THE UNIVERSITY OF MANITOBA

THE POTENTIAL FOR SOLID TRAIN MOVEMENTS OF GRAIN IN EASTERN CANADA

by

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ABSTRACT

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By 1985, the demand for Canadian grain is expected to increase by approximately 50 percent. As demand increases, eastern Canada's grain transportation system will be called upon to move a level of grain far exceeding any past performance. Traditionally, eastbound grain has been moved aboard lake vessels. During the past decade, the Great Lakes fleet has operated near maximum capacity. In order for the transportation system not to be a constraining factor alternative grain handling methods must be ascertained. As suggested by this thesis, an alternative mode which could be utilized is to move grain by solid train direct from the Prairies to eastern destinations.

The general objectives of this thesis are to examine the physical and economic feasibility of solid train movements. A model is therefore developed in order to determine the least cost movement of grain through eastern Canada. The model is examined under four different scenarios. The first solution examines the transportation system as it exists today. The remaining three scenarios simulate the optimal grain flow patterns resulting from the various levels of demand the eastern sector may

face by 1985. From the analysis it is possible to develop policy prescriptions regarding the rationalization of eastern Canada's grain transportation system.

Throughout the analysis the direct rail routes consistently perform as a least cost alternative. The cost advantages of direct rail movements are evident from two main sources. The first source of reduced cost lies with the efficiency gained from solid train operations. Secondly, grain railed direct from the Prairies is able to avoid the costly step transloading at Thunder Bay. The use of direct rail routes provides a potential increase in eastern Canada's grain handling capacity. Solid train movements out of Thunder Bay also increase capacity; however, unlike the direct rail routes, rail movements out of Thunder Bay result in an increase in average transportation cost.

In the absence of any all-rail movements, eastern Canada's ability to export grain will be limited to approximately 11.3 million tonnes. If export demand reaches the expected level, potential grain sales will have to be foregone. As demonstrated in this thesis, solid trains provide a feasible method by which to increase eastern Canada's export capacity. Solid train movements, if properly used, can also reduce the average cost of transporting grain in the eastern sector. In addition to increasing capacity and decreasing costs, all-rail routes enable eastern ports to function on a year-round basis.

With the use of solid trains, the eastern transportation system can potentially satisfy the level of domestic and export demand expected by 1985. However, unless the eastern transportation system includes solid trains, Canada's grain movement goals may well not be realized.

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Chapter I

INTRODUCTION

1.1 PROBLEM STATEMENT

Canada at present faces a myriad of complex transportation issues. Historically, the movement of grain has been the subject of considerable political and economic concern. Within the Canadian economy, grain retains an important position in terms of both export trade and domestic consumption. Given the national prominence which grain enjoys, it seems logical that grain transportation in Canada should be as efficient as possible. However, similar to many systems which have developed over a number of generations, the transportation of grain encompasses a variety of practices and procedures which fall short of their potential. The complicated interaction between various grain related factors along with the harsh geographic nature of Canada serve to exacerbate the problems inherent in the movement of grain. In order for Canada to achieve its handling potential, various transportation problems must be overcome.

The Prairie Provinces are generally considered as the major production area for Canadian grain.[1] Grain which is delivered to the primary elevator system is later moved to one of three port areas--the West Coast, Churchill or Thunder Bay. The utilization and final destination

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[1] During 1969-78, the Prairie Provinces produced 88 percent of Canadian grain--grain in this context refers to wheat, oats, barley, rye, flaxseed and rapeseed. Canada Grains Council, Canada Grain Industry Statistical Handbook 79 (Winnipeg: Canada Grains Council, 1979), pp. 9-11.

of grain determines its transportation mode. Thus, the grain destined for Churchill and the West Coast moves directly to the port by rail, is cleaned there and subsequently loaded onto ocean-going vessels for export. For eastward movement of grain, however, Thunder Bay is generally considered as an interim cleaning and collection point prior to further shipment east via the Great Lakes-St. Lawrence Seaway system.

Shipments of grain to eastern Canada include grain for domestic as well as export purposes. Initially, domestic and export grain moves via similar methods; however, after domestic grain arrives at eastern transfer elevators, it is distributed to local sites rather than being loaded onto ocean vessels for export. Domestic demand in eastern Canada is considered to be relatively stable since it depends largely upon livestock and human populations. Export demand, on the other hand, is basically a function of world weather conditions and is, therefore, likely to fluctuate greatly from year to year.

In addition to serious concerns about whether Canada can produce enough grain to meet export demand, the major challenge presently facing the grain industry is its ability to deliver adequate quantities of grain to export positions. Given world trends for demand and supply, foreign demand for Canadian grain is expected to rise dramatically. The Canadian Wheat Board estimates that by 1985 the export demand for Canadian grain will be approximately 30 million tonnes per year,[2] as

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[2] H.F. Bjarnason, "Distribution of Exports and Demand Trends," an address to the Canadian Co-operative Wheat Producers Meeting, Winnipeg, July 13, 1978, p. 10.

compared to our 1977-78 record export level of 21.5 million tonnes.[3] Figure 1 illustrates the expected export demand for Canadian grain.

In view of the expected increase in export demand, the grain transportation system must either keep pace or else become a constraining factor. In a situation where the transportation system restricts the supply of grain, the potential demand remains unsatisfied. The resulting disequilibrium between supply and demand translates into a reduction of potential grain exports. According to some observers, transportation and handling limitations have, in recent years, placed a ceiling on the amount of grain which Canada can export. Had transportation been available in 1977-78 when demand was high, Canada could have increased grain exports by 4.5 to 5.5 million tonnes.[4] Inability to meet demand is undesirable for the Canadian economy in general and grain producers in particular. Given the assumption that satisfying export demand will continue as an important economic and social goal, it is logical to contend that the present grain transportation system will require substantial improvements.

Basically, there are two means by which to increase Canada's grain handling capacity. The first method is to provide an extended and more efficient use of the present facilities. Secondly, new facilities or operational modes could be introduced to augment the current system. Given these two alternatives, there exists a variety of methods and locations where improvements could be instituted. Each possible type of

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[3] H.F. Bjarnason, "International Market Trends in the Future," an address to the Seventh Farm Leaders' Course, Winnipeg, February 26, 1980, p. 15.

[4] Ibid.

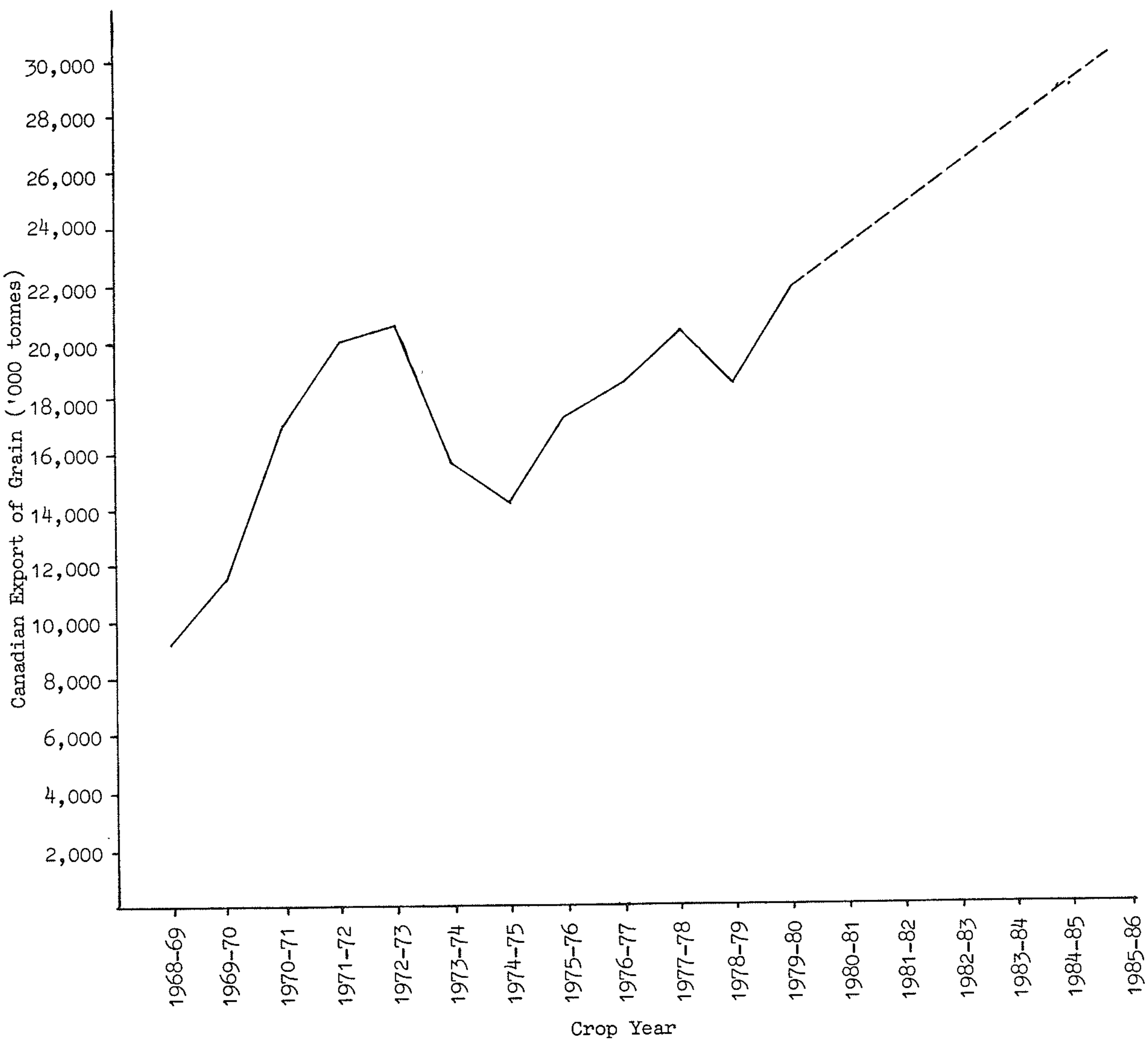

Figure 1

Canadian Export Grain Trade Trend

Source: Canada Grains Council, Statistical Handbook 80 (Winnipeg: Canada Grains Council, 1980), p. 59.

improvement carries with it certain advantages and disadvantages which deserve serious consideration.

The first major aspect to be examined is the relative benefit of shipping grain through the Pacific Coast vis-a-vis an eastern route. In recent years the Pacific export terminals have increased in popularity for two main reasons; namely, the availability of an ice-free port, and the changing import-export patterns which have made the Asian markets more prominent.

Recent estimates predict that by 1985, from 43 to 52 percent[5] of Canadian grain exports will move west. As the West Coast terminals presently operate near capacity, any additional westward movement of grain is likely to require more extensive terminal elevator capacity. Presently some major expansion plans are underway at Prince Rupert. Although the Pacific terminals are expected to receive the greatest surge in demand, the eastern sector also will be called upon to handle a significant increase in volume, as Canada's export levels increase. Therefore, the eastern sector of our grain transportation system will be required to play a critically important role if Canada is to meet its export goals in 1985.

Similar to the Pacific route, the eastern sector is not without capacity constraints. During the past decade, the Great Lakes fleet has operated near its maximum level.[6] In addition, the Great Lakes-St. Lawrence Seaway system is rapidly approaching serious physical constraints.

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[5] Booz, Allen & Hamilton Inc., Grain Transportation and Handling in Western Canada (Ottawa: Grains Group, 1979), p. III-2.

[6] Canada Grains Council, Grain Handling and Transportation in Eastern Canada (Winnipeg: Canada Grains Council, 1975), p. 98.

One area of particular concern is the Welland Canal which is considered to be a potential bottleneck in Seaway shipping.[7] There are various methods available which could increase the level of grain which could be moved through the Seaway. Unfortunately, the capital costs required to increase the Seaway's grain handling capacity may be prohibitive, especially when the seasonal nature of inland shipping is taken into account.

Given the increased demand for grain, and the serious capacity constraints in the present system, it would appear important to study the economic feasibility of moving grain east by rail. It can be argued that with minor modifications to plant and procedures, railways can handle a sizeable portion of the grain moving to eastern Canada. Both the CNR and the CPR contend that in the eastern sector their plants are capable of handling much greater volumes of grain.[8] In order to utilize excess capacity as well as provide for a second year-round export route, two types of solid train[9] movements could be introduced (increased). These are:

1. movement of grain out of Thunder Bay to Quebec and Atlantic elevators and/or,

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[7] Jacques Lesstrang, Seaway (Seattle, Washington: Superior Publishing Company, 1976), pp. 205-206.

[8] Canada Grains Council, Grain Handling and Transportation in Eastern Canada, op. cit., p. 109.

[9] Solid trains basically carry a homogeneous commodity and can be broken into a configuration of less than a train load lot for loading and unloading purposes.

2. direct rail movement from the Prairies to the Quebec and Atlantic elevators.

1.2 OBJECTIVES OF THE STUDY

From a national standpoint, it appears important to examine the potential and relative economics of an eastern all-rail route for western Canadian grain. If prospects for future rail movements in eastern Canada warrant such action, the optimal location and facilities capable of handling solid trains will be determined. In order to achieve this general purpose, four specific objectives are:

1. to examine qualitatively the feasibility and potential for solid train movements,
2. to build a mathematical model which can be used to determine the minimum total cost movement of grain in eastern Canada,
3. to use the model to derive the optimal pattern of eastern grain movements under various scenarios, and
4. to determine the implications of the results in order to suggest policy recommendations for the rationalization of the eastern grain transportation system.

1.3 OUTLINE OF THE STUDY

To this point, Chapter One has introduced the problem and set out the objectives of this study. The second chapter presents an evolution of the problem as illustrated through a historic review of related literature. Chapter Three describes the basic dimensions of the eastern Canadian grain transportation system. The particular aspects of the eastern system that are examined include: demand for grain, the production of grain, grain elevator facilities, the Great Lakes-St. Lawrence Seaway system, and the railway network. The theoretical framework used in this thesis is introduced in the fourth chapter. Chapter Five provides a model specification with which to evaluate grain movements to and within eastern Canada. Once the model is specified, it can be used to analyze various possible transportation scenarios. Chapter Six analyzes the results computed by the model, with special interest in the occurrence, and relative economics of solid train movements. The final chapter presents the conclusions, recommendations, and limitations of the study.

Chapter II

REVIEW OF RELATED LITERATURE

In recent years, numerous studies and articles have been written in response to grain transportation issues. Often this research although not directly related to an all-rail movement of grain, has been successful in analyzing or describing a particular component within the eastern Canadian grain transportation system. Individual studies have concentrated upon such aspects as Seaway, elevator, or railway operations. Normally, the content of present research is shaped by relevant previous work. This study is no exception; thus, in order to discuss the relevant literature, a historical review is presented. Since this particular study involves quantitative and qualitative analysis, there is understandably a wide range of possible literature upon which to draw.

The first article to be considered is Stollsteimer's[10] paper which deals with the problem of simultaneously determining the number, size, and location of plants which minimize total system costs. Total system costs are defined as the combination of transportation and processing costs involved in assembling and processing a raw product. Theoretically, the model is designed to determine the optimal configuration of plants in the aim of providing efficiency to both the industry in question and society in general. The analytical procedure put forward in Stollsteimer's article appears to be applicable to a fairly wide range

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10 J.F. Stollsteimer, "A Working Model for Plant Numbers and Location," JFE, Vol. 45, August 1963, pp. 631-645.

of location and transportation problems. Based upon the economic logic of Losch,[11] Isard,[12] and Lebefer,[13] Stollsteimer's model employs mathematical programming to algebraically minimize total collection and processing costs.

Subsequent research conducted by McDonald,[14] and Tyrchniewicz and Tosterud[15] provide modified versions of Stollsteimer's approach. McDonald devised a linear programming model to mathematically optimize transfer costs and facility requirements for United States grain exports. Within McDonald's model, grain flows from surplus production regions to consuming regions both within and outside of the United States. Analysis of 16 port areas and three ship sizes led to the conclusion that any future construction of elevator facilities should be designed for high throughput rather than increased storage.

In a study involving grain collection, Tyrchniewicz and Tosterud applied an alternative form of linear programming. The purpose of the study was to provide a model under which an optimal grain collection pattern could be determined. Attaining an optimal collection system

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[11] A. Losch, The Economics of Location (translated by W.H. Woglom with assistance of W.F. Stolper), (New Haven, Conn.: Yale University Press, 1954), pp. 109-123.

[12] W. Isard, Location and Space Economy (New York: John Wiley & Son, 1956).

[13] L. Lebefer, Allocation in Space: Production, Transportation and Industrial Locations (Amsterdam: North Holland Publishing Co., 1958).

[14] J. McDonald, "A Linear Programming Model to Optimize the Transfer Costs and Facility Requirements for U.S. Grain Exports," unpublished Ph.D. Thesis, Ohio State, 1969.

[15] E.W. Tyrchniewicz and R.J. Tosterud, "A Model for Rationalizing the Canadian Grain Transportation and Handling Systems on a Regional Basis," AJAE, 1974, pp. 805-814.

called for rationalizing the existing network of farm trucks, primary elevators, and rail lines. Stollsteimer, McDonald, Tyrchniewicz and Tosterud each provide an example of how linear programming can be applied when analyzing grain transportation problems.

During the early 1970's, the Federal Government was faced with escalating grain transportation problems. In response, the Grains Group commissioned a series of economic studies. The first study, conducted by P.S. Ross & Partners[16] examined the cost of moving grain through eastern terminal and transfer elevators. The method used to estimate elevator costs required indepth accumulation and analysis of accounting data. Once current (1969) cost estimates were determined, it became possible to forecast cost expectations for 1975 and 1980. Unfortunately, the accounting approach fails to accommodate changing economic conditions and as a result proves inadequate as a forecasting method. This inadequacy is especially significant in light of the inflationary pressure experienced by the Canadian economy during the past decade.

In a later study, P.S. Ross & Partners[17] evaluated an alternative grain transportation system. The study determined that a hypothetical arrangement of approximately 80 inland terminals would provide for the lowest possible grain collection cost. It should be noted that the study examined costs, but failed to assess the operating feasibility of inland terminals. Since the completion of the study, costs have escalated at a rapid rate. In the absence of further research, it is un-

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16 P.S. Ross & Partners, Eastern Terminal Grain Elevator Cost Study (Ottawa: Grains Group, February 1971).

17 P.S. Ross & Partners, Grain Handling and Transportation Costs in Canada (Ottawa: Grains Group, April 1971).

clear whether a network of inland terminals could continue to provide a least cost grain collection system.

The final report of the Grains Group series was completed in 1972 by the consulting firm of Kates, Peat, Marwick & Co.[18] Basically, the study set out to evaluate eastern grain movements via rail and water modes. An analysis of cost and transportation patterns was conducted for both the traditional as well as potential routes and handling methods. Assessment of the impacts which resulted from a change to the existing transportation system was confined to the immediate physical and economic effects.

Included in the study was a costing model for unit train movements of grain. Unit train costs were approximated using a detailed formula derived from similar studies undertaken by Kates, Peat, Marwick & Co. The data base for the unit train model was comprised of published information for several railroads in both Canada and the United States. Costing formulas found in the model provide for variable and capital costs, as well as a contribution to fixed costs. Included in the research was a complete description of rail loading characteristics at eastern elevator locations.

Kates, Peat, Marwick & Co., found Seaway shipments of grain to be less costly than all-rail movements. Only in a situation where total eastern grain movements exceeded Seaway capacity, was an all-rail movement from the Prairies to eastern destinations favoured. Overall, the occurrence of all-rail movements were viewed as a source of competition for the Seaway, rather than being complementary in nature. However, the

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[18] Kates, Peat, Marwick & Co., Grain Transportation in Eastern Canada (Ottawa: Grains Group, 1972).

study neglected to account for two very important issues. First, the cost of collecting grain for a unit train vis-a-vis traditional movements was not discussed. Secondly, the relative cost and feasibility of utilizing existing facilities for cleaning grain on the Prairies was not addressed. Also, since the study was completed almost nine years ago, it is possible that the relative costs involved in moving grain by rail versus water may have changed. An inclusive up-to-date study is, therefore, required if current viability of all-rail movements is to be seriously evaluated.

The Canada Grains Council followed the Grains Group in sponsoring their own series of grain transportation studies. Two projects undertaken by the Canada Grains Council specifically apply to grain transportation in eastern Canada. One of these projects examines grain flows and transportation problems in the eastern sector. It suggested that steps should be taken to allow the loading and unloading of unit trains at Thunder Bay and Lower St. Lawrence ports, respectively. The report proposed two recommendations with regards to all-rail grain movements. The first recommendation was to rail a greater portion of eastern Canada's domestic grain from Thunder Bay during the winter months. Secondly, the study conceded that adequate modifications to loading and unloading facilities may make unit train movements of feed grain from the Prairies to Quebec elevators economically feasible.[19]

The terms of reference of the second Canada Grains Council study included an indepth examination of handling facilities and grain movements at eastern transfer elevators. Opinions of various grain industry

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[19] Canada Grains Council, Grain Handling and Transportation in Eastern Canada, op. cit., pp. 102-109.

groups were collected in Ontario, Quebec and the Atlantic Provinces. One policy topic discussed was the use of all-rail grain movements. The study encouraged the increased movement of grain directly from the Prairies to eastern Canada. Further, it suggested that additional research be conducted to assess the relative economies of unit train movements vis-a-vis the traditional rail-water route.[20]

The next set of studies to be assessed examines grain handling capacity in eastern Canada. Bryden Development Consultants[21] conducted a study estimating the level of grain which is expected to move via the Great Lakes by 1990. Subsequent research completed by Westburn Development Consultants[22] analyzed past trends in order to predict the demand for grain handling facilities in eastern Canada to the year 1985. Both the Bryden and Westburn studies were valuable in assessing the grain handling capacities of individual components within the Canadian grain handling system. There was, however, one major drawback to the Bryden study. The expected increase in United State grain shipments was omitted when calculating the amount of Canadian grain which can be potentially accommodated by the Seaway. In a later study, Weaver[23] presented a succinct summary of expected system capacities and grain movements.

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[20] Canada Grains Council, Eastern Grain Handling and Transportation Report (Winnipeg: Canada Grains Council, 1979).

[21] Bryden Development Consultants Ltd., Grain Movement on the Great Lakes to 1990, prepared for the Dominion Marine Association, Ottawa, 1978.

[22] Westburn Development Consultants Ltd., Report Respecting the Demand for Grain Handling and Storage Facilities East of Thunder Bay to 1985, Winnipeg, 1978.

[23] G.D. Weaver, "Present and Projected Capacity Considerations for the Eastern Grain Handling and Transportation System," Winnipeg, Canada Grains Council, 1980.

Over the years there have been a number of studies evaluating various components of the eastern grain transportation system. Such research has provided valuable insight into individual aspects of grain transportation; however, with the exception of a recent article by Carson and Tangri,[24] there has been a reluctance to analyze the problem from a systems approach. Since individual components are interrelated, a systems approach should logically provide a more beneficial analysis.

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[24] A.J. Carson and Om P. Tangri, "St. Lawrence Seaway Viability in Terms of Grain Movement: Implications for Public Policy," unpublished paper, University of Manitoba, 1980.

Chapter III

DESCRIPTION OF THE EASTERN GRAIN HANDLING SYSTEM

The eastern Canadian grain transportation system consists of a complex interaction of individual components. The primary objective of the system is to move grain from western Canada to domestic and export demand at eastern grain elevators. Prairie grain flows through the eastern system by a combination of rail and water modes. This chapter examines: demand, supply, elevator facilities, the Great Lakes-St. Lawrence Seaway, and the railway network which make up the eastern Canadian grain transportation system.

For the purpose of discussion, the grain elevators located at eastern Canadian ports will be grouped together geographically. The various port locations are illustrated in Figure 2. Terminal elevators located along Lake Superior at Thunder Bay will form one group. The second group is comprised of transfer elevator facilities located at ports along Lake Huron's Georgian Bay. These include: Port McNicoll, Midland, Collingwood, Owen Sound, Goderich and Sarnia. The elevators located along Georgian Bay will be denoted as Bay ports. Further down the Great Lakes is the third group of elevators known as the Lake Ports. The Lake Ports are comprised of: Port Colbourne, Toronto, Kingston and Prescott. The fourth group of ports is located on the St. Lawrence River and will be referred to as the Quebec ports. The Quebec ports include: Montreal, Sorel, Trois Rivieres, Quebec City, Baie Comeau and

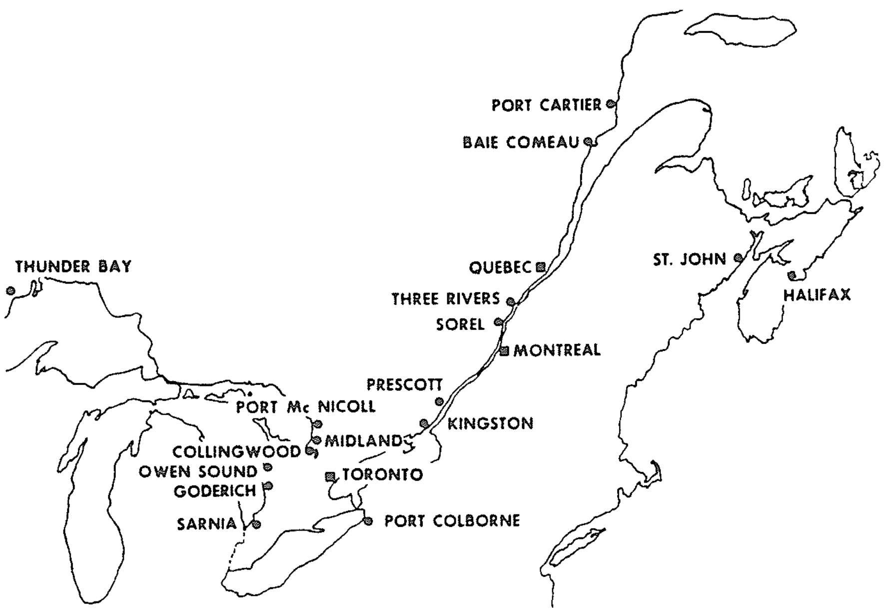

Figure 2

Port Locations Along the Great Lakes-St. Lawrence Seaway System

Source: Canadian International Grains Institute, Grains and Oilseeds: Handling, Marketing, Processing (Winnipeg: Canadian International Grains Institute, 1973), p. 109.

Port Cartier. The fourth and most easterly group is the Atlantic ports which incorporate Saint John and Halifax.

3.1 DEMAND FOR GRAIN

Within the Canadian grain industry, the flow of grain is essentially determined by demand, and as such, it is necessary to forecast the probable levels of both domestic and export demand in advance of developing any estimates of production. Demand is generated in domestic and international arenas and further subdivided by geographic region.

3.1.1 Domestic Demand

Domestic demand is made up of grain consumed within Canada. Consumption can be in the form of human food, livestock feed, or industrial use. Utilization and final destination of domestic grain will determine its transportation mode. Eastern Canada's domestic demand for grain has essentially three sources of supply: local, the United States, and western Canada. Shipments of grain from the United States into eastern Canada consist almost totally of feed corn. Farms located in eastern Canada produce a variety of grain crops, the primary ones being corn, soybeans, barley and soft wheat. Although there is some domestic grain production in eastern Canada, no one geographic area is self-sufficient in wheat, oats, barley, rye, flax or rapeseed. The result is a net domestic demand for western Canadian grain in eastern Canada.

A significant portion of domestic grain consumed within eastern Canada moves directly to consumption sites. Alternatively, grains can move to one of the port areas for later distribution by road and rail to local mills, distilleries, feed lots, and other industrial locations. Table 1 illustrates the net domestic demand for western Canadian grain at eastern ports during the past five years. The majority of domestic grain is transported to eastern port elevators aboard lake vessels, with a small amount arriving by rail. Rail shipments may move directly from western Canada or be re-routed through Thunder Bay.

Characteristically, domestic demand increases at a relatively constant rate. The increase in domestic demand for grain is affected by:

1. per capita consumption of industrial grain products,
2. population growth,
3. per capita consumption of meat,
4. consumer preference,
5. livestock numbers, and
6. feed rations.

In a recent publication, the Canada Grains Council estimated that by 1985 domestic demand for grain in eastern Canada will on the average be 1.416[25] times greater than in 1978. Assuming that feed ratios, relative prices of United States and Canadian grain, and the distribution of domestic consumption remain constant, it is possible to calculate the expected level of domestic demand by port area in 1985. Multiplying the expected increase in domestic demand by the average demand at each port area yields estimated net domestic demand as seen in Table 2. The use of a five year average is appropriate since it smooths out any atypical fluctuations in local grain production brought about by stochastic weather influences.

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[25] Derived from: Canada Grains Council, Market Projections 1985 (Winnipeg: Canada Grains Council, 1979), pp. 19-24.

TABLE 1

Net Domestic Demand for Western Canadian Grain at Eastern Ports

Crop Year	Thunder Bay	Bay Ports	Lake Ports	Quebec Ports	Atlantic Ports	Total
	....................'000 tonnes....................					
1973-1974	628	402	520	560	85	3,195
1974-1975	721	323	466	1,440	70	3,020
1975-1976	702	291	398	1,469	51	2,911
1976-1977	386	236	401	1,277	62	2,362
1977-1978	473	318	560	1,509	47	2,907
Average	582	314	469	1,451	63	2,816

Source: Derived from Statistics Canada, Grain Trade of Canada, Ottawa, annual, Table 35.

TABLE 2

Estimated Net Domestic Demand for Western Canadian Grain at Eastern Ports - 1985

Thunder Bay	Bay Ports	Lake Ports	Quebec Ports	Atlantic Ports	Total
...........................'000 tonnes...........................					
823	444	664	2,053	89	4,073

3.1.2 Export Demand

Export demand represents the largest component in the total demand for western Canadian grain. Fluctuations in export demand are influenced by:

1. Canadian share of international grain markets,
2. crop production in importing countries,
3. crop production in competing exporting countries,
4. per capita consumption in importing countries,
5. population growth, and
6. consumer preference.

The above list denotes several potential sources of fluctuations in terms of export demand for grain. World weather conditions are likely to cause the greatest fluctuations in the international grain markets. Crop failure in one area of the world will reappear at another location as export demand. Inspite of the variability, there is an underlying growth in demand stemming primarily from the exponential increase of world population. Nations unable to feed themselves are forced to import increasingly larger quantities of grain. The expected increase in world demand for wheat and coarse grains is illustrated in Figure 3 and Figure 4, respectively.

Export demand for Canadian grain originates in foreign countries but can be conceptually transferred to Canadian ports. Port locations act as delivery points where foreign buyers actually receive their grain. Export price varies slightly between port areas generally reflecting a difference in transportation costs. Table 3 records the throughput activity of Canada's five export clearance sectors.

According to Table 3, Thunder Bay, Quebec and the Atlantic ports accounted for approximately 52.8 percent of total Canadian grain exports between the years 1968-1978. During that time, the Pacific ports exported 41.7 percent of the Canadian total. The remaining 5.5 percent of grain exports out of Canada moved out of the Churchill terminal or across the border into the United States.

Numerous studies have been completed forecasting the future distribution of grain exports between the East and West Coasts. As definitive estimates regarding future export levels are virtually impossible to attain, normally a predicted range of export levels is reported. Table 4 denotes a range in the quantity of grain expected to be exported through eastern Canada in 1985.

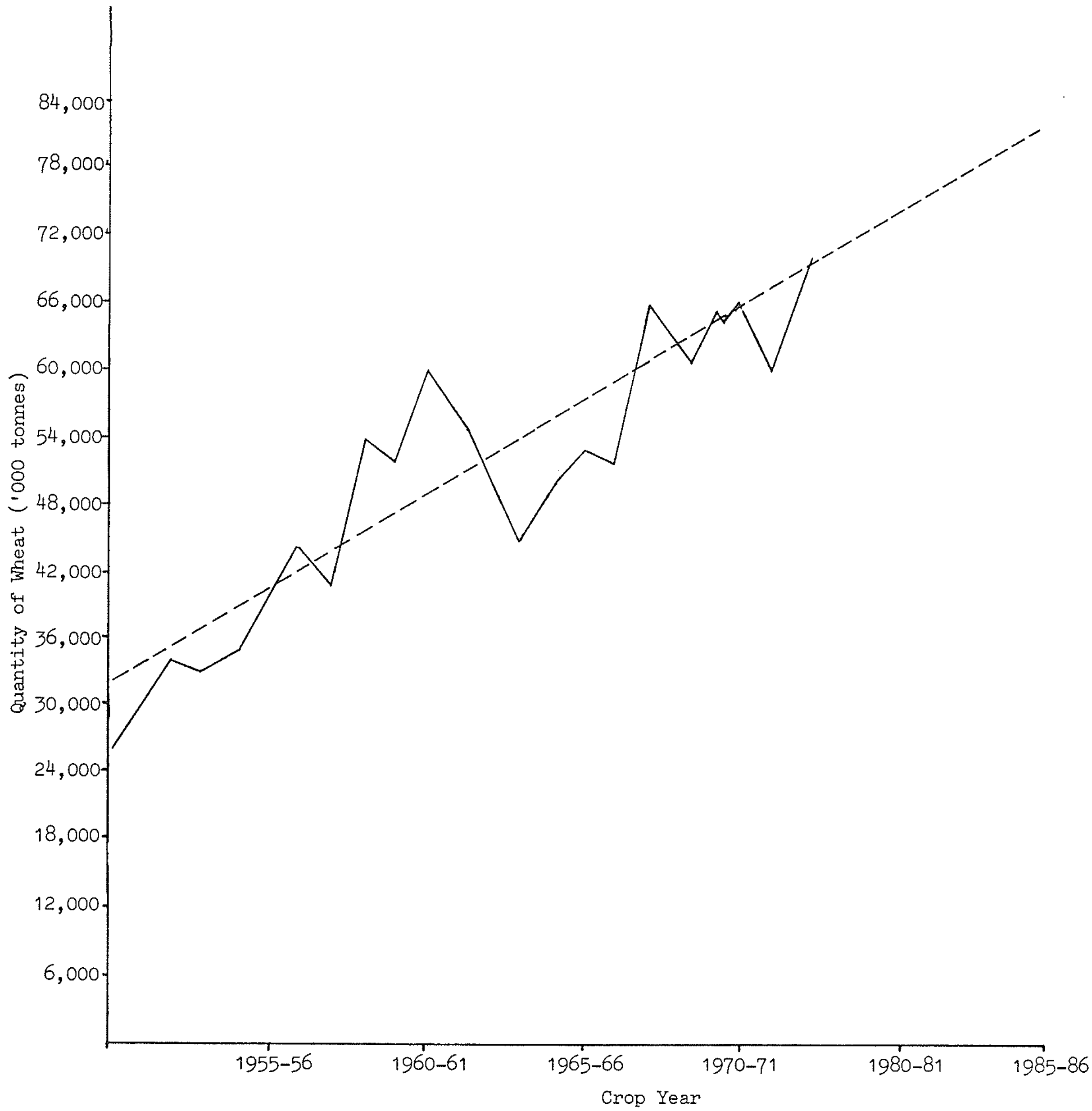

Figure 3

World Wheat Trade Trend

Source: International Wheat Council, Wheat Statistics, London, annual, Table 4C.

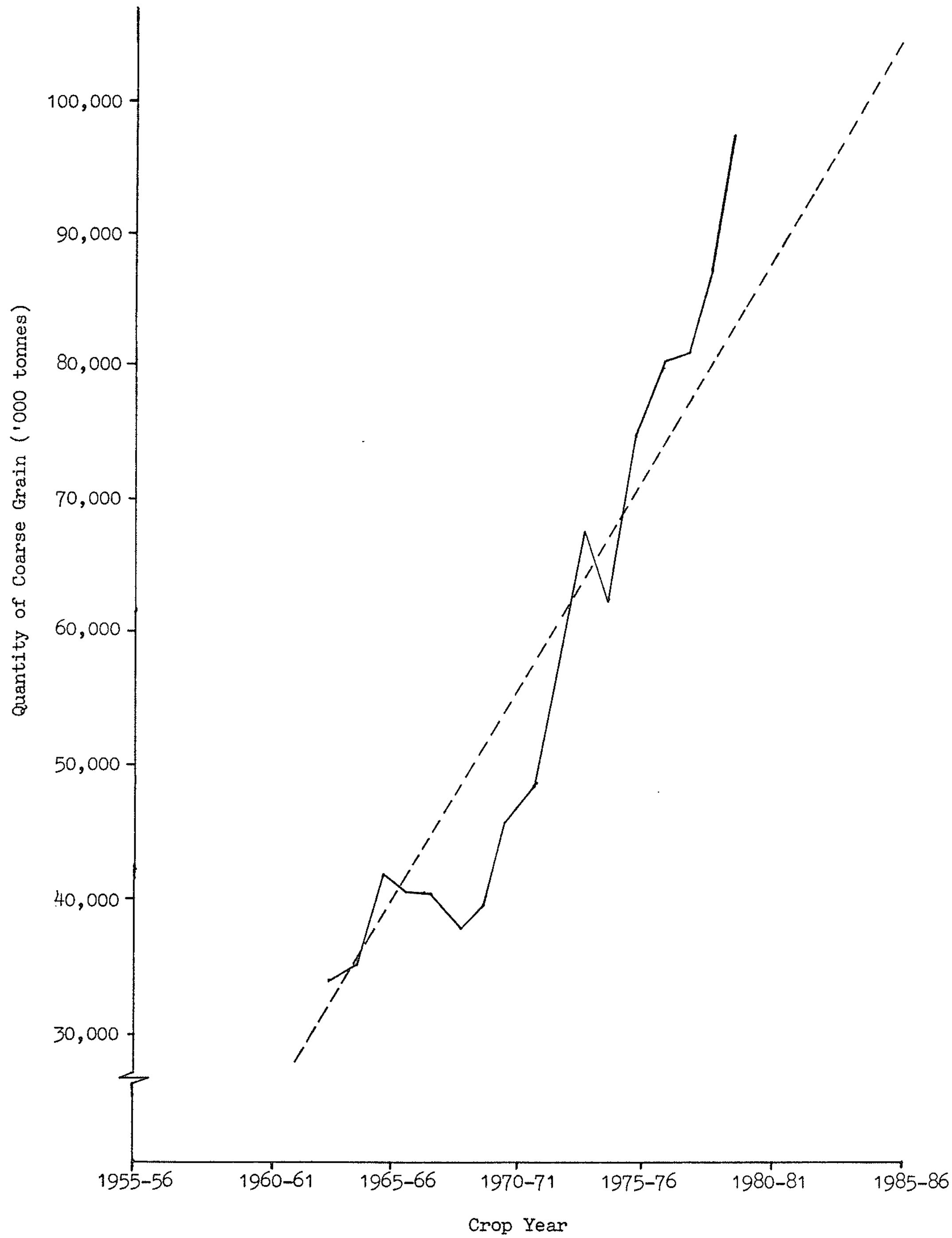

Figure 4

World Coarse Grain Trade Trend

Source: H.F. Bjarnason, "International Market Trends in the Future," an address to the Seventh Farm Leaders Course, Winnipeg, July 26, 1980, p. 8.

TABLE 3

Bulk Exports of Canadian Grain By Clearance Sector

Crop Year	Pacific Ports	Quebec Ports	Atlantic Ports	Churchill	Thunder Bay	U.S.A. Imports	Total
	....	....	....	'000 tonnes	....	....	....
1968-1969	4,951	2,249	577	615	304	207	8,903
1969-1970	5,089	4,505	882	598	229	292	11,595
1970-1971	6,660	7,685	818	637	907	214	16,922
1971-1972	7,947	8,976	940	667	1,054	352	19,934
1972-1973	9,036	8,688	943	638	872	321	20,498
1973-1974	6,494	6,473	594	462	497	367	14,887
1974-1975	5,381	6,230	788	498	816	352	14,065
1975-1976	6,535	8,444	865	518	548	337	17,247
1976-1977	7,348	8,144	792	735	1,050	282	18,351
1977-1978	8,439	9,247	806	692	916	114	20,214
Average	6,788	7,064	801	606	720	284	16,263

Source: Canada Grains Council, Canadian Grain Industry Statistical Handbook '79 (Winnipeg: Canada Grains Council, 1979), p. 66.

TABLE 4

Estimated Export Demand at Eastern Ports in 1985

Source of Estimate	Level of Estimate
	...'000 tonnes...
Booz Allen, for the Grains Group	8,200-17,200
Canada Grains Council	14,500-15,800
Canadian Wheat Board	10,800-15,900
Dominion Marine Association	11,400-14,900

Source: as cited by G.D. Weaver, "Present and Projected Capacity Considerations for the Eastern Grain Handling and Transportation Systems," Winnipeg, Canada Grains Council, 1980, p. 17.

Since each estimate is based upon different assumptions and analytical techniques they are not directly comparable. If the average proportion of grain moving east versus west remains as it was between 1968 and 1978, approximately 52.8 percent of Canadian grain will be exported through eastern elevators. Assuming the Wheat Board's estimated 1985 export level of 30 million tonnes, 15.8 million tonnes of export grain will move through Thunder Bay, Quebec and the Atlantic elevators. The eastern export figure of 15.8 million tonnes falls within all the export ranges recorded in Table 4, with the exception of the Dominion Marine Association. The Dominion Marine Association provides estimates at a somewhat lower range. In addition, the lower export level estimated by the Booz-Allen study is well below the export level of 15.8 million tonnes. It should be noted that the Booz-Allen study includes a wide range of exports. Although the lower level is considerably below 15.8 million tonnes, the upper level is 17.2 million tonnes.

Even though the estimates vary greatly it is conceivable that each individual prediction could prove to be true under certain conditions. Assuming that the distribution of exports between the East and West Coasts remains constant, and that exports increase, the Canada Grains Council and the Canadian Wheat Board estimates may well be the most reasonable.

The export range found in Table 4 represents demand only, and in no way reflects the ability of the present grain handling system to place grain at an export position. The estimated export levels illustrated in Table 4 represent potential grain sales Canada could take advantage of only if the handling capacity of the present system does not become a constraining factor.

3.2 PRODUCTION OF GRAIN

The Prairie Provinces are considered the principal production area for Canadian grain. During 1978, the prairie region accounted for 82 percent[26] of the total Canadian grain production. Together Manitoba, Saskatchewan, and Alberta produced 37,894,000 tonnes[27] of grain. The disposition of the six principal western Canadian grains accounts for 85 to 90 percent[28] of the total volume of grain within the commercial grain handling system in any one year. Of the grain not produced on the Prairies, approximately 10 percent[29] moves into the commercial handling sys-

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26 Bryden Development Consultants, op. cit., p. 3.

27 Canada Grains Council, Canadian Grain Industry Statistical Handbook '79, op. cit., p. 22.

28 Bryden Development Consultants, op. cit., p. 3.

29 Ibid.

tem.

Canada's production of grain in the future is expected to increase significantly. Agronomic practices are constantly improving by way of higher yielding varieties, higher quality inputs, improved machinery, and knowledge, to name only a few. The Canadian Wheat Board considers that the target level of production necessary to meet future demand is well within our grasp.

> The board view taken on the basis of widespread optimism among grain producers and agricultural scientists is that Prairie farmers can readily produce enough to meet increased foreign and domestic demand, provided that we can sell all that is grown at prices covering the cost of production.[30]

A recent article by Kraft[31] questions Canada's ability to produce enough grain to satisfy the level of demand expected by 1985. Kraft's study, based upon historic price and production trends, concedes that production levels are highly dependent upon the profitability of grain production. Thus, it can be assumed that so long as the price received for grain is sufficient, prairie grain farmers will react with more of the additional production needed to meet export commitments.

Weather permitting, the Prairie grain producers have historically been successful in fulfilling production goals. Assuming that grain production is not a limiting factor, the next question to be addressed is in regard to the distribution of production between eastern Canada and the West Coast. Within the Prairie Provinces, the Canadian Wheat Board operates a block shipping system which determines the directional

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30 H.F. Bjarnason, "International Market Trends in the Future," op. cit., p. 17.

31 D.F. Kraft, "Past and Potential Grain Production," unpublished paper, University of Manitoba, January 1980.

flow of grain. Under normal conditions all grain flowing eastward originates in either Saskatchewan or Manitoba. In addition to supplying eastern destinations, Saskatchewan grain is also shipped to terminal elevators on the West Coast. For purposes of this thesis, Manitoba and Saskatchewan are the designated production areas for all western Canadian grain moving east.

Saskatchewan far exceeds any other province in grain production. The grain which is produced is either used on the farm as feed or seed, sold to neighbours, trucked to local processing plants, or marketed through the commercial transportation system. Table 5 indicates the quantity of grain marketed through primary elevators in Manitoba and Saskatchewan. In terms of the amount of grain moving into the commercial transportation system, Saskatchewan and Manitoba, on the average, accounted for 56 and 15 percent, respectively.[32] Assuming that relative marketing percentages remain constant, and that handling and transportation capacity equals demand then it is possible to calculate the quantity of Manitoba and Saskatchewan grain to be marketed by 1985. For example, if by 1985 the total demand for western Canadian grain reaches 34.10 million tonnes, Saskatchewan producers will market approximately 19.10 million tonnes while Manitoba's marketings will be approximately 5.12 million tonnes.

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[32] Five year average for 1974-1978, derived from: Statistics Canada, Grain Trade of Canada, Ottawa, annual, Table 8.

TABLE 5

Net Receipts of Grain at Primary Elevators

Crop Year	Saskatchewan	Manitoba	Total
	..................'000 tonnes	....	
1968-1969	7,164	2,513	9,677
1969-1970	8,958	2,548	11,506
1970-1971	11,462	2,824	14,286
1971-1972	17,333	3,472	20,805
1972-1973	14,900	3,460	18,360
1973-1974	12,171	3,106	15,277
1974-1975	10,913	2,785	13,698
1975-1976	12,112	3,013	15,125
1976-1977	12,198	3,346	15,544
1977-1978	14,407	4,548	18,958

Source: Statistics Canada, <u>Grain Trade of Canada</u>, Ottawa, annual, Table 8.

3.3 GRAIN ELEVATORS

The demand for grain handling facilities is contingent upon the volume and direction of grain flows, as well as the amount of influence exerted by industry and government in respect to the utilization of grain elevators. The three types of grain handling facility presently in use in Canada include: primary, terminal, and transfer elevators. Primary elevators are principally used to receive grain directly from producers for either storage and/or forwarding. The terminal elevators receive grain and provide official weighing and inspection, after which the grain is cleaned, treated, stored, and subsequently forwarded to its final destination. Transfer elevators have two principal uses. The first is to receive grain that has been officially weighed and inspected at another elevator. Secondly, transfer elevators in eastern Canada are used in the receiving, cleaning, and storage of locally produced grain.

3.3.1 Primary Elevators

Primary elevators are located throughout the Prairie Provinces. Due to consolidation and abandonment, the number of primary elevators has declined from 4,800 in 1971 to about 3,700 in 1978, and it is expected to continue to drop to about 2,600 in 1985.[33] Consolidation can be expected to improve the efficiency of prairie rail and elevator operations while concurrently requiring somewhat longer truck hauls by producers. The primary elevator system exhibits an inverse relationship between handling capacity and the number of elevators. The decline in the number of primary elevators allows the remaining elevators to operate with

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33 Booz, Allen & Hamilton, Inc., op. cit., p. vi-2.

increased economies of scale. In the past five years, cleaning equipment has been installed at some of the high throughput primary elevators; however, the vast majority of primary facilities still lack the ability to clean grain to Canadian export standards.[34] Regardless of the lack of cleaning capacity, the primary elevator system is not expected to restrain future system capacity.[35]

The service provided by primary elevators is generally one of collection; grain is unloaded from producer's trucks, stored, and later loaded onto rail cars for further shipment. A study done by Tyrchniewicz, Butler and Tangri[36] estimated that in 1968 the average cost of transporting a tonne of grain from farm to country elevator was $1.15. Using general wholesale prices as an index, the comparable 1978 estimate would be $2.60 per tonne.

3.3.2 Terminal Elevators

Canada prides herself on the quality of its export product and as such all export grain is exposed to a stringent cleaning process. Historically, terminal elevators have been responsible for cleaning grain. Within the area under study,[37] there are 13 terminal elevators located at Thunder Bay, a single terminal at the Port of Churchill, and inland

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34 Ibid., p. vi-3.

35 Opinion expressed by R. Gosselin, Licensing Officer, Canadian Grain Commission, in a personal interview, September 1980.

36 E.W. Tyrchniewicz, A.H. Butler and Om P. Tangri, The Cost of Transporting Grain by Farm Truck, Research Report No. 8 (Winnipeg: Center for Transportation Studies, July 1971), p. 36.

37 The area under study is considered to be the land area east of the Alberta-Saskatchewan border.

terminals located at Moose Jaw and Saskatoon.

The Thunder Bay terminals have generally functioned as an interim destination for grain moving east. Grain is railed from primary elevator sites to Thunder Bay where it is unloaded, cleaned, dried (if necessary), and stored in anticipation of further eastward movement either by rail or water. Figure 5 examines capacity and throughput projections for the terminal elevators at Thunder Bay.

> The exhibit (Figure 5) compares terminal capacity at Thunder Bay with the average demand based upon 12 shifts per week (as operated during 1977-78), 18 shifts per week, and 21 shifts per week of terminal operations. It can be seen that there is adequate capacity if the number of shifts rises to 18 as necessary, during peak periods.[38]

The terminal facility at Churchill exported an annual average of approximately 667,000 tonnes of grain between 1968 and 1978. There are several issues which make an increase in Churchill's export level unlikely. Until the stability problems associated with discontinuous permafrost have been solved, the Churchill railway line will be restricted to box car traffic. Other difficulties which limit the use of Churchill include the constraints of a limited season, marketing opportunities, marine technology and marine insurance.[39] Given the above problems, Churchill's throughput is not expected to increase. For the purpose of this thesis, it is assumed that Churchill exports will be maintained at their present level.

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38 Booz, Allen & Hamilton, Inc., op. cit., p. vii-7.

39 Ibid., p. vii-8.

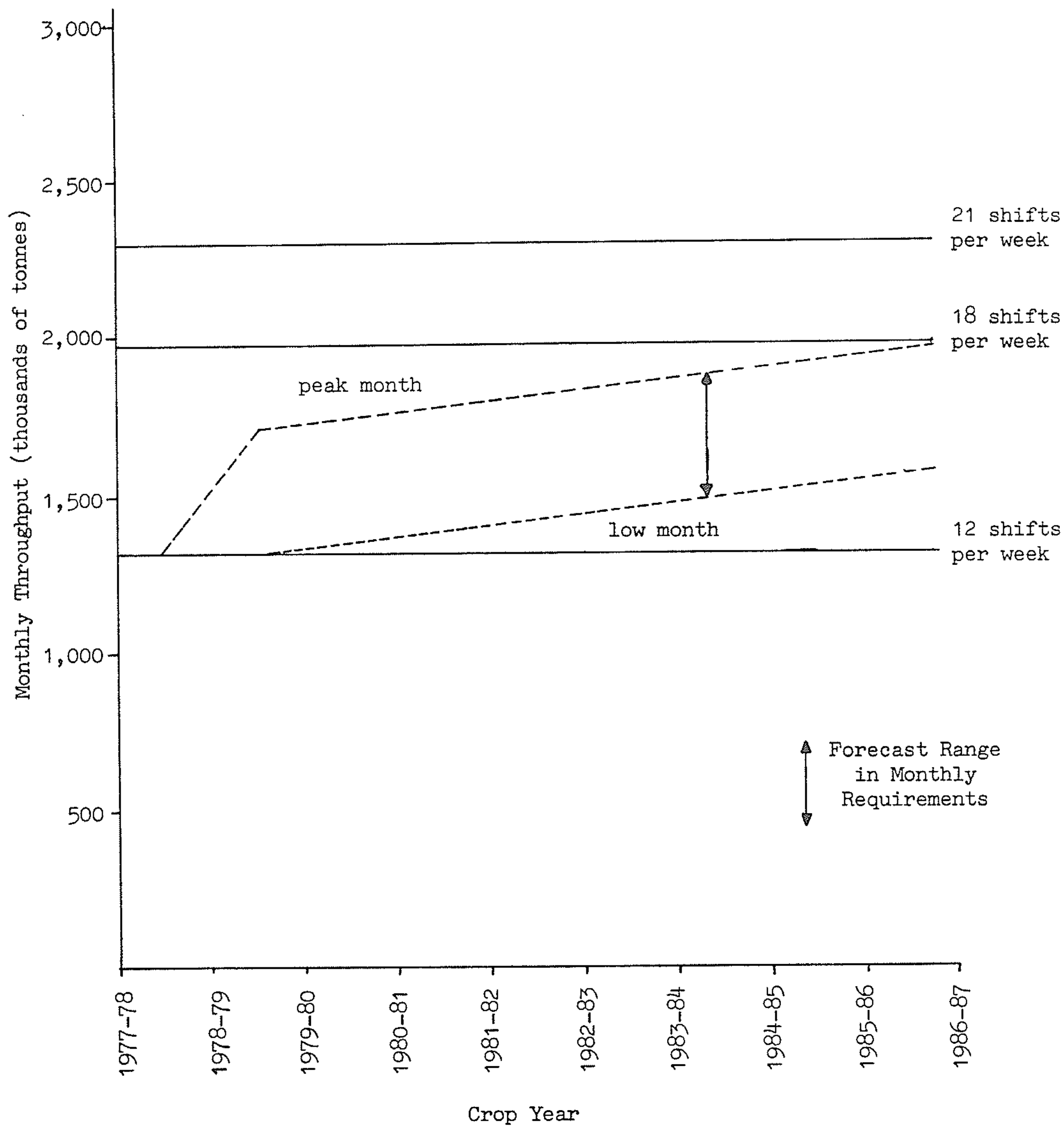

Figure 5

Capacity and Throughput Projections--Thunder Bay

Source: Booz-Allen & Hamilton Inc., Grain Handling and Transportation in Western Canada (Ottawa: Grains Group, 1979), p. vii-7.

The inland terminals located at Moose Jaw and Saskatoon were constructed in 1914. In terms of the physical capacity and design, these two inland terminals can be considered to be replicas of each other. At the time of construction, both terminals consisted of a 14,000 tonne workhouse and a 84,012 tonne annex, with additional annexes of 56,007 tonnes added in 1931.[40] Both inland terminals have the ability to clean grain to export standards with Saskatoon's cleaning capacity being slightly greater than that of the Moose Jaw elevator. In the past, there have been shipments of clean grain from Saskatoon to both Churchill and the Neptune Terminal in Vancouver.[41] The principal crop handled at Saskatoon and Moose Jaw has been wheat, but since the 1950's a large quantity of rapeseed has also been handled. Grain moves to inland terminals either by rail car or truck. The average hauling distance to terminal elevators far exceeds that of the primary elevators. In order to generate sufficient business a grain collection area with a radius of approximately 100 miles will be needed.[42] Thus, the average distance grain is hauled to inland terminals will be 50 miles. In 1978 terms,

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[40] N.I. Biblow and R.G. Monilaus, Canadian Government Elevators Operations Manual (Winnipeg: Canadian Government Elevators, July 1973), p. 1.

[41] In 1971, as an experiment, Federal Grain Ltd. organized a unit train movement of clean export grain from the inland terminal at Saskatoon to the Neptune Terminal in Vancouver. Statement by D.G. Stephens, Canadian International Grains Institute, in a personal interview, October 1980.

[42] A collection radius of 100 miles is similar to the maximum commercial trucking distance under the Canadian Wheat Board's program to truck grain to interior terminals. The experimental program was in place during the 1971/72-1974/75 crop years.

TABLE 6

Potential Capacity of Terminal Elevators

	Thunder Bay	Saskatoon	Moose Jaw
	..............'000 tonnes per year..............		
Storage	2,202	154	154
Cleaning	45,880[a]	2,216[a]	1,756[a]
Rail Loading	4,998[b]	4,201	3,780
Total Handling (clean grain)	25,693[c]	2,216	1,756

[a]Assumes three shifts per day for 365 working days a year.

[b]Calculated taking into account the continued use of Seaway shipping, Bryden Development Consultants Ltd., Grain Movement on the Great Lakes to 1990, prepared for the Dominion Marine Association, Ottawa, 1978, p. 152.

[c]Calculated using a maximum terminal throughput ratio of 11.67 as cited by G.D. Weaver, "Present and Projected Capacity Considerations for the Eastern Grain Handling and Transportation System" (Winnipeg: Canada Grains Council, 1980), p. 11.

the cost for commercially hauling grain 50 miles amounted to $4.94 per tonne.[43]

The inland terminals have generally been used for storage, consequently throughput potential has never been achieved. Table 6 embodies the potential capacity for terminal elevators. The Moose Jaw and Saskatoon terminals have the annual capability to clean 1,756,000 and 2,216,000 tonnes, respectively, when operated at full capacity. Full capacity estimates are based upon constant operation and allow for no down time. Port terminals are considered to be operating at full capacity if the handling to storage ratio is approximately equal to 12. However, in the case of inland terminals a turn-over rate greater than 12 is possible since the arrival and departure of lake or ocean vessels need not be coordinated. Since the collection and loading functions of inland terminals need only interphase truck and rail modes, their use is more controlable than a terminal located on lake or ocean ports.

The maximum throughput at the Thunder Bay termals was 15.0 million tonnes[44] during the 1978-1979 crop year. Using throughput ratios it has been estimated that the potential capacity of the present elevator facilities at Thunder Bay is in the vicinity of 25.7 million tonnes of grain per year. For Canada to meet its demand for grain the existing terminal elevators located inland and at Thunder Bay will have to be used more extensively.

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[43] Average commercial rates for a 50 mile grain haul. Derived from the stated rates of Arnold Bros. Transport of Winnipeg, and Musty Transport Ltd. of Saskatoon.

[44] Jack Francis, Winnipeg Free Press, October 15, 1980. p. 71.

3.3.3 Transfer Elevators

Transfer elevators are located at the Georgian Bay, Lake ports, Quebec ports, and Atlantic ports. Unlike terminal elevators, the transfer elevators have very limited grain cleaning capability, and simply transfer grain from one transportation mode to another. The lag period between delivery and shipment of grain makes storage capacity necessary. Transfer elevators also function as a point from which to distribute domestic grain to local consumption sites.

The nine Bay port elevators have a current storage capacity of 953,550 tonnes.[45] Built between 1904 and 1920, the Bay port elevators were designed to transfer grain from lake vessels to rail for movement past the primitive Welland and Lachine Canals. Once loaded on rail cars, the grain was delivered to Quebec ports or other eastern destinations. In 1932, the Welland Canal was expanded to allow passage of full size lake vessels. The impact was felt at the Bay port elevators as business began to pass them by. A near fatal blow was struck to Bay port operations when the St. Lawrence Seaway opened in 1959. Transfer functions were no longer necessary or even possible in many cases. As more grain began to move directly from Thunder Bay to the ice-free ports of Quebec, larger vessels were brought into service. Inadequate warfs and outdated loading facilities further exacerbated the inefficiency of Bay port operations. Since the time when business began to bypass the Georgian Bay region there has been almost no modernization or improvement to the Bay port facilities. At most of the Bay port elevators the process of receiving, handling, and loading remains virtually the same

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[45] Canadian Grain Commission, Grain Elevators in Canada (Ottawa: Agriculture Canada, 1979), p. xvi.

as the day the facilities were first put in operation.

The Bay port elevators have come to rely upon local business to support operations. Due to the relative success of agriculture, those elevators located to the south have been able to generate much more business than the elevators located along the northern stretch of Georgian Bay. In addition to handling locally produced crops, and distributing domestic grain, the elevators have become net recipients of Federal Government support. The Canadian Wheat Board's Winter Atlantic Export Program and the Atlantic and East railway subsidy have both aided in sustaining a minimal throughput level. If the present elevator facilities were not paid for, it is doubtful whether the Bay port elevators could remain in business.

Lake port elevators have also faced a declining throughput level. Built in the early 1900's, the six Lake port elevators at present have a total storage capacity of 538,520 tonnes.[46] Elevator facilities were constructed on the lower Great Lakes for the purpose of transferring grain from lake vessels to rail or canal vessels. After the Welland Canal was improved in 1932, large lake vessels could navigate the Great Lakes up to Kingston. The inadequacy of the Lachine Canal prevented further water movement except on specially designed canal vessels. Completion of the Seaway in 1959 caused transfer functions at Lake ports to become redundant, as direct shipments began to bypass the Lake port elevators.

46 Ibid.

Similar to the Bay ports, the Lake port elevators have come to depend upon local crop production, domestic distribution, and Government programs in order to support throughput. The elevators located at Port Colbourne, Prescott, and Toronto have enjoyed a reasonable level of domestic business. Kingston, on the other hand, is not located in a particularly good agricultural area and as a result has suffered from low volume movements. Direct exports out of the Lake ports are severely limited due to poor docking facilities and diseconomies of loading. Despite low throughput levels, the Lake port elevators have proved more successful than the Bay ports elevators in adapting to present grain flows. The relative success of the Lake port elevators can be explained by the fact that they are located in a more highly populated area than the Bay ports. As a result, domestic demand particularly for industrial use is more prelevant than in a less populated area.

Quebec transfer elevators are involved with both domestic and export grain movements. The Quebec elevators are located along the St. Lawrence River and benefit from ice-free conditions year round. The importance of the Quebec elevators has increased greatly since the completion of the St. Lawrence Seaway. The majority of Canadian export grain is presently moved by lake vessels from Thunder Bay to Quebec ports where it is transloaded onto ocean-going vessels. In addition to Canadian movements, United States grain from terminals at Duluth, Chicago, and Toledo also flows through the Quebec elevators.

Since Seaway completion, there have been numerous improvements to the Quebec transfer elevators. During the early 1960's, the transfer elevators located at Sorel, Trois Rivieres, and Quebec City embarked upon construction and improvements which provided a significant capacity increase. As a result of the demand to move increased volumes of grain, Cargill Grain Company built the Baie Comeau elevator which opened in 1960, the National Harbours Board officially opened Montreal No. 4 in 1963, and Louis Dreyfus Canada Ltd. opened an elevator at Port Cartier in 1967. This brings the number of Quebec elevators to nine with a total grain storage capacity of 1,790,850 tonnes.[47] The expanded throughput expected to occur at Quebec elevators has resulted in plans to construct a new elevator facility at Gros Cacouna, Quebec. The new elevator is expected to be completed in about two years and will add approximately 265,000 tonnes[48] to current storage capacity. With the expansion and modernization which has taken place in the Quebec sector it is possible to conclude that the Quebec elevators are capable of handling those volumes of grain generated through the United States and Canadian Great Lakes ports and moved on the present lake fleet.[49]

The distance from the grain producing area to the Atlantic transfer elevators causes them to be the least attractive alternative in terms of exporting grain. If it was not for the Government sponsored Atlantic and East railway subsidy, and the Winter Atlantic Export program, shipments through the Atlantic elevators would probably be confined to domestic movements. Historically, grain shipments into the Atlantic transfer elevators have been handled by rail. The elevators at Saint John are not equipped to receive grain by water. The only grain receiv-

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47 Ibid.

48 Weaver, op. cit., p. 15.

49 Canada Grains Council, Grain Handling and Transportation in Eastern Canada, op. cit., p. 79.

ing from vessels is carried out by a single marine tower installed at the Halifax elevator in 1966.

Part of the reason for the low level of grain movements by water to Atlantic elevators is the fact that the hulls of lake vessels are not well reinforced and consequently few lake vessels can safely cross open water to reach Atlantic ports. Poor utilization of Atlantic elevator facilities brings about a cost revenue squeeze and generally provides little motivation to improve facilities. Table 7 records the historic and potential capacity for eastern elevators. The transfer elevators located at the Bay and Lake ports have capacities which far exceed the level of domestic demand they are expected to face by 1985. The only port area expected to face a substantial increase in demand are the Quebec ports. By 1985 the Quebec ports will have a throughput capacity of 17.748 million tonnes, which represents a 6.727 million tonne increase over maximum historic levels.

Within the eastern grain transportation system, the primary and terminal elevators presently operate with excess capacity. The transfer elevators at the Quebec ports operate much more closely to maximum capacity levels. The Bay port and Lake port transfer elevators are not involved in export movements, and as such their throughput will be limited to domestic demand. As export demand escalates, it may become necessary to utilize the Atlantic ports for overseas shipments. However, at present their purpose is generally confined to domestic shipments.

TABLE 7

Historic and Potential Capacity for Canadian Grain at Transfer Elevators

	Bay Ports	Lake Ports	Quebec Ports	Atlantic Ports
	........'000 tonnes of grain per year........			
Historic Maximum[a]	2,073	1,314	11,021	1,007
Potential - 1985[b]	2,585	1,422	17,748	1,163

[a]Statistics Canada, Grain Trade of Canada, Ottawa, annual, Table 35.

[b]Westburn Development Consultants Ltd., Report Respecting the Demand for Grain Handling and Storage Facilities East of Thunder Bay to 1985, Winnipeg, 1978, p. 14.

3.4 THE GREAT LAKES-ST. LAWRENCE SEAWAY SYSTEM

Three major sources combine to generate total grain flows through the Great Lakes-St. Lawrence Seaway system: grain from western Canada moving to domestic and export markets, eastern Canadian grain, and United States grain for trans-shipment. United States grain flows are a product of two major factors: the international demand for United States grain exports in the Atlantic rim countries, and the competitive price of positioning grain at Quebec elevators relative to positioning the same grain in either Gulf or United States Atlantic export ports. Western Canadian grain constituted 45.2 percent[50] of the total grain moving through the Welland Canal in 1978; meanwhile, American grain accounted

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50 The St. Lawrence Seaway Authority, The Seaway: Operations, Outlook, Statistics (Ottawa: St. Lawrence Seaway Authority, 1979), p. 11.

for the remaining 54.8 percent for a total 29.8 million tonnes.[51]

The Great Lakes-St. Lawrence Seaway system is presently handling the greatest volume of grain ever. The transportation and handling of such large volumes of grain heavily tax upon existing facilities which already operate close to their capacity. The first major concern is the physical capacity of the Great Lakes-St. Lawrence Seaway system's locks, canals, and dock structures. In 1959, when the St. Lawrence Seaway system was completed, it created a fourth sea coast in North America. Since that time over 20 years have passed and the Seaway system is faced with numerous physical problems. The Seaway's maximum draft of 27 feet restricts passage of large ocean vessels. Certain ports, particularly Thunder Bay, are experiencing silting problems, canals and locks are quickly nearing capacity, and many docking and loading facilities are in dire need of modernization. Traffic levels on the Seaway are nearing a saturation point. A study done by the United States Army Corps of Engineers has revealed that by 1990 traffic in the Seaway system will be so great that a permanent jam-up will occur at the Welland Canal.[52]

Extending the Seaway shipping season to a year-round operation will definitely increase throughput capacity; however, the resulting economic benefits do not appear to be nearly as clear cut. In the early 1970's, the United States Water Navigation Board surmized that an effort to keep the Seaway functioning year-round would be beneficial.[53] Year-round operation will require either the extensive use of ice breakers or a bub-

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[51] Ibid.

[52] Lesstrang, op. cit., pp. 205-206.

[53] As cited by Lesstrang, op. cit., p. 156.

bling system to keep waterways passable, each of which are very costly. A more recent Canadian study concludes that a program to maintain year-round navigation would at best be only possibly beneficial.[54]

In addition to the physical limitations of the Great Lakes-St. Lawrence Seaway system, lake fleet capacity is also a limiting element.

> The maximum amount of grain that has been carried by the Great Lakes Fleet was 635 million bushels (17.8 million tonnes) of Canadian and United States grain in 1973, when the fleet worked to almost full capacity.[55]

Assuming that the relative amount of United States grain moved via the Canadian lake fleet remains constant, fleet capacity can be increased by reducing the time devoted to loading and unloading grain. The greater use of ocean-going vessels for direct ocean shipments originating from Thunder Bay does not appear to be very feasible. Unlike lakers, ocean vessels are not specially designed to navigate in confined waters. The holds of ocean vessels are generally built to carry a variety of cargo and are often not suited to loading grain. Ocean vessels sit high in the water requiring a specialized loading spout not commonly in use at Thunder Bay terminals. Salties loading at Thunder Bay may have to be shifted to new positions several times while the cargo of grain is constantly being leveled. Usually loading cannot be completed at Thunder Bay because the ships would sit too low in the water violating the Seaway's 27 foot draft. As a result, direct export shipments are often required to top-off their load at Quebec ports. Due to the problems inherent in coordinating ships and grain deliveries, there are

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54 L.B.A. Partners Ltd., The Seaway in Winter: A Benefit Cost Study (Ottawa: St. Lawrence Seaway Authority, 1978).

55 Canada Grains Council, Grain Handling and Transportation in Eastern Canada, op. cit., p. 98.

inefficiencies involved when a ship must dock more than once or be shifted from one docking position to another.

Pilotage is required both in shifting as well as inland navigation where ocean vessels are concerned. The restricted availability and cost of pilotage serve as a deterrent for ocean vessels accepting delivery of export grain at Thunder Bay. Thunder Bay, unlike most other harbours, does not have an established set of regulations for vessel conduct. The lack of regulation has promoted poor liaison between dock workers and foreign crews and has consequently caused reduced cooperation and inefficiency. The aforementioned factors along with Seaway congestion has discouraged ocean-going vessels from picking up grain cargos at elevators located along inland waterways. Future exports of grain directly from Thunder Bay are not expected to exceed the 1979-1980 record level of 1.222 million tonnes.[56]

The fleet of lake vessels which at one time was partial to transporting grain has now diversified into other commodities. The completion of the Seaway permitted an interaction of grain shipments and iron ore back hauls, reducing the occurrence of dead heading and thus providing a more profitable shipping operation. Iron ore shipments move from Labrador and eastern Quebec to industrial centers located in southern Ontario and the north central United States. Profit margins available from iron ore, stone, and coal shipments have increased relative to grain movements.

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56 Frances, op. cit., p. 71.

> It is not surprising that the improvements in the Canadian fleet in recent years have been based upon development in important trade other than grain and tend to have been the construction of self unloaders and the conversion of bulk carriers to self unloaders.[57]

It appears that short of large unforeseen expenditures, the physical capacity of the Seaway as well as the grain handling capability of the Great Lakes fleet could quite likely develop into a constraint on moving larger volumes of grain. A definitive estimate of the Seaway's physical capacity is extremely illusive, since it is directly related to economic activity in other industries. By examining ship carrying capacity and average trips per season it is possible to calculate a hypothetical carrying capacity for the Great Lakes fleet. In 1985, the Lake Fleet is expected to be able to handle 13.318 million tonnes[58] of Canadian grain. This represents a 0.899 million tonne increase over the 1975-1976 record level of 12.419 million tonnes.[59] If the eastern Canadian grain transportation system relies solely upon water movements, potential future demand for grain will not be met. Figure 6 illustrates the potential discrepancy between eastern export demand and the capacity of the Great Lakes-St. Lawrence Seaway System.

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[57] Canada Grains Council, Grain Handling and Transportation in Eastern Canada, op. cit., p. 89.

[58] Weaver, op. cit., p. 3.

[59] Statistics Canada, Grain Trade of Canada, op. cit., annual, Table 35.

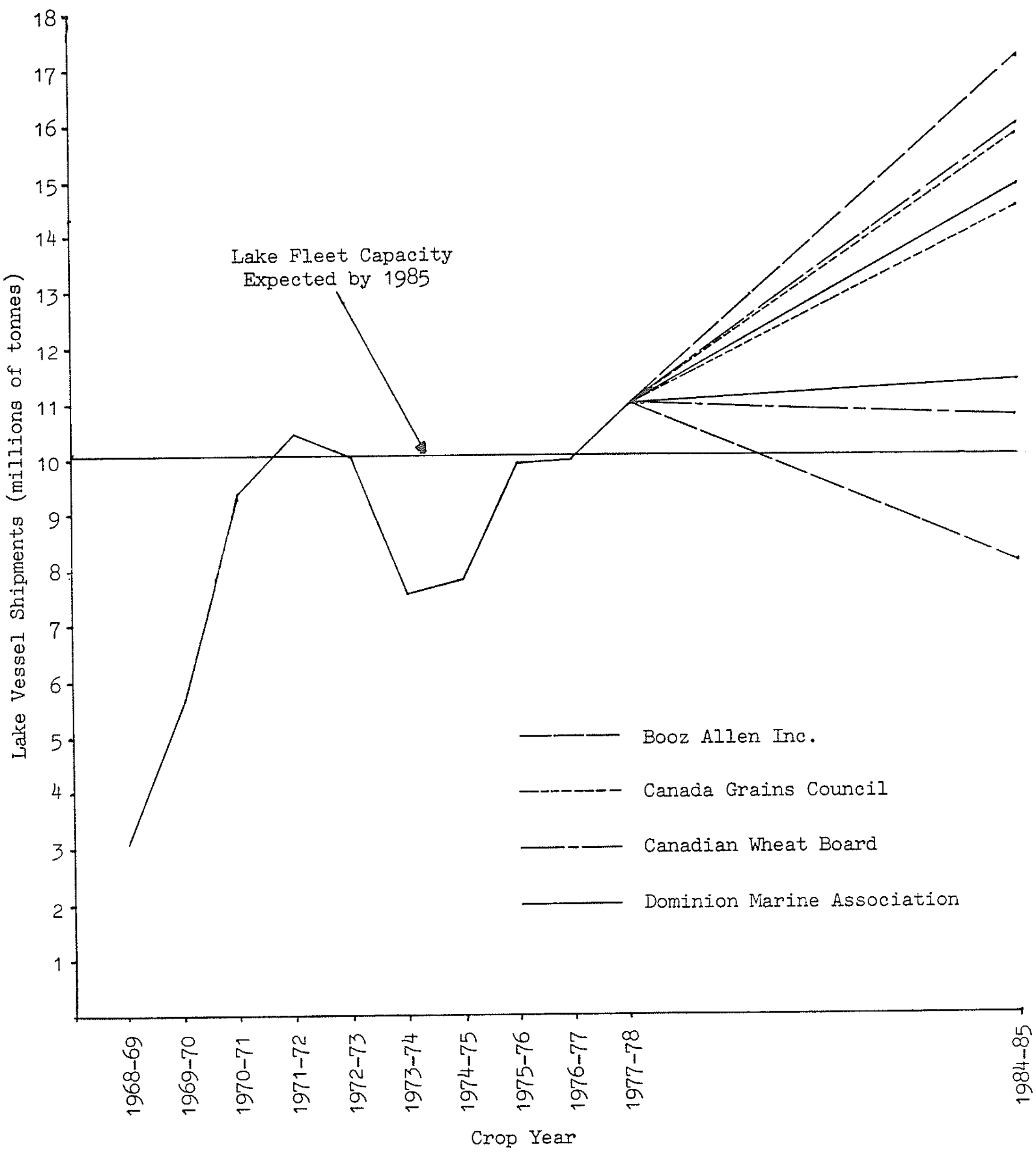

Figure 6

Capacity of the Great Lakes Fleet to 1985

Source: Statistics Canada, Grain Trade of Canada, Ottawa, annual, Table 35; G.D. Weaver, "Present and Projected Capacity Considerations for the Eastern Grain Handling and Transportation System" (Winnipeg: Canada Grains Council, 1980), p. 17.

In Figure 6, the expected export capacity of the lake fleet is illustrated by a horizontal line. In calculating export capacity, the expected domestic demand of 3.250 million tonnes is deducted from total fleet capacity of 13.318 million tonnes. As a result, 10.069 million tonnes of capacity is available for export movements.

During the 1971-72, 1972-73 and 1977-78 crop years the level of lake movements is expected to exceed the 1985 capacity of the Great Lakes fleet. By 1985 domestic movements will have increased considerably. As a result, the fleet capacity available to export grain will be somewhat less than previous shipping records. The export capacity of the Great Lakes fleet will be inadequate in handling the expected export demand.[60] According to Figure 6, the only export estimate which could be accommodated by the expected fleet capacity is the lower range of the prediction made by Booz-Allen Inc. With the exception of the lower range of the forementioned study, it is clear that the lake fleet will be unable to meet 1985 export demand. If there is no expansion of lake fleet capacity, rail movements will be required in order to satisfy eastern Canadian export demand.

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[60] For further information on the specific export levels, refer to p. 27.

3.5 THE RAILWAY NETWORK

Traditionally, grain is loaded from primary elevators onto rail cars, and subsequently moved via train load lots to Thunder Bay. Aboard one train there may be many different grains, and grades of grain. Once unloaded, and cleaned at Thunder Bay, the grain is moved further east either by Seaway or rail. During the 1978-1979 crop year, 93.5 percent of all shipments were made aboard vessels, as opposed to the 6.5 percent by rail.[61]

Over the years, the Federal Government has supported eastern Canadian rail movements through the Feed Freight Assistance and the Atlantic and East rail subsidy. The Feed Freight Assistance Act was originally passed in 1941, and subsequently amended in 1976. Shipment of western Canadian feed grains to points west of Montreal are no longer subsidized. Similar grain shipments to central Quebec, and the Atlantic Provinces[62] are presently transported under reduced subsidies.

In 1961, the Federal Government enacted the Atlantic and East ("At and East") subsidy applying it to the all-rail movements of grain originating at the Bay port elevators destined for the Atlantic region. Another government sanctioned movenment is the Canadian Wheat Board's Atlantic Export program. This program commences each year by directing a few cargos of grain to the Bay ports during the mid-summer, increasing the volume towards fall and finally taking whatever elevator space they feel is necessary to complete the program before Great Lakes navigation closes. Also, some loaded vessels at the Bay port elevators may be pro-

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61 Weaver, op. cit., p. 3.

62 C.E. Bray, Canadian Feed Grain Policy (Washington, D.C.: U.S.D.A., March 1978), p. 14.

viding additional storage over the winter. Between 1968 and 1978, an annual average of 662,500 tonnes[63] moved from the Bay port elevators to the Atlantic elevators under the "At and East" grain rates. Part of the movement has included grain shipped under the Winter Atlantic Export program.

Basically, "At and East" rates have attempted to partially compensate for the reduced throughput experienced when the Seaway was opened. Although beneficial in some respects, the basic rationale behind railway subsidization is subject to serious criticism. In comparative terms, the "At and East" subsidy is dwarfed by western Canada's Statutory Rail rates. Within the area under study, statutory rates apply to all western Canadian grain and grain products railed to Thunder Bay or Armstrong, Ontario. Thus, all grain moving east has its rail costs subsidized as far as the Thunder Bay terminals. If the full cost of transporting grain by rail is to be reflected, compensatory rail rates must be adopted. Railways are likely to be much more willing to accommodate larger and innovative grain movements if losses are not incurred for every tonne of grain transported. It should be recognized that the relative profitability of hauling grain compared to other commodities should also be considered when analyzing the railway's willingness to haul grain.

The use of solid trains provide one way in which grain transportation may be increased and made more efficient. The definition of unit and solid trains are often confused. Technically, a unit train refers to a train which loads, moves, and unloads as a unit. Solid trains can be

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63 Derived from: Statistics Canada, Grain Trade of Canada, op. cit., annual, Table 35.

broken up in the loading and unloading process but are transported as a unit and operated on a regularly scheduled basis. The actual occurrence of unit trains is fairly rare. In most cases those trains referred to as unit trains should actually be defined as solid trains.

As mentioned in Chapter One, there are two types of solid train movements which could be introduced (increased). These are:

1. movements out of Thunder Bay to the Quebec and Atlantic elevators, and/or
2. direct rail movements from the Prairies to the Quebec and Atlantic elevators.

All-rail movements passing through Thunder Bay have occurred in the past. Table 8 denotes the amount of grain railed out of Thunder Bay to eastern transfer elevators. Grain is moved out of Thunder Bay by rail in one of two ways. The first method is when grain moves to eastern transfer elevators from which it may either be exported or distributed to consumption sites. During the years 1968-1978, an average of 193,000 tonnes[64] of grain moved via this transportation mode. The second all-rail route out of Thunder Bay accounts for approximately 404,000 tonnes[65] per year and moves domestic grain directly from Thunder Bay terminals to individual consumption sites without using transfer elevators as an interim destination.

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[64] Derived from: Ibid., Table 12.

[65] Derived from: Ibid., Table 35.

TABLE 8

Destination of Rail Shipments out of Thunder Bay

Crop Year	Bay Ports	Lake Ports	Quebec Ports	Atlantic Ports
	..................tonnes..................			
1968-1969	0	1,066	2,181	23,537
1969-1970	216	928	1,005	17,889
1970-1971	1,318	4,838	16,281	14,010
1971-1972	747	10,641	283,370	10,965
1972-1973	2,237	9,494	229,450	0
1973-1974	4,586	19,318	312,998	117,323
1974-1975	8,189	16,998	303,994	47,257
1975-1976	12,400	13,999	63,531	5,646
1976-1977	8,514	5,340	31,992	10,982
1977-1978	11,388	17,076	244,311	41,644

Source: Statistics Canada, Grain Trade of Canada, Ottawa, annual, Table 12.

The Export Winter Rail Program was established at the close of Seaway shipping in 1971. The purpose behind the program is to increase grain movement by utilizing system capacity. Under the direction of the Canadian Wheat Board, export grain moves from Thunder Bay to the Quebec ports of Montreal, Sorel, Trois Rivieres and Quebec City.[66] The first grain train departed Thunder Bay on January 18, 1972 and the first year of the program was completed on March 29, 1972 with a total movement of 280,000 tonnes.[67] A special freight rate was negotiated with the Canadian Pacific and Canadian National Railways to cover the programs rail movement. The negotiated rate was to involve train load lots of 65 to 80 rail cars which were operated in a solid train fashion.

The Winter Export Rail Program applies only to grains railed out of Thunder Bay during the winter months when the Great Lakes-St. Lawrence Seaway system is closed; however, it is conceivable that rail shipments could continue throughout the year. One drawback to a year-round all-rail movement would be rail car inventories. During the 1978-1979 crop year there were approximately 22,000[68] railway cars hauling grain on a regular basis. The total grain fleet consists of about two-thirds railway owned box cars with the remainder being government owned hopper cars. The vintage of the box car fleet, results in a high attrition rate. Despite the 2,000 cars[69] presently on order by the C.W.B., it is

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66 The transfer elevators located at Baie Comeau and Port Cartier are not included as possible destinations since they are not serviced by rail lines.

67 Derived from: Statistics Canada, Grain Trade of Canada, op. cit., Table 35.

68 Booz, Allen & Hamilton, Inc., op. cit., p. viii-1.

69 Ibid.

expected that a substantial increase in rolling stock will be required by 1985. If all-rail movements are to operate on a year-round basis new locomotive and rolling stock must be purchased. The implications of capital purchases will be further discussed in Chapter 5.

Increased rail shipments from Thunder Bay represents one way to increase all-rail movements of grain. A second all-rail alternative is to load solid trains on the Prairies and move them directly to the Quebec and Atlantic transfer elevators. Georgian Bay and Lake port elevators are not considered as possible destinations for solid train movements of grain. The inability of the Bay and Lake port elevators to export grain results in total demand based upon levels of domestic consumption which is too low to warrant continuous solid train movements.

As denoted in Table 9 rail shipments direct from the Prairies to eastern elevators have occurred in the past. The level of direct rail shipments has been low and relatively inconsistent due to the grain industry's perception of rail as a high cost mode. With the exception of a few sporadic export movements, direct rail shipments have been confined to feed grains.[70]

> Almost all feed grains flowing eastward from the Prairies producing area move through Thunder Bay with the exception of small amounts of feed moving directly by rail to eastern markets and unit train movements direct from interior terminals to St. Lawrence ports.[71]

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[70] J. Lukasiewicz, <u>The Railway Game</u> (Toronto: McClelland and Stewart Ltd., 1976), p. 227.

[71] Canada Grains Council, <u>Grain Handling and Transportation in Eastern Canada</u>, op. cit., p. 6.

TABLE 9

Destination of Rail Shipments Direct from Western Canada

Crop Year	Bay Ports	Lake Ports	Quebec Ports	Atlantic Ports
	........................tonnes........................			
1968-1969	0	236	554	460
1969-1970	47	54	1,270	55
1970-1971	78	824	1,730	363
1971-1972	0	842	3,056	0
1972-1973	0	561	28,307	0
1973-1974	0	740	22,127	0
1974-1975	803	5,744	133,709	0
1975-1976	528	7,059	16,249	0
1976-1977	430	10,278	10,642	0
1977-1978	2,438	11.345	12,389	0

Source: Statistics Canada, Grain Trade of Canada, Ottawa, annual, Table 35.

There are many considerations which must be addressed when assessing the potential for direct rail shipments. If grain is to move directly from the Prairies to eastern transfer elevators, some arrangements must be provided for cleaning grain before it leaves the Prairies. In the past, cleaning grain has created a problem for direct rail movements, but this problem can be overcome if the grain is cleaned at inland terminals. In order to make all-rail grain transportation economically viable, solid trains rather than the traditional form of grain train must be adopted because the nature of solid trains requires that a large quantity of grain be made available at one location. Export and domestic grain must be moved if an adequate volume is to be attained; therefore, Prairie facilities capable of cleaning grain to export standards are necessary. Given the above requirements, the only facilities within the designated production area capable of sustaining a solid train movement are the inland terminals located at Moose Jaw and Saskatoon. Sufficient supply could be made available if grain was commercially trucked to the inland terminals from within a 100 mile radius.

The next aspect which affects direct as well as all-rail movements through Thunder Bay relates to the rail receiving capacity of Quebec and Atlantic elevators. Of the Quebec elevators, Quebec City and Montreal No. 4 elevator are the most suited for unloading solid trains. The transfer elevator at Quebec City has recently installed a modern unloading facility capable of handling solid trains, and the layout of Montreal No. 4 makes installation of a loop track possible. Halifax also is a likely destination for all-rail movements to the Atlantic region due to its relatively large storage and rail receiving capacity. With the exception of Quebec City, all other eastern transfer elevators served by rail use the push-pull method for positioning rail cars, as shown in Figure 7.

To gain full effect, a continuous loading operation is required for solid trains. It is possible that the inland terminals and at least some of the terminals at Thunder Bay may be able to adapt to such an operation. Improvements must also be made at Eastern destinations if solid trains are to be unloaded in a continuous and efficient manner while at the same time not interfering with other elevator operations. Two possible track configurations that could provide continuous unloading are shown in Figure 8.

The push-pull method shown in Figure 7 requires that trains be split up in order for them to be unloaded. Rail cars are pushed up to the unloading pit, and following unloading, they are pulled away from the elevator and spotted on another track until such a time when they once again can be formed into a train load lot. In the case of the proposed track configuration (shown in Figure 8), grain trains need not be broken up. While in a looping pattern the train will pass over the unloading pits thereby allowing a constant unloading process. With the advent of loop tracks, solid trains may be operated in a much more efficient manner.

The final and possibly the most serious all-rail consideration is in regards to estimating the amount of additional traffic Eastern rail lines can absorb. The level, and timing of other commodity movements will directly affect the quantity of grain which may be railed eastward.

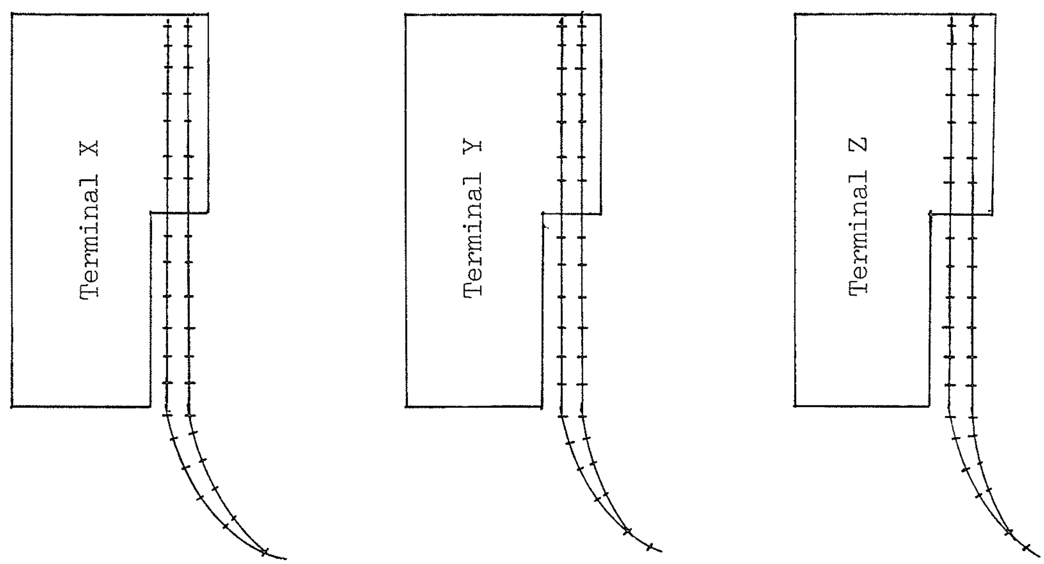

Figure 7

Present Track Configuration

Source: Canada Grains Council, Grain Handling and Transportation in Eastern Canada (Winnipeg: Canada Grains Council, 1975), p. 51.

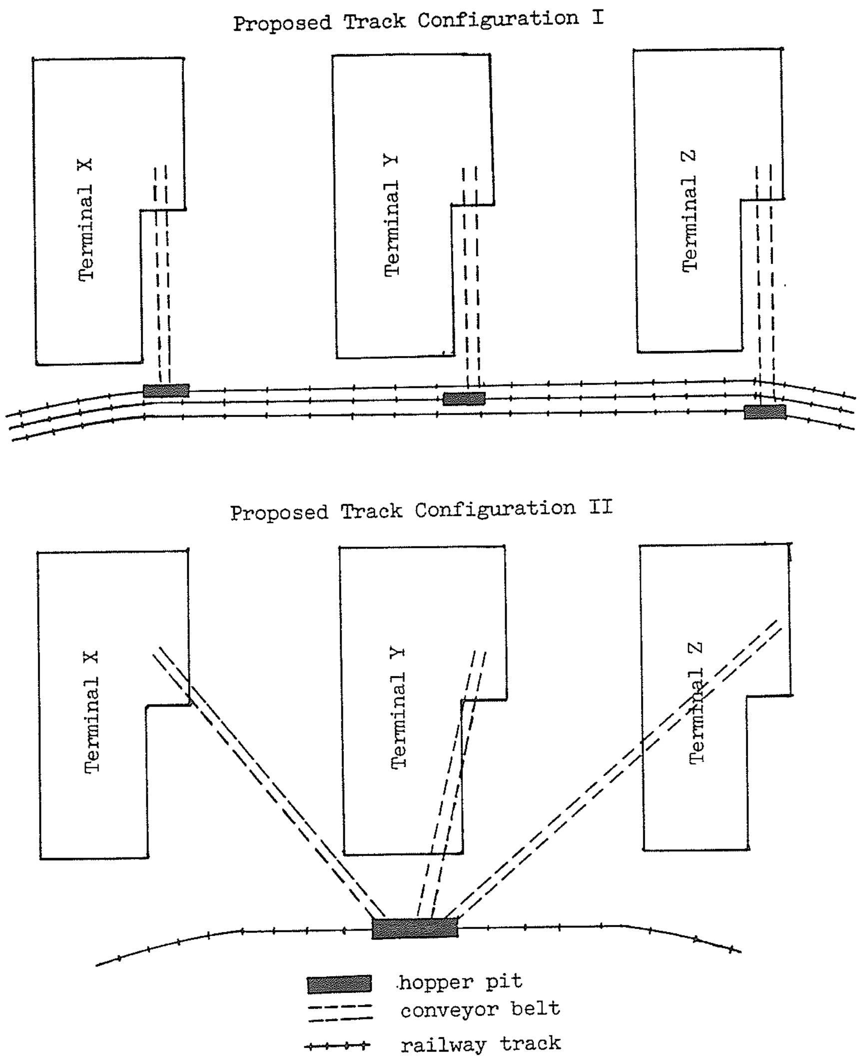

Figure 8

Possible Track Configurations for
Constant Unloading

Source: Canada Grains Council, <u>Grain Handling and Transportation in Eastern Canada</u> (Winnipeg: Canada Grains Council, 1975), pp. 51-52.

> Single track does not have an exact or readily identifiable capacity limit. Rather, there is a range of workload in which traffic congestion and aggregate train delay become increasingly intolerable to the point where the operation can no longer be considered economically acceptable. The single track capacity is somewhere in this range - just where depends upon a number of factors such as an average train load, average train speeds, train mix and priorities, and the amount of train delay that can be tolerated.[72]

Although difficult to quantify, there does appear to be excess rail capacity in eastern Canada. East of Winnipeg the railways have achieved a margin of sufficiency which will hold them for a few years without further expansion.[73]

> It was pointed out that efforts made during the Plant Improvement Program of the 1970's merely kept pace with traffic growth in large segments of the transcontinental route although some surplus was achieved in central and eastern Canada.[74]

If the maximum number of additional solid trains the Eastern railway system can handle per day at any one point is five,[75] the total incremental carrying capacity will be 10.250 million tonnes per year. Table 10 illustrates both the historic and potential throughput levels for rail movements of grain in eastern Canada.

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72 Canadian National Railways, "Railway Capacity - CN Trans Continental Route," unpublished paper, CN Rail Operations, Montreal, October 1980, p. 13.

73 Ibid., p. 11.

74 Ibid., p. 13.

75 This figure is based upon interviews with knowledgeable people in the railway industry.

TABLE 10

Past and Potential Grain Movements by Rail

Function	Historic Maximum[a]	Present Capacity[b]
	............'000 tonnes per year...........	
Quebec Receiving[c]	438	5,412
Atlantic Receiving[d]	868	3,936
Saskatoon Loading	218	2,216
Moose Jaw Loading	184	1,756
Thunder Bay Loading	1,124	4,998
Direct Rail	141	3,962
Total Eastern Rail	615	10,250

[a]Derived from: Statistics Canada, Grain Trade of Canada, Ottawa, annual, Table 35.

[b]This applies to the capacity to move clean grain.

[c]Includes both Quebec City and Montreal elevators derived from: Kates, Peat and Marwick, Grain Transportation in Eastern Canada (Ottawa: Grains Group, 1972), Appendix J.

[d]Estimations relate to the Halifax elevator and are derived from: Kates, Peat and Marwick, Grain Transporation in Eastern Canada (Ottawa: Grains Group, 1972), Appendix J.

In the past, the quantity of western Canadian grain moving east by all-rail routes has been minimal. The past record shows that eastern all-rail movements of solid trains are feasible, at least in a physical sense. What remains to be examined is the economic viability of solid train movements.

Chapter IV

THEORETICAL FRAMEWORK

This chapter introduces the theoretical framework as it relates to an eastern all-rail movement of grain. An all-rail route for grain transportation will produce a number of effects that transcend various sectors of the economy. An indepth analysis of all the related effects is beyond the scope of this study. The direct effects to be considered have been separated into four sections. These are:

1. producer,
2. industry,
3. national, and
4. international effects.

Prior to examining any specific theoretical aspects of grain transportation, a brief description of the structure and conduct of the world grain market may be helpful.

4.1 ORGANIZATION OF THE WORLD GRAIN MARKET

The manner in which an all-rail route will affect Canada's economy would depend upon the assumptions made in regards to the behaviour of the world grain markets. It has been argued that a more efficient grain transportation system would result in Canada's ability to sell export grain at reduced world prices. While there are certain inherent advantages to an efficient transportation system, the concept of export price competition is not necessarily valid unless it is assumed that the world grain market operates under a perfectly competitive structure.

Studies completed by McCalla[76] and Alouze, et al.,[77] provide a structural examination of the world grain markets. These studies specifically refers to the world wheat markets and concludes that market structure is oligopolistic rather than perfectly competitive. Prior to the mid-1960's, Canada and the United States operated as duopolists with Canada assuming the position of price leader. Productive capacity, share of world markets, and storage capability were three important factors which permitted Canada and the United States to control international price and supply of grain.

During the mid-1960's, an increase in grain stocks, accompanied by a decrease in both world demand and Canada's market share, led Canada to undercut existing world price. The ensuing price war signalled the collapse of the duopoly structure. Through the next few years, grain exporting nations jockeyed for position in an unstable oligopolistic structure. Out of the unstable world conditions evolved a form of stable oligopoly known as a triopoly. Exporting countries involved in the triopoly included Australia, the United States and Canada. Throughout the 1960's and 1970's, the United States increasingly outpaced Canada in terms of both grain production and relative share of the world market. The result is that the United States presently acts as a price leader, a position which was previously occupied by Canada.

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76 A.F. McCalla, "Duopoly Model of World Wheat Pricing," JFE, Vol. 48, 1966, pp. 711-727.

77 C.M. Alouze, A.S. Watson and N.H. Sturgess, "Oligopoly Pricing in a World Wheat Market," AJAE, Vol. 60, 1978, pp. 173-175.

It is likely that the triopoly structure will be maintained so long as world demand continues to increase. Since future world demand for grain is expected to increase significantly it is presumed that each country holding a position in the triopoly will enjoy an expanded level of grain exports. If the relative market shares remain constant, there would appear to be little motivation for one nation to undercut price, thus provoking a price war.

The theory outlined above argues that, at present, world grain prices are basically set by the United States, with national market shares being agreed upon among the triopoly nations. Normally, in a triopoly structure the amount of price competition for comparable products (in this case, grades of grain) is very minimal. Thus, it would appear that any cost benefits to be gained from a more efficient eastern grain transportation system would be absorbed mainly inside the Canadian boundaries.

4.2 PRODUCER EFFECTS

Within western Canada there are a large number of grain producers who individually have virtually no control over price. The relative number of grain producers as compared to the buyers results in the producer behaving as a price taker. Due to its biological nature, grain production is unstable. The yield factor for grain falls victim to the many natural stochastic influences. Once seeded, the acreage of grain within a particular crop year cannot be increased, therefore, in the short-run grain production is seen as being inelastic.

In recent years there has been a rapid increase in production. Due to the competitive nature of agriculture and the rapid development of production techniques, there has been a tendency for the supply curve to move to the right. Supply of grain includes both production as well as stocks of grain carried over from preious years. Carryover may be stored on the farm or at any other storage facility within the industry. The combination of current production plus carried over inventory causes the supply curve for grain to be more elastic than when only current production is considered. It should be noted that in the short-run (one crop year) the supply curve for grain is relatively inelastic and discontinuous. Discontinuity of supply can be illustrated in a number of ways. As the time period is extended beyond the short-run, the supply curve may actually become step-like. For the purpose of this thesis, the supply curve will be viewed in a long-term context as continuous and upward sloping to the right.

Direct producer effects can be explained through supply analysis. Conceptually, an individual producer's supply curve includes current production plus on-farm carryover. In Figure 9, the three curves S_1, S_2, and S_3 represent supply curves for three individual grain producers in western Canada. The summation of each individual producer's supply curve plus grain on route and in storage at primary, terminal, and transfer elevators accounts for the total supply of western Canadian grain.

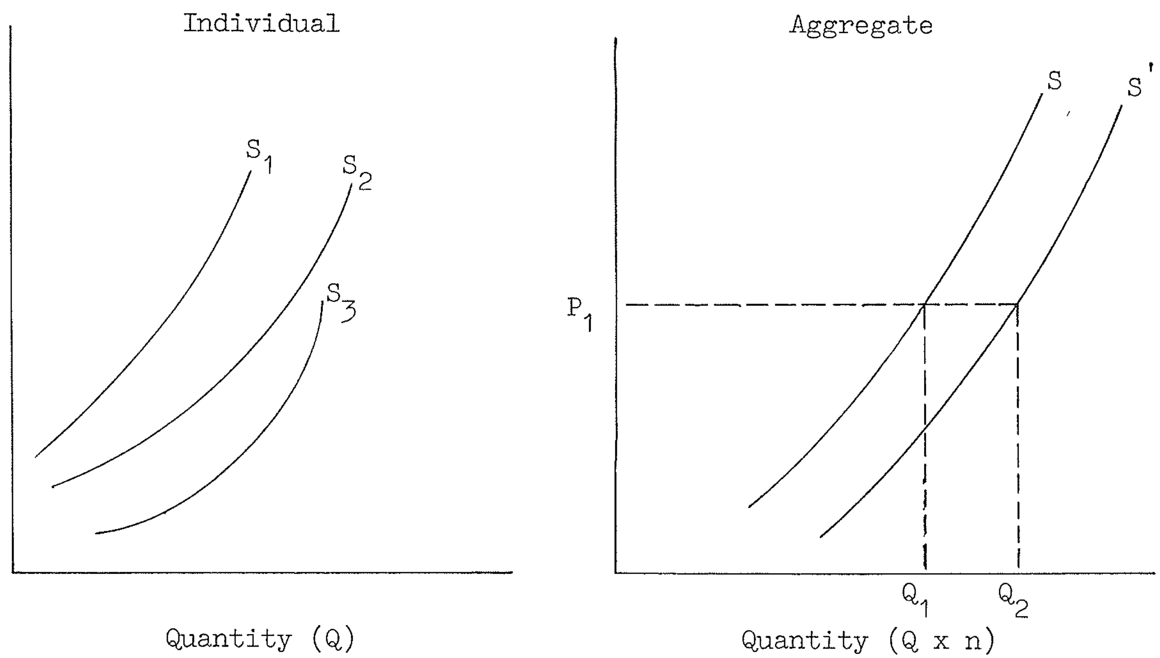

Figure 9

Individual and Aggregate Supply of Grain

Transporting grain via all-rail routes may affect grain producers in two main ways. The first possibility is an increase in the handling capacity of eastern Canada's grain transportation system. Assuming it is handling capacity not demand which limits ability to deliver, including the added capacity of an all-rail route may result in a shift in the supply curve. This is shown in Figure 9 where S, the original aggregate supply curve, shifts to S′.

All other things being equal an extension of system capacity resulting in an outward shift of the supply curve allows producers to deliver additional grain at every price level. According to Figure 9, at producer price P_1 an increase in capacity will result in a $(Q_2 - Q_1)$ increase in the aggregate quantity of grain which will be supplied by western Canadian producers. In the short run (within one crop year), supply will be increased by drawing upon inventories. Long run supply increases will have to come about through improved and intensified agronomic practices.

The ability to deliver significant quantities of grain is very important to the western Canadian producer. Quotas determine a producer's ability to deliver and are of crucial importance. If capacity improvements are instituted, the amount of western Canadian grain which can be delivered to eastern destinations also increase. So long as the quantity of resources devoted to grain production does not increase faster than the incremental handling capacity, producer's return per acre should increase.

The second way in which an all-rail route may affect producers is through transportation cost. The actual cost of moving grain is of great importance. It should be noted that deductions made from producer price are not necessarily equivalent to actual transportation cost. Producers are responsible for the average rather than actual cost of a particular grain movement. If overall deductions fail to compensate for total cost, the difference must be made up from other sources, specifically:

1. part of the producer's cost of production,
2. value of dockage or screenings in the grain,
3. operating losses by elements of the industry (railways or grain handling companies), and
4. the federal government through direct subsidies.

Depending upon location, there exist established rates to be paid for handling and transporting grain. The price a producer receives for grain is equal to the market price less marketing costs which include handling and transportation. If transportation costs increase while market price remains constant, the producer price will decline. Similarly, if transportation costs decrease, the result could be higher than producer prices, depending upon the competitiveness of the markets and/or government policy. Figure 10 illustrates how transportation costs affect the producer's price for grain.

In Figure 10, transportation costs are shown to be a function of distance from the market place. Market price is shown by Pm which is equal to the vertical height AB. Producer price is given as the difference between market price and transportation cost. The distance from a production site to the market place is inversely related to producer price. In other words, as distance to market increases transportation cost increases causing a reduction in the price a producer receives.

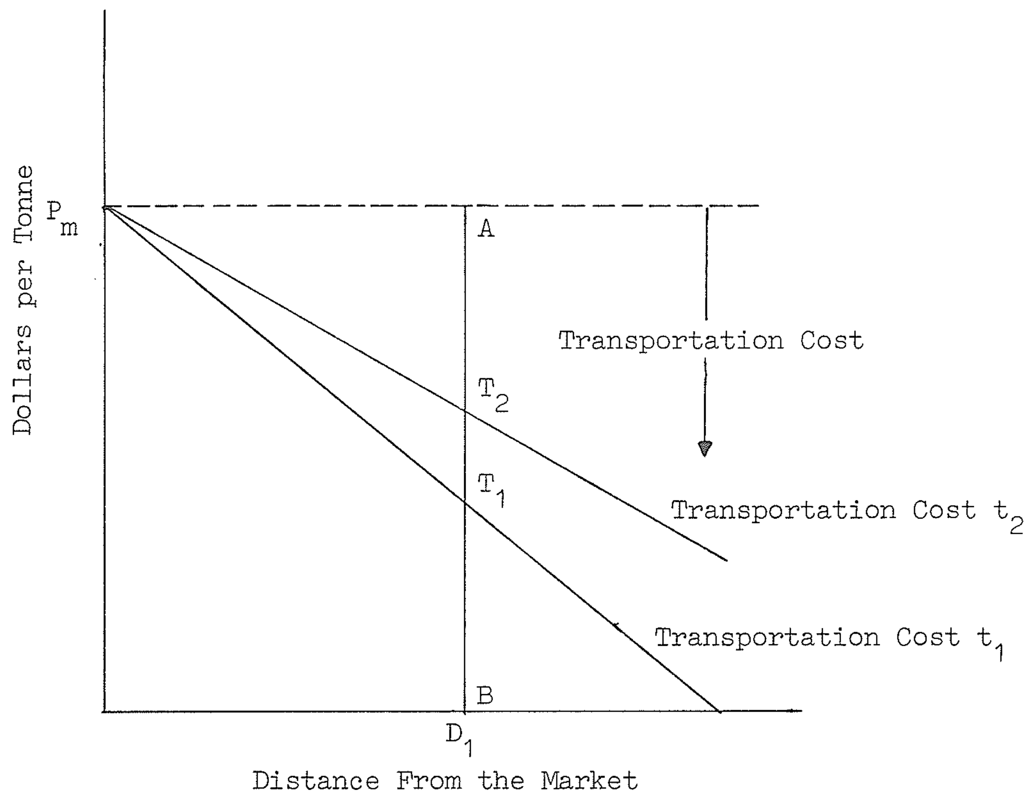

Figure 10

The Effect of Transportation Costs on Producer Price

In Figure 10, the present eastern grain transportation system displays the cost curve T_1. Grain producers located at D_1 will, therefore, receive a producer price of AB - $AT_1 = BT_1$ for a tonne of grain. If all-rail routes prove to be a low cost alternative, an increase in rail movements will cause a decrease in total transportation costs, shown by a shift in the transportation cost curve from T_1 to T_2. It is assumed (for the purposes of simplification) that any resulting benefit will be averaged out between all grain producers in western Canada. The all-rail route would thus result in a producer located at D_1 receiving an individual cost saving of $(T_1 - T_2)$ for every tonne of grain shipped. The saving in transportation cost would have the effect of increasing the net income of an individual grain producer. Producer returns can be maximized by positioning grain at the destination which has the combination of highest price and least deductions.

Analogous reasoning can be used in order to indicate the manner in which grain producers could react to an increase in transportation costs. Increased transportation costs reduce the returns a producer receives per tonne of grain. In such a case, producers would likely consider decreasing the acreage devoted to grain in order to seek out a more profitable use for their scarce resources.

4.3 INDUSTRY EFFECTS

The volume of grain that can be positioned and the cost of positioning grain are important to both grain producers and the economy of Canada. The capability to transport and position grain in significant volumes should, therefore, represent a long term planning priority of the grains industry. Industry effects provide the basic underlying theory regarding commodity movements. Changes in the grain transportation system basically affect the grain and transportation industries by altering the pattern of grain movements. The following theoretical analysis is desinged to provide two insights. The first being to determine the flow of grain between competing markets. The second relates to conceptualizing the part played by transportation and elevator costs in rationalizing the eastern Canadian grain handling system.

In terms of this study, the total demand for grain consists of both domestic and export movements. Domestic demand is fairly consistent increasing in small incremental amounts. Variability in total demand for grain stems primarily from international market fluctuations. Finally, the combination of export and domestic demand, one can argue, represents a derived demand for port facilities.

From the above, it follows that for a particular terminal or transfer elevator, grain handling facilities, reliability of delivery, and location will affect the specific level of demand. Factors operating within the grain industry determine the particular distribution pattern for grain supplies. While producers are concerned with transportation costs and ability to deliver, they maintain no control over off-farm demand nor are they able to influence the mechanism of supply distribution.

Bressler and King provide a good illustration of the manner in which the distribution of a commodity between two or more competing markets can be conceptualized.[78] In their analysis, site price is defined as the market price less transfer costs from the particular site in question.

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[78] R.G. Bressler and R.A. King, Markets, Prices and Interregional Trade (New York: John Wiley & Sons Inc., 1970), pp. 124-129.

The situation considered is when more than one market area is competing for the available supply. This is analogous in concept to the idea of one port area competing with another for the available supply of western Canadian grain.

According to Bressler and King, the Law of Market Areas asserts that "the boundary between two competing markets is the locus of points so situated that the site price (market price net of transfer cost) for shipments made to the competing markets are equal."[79] If market prices are equal, supply will first flow to the market where transportation costs are lowest. Inter-market competition for a single commodity is illustrated in Figure 11. In the diagram there are two competing markets depicted as markets A and B. The price in A is fixed while the price at market B is allowed to fluctuate. If there are equal prices at the two markets (price c at market B) then the competitive boundary will consist of all points where the difference in transportation cost is equal to zero. These are the points where the transfer cost to market A is equal to the transfer cost to market B. The boundary between the two market areas will comprise the locus of points where the distance to the two markets is equal. The perpendicular bisector of the straight line connecting the two markets will define the market boundary.

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[79] Ibid., p. 127.

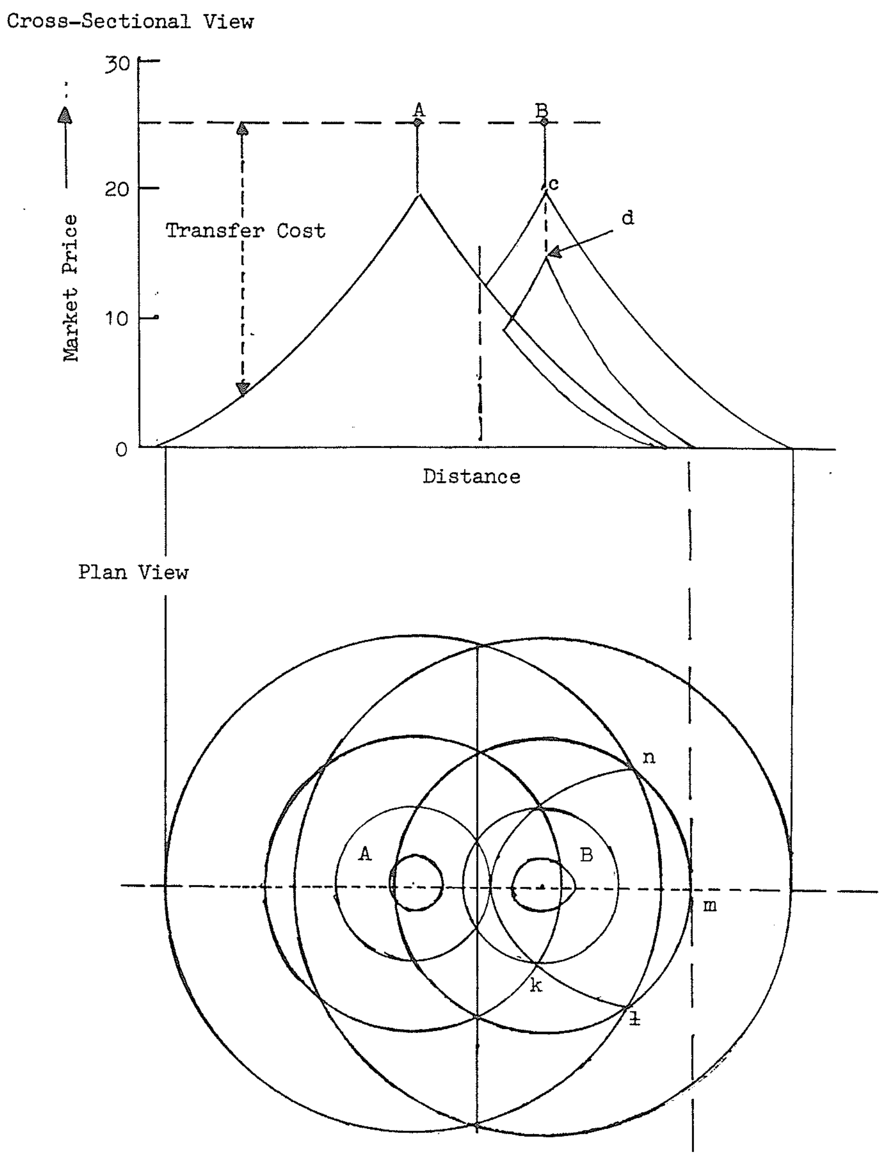

Figure 11

The Allocation of Production Sites Between
Two Competing Markets

Source: R.G. Bressler and R.A. King, Markets, Prices and International Trade (New York: John Wiley & Sons Inc., 1970), p. 128.

In the case where the price in market B falls below that of market A, then the boundary will move towards market B. It is now profitable for some of the supply which was previously moving to market B to instead move to market A. The new boundary is the locus of points where alternative transfer costs are constant and equal to the difference in market price, but they are no longer of equal distance from the two markets. Similarly, if the price at market B was again reduced, then a still greater amount of supply would shift to A. In other words, a decrease in price (or an increase in transportation charges to a certain market) will reduce the relative distribution to that market. On the other hand, an increased market price (or decreased transportation cost) can create increased supply flowing into a particular market site.

The actual slope of market boundaries will depend upon the mathematical form of the transfer cost function. If the transfer costs involved are a linear function of distance the boundary can be restated as a constant difference in distance to the two markets. In linear form the market boundary would be a hyperbola. With a curvelinear cost function, the controlling difference is transfer cost not distance. The resulting curve although not theoretically a mathematical hyperbola is referred to as an economic hyperbola.[80]

In the case of curvilinear transportation cost function, it is possible that the area which supplies market B could be completely enclosed by the supply area for market A. At price d, the area which distributes its supply to market B is enclosed by the curve lknm (in the lower panel). The area from which site A draws its supply includes the entire

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[80] Bressler and King, op. cit. p. 129.

production area with the exception of that enclosed area which serves market B.

It is now possible to conceptualize how a change in demand (price) or transportation costs can affect the level of supply which moves to a market site. For this particular study, we may consider export elevators as a market site and all-rail costs as a component in total transportation costs.

Conceptually, if the origin and destination of grain shipments are known then it will be possible to rationalize the system given the location theory prioneered by Losch[81] and subsequently described by Bressler and King.[82] Figure 12 illustrates a way by which transfer and plant costs can be combined in order to minimize total system cost. Transfer costs are incurred for the following services: trucking, handling and storage at primary elevators, as well as for rail and/or water transportation. In other words, transfer costs represent the cost of moving grain from the farm gate to the market place. For grain moving eastward, terminal and transfer elevators conceptually represent the market place. Plant costs involved in eastward grain movements are analogous to the cost of operating eastern terminal and transfer elevators. Terminal and transfer elevators, operating as collection sites, are assumed to be subject to economies and perhaps diseconomies of scale depending upon throughput levels. The optimum organization of transfer and plant cost involves a balance between decreasing average plant costs and increasing transfer costs.

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81 Losch, op. cit.

82 Bressler and King, op. cit., pp. 141-144.

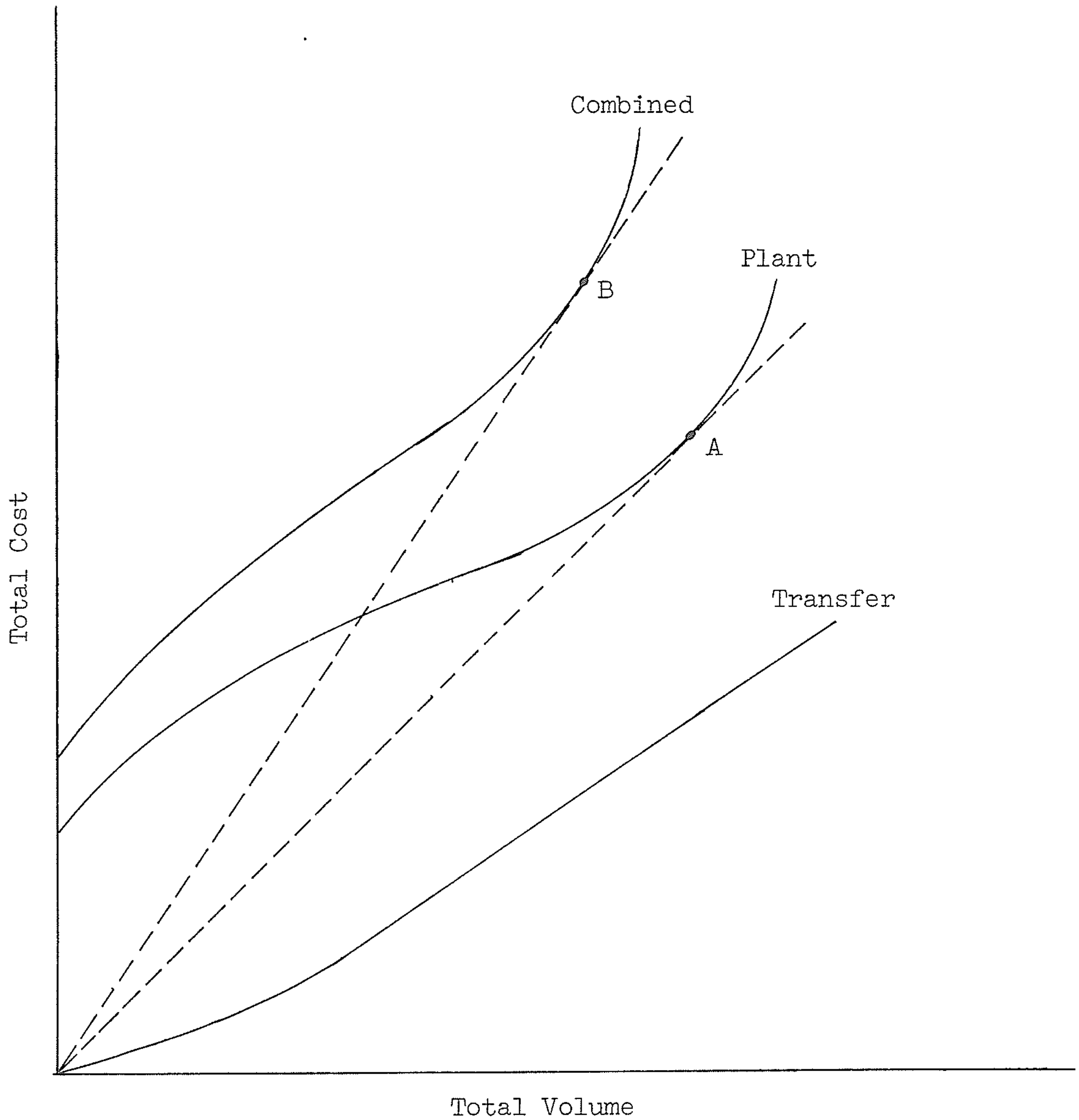

Figure 12

Combination of Transfer Costs and Plant Costs to Determine Optimum Grain Movement

Source: R.G. Bressler and R.A. King, Markets, Prices and Interregional Trade (New York: John Wiley & Sons Inc., 1970), p. 143.

The plant costs shown in Figure 12 suggest that unit costs for plant operations will decrease over a considerable range of volume and eventually begin to increase. Point A represents the lowest per unit cost with regards to plant costs. When plant costs are combined with transfer costs, point A is no longer the optimum point; instead, the lowest possible per unit cost now occurs at point B.

The above theory provides a way to combine plant and transfer costs in order to approximate the total cost of moving grain. By minimizing total cost, it will be possible to rationalize the eastern transportation and grain handling system. Since there are handling facilities presently in existence, it will be assumed that at least initially these facilities will remain within the system. It is possible that certain elevators due to location, inefficiency, or transportation cost may be deemed uneconomic and eventually removed from service. Likewise, transportation routes may be removed or added based upon physical feasibility or cost.

Any system with a combination of transportation and handling links has a total capacity equal to the ability of the smallest link in the system. Capital investments either in maintaining efficiency, or expanding the capacity are made among other considerations on the basis of the relative profitability of these investments. Grain flows directly affect return on transportation investment, thus the manner in which grain is routed will have a direct bearing upon the location of capital investment.

4.4 NATIONAL EFFECTS

Producer and industry effects will, in turn, influence Canada's national economy. As mentioned earlier, the provision of eastern all-rail routes could expand the present system's handling capacity. The second possibility is that including all-rail routes may decrease transportation costs and as such provide a more efficient system. Figure 13 illustrates the direct impact that all-rail routes may have on Canada's economy.

In Figure 13, S_{1978} represents the western Canadian supply of grain during 1978. The horizontal line denoted by D_{1978} depicts the export demand for western Canadian grain in the same year. As explained earlier, Canada generally accepts the world price for grain, therefore, within any one year export price will remain relatively constant regardless of the quantity supplied. The 1978 equilibrium between supply and demand shows western Canada supplying Q_1 tonnes of grain.

By the year 1985, it is assumed that the demand for Canadian export grain will increase to D_{1985}. Concurrent production increases will result in an outward shift in supply to S_{1985}. Thus, with the use of existing, and planned facilities, Q_2 tonnes of grain could be exported in 1985. Assuming that the grain handling capacity of the system is the limiting factor, implementing increased all-rail movements could result in an incremental amount of grain being moved east. It is likely that improvements to existing facilities would be necessary if all-rail movements are to increase system capacity to S_{1985}'. The outward shift in supply due to the increased use of all-rail movements would mean an additional $(Q_3 - Q_2)$ tonnes of grain moved east each year. This represents a $[(Q_3 - Q_2) \times P_{1985}]$ increase in total revenues received.

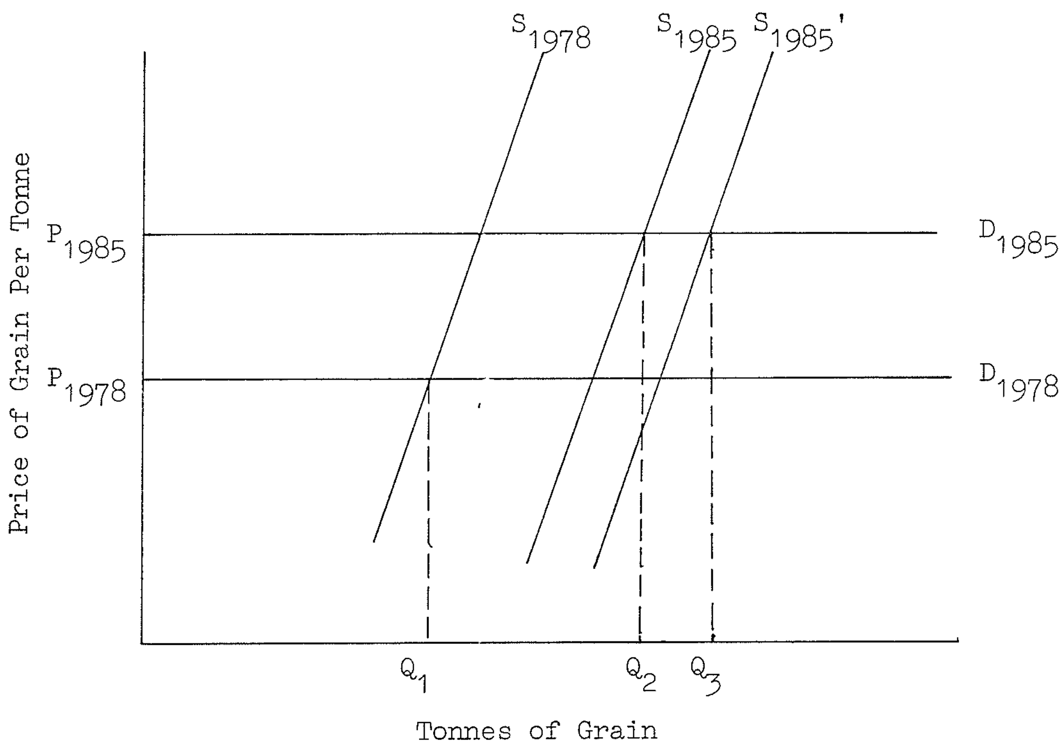

Figure 13

The National Effect of All-Rail Grain Movements

The national macro-economic implications of an increase in grain movements would benefit three interest groups: producers, the transportation industry, and the federal government which is synonomous with the taxpayers. Producers would benefit from increased quotas, and an improved net return per acre. Improved net returns per acre is partly dependent upon transportation cost savings being passed on to the producers. In addition to producer benefits, certain sectors of the grain transportation industry would gain from a more efficient use of existing facilities. The Canadian taxpayer would also be made better off due to the fact that increased grain exports improves our balance of payments situation.

The second possible outcome of all-rail grain movements is a change in the total cost of transporting grain. Given Canada's inability to significantly alter the world price of grain, cost savings due to a more efficient transportation system will be absorbed within the country. Direct transportation related cost benefits would basically accrue to the producer and/or the grain transportation industry. If grain producers receive the benefits, the return per tonne of grain sold would increase. In the case where the grain transportation industry retains the benefit, the cost savings would likely appear as increased revenues either to be reinvested or distributed to shareholders.

The discussion concerning the effect of capacity and cost benefits has examined only the very basic first round effects. The overall picture can only be evaluated once the relevant economic multipliers have been accounted for. This implies a complex IS-LM type of analysis. In addition, if the actual benefits and losses are to be assessed, a more complete analysis based on welfare economics must be undertaken. This involves the underlying gains and losses brought about by including all-rail routes in the grain transportation system. While the benefits of such welfare and macro-economic analysis are recognized, they are beyond the scope of this particular study.

4.5 INTERNATIONAL EFFECTS

On the international scene, it is important for an exporting nation to have the ability to increase its level and consistency of demand through product differentiation. Due to the price determining mechanism of the world grain markets, non-price differentiation has become prevalent. One very important non-price factor is an importing nation's perception of an exporter as a reliable source of supply. Grain is imported in order to provde for sufficient food supplies and as such the importing nation is extremely concerned about the timing and reliability of supply. Unfortunately, it can be argued that Canada's image as a reliable grain exporter is far from flawless.

The capacity which is relevant to maximizing returns is not the ability to handle the expected average volumes but the ability to handle expected maximum volumes. An inability to handle peak demand results in lost sales and lost credability. Dependence upon a transportation system that cannot accommodate maximum volumes can result in lost buyer confidence in the exporter's ability to deliver grain.

The vast majority of grain export agreements are negotiated including the provision that inter-country transportation costs become the responsibility of the importing nation. The days an ocean-going vessel spends in port has a large effect upon the total cost of the voyage.[83] International supply and demand conditions dictate how willing an importing nation will be to absorb high port costs. Conceptually, port costs have become a component in the total price which an importing country pays for grain. During times of low supply, inefficiency resulting in inflated costs may be tolerated by an importing nation. However, when the international market has surplus stock, low port costs will provide the particular exporting nation with a distinct comparative advantage. Reliable delivery of export grain will likely generate consumer loyalty in the international market. From an exporting nation's standpoint, reliable supply of grain may be perceived as a way in which to generate consumer loyalty, as evidenced through long term importing agreements.

The location, regulations, and facilities at ports will affect shipping costs. The location of the port does not pose a serious problem unless there is some physical aspect which makes navigation to, or within a port hazardous. Shipping charges per mile are relatively low; therefore, unless there is a significant difference in distance, the total cost effect will be slight. Port regulations are fairly consistent, varying only slightly from one location to the next. Regulations pertaining to pilotage and towing provide for potential delays in the loading and movement of ocean vessels. The manner in which the port facilities are utilized contributes a great deal to the variability of transportation costs. If a particular port area enjoys relatively efficient facilities then it is generally expected that an importing na-

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[83] M.L. Davis, "Costs of Shipping United States Grain Exports to Principal World Markets," unpublished Master's thesis, Iowa State University, 1968, p. 15.

tion's preference for low transportation costs will cause an increase in demand for grain at that location. All-rail transportation of grain would provide a method by which Quebec and Atlantic transfer elevators could be in use throughout the year, rather than being restricted to the Seaway shipping season. A more steady year-round utilization of port facilities would surely be advantageous since it would reduce congestion and lower the resulting demurrage charges.

Another important aspect of deliverability is the event of a labor stoppage. Hickson[84] found that labor strikes severely impede Canada's export reliability. In addition to labor difficulties, occasional physical impediments may arise which restrict grain movements. A recent example of a physical restriction is the situation where a damaged bridge in Vancouver reduced potential grain exports. If an alternative route was available for year-round exports then the closure of one route due to physical or labor related restrictions would reduce but not completely frustrate Canada's attempts to fulfill export commitments. An all-rail movement of grain may provide a method by which the eastern transfer elevators could be used to export grain throughout the year allowing Canada a much more flexible delivery system.

Questionable port efficiency and unreliability can be blamed for a loss or at least a reduction in potential export sales. If an eastern all-rail route is successful either in increasing port efficiency, supply reliability, or system capacity, then Canada's position as a grain exporter will be enhanced.

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84 A. Hickson, "An Econometric Model to Assess the Costs of Labour Disputes in the Canadian Grain Movement System," unpublished Master's thesis, University of Manitoba, 1978.

Chapter V

THE MODEL

5.1 CONCEPTUAL MODEL

In this section a mathematical model representing the eastern grain handling system is briefly outlined. As mentioned in Chapter Four, the theoretical basis of the model can be found in the location theory originally proposed by Losch.[85] Eastern Canada's grain handling system is actually a complex interaction of individual components. The model attempts to imitate the actual grain transportation system in a somewhat simplified and more clearly understood form. Theoretically, the prevailing grain transportation system directly affects grain producers, the Canadian grain and transportation industry, Canada's economy, and various international aspects. However, all of these do not fall within the scope of the model. The foremost thrust of this study relates to the way in which a change in the pattern of grain flows will affect the handling and transportation sectors of the Canadian grain industry. Thus, it is the transportation and handling interactions which are encompassed within the model. In order to conceptualize how individual pieces of the model fit together, a brief description is necessary.

The basis of the model is the supply and demand for western Canadian grain. In actuality the various types, and in fact grades of grain, are somewhat different. Demand and cleaning requirements may vary slightly,

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85 Losch, op. cit.

depending upon the type and grade of grain. For the purpose of simplicity, grain flowing through the model will be treated as a homogeneous commodity. The primary source of supply is considered to be thousands of individual producer sites throughout Manitoba and Saskatchewan. Grain is either moved from the farm gate to primary elevators via farm truck, or else commercially trucked to inland terminals at Moose Jaw or Saskatoon. Including all the primary elevators would unduly complicate the model; therefore, representative shipping points were selected at central locations. In the case of grain moving through primary elevators, Carberry, and Craik were chosen to represent Manitoba and Saskatchewan, respectively. Carberry and Craik were selected since they are centrally located within the grain producing regions of the grain producing area of their respective provinces.

Western Canadian grain is used for both domestic and export purposes. Demand conceptually occurs at eastern terminal and transfer elevators located within geographic port areas. Domestic demand within a particular port area is fairly stable; however, export demand will be allowed to shift between Thunder Bay, Quebec, and the Atlantic ports, based upon the relative transportation costs, and throughput capacities. The model deals with the flow of western Canadian grain and as such requires that United States and locally produced eastern Canadian grain movements be netted out of the system. Once United States and eastern Canadian grain movements have been accounted for, the residual system capacity is available to western Canadian grain which is moving to eastern destinations.

The basic purpose of the model is to move western Canadian grain from its point of production to the point of demand which is conceptually located at eastern elevators. There are various routes included in the model by which grain can be transported eastward. As is illustrated in Figure 14, grain originates in Manitoba and Saskatchewan and subsequently flows through an intermodal transportation system to reach the point of demand. The specific components within the model include:

1. collection of grain at primary elevators or inland terminals;
2. railway and/or Seaway transportation;
3. Thunder Bay terminal and,/or transfer elevator services; and
4. ocean shipping.

Depending upon the particular route, each of the aforementioned components has its own individual and unique cost.[86] The objective function of the model derives total system cost by multiplying the quantity of grain flowing through the system (in tonnes) by the cost per tonne. In general terms, a mathematical programming approach is followed and as such, the model allows various components to interact in order to provide the lowest total cost grain movement. Within the context of this model, optimization can be defined as minimizing the total cost of moving a specified level of grain from Prairie farms to eastern elevators.

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86 Individual cost components will be discussed in a later subsection (see 5.4 Cost Considerations).

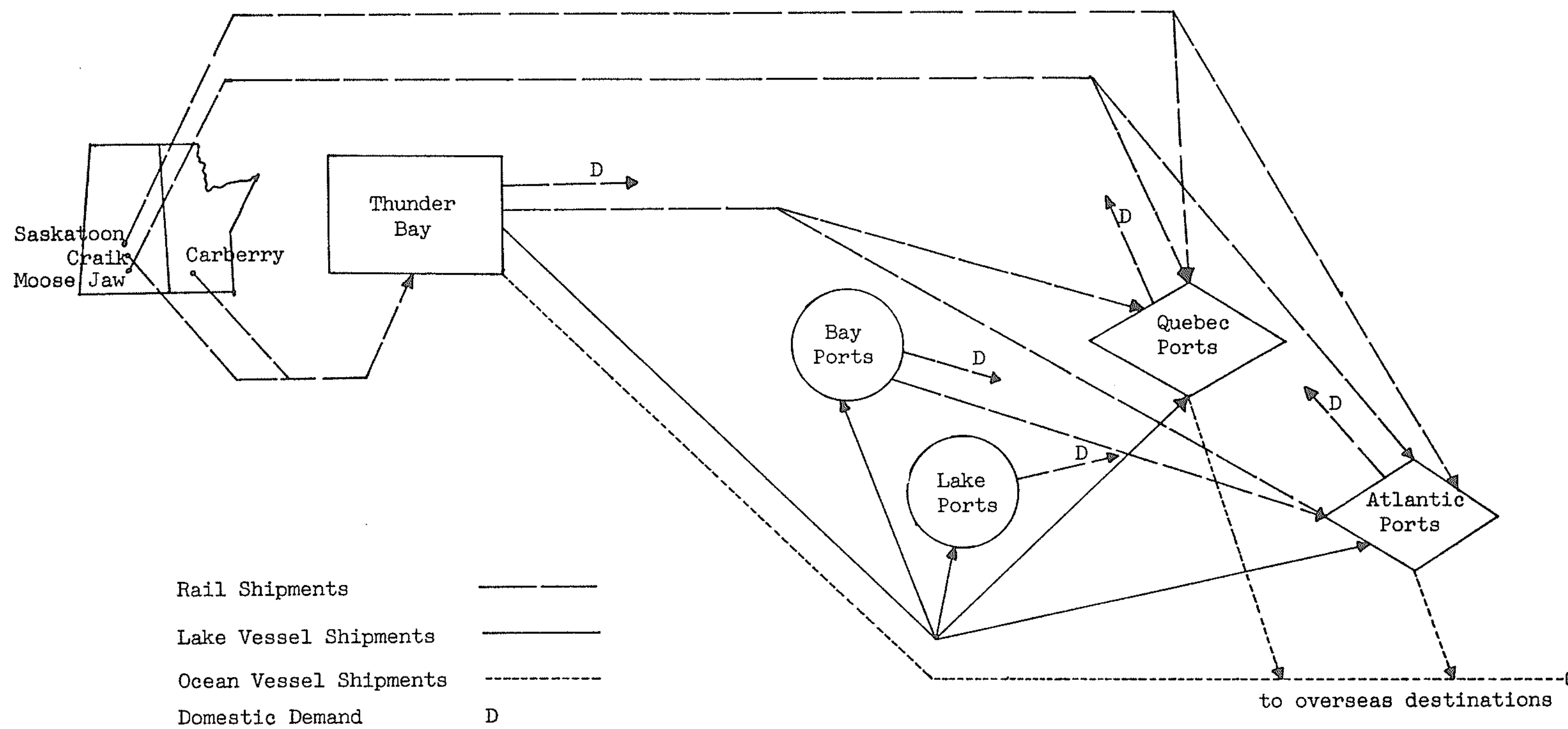

Figure 14

Eastern Grain Routes Included in the Model

5.2 MATHEMATICAL MODEL

Mathematically, the model can be specified as follows:

Minimize Total Transportation Cost = $\Sigma \Sigma \Sigma C_{ijk} X_{ijk}$

Subject to: $\sum_j \sum_k X_{ijk} < S_i$ $\quad i = 1, 2, 3, 4$

$\sum_i \sum_k X_{ijk} < D_j$ $\quad j = 1, 2, 3, 4, 5$

$\sum_i S_i = \sum_j D_j$ $\quad k = 1, 2, 3, \ldots, 36$

$0 \leq X_{ijk}$ Potential Capacity Constraints

Where C_{ijk} is the cost of transporting grain from supply point i to demand point j via transport mode k; and, X_{ijk} represents the amount of grain shipped from supply point i to demand point j via transport mode k. The model allows for 36 (n = 36) possible routes over which grain may be transported. The notation Si represents the supply of grain at point i, while D_j is the demand for grain at point j. Demand is allowed to fluctuate from one demand site to another. In the case of supply, S_i is limited to the quantity of marketable grain that can be potentially produced within a particular province. For example, the amount of grain which flows through Carberry cannot exceed the amount of grain marketed in Manitoba. The four possible sources of supply (S_i's) include the primary elevator sites of Craik, Saskatchewan and Carberry, Manitoba, as well as, inland terminals located at Moose Jaw and Saskatoon. Eastern demand sites (D_j's) are represented by elevator facilities located at Thunder Bay, Bay ports, Lake ports, Quebec ports, and the Atlantic ports. Although total supply (Σ S_i) is set equal to total demand (Σ

D_j), actual supply at individual ports does not usually equal demand directly. In order to prevent inventory changes at eastern elevators, total receipts are required to equal total shipments. Since inventory levels are not allowed to change, the amount of carryover presently stored at eastern elevators will be maintained.

Each individual route is subject to certain capacity constraints which will limit the quantity of grain (X_{ijk}) which can be transported. As mentioned in Chapter Three, each particular route has its own specific capacity constraints. As an example, the direct rail route from Saskatoon to Quebec City may be constrained by any of the following:

1. supply of grain to the Saskatoon terminal,
2. the cleaning, handling, and rail loading capacity at the Saskatoon terminal,
3. rail capacity in eastern Canada,
4. rail unloading and handling capacity at the Quebec elevators, or
5. the domestic and export demand at the Quebec elevators.

The model searches out cost efficient transportation routes by identifying origins, possible intermediate transfer positions, and final destinations of grain movements. The first route selected by the model will be the least cost alternative. The least cost alternative route is used until one of its particular capacity constraints is reached. In other words, as much grain as is physically possible will move by the least cost route. Following this, the model will select the next least cost alternative out of the remaining routes. In a step-like procedure, least cost routes are identified until the selected collection of grain routes either accommodates the total quantity of grain to be moved, or else total system capacity is exceeded. Once total system capacity is met, all possible routes have been used as extensively as is physically possible. Overall, the model is constrained by:

1. maximum grain production within the supply region,
2. handling, cleaning, and loading capacity at elevators,
3. rail carrying capacities,
4. carrying capacity of the Great Lakes fleet, and
5. the level of domestic and export demand for western Canadian grain at eastern elevators.

5.3 ANALYTICAL TECHNIQUE

The next step is to determine which type of analytical technique is best suited to the model presented in the previous section. Generally, the application of mathematical programming is much less complicated than computer simulation models. Mathematical programs are able to determine an optimal solution given an objective function which is subject to certain constraints. Unlike linear programming, quadratic programming has the advantage of not being confined to a linear objective function. However, when the assumption of linearity is dropped, it becomes more difficult to estimate the objective function. The relevant question to be considered is whether or not grain transportation costs can be considered as linear in nature.

In relation to railway costs, linearity appears to be a reasonable assumption. Griliches[87] reviewed four econometric studies which were conducted in order to determine if prevalent economies of scale exist in

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[87] Z. Griliches, "Cost Allocation in Railroad Regulation," The Bell Journal of Economics, Spring 1973, pp. 26-41.

railway operations. The studies reviewed include: Borts,[88] Klein,[89] and Meyer, et al.[90] If the smallest railroads are excluded from consideration, the consistent finding of the four previously mentioned econometric studies is that "there is very little or no evidence of economies of scale in the railroad industry."[91]

Within a relevant range of output the linearity of railway costs appears to be an acceptable assumption.

> Under present conditions of maturity most main line railroad facilities and the operation therein have had a chance to become closely adjusted to the density of traffic handled and the revenues derived therefrom, so that average unit costs tend to be nearly uniform over a wide range of densities and the cost of handling additional increments of business are not likely to be much below average costs.[92]

Providing that the utilization of railway facilities or densities of traffic are maintained within what can be referred to as the relevant range, the application of linearity to railway costs is a reasonable assumption. Also, the additional effort necessary for the determination of specific or actual costs may not yield any better results. The Commission on the Cost of Transporting Grain by Rail was compelled to note

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[88] G.H. Borts, "The Estimation of Rail Cost Function," Econometrica, Vol. 28, No. 1, January 1960, pp. 108-131; see also, G.H. Borts, "Production Relations in the Railway Industry," Econometrica, Vol. 20, No. 1, January 1952, pp. 71-79.

[89] L.R. Klein, A Textbook of Econometrics (Evanston, Ill.: Row, Peterson & Co., 1953).

[90] J.R. Meyer, et al., The Economics of Competition in the Transportation Industries (Cambridge, Mass.: Harvard University Press, 1959).

[91] Griliches, op. cit., p. 36.

[92] John Heads, The Economic Basis for Transport Subsidies (Ottawa: Canadian Transport Commission, 1975), p. 16f., from H.A.A. De Melverda, "The Illusion of Fixed Costs," International Economic Papers, 1952, pp. 152-177.

that "contrary to the belief of some, substitution of specific costs for system average or allocated costs does not necessarily result in a substantial improvement in the accuracy or reliability of the cost estimates."[93]

The linearity of elevator costs is less evident. Logically it seems that the operation of elevator facilities is subject to economies of scale (decreasing average cost curves). A study conducted by Tangri, Zasada, and Tyrchniewicz[94] found that economies of scale were evident in primary elevator operations. If it is assumed that curvelinear cost functions apply to terminal and transfer elevators, then the procedure for estimating the objective function becomes much more complicated. Due to the unavailability of necessary cost data, estimation of curvelinear cost functions for eastern elevators is virtually impossible. Also, even if the relevant cost data were available, it would most likely be in a highly aggregated form which does not allow an examination of individual costs such as cleaning, and rail receiving which are of utmost importance in this analysis.

It is quite possible that the actual total cost function regarding the transportation of grain (the model's objective function) could conceivably be curvelinear. However, bearing in mind the extensive data problems inherent in estimating curvelinear functions, and the fact that curvelinear costs may be no more reliable than the particular technique

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[93] The Commission on the Cost of Transporting Grain by Rail, Report, Vol. I, Supply and Services Canada, Ottawa, 1976, p. 32.

[94] Om P. Tangri, D. Zasada, and E.W. Tyrchniewicz, Country Grain Elevator Closures: Implications for Grain Elevator Companies, Research Report No. 10 (Winnipeg: Center for Transportation Studies, University of Manitoba, January 1973), p. 57.

used to obtain them, the additional effort necessary for the determination of actual or specific costs may not improve the quality of the results. Thus, the application of a linear objective function is deemed to be acceptable and will be used in the model.

Linear programming is a mathematical technique which determines the most profitable course of action in a situation where a number of variables are involved, where many possible courses of action are available, and where the problem can be mathematically expressed in linear terms. Two previously mentioned grain transportation studies which utilize linear programming are Tyrchniewicz[95] and McDonald.[96] Transportation algorithms have been designed which greatly reduce the complexity of computer programming. Such algorithms provide a special application of the linear programming technique whereby a homogeneous commodity is moved from supply to demand. For the model specified here, the computer package used was LP1.

5.4 COST CONSIDERATIONS

Having decided upon the parameters of the model, the corresponding costs constituting the objective function must be determined. Due to the inavailability of a more recent set of complete cost data, 1978 was selected as the base year for the study. All estimates within the model are calculated based upon 1978 information.

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[95] Tyrchniewicz and Tosterud, op. cit.

[96] McDonald, op. cit.

The actual values for grain handling and transportation services are treated exogeneously and have been, therefore, determined outside the model. In the case of elevator, Seaway, and ocean shipping, "economic cost" figures are unavailable; for this reason, published rates and tariffs are substituted in their place. The apparent costs (rates) may at times not be exactly equal to the actual cost incurred in the provision of a grain handling or transportation services. If total revenue (rates x quantity) exceeds the economic cost, the company providing that particular handling or transportation service will enjoy pure profit. On the other hand, if total revenue is less than actual cost, then the provision of service results in a net loss.

Within this study, total cost is defined as the dollar value per tonne which must be paid in order to receive grain handling and transportation services. In all cases except for railway transportation, rates of service (tariffs) are assumed to be set at a level sufficient to cover both short run variable cost, as well as long run total costs. Railway rates are an exception since they are subsidized by both the federal government, and railway losses. In the aim of consistency, full rail cost will be estimated, and instituted into the model. In this way the full cost of both grain handling and transportation services will be provided for.

5.4.1 Collection Costs

Included in the model are two separate grain collection networks; grain may either be hauled by farm truck to a primary elevator, or commercially trucked from within a 100 mile radius to inland terminals located at Moose Jaw and Saskatoon. As mentioned in Chapter Three, the average cost of hauling grain from farm to primary elevator via farm truck is estimated at $3.60 per tonne while the cost of transporting grain an average of 50 miles in commercial trucks is $4.94 per tonne.

In addition to trucking, grain collection includes the cost of handling grain at primary or inland terminal elevators. The Canadian Grain Commission is responsible for determining the maximum allowable tariffs for elevator services in Canada. Maximum tariffs are set for each individual type of grain moving through primary, terminal, and transfer elevators. Elevator companies are then free to set their own rates for elevator services at a level equal to or somewhat lower than the maximum allowable rate. Total elevator costs also include any fees which must be paid to agents providing services such as administration and inspection. Since the forementioned agency fees are generally consistent for all types of grain flowing through a particular route, they will be defined as constant charges.

A number of privately owned companies operate primary elevators in Manitoba and Saskatchewan.[97] Rates for elevator services are generally set very close to the maximum allowable level with only a slight difference between elevator companies. For this reason, it is necessary to select individual elevator companies which will adequately represent primary elevator costs. Due to relative size, and constant dispersion of elevator operations, Saskatchewan Wheat Pool and Manitoba Pool Elevators were selected as a proxy for primary elevator operations in Saskatchewan and Manitoba, respectively. In order to calculate primary eleva-

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97 Appendix A lists the location, ownership and storage capacity of primary, terminal and transfer elevators included in the model.

tor costs, average net receipts of the six principal grains were multiplied by the Saskatchewan Wheat Pool and Manitoba Pool Elevators' handling rates. The calculations yielded a cost for regular service which includes receiving, elevation, and loading of grain. After adding the storage, interest, and administration fees, the average cost of moving grain through primary elevators in Saskatchewan was $8.70 per tonne, while Manitoba costs were slightly higher at $9.50 per tonne.[98]

In 1978, the Moose Jaw and Saskatoon terminal elevators were operated by a division of the Canadian Grain Commission known as the Canadian Government Elevators.[99] As was the case with primary elevators, the terminal elevator companies are free to set their own individual rates so long as they do not exceed the maximum rate allowed by the Canadian Grain Commission. For the purposes of the model, inland terminal rates were calculated by multiplying Saskatchewan's average net grain receipts by the Canadian Government Elevators' handling rates. All grain moving through inland terminals is elevated, cleaned, stored, and finally loaded onto rail cars. In addition to the aforementioned handling charges, total inland and terminal costs include constant charges for administration, storage, Canadian Grain Commission services, and superintendence. Administrative fees are paid to the Canadian Government elevators for performing management and bookkeeping services. The Canadian Grain Commission fees cover the cost of inspecting, and grading grain as it is unloaded at inland terminal elevators. Superintendence fees are paid to an agent for supervising rail car loadings, and ensuring cargoes are

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98 For further information regarding primary and inland terminal costs refer to Appendix B.

99 The Saskatoon terminal has since been sold to Northern Sales Ltd.

loaded in good condition.

Unlike primary elevators, terminal elevator costs include a grain cleaning service. According to the model, grain moving through Moose Jaw and Saskatoon terminals is railed directly via solid trains to eastern transfer elevators. Eastern transfer facilities possess very minimal cleaning facilities; therefore, grain must be cleaned at inland terminals prior to being loaded onto solid trains. The average cost of cleaning grain at inland terminals is $0.89 per tonne. After cleaning costs have been added to handling and storage costs, the cost of moving grain through an inland terminal totals $6.82 per tonne.

Total collection costs for primary and inland terminals can be calculated by adding together the respective elevator and trucking costs. The average total cost of moving uncleaned grain from farm gate through Saskatchewan's primary elevators is $11.30 per tonne, while Manitoba grain collection costs are slightly higher, $12.10 per tonne. It is estimated that the average total cost for moving clean grain through Moose Jaw and Saskatoon terminals is $11.86 per tonne. After commercial trucking and grain cleaning has been taken into account, the cost of moving grain out of inland terminals exceeds the cost of moving grain through Saskatchewan's primary elevators by only $0.56 per tonne.

5.4.2 Railway Costs

Three types of railway costs are incorporated within the model. The first railway cost to be discussed relates to grain presently moved from the Prairies to Thunder Bay under statutory rates. In 1974, the Snavely Commission reported that statutory freight rates were adequate to covering only a portion of rail related grain transportation costs. If the full cost of transporting grain by rail is to be met, freight rates which provide the railways with full compensation (compensatory rates) must be adopted. In 1978, the compensatory rate for grain movement was 3.33[100] times as great as the prevailing statutory freight rate. Adoption of compensatory rates would provide a situation where railway companies are able to just cover the cost of transporting grain.

Transportation of grain in a clean or uncleaned state is a significant consideration in the analysis of rail costs. At present, whole grain moves from primary elevators to Thunder Bay terminals mixed with waste material known as dockage (screenings). Dockage comprises about 3 percent[101] of the total volume of grain shipped to terminal elevators. In order that compensatory rates properly reflect the cost of transporting a tonne of whole grain,[102] a surcharge of 3 percent will be added. Adding a surcharge to compensatory rates provides for the total cost of moving a tonne of whole grain from primary elevators to terminals located at Thunder Bay. More specifically, the total cost of railing whole grain from Craik, Saskatchewan to Thunder Bay is $15.91 per tonne, while a similar movement originating from Carberry, Manitoba costs $12.25 per tonne.[103]

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[100] V.J. Fields, "The Influence of Grain Freight Rates on the Farm Land Market in the Prairie Provinces," unpublished Master's thesis, University of Manitoba, 1980, p. 158.

[101] Board of Grain Commissioners, Grain Cleaning in Canadian Elevators (Winnipeg: Board of Grain Commissioners, 1971), p. 17.

[102] Whole grain is analogous to clean grain, and is considered to include no screening or dockage.

[103] For further information on the calculation of compensatory rates, refer to Appendix E.

The second set of railway costs to be calculated were for solid trains moving directly from the Prairies or Thunder Bay, to the Quebec or Atlantic transfer elevators. Presently, there are no such solid train movements in continuous operation, and as a result, no published rates are available. In order to determine a representative solid train cost, the Kates, Peat, Marwick & Co.'s[104] unit train costing model, first completed in 1971, was indexed up to 1978 cost levels.[105] The model provides for full operating costs, as well as a contribution to overhead and fixed costs such as head office administration, switching yards, rights of way, etc. Included in the costing model is a capital allowance for the purchase and replacement of locomotives, and hopper cars. The decision to purchase new equipment rather than utilizing existing equipment was based on the assumption that there is no excess capacity in terms of Canada's locomotive and rolling stock.

Further assumptions made in the solid train model regarding speed, utilization, and routing of trains are based on the use of existing facilities. The solid trains included in the model are made up of 100 hopper cars having a total train capacity of 8,200 tonnes. Due to the logistics, maintenance, and weather problems encountered by solid trains, a utilization rate of approximately 80 percent is expected. Within the model, solid trains travel an average of 25 miles per hour, with 24 hour stops at both the origin and terminating points for the purpose of loading and unloading. The points of origin are the inland terminals at Moose Jaw and Saskatoon, and the terminal elevators at

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[104] Kates, Peat, Marwick & Co., op. cit., Appendix F.

[105] A complete discussion of the solid train costing model is presented in Appendix E.

Thunder Bay. The transfer elevators at Quebec City and Halifax provide the eastern destinations of solid trains.

The relative cost differences between solid train and compensatory rates are basically as was expected. Both of these rates are designed to cover total movement costs, including a reasonable return on investment. There are obvious cost savings in the operation of solid trains vis-a-vis the traditional rail movement of grain. Since solid trains continuously move one commodity from a specific origin to a specific destination, the incidental costs associated with switching and car turn-around times ar reduced significantly. Solid train movements provide extended and more efficient use of plant facilities, since trains spend less time in marshalling yards and more time in operation. As a result, solid trains have a higher yearly carrying capacity than traditional mixed commodity trains.

It is logical to contend that solid train costs should be less than the compensatory rate associated with a traditional rail movement of grain. For instance, the compensatory rate (plus 3 percent surcharge) for a rail movement from Moose Jaw to Thunder Bay is $15.14 per tonne. According to Kates, Peat, Marwick & Co.'s rail costing model, a similar solid train movement would result in a cost of $10.50 per tonne. Therefore, the use of solid trains provides a cost saving of $4.64 per tonne on a hypothetical grain movement from Moose Jaw to Thunder Bay.

The third set of railway costs are for Atlantic and East rail movements. As mentioned in Chapter Three, the Canadian Government subsidizes "At and East" rail movements in order to support throughput levels. In 1978, the "At and East" rail rate for grain moving from Bay port elevators to Atlantic elevators was $5.57[106] per tonne. In the case of "At and East" movements, subsidized rail rates were used in the model. Even at a subsidized rate the cost of the "At and East" movement is prohibitive. Apparently the "At and East" movements are a high cost alternative even when subsidized by the Canadian government.

5.4.3 Thunder Bay Terminal Costs

Within the model, grain grown in Manitoba and Saskatchewan is trucked by producers to primary elevators and subsequently railed to terminal elevators located at Thunder Bay. Grain arriving from primary elevators must be cleaned at the Thunder Bay terminals prior to being railed to local consumption sites, exported directly aboard ocean vessels, or forwarded either by rail or water to eastern transfer elevators. The proportion of each type of grain moving by a particular route will determine terminal elevator costs. For example, the average proportion of particular types of grain will differ depending on whether the shipment is forwarded, exported directly, or consumed at local sites. Sinc handling tariffs differ between grain types it is necessary to multiply the average percentage of each type of grain by its particular elevator tariffs in order to calculate the average terminal elevator cost for each grain route.[107]

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[106] Statement by B. Stacey, Information Department, Canadian Wheat Board, in a personal interview, November 1980.

[107] For further information regarding the calculation of Thunder Bay terminal elevator costs, refer to Appendix C.

In addition to the handling costs mentioned above, there are also constant charges which can be applied to specific grain routes. The Canadian Grain Commission is responsible for weighing and grading grain as it is unloaded at Thunder Bay. Thus, Canadian Grain Commission fees are generally applied to all grain moving through the Thunder Bay terminals. Superintendence is a fee paid to an agent to supervise the loading of vessels and rail cars. Grain forwarded to eastern elevators or exported directly is subject to superintendence fees. Superintendence of forward moving grain becomes a terminal elevator cost, while superintendence fees for direct export movements are included in ocean shipping costs. Loading of grain destined for local consumption sites requires no supervision. The next constant charge to be considered is forward brokerage which is paid to an agent for handling all documentation as a vessel completes loading. Forward brokerage fees are paid on grain loaded aboard both lake and ocean vessels. Lake shipments are assessed an additional Lake Shipping Clearance Association fee to cover the cost of allocating lakers to the various Thunder Bay terminals.

After both handling and constant charges have been accounted for, the average total cost of moving clean grain out of the Thunder Bay terminals can be estimated. The average terminal cost of moving grain to local consumption sites is $6.05 per tonne. Terminal costs for grain forwarded to eastern transfer elevators amounts to $4.62 per tonne by water, and $5.38 per tonne by rail. The relative cost difference of $0.76 per tonne is due to the added terminal charge assessed for loading rail cars. Grain exported directly out of Thunder Bay carries a terminal cost of $5.87 per tonne.

5.4.4 Lake and Ocean Shipping Costs

There are two distinct types of shipping costs embodied within the model. The first set of costs pertains to grain moved aboard lake vessls, and the second category refers to ocean shipping costs.

In the model, the Canadian Great Lakes fleet is responsible for moving western Canadian grain from Thunder Bay to the Bay port, Lake port, Quebec and Atlantic transfer elevators. For the purpose of estimating lake shipping costs, specific destinations were chosen for each group of ports. Representative elevators were chosen based upon location, and elevator handling capacities. Midland was chosen to represent the Bay ports, with Prescott, Quebec City, and Halifax corresponding to the Lake, Quebec, and Atlantic ports.

Lake shipping costs include lake freight, brokerage fees, cargo rates, insurance charges, and the Welland Canal and Seaway tolls. Lake freight is paid to the lake vessel owner for supplying the vessel to move grain from Thunder Bay to eastern destinations. Lake freight brokerage is paid to an agent who handles all arrangements for lake vessels, such as the payment of tolls. Cargo rates are paid to the Lakehead Harbour Commission for the use of the Thunder Bay harbour facilities. Insurance charges are paid to an insurance company in order to cover the value of all grain cargoes in case of mishap while in transport. All water movements, except those destined for the Bay ports, are subject to Welland Canal tolls. In addition to the Welland tolls, vessels moving to positions east of the Lake ports are also assessed St. Lawrence Seaway tolls. The average total cost of moving a tonne of clean grain aboard lake vessels from Thunder Bay to the Bay ports (Midland) is \$5.66, to the Lake ports (Prescott) \$8.37, and in terms of the Quebec (Quebec City) and Atlantic ports (Halifax) the per tonne cost amounts to \$7.94 and \$13.44, respectively.[108]

Ocean shipping costs are somewhat similar in nature to the lake shipping costs discussed above. Grain destined for export through the eastern clearance sector is picked up by ocean vessels either at Thunder Bay, Quebec, or the Atlantic ports. Export shipments made directly out of Thunder Bay are subject to Welland Canal and St. Lawrence tolls. All ocean shipments are assessed a wharfage fee for the use of port facilities as well as a superintendence fee paid to the Canadian Grain Commission for supervising loading and final inspection of grain cargoes.

The majority of trade contracts negotiated with foreign buyers provide for export grain to be delivered free on board. Since the cost of ocean freight is absorbed by the importing nation, the export price of Canadian grain will vary slightly from one port area to another. It is reasonable to assume that for comparable grain, the differences in export price between port areas should be equal to the corresponding difference in ocean shipping costs between said ports. If an importing nation incurs additional ocean shipping cost of \$9.57 per tonne when grain is picked up at Thunder Bay vis-a-vis Quebec ports then it would seem reasonable that the Thunder Bay price should be at least \$9.57 lower than the price of comparable grain in store at the Quebec elevators. The model assumes that export price differences are equilavent to ocean shipping costs between port areas. As such, export price may be considered constant so long as the relative difference in ocean shipping cost

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108 A more complete breakdown of lake shipping costs is provided in Appendix F.

becomes part of Canada's total grain transportation cost. Any ocean shipping costs which exceed the ocean rate between an importing nation and Halifax will be assigned as a cost to that particular grain route. For example, if ocean shipping costs from Thunder Bay to Antwerpt, Netherlands, exceeds the ocean rate from Halifax to Antwerpt by $10.13 per tonne, export price is assumed to be constant and $10.13 will be added to the cost of exporting grain directly out of Thunder Bay. In this way, differences in ocean shipping costs between port areas appear as a transportation cost rather than a price difference.

In the model, ocean shipping cost from Thunder Bay to a point equivalent to Halifax is estimated to be $10.20 per tonne. Due to the relative proximity of the Quebec ports to Halifax, ocean shipping costs on export grain moved out of Quebec ports is only $0.63 per tonne. Although there is no ocean freight applied to grain exported out of Halifax, superintendence and wharfage fees are incurred which total $0.17 per tonne.[109]

5.4.5 Transfer Elevator Costs

The final cost component to be considered is transfer elevator costs, which are calculated in a manner similar to primary and terminal elevator costs. Specific handling tariffs at each port area are multiplied by the average portion of each type of grain in order to estimate transfer elevator costs. There is no provision made for constant charges at the Bay port and Lake port elevators, since these facilities simply transfer previously weighed and inspected grain from lake vessels to

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[109] A complete breakdown of ocean shipping costs is included in Appendix F.

rail cars. Any constant charges applicable to export shipments out of the Quebec and Atlantic transfer elevators have previously been included in the category of ocean shipping costs.

Bay port elevators accommodate domestic grain moving to local consumption sites, as well as grain which is forwarded to Atlantic elevators under the "At and East" rail rates. The cost of moving local domestic shipments through Bay port elevators is $3.25 per tonne.[110] Grain forwarded to the Atlantic region carries an estimated Bay port elevator cost of $2.75 per tonne. The discrepancy between Bay port elevators costs is due to the difference in the average proportion of each type of grain within domestic vis-a-vis "At and East" movements.

The transfer costs for domestic grain flowing through Lake port elevators to local consumption sites is $3.15 per tonne. Similar movements of domestic grain through the Quebec and Atlantic elevators have costs of $3.25 and $2.95 per tonne, respectively. The model does not include the cost of railing domestic grain from transfer elevators to individual consumption sites; however, the cost of loading domestic grain onto rail cars is accounted for and included in transfer elevator costs.

In addition to domestic movements, the Quebec and Atlantic elevators also transfer grain from rail cars and lake vessels to ocean vessels for export. The average total cost of moving export grain through Quebec elevators is $2.65 per tonne, while Atlantic elevator costs are slightly lower at $2.58 per tonne.

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[110] For more detailed transfer elevator calculations, refer to Appendix D.

5.4.6 Total Route Costs

Now that individual cost considerations have been examined it is important to organize the individual cost components into complete grain routes. Appendix G provides a complete analysis of the various cost components within each of the model's 36 possible routes. In order to visualize how individual cost components fit together, three particular routes are examined here.

The first route is an all-rail solid train movement direct from Saskatoon to an export position at the Quebec transfer elevators. Included in this route are commercial trucking, inland terminal, solid train, Quebec transfer elevator, and ocean shipping costs. Overall, the average total cost for moving grain via this direct rail route is $37.47 per tonne.

The second route to be considered provides an all-rail movement from Craik to export positions at the Quebec transfer elevators. The cost components included in this route are farm trucking, primary elevator, railway, Thunder Bay terminal, solid train, Quebec elevator, and ocean shipping. The all-rail route has an average total cost of $48.95 per tonne.

The final route to be examined is for a traditional rail-water movement from Craik to an export position at the Quebec transfer elevators. The rail-water route follows a similar pattern to the all-rail route, except for the Thunder Bay to Quebec leg, where lake vessels replace solid train movements. The second difference between the all-rail and the rail-water route is in regards to terminal elevator costs. There is a special charge for loading rail cars at terminal elevators. If lake vessels are loaded there is no special loading fee. Therefore, the terminal costs for a rail-water route are slightly lower than is the case with a rail-rail movement. The average total cost of moving a tonne of grain via the rail-water route is $43.05.

It should be noted that although the origins of the three aforementioned routes are not the same, Craik does fall within the 100 mile grain collection radius of the Saskatoon terminal. Therefore, it is possible to compare relative movement costs at least on an approximate basis. If there is any prevalent bias included in this comparison, it will be in favor of the grain which moves out of primary elevators.

It appears that of the three routes, the direct rail movement out of the Saskatoon terminal represents the least cost alternative. The traditional rail-water route provides the second lowest cost movement, with the all-rail route coming in a distant third. The direct solid train movement enjoys an average total cost advantage of $5.58 per tonne over the more accepted rail-water movement.

In analyzing the model's results, average total cost of transporting a tonne of grain will be used as a proxy for system efficiency. It is recognized that regional or interregional welfare benefits, and losses resulting from grain transportation are not completely reflected in average total costs. However, they are beyond the scope of this study.

5.4.7 Capital Costs

Within the model, it should be stressed that the capital costs are included in the total cost of transporting grain. It is assumed that the existing plant and equipment will be used. The only modifications made to the existing system involve the installation of unloading facilities (loop tracks), increasing the cleaning capacity at the inland terminals, and the purchase of solid trains.

The question of the capital cost of installing loop tracks and cleaning facilities was not directly addressed in this study. Loop track installation requires the purchase of land, laying of track, construction of unloading pits, and the installation of conveyor systems. The expansion of cleaning facilities at inland terminals necessitates the purchase and installation of cleaning equipment as well as the possible construction of additional cleaning space. An indepth evaluation of the cost of such alterations was beyond the scope of this thesis as it would have required carefully designed engineering studies as well as information on several ponderables-- such as, long term interest rates, capitalization rates, efficiency of capital and, last but not least, the thorny question of appropriate allocation of these costs among the various interest groups.

The estimates of solid train costs are included as an integral part of the model. The solid train costing model is outlined in Appendix E. Included in the formula is the capital cost of purchasing both locomotives and hopper cars. In 1978, the original cost of a locomotive was $912,600 while a hopper car carried a price tag of $44,190.[111] Based upon these figures, a solid train comprised of five locomotives and 110 hopper cars[112] would have a purchase price of $8.982 million. Consider-

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111 1978 capital costs were collected from the Canadian National Railway, Winnipeg.

112 Although the solid trains operate in 100 car units, 110 cars are purchased. The 10 extra cars are needed to fill in for those cars which are being repaired.

ing the number of solid trains which may be placed in operation, the capital outlay will be substantial.

The manner in which the solid trains are purchased is of great importance in terms of policy formulations. There are a number of ways in which solid trains can be purchased. One method is for the government (either federal or provincial) to acquire solid trains. The trains would, in turn, be lent out to the railways under an agreement that they be used solely for grain transportation. In recent years, there has been a move toward government purhcases of hopper cars. Such purchases actually represent a transportation subsidy. The implementation of subsidy programs is not uncommon in the transport industry. Although fairly common, subsidy programs are not without considerable criticism.

Within this study, an attempt is made to evaluate solid train operations without the interference of subsidies. For this reason, it was decided that the purchase of solid trains should be financed by the railways with the resulting capital costs included in the rail rates. The first method is for the railways to finance solid train purchases out of retained earnings. In such a case, return on investment will be expected by the railway stockholders and/or management. The second way in which the railways may finance the purchase of solid trains is by borrowing. If the funds are borrowed, interest expenses will be incurred. In a situation where the expected rate of return equals the interest rate, capital accumulation rates will be equal regardless of whether the investment is financed out of borrowed funds or retained earnings. Capital accumulation rates allow adequate funds to be set aside each month in order to cover capital costs.

The solid train model used in this study provides for the capital cost of solid train purchases. The capital costs are calculated on a per tonne basis which are heavily dependent upon solid train utilization. The annual amount of grain which a solid train can haul is directly related to the length of a round trip. As the length of haul increases, capital cost per tonne will also increase.

Chapter VI

ANALYSIS AND RESULTS

6.1 EXPLANATION OF SCENARIOS

Throughout this chapter, the model discussed in the previous chapter is used to analyze four different grain handling scenarios. Each scenario is portrayed by specific grain movement costs, capacity limitations, and the demand for western Canadian grain at eastern elevators.

Scenario One is considered to be the base solution. Grain marketings, and handling capacities are set equal to their maximum historic levels. Historic capacitiy is taken to be the greatest quantity of grain which has moved through a particular handling facility during any one year.[113] Within the first scenario, domestic demand is assumed at an average 1974-1978 level of 2.879 million tonnes per year. Grain exports through the Thunder Bay, Quebec, and Atlantic elevators are set at the 1977-1978 record level of 10.969 million tonnes. Export demand combined with domestic requirements results in a total eastern grain movement of 13.848 million tonnes.

Grain movements are based upon political as well as economic issues, with transportation subsidies often used as a tool for regional development. Scenario One attempts to first establish a situation which simulates present grain flows (including government policies); and subsequently move towards a system which disregards government policy,

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[113] For further information on capacities, refer to Appendix H.

thereby allowing the minimization of grain transportation costs. Three individual situations are compared within the first scenario:

1. statutory rates with average "At and East" movements of 0.663 million tonnes included in the solution;
2. compensatory rates with average "At and East" movements of 0.663 million tonnes included in the solution; and,
3. compensatory rates with "At and East" movements included in the solution only if they prove to be a least cost alternative.

As mentioned in Chapter Five, the statutory rates presently in place in western Canada fail to account for the full cost of transporting grain by rail. Nevertheless, as a point of departure it is beneficial to examine the pattern, and cost of moving grain under statutory rates. The "At and East" rates provide a second way in which railway movements of grain have been subsidized. As is the case with statutory rates, "At and East" rates also artificially lower the actual cost of railway service.

If an optimal grain transportation system is to be determined, full railway costs must be instituted. Compensatory rates are expected to provide the full cost of railway service, and as such, command a more adequate allocation of resources. In the case of "At and East" rates, government policies regarding grain routes will be recognized only within the first two base solutions. In the third base solution, the model will select routes in order to minimize total cost. Rail movements from the Bay ports to Atlantic elevators ("At and East") will be included only if they are cost effective. In other words, "At and East" movements will enter the optimal solution only if their cost is lower than alternative routes.

The remaining three scenarios simulate how effective the eastern system will be in handling an increased flow of grain. By increasing grain flows, it is possible to create conditions similar to those which eastern Canada may face as domestic and export demand increase to their expected 1985 levels. As noted in Chapter Three, by 1985 total domestic demand will be approximately 4.073 million tonnes. At the same time, eastern Canadian exports are expected to increase to a level somewhere between 10.969 and 17.2 million tonnes. It was judged beneficial to examine the alternative export levels which fall between 10.969 and 17.2 million tonnes; therefore, 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, and 17.0 million tones are also selected as potential eastern export levels. In addition to the above, the model also determines the maximum quantity of grain which may potentially be moved under the second, third, and fourth scenarios.

It is assumed that sufficient grain can be produced to satisfy demand. The grain which is produced in western Canada is either used on the farm, delivered to local processing sites, or marketed through the commercial transportation system. On the average, 55 percent[114] of the grain which enters the commercial transportation system in western Canada moves east. Given that Manitoba provides 15 percent of Canada's total grain supply, it follows that approximately 27 percent of all grain moving east will originate in Manitoba. The remaining 73 percent of the grain moving east is supplied by Saskatchewan farmers.

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[114] Booz, Allen & Hamilton, op. cit., p. III-2.

In Scenario Two, the capacity of the eastern grain handling system is constrained by the throughput potential of the facilities which are expected to be in use in 1985. It is assumed that the only significant change which needs to be included is the transfer elevator to be constructed at Gros Cocuna, Quebec. Within the second scenario, direct solid train movements from inland terminals to the eastern transfer elevators are not permitted, but solid train movements are allowed between Thunder Bay and the Quebec or Atlantic transfer elevators. Restricing solid train movements from the Prairies, while at the same time allowing solid train shipments from Thunder Bay, creates a situation where an all-rail movement similar to the Canadian Wheat Board's Winter Export Program can be used on a year-round basis.

Scenario Three is similar to the second scenario except for the fact that it allows for possible direct rail movements. In addition to railing grain out of Thunder Bay, it also allows grain to move by solid train directly from the Moose Jaw and Saskatoon terminals to the Quebec or Atlantic transfer elevators. The amount of grain that can move via direct rail routes is subject to the potential throughput capabilities of the inland terminals.

The fourth and final scenario expands the potential of solid train service. The various export levels are rerun under the condition that rail loading capacity at terminal elevators is increased by 25 percent. For example, whereas the maximum Saskatoon capacity was 2.216 million tonnes in Scenario Three, in the fourth scenario its corresponding potential is set at 2.770 million tonnes. Increasing the Moose Jaw and Saskatoon throughput by a 25 percent margin will require alterations, and modernization of existing plant and equipment. It is unlikely that inland terminal capacity can be increased much more than 25 percent, due to physical limitations, and grain collection problems. In order to cope with increased terminal throughput, rail unloading capabilities of the Quebec and Atlantic elevators must also be increased. For the purpose of Scenario Four, the rail receiving capabilities of the Quebec and Atlantic elevators are set equal to the eastern railway's grain hauling capacity. Relaxing the restrictions placed upon Quebec and Atlantic rail receiving capacity will make it possible to determine whether the demand for rail unloading is sufficient to warrant the installation of a loop-track. It should be noted that although solid train loading and unloading capabilities are increased, rail movements within Scenario Four are still confined by the eastern railway system's overall ability to transport grain. Even though loading and unloading capacity is increased, the total amount of grain which can move to eastern Canada by solid train is still restricted to the excess capacity which exists on the eastern rail lines.

6.2 GRAIN FLOWS

In analyzing the four scenarios, the first aspect to be evaluated is the resulting grain flow patterns.[115] The grain flows provided by the model represent a combination of commodity movements which will minimize the cost of transporting a specified volume of grain.

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115 Further information regarding grain flow results are included in Appendices I, J, K, and L.

6.2.1 Scenario One

The first scenario provides for an eastward movement of 10.969 million tonnes exports, and 2.879 million tonnes of domestic grain (Figure 15). In the case of statutory rates, traditional rail-water movements are the first routes to enter the solution. The historic capacity of the Great Lakes Fleet has been fully utilized at the export level of 10.022 million tonnes. As a result, direct rail shipments enter the solution as the next best alternative. Since direct rail routes have seldom been used, historic rail capacities are very restrictive. Only 0.141 million tonnes are allowed to move from Moose Jaw to Quebec via the direct rail mode. After the direct rail has been exhausted, grain begins to travel to export destinations directly from Thunder Bay. At the record level of 10.969 million tonnes, a total of 0.806 million tonnes of grain are exported out of Thunder Bay. Other exports include 9.563 and 0.600 million tonnes moving out of the Quebec and Atlantic elevators, respectively.

If compensatory rates replace statutory rates, the priority of routes is altered; however, the pattern of grain flows will remain as illustrated in Figure 15. Compensatory rates greatly exceed statutory rates. Since the cost of operating a solid train is less than the compensatory rates, direct solid train movements replace rail-water as the least cost route. The result is that solid train movements from Moose Jaw to Quebec will be the first routes to enter the solution, followed by rail-water, and finally direct export out of Thunder Bay. Although the flow of grain for statutory and compensatory rates is similar, the resulting costs are quite different (as is discussed later in this chapter).

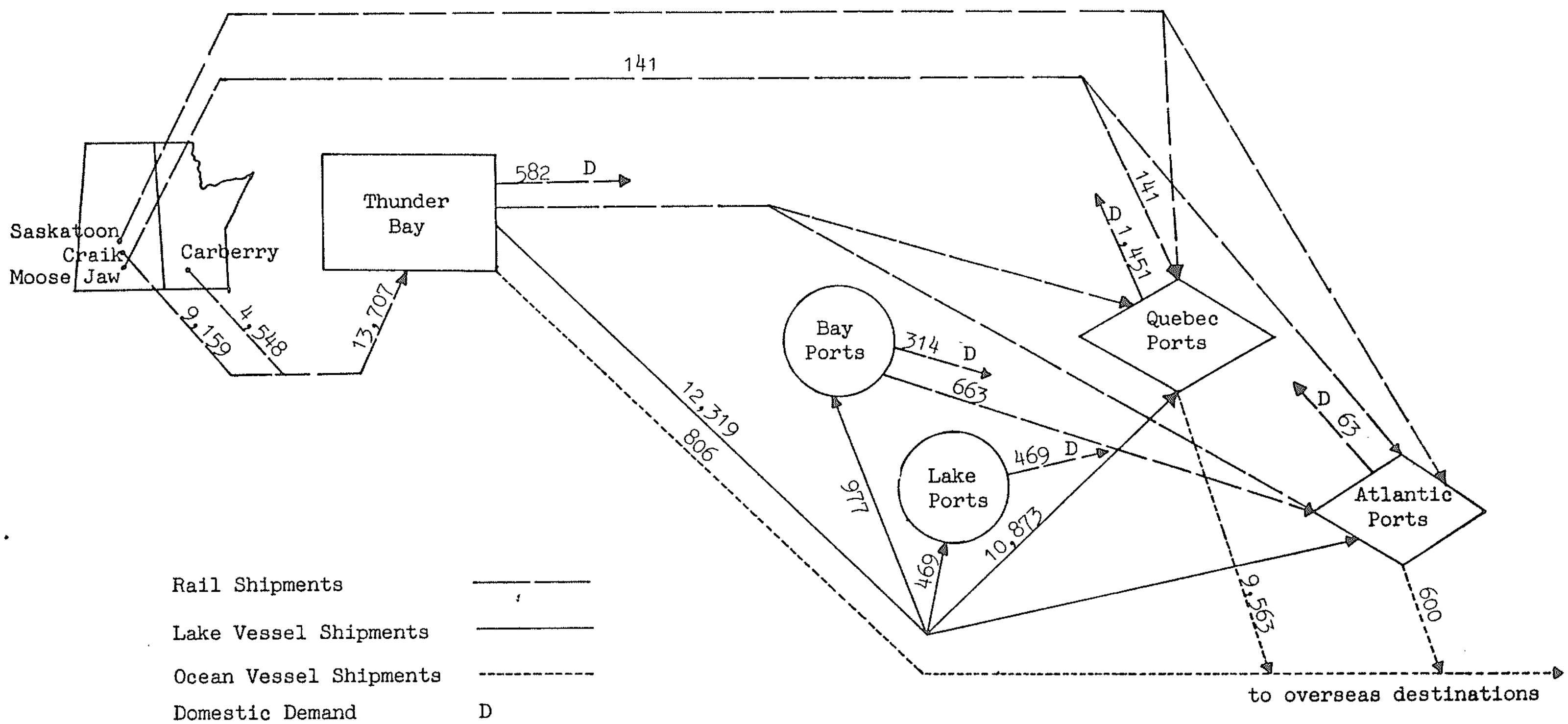

Figure 16

Scenario One Grain Flows Including Average "At and East" Movements

Grain flows described in Figure 15 include an average "At and East" movement of 0.663 million tonnes. Even though "At and East" movements are not a low cost alternative, they are forced through the system in a manner similar to the way in which a government policy functions. Once the "At and East" grain reaches the Atlantic elevators, 0.063 million tonnes is shipped to local consumption sites, while the remaining 0.600 million tonnes is exported.

As shown in Figure 16, "At and East" movements fail to freely enter a minimal cost solution. Grain which was previously exported via the "At and East" route is now exported directly out of Thunder Bay. Once the 1.222 million tonne limit on Thunder Bay exports has been reached, the next least cost route is a lake vessel shipment from Thunder Bay to the Atlantic elevators. Out of the 0.240 million tonnes which arrive at Atlantic elevators, 0.063 million tonnes move to local consumption sites with 0.177 million tonnes going for export. Export grain is routed through the Atlantic elevators only because the Quebec elevators have previously reached their historic maximum throughput of 11.021 million tonnes. As expected, once the "At and East" movements are no longer forced through the system, throughput at Bay port and Atlantic elevators decreases. The Bay port elevators suffer a decrease of 0.663 million tonnes, while throughput at the Atlantic elevators declines by 0.423 million tonnes. Without "At and East" movements, the Bay Port elevators are used only as a distribution point for locally consumed grain.

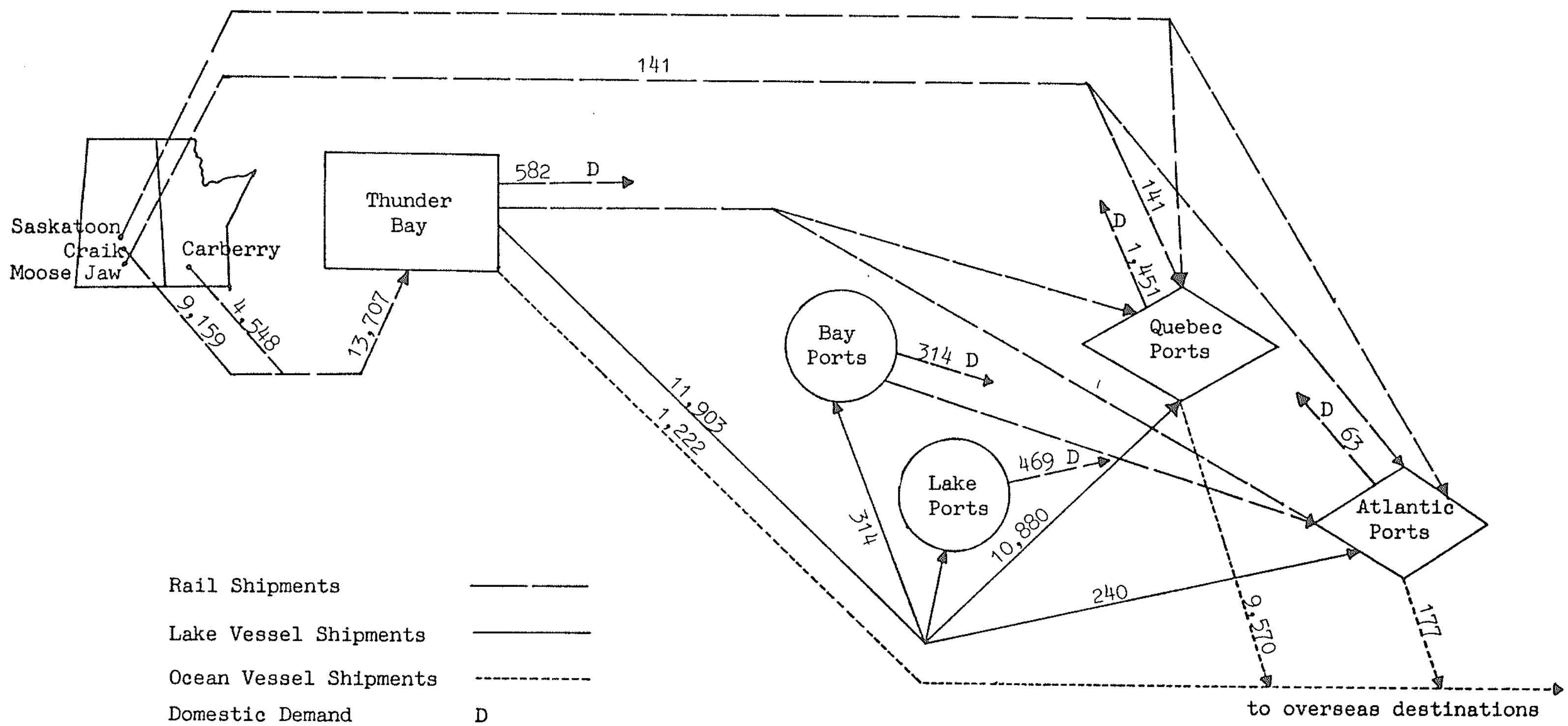

Figure 16

Scenario One Grain Flows With No "At and East" Movements

6.2.2 Scenario Two

Within Scenario Two, all-rail movements are restricted to solid trains originating from Thunder Bay. At an export level of 10.969 million tonnes, and a domestic movement of 4.073 million tonnes, only the traditional rail-water routes need enter the optimal solution. In regards to grain transported out of Thunder Bay, lake shipments are of least cost, followed by direct exports by ocean vessels, and finally solid train movements. Therefore, lake shipments are the first routes used. As depicted in Figure 17, 12.121 million tonnes of grain are moved via laker from Thunder Bay to Quebec. Once at Quebec, 10.068 tonnes of grain is transloaded onto ocean vessels for export. The remaining 2.053 million tonnes is transferred to rail cars for distribution to local consumption sites. Since lake shipments have already been used to their maximum potential of 13.318 million tonnes, it becomes feasible to export 0.901 million tonnes of grain directly from Thunder Bay aboard ocean vessels. At this point, Quebec and Thunder Bay account for total eastern exports of 10.969 million tonnes.

As exports increase to 11.290 million tonnes, both lake shipping, and Thunder Bay exports are fully utilized (Figure 18). Lake shipments out of Thunder Bay to the Bay, Lake, Quebec and Atlantic ports equals the annual lake fleet capacity of 13.318 million tonnes. Meanwhile, direct exports out of Thunder Bay (via ocean vessels) have reached their assumed capacity of 1.222 million tonnes per year. Once lake and ocean vessel movements have been used to their fullest extent solid trains are able to enter the solution as a cost effective route. The solid train movements depart from Thunder Bay destined for the Quebec elevators.

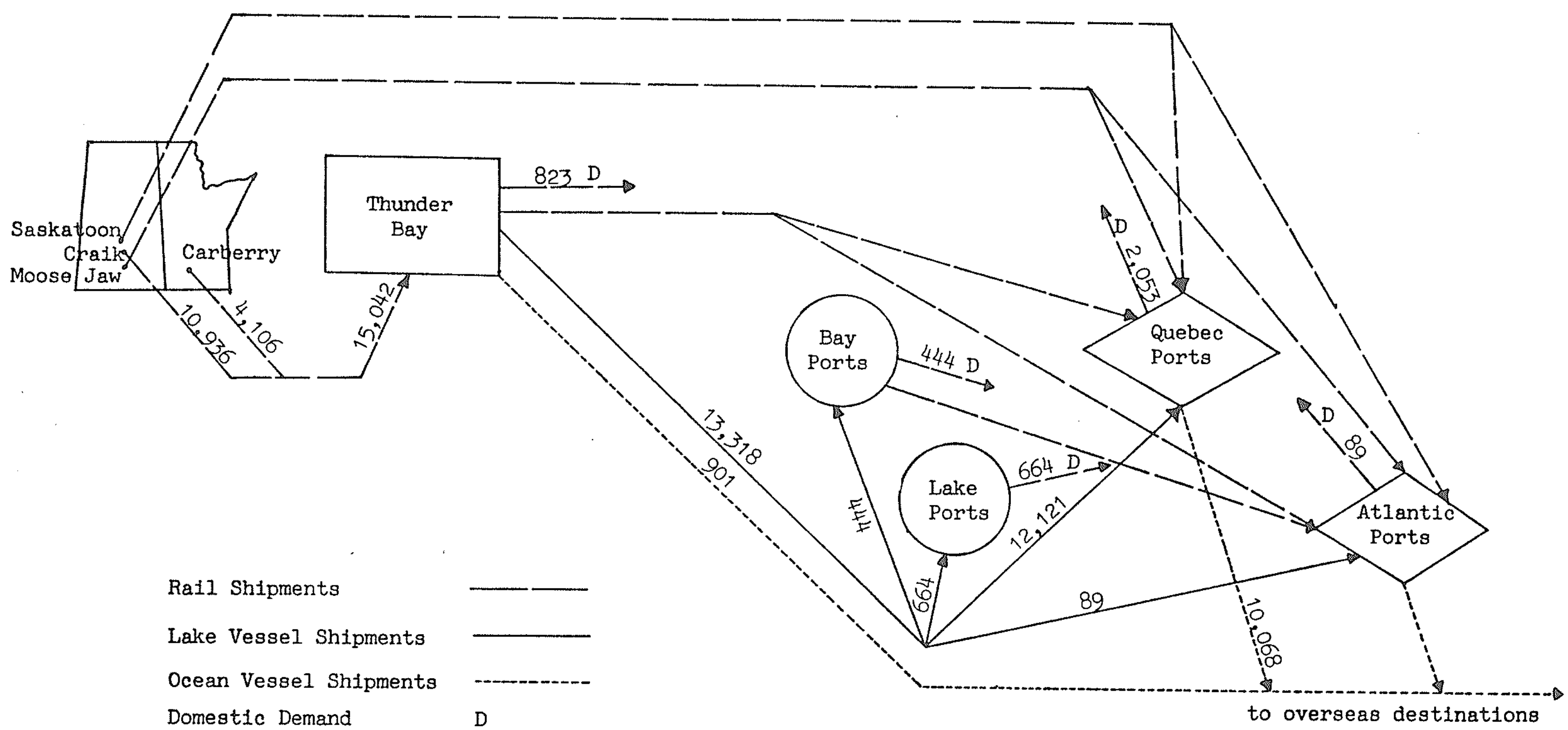

Figure 17

Scenario Two Grain Flows at the Export Level
of 10.969 Million Tonnes

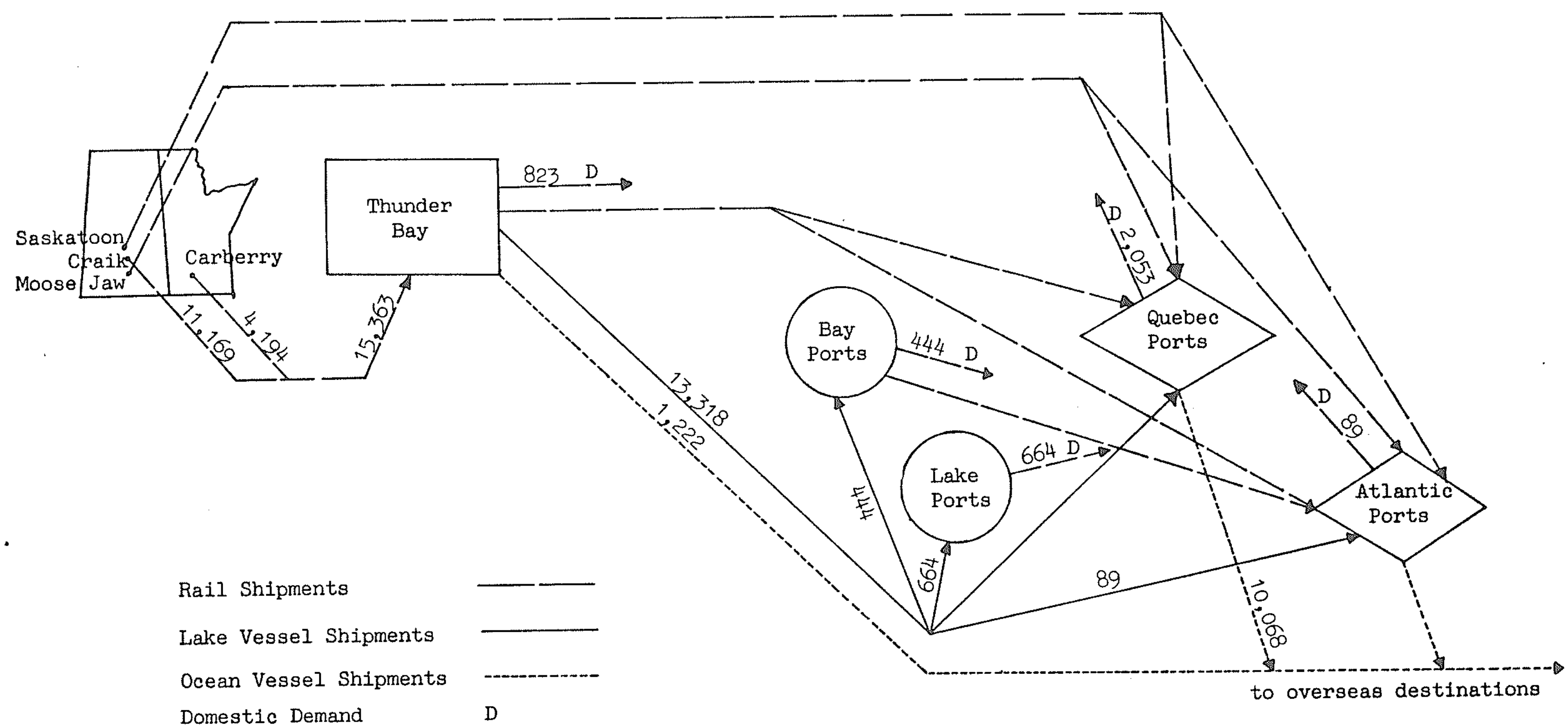

Figure 18

Scenario Two Grain Flows at the Export Level of 11.290 Million Tonnes

While export demand increases, solid train movements also increase. As seen in Figure 19, total system capacity is eventually achieved at an export level of 15.465 million tonnes. When 4.175 million tonnes of solid train movements are added to domestic rail shipments, Thunder Bay's rail loading capacity converges to its maximum limit of 4.998 million tonnes. Since both Seaway and rail capacities have been exhausted, Scenario Two's maximum grain handling capacity has been attained. At the upper export level of 15.465 million tonnes, 14.243 million tonnes is exported out of Quebec while 1.222 million tonnes move by ocean vessels direct from Thunder Bay to overseas destinations. Meanwhile, the Atlantic elevators are used only for domestic distribution.

6.2.3 Scenario Three

In the third scenario, solid train movements are allowed to originate at the inland as well as Thunder Bay terminals. Since solid train movements direct from the Prairies are of least cost, they are the first routes to enter the optimal solution at any export level. A total of 3.972 million tonnes moves by solid train from the inland terminals to the Quebec elevators. As is displayed in Figure 20, the solid train route from Moose Jaw to Quebec accounts for 1.756 million tonnes. Similar movements from Saskatoon to Quebec supply the remaining 2.216 million tonnes. The amount of grain which moves via direct rail routes would be greater if it were not for the limited throughput potential of the existing Moose Jaw and Saskatoon terminals.

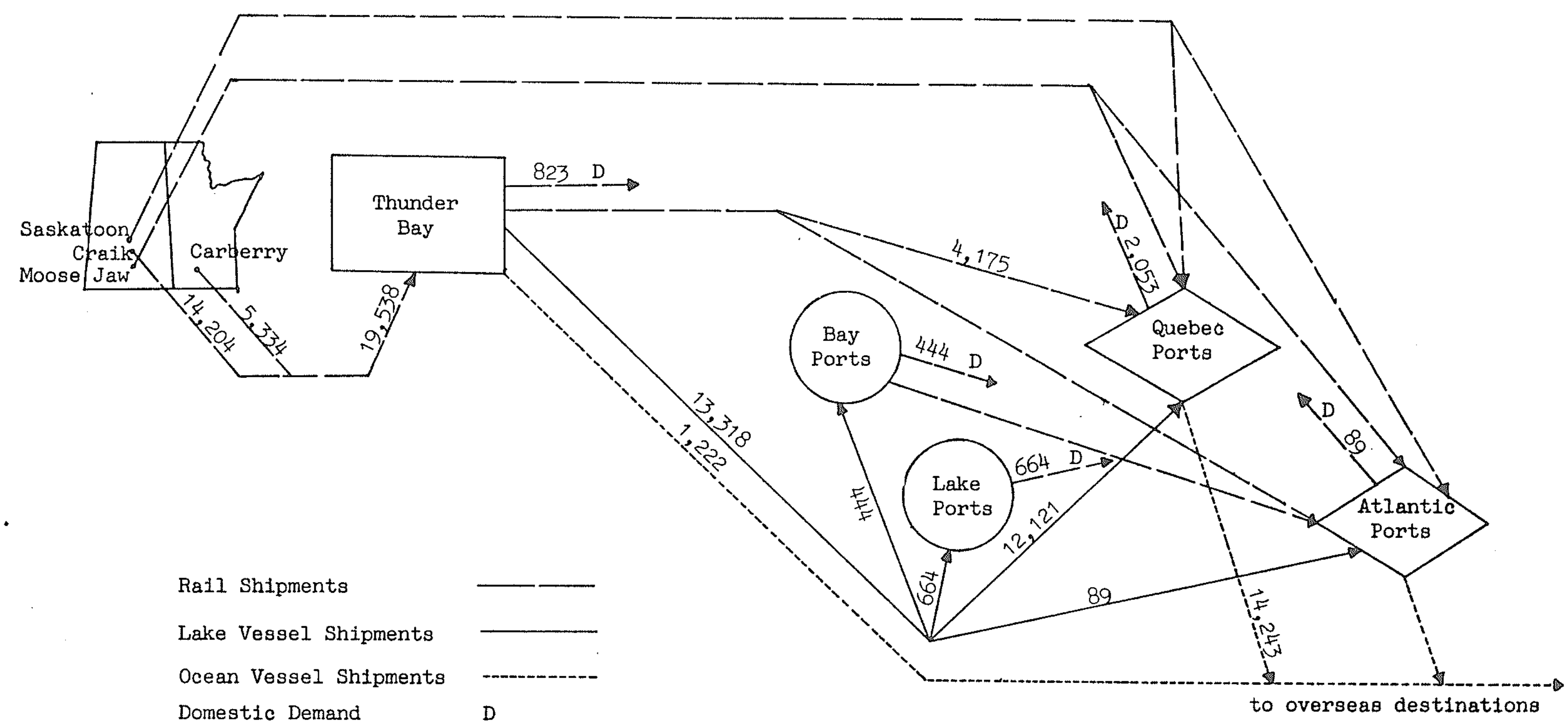

Figure 19

Scenario Two Grain Flows at the Maximum Export Level of 15.465 Million Tonnes

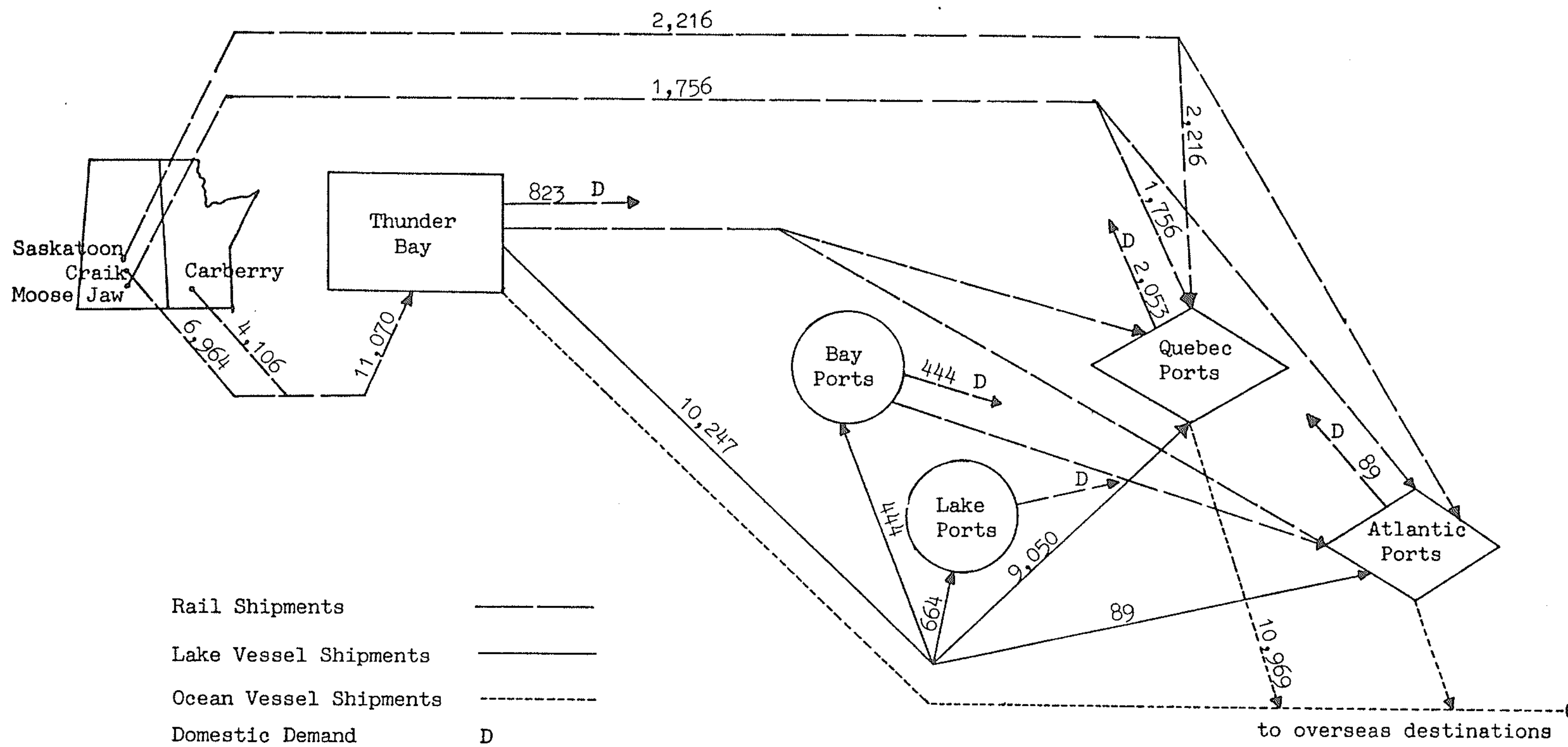

Figure 20

Scenario Three Grain Flows at the Export Level of 10.969 Million Tonnes

At the 10.969 export level, 10.247 million tonnes of grain is moved by water from Thunder Bay to the eastern elevators. As export levels increase, water movements to the Quebec elevators will also increase up to the point where lake shipments arrive at their maximum capacity of 13.318 million tonnes. Once lake shipping and direct rail shipments have been used to their potential, 10.040 million tonnes of export grain, and 2.053 million tonnes of domestic grain have been moved through the Quebec elevators. Thus far (in the model), the level of exports has not been large enough to allow export movements through the Atlantic elevators. According to the model, the Atlantic elevators are restricted to domestic movements during the time of relatively low exports.

Direct solid train movements together with lake shipments out of Thunder Bay provide for a total export movement of 14.040 million tonnes. For exports to increase above 14.040 million tonnes, direct exports out of Thunder Bay (by ocean vessel) must enter the solution. Only after the maximum capacity, 1.222 million tonnes, has been exported directly out of Thunder Bay, does it become cost effective to rail grain from Thunder Bay to the Quebec elevators. In Scenario Two, there were no direct rail movements; consequently, the capacity of water modes was exceeded at an export level of 11.290 million tonnes. The third scenario permits 3.972 million tonnes to move directly by rail; and, since they are the first rates to enter the optimal solution, the maximum capacity of water modes (lake and Thunder Bay exports) are not completely utilized until 15.262 million tonnes have been exported. Once the water routes in Scenario Three have been depleted, a total of 1.440 million tonnes is railed from Thunder Bay to Quebec. At this point, Quebec's rail receiving capacity of 5.412 million tonnes has been reached.

In order to export more than 16.702 million tonnes (11.290 by water modes and 5.412 by rail), grain which was previously railed from Saskatoon to Quebec is re-routed to the Atlantic elevators. Quebec elevator throughput is maintained at maximum capacity based upon two sources: the 0.089 million tonnes of grain which had previously moved to the Atlantic elevators by water now arrives at the Quebec elevators, and rail shipments from Thunder Bay are substituted for that quantity of grain which previously arrived directly from Saskatoon. Once the quantity of grain railed directly to the Atlantic elevators reaches 1.163 million tonnes, the Atlantic elevators will be working at their maximum capacity. Now that rail receiving capacity at both the Quebec and Atlantic elevators, as well as direct exports out of Thunder Bay, have been used to their potential, total system capacity has been attained. Figure 21 describes the grain flows which result from Scenario Three's maximum movement of 17.865 million tonnes of export and 4.073 million tonnes of domestic grain. Out of total exports, Thunder Bay, Quebec, and the Atlantic elevators account for 1.222, 15.569, and 1.074 million tonnes, respectively.

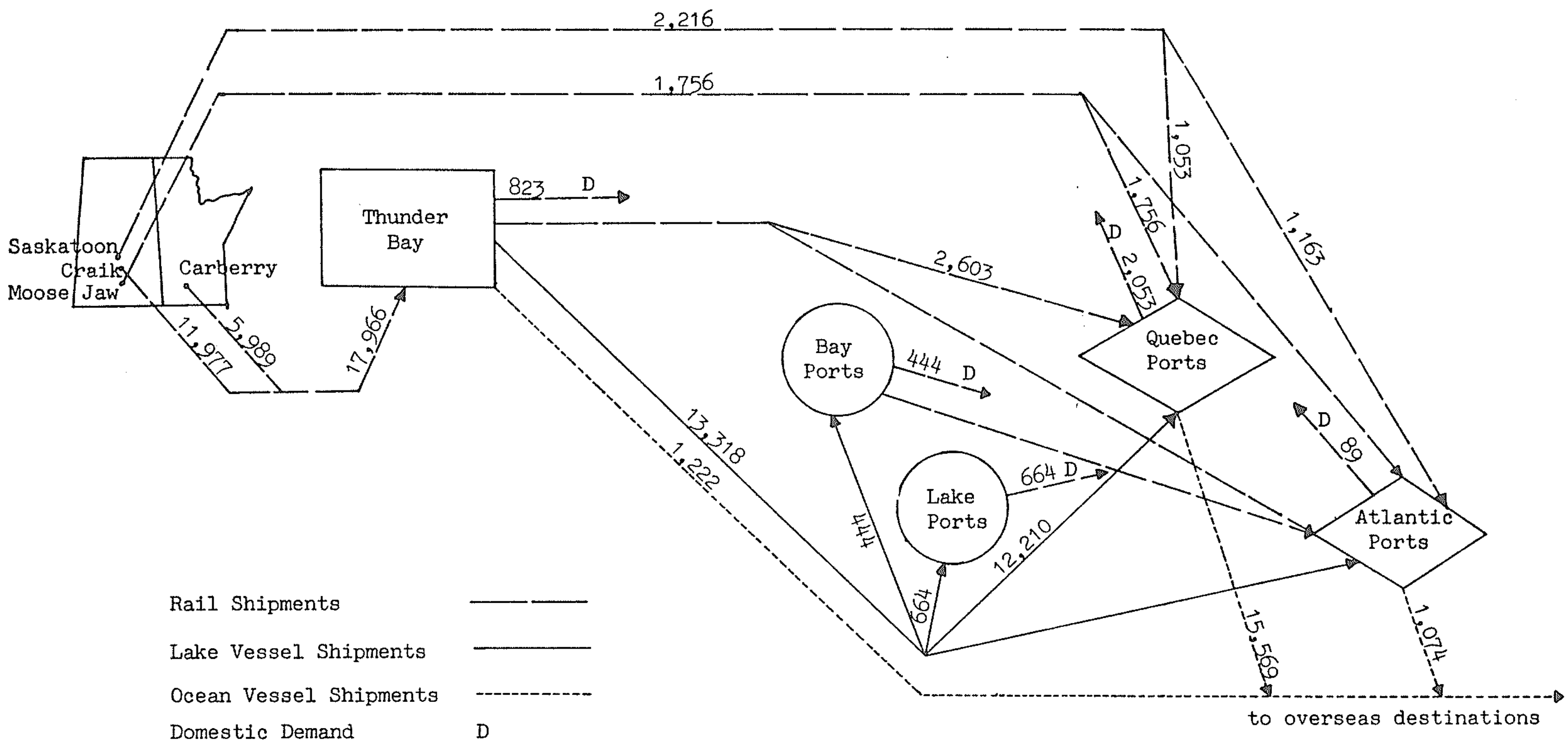

Figure 21

Scenario Three Grain Flows at the Maximum Export Level of 17.865 Million Tonnes

6.2.4 Scenario Four

The fourth scenario increases direct rail capacity by 25 percent. The results of Scenario Four are quite similar to those found in the third scenario. The basic difference being a 25 percent increase in the amount of grain which is railed directly from the Prairie terminals. According to Figure 22, there will be 2.195 million tonnes of grain moving from Moose Jaw to Quebec via solid trains. Direct rail movements from Saskatoon to Quebec will account another 2.770 million tonnes. The 25 percent increase in capacity allows an additional 0.993 million tonnes of grain to be railed to eastern elevators.

At the 10.969 level of exports, a 0.993 million tonne increase in direct rail movements will cause an equivalent decrease in lake shipping. There will still be 10.969 million tonnes exported out of the Quebec elevators regardless of whether the grain arrives by rail or water. If grain exports increase above 15.033 million tonnes, direct export movement from Thunder Bay will come into the solution. Once Thunder Bay exports are maximized, the next least cost route to be used involves solid trains travelling from Thunder Bay to the Quebec elevators. Only 0.662 million tonnes of grain is railed from Thunder Bay to Quebec before the potential throughput of Quebec elevators is depleted. At this point a total of 17.748 million tonnes of grain is being moved through the Quebec transfer facilities. Exports and domestic shipments out of Quebec amount to 15.695 and 2.053 million tonnes, respectively.

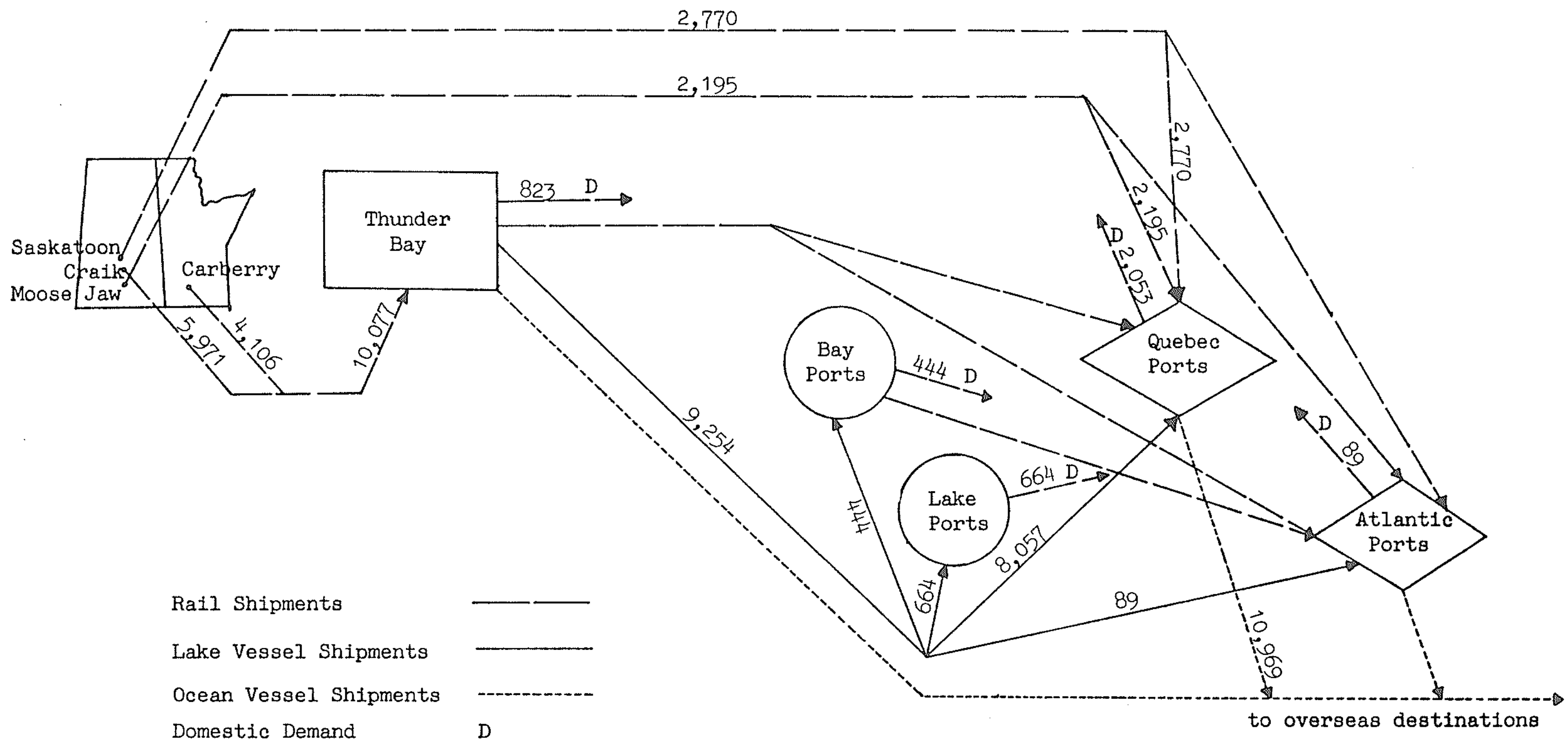

Figure 22

Scenario Four Grain Flows at the Export Level of 10.969 Million Tonnes

Given the capacity constraints in Scenario Four, the maximum quantity of grain which can be exported through eastern Canada is 17.991 million tonnes. The grain flows which would follow from a total grain movement of 22.044 million tonnes (17.991 export and 4.073 domestic) are shown in Figure 23. At this maximum export level, water movement to the Atlantic elevators has been substituted in place of water movements to Quebec. In the third scenario, Quebec's limited capacity to receive grain by rail made it necessary to substitute direct rail movements to the Atlantic elevators in place of rail movements to Quebec. However, since the fourth scenario permits Quebec an expanded rail receiving capacity, it becomes possible to substitute rail movements to Quebec in place of the previous water movements. The ability to rail increased levels of grain into Quebec means that lake shipping capacity previously used to move grain from Thunder Bay to Quebec can, instead, be utilized to transfer grain to the Atlantic elevators. As illustrated in Figure 23, a total of 1.163 million tonnes is transported from Thunder Bay to the Atlantic elevators aboard lake vessels. Exports out of the Atlantic elevators amount to 1.074 million tonnes. A further 0.89 million tonnes is moved through the Atlantic elevators for domestic use. As was the case in Scenario Three, eastern grain movements are maximized at the point where the throughput capacity of the Atlantic elevators has been completely utilized.

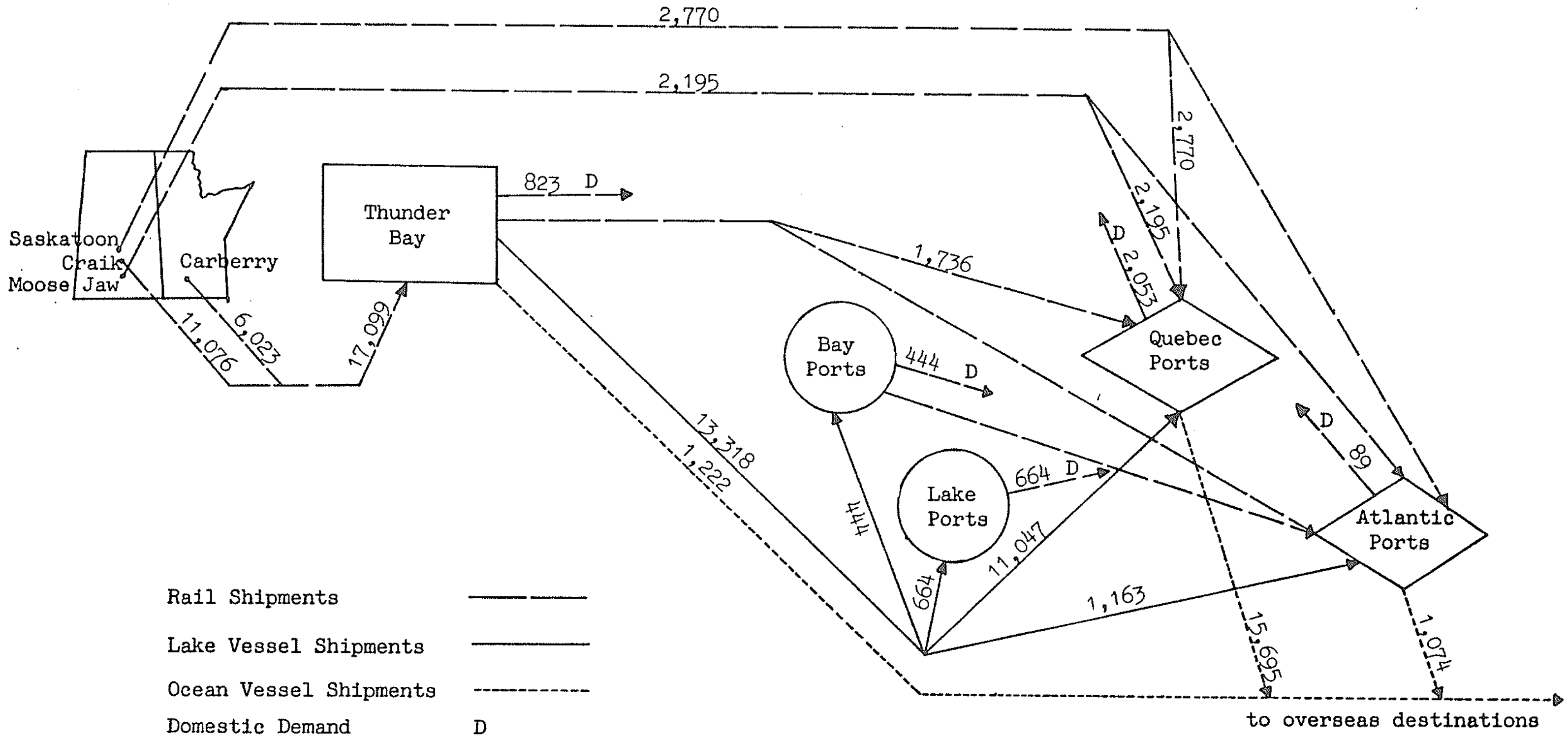

Figure 23

Scenario Four Grain Flows at the Maximum Export Level of 17.991 Million Tonnes

6.3 TOTAL GRAIN MOVEMENT COSTS

The second major aspect to be evaluated is cost. Since each of the four scenarios involve a different combination of transportation routes, the results will be discussed in terms of total system cost. Table 11 lists the estimated costs of moving grain to eastern locations.

In Scenario One, cost is first estimated based upon statutory rail rates. Under statutory rates, transporting 13.848 million tonnes of grain bears a total cost of $436.3 million. Comparable grain movements under compensatory rates are valued at $597.7 million. The relative difference between statutory rates and compensatory rates is not an actual cost saving. Since statutory rates fail to cover the total cost of hauling grain, the difference between statutory and compensatory rates is actually equivalent to the summation of the railway's grain related losses, plus any rail subsidies provided by government. Compared to statutory rates, compensatory rates are much more accurate in portraying total grain transportation costs. Using compensatory rates, the full cost of moving 13.848 million tonnes of grain is estimated to be $41.86 per tonne. The preceeding values apply to export movements of 10.969 million tonnes with average "At and East" shipment forced through the system. If "At and East" movements are eliminated, total grain movement costs will decrease by $2.4 million. In a situation where "At and East" movements are no longer utilized, average costs will decrease from $41.86 to $41.69 per tonne.

TABLE 11

Cost of Moving Grain to Eastern Elevators

	Export Level ('000 tonnes)	Domestic Grain Movement ('000 tonnes)	Total Grain Movement ('000 tonnes)	Total Cost ('000 dollars)	Average Total Cost ($/tonne)
Scenario One					
Statutory rates[a]	10,969	2,879	13,848	436,300	31.51
Compensatory rates[b]	10,969	2,879	13,848	579,700	41.86
Compensatory rates[c]	10,969	2,879	13,848	577,300	41.69
Scenario Two	10,969	4,073	15,042	627,500	41.71
Scenario Three	10,969	4,073	15,042	603,000	40.08
Scenario Four	10,969	4,073	15,042	596,900	39.68

[a] With average "At and East" movements forced through the system.

[b] Same as above with compensatory rates substituted for statutory rates.

[c] Compensatory rates with "At and East" movements included in the solution only if they prove to be least cost alternatives.

The first scenario includes average domestic movements. Since average levels of domestic demand are not equal to expected future levels (1985), direct cost comparisons between all scenarios are not possible. However, those costs resulting from the second, third, and fourth scenarios are commensurate, since each includes the domestic movements expected by 1985. In Scenario Two, the total cost of transporting 15.042 million tonnes of grain is $627.5 million. This works out to an average cost of $41.71 per tonne. If direct rail routes are allowed to enter the solution (as in Scenario Three), total movement costs are $603.0 million. Thus, by utilizing the existing potential for solid trains, eastern Canadian grain movement costs will decrease by $24.5 million or $1.63 per tonne. Expanding solid train capacity (as in Scenario Four), yields an additional cost saving of $6.1 million which further reduces total cost to $596.9 million. This can be translated into a savings of $0.40 per tonne. In relative terms, solid trains operate at low costs; therefore, their use allows for a significant reduction in cost.

If maximum grain movements for each scenario are compared, a similar cost pattern is visible. Table 12 denotes the cost associated with the maximum grain movements of each scenario. According to Scenario Two, the maximum amount of grain which can be moved via water routes is 15.363 million tonnes (11.290 export and 4.073 domestic). The cost of such a movement is $41.83 per tonne. As direct rail routes are brought into service (Scenario Three) grain movements increase while costs decrease. It should be noted that the maximum grain movements under Scenario Three include not only direct rail routes out of the inland terminals, but also solid train movements from Thunder Bay. Solid train

TABLE 12

Cost of Moving Maximum Levels of Grain to Eastern Elevators

	Export Level ('000 tonnes)	Domestic Grain Movement ('000 tonnes)	Total Grain Movement ('000 tonnes)	Total Cost ('000 dollars)	Average Total Cost ($/tonne)
Scenario Two	11,290[a]	4,073	15,363	642,710	41.83
	15,465	4,073	19,538	842,300	43.11
Scenario Three	17,865	4,073	21,938	916,800	41.75
Scenario Four	17,991	4,073	22,064	909,700	41.23

[a]Maximum grain exports with no solid train movements.

movements out of Thunder Bay are a costly procedure since an additional handling charge is incurred. The use of Thunder Bay as a transloading site is relatively costly when compared to a direct rail movement out of the inland terminals. Since grain moves to Thunder Bay by a traditional grain train and then on by solid train, the overall movement cost is considerably higher than if the grain was to move directly by solid trains. When Thunder Bay routes are used (Scenario Two) potential exports increase from 11.290 to 15.465 million tonnes; however, the consequence of such a movement is that average costs increase from $41.83 to $43.11 per tonne.

Overall, it appears that direct rail routes not only make increased throughput possible, but also reduce transportation costs. The same situation does not hold true in the case of all-rail movements out of Thunder Bay. The preceeding analysis has shown that solid trains operating out of Thunder Bay are successful in increasing capacity, but they do so at a significant cost disadvantage.

Chapter VII

CONCLUSIONS AND POLICY IMPLICATIONS

Canada's grain handling ability has recently come under serious criticism. As grain movements increase, transportation problems may well become the nemesis of the Canadian grain industry. Solid trains present one approach by which certain grain transportation problems may be overcome.

The general objective of this thesis was to evaluate the physical and economic potential for solid trains in eastern Canada. As set out in Chapter One, the specific objectives were to:

1. examine qualitatively the feasibility and potential for solid train movements,
2. build a mathematical model which would facilitate the minimum total cost movement of grain in eastern Canada,
3. use the model to derive the optimal pattern of grain movements under various scenarios, and
4. determine the implications of the results in order to provide a basis for policy recommendations for the rationalization of the eastern grain transportation system.

The feasibility of solid train operations is discussed in the first section of this chapter. A summary of the model's results is presented next. Following that, conclusions and policy implications are presented. The final two sections of this chapter discuss model limitations and suggestions for further research.

7.1 FEASIBILITY OF SOLID TRAIN OPERATIONS

In the past, eastern grain movements have been basically restricted to traditional rail-water routes. However, expectations of future demand may prompt an adoption of more innovative procedures. The eastern grain handling system exhibits a definite potential for solid train use. Solid trains may provide one avenue by which certain grain handling problems can be resolved.

The lack of cleaning facilities at transfer elevators means that grain must be cleaned prior to shipment. In order to collect and clean adequate quantities of grain, inland and Thunder Bay terminals must be used as loading points. In the case of solid train movements out of Thunder Bay, the grain is moved to Thunder Bay in an uncleaned state and is cleaned at the Thunder Bay terminals prior to being loaded onto solid trains. Consequently, all the grain which moves by solid train has been cleaned to dxport standards. The inland terminals located at Saskatoon and Moose Jaw are presently capable of loading 2.216 and 1.756 million tonnes of clean grain, respectively. Due to more extensive facilities, Thunder Bay retains an annual loading capacity of 4.998 million tonnes.

At present, the eastern rail network is experiencing excess capacity. Therefore, it is assumed that the existing track has the ability to absorb solid train movements. However, the same conclusion cannot be made in regards to locomotives and rolling stock. Rail car shortages have become a common occurrence. If a continuous solid train movement is to be undertaken, new locomotives and hopper cars must be purchased.

The logical destinations of these new solid trains are the transfer elevators located at the Quebec and Atlantic ports. The ability to export grain provides these elevators with a potential level of business sufficient to support solid train movements. Rail receiving can be improved at both these destinations with the installation of loop tracks.

Presently, it is rail loading, not rail receiving which limits the use of solid trains. At the inland terminals, grain collection and cleaning, restrict the loading of solid trains. If more grain is to be shipped, grain cleaning capabilities must be increased. Grain collection provides a more difficult problem. Logistical complications place restrictions upon the amount of grain which can be moved through a particular terminal. For these reasons, a throughput increase of more than 25 percent is not considered to be feasible. With a 25 percent increase, direct solid train movements will attain a potential maximum of 4.965 million tonnes. Saskatoon will be capable of loading 2.770 million tonnes; meanwhile, Moose Jaw will account for the remaining 2.195 million tonnes.

Thunder Bay terminals do not face the same type of constraints as the inland terminals. The potential for rail loading at Thunder Bay is extensive. Solid train movements out of Lakehead will be ultimately restricted by the throughput capacity at the Quebec and Atlantic elevators.

7.2 SUMMARY OF RESULTS

The results of the first scenario clearly show that even at a subsidized rate, "At and East" movements are far from being a low cost transportation alternative. At the record export level of 10.969 million tonnes, the use of "At and East" routes results in an additional cost of

$2.4 million. Since "At and East" movements are not cost efficient, they never once freely enter an optimal pattern of grain movements. In terms of throughput, the "At and East" movements are successful in increasing the utilization of the Bay port and Atlantic transfer elevators. This allows for some regional economic benefits; however, since the "At and East" movements do not allow for minimum total cost, it would appear inefficient to force them through the system.

Throughout the analysis, direct rail routes consistently perform as a low cost alternative. Cost advantages of the direct rail movements are evident from two sources. The first source of reduced cost lies in the efficiency gained from solid train operations. Secondly, grain railed directly from the Prairies is able to forego the costly step of unloading, cleaning, and reloading at Thunder Bay. The potential for direct solid train routes represents one way to increase eastern Canada's grain handling capacity. In addition to increasing capacity, the utilization of direct rail routes also serves to reduce the average transportation costs of moving grain.

Within the model solid trains were also used to rail grain from Thunder Bay to eastern elevators. Like the direct rail routes, all-rail routes out of Thunder Bay cause an increase in system capacity. However, unlike the direct rail routes, Thunder Bay movements result in an increase in average transportation costs. The cost of railing grain to Thunder Bay by a traditional grain train, along with the Thunder Bay elevator costs cause such all-rail routes to be second only to the "At and East" movements in terms of high cost.

Table 13 provides a summary of the results found in this study. Domestic shipments of 4.073 million tonnes were given first priority in terms of grain movements with the remaining capacity available to export movements. In Table 13, the results are displayed with regard to the export level. The costs shown in the table were calculated, based upon the average cost of moving both export and domestic grain. Since the first scenario was primarily a base solution, it is not included in the summarized results.

In the absence of any rail movements, eastern Canada will be limited to exporting 11.290 million tonnes of grain. This includes 10.068 million tonnes exported from Quebec, with the remaining 1.222 million tonnes exported directly out of Thunder Bay. The total cost associated with moving 11.290 million tonnes of export and 3.250 million tonnes of domestic grain by water is $41.83 per tonne. If grain is allowed to move through Thunder Bay via all-rail routes, maximum eastern exports will increase to 15.465 million tonnes. Therefore, all-rail routes result in a potential export increase of 4.178 million tonnes. Using all-rail routes in this manner induces an average cost increase of $1.28 per tonne.

The use of existing direct rail capability, further increases eastern exports. By including direct rail routes, it becomes possible to move 17.865 million tonnes of export and 4.073 million tonnes of domestic grain. Total movement costs amount to $916.8 million which is equivalent to $41.75 per tonne. When compared to a transportation system which includes no rail service, all-rail routes allow for a 43 percent

TABLE 13

Summary of Results

Scenario	Export Level	Solid Train Movements: Saskatoon to Quebec	Solid Train Movements: Moose Jaw to Quebec	Solid Train Movements: Thunder Bay to Quebec	Total Cost ('000 $)	Average Cost ($/ tonne)
	..............'000,000 tonnes..............					
Two	10.969[a]	-	-	-	627,500	41.71
	11.290[b]	-	-	-	642,700	41.83
	15.465[c]	-	-	4.175	842,300	43.11
Three	10.969[a]	2.216	1.756	-		40.08
	17.865[c]	2.216	1.756	2.603	916,800	41.75
Four	10.969[a]	2.770	2.195	-		39.68
	17.991[c]	2.770	2.195	1.736	909,700	41.23

[a]Historic maximum level of exports through eastern Canada.

[b]Maximum export capacity using no solid train movements.

[c]Maximum export capacity under optimal conditions.

increase in grain movements. At the same time, total cost incurred when moving an average tonne of grain decreases by approximately 2 percent.

If direct rail capacity is increased by 25 percent, eastern exports can attain their maximum level of 17.991 million tonnes. At this point, total grain movement costs are $909.7 million which converts to $41.23 per tonne. In other words, if direct rail capacity is extended, an additional 0.126 million tonnes of grain can be exported while further reducing average movement costs by $0.52 per tonne.

Throughout the analysis, the Quebec ports provided the least costly route for eastern exports. Consequently, the Quebec elevators handle the vast majority of grain moving through eastern Canada. Direct exports out of Thunder Bay represent the next best route for foreign shipments. The Atlantic ports are used for export purposes only after both Quebec and Thunder Bay exports have been exhausted. The Thunder Bay elevators themselves always maintain excess capacity. Slack capacity was also evident at the Bay and Lake port elevators. Ultimately, it was the throughput capacities of the Quebec and Atlantic elevators which served to restrict eastern grain movements.

7.3 CONCLUSIONS

If the Canadian Wheat Board's export goals are to be fulfilled, all possible routes will have to function at or near their capacity levels. In recent years, it has been argued that the grain industry should focus its attention on the Pacific routes. While it is true that Pacific exports are increasing, we must not lose sight of the fact that eastern grain movements will also increase significantly. Grain moving west is mainly confined to export shipments. On the other hand, eastern movements include export as well as domestic grain.

Numerous predictions have been put forward in an attempt to quantify the proportion of grain expected to move west rather than east. As mentioned in Chapter One, by 1985 the West Coast will account for between 43 and 52 percent of Canadian grain exports. When both export and domestic demand are considered, the average amount of grain expected to move west is 45 percent. Thus, the eastern sector will be expected to transport an average of 55 percent of Canada's total demand.

Throughout the analysis, various export levels have been examined. In order to clearly demonstrate the advantages of solid trains, the Canadian Wheat Board's estimate will be evaluated in a more indepth manner here. By 1985, the Wheat Board predicts that export demand for Canadian grain will be 30 million tonnes. After 4.073 million tonnes of eastern domestic demand is added, the total amount of grain to be transported is 34.073 million tonnes. Assuming that 55 percent moves east, the eastern sector will be expected to transport approximately 18.740 million tonnes. On the average, exports out of Churchill account for about 0.606 million tonnes. Therefore, it is conceivable that by 1985 the eastern system will be asked to transport 14.061 million tonnes of export, and 4.073 million tonnes of domestic grain annually.

Domestic demand is usually given first priority in terms of grain movements. The capacity which remains after domestic requirements are fulfilled is subsequently available to export grain. In the past, the rail-water routes have been fairly successful in meeting export demand. A similar performance is not likely to occur in the future. In the absence of all-rail routes, the maximum quantity of export grain which can be moved (via the Seaway) is 11.290 million tonnes. If eastern export demand does in fact reach 14.061 million tonnes, 2.771 million tonnes of potential grain sales will have to be foregone. Canada's resulting loss of revenue will depend upon the export price of that grain which could potentially have been sold. For example, if export price was $220.00 per tonne, potential revenue losses would be in the order of $609.6 million per year.

Utilizing solid trains out of Thunder Bay will increase eastern export ability to 15.465 million tonnes. In other words, a year-round solid train movement out of Thunder Bay will satisfy 1985 exports. The cost of moving 14.061 million tonnes of export and 4.073 million tonnes of domestic grain is $774.7 million ($42.72 per tonne). Such a movement requires 2.771 million tonnes of grain to be transported from Thunder Bay to the Quebec elevators aboard solid trains. In order to transport 2.771 million tonnes of grain, 6.5 solid trains will be needed. Since it is impossible to have one-half a train, seven solid trains would have to be purchased. One train out of the seven would spend only six months of each year operating as a solid train. For the remaining one-half of the year, the train could be broken up and used for regular rail service. Unless one of the seven solid trains is used for half the year in some service other than solid train operations, there will exist a situation where an overabundance of resources has been devoted to solid train movement.

The use of solid trains out of the inland terminals and Thunder Bay will result in a potential export level of 17.865 million tonnes. Since only 14.061 million tonnes is to be exported, the rail routes between Thunder Bay and Quebec need not be used in conjunction with direct movements. In terms of direct rail movements, 2.216 million tonnes is railed out of the inland terminal at Saskatoon, with 1.756 million tonnes moving out of the Moose Jaw terminal. The destination for both these shipments is the Quebec elevators. If direct rail routes are used in conjunction with the traditional rail-water routes, the total cost of moving 4.073 million tonnes of domestic and 14.061 million tonnes of export is $733.4 million ($40.44 per tonne). When compared to solid train movements out of Thunder Bay, direct rail shipments provide a cost saving of $41.3 million. To facilitate such a direct rail movement 14.8 solid trains are required. Assuming that 15 trains are purchased, one of the 15 will operate as a solid train for only 20 percent of the year. For the remaining 80 percent of the year, the locomotives and hopper cars can function as regular grain trains.

Potential exports can be increased to 17.991 million tonnes, and operating costs decreased should direct rail capacity be expanded by 25 percent. Minor improvements to plant and equipment will allow 4.965 million tonnes of grain to be shipped from inland terminals to Quebec. The total cost of moving 14.061 million tonnes of export and 4.073 million tonnes of domestic grain is $727.6 million ($40.12 per tonne). Slight improvements to the direct rail routes will result in an operational cost savings of $5.8 million per year. Expanded direct rail service will require the use of 17.8 solid trains. Out of the 18 solid trains which would need to be purchased, one of these trains is required to operate as A solid train for only part of the year. For the remaining 20 percent of the year one solid train could see service as a traditional grain train.

It appears that utilizing the existing potential for direct solid train movements will provide a cost saving of $41.3 million. Existing potential is considered to be the maximum amount of grain which can be handled at the present facilities without any improvements. The only capital investment which is necessary is the purchase of solid trains. Since the capital cost of the solid trains are included in the solid train costing model, no additional funds need be allocated. As mentioned previously, direct rail service requires minor changes to the existing facilities. The capital cost of these improvements has not been assessed in this thesis. However, since operational savings are estimated in the order of $5.8 million, it would seem that in the long run such improvements will be advantageous. The second reason why such improvements will be advantageous relates to the overall increase in system capacity. A 25 percent increase in direct rail movement allows eastern Canada to potentially export an extra 0.126 million tonnes. Although not required at present, this added capacity will most likely be required in some future year. At an export price of $220 per tonne, this will mean an annual increase in grain sales of $27.7 million. Therefore, it is fairly obvious that the improvements will be beneficial.

In conclusion, it is possible to state that solid train routes can provide substantial increases in capacity. Solid train movements if used correctly can also reduce the average cost of transporting grain through eastern Canada. With the use of solid trains, the eastern transportation system can potentially fulfill those levels of domestic and export demand expected by 1985. However, unless eastern grain transportation includes solid trains, Canada's grain movement goals will not be realized.

The conclusions of this thesis are somewhat different from those of the studies mentioned in Chapter Two. Previously all-rail movements have been recommended only during the winter when Seaway shipping is closed. All-rail routes were not recommended on a continuous basis mainly because their use was not seen as being cost competitive with water movements. The findings of this thesis agree that when considered separately, water transportation is less costly than rail. This is to say that a solid train movement from Thunder Bay to Quebec is more costly than a comparable movement aboard lake vessels. However, when the entire grain handling system is examined from farm gate to eastern destinations, it becomes apparant that direct rail routes are the least costly alternative.

The use of compensatory rates causes those cost savings associated with solid trains to be much more distinct. The rationale for implementing compensatory rates is simple and conceptually sound. If compensatory rates are not used, full rail costs are not accounted for. Statutory rates provide the traditional rail-water routes with an artificial (subsidized) cost advantage over direct solid train movements. In the past, this type of subsidized cost has tended to mask the potential efficiency of solid train operations. The end result being that too many resources have been allocated to rail-water routes.

7.4 POLICY IMPLICATIONS

The results of this thesis are useful in evaluating future policy alternatives. The first policy implication to be discussed deals with the "At and East" grain movements. If minimum cost is used as a criterion, it follows that the "At and East" movements should be abandoned. It can be argued that cost savings gained through "At and East" elimination could be distributed from the gainers to the losers. Hence, the Georgian Bay and Atlantic regions could receive some compensation for reduced grain throughput. So long as the net benefits gained by abolishing "At and East" movements outweigh the resulting welfare losses, a pareto optimal solution is attainable.

The decision to discontinue the "At and East" movement in no way implies that the Bay port and Atlantic elevator should be abandoned. As time passes, it is expected that both of these facilities will be required to make a significant contribution to system capacity. Corn and soybean production is expanding rapidly in Ontario. As a result, the existing facilities at the Bay and Lake ports will be needed to handle local production, as well as domestic demand. The Atlantic ports not only distribute domestic grain, but also maintain a potential export capacity of approximately 1.074 million tonnes. Since all of eastern Canada's export capacity may well be needed in the future, the Atlantic export route should be maintained.

The results of the model suggest that in relative terms a solid train movement out of Thunder Bay is a high cost endeavour. In the past, the Canadian Wheat Board has encouraged such movements under their Winter Export Program. It is the contention of the Board that winter movements out of Thunder Bay increase export capacity, and utilize facilities which would otherwise lie dormant. These arguments are valid; however, basically the same results can be achieved at a lower cost if direct routes were used. When grain is railed from primary elevators through Thunder Bay, the existing capacity at inland terminals lies idle. On the other hand, if grain is railed directly from inland terminals, the Thunder Bay elevators are not used as extensively as they could be. Therefore, as far as slack capacity is concerned, there is a trade-off between which route is advantageous.

Rail movements out of Thunder Bay are very costly regardless of whether they occur in winter or summer. For this reason, the Canadian Wheat Board's Winter Export Program should be phased out. In its place a new program should be implemented which promotes the use of direct rail routes from the inland terminals to the Quebec elevators. To facilitate low cost direct rail movements, solid trains should be purchased and operated. Also, in order to realize full economic benefits, solid trains should operate on a continuous year-round basis. Occasionally it may be necessary to operate one train as a solid train for only part of the year. By sharing the use of a train, it is possible to maximize the capacity of all-rail routes while at the same time making better use of the newly acquired locomotives and hopper cars.

The inland terminals at Saskatoon and Moose Jaw have a combined capacity of 3.972 million tonnes. The Quebec facilities are presently capable of receiving 3.972 million tonnes of grain; however, in order for solid trains to operate effectively it is suggested that more efficient unloading systems ought be put in use. The Quebec City elevator already has fairly extensive unloading capacity, but if solid trains are to be unloaded in a continuous process, the existing loop track must be extended. Montreal No. 4 is the only other Quebec elevator that has a layout capable of accommodating a loop track; consequently, loop track construction is proposed at that location.

The throughput potential of inland terminals should be increased as well. Grain cleaning ability is the factor which apparently limits the amount of grain which can move through Saskatoon and Moose Jaw. Therefore, cleaning equipment should be installed in order to allow a 25 percent increase in capacity. In addition (although not absolutely required), rail loading improvements at inland terminals may provide for a more expedient grain handling system.

Since direct solid train movements both reduce cost and increase capacity they should receive first priority in terms of route selection. On the other hand, since solid train movements out of Thunder Bay were found to be costly, their use should be confined to increasing grain movements only after direct rail, rail-water, and Thunder Bay exports have been depleted. All-rail routes may transport either domestic or export grain during the months when the Seaway is open. However, during the winter when the Seaway is closed, it would be advisable for rail routes to move export grain. If export grain is made available during the time when the Seaway is closed, eastern Canada will be able to function as a year-round export route. Consequently, Canada will be able to export grain from both the West Coast, and the Quebec ports on a continuous basis. Year-round exports out of Quebec will add flexibility and capacity to Canada's grain marketing process. The above argument assumes that domestic demand can be satisfied during the summer months. If domestic movements are required during the winter then they also could be moved via solid train. The consequence of moving domestic grain during the winter is that the potential for winter exports through eastern ports would be reduced.

It is the recommendation of this thesis that improvements should be undertaken at the inland terminals and Quebec elevators. Once the improvements are completed, an annual grain shipment of 4.965 million tonnes should move via solid trains from the Prairies to the Quebec City and Montreal No. 4 elevators. In specific terms, 2.770 million tonnes should originate from Saskatoon with 2.195 million tonnes railed directly out of Moose Jaw. Rail movements from Thunder Bay to the Quebec elevators should take place only after eastern grain movements (export and domestic) reach 20.328 million tonnes. The Atlantic elevators ought to be serviced by water rather than rail routes, and should be used for export purposes only after all other possibilities have been exhausted.

If the above recommendations were carried out, a number of complications would undoubtedly arise. The implementation of direct rail routes requires a re-evaluation of traditional grain movement patterns. Success at such a task calls for a revamping of existing practices and attitudes within the grain industry. It is well recognized that the nature of the Canadian grain industry does not provide for easy acceptance of new programs. There are a number of reasons why certain institutions may not completely favor a solid train movement.

The Canadian Wheat Board operates as the primary grain marketing agency in Canada. One of the fundamental goals of the Wheat Board is to provide an equal opportunity for farmers to deliver grain. The turnover rate and storage capacity at inland terminals far exceeds those of the primary elevators. With the advent of direct rail movements out of inland terminals, those farmers located near a terminal will have a distinct advantage in terms of the amount of grain they are able to deliver. If a system of equitable delivery is to be maintained, the present block shipping system will have to be modified. The Canadian Wheat Board is understandably hesitant about altering a system (block shipping) which, in their opinion, is operating successfully. However, as judged by their Winter Export program, it would seem that the Wheat Board is not opposed to using solid trains out of Thunder Bay.

In addition to the Wheat Board, there are a number of private companies which have a vested interest in solid train operations. The grain companies which operate terminal elevators at Thunder Bay will in all likelihood not favour a direct-rail program which bypasses their facilities (located at Thunder Bay). They are, however, likely to favour a solid train movement which originates from Thunder Bay since such movements will increase the use of their terminals.

Those grain companies which operate primary elevators within a 100-mile radius of Saskatoon and Moose Jaw will also be less than satisfied with a direct-rail movement. If grain is moved to inland terminals it will have to bypass the primary elevator system. It can be argued, therefore, that in the short run, the primary elevators adjacent to inland terminals would suffer a reduction in throughput if direct rail movements were instituted. In the longer run, however (say, by 1985), it can be argued that the level of grain exports may have increased to the point where both the inland terminals and the surrounding primary elevators will be used to their maximum extent.

It is important to point out that not all of the institutional interests involved in the grain industry are opposed to solid train movements. The railways would favour solid train use so long as excess rail capacity can be utilized. Any contribution that solid train operation may make towards covering fixed costs will prove beneficial to the railways. A similar situation exists with respect to the elevator companies located in Quebec. Solid train movements serve to increase the utilization of the Quebec elevators. Providing that the handling rates charged adequatley reflect costs, an increased throughput will result in a greater return on investment.

The key issue in any grain movement is cooperation between the Wheat Board, the grain companies, and the railways. It appears that the grain industry is beginning to realize the potential of solid train movements. The potential exists, the relevant question is whether we will take advantage of it.

7.5 LIMITATIONS OF THE STUDY

Linear programming creates a simplified model which adds necessary clarity when analyzing a complex transportation system. However, linear programming is based upon certain assumptions which may act as a limitation to the model. In relation to costs, the model assumes a static rather than dynamic state. Thus, the policy recommendations which stem from the analysis are based upon the assumption that the status quo will be maintained. There is no allowance made for the possibility of cost saving technological changes, such as a new form of grain cleaning. If new technology was adopted, the probable result would be a decrease in operating costs. So long as technological changes occur consistently throughout the grain industry, there will be a tendency for grain flow patterns to remain unchanged. If cost saving innovations are adopted in only one sector of the grain transportation industry then there may be a shift in the optimal pattern of grain movements.

The linearity found within the model creates a situation which may be somewhat inconsistent with the actual operations of the grain industry. For example, within the model the cost of handling a tonne of grain is constant regardless of the level of throughput. The principles of economies and diseconomies of scale are not fully portrayed in the model due to the linear nature of the mathematical functions.

Within the grain industry, there are obvious logistical problems which the model fails to take into consideration. Machinery breakdowns, poor weather, labour stoppages, etc., all serve to create bottlenecks in the system. In addition, it is well known that in Canada the many different grades of grain tend to exacerbate the difficulties associated with coordinating grain movements. The model's failure to account for such things as potential bottlenecks and inconsistent grain shipments, results in a downward bias on the total movement cost and an upward bias in terms of capacity.

It should be noted that the capacity and cost figures included in the model are estimates and should be treated as such. The movement costs included in the model are fairly defensible in themselves; however, since incremental costs incurred through logistical problems, and opportunity costs of slack capacity are not taken into account the results may not be fully representative of the situation. As logistical problems develop, the cost of moving grain increases. If one mode is prone to grain movement problems then it is conceivable that the actual cost of the movement may be greater than the apparent cost suggests.

Despite its faults, the model still provides a useful way to evaluate the use of solid trains within the eastern Canadian grain transportation system. The grain flow pattern resulting from the model can be assumed to be fairly constant. Thus, once a base solution is determined, various export levels can be tested for comparative purposes. Evaluating the changing costs and grain flow patterns allows derivation of useful conclusions. Overall, the results of the model are deemed to be fairly reasonable and consistent when compared to the expected behavior of the grain transportation system in eastern Canada.

7.6 SUGGESTIONS FOR FURTHER RESEARCH

There are several important areas in which the findings of this thesis could be extended. The first refers to the cost of improving the direct rail system. The conclusions of this thesis suggest that such capital costs would be significantly less than the operational cost savings. Capital costs were alluded to in the thesis, but they were never actually estimated. In order to determine actual capital costs a complicated engineering study must be conducted. Altering a facility at one location, for example, may have a slight secondary effect on other operations. Increasing the capacity at on phase of an operation may well result in congestion at some other location. While these problems are outside the scope of this thesis, they are nevertheless important, and should be included in a study which specifically sets out to estimate the capital cost of direct rail improvements.

Secondly, the impact of grain cleaning should be further investigated. Traditionally, the vast majority of grain moving east has been cleaned at Thunder Bay. With the advent of direct rail routes, Thunder Bay is by-passed making it necessary to clean grain either on the Prairies or at eastern transfer elevators. Due to the capabilities of inland terminals, it was decided that grain would be cleaned on the Prairies prior to being railed to eastern destinations. Another possibility would have been to install grain cleaning equipment at eastern locations. It will be beneficial to study the location of grain cleaning facilities, keeping in mind such things as transportation costs, system capacity, and multiplier effects on regional economies.

Within this thesis, grain was treated as a homogeneous commodity. If homogeneity is assumed, there is an upward bias created with regard to the system's handling capacity. To gain a more accurate estimate, costs and capacities should be approximated for each individual grain type. The results of such a study would reveal the cost of handling one commodity vis-a-vis the numerous grains present in a highly integrated grading system.

Possibly the most controversial issue which results from the thesis is the distribution of potential costs and benefits. First it must be determined how benefits ought to be divided between the national economy, the grain industry, and western Canadian producers. The obvious solution is for all the involved parties to receive some portion of the economic benefits accruing from solid train operations. The question of how to distribute the benefits may be resolved by examining the multiplier effects in the related sectors of the economy.

Once the exact distribution of benefits is determined, further work is required in order to decide how producer benefits should be allocated while still maintaining an equal opportunity to deliver. Those producers which are within trucking distance to inland terminals will have a distinct advantage in terms of their ability to deliver grain. Obviously the block shipping system must be altered somewhat in order to provide producers with equal opportunities regardless of location.

A subsequent area of concerns deals with the various alternatives for capital investment. The existing rail and water routes which are capable of transporting grain will in all likelihood be fully utilized in the near future. If grain movements are to increase beyond that point, extensive capital investments will be required. It is fairly obvious that the Quebec elevator facilities should be expanded. What is far less clear is whether Quebec's expanded capacity should be supplied by lake vessels or rail car. In order to decide between water or rail expansion, a cost-benefit study should be conducted. This would require the analysis of options such as expansion and deepening of the Seaway, additions to the grain hauling fleet, grain elevator construction, and the possibility of additional railway construction in eastern Canada. Given the assumption that Canada wishes to maintain her position as a grain exporter, future capital investments are important. Investment plans must be formulated well in advance of their desired implementation date; otherwise, potential grain sales may well be lost.

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Appendix A

GRAIN ELEVATORS

Table A1

Licensed Primary Elevators

Company	Manitoba		Saskatchewan		Total	
Cargill Grain Co. Ltd.	22	(25)	108	(137)	130	(162)
Manitoba Pool Elevators	206	(264)	-	-	206	(264)
Parrish & Heimbecker, Ltd.	3	(3)	24	(25)	27	(28)
Paterson & Sons Ltd., N.M.	34	(36)	37	(50)	72	(86)
Pioneer Grain Co. Ltd.	9	(11)	214	(331)	223	(342)
Saskatchewan Wheat Pool	-	-	755	(1,216)	755	(1,216)
United Grain Growers	80	(112)	178	(268)	258	(380)
Other Licensed Companies	2	(3)	3	(5)	5	(8)
TOTALS	356	(454)	1,319	(2,032)	1,675	(2,486)

Note: In most cases where a grain company operates two or more elevators at one location, the operations have been combined under a single manager. This has been aided by trading of elevators between companies. The bracketed figures indicate the licensed separate units.

Source: C.F. Wilson, Grain Marketing in Canada (Winnipeg: Canadian International Grains Institute, 1979), p. 26; citing Canadian Grain Commission, Grain Elevators in Canada, Crop Year 1977-78 (Winnipeg: Canadian Grain Commission, 1977), Table 8, p. viii.

Table A2

Licensed Terminal Elevators

Location	Licensee	No. of Elevators	Capacity in Tonnes
Manitoba			
Churchill	National Harbours Board	1	140,020
Saskatchewan			
Moose Jaw	Canadian Government Elevators		154,020
Saskatoon	Canadian Government Elevators		154,020
		2	308,040
Ontario			
Thunder Bay	Cargill Grain Co. Ltd.		161,020
	Manitoba Pool Elevators, No. 1		167,460
	Manitoba Pool Elevators, No. 3		215,630
	Parrish & Heimbecker, Ltd.		47,600
	Richardson Terminals Ltd.		210,030
	Saskatchewan Wheat Pool, No. 4		223,180
	Saskatchewan Wheat Pool, No. 5		133,020
	Saskatchewan Wheat Pool, No. 6		169,140
	Saskatchewan Wheat Pool, No. 7		362,650
	Saskatchewan Wheat Pool, No. 8		70,160
	Saskatchewan Wheat Pool, No. 15		119,670
	United Grain Growers Ltd. 'A'		231,030
	United Grain Growers Ltd. 'M'		91,010
		13	2,201,600
TOTAL		16	2,649,660

Source: Canadian Grain Commission, Grain Elevators in Canada, Crop Year 1978-79 (Winnipeg: Canadian Grain Commission, 1978), Table 3, p. xv.

Table A3

Licensed Transfer Elevators

Location	Licensee	No. of Elevators	Capacity in Tonnes
Bay Ports			
Port McNicoll	Marathon Realty Co. Ltd.		182,030
Midland	Canada Steamship Lines Ltd.		74,210
	Midland Simcoe Elevator Co. Ltd.		119,020
(Triffin)	C.N.R.		130,220
Collingwood	Collingwood Terminals Ltd.		56,010
Owen Sound	The Great Lakes Elevator Co. Ltd.		112,020
Goderich	Goderich Elevator Co. Ltd., No. 1		84,010
	Goderich Elevator Co. Ltd., No. 2		44,810
Sarnia	Maple Leaf Mills Ltd.		151,220
		9	953,550
Lake Ports			
Port Colbourne	Maple Leaf Mills Ltd.		63,010
	National Harbours Board		84,010
	Robin Hood Multifoods Ltd.		59,650
Toronto	Toronto Elevators Ltd.		112,020
Kingston	Canada Steamship Lines Ltd.		65,810
Prescott	National Harbours Board		154,020
		6	538,520
Quebec Ports			
Baie Comeau	Cargill Grain Co. Ltd.		413,840
Montreal	National Harbours Board, No. 1		112,020
	National Harbours Board, No. 3		140,020
	National Harbours Board, No. 4		154,020
	National Harbours Board, No. 5		142,820
Port Cartier	Port Cartier Elevator Company		292,980
Quebec City	Bunge of Canada Ltd.		224,030
Sorel	Sorel Elevators Ltd.		146,460
Trois-Rivieres	Three Rivers Elevators Ltd.		164,660
		9	1,790,850

(Continued)

Table A3 (Continued)

Location	Licensee	No. of Elevators	Capacity in Tonnes
Atlantic Ports			
Saint John	C.N.R.		14,000
West Saint John	Marathon Realty Co. Ltd.		44,160
Halifax	National Harbours Board		144,290
		3	202,460
TOTAL		27	3,485,370

Source: Canadian Grain Commission, Grain Elevators in Canada, Crop Year 1978-79 (Winnipeg: Canadian Grain Commission, 1978), Table 4, p. xvi.

Appendix B

PRIMARY ELEVATOR AND INLAND TERMINAL COSTS

Table B1

Average Net Receipts at Primary Elevators[a]
(1974-1978)

	Wheat	Oats	Barley	Rye	Flaxseed	Rapeseed	Total
Manitoba	57.0	6.0	26.0	1.0	6.0	4.0	100.0
Saskatchewan	83.0	1.0	11.0	1.0	1.0	3.0	100.0

[a]Figures are shown as percentages.

Source: Statistics Canada, Grain Trade of Canada, Ottawa, annual, Table 8.

Table B2

Primary Elevator Tariffs for Regular Service[a]

	Wheat	Oats	Barley	Rye	Flaxseed	Rapeseed
	..............dollars per tonne..............					
Manitoba Pool Elevators	4.90	7.30	6.05	5.80	6.85	6.85
Saskatchewan Wheat Pool	4.50	6.65	5.55	4.75	6.85	6.85

[a]Regular Service includes: receiving, elevating and loading out.

Source: Summary - 1978 Primary Elevator Tariffs, Canadian Grain Commission, mimeographed copy.

Table B3

Constant Charges for all Grain Moving Through Primary Elevators

	Primary Elevator Located in Manitoba and Saskatchewan
	.....dollars per tonne......
Carrying Charges[a]	3.61
Administration Fees[b]	0.35
TOTAL	3.96

[a]Carrying Charges include: interest and storage costs (average period of storage is assumed to be two months); Canadian Wheat Board, Annual Report 1978-79, Table A, p. 45.

[b]Administrative Fees are paid to the grain companies for performing administrative services; "Running a Tonne Through the System," Grain Matters, a letter from the Canadian Wheat Board, July 1979, p. 4.

Table B4

Calculation of Primary Elevator Costs

	Manitoba Primary Elevators	Saskatchewan Primary Elevators
Wheat	\$4.90 x 0.570 = \$2.793	\$4.50 x 0.830 = \$3.735
Oats	7.30 x 0.060 = 0.438	6.65 x 0.010 = 0.067
Barley	6.05 x 0.260 = 1.573	5.55 x 0.110 = 0.611
Rye	5.80 x 0.010 = 0.058	4.75 x 0.010 = 0.048
Flaxseed	6.85 x 0.060 = 0.411	6.85 x 0.010 = 0.069
Rapeseed	6.85 x 0.040 = 0.274	6.85 x 0.030 = 0.206
Subtotal	\$5.54	\$4.74
Constant Charges[a]	3.96	3.96
Average Total Cost Per Tonne	\$9.50	\$8.70

[a] Individual Constant Charges for primary elevators are indicated in Table B3.

Table B5

Inland Terminal Elevator Tariffs[a]
(Effective August 1, 1978)

	Wheat	Oats	Barley	Rye	Flaxseed	Rapeseed
	..............dollars per tonne..............					
Receiving, Elevating and Shipping	2.40	4.05	3.00	2.40	3.00	3.90
Cleaning	0.80	1.40	1.00	0.80	2.20	2.35
Additional Charge for Shipping Grain in Railway Cars	0.80	1.30	1.00	0.80	0.95	0.95
TOTAL	4.00	7.20	5.00	4.00	6.15	7.20

[a]Canadian Government Elevators located at Moose Jaw and Saskatoon.

Source: Summary - 1978 Terminal Elevator Tariffs, Canadian Grain Commission, mimeographed copy.

Table B6

Constant Charges for all Grain Moving Through Inland Terminals

	Inland Terminal Elevators at Moose Jaw and Saskatoon
	.....dollars per tonne......
Carrying Charges[a]	1.81
Administration Fees[b]	0.35
Canadian Grain Commission Fees[b]	0.38
Superintendence[b]	0.02
TOTAL Constant Charges	2.56

[a]Inland terminal Carrying Charges (interest and storage) are assumed to be one-half of average primary elevator carrying charges.

[b]Derived from: "Running a Tonne Through the System," Grain Matters, a letter from the Canadian Wheat Board, July 1979, p. 4.

Table B7

Calculation of Inland Terminal Costs

	Canadian Government Elevators Moose Jaw and Saskatoon
Wheat	$4.00 x 0.830 = $3.320
Oats	7.20 x 0.010 = 0.072
Barley	5.00 x 0.110 = 0.550
Rye	4.00 x 0.010 = 0.040
Flaxseed	6.15 x 0.010 = 0.062
Rapeseed	7.20 x 0.030 = 0.215
Subtotal	$4.26
Carrying Charges[a]	2.56
Average Total Cost Per Tonne	$6.82

[a]Individual Constant Charges for inland terminals are indicated in Table B6.

Appendix C

THUNDER BAY TERMINAL ELEVATOR COSTS

Table Cl

Average Grain Movements Through Thunder Bay[a]
(1874-1878)

	Wheat	Oats	Barley	Rye	Flaxseed	Rapeseed	Total
Domestic Shipments	30.50	15.12	54.12	0.23	0.02	-	100.0
Forwarded	76.67	2.72	20.10	0.22	0.31	-	100.0
Exported Directly	22.36	13.61	15.42	7.36	22.50	18.75	100.0

[a]Figures are shown as percentages.

Source: Statistics Canada, Grain Trade of Canada, Ottawa, annual, Table 12.

Table C2

Terminal Elevator Tariffs - Thunder Bay
(Effective August 1, 1978)

	Wheat	Oats	Barley	Rye	Flaxseed	Rapeseed
	....	....dollars	per	tonne....	....	
Receiving, Elevating and Shipping	2.50	4.10	3.10	2.50	3.40	4.00
Cleaning	0.92	1.63	1.15	0.99	2.35	2.35
Storage[a]	0.47	0.47	0.47	0.47	0.47	0.47
Subtotal	3.89	6.20	4.72	3.96	6.22	6.82
Additional Charges for Shipping in Railway Cars or Trucks	0.80	1.30	1.00	0.80	0.95	0.95
TOTAL	4.69	7.50	5.72	4.76	7.17	7.77

[a]Average cost per tonne for terminal storage during the 1977-78 crop year, Grain Matters, a letter from the Canadian Wheat Board, July 1979, p. 4.

Source: Summary - 1978 Terminal Elevator Tariffs, Canadian Grain Commission, mimeographed copy.

Table C3

Constant Charges Incurred for All Grains Moving Through Thunder Bay

	Domestic	Forwarded by Rail	Forwarded by Water	Exported Directly
	............dollars	per tonne	....	
Lake Shippers Clearance Association Fees	-	-	0.04	-
Superintendence	-	0.02	0.02	0.02
Forward Brokerage	-	-	0.05	0.05
Canadian Grain Commission Fees	0.38	0.38	0.38	0.38
TOTAL Constant Charges	0.38	0.40	0.49	0.45

Source: "Running a Tonne Through the System," Grain Matters, a letter from the Canadian Wheat Board, July 1979, p. 4.

Table C4

Calculation of Thunder Bay Terminal Costs

Grain	Domestic	Forwarded by Rail	Forwarded by Water	Exported Directly
Wheat	$4.69 x 0.305 = $1.430	$4.69 x 0.767 = $3.597	$3.89 x 0.767 = $2.984	$3.89 x 0.224 = $0.871
Oats	7.50 x 0.151 = 1.133	7.50 x 0.027 = 0.203	6.20 x 0.027 = 0.167	6.20 x 0.136 = 0.843
Barley	5.72 x 0.541 = 3.095	5.72 x 0.201 = 1.150	4.72 x 0.201 = 0.949	4.72 x 0.154 = 0.727
Rye	4.76 x 0.002 = 0.010	4.76 x 0.002 = 0.010	3.96 x 0.002 = 0.008	3.96 x 0.074 = 0.293
Flaxseed		7.17 x 0.003 = 0.022	6.22 x 0.003 = 0.019	6.22 x 0.225 = 1.400
Rapeseed				6.82 x 0.188 = 1.282
Subtotal	$5.67	$4.98	$4.13	$5.42
Constant Charges[a]	0.38	0.40	0.49	0.45
Average Total Cost Per Tonne	$6.05	$5.38	$4.62	$5.87

[a]Individual Constant Charges for Thunder Bay terminals are indicated in Table C3.

Appendix D

TRANSFER ELEVATOR COSTS

Table Dl

Average Domestic Grain Movements Through Transfer Elevators[a]
(1974-1978)

	Wheat	Oats	Barley	Rye	Flaxseed	Rapeseed	Total
Bay Ports	50.6	23.6	18.8	1.5	-	-	100.0
Lake Ports	74.9	9.7	9.3	0.6	5.5	-	100.0
Quebec Ports	56.9	9.0	33.7	0.4	-	-	100.0
Atlantic Ports	91.9	0.1	8.0	-	-	-	100.0

[a]Figures are shown as percentages.

Source: Statistics Canada, Grain Trade of Canada, Ottawa, annual, Table 35.

Table D2

Average Export Grain Movements Through Transfer Elevators[a]
(1974-1978)

	Wheat	Oats	Barley	Rye	Flaxseed	Rapeseed	Total
Quebec Ports	76.7	0.4	21.2	0.4	0.9	0.4	100.0
Atlantic Ports	93.5	0.1	4.4	0.1	1.8	0.1	100.0

[a]Figures are shown as percentages.

Source: Statistics Canada, _Grain Trade of Canada_, Ottawa, annual, Table 35.

Table D3

Transfer Elevator Tariffs - Bay and Lake Port Elevators[a]
(Effective August 1, 1978)

	Wheat	Oats	Barley	Rye	Flaxseed	Rapeseed
	.............dollars per tonne.............					
Receiving and Shipping Grain for Domestic Use From Vessels to Railway Cars	2.85	4.65	3.55	2.85	3.85	4.55
Receiving and Shipping Grain for Export From Vessels or Rail Cars to Railway Cars	2.90	4.45	3.35	2.70	3.65	4.30

[a] Midland Simcoe and Prescott elevators are used as proxy distance for Bay Port and Lake Port elevators, respectively.

Source: Summary - 1978 Transfer Elevator Tariffs, Canadian Grain Commission, mimeographed copy.

Table D4

Transfer Elevator Tariffs - Quebec and Atlantic Ports[a]
(Effective August 1, 1978)

	Wheat	Oats	Barley	Rye	Flaxseed	Rapeseed
	..............dollars per tonne..............					
Receiving and Shipping Grain for Domestic Use From Vessels or Railway Cars to Railway Cars	2.85	4.65	3.55	2.85	3.85	4.55
Receiving and Shipping Grain for Export From Vessels or Railway Cars to Vessels	2.50	4.10	3.10	2.50	3.40	4.00

[a]Quebec City and Halifax elevators are used as proxy distance for Quebec and Atlantic Port elevators, respectively.

Source: Summary - 1978 Transfer Elevator Tariffs, Canadian Grain Commission, mimeographed copy.

Table D5

Calculations of Bay Port Elevator Costs

	Domestic Grain Loaded Onto Railway Cars	Grain Railed to Atlantic Ports
Wheat	\$2.85 x 0.506 = \$1.442	\$2.70 x 0.935 = \$2.525
Oats	4.65 x 0.236 = 1.097	4.45 x 0.001 = 0.004
Barley	3.55 x 0.188 = 0.667	3.35 x 0.044 = 0.147
Rye	2.85 x 0.015 = 0.043	2.70 x 0.001 = 0.003
Flaxseed		3.65 x 0.018 = 0.066
Rapeseed		4.30 x 0.001 = 0.004
	------	------
Average Total Cost Per Tonne	\$3.25	\$2.75

Table D6

Calculation of Lake Port Elevator Costs

	Domestic Grain Loaded Onto Railway Cars
Wheat	$2.85 x 0.749 = $2.135
Oats	4.65 x 0.097 = 0.451
Barley	3.55 x 0.093 = 0.330
Rye	2.85 x 0.006 = 0.017
Flaxseed	3.85 x 0.055 = 0.208
Average Total Cost Per Tonne	$3.15

Table D7

Calculation of Quebec Port Elevator Costs

	Domestic Grain Loaded Onto Railway Cars	Export Grain Loaded Onto Ocean Vessels
Wheat	$2.85 x 0.569 = $1.622	$2.50 x 0.767 = $1.918
Oats	4.65 x 0.090 = 0.419	4.10 x 0.004 = 0.016
Barley	3.55 x 0.337 = 1.196	3.10 x 0.212 = 0.657
Rye	2.85 x 0.004 = 0.011	2.50 x 0.004 = 0.010
Flaxseed		3.40 x 0.009 = 0.031
Rapeseed		4.00 x 0.004 = 0.016
	------	------
Average Total Cost Per Tonne	$3.25	$2.65

Table D8

Calculation of Atlantic Port Elevator Costs

	Domestic Grain Loaded Onto Railway Cars	Export Grain Loaded Onto Ocean Vessels
Wheat	\$2.85 x 0.919 = \$2.619	\$2.50 x 0.935 = \$2.338
Oats	4.65 x 0.001 = 0.047	4.10 x 0.001 = 0.004
Barley	3.55 x 0.080 = 0.284	3.10 x 0.044 = 0.136
Rye		2.50 x 0.001 = 0.003
Flaxseed		3.40 x 0.018 = 0.061
Rapeseed		4.00 x 0.001 = 0.040
	------	------
Average Total Cost Per Tonne	\$2.95	\$2.58

Appendix E

RAILWAY COSTS

Calculation of Statutory and Compensatory Rail Rates for Transporting Grain

Statutory freight rates[116] on grain moving to Thunder Bay or Armstrong, Ontario from:

	Cereals	Oilseeds
Carberry, Manitoba	16.0 cents/100 pounds	17.5 cents/100 pounds
Craik, Saskatchewan	21.0 cents/100 pounds	32.5 cents/100 pounds
Moose Jaw, Saskatchewan	20.0 cents/100 pounds	21.5 cents/100 pounds
Saskatoon, Saskatchewan	22.0 cents/100 pounds	23.5 cents/100 pounds

According to Appendix B, Table 1, the average net receipts of grain at primary elevators is as follows:

	Cereals	Oilseeds
Manitoba (M.P.E.)	90.0 percent	10.0 percent
Sasktachewan (S.W.P.)	96.0 percent	4.0 percent

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116 Statistics Canada, Grain Trade of Canada, 1977-78, Ottawa, Table 76, p. 78.

Statutory rates for moving an average tonne of grain to Thunder Bay or Armstrong, Ontario from:

Carberry, Manitoba	$3.57/tonne
Craik, Saskatchewan	$4.64/tonne
Moose Jaw, Saskatchewan	$4.41/tonne
Saskatoon, Saskatchewan	$4.85/tonne

1978 compensatory rates for moving an average tonne of grain to Thunder Bay from:

Carberry, Manitoba	3.33 x $3.57 = $11.89/tonne
Craik, Saskatchewan	3.33 x $4.64 = $15.45/tonne

Compensatory rates plus a 3 percent surcharge for moving dockage equals the total cost of moving an average tonne of grain from:

Carberry, Manitoba	1.03 x $11.89 = $12.25
Craik, Saskatchewan	1.03 x $15.45 = $15.91

Solid Train Model

Costs of solid train operations were estimated using a detailed cost formula developed for this purpose by Kates, Peat, Marwick & Co. Application of the formula to operational data enabled an estimation of long-term variable costs.

The formula was developed from experience gained by Kates, Peat, Marwick & Co. and by Peat, Marwick, Mitchell & Co. (U.S.), in carrying out economic studies for railroads over a period of years. Published data for a number of U.S. railroads were also used.

All cost elements having a bearing on solid train operations were included. The main cost categories are:

1. train crew wages
2. miscellaneous train expenses
3. maintenance of way, structures
4. maintenance of locomotives
5. maintenance of cars
6. locomotive diesel fuel
7. capital cost of cars
8. capital cost of locomotives
9. traffic and general expense
10. switching costs.

Train Crew Wages

These costs were calculated on the same basis as a normal freight operation, with a provision for 50 percent deadheading of crews.

Miscellaneous Train Expenses

This cost category summarizes the contribution of the following cost elements:

1. superintendance
2. dispatching
3. signal towers
4. crossing protection
5. communications systems
6. insurance
7. stationery and printing
8. train supplies
9. accident accounts (road)
10. locomotive lubricants, sand, cooling water
11. engine house expense
12. all costs related to caboose.

Capital Costs of Cars and Locomotives

These costs include both depreciation and interest costs. An average cost of return on investment (including equity and borrowed capital) of 12 percent was assumed.[117] (Terms: 20-year life and equal annual payment hopper cars, and a 15-year life and equal annual payments for locomotives.)

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[117] Interest rates were calculated from, Bank of Canada Annual Report 1978.

A salvage value of 10 percent is assumed for both hopper cars and locomotives. In 1978, the original cost of hopper cars and locomotives was \$44,190 and \$912,690, respectively.[118]

Capital Recovery Factor (C.R.F.) = 1/Future Value of a Uniform Series.

C.R.F. for Locomotives:

C.R.F.(15, 12 percent) = 1/37.28 = 0.026824

C.R.F. for Hopper Cars:

C.R.F. (20, 12 percent) = 1/72.025 = 0.013879

Total Recovery Factor (T.R.F.) = Interest Rate x Original Cost (O.C.) + C.R.F. x (O.C. - Salvage Value)

T.R.F. for Locomotives:

T.R.F. = (0.12 x \$912,960) + [0.026824 x (\$912,690 - \$91,269)]
= \$131,557 per year.

T.R.F. for Hopper Cars:

T.R.F. = (0.12 x \$44,190) + [0.013879 x (\$44,190 - \$4,419)]
= \$5,855 per year.

<u>Traffic and General</u>

This category contains head office overheads directly affected by the solid train operation. It includes for such items as legal and regulatory considerations.

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118 1978 capital cost were collected from the Canadian National Railways, Winnipeg.

Switching Costs

This cost category includes the following cost elements:

1. yard maintenance
2. maintenance of switch engines
3. switch engine fuel
4. switch engine lubricants, sand, cooling water
5. yard crews
6. yard superintendents
7. yard supplies
8. accident accounts (yard).

Method Employed in the Cost Formula

The formula attributes each element of rail cost to one or more of the following seven factors:

1. gross tonne miles
2. train miles
3. locomotive unit miles
4. car miles
5. carloads originated and terminated
6. switch engine hours
7. time (car days and locomotive days).

Some cost elements are based upon one factor only. An example is train crew wages, which are based solely upon train miles. Other cost elements are based upon more than one factor. An example is maintenance of cars, which is based upon car miles, carloads originated and terminated, and time. Three factors are required in the latter case because car maintenance arises from wear and tear incurred through line haul, load and unload activity, and from deterioration due to exposure to the elements over a period of time.

Variability of Cost Elements

The long-term incremental cost method involves the use of variability factors which determine the extent to which costs increase as utilization increases. A comprehensive set of variabilities, based upon research into the variabilities of cost accounts for a number of railroads was used. The majority of the important cost categories use 100 percent variability (i.e., solid train is assigned the full cost, with no fixed cost, or cost sharing with other traffic). These are:

1. train crew wages
2. maintenance of cars
3. maintenance of locomotives
4. locomotive diesel fuel
5. capital costs of cars
6. capital costs of locomotives.

The other main cost categories were considered to have fixed and variable components. These categories, and their variability, are shown below.

1. miscellaneous train expenses--variability ranges from 20 percent for crossing protection, communications systems, and stationery to 100 percent for train supplies and accident accounts
2. maintenance of way and structures--66 percent variability on rail and tie maintenance, 35 percent on work equipment maintenance and 14 percent on other maintenance expenses

3. traffic and general--10 percent variability on general (e.g., legal) expenses and 20 percent variability on traffic (e.g., marketing) expenses

4. switching costs--variability ranges from 50 percent for superintendents to 100 percent for maintenance and fuel of switch engines, yard crews and accidents.

Indexing of Costs

The model was originally based on 1970 costs; therefore, in order to update costs to 1978 levels, cost indexes were used. The following indexes were used to update the study.

1. diesel fuel index
2. transportation equipment industry index
3. railway workers wages
4. wage rates at financial institutions
5. business service index
6. construction material index
7. manufacturing industry selling price index
8. wholesale price index.

Table E1 indicates a complex breakdown of incremental costs in the solid train model.

Table El

Solid Train Incremental Costing Model

Variable	Cost Component	% Contribution of Component	Coefficient
Gross Tonne Miles (1,000)	Maintenance of Roadbed	37.8	
	Maintenance of Locomotives	26.1	
	Locomotive Fuel	36.1	

		100.0	$1.70
Train Miles (100)	Caboose	2.0	
	Train Supplies	15.6	
	Accident Accounts	7.1	
	Train Crew Wages	66.5	
	Other Transportation Expenses	8.8	

		100.0	$584.91
Locomotive Unit Miles (100)	Maintenance of Locomotives	60.7	
	Other Locomotive Expenses	39.3	

		100.0	$39.57
Car Miles (100)	Maintenance of Cars	50.5	
	Train Supplies	20.1	
	Traffic and General Expenses	17.3	
	Other Transportation Expenses	12.1	

		100.0	$2.50
Carloads Originating and Terminating	Maintenance of Cars	57.0	
	Traffic and General Expenses	43.0	

		100.0	$6.21
Switch Engine Hours	Maintenace of Yard	2.0	
	Maintenace of Switching Locomotives	6.7	
	Maintenance of Cars	7.5	
	Yard Service	78.5	
	Accident Accounts	2.9	
	Other Transportation Expenses	2.4	

		100.0	$75.09
Fixed Maintenance	Maintenace of Cars	100.0	$351.09

Contribution to Fixed Costs

In order to derive an estimate for the minimum rate that could be realistically charged by the railways for the solid train operation, a contribution to fixed costs at 40 percent of variable costs was added to cover these accounts not included in the model. This corresponds to the average ratio of fixed to variable costs derived by Mr. D.H. Hay and presented in Volume III of the Report of the McPherson Royal Commission on Transportation.[119]

The only instance in which Kates, Peat, Marwick & Co.'s definition of a variable cost differed from Mr. Hay's was in the case of "Return on Investment - Roadway." Mr. Hay considered that the investment in roadway would depend on the volume of traffic where Kates, Peat, Marwick & Co. assumed no variation in roadway investment as a result of the incremental traffic. The assumption as to speed, routing and tons carried are based on the use of the existing facilities with no improvement required.

It is assumed that the 40 percent representing the railways' fixed costs is the minimum that the railways would be willing to apply in calculating rates. In fact, this would provide the railways with a reasonable profit, since their fixed costs must be assumed to be covered by their revenues on existing traffic.

The following assumptions were made for the solid train service:

1. 100 hopper car trains at 82 tonnes per car, no backhaul

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119 D.H. Hay, "The Problem of Grain Costing," Royal Commission on Transportation, Volume III (Ottawa: Queen's Printers, 1962), pp. 193-367.

2. 24 hour terminal time at each end

3. 80 percent utilization of train

4. average train speed of 25 m.p.h.

Tables E2 to E7 are worksheets completed to estimate the average total cost for the six solid train movements included in the model. The resulting solid train costs are summarized in Table E8.

Table E2

Solid Train Cost Analysis

Route: Moose Jaw to Quebec City 1,897 miles
Empty return 1,897 miles
24-hour stop at each end--hopper cars

Configuration: 100 cars, 82 tonnes/car, 5 locomotives @ 3,000 h.p.
Trailing Load: 100 cars x 82 tonnes/car = 8,200 tonnes
plus cartare 100 cars x 27 tonnes/car = 2,700 tonnes
= 10,900 tonnes total.

Gross Tonne Miles: 10,900 + 2,700 x 1,897 miles/1,000 x \$1.70	= \$43,859
Train Miles: 3,794 miles/100 x \$584.91	= 22,191
Locomotive Unit Miles: 5 units x 3,794 miles/100 x \$39.57	= 7,506
Car Miles: 100 cars x 3,794 miles/100 x \$2.50	= 9,485
Car Loads O + T: 100 cars x 2 x \$6.21	= 1,242
Switch Engine Hours: 16 hours orig. + 16 hours term x \$75.09	= 2,403
Fixed Maintenance: 110 cars x \$351/year ÷ 35 trips/year[a]	= 1,103
Car Capital Cost: 110 cars x \$5,855/year ÷ 35 trips/year	= 18,401
Locomotive Capital Cost: 5 locomotives x \$131,557/year ÷ 35 trips/year	= 18,794

Total Operating Cost	\$124,984
Contribution to fixed cost at 40 percent	49,994

Total Cost/Train Load	\$174,978

ESTIMATED AVERAGE TOTAL COST	\$21.34/tonne

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[a] Trips per year are based upon 80 percent utilization, average rail speeds of 25 m.p.h., and a 24-hour stop at both the originating (loading) and terminating (unloading) end.

Table E3

Solid Train Cost Analysis

Route: Moose Jaw to Quebec City 2,513 miles
Empty return 2,513 miles
24-hour stop at each end--hopper cars

Configuration: 100 cars, 82 tonnes/car, 5 locomotives @ 3,000 h.p.
Trailing Load: 100 cars x 82 tonnes/car = 8,200 tonnes
plus cartare 100 cars x 27 tonnes/car = 2,700 tonnes
= 10,900 tonnes total.

Gross Tonne Miles: 10,900 + 2,700 x 2,513 miles/1,000 x $1.70	= $58,101
Train Miles: 5,026 miles/100 x $584.91	= 29,398
Locomotive Unit Miles: 5 units x 5,026 miles/100 x $39.57	= 9,944
Car Miles: 100 cars x 5,026 miles/100 x $2.50	= 12,565
Car Loads O + T: 100 cars x 2 x $6.21	= 1,242
Switch Engine Hours: 16 hours orig. + 16 hours term x $75.09	= 2,403
Fixed Maintenance: 110 cars x $351/year ÷ 28 trips/year[a]	= 1,379
Car Capital Cost: 110 cars x $5,855/year ÷ 28 trips/year	= 23,002
Locomotive Capital Cost: 5 locomotives x $131,557/year ÷ 28 trips/year	= 23,492
Total Operating Cost	$161,526
Contribution to fixed cost at 40 percent	64,610
Total Cost/Train Load	$226,136
ESTIMATED AVERAGE TOTAL COST	$27.58/tonne

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[a] Trips per year are based upon 80 percent utilization, average rail speeds of 25 m.p.h., and a 24-hour stop at both the originating (loading) and terminating (unloading) end.

Table E4

Solid Train Cost Analysis

Route: Moose Jaw to Quebec City	1,977 miles
Empty return	1,977 miles
24-hour stop at each end--hopper cars	

Configuration: 100 cars, 82 tonnes/car, 5 locomotives @ 3,000 h.p.
Trailing Load: 100 cars x 82 tonnes/car = 8,200 tonnes
plus cartare 100 cars x 27 tonnes/car = 2,700 tonnes
= 10,900 tonnes total.

Gross Tonne Miles: 10,900 + 2,700 x 1,977 miles/1,000 x $1.70	= $45,708
Train Miles: 3,954 miles/100 x $584.91	= 23,127
Locomotive Unit Miles: 5 units x 3,954 miles/100 x $39.57	= 7,823
Car Miles: 100 cars x 3,954 miles/100 x $2.50	= 9,885
Car Loads O + T: 100 cars x 2 x $6.21	= 1,242
Switch Engine Hours: 16 hours orig. + 16 hours term x $75.09	= 2,403
Fixed Maintenance: 110 cars x $351/year ÷ 33 trips/year[a]	= 1,170
Car Capital Cost: 110 cars x $5,855/year ÷ 33 trips/year	= 19,517
Locomotive Capital Cost: 5 locomotives x $131,557/year ÷ 33 trips/year	= 19,933
Total Operating Cost	$130,808
Contribution to fixed cost at 40 percent	52,323
Total Cost/Train Load	$183,131
ESTIMATED AVERAGE TOTAL COST	$22.33/tonne

[a] Trips per year are based upon 80 percent utilization, average rail speeds of 25 m.p.h., and a 24-hour stop at both the originating (loading) and terminating (unloading) end.

Table E5

Solid Train Cost Analysis

Route: Moose Jaw to Quebec City 2,566 miles
Empty return 2,566 miles
24-hour stop at each end--hopper cars

Configuration: 100 cars, 82 tonnes/car, 5 locomotives @ 3,000 h.p.
Trailing Load: 100 cars x 82 tonnes/car = 8,200 tonnes
plus cartare 100 cars x 27 tonnes/car = 2,700 tonnes
= 10,900 tonnes total.

Gross Tonne Miles: 10,900 + 2,700 x 2,566 miles/1,000 x $1.70	= $59,326
Train Miles: 5,132 miles/100 x $584.91	= 30,013
Locomotive Unit Miles: 5 units x 5,132 miles/100 x $39.57	= 10,154
Car Miles: 100 cars x 5,132 miles/100 x $2.50	= 12,830
Car Loads O + T: 100 cars x 2 x $6.21	= 1,242
Switch Engine Hours: 16 hours orig. + 16 hours term x $75.09	= 2,403
Fixed Maintenance: 110 cars x $351/year ÷ 27 trips/year[a]	= 1,430
Car Capital Cost: 110 cars x $5,855/year ÷ 27 trips/year	= 23,854
Locomotive Capital Cost: 5 locomotives x $131,557/year ÷ 27 trips/year	= 24,362
Total Operating Cost	$165,619
Contribution to fixed cost at 40 percent	66,248
Total Cost/Train Load	$231,867
ESTIMATED AVERAGE TOTAL COST	$28.28/tonne

[a] Trips per year are based upon 80 percent utilization, average rail speeds of 25 m.p.h., and a 24-hour stop at both the originating (loading) and terminating (unloading) end.

Table E6

Solid Train Cost Analysis

Route: Moose Jaw to Quebec City	1,078 miles
Empty return	1,078 miles
24-hour stop at each end--hopper cars	

Configuration: 100 cars, 82 tonnes/car, 5 locomotives @ 3,000 h.p.
Trailing Load: 100 cars x 82 tonnes/car = 8,200 tonnes
plus cartare 100 cars x 27 tonnes/car = 2,700 tonnes
= 10,900 tonnes total.

Gross Tonne Miles: 10,900 + 2,700 x 1,078 miles/1,000 x \$1.70	= \$24,923
Train Miles: 2,156 miles/100 x \$584.91	= 12,611
Locomotive Unit Miles: 5 units x 2,156 miles/100 x \$39.57	= 4,266
Car Miles: 100 cars x 2,156 miles/100 x \$2.50	= 5,390
Car Loads O + T: 100 cars x 2 x \$6.21	= 1,242
Switch Engine Hours: 16 hours orig. + 16 hours term x \$75.09	= 2,403
Fixed Maintenance: 110 cars x \$351/year ÷ 52 trips/year[a]	= 743
Car Capital Cost: 110 cars x \$5,855/year ÷ 52 trips/year	= 12,386
Locomotive Capital Cost: 5 locomotives x \$131,557/year ÷ 52 trips/year	= 12,650
Total Operating Cost	\$76,614
Contribution to fixed cost at 40 percent	30,645
Total Cost/Train Load	\$107,259
ESTIMATED AVERAGE TOTAL COST	\$13.08/tonne

[a]Trips per year are based upon 80 percent utilization, average rail speeds of 25 m.p.h., and a 24-hour stop at both the originating (loading) and terminating (unloading) end.

Table E7

Solid Train Cost Analysis

Route: Moose Jaw to Quebec City 1,694 miles
Empty return 1,694 miles
24-hour stop at each end--hopper cars

Configuration: 100 cars, 82 tonnes/car, 5 locomotives @ 3,000 h.p.
Trailing Load: 100 cars x 82 tonnes/car = 8,200 tonnes
plus cartare 100 cars x 27 tonnes/car = 2,700 tonnes
= 10,900 tonnes total.

Gross Tonne Miles: 10,900 + 2,700 x 1,694 miles/1,000 x $1.70	= $39,165
Train Miles: 3,388 miles/100 x $584.91	= 19,817
Locomotive Unit Miles: 5 units x 3,388 miles/100 x $39.57	= 6,703
Car Miles: 100 cars x 3,388 miles/100 x $2.50	= 8,470
Car Loads 0 + T: 100 cars x 2 x $6.21	= 1,242
Switch Engine Hours: 16 hours orig. + 16 hours term x $75.09	= 2,403
Fixed Maintenance: 110 cars x $351/year ÷ 38 trips/year[a]	= 1,016
Car Capital Cost: 110 cars x $5,855/year ÷ 38 trips/year	= 16,949
Locomotive Capital Cost: 5 locomotives x $131,557/year ÷ 38 trips/year	= 17,310
Total Operating Cost	$113,075
Contribution to fixed cost at 40 percent	45,230
Total Cost/Train Load	$158,305
ESTIMATED AVERAGE TOTAL COST	$19.31/tonne

[a] Trips per year are based upon 80 percent utilization, average rail speeds of 25 m.p.h., and a 24-hour stop at both the originating (loading) and terminating (unloading) end.

Table E8

Summary of the Average Total Costs of Moving Grain
by Solid Train

Destination	Origin: Moose Jaw	Saskatoon	Thunder Bay
	..............dollars per tonne..............		
Quebec Ports	21.34	22.33	13.08
Atlantic Ports	27.58	28.28	19.31

Appendix F

GREAT LAKES-ST. LAWRENCE SEAWAY AND OCEAN SHIPPING COSTS

Table F1

Great Lakes-St. Lawrence Seaway Shipping Costs

	Thunder Bay to			
	Bay Ports (Midland)	Lake Ports (Prescott)	Quebec Ports (Quebec City)	Atlantic Ports (Halifax)
	................dollars per tonne.................			
Lake Freight[a]	5.03	7.50	6.66	12.16
Brokerage	0.10	0.10	0.10	0.10
Cargo	0.05	0.05	0.05	0.05
Insurance	0.48	0.48	0.48	0.48
Tolls:				
Welland Canal	-	0.24	0.24	0.24
St. Lawrence	-	-	0.41	0.41
Average Total Cost	5.66	8.37	7.94	13.44

[a]Derived using a weighted average of lake freight for grain, Statistics Canada, Grain Trade of Canada 1977-78, Ottawa, p. 83.

Source: "Running a Tonne Through the System," Grain Matters, a letter from the Canadian Wheat Board, July 1979, p. 5.

Table F2

Ocean Shipping Costs

	Thunder Bay	Quebec Ports (Quebec City)	Atlantic Ports (Halifax)
	..............dollars per tonne..............		
Ocean Freight[a]	9.48	0.46	-
Tolls:			
Welland Canal	0.24	-	-
St. Lawrence	0.41	-	-
Wharfage	0.05	0.15	0.15
Superintendence	0.02	0.02	0.02
Average Total Cost	10.20	0.63	0.17

[a] Derived from Canada Grains Council, Statistical Handbook 78 (Winnipeg: Canada Grains Council, 1979), Table 92, p. 193.

Source: "Running a Tonne Through the System," Grain Matters, a letter from the Canadian Wheat Board, July 1979, p. 5.

Appendix G

TOTAL TRANSPORTATION COSTS FOR SPECIFIC GRAIN ROUTES

Table G1

Average Total Cost of Moving Grain Via Solid Train Routes to Eastern Export Positions

Cost Components	Moose Jaw to Quebec Ports	Moose Jaw to Atlantic Ports	Saskatoon to Quebec Ports	Saskatoon to Atlantic Ports
	............dollars per tonne............			
Commercial Trucking	4.94	4.94	4.94	4.94
Inland Terminal Costs	6.82	6.82	6.82	6.82
Total Collection Costs	11.86	11.86	11.86	11.86
Solid Train Movements	21.34	27.58	22.33	28.28
Transfer Elevator Costs	2.65	2.58	2.65	2.58
Ocean Shipping Costs	0.63	0.17	0.63	0.17
TOTAL	36.48	42.19	37.47	42.89

Table G2

Average Total Cost of Moving Grain Via Solid Train Routes to Eastern Domestic Positions

Cost Components	Moose Jaw to		Saskatoon to	
	Quebec Ports	Atlantic Ports	Quebec Ports	Atlantic Ports
	............dollars per tonne............			
Commercial Trucking	4.94	4.94	4.94	4.94
Inland Terminal Costs	6.82	6.82	6.82	6.82
Total Collection Costs	11.86	11.86	11.86	11.86
Solid Train Movements	21.34	27.58	22.33	28.28
Transfer Elevator Costs	3.25	2.95	3.25	2.95
TOTAL	36.45	42.39	37.44	43.09

Table G3

Average Total Cost of Moving Grain Via All-Rail Routes to Eastern Export Positions

Cost Components	Craik, Saskatchewan to Thunder Bay	Craik, Saskatchewan to Quebec Ports	Craik, Saskatchewan to Atlantic Ports	Carberry, Manitoba to Thunder Bay	Carberry, Manitoba to Quebec Ports	Carberry, Manitoba to Atlantic Ports
	...dollars per tonne...					
Trucking Costs	2.60	2.60	2.60	2.60	2.60	2.60
Primary Elevator Costs	8.70	8.70	8.70	9.50	9.50	9.50
Total Collection Costs	11.30	11.30	11.30	12.10	12.10	12.10
Rail Costs to Thunder Bay	15.91	15.91	15.91	12.25	12.25	12.25
Thunder Bay Elevator Costs	4.62	5.38	5.38	4.62	5.38	5.38
Solid Train Movements	-	13.08	19.31	-	13.08	19.31
Transfer Elevator Costs	-	2.65	2.58	-	2.65	2.58
Ocean Shipping Costs	10.20	0.63	0.17	10.20	0.63	0.17
TOTAL COST	42.03	48.95	54.65	39.17	46.09	51.79

Table G4

Average Total Cost of Moving Grain Via All-Rail Routes to Eastern Domestic Positions

Cost Components	Craik, Saskatchewan to			Carberry, Manitoba to		
	Thunder Bay	Quebec Ports	Atlantic Ports	Thunder Bay	Quebec Ports	Atlantic Ports
	................dollars per tonne................					
Trucking Costs	2.60	2.60	2.60	2.60	2.60	2.60
Primary Elevator Costs	8.70	8.70	8.70	9.50	9.50	9.50
Total Collection Costs	11.30	11.30	11.30	12.10	12.10	12.10
Rail Costs to Thunder Bay	15.91	15.91	15.91	12.25	12.25	12.25
Thunder Bay Elevator Costs	6.05	5.38	5.38	6.05	5.38	5.38
Solid Train Movements	-	13.08	19.31	-	13.08	19.31
Transfer Elevator Costs	-	3.25	2.95	-	3.25	2.95
TOTAL COST	33.26	48.95	54.85	30.40	42.81	51.99

Table G5

Average Total Cost of Moving Grain Via Rail-Water Routes to Eastern Export Positions

Cost Components	Craik, Saskatchewan to Quebec Ports	Craik, Saskatchewan to Atlantic Ports	Carberry, Manitoba to Quebec Ports	Carberry, Manitoba to Atlantic Ports
	...............dollars per tonne...............			
Trucking Costs	2.60	2.60	2.60	2.60
Primary Elevator Costs	8.70	8.70	9.50	9.50
Total Collection Costs	11.30	11.30	12.10	12.10
Rail Costs to Thunder Bay	15.91	15.91	12.25	12.25
Thunder Bay Terminal Costs	4.62	4.62	4.62	4.62
Lake Shipping Costs	7.94	13.44	7.94	13.44
Transfer Elevator Costs	2.65	2.58	2.65	2.58
Ocean Shipping Costs	0.63	0.17	0.63	0.17
TOTAL	43.05	48.02	40.19	45.16

Table G6

Average Total Cost of Moving Grain Via Rail-Water Routes to Eastern Domestic Positions

	Craik, Saskatchewan to			
Cost Components	Bay Ports	Lake Ports	Quebec Ports	Atlantic Ports
	................dollars per tonne................			
Trucking Costs	2.60	2.60	2.60	2.60
Primary Elevator Costs	8.70	8.70	8.70	8.70
Total Collection Costs	11.30	11.30	11.30	11.30
Rail Costs to Thunder Bay	15.91	15.91	15.91	15.91
Thunder Bay Terminal Costs	4.62	4.62	4.62	4.62
Lake Shipping Costs	5.66	8.37	7.94	13.44
Transfer Elevator Costs	3.25	3.15	3.25	2.95
TOTAL	40.74	43.35	43.02	48.22

Table G7

Average Total Cost of Moving Grain Via Rail-Water Routes to Eastern Domestic Positions

Cost Components	Carberry, Manitoba to			
	Bay Ports	Lake Ports	Quebec Ports	Atlantic Ports
	................dollars per tonne................			
Trucking Costs	2.60	2.60	2.60	2.60
Primary Elevator Costs	9.50	9.50	9.50	9.50
Total Collection Costs	12.10	12.10	12.10	12.10
Rail Costs to Thunder Bay	12.25	12.25	12.25	12.25
Thunder Bay Terminal Costs	4.62	4.62	4.62	4.62
Lake Shipping Costs	5.66	8.37	7.94	13.44
Transfer Elevator Costs	3.25	3.15	3.25	2.95
TOTAL	37.88	40.49	40.16	45.36

Table G8

Average Total Cost of Moving Grain Via Rail-Water-Rail Routes to Eastern Export Positions

Cost Components	Craik, Saskatchewan to Atlantic Ports	Carberry, Manitoba to Atlantic Ports
	..............dollars per tonne...............	
Trucking Cost	2.60	2.60
Primary Elevator Cost	8.70	9.50
Total Collection Costs	11.30	12.10
Rail Cost to Thunder Bay	15.91	12.25
Thunder Bay Terminal Costs	4.62	4.62
Lake Shipping to Bay Ports	5.66	5.66
Bay Port Elevator Cost	2.75	2.75
"At and East" Rail Movements	5.57	5.57
Atlantic Elevator Costs	2.58	2.58
Ocean Shipping Costs	0.17	0.17
TOTAL	51.31	45.70

Table G9

Average Total Cost of Moving Grain Via Rail-Water-Rail Routes to Eastern Domestic Positions

Cost Components	Craik, Saskatchewan to Atlantic Ports	Carberry, Manitoba to Atlantic Ports
	..............dollars per tonne...............	
Trucking Cost	2.60	2.60
Primary Elevator Cost	8.70	9.50
Total Collection Costs	11.30	12.10
Rail Cost to Thunder Bay	15.91	12.25
Thunder Bay Terminal Costs	4.62	4.62
Lake Shipping to Bay Ports	5.66	5.66
Bay Port Elevator Cost	2.75	2.75
"At and East" Rail Movements	5.57	5.57
Atlantic Elevator Costs	2.95	2.95
TOTAL	48.76	45.90

Appendix H

CAPACITY CONSTRAINTS

Table H1

Capacity Constraints

	Scenario One	Scenario Two	Scenario Three	Scenario Four
	..........'000 tonnes per year...........			
Elevator Throughput:				
Thunder Bay	15,000	25,693	25,693	25,693
Bay Ports	2,073	2,585	2,585	2,585
Lake Ports	1,314	1,422	1,422	1,422
Quebec Ports	11,021	17,748	17,748	17,748
Atlantic Ports	1,007	1,163	1,163	1,163
Railway Capacities:				
Moose Jaw Loading	-	-	1,756	2,195
Saskatoon Loading	-	-	2,216	2,770
Direct Rail	141	-	3,972	4,965
Thunder Bay Loading	1,124	4,998	4,998	6,248
Quebec Receiving	438	5,412	5,412	11,213
Atlantic Receiving	868	3,936	3,936	11,213
Total Eastern Rail	615	10,250	10,250	10,250
Lake Shipping:				
	12,319	13,318	13,318	13,318

Appendix I

RESULTS OF SCENARIO ONE

Table I1

Total Cost of Moving Grain to Eastern Elevators

Eastern Export Level (,000 tonnes)	Total Eastern Domestic Movement (,000 tonnes)	Total Grain Movement (,000 tonnes)	Total Cost (,000 dollars)	Average Total Cost ($/tonne)
10,969[a]	2,879	13,848	436,300	31.51
10,969[b]	2,879	13,848	579,700	41.86
10,969[c]	2,879	13,848	577,300	41.69

[a]Statutory Rates with Average "At and East" movements forced through the system.

[b]Same as above with compensatory rates substituted for statutory rates.

[c]Compensatory rates with "At and East" movements included in the solution only if they prove to be a low cost alternative.

Table I2

Eastern Movement of Grain by Solid Train

Eastern Export Level	Thunder Bay to		Moose Jaw to		Saskatoon to	
	Quebec Ports	Atlantic Ports	Quebec Ports	Atlantic Ports	Quebec Ports	Atlantic Ports
	....................'000 tonnes....................					
10,969[a]	-	-	141	-	-	-
10,969[b]	-	-	141	-	-	-
10,969[c]	-	-	141	-	-	-

[a]Statutory rates with average "At and East" movements forced through the system.

[b]Same as above with compensatory rates substituted for statutory rates.

[c]Compensatory rates with "At and East" movements included in the solution only if they prove to be least cost alternatives.

Table I3

Movements of Grain by Water

Eastern Export Levels	Thunder Bay to Bay Ports	Lake Ports	Quebec Ports	Atlantic Ports	Total Water Movements
	....................'000 tonnes....................				
10,969[a]	977	469	10,873	-	12,319
10,969[b]	977	469	10,873	-	12,319
10,969[c]	314	469	10,880	240	11,903

[a]Statutory rates with average "At and East" movements forced through the system.

[b]Same as above with compensatory rates substituted for statutory rates.

[c]Compensatory rates with "At and East" movements included in the solution only if they prove to be a least cost alternative.

Table I4

Movement of Grain Through Eastern Elevators

Eastern Export Levels	Thunder Bay	Bay Ports	Lake Ports	Quebec Ports	Atlantic Ports
	....................'000 tonnes....................				
10,969[a]	13,707	977	469	11,014	663
10,969[b]	13,707	977	469	11,014	663
10,969[c]	13,707	314	469	11,021	240

[a]Statutory rates with average "At and East" movements forced through the system.

[b]Same as above with compensatory rates substituted for statutory rates.

[c]Compensatory rates with "At and East" movements included in the solution only if they prove to be a least cost alternative.

Table I5

Exports of Grain by Clearance Sector

Eastern Export Levels	Thunder Bay	Quebec Ports	Atlantic Ports
	..................'000 tonnes	....	
10,969[a]	806	9,563	600
10,969[b]	806	9,563	600
10,969[c]	1,222	9,570	177

[a]Statutory rates with average "At and East" movements forced through the system.

[b]Same as above with compensatory rates substituted for statutory rates.

[c]Compensatory rates with "At and East" movements included in the solution only if they prove to be a least cost alternative.

Appendix J

RESULTS OF SCENARIO TWO

Table J1

Total Cost of Moving Grain to Eastern Elevators

Eastern Export Level (,000 tonnes)	Total Eastern Domestic Movement (,000 tonnes)	Total Grain Movement (,000 tonnes)	Total Cost (,000 dollars)	Average Total Cost ($/tonne)
10,969	4,073	15,042	627,500	41.71
11,000	4,073	15,073	628,800	41.72
11,290[a]	4,073	15,363	642,710	41.83
12,000	4,073	16,073	675,300	42.01
13,000	4,073	17,073	723,500	42.38
14,000	4,073	18,073	771,700	42.70
15,000	4,073	19,073	819,800	42.98
15,465[b]	4,073	19,538	842,300	43.11

[a]Maximum eastern exports with no solid train movements.

[b]Maximum eastern exports under optimal conditions.

Table J2

Eastern Movement of Grain by Solid Train

Eastern Export Level	Thunder Bay to		Moose Jaw to		Saskatoon to	
	Quebec Ports	Atlantic Ports	Quebec Ports	Atlantic Ports	Quebec Ports	Atlantic Ports
	......................'000 tonnes......................					
10,969	-	-	-	-	-	-
11,000	-	-	-	-	-	-
11,290 [a]	-	-	-	-	-	-
12,000	710	-	-	-	-	-
13,000	1,710	-	-	-	-	-
14,000	2,710	-	-	-	-	-
15,000	3,710	-	-	-	-	-
15,465 [b]	4,175	-	-	-	-	-

[a] Maximum eastern exports with no solid train movements.

[b] Maximum eastern exports under optimal conditions.

Table J3

Movements of Grain by Water

Eastern Export Levels	Thunder Bay to Bay Ports	Thunder Bay to Lake Ports	Thunder Bay to Quebec Ports	Thunder Bay to Atlantic Ports	Total Water Movements
	....................'000 tonnes				
10,969	444	664	12,121	89	13,318
11,000	444	664	12,121	89	13,318
11,290[a]	444	664	12,121	89	13,318
12,000	444	664	12,121	89	13,318
13,000	444	664	12,121	89	13,318
14,000	444	664	12,121	89	13,318
15,000	444	664	12,121	89	13,318
15,465[b]	444	664	12,121	89	13,318

[a] Maximum eastern exports with no solid train movements.

[b] Maximum eastern exports under optimal conditions.

Table J4

Movement of Grain Through Eastern Elevators

Eastern Export Levels	Thunder Bay	Bay Ports	Lake Ports	Quebec Ports	Atlantic Ports
	..................'000 tonnes..................				
10,969	15,042	444	664	12,121	89
11,000	15,073	444	664	12,121	89
11,290[a]	15,363	444	664	12,121	89
12,000	16,073	444	664	12,831	89
13,000	17,073	444	664	13,831	89
14,000	18,073	444	664	14,831	89
15,000	19,073	444	664	15,831	89
15,465[b]	19,538	444	664	16,296	89

[a]Maximum eastern exports with no solid train movements.

[b]Maximum eastern exports under optimal conditions.

Table J5

Exports of Grain by Clearance Sector

Eastern Export Levels	Thunder Bay	Quebec Ports	Atlantic Ports
	................'000 tonnes................		
10,969	901	10,068	-
11,000	932	10,068	-
11,290[a]	1,222	10,068	-
12,000	1,222	10,778	-
13,000	1,222	11,778	-
14,000	1,222	12,778	-
15,000	1,222	13,778	-
15,465[b]	1,222	14,243	-

[a]Maximum eastern exports with no solid train movements.

[b]Maximum eastern exports under optimal conditions.

Appendix K

RESULTS OF SCENARIO THREE

Table K1

Total Cost of Moving Grain to Eastern Elevators

Eastern Export Level (,000 tonnes)	Total Eastern Domestic Movement (,000 tonnes)	Total Grain Movement (,000 tonnes)	Total Cost (,000 dollars)	Average Total Cost ($/tonne)
10,969	4,073	15,042	603,000	40.08
11,000	4,073	15,073	604,300	40.09
12,000	4,073	16,073	646,600	40.23
13,000	4,073	17,073	688,800	40.34
14,000	4,073	18,073	731,100	40.45
15,000	4,073	19,073	773,600	40.56
16,000	4,073	20,073	820,300	40.87
17,000	4,073	21,073	869,600	41.27
17,200	4,073	21,273	880,300	41.38
17,865 [a]	4,073	21,938	916,000	41.75

[a] Maximum eastern exports under optimal conditions.

Table K2

Eastern Movement of Grain by Solid Train

Eastern Export Level	Thunder Bay to		Moose Jaw to		Saskatoon to	
	Quebec Ports	Atlantic Ports	Quebec Ports	Atlantic Ports	Quebec Ports	Atlantic Ports
	..................'000 tonnes..................					
10,969	-	-	1,756	-	2,216	-
11,000	-	-	1,756	-	2,216	-
12,000	-	-	1,756	-	2,216	-
13,000	-	-	1,756	-	2,216	-
14,000	-	-	1,756	-	2,216	-
15,000	-	-	1,756	-	2,216	-
16,000	738	-	1,756	-	2,216	-
17,000	1,738	-	1,756	-	1,918	298
17,200	1,938	-	1,756	-	1,718	498
17,865[a]	2,603	-	1,756	-	1,053	1,163

[a] Maximum eastern exports under optimal conditions.

Table K3

Movement of Grain by Water

Eastern Export Levels	Thunder Bay to Bay Ports	Thunder Bay to Lake Ports	Thunder Bay to Quebec Ports	Thunder Bay to Atlantic Ports	Total Water Movements
	....................'000 tonnes				
10,969	444	664	9,050	89	10,247
11,000	444	664	9,081	89	10,288
12,000	444	664	10,081	89	11,288
13,000	444	664	11,081	89	12,288
14,000	444	664	12,081	89	13,288
15,000	444	664	12,121	89	13,318
16,000	444	664	12,121	89	13,318
17,000	444	664	12,210	-	13,318
17,200	444	664	12,210	-	13,318
17,865[a]	444	664	12,210	-	13,318

[a]Maximum eastern exports under optimal conditions.

Table K4

Movement of Grain Through Eastern Elevators

Eastern Export Levels	Thunder Bay	Bay Ports	Lake Ports	Quebec Ports	Atlantic Ports
	...................'000 tonnes...................				
10,969	11,070	444	664	13,022	89
11,000	11,101	444	664	13,053	89
12,000	12,101	444	664	14,053	89
13,000	13,101	444	664	15,053	89
14,000	14,101	444	664	16,053	89
15,000	15,101	444	664	16,093	89
16,000	16,101	444	664	16,831	89
17,000	17,101	444	664	17,622	298
17,200	17,301	444	664	17,622	498
17,865[a]	17,966	444	664	17,622	1,163

[a]Maximum eastern exports under optimal conditions.

Table K5

Exports of Grain by Clearance Sector

Eastern Export Levels	Thunder Bay	Quebec Ports	Atlantic Ports
	................'000 tonnes................		
10,969	-	10,969	-
11,000	-	11,000	-
12,000	-	12,000	-
13,000	-	13,000	-
14,000	-	14,000	-
15,000	960	14,040	-
16,000	1,222	14,778	-
17,000	1,222	15,569	209
17,200	1,222	15,569	409
17,865[a]	1,222	15,569	1,074

[a] Maximum eastern exports under optimal conditions.

Appendix L

RESULTS OF SCENARIO FOUR

Table Ll

Total Cost of Moving Grain to Eastern Elevators

Eastern Export Level (,000 tonnes)	Total Eastern Domestic Movement (,000 tonnes)	Total Grain Movement (,000 tonnes)	Total Cost (,000 dollars)	Average Total Cost ($/tonne)
10,969	4,073	15,042	596,900	39.68
11,000	4,073	15,073	598,200	39.69
12,000	4,073	16,073	640,500	39.85
13,000	4,073	17,073	682,600	39.98
14,000	4,073	18,073	725,000	40.12
15,000	4,073	19,073	767,300	40.23
16,000	4,073	20,073	809,800	40.34
17,000	4,073	21,073	856,900	40.66
17,200	4,073	21,273	867,700	40.79
17,991[a]	4,073	22,064	909,700	41.23

[a]Maximum eastern exports under optimal conditions.

Table L2

Eastern Movement of Grain by Solid Train

Eastern Export Level	Thunder Bay to		Moose Jaw to		Saskatoon to	
	Quebec Ports	Atlantic Ports	Quebec Ports	Atlantic Ports	Quebec Ports	Atlantic Ports
	........................'000 tonnes........................					
10,969	-	-	2,195	-	2,770	-
11,000	-	-	2,195	-	2,770	-
12,000	-	-	2,195	-	2,770	-
13,000	-	-	2,195	-	2,770	-
14,000	-	-	2,195	-	2,770	-
15,000	-	-	2,195	-	2,770	-
16,000	-	-	2,195	-	2,770	-
17,000	745	-	2,195	-	2,770	-
17,200	945	-	2,195	-	2,770	-
17,991[a]	1,736	-	2,195	-	2,770	-

[a] Maximum eastern exports under optimal conditions.

Table L3

Movement of Grain by Water

Eastern Export Levels	Thunder Bay to Bay Ports	Thunder Bay to Lake Ports	Thunder Bay to Quebec Ports	Thunder Bay to Atlantic Ports	Total Water Movements
	......................'000 tonnes......................				
10,969	444	664	8,057	89	9,254
11,000	444	664	8,088	89	9,285
12,000	444	664	9,088	89	10,285
13,000	444	664	10,088	89	11,285
14,000	444	664	11,088	89	12,285
15,000	444	664	12,088	89	13,285
16,000	444	664	12,121	89	13,318
17,000	444	664	12,038	172	13,318
17,200	444	664	11,838	372	13,318
17,991[a]	444	664	11,047	1,163	13,318

[a]Maximum eastern exports under optimal conditions.

Table L4

Movement of Grain Through Eastern Elevators

Eastern Export Levels	Thunder Bay	Bay Ports	Lake Ports	Quebec Ports	Atlantic Ports
	..................'000 tonnes..................				
10,969	10,077	444	664	13,022	89
11,000	10,108	444	664	13,053	89
12,000	11,108	444	664	14,053	89
13,000	12,108	444	664	15,053	89
14,000	13,108	444	664	16,053	89
15,000	14,108	444	664	17,053	89
16,000	15,108	444	664	17,086	89
17,000	16,108	444	664	17,748	172
17,200	16,308	444	664	17,748	372
17,991[a]	17,099	444	664	17,748	1,163

[a] Maximum eastern exports under optimal conditions.

Table L5

Exports of Grain by Clearance Sector

Eastern Export Levels	Thunder Bay	Quebec Ports	Atlantic Ports
	................'000 tonnes	....	
10,969	-	10,969	-
11,000	-	11,000	-
12,000	-	12,000	-
13,000	-	13,000	-
14,000	-	14,000	-
15,000	-	15,000	-
16,000	967	15,033	-
17,000	1,222	15,695	83
17,200	1,222	15,695	283
17,991[a]	1,222	15,695	1,074

[a] Maximum eastern exports under optimal conditions.