construction. Taken to its logical conclusion, the Crow package will see increasing consolidation of main rail line, and increasing reliance upon larger trucks using the main provincial highways to move grain from the farm gate to the delivery point. Rationalization of transportation (moving to lower unit cost technologies) proceeds in step with rationalization of grain handling and production. If current trends persist, then we can expect to see larger (and fewer) farms and elevators, and correspondingly fewer delivery points, increased distances in road haulage from farm gate to the elevator, and finally larger and/or more trucks. It is this last question, namely the numbers and sizes of grain delivery vehicles which is of greatest significance for this paper.

The major elements of the problem can now be identified. First, the extent to which grain will be diverted to the road network from the rail system will obviously depend upon the overall growth in the demand for freight transport; in turn this is dependent upon the growth in the demand for agricultural produce from the Prairies. As noted, there is some basis for questionning whether past growth trends will be repeated in the next decade. Second, the extent to which any increase in freight movement is shifted to the road system is a function of several explicit decisions made both by the railways and provincial highways departments, and also by the farmers and trucking industry. In particular branch line abandonments will obviously condition modal shifts, as will expenditures made by the provincial governments with respect to secondary road improvements. In terms of individual decisions made by the producer and trucking firms, the choice of technology, in this case the decisions concerning the shipments of grain by owner operators (farmers) and commercial "for hire" fleets in the movement of grain may have profound movements on the ultimate volume of traffic on the road system. Third, and closely related to the second element, is the physical/engineering relationship between truck traffic and road damage.

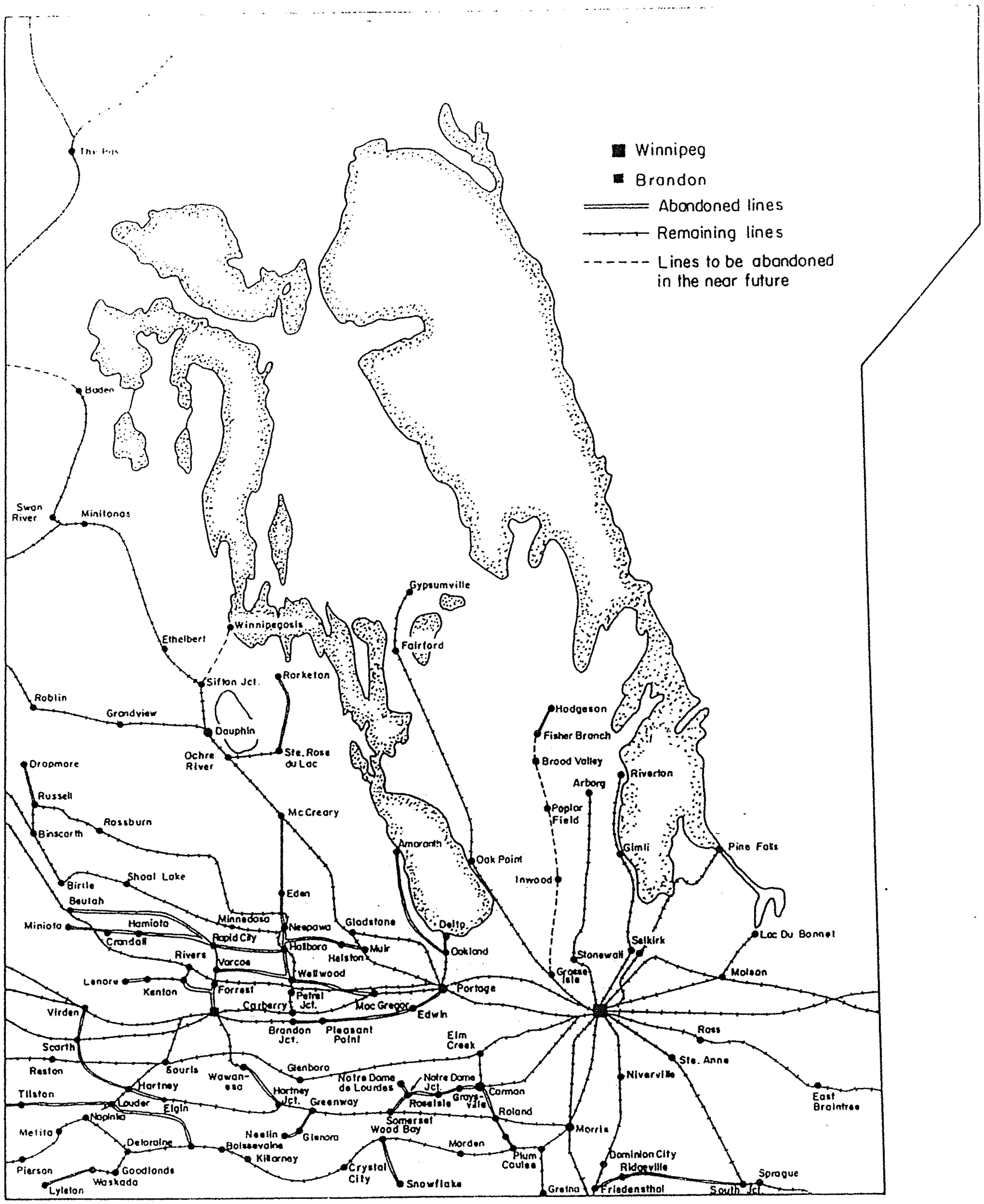


Figure 4.

Rail Network in Manitoba: 1983

The conceptual basis for estimating the fiscal incidence of diverting grain movements from rail to road can be demonstrated in a simple figure as shown below.

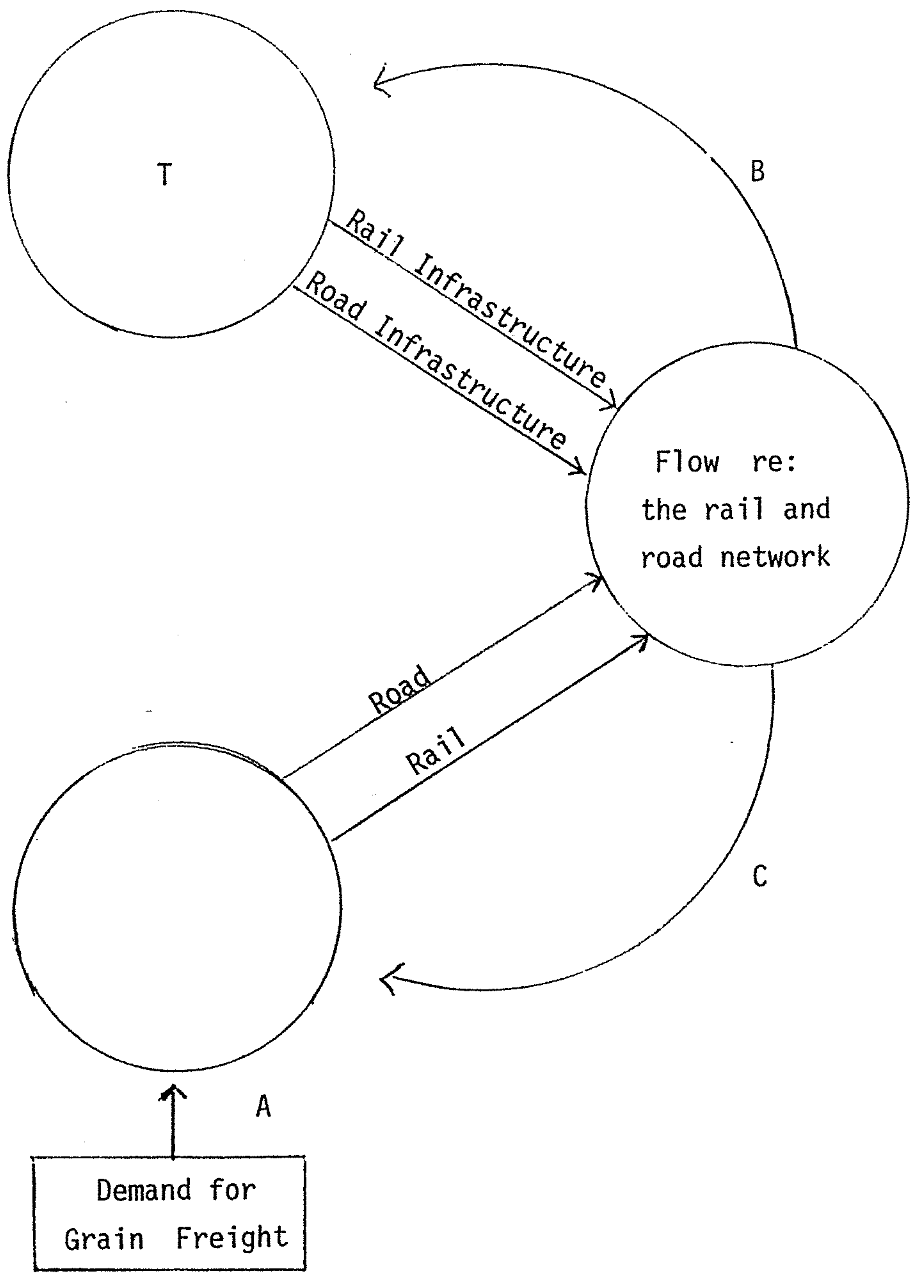


Figure 5.

Revised Systems Model
of Grain Transport

A. Influence of Prices on the Activity System

Two basic relationships are important here. First, the world demand for grain will clearly affect the demand for transportation services by way of directly mediating the amount of grain grown in total. Second, and more subtly, the ratio of the price of export grains (wheat, oats, barley, etc.) to specialty crops (peas, soybeans, etc.) will influence the "mix" of agriculture. The product mix of prairie agriculture will in turn tend to produce differential impacts on the rail and road system.

These two important factors are impossible to quantify in terms of their ultimate influence of the demand for rail versus road services, but must be considered when any transport forecasts are made.

B. Influence of Flows on the Activity System

Here, there is a potential influence on service levels encountered on the rail and road networks back to the crops which are actually produced. Part of the reason why prairie agriculture is turning to specialty crops may be the uncertainties encountered in using the rail - shipping port link. Interruptions in the forms of labour disputes, eventually do cost the farmer, and one way to reduce exposure to these risks is to diversify the crop. Of course, low and uncertain prices for export grains are probably the dominant factor in this shift toward specialty crops.

C. Influence of Flows on the Transport System

This link in the system contains the most significant relationships for the purposes of this study.

First, there is the choice of mode by the producer/shipper (farmer). Experience from the United States suggests that grain can be hauled over surprisingly long distances by truck. Data for Canada is unavailable, but the potential exists for some producers to exploit improved technology embodied in trucks.

Second, the organization of the trucking industry will respond to increased flows on the network. Individual shippers, as their farming operations grow, will exploit economies of scale and move to larger vehicles. Another alternative is for commercial trucking to move grain from the farm gate to delivery point. Finally, and perhaps most significantly is the operation of the trucker/farmer in leasing services to other producers. As shall be demonstrated below, many of these relationships fail empirically, simply for lack of suitable data.

Third, flows over the rail and road network have profound influence on infrastructure life and responses by the railways and provinces in terms of upgrading or renewal. The branch line problem basically stems from a deficiency of non-grain traffic which produces serious losses for the railways. Improved highways have both opened the possibility for general freight movements on the road system, thereby reducing the attractiveness of rail shipping for many commodities, and at the same time produced the problem which this study seeks to illuminate.

Fourth, there is the relationship between increased flows on the road network and the physical damage to the highway structure. As shall be demonstrated there is no simple relationship between volumes or weight shipped and road damage. In fact, the traditional relationships which have been used to design roads are now under fundamental revision, and these basic engineering relationships are very much in doubt. This considerably complicates estimates of the cost of traffic diversion from rail to road.

Before considering these relationships in greater detail, it is useful to present some descriptive material on grain production and transportation in Manitoba.

2.0 Manitoba Freight Movements

Table 1 presents the basic data on Manitoba rail traffic for the years 1979 and 1980 in terms of both origins and destinations. By far the largest part of this is through traffic. In general the traffic which is internal to Manitoba represents approximately 35 percent with respect to all traffic inbound and 20 percent with respect to outbound traffic.[1]

Table 2 presents similar data with respect to truck traffic in the years 1979 and 1980. It is immediately apparent that in terms of tonnage, rail dominates truck movements, but it must be pointed out that this table only presents "for hire" truck movements. A considerable volume of truck movements is undertaken by private and farm vehicles, however, estimates for this movement are unavailable on a similar basis as presented in Table 2.

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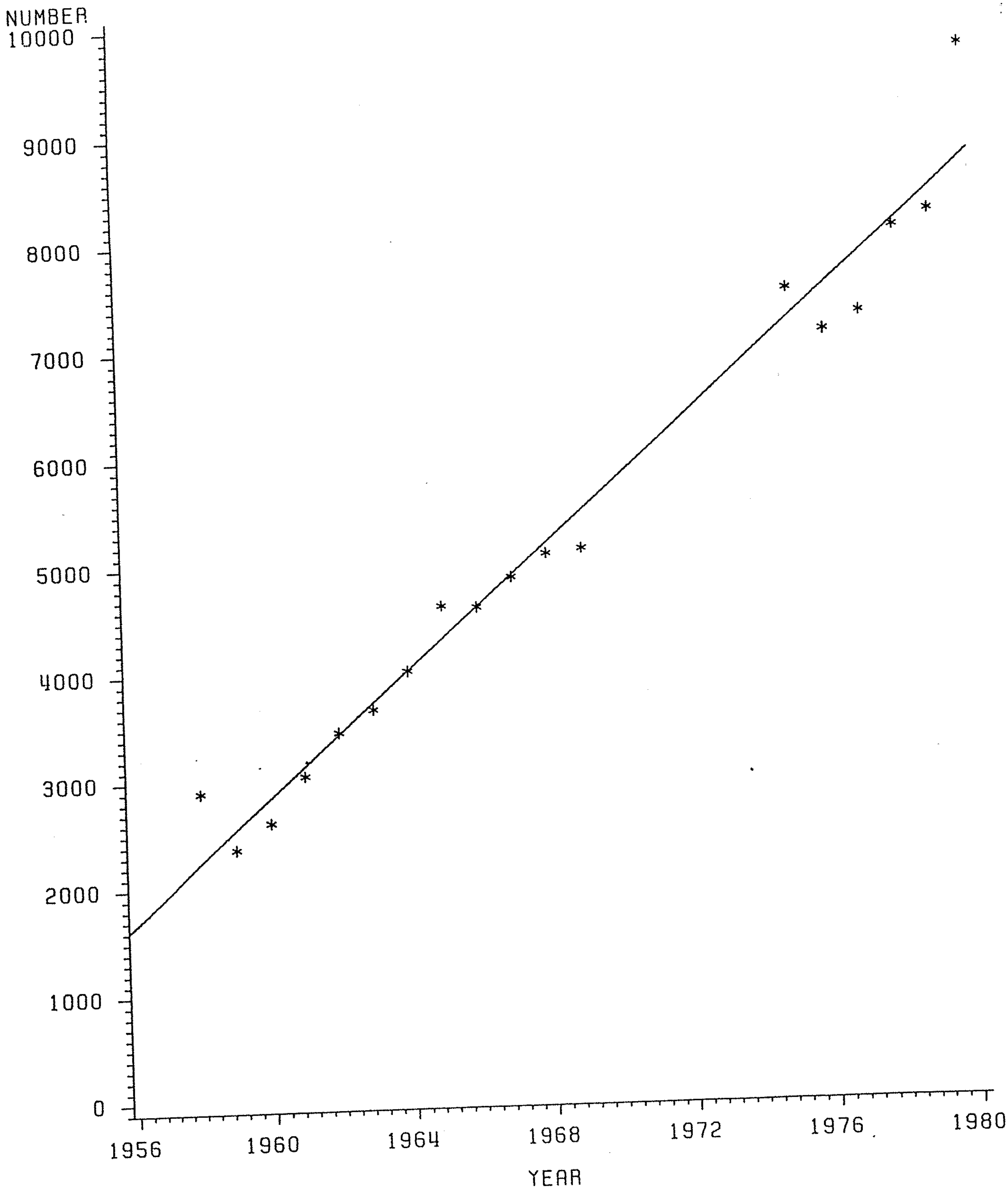
1. Note: Churchill, Manitoba is not serviced by road.

MANITOBA REVENUE OPERATED TRUCKS



SOLID LINE IS TREND INCREASE
DATA SHOW TOTAL NUMBER OF TRUCKS (ALL CLASSES) OPERATED ANNUALLY
DATA DERIVED FROM STATSCAN 53-205, 53-222, 53-223
1970:74 INTERPOLATED DUE TO LACK OF DATA

Figure 6.

TABLE 2.

MANITOBA RAIL TRAFFIC, 1979, 1980[1]
(TONS)

	Live Animals		Food, Feed, Beverages and Tobacco		Crude Materials, Inedible		Fabricated Materials, Inedible		End Products, Inedible		Special Types of Traffic[7]		GRAND TOTAL	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Western Canada[2]	28 24	0 22	278,826 336,027	125,129 138,102	661,502 470,526	659,305 655,612	780,552 799,046	620,385 388,833	15,705 14,310	65,589 62,081	130,721 140,629	251,362 282,246	1,867,334 1,760,563	1,721,770 1,526,896
Manitoba[3]	2,107 2,887	2,107 2,887	165,129 235,702	165,129 235,702	1,642,044 1,791,144	1,642,044 1,791,144	235,952 341,566	235,952 341,566	26,550 34,057	26,550 34,057	6,499 6,202	6,499 6,202	2,078,281 2,411,558	2,078,281 2,411,558
Eastern Canada[4]	1,089 620	23,207 16,035	243,850 208,809	481,149 539,865	106,337 76,871	345,554 255,314	487,698 524,498	528,293 560,688	271,604 285,942	20,006 24,219	626,589 670,871	354,134 380,419	1,737,167 1,767,611	1,752,343 1,776,540
U. S. by Rail[5]	-	-	58,739 75,742	11,746 34,467	89,436 137,358	167,760 160,055	114,512 146,468	422,967 463,571	39,779 52,782	5,368 5,287	12,396 15,965	392 236	314,862 428,315	607,931 663,616
Marine[6]	-	-	2,824 4,061	3,817,975 3,567,914	13,278 416	476,777 597,665	7,821 8,629	32,791 35,421	9,508 10,365	3,231 1,144	35,852 37,294	18,880 21,524	69,283 60,765	4,349,654 4,223,668
TOTAL	3,224 3,531	25,314 18,944	749,368 860,341	4,601,128 4,516,050	2,512,601 2,476,315	3,291,444 3,459,790	1,626,540 1,820,207	1,852,554 1,790,079	363,151 397,456	120,749 126,788	812,062 870,961	631,275 690,627	6,066,946 6,428,811	10,522,464 10,602,278

1. Derived from Railway Commodity Origin and Destination Statistics provided by Statistics Canada on microfiche. Figures represent traffic destined to or originating in Manitoba.
2. Western Canada includes B.C., Alberta, Saskatchewan and N.W.T.
3. Movements within Manitoba.
4. Eastern Canada includes Ontario, Quebec, New Brunswick, Nova Scotia, P.E.I. and Newfoundland.
5. Includes movements through other provinces as well as direct.
6. Includes all rail shipments handled by ports for international trade.
7. Includes container piggyback, mixed carload freight, freight forwarder and shipper association traffic, and non-carload shipments (L.C.L., Express, etc.).

1979 figures in larger type
1980 figures in smaller type

TABLE 3.

MANITOBA TRUCK TRAFFIC, 1979, 1980 [1]

(Thousands of Tons)

	Live Animals		Food, Feed, Beverages and Tobacco		Crude Materials, Inedible		Fabricated Materials, Inedible		End Products, Inedible		General or Unclassified Freight		GRAND TOTAL	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Western Canada [2]	30 33	4 22	119 68	226 186	90 91	16 75	286 418	328 196	117 92	246 221	30 11	4 28	672 714	824 731
Manitoba [3]	68 193	68 193	385 448	385 448	1,184 1,254	1,184 1,254	1,871 1,003	1,871 1,003	144 267	144 267	27 60	27 60	3,804 3,225	3,804 3,225
Eastern Canada [4]	4 5	7 47	167 133	207 236	11 4	47 17	218 340	283 195	71 132	99 105	14 15	40 22	485 633	683 624
TOTAL	102 231	79 262	671 649	818 870	1,285 1,349	1,247 1,346	2,375 1,761	2,482 1,394	332 491	489 593	71 86	71 110	4,961 4,567	5,311 4,576

1. Derived from Statistics Canada 53-224 For-Hire Trucking Survey, 1979, 1980, Figures include movements over 15 miles by for-hire carriers with annual revenues exceeding $100,000. International movements are excluded. Estimates are subject to varying degrees of error.
2. Western Canada includes B.C., Alberta, Saskatchewan, Yukon and N.W.T.
3. Movements within Manitoba.
4. Eastern Canada includes Ontario, Quebec, New Brunswick, Nova Scotia, P.E.I. and Newfoundland.
5. Numbers may not add properly due to rounding.

1979 in larger type
1980 in smaller type

2.0 The Manitoba Trucking Industry

The Manitoba Motor Vehicle Branch classifies trucks into four major classes based upon major use. These comprise "for-hire", "commercial", "farm", and "other" as shown in Table 4 below.

Table 4.

Trucks Licenced by Class, Manitoba 1981[1]

Licence Class	Number	Percent
Public Service	2,915	1.6
Private	15,263	8.3
Farm	66,308	36.1
"Other"	99,320	54.0
TOTAL	183,806	100.0

Public service or "for-hire" trucks are authorized to carry freight for compensation, and operate under a variety of regulations which govern routes and commodities. Farm trucks are registered to owners who, in the opinion of the registrar, engage in significant farm operations. Finally, "other" comprises vehicles used for private use (under 3700 kg.), publicly owned vehicles (generally within city limits). The distribution of trucks by weight is shown below in Table 5.

Table 5.

Summary of Gross Vehicle Weights of Manitoba Trucks by Type, 1982 [1]

Gross Vehicle Weight Range (kilograms)	Number of Trucks: For-Hire	Commercial	Farm	Other	Total
Under 4,001	128	8,702	38,571	69,133	116,534
4,001 - 6,000	22	1,304	4,603	2,267	8,196
6,001 - 8,000	16	462	3,260	736	4,474
8,001 - 10,000	46	451	3,867	1,057	5,421
10,001 - 12,000	69	474	4,166	1,478	6,187
12,001 - 14,000	62	488	3,990	786	5,326
14,001 - 16,000	20	139	505	180	844
16,001 - 18,000	7	35	223	125	390
18,001 - 20,000	58	172	1,218	483	1,931
20,001 - 24,000	83	285	1,645	900	2,913
24,001 - 28,000	45	117	67	271	500
28,001 - 32,000	43	39	25	105	212
32,001 - 36,000	49	64	24	184	321
36,001 - 40,000	934	644	290	955	2,823
40,001 - 48,000	102	12	5	16	135
Over 48,000	440	48	29	93	610
TOTAL	2,124	13,436	62,488	78,769	156,817

1. Source: Manitoba vehicle registration file, December 1982.

Farm vehicles are of most interest for this study and Tables 6 and 7 show the distribution of farm trucks by weight class (and assumed type), and the distribution of fleets. Typically, a grain farmer might own a half-ton pick-up plus a larger vehicle for moving grain to the delivery point.

Table 6.

Farm Trucks by Gross Vehicle Weight, 1982 [1]

Gross Vehicle Weight Range (kilograms)	Number of Farm Trucks	Percentage of Farm Trucks	Assumed Truck Type [2]
Under 4,001	38,571	61.7	1/2 and 3/4 ton
4,001 - 6,000	4,603	7.4	1 ton single-axle
6,001 - 8,000	3,260	5.2	2 ton single-axle
8,001 - 10,000	3,867	6.2	3 ton single-axle
10,001 - 12,000	4,166	6.7	4 ton single-axle
12,001 - 14,000	3,990	6.4	5 ton single-axle
14,001 - 16,000	505	0.8	3 ton tandem-axle
16,001 - 18,000	223	0.4	4 ton tandem-axle
18,001 - 20,000	1,218	2.0	5 ton tandem-axle
20,001 - 24,000	1,645	2.6	5 ton tandem-axle
24,001 - 28,000	67	0.1	6 ton tandem-axle
28,001 - 32,000	25	0.0	tractor and trailer
32,001 - 36,000	24	0.0	tractor and trailer
36,001 - 40,000	290	0.5	tractor and trailer
40,001 - 48,000	5	0.0	tractor and trailer(s)
Over 48,000	29	0.0	tractor and trailer(s)
TOTAL	62,488	100.0	

Table 7.

Manitoba Farm Truck Fleets, over 4,000 kg., 1982 [1]

Number of Trucks in Fleet	Number of Fleets	Total Number of Trucks
1	15,524	15,524
2	2,939	5,878
3	452	1,356
4	104	416
5	50	250
6	20	120
7	15	105
8	13	104
9	8	72
10	3	30
11	0	0
12	1	12
13 - 15	2	29
16 - 20	0	0
21 - 25	1	21
TOTAL	19,132	23,917

1. Source: Manitoba vehicle registration file, December 1982
2. These represent estimates from industry standards and should be treated as gross indicators. Within weight class, there is a distribution of truck types

Most farm vehicles are owned outright by the operator, but a small proportion are either leased, or subcontracted. (Subcontracting involves the lease of a truck and usually a driver). As Table 8 shows, only .2 percent of farm vehicles were leased or subcontracted in 1982.

Table 8.

Manitoba Leased Trucks by Type, Over 4,000 kg., 1982

Truck Type	Vehicles leased or Contracted	Lease Percent of Total Registered
For-Hire	758	38.0
Commercial	632	13.4
Farm	39	0.2
Other	320	3.3
TOTAL	1,749	4.3

Source: Manitoba vehicle registration file, December 1982.

III. THE IMPACT OF DIVERTED GRAIN SHIPMENTS ON THE ROAD INFRASTRUCTURE:

The previous section has served to identify the major elements of the problem and describe the basic infrastructure and transport flows within the Province of Manitoba. This section examines the main elements in more detail. In particular a summary discussion of freight demand and modal shift modelling is presented, followed by a summary of the engineering relationships between traffic volumes and road damage. As shall be demonstrated, conceptual problems and data deficiencies preclude a straight-forward resolution of the problem and estimates of the fiscal incidence of diverted road traffic will have to rely upon more "stylized" procedures.

1.0 Freight Forecasting

Appendix 1 presents a fairly complete review of current methodology in freight demand and forecasting. Essentially there are two procedures comprising a macro and micro approach. The macro approach is usually embedded within an input-output or regional econometric model. Population changes, induced demand for manufacturing and other macro variables are used to drive a demand for transportation relationship, in which freight rates and services factors do not play a significant role. This form of model is useful for developing a general analysis of freight demand, however the lack of validated regional econometric models has eliminated the possibility that one can develop useful freight forecasts, by commodity for a relatively small region such as Manitoba.

Micro models usually proceed by explicitly incorporating the service and price factors needed to model the demand for a specific transport service. Several models attempt to explicitly develop relationships by commodity and mode.

In general, freight forecasting has been a disappointment. Unlike passenger demand which is largely determined by population (except for airline traffic which is also heavily dependent upon incomes), freight demand relies heavily upon first developing a model of the demand for the underlying commodity. Where this is determined by international price movements such as in the case of export grains, prediction becomes difficult. The factors noted above (international demand for food and the vagaries of international grain pricing) are critical, and unpredictable.

Most analysis usually relies upon some form of trend analysis, whether this be the simple extrapolation that produces estimates for freight movement increase in the order of 2 - 3 percent per annum for Manitoba over the next few years, or the more sophisticated time series analysis described in the appendix.

2.0 Modal Split

Traditionally modal split has been estimated after the basic demand for freight services has been accomplished. Recently, as explained in the appendix, freight demand has been integrated with modal split in the form of generalized (and separable) demand functions which are capable of supporting analysis using duality theorems to produce consistent and estimable input demand equations. These estimates, while providing valuable insights into matters such as the cross price elasticities of demand, do not address what will be seen below to be the really critical question, namely the choice of transport technology, especially in the private trucking sector. Furthermore, the literature does not deal with the basic industrial organization issues of the trucking industry, especially as it pertains to the development of "for-hire" trucking versus private trucking. This is less a failing of the theory, and more the result of a very imperfect data base upon which to construct empirical models of modal choice between rail and trucking. The paucity of information relating to private trucking and the decision making/choice behaviour which prompts a shipper to elect to ship using their own vehicles versus a common or for-hire carrier has precluded the necessary analysis.

In summary, the freight forecasting and modal split literature has been reasonably successful in developing macro models of general national freight movements, but, because of data problems has not yet developed the regionally sensitive and commodity specific models needed to produce reliable predictions of such pragmatic questions such as the increased road traffic to be expected from both rail line abandonment and future grain production. The complexity of this problem will become more apparent in the sections below.

3.0 Considerations Relating to the Impact of Truck Traffic on Road Cost

A critical element in estimating the impact of additional truck traffic on provincial budget is the increased cost due to maintenance, upgrading and rebuilding. Although one might suspect that the engineering literature would provide relatively unambiguous conclusions on this matter, this is not the case. Great uncertainty exists on the physical impacts of truck traffic. There is face validity to the assertion that more heavy trucks accelerate damage and shorten the physical life of a road; there is little actual concensus on the magnitude of these impacts. The fact that the Road and Transportation Association of Canada (RTAC) has just commissioned a multimillion, multi-year project to analyse their questions demonstrate the degree of uncertainty and outright confusion in this regard.

Roads fall into two broad structural groups - paved and gravel. In general, the problem of road deterioration and traffic relates to paved structures, since a deteriorated gravel surface can usually be restored by regrading. Increased traffic may accelerate the need to lay down more gravel, the cost of which is not significant.

Paved roads are of two varieties, flexible (asphalt) and rigid (concrete). The flexible pavement usually consists of three strata:

- surface (asphaltic concrete);
- bare (gravel, stone and sand composites with or without stabilizing);
- subbase (additional material or preparation of the indigenous surface).

The rigid pavement consists of a surface of plain or reinforced concrete over a subbase similar to that used in flexible pavements.

The problem of designing structures to withstand repeated dynamic impacts produced by loaded vehicles is most often related to the major research used in the construction of the Interstate Highway System in the United States. Generally there are three approaches to the design of pavement structures:

a. Empirically Based Models

The major example of this approach is exemplified by the American Association of State Highway and Transportation Officials (AASHTO). In the design of the Interstate System, repeated trials were undertaken with a wide configuration of truck types, loads and pavement structures. From these experiments a comprehensive set of formulae to design roads were devised. It is important to stress that these formulae must always be recalibrated for unique loading and environmental conditions. To merely "gross up" the figures is not correct.

b. Deductive Procedures

Based upon what is known of the material's properties, it is possible to infer physical life, maintenance schedules and other features of roadway deterioration. This approach to pavement design is theoretically based, and should produce accurate results, provided one knows enough about the physical and chemical properties of the materials under stress. A potential problem with this procedure is that not enough is known about these properties, especially under extreme environmental conditions.

c. Systems Based Procedures

This class of design techniques is relatively new and may be reviewed as a blend of the previous two. Its use is not so much in the physical design of a particular road, but in the maintenance of a system. Shifting load and traffic pattern may be introduced into the model to find the optimum maintenance schedule.

All of these pavement design approaches suffer from the same general defects. First, roadway deterioration is long run and generally not amenable to laboratory analysis. While aspects of wear and tear may be simulated, the impact of environmental stress (freezing, thawing, flooding and wind) and its interaction with physical impacts cannot be so analysed. Second, there is a difference in impact between static loads, and dynamic load effects. Moving trucks present a varying load to the road surface which is a function of the road and load characteristics. Much of the current practice especially for bridge design used static loading concepts and measures when dynamic loads may be twice as large. Third, calibration of AASHTO formula require mobile monitoring devices, since overloaded vehicles can avoid the fixed scales, normally used to monitor truck weight and dimension. Fourth, while deductive methods offer significant promise in accurate prediction of design requirement and therefore the cost impact of heavier trucks, much more basic information is needed on the properties of the materials involved.

The general concensus is that more frequent, heavier traffic will produce lower service lives and increased maintenance. A question which is not addressed in the literature, and which could be potentially significant is the relation between service life and maintenance. Many appear to feel that maximum life is essential and roads should be built to last. An alternative view is to design roads with relatively short lives and reconstruct when necessary. Alberta follows the first approach, while Saskatchewan adopts a much shorter design life in its road constructions. The present value of costs associated with each of these differing philosophies is not well understood, but it may be that short design lives could be less expensive than the alternative "gold plating" approach.

A final and crucial point for this analysis is that Canadian highways are characterized by low traffic and extreme weather. The evidence is not strong that the cost impact of annual freezing and thawing on roads would be outweighed by even a doubling of truck traffic. There is no analysis available that sheds any insight into this basic question.

4.0 Summary

The difficulties in econometric estimates of freight demand, coupled with the uncertainties surrounding the relationship between truck traffic and road damage forces consideration of an alternative methodology to estimate the fiscal impact of diverted traffic from rail to road. This "stylized" procedure represents typical estimates produced in a number of jurisdictions and does portray a reasonable "first" cut into the problem. However, a number of conceptual weaknesses must be considered, as well as some of the general factors noted in the first section of the paper.

IV. INCREMENTAL ROAD COSTS ASSOCIATED WITH RAIL-LINE CLOSURES:

1.0 A Stylized Method of an Estimation of Fiscal Incidence:

There are a number of rough rules of thumb which permit the calculation of "back of the envelope" estimates of increased road costs due to rail-line abandonment. This section of the report outlines one approach, primarily to illustrate the general magnitude of costs involved. However, there are sufficient uncertainties associated with such an exercise to cause serious doubt about any estimate produced by all current costing methodologies used in highway impact analysis.

The following steps comprise the method:

a. Estimates of increased truck traffic due to abandonment;
b. Conversion of increased truck movements to an annual average daily traffic (AADT) and/or change in equivalent single-axle loading (ESAL);
c. Computation of changes in the physical life and/or maintenance requirements of the road bed;
d. Calculation of the change in net present value.

Each of these steps will now be discussed and evaluated.

a. Estimations of Increased Truck Traffic

All provincial highways departments maintain regular traffic counts on the links within their respective systems. In most cases, certainly on the secondary (gravel) road systems (termed provincial roads in Manitoba), this consists of regular sampling using road side counter (usually for one week out of the year). On the provincial highway systems (paved) this will be done on a daily basis, and around certain key junctions, two way traffic flows will be recorded.

Unfortunately, these counts do not permit the discrimination between cars and trucks, and give no indication of the weight of respective axle impacts. As a result, roadside observation is used to calculate the proportion of trucks passing a given point during a day a week. In some instances, the vehicle weigh stations may be used to corroborate data, but usually, a provincial average is applied to these links which are believed to be incurring a greater truck traffic due to modal shifts.

Usually, it is assumed, in the absence of direct observation, that in those areas where rail-lines are abandoned, increased traffic counts are due to solely a greater number of trucks hauling grain. For areas where grain dependent lines have recently been abandoned this is probably reasonable, but it is a risky assumption in other regions with a more diversified economic base. Observed increases in traffic are averaged using provincial truck/car ratios to obtain an increased average annual daily trip (AADT) count.

b. Conversion of Increased Traffic to AADT or ESAL

Once an increased figure for overall truck traffic is obtained for the secondary road network, one could proceed directly to certain engineering formula (usually simplifications of the AASHTO data derived from the mid-fifties) which provide some basis for computing changes in the physical life and/or maintenance requirements associated with changed traffic counts.

A more sophisticated approach is to convert the observed traffic into a number of equivalent axle loadings (ESAL). One can proceed by assuming the existing technology is in place, and that the assumed increase in grain traffic on the roads is carried by the average farm vehicle (about 18,000 pounds or 18 kip and capable of carrying about 200 bushels of grain). Each additional truck movement as computed by an increase in one unit of AADT is then equivalent to an added ESAL (1 ESAL = 18 kip).

A better approach is to recognize that trucking technology will probably change, especially under the impact of additional grain volumes. Producers may resort to increased use of larger vehicles, especially if longer hauls are required, or possibly they may utilize commercial trucking. As outlined in Appendix 2, 800 bushels of grain in a 74 kip vehicle has a lower ESAL than four passes of a smaller 200 bushel (18 kip) vehicle. (see Hall. Vol. 2, Chapter 3). The evolution of trucking technology, especially as implemented by the producer is a crucial variable in calculating the actual impact of increased truck traffic on secondary roads. Most studies assume a static truck technology, and those which speculate on any changed mix do not shed much light on the expected distribution in vehicle types and change over the next ten years.

c. <u>Conversion of Increased AADT (or ESALs) into Incremental Road Costs</u>

Assuming a constant trucking technology, there is no difference between using increased AADT or ESAL in the computation of incremental road costs. Some analysts employ the concept of reduced road life, while others calculate the increased maintenance costs associated with ensuring the original design life. There is an important and subtle point here. Roads have a design life which is related to both the traffic volumes and loads, plus the environment. As indicated in Appendix 2, engineering studies on the relation between road costs and traffic usually employ data obtained from the research done in the fifties associated with designing the U. S. Interstate system. From the perspective of western Canada, the greatest weakness of this work is that extreme weather conditions were never really properly integrated into the analysis. The few studies which did consider the impact of the freezing/thawing cycle concluded that this had a very dramatic effect on road life.

The work undertaken thus far for Canadian situations generally employs these formulae. For example, the study done in Manitoba employs the concept of a shortened physical life caused by increased traffic.

d. <u>Imputation of a Net Present Cost to Changed Physical Life</u>

This is a straight-forward calculation. Present construction costs are carried forward to the future, usually in constant dollars.

The difference between constructing the facilities at time t = K and time t = K-L (where L is the reduced life in years) becomes the increased costs associated with road damage.

The result of this aggregative analysis for Manitoba produces estimates in the \$20 - \$30 million range over the period 1977 - 2000 A.D. This represents the change in the net present value of expenditures occasioned by the fact that the life of the road system is reduced by increased traffic. Repair and renovation expenditures are discounted to the present (1982). It is interesting to note that the magnitude of expenditure represents about 20 percent of the present annual construction and maintenance outlay for the entire highway system (non-urban).

2.0 Evaluation and Suggested Methodology for Estimating Incremental Road Costs

Most highway departments, because of an impoverished data base are required to resort to a number of simplistic assumptions regarding the incremental road costs associated with modal shifts from rail to truck. The case of increased grain traffic associated with rail-line abandonment can be dated, and it then becomes reasonable to impute increased traffic on the system after that abandonment to increased grain traffic. The methods generally all employ simple averaging techniques, and a system of formulae (rules of thumb) which are well integrated into the engineering literature (which is not to say that they are particularly accurate).

Some of the weaknesses to this approach have been noted above. Perhaps the greatest problem however, is that there is no explicit recognition of the multifarious influences on road traffic. In particular, increased truck movements of grain are only in part due to rail-line abandonment. Equally important are the general trends noted above such as increased farm sizes, fewer producers, fewer delivery points and increased production of specialty crops. Except for the decline in delivery points, which is both a function of rail-line rationalization and a natural tendency toward economies of scale in grain handling, the other factors in truck traffic growth do not generally result from explicit policies to alter the rail networks, and therefore may not be explicitly assigned as partial responsibilities of the Federal Government. To properly assess the impact of rail-line closures and their attendant modal shifts requires considerably more elaborate methodologies, the elements of which are now sketched.

First, and foremost, the relationship between increased traffic and incremental road costs needs renewed research. To detail the specific research requirements is beyond the scope of this particular study, but crucial to any analysis is a more sophisticated consideration of the relation between physical life, maintenance costs, and environmental factors. Also significant is the question of design life. As mentioned elsewhere in this study, one can approach the infrastructure investment by designing roads to their maximum life, under the assumption that this ultimately is the most cost effective approach requiring fewer maintenance resources. However, this assumption is largely intuitive. It may well be that a road network embodying a shorter design life could be more economical in the long run, especially if environmental factors play a significant role in the durability of pavements and gravel. This issue is but part of a wider problem in the economic analysis of infrastructure investment and project appraisal in capital construction. In highways, the traditional relationships so long trusted by engineers are now coming under greater scrutiny in the face of major problems in the United States with the Interstate system.

Associated with these road design issues is the question of bridge impact. Few studies acknowledge that increased traffic has serious implications for bridge life and safety, yet especially when dynamic loads (weight which is moving) are considered, it is possible that the greatest impact is on the bridge system not the roads. None of the prairie provinces appears to have done much work in this regard.

Second, the issue of trucking technology is pivotal. An analysis of incremental road costs must properly assess the producers' decision-making and avoid simplistic assumptions about continued use of vehicles which happened to have been typical during the past ten years. At the very minimum, cross sectional surveys of motor vehicles use on farms are essential. From this, assuming that the present age of the vehicle is also obtained, it should be possible to predict the average G.V.W. of trucks on the farms, as well the mix of vehicles used by commercial trucking firms. Scenarios may then be properly constructed to estimate the effect of different producer decisions concerning the choice of vehicle. Even a doubling of the grain carrying capacity of the average farm truck may have a major impact in lowering the overall impact of increased truck traffic on the roads. As an aside it is interesting to speculate whether an accelerated capital cost provision which favoured larger vehicles might encourage increased use of such vehicles and obviate much of the problem of road damage.

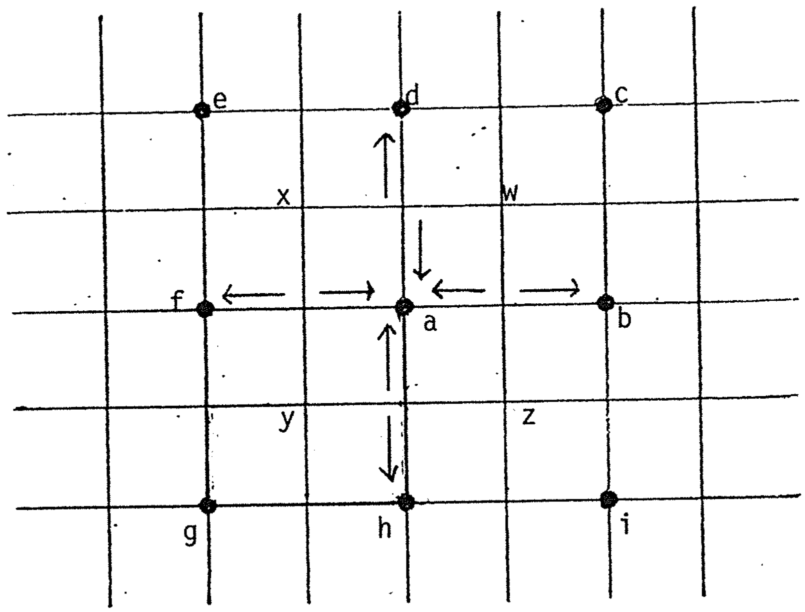
A third step toward a more sophisticated approach would be to undertake a complete survey of traffic, especially in those areas which have recently experienced the loss of grain dependent rail-lines. This could be a combination of actual surveys of producers and direct observation. Included in such a survey, would not only be an analysis of the types of trucks employed, but equally importantly, the route assignment of the changed truck flows. Most models which attempt to analyse the change in distance hauled when an elevator is closed assume that the next closest delivery point will be used. Many things intervene in the choice of delivery point including factors such as dealer preference, and the combining of grain delivery with other trip purposes. At the very minimum a probabilistic assignment over the road network is needed to provide an accurate picture of the true impact of increased truck traffic.

Fourth, and related to the previous point is the careful accounting for the particular links which are affected by rail-line abandonment and modal shift. It is safe to assume that the provincial trunk roads, which provide service from the farm gate to the provincial road would be at worst unaffected by any modal shift, and could even experience reduced damage especially as larger vehicles are employed. It is quite likely that the paved provincial highway system would suffer few ill effects since any increased grain movement would be sufficiently small as to make a measurement of impact problematic. Also, to the extent that commercial trucking was used to ship to more remote delivery points, the larger vehicles employed would not place undue stress on the road. It is the provincial road system, predominately gravel, which would bear the greatest impact of increased traffic. Yet, damage to this type of road is relatively easy to remedy. A simple conceptual model (from Shurson, 1971) assists in clarifying some of the issues.

Consider a transportation grid superimposed on a producing area as shown below in Figure 7, where the lines are roads and the circles are delivery points. The arrows indicate the typical route assignment around the delivery point "a".

Figure 7.

Route Assignment over Agricultural Shed



Since each of the agricultural sheds is square, the average hauling distance is given by:

$d = \frac{1}{2} (A^{\frac{1}{2}})$. (Where A is the area of the agricultural shed).*

It is possible to use this formula to calculate hauling distance and truck volumes as delivery points are reduced; or what amounts to the same thing as shed areas are increased. Figure 8 below is a reproduction of Figure 2.2 found in Shurson (1971).

It is possible to extend this analysis very simply to consider which routes in particular are directly affected by a withdrawal of a delivery point. Shown below is the figure from above, except that the delivery point "a" has been explicitly identified. Now, if "a" is

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* A represents the area of an agricultural shed (wxyz) therefore, the distance xy is $A^{\frac{1}{2}}$ and the average hauling distance is ½ of xy producing $d = \frac{1}{2} (A^{\frac{1}{2}})$.

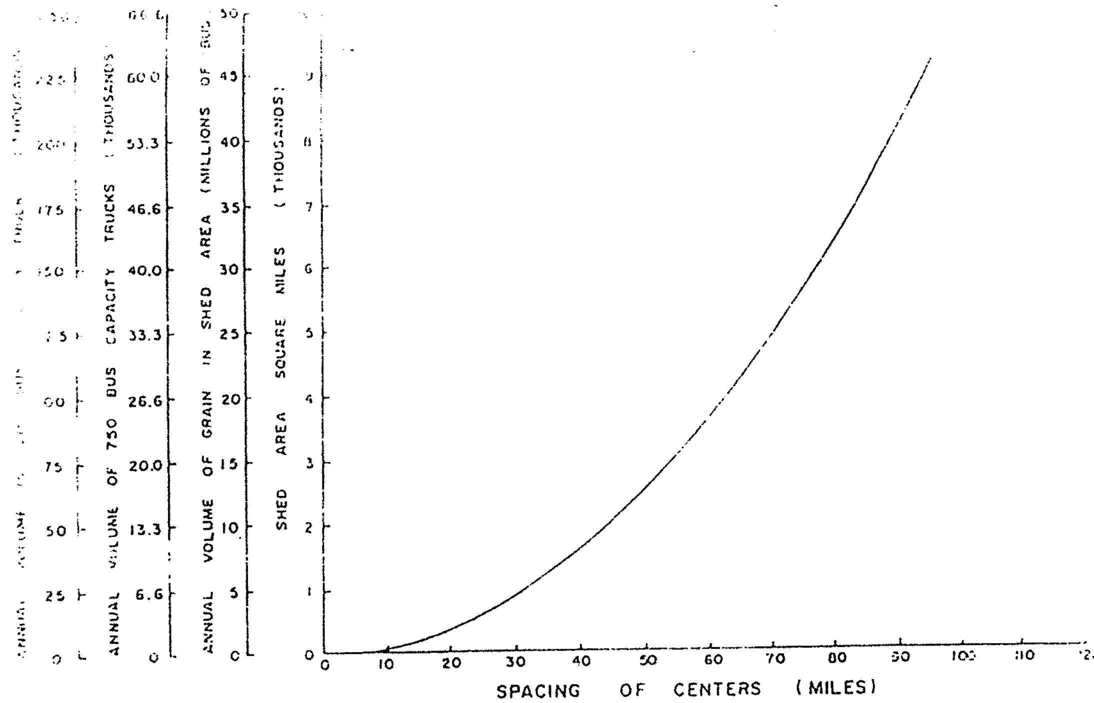
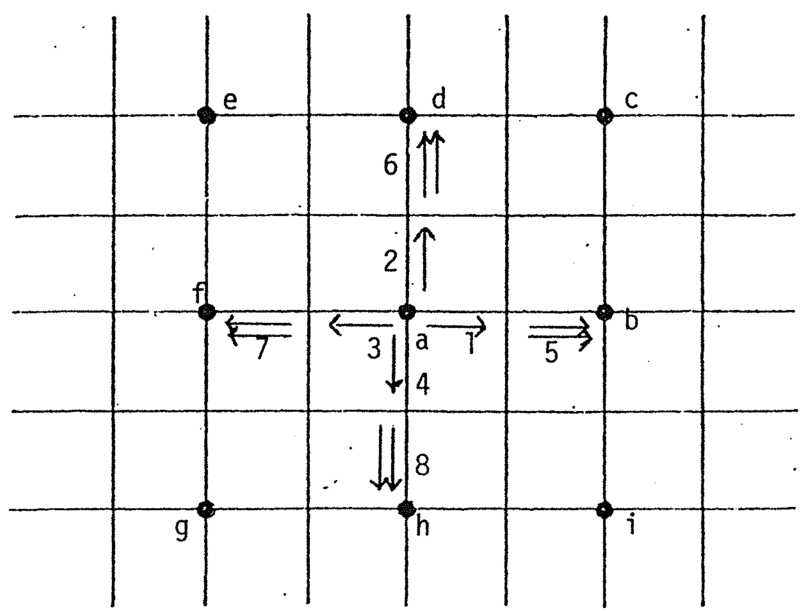


Figure 8.

SHED AREA, VOLUME OF GRAIN AND ANNUAL TRUCK VOLUMES AS A FUNCTION OF CENTER SPACING

withdrawn, the traffic remains constant on links 1-4, but increases on links 5-8 as shown below in Figure 9. This modal shift, due to closure of a specific delivery point, only affects half the road links in a particular shed, assuming shortest distance choices are made by the producer.



(a is deleted)

Figure 9.

Route Assignment Due to Delivery Point Closure

Consider now, the situation when two delivery points are eliminated in this grid such as depicted below in Figure 10. The producer located at node X has a total of 13 trip alternatives all of equal distance. Certainly, in a real world situation, there may not be so many competing routes and destinations, none-the-less, this simple model does illustrate the nature of the analytical and computational problem.

Also important is the possibility that route assignment may differentially "load" links on the network. *A priori* it is not possible to predict the specific traffic loading on any given link without a model of trip choice. Some routes will load less and some more, after rail-line closures.

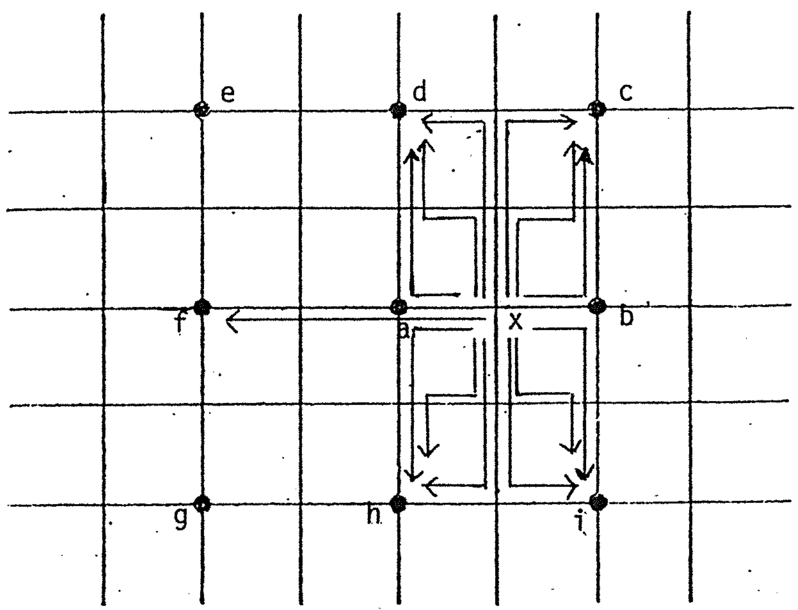


Figure 10.

Link Loading Due to Delivery Point Closure

(b and q are deleted)

In summary, any appropriate methodology to derive specific numerical charges accruing to the road network as a result of rail-line closures and modal shifts in particular must move beyond the simplistic aggregative analyses which predominate research at the moment. Efforts are underway to refine the road impact studies, as mentioned above and economic analysis must await this second generation literature. What is feasible (technically at any rate) is additional economic analysis on the following matters:

a. Decisions by producers on the technology of truck transport (i.e., choice of vehicle size).

b. Evolution of commercial trucking in response to modal shift.

c. Route assignment behaviour by producer.

3.0 Synthesis and Quantitative Scenarios

Starting with the total cost of some $20 - $30 million to 2000 as calculated by the Manitoba Government on the basis of a very simple aggregative estimation of the incremental road cost associated with grain dependent rail-line closures, what is the confidence region around such an estimate? One approach would be to vary parameters such as interest rates, but this has little scope for insight. Since this simple aggregative approach does not include the interesting behavioural relationship noted in the previous section, the most revealing approach is to undertake a number of qualitative scenarios, to examine the possible interactions between road changes and factors such as:

a. choice of transport technology;

b. mix of private and commercial trucking;

c. trip choice and destination choices by producers and commercial trucking firms;

d. overall changes in the mix of crops grown in Manitoba (i.e., the proportion of specialty crops);

e. overall growth in grain production;

f. overall growth in agricultural processing, especially meat packing.

Factor	Direction of Impact	Probable Magnitude
a. Retention of small (less than 200 bu.vehicle, private trucking)	+	medium
b. Increasing one of larger vehicles (commercial trucking, more than 50% in 750 bu.)	-	medium to large
c. Increased farm size and fewer producers	-	slight
d. Increased proportion of specialty crops grown	+	slight
e. Shortening of design life in road construction	?	?
f. Increase (doubling) of grain production (over next 10 years)	+	medium

Each of these factors has been reviewed above, but it is worth considering each briefly in turn by way of summary. First it seems clear that were small trucks to predominate in grain transport, there would be a significant increase in road cost as a result of rail-line abandonment. This may be taken as a baseline case reflecting the assumptions underlying the current estimation procedures. The second possibility is the increased use of larger vehicles, such as would be the case were commercial trucking to become a more significant mode. The potential impact of a widespread move toward larger vehicles could be very significant; perhaps even reducing any increased road cost from rail-line abandonment to zero or even lower (i.e., result in <u>lower</u> road costs overall).

The next set of possibilities relate more to the general environment in the farm economy. Fewer, larger farms are likely to be associated with the use of larger vehicles and/or commercial trucking and really should be perceived as a determinant of trucking technology. Greater productions of specialty crops, marketed outside of the centralized agencies, will produce a greater impact upon the roads, and increase, slightly, the road costs. Finally, if prairie grain production increases significantly, upward pressure on road costs may be expected.

In all, the range of \$20 - \$30 million in Manitoba for increased road costs associated with rail-line abandonment is reasonable under the assumption of a static transportation technology and agricultural environment. To the extent that the present trends toward rationalization in production and handling persist, and there is a sommensurate shift toward larger vehicles, these figures are an over-estimate. There is very little basis for saying there will be no impact on road costs from modal shifts, but equally there is no basis for claiming significant costs. In any case, even estimates of the net present value of increased road costs over the next fifteen years are only about 20 percent of the current annual expenditures.

Recommendations for Further Research

The very tentative nature of the findings in this report clearly argue for more research. Specifically, the following two studies are needed to better estimate the costs to the road network of grain transportation:

a. Survey of Farm Trucking Technology

Although there have been a number of surveys undertaken of farm trucking little is explicitly known about the probable adoption of alternative technologies. In particular, if farms continue to grow in size, and become fewer in number, the probability increases that producers will elect either to use larger vehicles or to use commercial trucking. A survey of present trucking technology correlated with other attributes of the farm operation would be useful at least in presenting a cross sectional view of the determinants of producer decision making with respect to the adoption of technology. This survey would have to include special questions which probed for the basis for adopting new transportation services, and go beyond the past surveys which have tended to inventory present vehicles.

b. Road Impact and Traffic

This research clearly is fundamental, not only to the issue at hand, but perhaps more basically to the entire question of maintenance and installation of the prairie road network. Work is proceeding, and economic analysis will have to await the conclusion of this research to prepare useable capital evaluations.

It is not suggested that the Council entertain these projects, but in the event that the issue of road damage arises in the context of the protracted negotiations over the Crow rate, or in the event that the provinces argue for substantial settlements for the damage caused by rail-line abandonment, it may wish to define an appropriate methodology for assessing these damages. This paper has outlined the major elements to such a study.

One concluding note is in order. It often appears that as we evolved from a rail dependent transportation system in the west, that new costs (such as road impacts) may be compensated by the cessation of other expenditures (such as branch line subsidies). Unfortunately, these costs are rarely offsetting and more importantly impossible to compare. There is no way to compare the variation in branch like payments (made to railways in compensation for their maintenance on grain dependent lines) with the variation in road costs associated with increased diversion of grain traffic to the highway system. Thus expectations that as one class of costs allegedly ceases others would increase in a matching and offsetting manner are unfounded. More than likely, a period will ensue during which the federal government will have to assume some responsibility for all classes of additional cost associated with grain movement.

APPENDIX I

ANNOTATED SELECT BIBLIOGRAPHY ON THE COST OF INCREASED TRUCK TRAFFIC

Annotated Select Bibliography on the Cost of Increased Truck Traffic

This bibliography is partial and serves to highlight the relevant work undertaken to analyse the increased road cost of truck traffic for Canadian and related experience.

Winfrey, R. "Economics of the Maximum Limits of Motor Vehicle Dimensions and Height" FHWA-RD-73-69,70:(Sept. 1968, Vols 1,2).

This study evaluates the impact on pavement structure for load levels of up to 30kip (single) and 50kip (tandem). [1]The AASHTO method was used with typical design and traffic factors. Loads and pavement thickness were varied with the following general conclusions:

- change in axle weight degrades pavement and shoulder structures;
- axle weight of 26kip (single) and 44kip (tandem) are feasible and gross vehicle weight (GVW) could rise to 120kip;
- axle weight and spacing can be used for regulation as GVW has no direct hearing on road damage.

Solomon D. et.al. "Summary and Assessment of Sizes and Weight Report" FHWA-RD-73-67 (Aug. 1971).

This is a critique of the work by Winfrey and makes the following points:

- the basic technical data are adequate;
- traffic loading has relatively little impact on pavement thickness;
- the various cost data (construction and operating) were adjusted to provide a sensitivity analysis which reduced the benefit cost ratio (reduced operating cost/increased road cost).

Walton, C.M., Brown, J.L. and Burke,D:"Assessment of Heavy Trucks on Texas Highways: An Economic Evaluation" Transportation Research Record: 725, 1979.

[1] 1 kp = 1000 lbs.

Two scenarios (status quo consisting of 20kip single, 34kip tandem and 80kip GVW and 26kip single, 44kip tandem, 120kip GVW) were considered in terms of the road cost impact. The general conclusions were that large freight tonnage should be confined to routes which are easier to maintain and maintenance costs decline with upgrading.

Phang W.A. Vehicle Weight Regulation and the Effects of Increased Loading on Pavement Ontario Department of Highways No. RR15. Nov. 1969.

Both flexible and rigid pavements are reviewed with respect to the cost implications of heavier truck movement. Rigid(concrete) roads were especially susceptible at the discontinuity between states. Upward revision in single axle loads from 18 to 24kip. This study used the AASHTO test deflection data, and no analysis of freezing and thawing effects was undertaken.

Clark M.F. Saskatchewan Highways and Transportation Presentation to Transportation Advisory Council on Vehicle Weight and Dimension.

The basic objective of this study was the proposal to unify trucking regulations for interprovincial freight movement. Recognized is that reducing axle loads or increased pavement thickness prolongs pavement life. Axle weight and frequency, not gross vehicle weight are the factors which reduce pavement life. Increased loads does increase road deterioration, however this is offset by increased greater effeciencies. Once again AASHTO procedures are used to establish recommended axle weight limits.

Raubert J. B. and Jordahl, P.A. "Effects on Flexible Highways of Increased Legal Vehicle Weight Using VESY-IIM" FHWA-RD-77-16 (Jan.1978).

A computer simulation model is used to evaluate pavement impact from increased vehicle weight. Significant features of the analysis are discrete axle modelling (spacing), seasonal variation of material properties and low temperature analysis. The model is calibrated using AASHTO Road Test data, as well as information from other evaluations. The main fundings were:

- Increasing axle load produces more fatigue cracking and rutting;

- pavement thickness reduces cracking and rutting;
- all environement produces cracking (except for the wet-no freeze zone) and cracking increases with colder ambient temperatures. In colder climates, low temperature failure was superimposed on fatigue cracking;
- earlier failure is associated with higher axle loading;
- service life is enhanced by accelerated maintenance (repairing);
- increasing axle loads increases maintenance to obtain a given standard of serviceability.

This is perhaps the most complete of the studies reviewed, but is based upon simulation of the basic AASTHO procedures. The model is not verified by controlled field trials.

Christianson, J. T., Shield, B.P.: "Evalution of the Relative Damage Effects of Wide Based Tire Loads on Pavements" Alberta Research Council HTE 175101.

This report presents the results of an experiment with two asphalt pavements which were fully instrumented to present data on failure. Measured were total deflection, strain at the asphalt subgrade interface, and vertical stress on the subgrade. The purpose of the test was to evaluate the relative impacts of wide base radial versus baisply tires on single and tandem axles. The conclusions were:

- biasply and wide base radial tires have the same damage potential;
- a single axle required about 60% of a tandem axle load;

Whitmae, P.P. et al, "Dynamic Pavement Loads of Heavy Highway Vehicles". Highway Research Board NCHRP1ON 1970.

This paper is noteworthy for its early attempt to grapple with the issue of dynamic loading. Traffic loads are a combination of both static and dynamic stress. The fact that dynamic loads are variable, greatly complicates the problem of analysing pavement performance. Dynamic loads are incorporated by over designing pavements based on conjectures about the ultimate impact. Road roughness, vehicle characteristics (weight, weight distribution) and vehicle speed appear to be the key variables. Using electronic monitoring and a series of step bumps, the study concluded that:

- vehicle suspension is not a factor;
- single axle dynamic loads are greater than that of tandem axles;
- dynamic loads are a significant proportion of the ultimate load presented by the static load;
- increased axle weight and speed produced higher peak dynamic loads;
- in general, dynamic loads can be as twice as high as static loads. In other words, a static load of 18kip per axle could in fact present a peak dynamic load of 36kip per axle;
- properties of the two can base major impacts on the dynamic load.

SUMMARY:

This appendix has presented an overview of the literature on pavement impact of heavy trucks. In general, this research is rudimentary and in some cases conjectural. The many complexities of material properties, plus the effects of environmental fluctuations preclude neat conclusions on this issue. There is no strong evidence that larger trucks will cause more damage and hence increase costs to road repair. It may be concluded that increased axle weight does reduce pavement life, increase maintenance requirement and increase costs. Some of the above mentioned studies argued that these increased costs are offset by the increased operator efficiencies. Indeed if larger trucks reduce the need to make as many trips, the actual impact on road surface may be reduced.

APPENDIX II

MODELS FOR FORECASTING FREIGHT DEMAND

APPENDIX

MODELS FOR FORECASTING FREIGHT DEMAND

INTRODUCTION:

The transportation of commodities appears to lend itself well to formal analysis using economic demand theory. First, it can be assumed that some sort of optimization process underlies commodity transport decisions - in general, the minimization of the total cost of the movement of the commodities. This means that models can be constructed which represent the costs of commodity transportation. The second freight transport demand is derived from the demands for the commodities themselves at points of consumption geographically separated from points of production. This is the case whether the commodity is to be used to satisfy a final or an intermediate demand. Therefore, the demand for freight transport can be directly related to production and consumption trends in the domestic and international economy. Models of freight transport demand should take into account both the costs of transport itself, and the demand for and supply of the goods which require transportation.

This survey discusses two related aspects of freight transport demand, namely forecasting transport demand, and the choice of shipper between modes of transport (modal split).

In the literature on forecasting the demand for freight transport, there are two basic types of models - micro-economic and macro-economic. Examples of models using the microeconomic approach, wherein the unit of study is the individual shipper, or firm, include the M.I.T. model, (Terzien 1975) and various similar cost-minimizing, profit-maximizing linear programming exercises such as in Daughety (1975), Friedlander and Spady (1980), and Oum (1979).

Macro-economic models include input-output models, spatial interaction (gravity) models, simultaneous equation models, and time-series models. Examples of macroeconomic models include those used by the CTC (1978) and Rao (1978).

MICROECONOMIC MODELS:

The focus of micro models is the single firm or individual as a decision-making unit. The procedure is to first specify the production function of the firm, (i.e., the relationship between inputs and outputs), is assumed to result from the firm's attempt to minimize costs (given the prices of various inputs) subject to a technical production function. The result of this optimization process is a set input demand equations. The demand for transport is derived from this input demand. In other words, the price of each input is re-specified to include its transport cost as well as its purchase price. The demand for transport is simply the volume of transport services required to move the least cost combination of inputs-plus-transportation. Modal choice can be introduced into microeconomic models like these, as it has been by Friedlander and Spady (1980) and (1981), so that demand functions are derived for transportation mode.

Such models are highly idealized and constrained by a number of assumptions. For example, the underlying production process is assumed to separable (i.e., there are no joint products) and prices of factors are assumed to be independent of quantities purchased. This last assumption is problematic with regard to transportation, since it is quite common for rates charged to vary as more commodities are shipped, or as a given quantity is shipped further, so that the price of the input "transportation" is actually not independent of the quantity purchased. With this complication, cost minimization can still occur, but this simple model is no longer adequate. Practical mathematical programming techniques are not readily available for dealing with functions wherein average transport costs decline with quantity. Other inadequacies include the omission of inventory (storage plus spoilage) costs and service uncertainty.

The first of these difficulties, inventory cost, is addressed by Friedlander and Spady (1980). They derive an explicit freight demand equation from a general cost function which recognizes the inter-relationship between rates and inventory costs. This makes shipping costs more accurate since they express both transportation rates and inventory costs. Inventory and transportation rates are assumed to be affected by the attributes of the shipment: value, density, length of haul, and size of shipment. Rate, average length of haul, and shipment size are then simultaneously determined using instrumental variables techniques. This specification improves upon the more general micro model. Daughety (1979) incorporates the effects of risk and uncertainty into his analysis, which also is an improvement in explaining actual behaviour.

The MIT model is a logit (binary choice) model which is quite general. A set of alternatives are open to each shipper, each being a combination of the attributes of the commodity to be shipped, the market attributes of the destination, the shipper attributes, and the service attributes of the mode of transport. The MIT model measures the probability that a shipper will choose a given alternative as a function of service, commodity, market, and shipper attributes. This model requires detailed cross-section data not easily found, and may require special surveys to obtain.

MACROECONOMIC MODELS:

Probably the most important Canadian macroeconomic transportation demand model is that of the Canadian Transport Commission (CTC). The model is a multi-modal, medium-term forecasting model. Since the demand for transportation is a derived demand, dependent on the state of the rest of the economy, structural variables describing economic activity in different regions are used to explain the demand for transport. The impact on transport demand of various changes in the macro-economy can thus be estimated. The model is linked to the CANDIDE macroeconomic model of the Canadian economy, although presumably other forecasts of economic activity may be inserted.

The CTC model is constructed to take into account changes in the structure of the economy, to which microeconomic models are insensitive. For example, levels of economic activity in different regions may change at different rates. Such alterations in the pattern of regional disparities can be incorporated into the model and their effects on freight transport demand be estimated.

Exploitation of new mineral resources, changes in consumption patterns, and changes in agricultural output can also be considered by a structural model of this type. The user simply specified values for "the state of the economy" and the model forecasts the demand for transport under that scenario. The demand for transport is derived from the demand for inter-regional trade, the magnitude of which is estimated based on the given scenario. Trade is postulated on clearing markets which feature excess demand or supply; markets with excess production transport commodities to markets with "excess consumption". The action of transporting goods is not "profit maximizing" in the micro sense. Rather, goods in excess supply for which there is a demand are assumed to be shipped as long as the cost of transportation does not exceed the price difference between the two markets. As excess production and consumption and/or the cost of transport, all of which influence the volume of transport demanded. Modal choice also enters the model, so that the costs of both complementary and competitive forms of transport influence the demand for each mode.

The CTC model is fundamentally different from its U.S. "counterpart", the MIT model. The MIT model uses microlevel transport variables to estimate demand; the CTC model uses aggregate structural economic variables. The MIT model measures the probability of a shipment taking place, given certain attributes; the CTC model measures the amount shipped between regions - thus MIT uses logit and CTC model uses regression analysis. While the main weakness of the MIT model is that it responds poorly to changes in levels of economic activity which can have a major impact on freight transport demand, the CTC model's weakness is that it cannot measure as well the impact of freight rate changes i.e., the elasticity of demand for freight transport by mode. Which of these weaknesses is the more important for forecasting freight demand depends on the relative changes in aggregate economic activity versus changes in rates.

Another type of macroeconomic model is the spatial, or gravity, model. With its characteristic multiplicative form. The volume of a commodity flowing between regions is seen to be proportional to a product function of the measures of economic activity in the regions and proportional to a decreasing function of the total cost of commodity transportation. In other words, the demand for transport is directly related to excess supply in one region, and excess demand in another, and inversely related to the cost of transportation. Models can be either unimodal (Black, 1972) or multimodal (Perle, 1965) and Mathematic, Inc. (1967-9). Perle's model explains transport by rail as a function of truck and rail freight rates, taking into account regions and types of commodities, but using dummy variables for production and consumption terms. Black's model relates transport demand to excess supply and demand. Kanafani (1983) considers Black's model too aggregative to use for forecasting, while in general gravity models require more data, and yet handle less well the determinants of demand and choice of mode than other transport demand models.

A third type of macro-economic model is the input-output model. Single region input-output models have been used for several transportation studies at the regional and national level, but generally for the purposes of broader economic planning and not just demand analysis. An example is the Sudan Transport Study by the ADAR Corporation (1974). Such single-region models are limited in their applicability however, because they can provide forecasts only at the gross national or regional level.

Input-output models have been extended to the multi-regional level in various studies, including Leontief (1970) and Chenery (1967). Multi-regional input-output models are complicated to construct; however, they are more adequate for modeling transportation demand, particularly in a regionally diverse country like Canada. Three types of multi-regional input-output methods have been used: the gravity method by Leontief, the column trade coefficient method by Chenery, and the row trade coefficient method, a variant of the column trade coefficient method. Like all input-output models, those used to estimate transport demand have restrictive assumptions. In particular the assumption of constant technological coefficients (a constant amount of any given input to produce any given output) is restrictive if the purpose is to estimate demand over a period when technology is being modified. However, for the purposes of freight transport demand, fixed coefficients do not pose a problem. An input-output model could be very useful in forecasting road and rail freight transport, considering the extreme interdependence of the level of transportation output and requirements and the level of activity elsewhere in the economy. Input-output is not essentially a forecasting system, but rather a system for allocating forecasted GNP among industries. Since most freight transport falls in the "intermediate" category, which does not show up in the GNP forecast, a projection of freight transport requirements (by mode if the tables are detailed enough), results. The quality of the results depends on the accuracy of the final demand estimates and the technical coefficients. The main problem with using input-output models is their cost, and the detail required to forecast a single industry.

Another method of modeling the transport sector is the time series method used by the CTC to complement its econometric model. Time series forecasts are mathematically difficult but conceptually simple. They rely on trends which have appeared in the past continuing into the future. They are most useful where institutional relationships predominate, or where unusual changes in the movements of variables are unlikely for some other reason. Like the other methods discussed they are relatively poor at long-term forecasts.

Freight transport can be adequately forecast for the short and medium-term (less than 5 years) because of the existence of traditional markets and sources of supply, long-term contracts, and ownership constraints, which discourage changes from past patterns of activity. Therefore, reliance on past behaviour to predict the near future does not seem unreasonable.

The CTC modeled the monthly movements of freight using both the ARIMA model and "Dynamic Regression". ARIMA forecasts are based solely on past trends, while the dynamic regression or "transfer function" approach, attempts to find associations between variables. At the same time, it treats both independent and explanatory variables as time series and models are constructed for each time series and the resulting residuals correlated. Dynamic regressions attempt to combine the benefits of forecasting by using trends with the benefits of using an understanding of the factors that influence changes in a variable. CTC investigations showed, however, that the explanatory power of regression analysis was often of less use for forecasting than projections based on the continuation of past patterns into the future. The CTC study attributed this partly to the complexity of transport demand, and partly to institutional constraints, difficult to quantify but paying a role dampening changes in transport demand variables, thereby improving forecasting record. Since results from dynamic regression models were only slightly better than from regular time series analysis, given its difficulty, dynamic regression was of limited use.

SUMMARY:

What is the relative value of macro versus micro models for forecasting freight transport demand? Essentially, this depends on the purpose of the forecast. Macroeconomic projections can serve as guides to national policy, and overall programs. They indicate how much transport is needed, and by what mode. Micro forecasts, on the other hand, best apply to specific links. They are useful in designing a particular facility and for forecasting volumes of traffic over a certain period of time. Micro models are concerned with choices of individuals: first whether to transport goods, and then by which mode to transport them. This is a substantially different concern from that of the macro models, which attempts to estimate and forecast the amount transported under varying economic conditions.

Which, if any, of these models might apply to the study at hand? At the core is the need to forecast the increase in traffic on provincial roads explicitly due to rail line abandonment. A first step in this task is to determine the trend in total truck traffic over time, not of any extra traffic resulting from rail rationalization. Forecasting this is complex using recent data, because rail lines have been continuously abandoned since 1967. Therefore, the appropriate data might have been from the pre-1967 period; however, time series models using pre-1967 data to forecast traffic from 1967 - 2000 are unlikely to be very accurate, if only because rates of growth of economic activity have slowed considerably since 1967. Consequently, it may be very difficult to differentiate between extra traffic from rail line abandonment and the ordinary trend increase in truck traffic. Nevertheless, it is a macro-type model which is necessary for this sort of forecast: micro models are clearly not appropriate when the need is to forecast overall traffic increase in the province.

Given the nature of transport demand, an input-output model might be the best to use for prediction, however, these models are enormously costly and time-consuming. The CTC model unfortunately concentrates on the rail and marine modes since these are federal responsibility; what is needed is to forecast truck traffic at the provincial level. Further, the CTC model aggregates wheat production nationally. In all, the CTC model does not appear useful for estimating provincial increases in hauling grain by truck. The CTC time series models may provide a useful reference for the use of time-series to forecast truck traffic with and without rail line abandonment.

SUMMARY OF TRANSPORT DEMAND FORECASTING MODELS:

In summary, it is clear that the models discussed above are not very useful for the purposes of estimating increased truck traffic in Manitoba.

Micro models of the type developed by Oum and others, are also not very useful. Perhaps their greatest limitation is that no route assignment is included in the decision-making process. These micro models are still quite aggregative in orientation, and while a model of the firm is employed, the route decisions of the individual firm are not explicitly incorporated into the analysis. Yet, as is explained in the main body of the text, it is this feature of the model a shift from rail to road which is of great significance for projecting the increase in costs of road maintenance.

In the first place, the micro models are not really applicable. Their focus on individual choice is inadequate when the need is to forecast overall trends in highway traffic, given certain changes in the rail system. This is first because farmers, faced with rail line abandonments have no choice but to truck their grain further than previously. Micro models of individual choice are not capable of dealing with this sort of circumstance. Should farmers decide to ship their grain by truck to port, or farther than the nearest grain elevator for reasons pertaining to service or price characteristics of the rail or truck mode, these decisions could be modeled with micro models such as that of Friedlander and Spady. The nature of grain: its bulk, low value and necessarily long shipping distances limit trucking. Competition between rail and truck is mainly for the carrying of commodities for which the service characteristics of trucks - speed, reliability, less loss and damage, etc. - give them some advantage although their rates are nearly always higher (see Rao). Therefore it is reasonable to assume that unless relative prices shift substantially export oriented grain will continue to be shipped as much as possible by rail, and any increase in trucking will consist of the increased distance from farm gate to a proximate delivery point.

MODELS OF MODAL CHOICE:

Models of freight modal choice are closely connected to models of freight transport demand. Wayne Cunningham (1982) describes four types of modal choice models.

Early models, particularly the "traditional" approach represented by Meyer et al, compared the historically-determined costs of transporting goods by rail and truck. Where goods were transported on the higher cost link, this was considered resource misallocation, and its cost measured by the rate difference multiplied by the value of the commodities shipped. These largely ignored service differentials, basing modal choice solely on costs. The weaknesses of traditional studies in areas such as cost measurement, cost aggregation, allocation of total costs among shipments, and ignoring quality of service made them inadequate for judging or predicting choice of mode.

Models of "revealed preference" also attempted to measure the amount of competition existing between rail and truck modes. Observations of the revealed preferences of shippers for each mode after shippers have selected their mode were related to shipment size, distance, commodity value and various other factors. A study by Rakowski (1976) showed that competition between modes exists for all but very long and very short hauls. Rail transport had a larger market share for long hauls, and bulky, low-value commodities. Surti and Ebrahimi (1972) also found that shipment size and distance explained most of the variance in traffic distribution in their study. Problems with these types of models arise mainly in the fairly arbitrary decision as to when modes are competing with each other.

Behavioural models, the class of modal split models recognize that the selection of mode may not be wholly rational due to incomplete information, and biases. Craig, (1973) developed a model incorporating three steps of modal choice - information search, decision making, and performance evaluation - which occur whenever a shipper transports freight. Irrationality enters the process because of the interaction of evaluation with information search; biases from previous evaluations can take the place of search, and active information - gathering occurs only when a previous choice has resulted in dissatisfaction. A study by Christenberry, cited in Cunningham, showed a moderately strong relationship between shipper's perceptions and modal split. Behavioural models make a contribution to the theory of choice in recognizing the impact of perceptions. Such models may be of use in modeling farmers' decisions to haul grain by small versus large trucks, or by their own versus a commercial truck.

Another type of mode choice model is the abstract mode model, also known as the first developed by Baumol and Quandt (1966). Baumol and Quandt theorize that the demand for transport was not dependent on any particular mode, but rather was related to the characteristics of that mode: speed, reliability, cost, and so on. People do not demand "train transport" but a particular set of attributes each with an imputed price. A mode is "abstract" in that it is only thought of in terms of its attributes, which could change over time or from link to link. Baumol and Quandt used this model for forecasting passenger travel demand, although it has been used for freight transport demand by Turner (1975).

Models of this type apply the concept of abstract modes and abstract commodities to mode choice. Ignoring inventory costs, the choice between two modes is made on the basis of a simple cost function (see Kanafani for an exposition), where cost per unit shipped on any mode is equal to the freight rate plus the cost of time (where the cost of time includes both the deterioration of the commodity transported and the cost of tied-up capital). The mode chosen for transport is the one for which costs are at a minimum. Clearly, this depends on the vector of the commodity characteristics as well as the mode characteristics, since the projected cost of deterioration and tied-up capital depends on the physical nature and value of the commodity. Mode, however, can affect this cost: for example, a mode with refrigeration available decreases the projected cost of deteriorization of perishable commodities. The service attributes of any particular mode determine the least cost choice for any particular commodity. A shippers indifference curves can then be mapped in modal space.

The abstract mode approach has the advantage that as modes change or new modes appear they can be incorporated easily into the model. However, one must question the importance of such flexibility here: first because new modes or the modification of existing modes is a long-term phenomenon, and second because the purpose of this study is to consider road and rail traffic. The model also requires detailed data on specific shipments. It presupposes the solutions to measurement of attributes and it does not incorporate behavioural factors which influence and explain modal selection.

An empirical test of this theory is found in McGinnis et al (1981). McGinnis' results are not surprising: those who ship by truck are most concerned with services like speed, reliability, and decreased loss and damage, while those preferring train have non-fragile products, large size shipments, and regarded speed and reliability as less important. The usual prediction about grain follows: grain will nearly always be shipped by rail. But this does not tell us anything about how much grain has to travel how far by road before it gets to the train. The most useful implication is that farmers are likely to haul their grain to the nearest rail connection, and not to one farther away. Of course this assumes that intervening preferences such as grain dealer attributes, or delivery point attributes do not intervene.

As well as the above deterministic mode choice model, there are stochastic mode choice models. Although the shipper is presumed to rationally choose according to the minimum cost principle, randomness appears in the choice function due to inaccuracies in the perception or measurement of costs, or other influences (i.e., preferences for dealers and delivery points). Binary or multi-nominal choice models can be applied at the macro level with commodity flow data or the micro level with individual shipper data. At the macro level, the models measure the proportion of individuals who choose a certain mode (or equivalently the probability that an alternative is the choice of an individual drawn randomly from the population); at the micro level, they measure number of times an alternative is chosen by an individual proportionate to the total number of times that individual chooses under the same conditions, giving once again a probability. Stochastic models seem to be better at prediction than deterministic models. (See Kanafani).

In their studies of inter-modal competition, both Boyer (1977) and Oum (1978) emphasize the importance of quality attributes, which had been largely neglected in earlier quantitative literature, (although texts like Kneafsey's (1975) presented service differences as the major factor in the historic shift of commodity transport from rail to truck). Boyer, for example, claims that previous studies vastly underestimated the economic value of service differentials. This underestimation meant that studies such as the one by Meyer et al, underestimated the relative cost of shipping by rail, and therefore led to the conclusion that small rail freight rate cuts would very effectively increase the rail share of the shipping market. In other words, the Meyer study (1959) overstated the price sensitivity of the demand for rail freight transport, because it understated the value of the greater convenience, reliability, and speed of truck transport. Boyer re-estimated the price sensitivity of modal split using a linear logit functional form estimated by ordinary least squares, and found that price sensitivity is only moderate; demand is sensitive to prices (a change in freight traffic with a change in rates = approx. 1) only when rail and truck split the share of traffic about 50/50, i.e., are close substitutes. Oum concludes from his estimates of elasticities that the rail and truck modes are highly substitutable in moving many commodities but not low value bulk goods like lumber and grain. Boyer does not find price elasticities to be as high as Oum and agrees that minor adjustments in prices would have little effect on volume of rail freight demanded. The conclusion about grain arising from Oum's study are true *a fortiori* of Boyer's study.

Oum also investigated the importance of quality variables in influencing the choice of mode. He found that speed and reliability were very important for shipping relatively high-value commodities such as fruits and vegetables, while less important for low value commodities such as lumber and metals. Further, the elasticity of demand for the rail mode decreases as distance hauled increases, due to the increasing cost disadvantage of trucks as length of haul increases. According to these conclusions, the demand for grain transport would be relatively unaffected by quality of transport characteristics. Consequently, if rail line abandonment were considered to constitute a decrease in quality of service, it is unlikely that farmers would switch modes. Boyer's estimates revealed that for goods which are largely carried by one mode (such as grain carried by rail) the price sensitivity of demand is low. From these two studies then, the tentative conclusion with regard to rail line abandonment (where it is squeezed into this framework!) is that even if it increases the price and decreases the quality of shipping grain by rail, grain will continue to be shipped by rail as much as is possible. High value farm products, such as live animals and specialty crops, are already shipped nearly completely by truck, so changes in the characteristics of rail transport will not affect them.

The conclusion that can be derived from this brief survey of mode choice models that none deal directly with the rail line abandonment situation although they do provide some insight into the nature of grain transport. Specifically unanswered is, how much traffic will be moving an increased distance due to rail line abandonment, and in what sort of vehicle will it move. The main problem with the first question is data. Detailed grain production data by locality is required, as are sound estimates of increased trucking distance. More difficult but certainly more important in determining the effect on roads of increased hauling of grain by truck is knowledge of the trucking technology. Faced with increased hauling distance, will farmers purchase larger trucks in order to reduce the number of hauls? Or will they opt for smaller, less expensive trucks and more trips? It would be interesting to construct a behavioural model of farmers' choice. Given cost of gasoline, trucks, and time, would the representative cost-minimizing farmer choose a smaller or larger truck? Microeconomic model choice models might have something to contribute here. But the choice of mode between rail and truck is never really at issue for grain.

Inter-modal choice is not, in the short or medium term, an important determinant of traffic. There are two major determinants of interest: the state of the economy (i.e., the level rate of growth, and regional distribution of output) and the abandonment of rail lines. Separating the effects of these and obtaining the data needed for forecasting is arduous. Examples of macroeconomic models include those used by the CTC and Rao.

MICROECONOMIC MODELS:

The focus of micro models is the single firm or individual as a decision-making unit. The procedure is to first specify the production function of the firm, (i.e., the relationship between inputs and outputs).

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