A SIMULATION MODEL FOR RATIONALIZING THE GRAIN TRANSPORTATION AND HANDLING SYSTEM IN WESTERN CANADA ON A REGIONAL BASIS

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And, finally, to my wife Karen and our "typically good-looking, intelligent Canadian son" Bobby, as a token to their sacrifice and dedication, I, in turn, dedicate this thesis.

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ABSTRACT

A Simulation Model for Rationalizing the Grain Transportation and Handling System in Western Canada on a Regional Basis

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Major Advisor: Dr. E. W. Tyrchniewicz

Considerable concern has arisen in recent years regarding the cost and effectiveness of the grain handling and transportation system in Canada. To maintain Canada's competitive position in world grain markets and to provide an acceptable service to producers at an acceptable cost, an economic reorganization or "rationalization" of the entire system is suggested.

Representing a modification of Stollsteimer's workable model for plant numbers and locations, the grain collection, handling and distribution rationalization model (CHAD) developed was designed: (1) to analyze grain handling and transportation rationalization at the regional level, and (2) as a simulation model capable of measuring the economic impact of country elevator and delivery point closures and rail line abandonment on grain producers, country elevators and the railways.

The study contains the description of a total of 122 individual simulations. These simulations are separable into four definable sets. The first set is composed of two parts: First, the CHAD model was constrained to consider farmer

preferences in the choice of their grain delivery point as provided under quota regulations, and secondly, the model was adapted to the classic location assumption of minimum cost/ distance. In effect, the system, in consideration of an institutional constraint, forced a solution on the model and then the model was modified to force a solution on the system. Once the environment of the model is designated, i.e., revealed preference or minimum cost/distance, rationalization of the system proceeds through the simulated abandonment of individual or combinations of (1) country elevators, (2) delivery points, and/or (3) rail lines. The following information is provided at each abandonment step: (1) an estimate of grain collection costs, (2) an estimate of country elevator operating costs, (3) an estimate of rail distribution costs, (4) an estimate of aggregate system costs, (5) the number of grain producers and amount of bushels diverted due to abandonment, and (6) effect of abandonment on average one-way distance to elevator. Both rates and true costs were used in estimating the cost of the grain handling and transportation system to the grain producer and in terms of resources utilized.

Given a variety of farm truck characteristics, e.g., size, age and volume of grain delivered, a second set of simulations was performed requiring all grain producers that owned and operated a truck with one of these characteristics to switch to the custom trucking of their grain. A third set of simulations was undertaken to determine the optimal location for the construction of new elevators in the study region with the objective function being to minimize grain producer collection costs. In addition, comparisons were drawn between cost estimates generated through the regional application of the CHAD rationalization model and Prairie cost estimates derived by the federally sponsored Grains Group analysis. The final simulation involved increasing the grain throughput of the regions handling and transportation system by 35 percent.

The various simulations were combined to form a rationalization procedure composed of nine steps. These steps involved the substitution of custom trucking for farm trucks used to deliver 2,000 bushels or less, an ordering of rail line abandonments and the closure of all elevators on remaining lines which were less than 100,000 bushel capacity.

A comparison of the Prairie cost estimates of the Grains Group analysis to the regional cost estimates provided by the application of CHAD, led to the implication that the chosen region may not have been in all respects a representative sample of the Prairies. This realization resulted in the conclusion that if the Grains Group was "right" for the Prairies and if CHAD was "right" for the chosen region, considerable caution must be exercised if suggested rationalization procedures are to be applied from macro to micro (Prairies to region) or micro to macro (region to Prairies).

CHAPTER I

INTRODUCTION

THE PROBLEM

The grain transportation and handling system is a critical component in the marketing of Canadian grain. Ultimately, the effectiveness of this system significantly influences on-farm grain prices as well as the number and volume of grain sales. Partly in recognition of this dependency between farm income and the grain transportation and handling system, considerable concern has arisen in recent years regarding the efficiency and effectiveness of this system. The existing system, it is contended, is outmoded and as such is and, if kept in operation, will continue to be a constraint on the effective marketing of Canadian grain. The existing system has become a burden on railways, elevator companies, grain producers and the Canadian economy: Railway companies contend that revenues derived from grain freight rates cover less than fifty percent of the costs incurred in providing their service; elevator companies find it necessary to subsidize their country elevator operations through revenues earned from their port terminal operations: with rising grain transportation and handling costs, pressure will be placed on regulatory agencies to increase transportation and handling rates charged to farmers; the Canadian economy pays directly through the subsidization of uneconomical rail branch lines and indirectly through the misallocation and waste of resources.

The criticism that has perhaps caused the greatest publicity centered around the speculation by certain members of Parliament, government spokesmen and grain elevator management that the grain transportation and handling system in Western Canada has reached its peak capacity in terms of grain throughput and that grain sales are being lost and will continue to be lost due to the awkwardness and inflexibility of the system. These criticisms reached a climax in early 1970 when members of the opposition in Parliament called for a formal and extensive inquiry into Canada's whole system of handling and selling grain. During a day-long debate on federal government grain handling policies, the opposition received substantial support in their motion of non-confidence in the administration. While the administration was able to organize its government forces to defeat the motion, the concern about the present and future adequacy of the grain transportation and handling system was so intense that it almost caused a national election.

If the Canadian grain transportation and handling system is to retain its current degree of private enterprise status in the future, the system must be profitable yet competitive. There is considerable doubt as to whether the existing system is either. During the last several years, individuals, companies, institutions and governments have provided evidence to substantiate these doubts leading to a number of proposed solutions to the problems confronting the transportation and handling system. Regardless of the source, a common theme has appeared in all of these proposals: Some form of reorganization of the country elevator system is mandatory and inevitable. Depending on the source, this reorganization could either involve the reduction and modification of existing facilities or the construction of new facilities. Not surprisingly, elevator companies are proponents of the former reorganization method. Elevator companies have been reducing their number of facilities and country elevator managers in recent years through closure, sale and consolidation.[1] A study recently conducted by the federally supported "Grains Group," considered initially the alternative of using existing structures and then proceeded to investigate three benchmark systems which all required the construction of new elevators. Railway companies have also been and will continue to be influential in the reorganization of the grain handling industry. The railway method is commonly referred to as branch line abandonment. As a result of the abandonment of uneconomical branch lines, the grain handling system of the future would be concentrated only on those rail

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[1]Federal Grain Ltd. went to the extent of selling its entire grain handling network.

lines which are considered profitable by the railways. It can be expected that as rail lines become noncompensatory (costs exceed revenues), grain deliveries and handlings will become more concentrated.

Whether the method employed is producer, elevator company, railway company or Grains Group orientated, the fundamental objective of the reorganization is to transform the grain transportation and handling system into a sounder economic base. The procedures suggested to accomplish this transformation are popularly referred to as grain transportation rationalization.

RATIONALIZATION OF GRAIN TRANSPORTATION

For the purposes of this study, rationalization of the grain transportation and handling system is concerned with grain collection, handling and distribution as functions which are physically interlinked, the objective being to modify, if necessary, each of these links thus contributing to the efficiency of the system as a whole.

The movement of grain may be separated into a domestic flow and an export flow. The transportation components of the system involved in this movement consist of: (1) the transporting of grain from farm to country elevator, and (2) the distribution of grain from country elevators to domestic and export markets. These transportation components may separately or together involve one, all, or a combination of truck, rail and inland water modes of transport. Another vital transportation component involves the movement of grain from the combine in the field to the farm storage site. In addition, there are sub-systems within the system in wich the movement of grain from farm to market is essentially "held-in-place." One such sub-system consists of country grain elevators where grain is held in-transit prior to its movement to domestic or export positions.

Grain transportation rationalization concerns more than the efficient organization and co-ordination of the physical or technical links of the system; it also must be concerned with institutional and policy characteristics which influence the movement of grain through the system. In Western Canadian grain transportation, technical and institutional rationalization are interdependent and should be considered as such. An excellent example of technical and institutional dependency in grain transportation rationalization is the adoption of the unit train technology and its effect, if any, on grain freight rate policy.

It may be useful at this point to demonstrate the interdependence between technical and institutional rationalization and to provide a more visible result of the potential effects of grain transportation rationalization. From a grain producer's viewpoint, the results of grain transportation rationalization will be expressed most visibly in the differenital between the pre-rationalization farm price and the post-rationalization farm price. For example, the export price for a bushel of wheat is determined in the world competitive market. Consequently, wheat producers are price takers. Generally, the on-farm price is the given export market price less: (1) the costs of delivering the grain to the country elevator (collection costs), (2) the costs of handling and storing the grain at the country elevator, (3) the costs of transporting the grain to export position, and (4) terminal costs. Technical grain transportation rationalization is concerned with all of these cost factors. To the extent that grain transportation rationalization affects these costs, farm prices are affected. This assumes, of course, that if there is a cost saving this saving is passed back to producers in the form of higher farm prices.

Institutional rationalization questions this assumption in that these costs may not be influenced by technical rationalization. Currently, the costs of handling and storing grain and the transporting of grain by railway are institutionally fixed rates, that is, costs 2 and 3 above may be considered constants. These charges may in fact be the same after rationalization as before rationalization. The costs of collection, however, are not fixed and are a function of, among other things, distance from farm to country elevator. If rationalization results in fewer elevators, total collection costs will increase. In summary, if costs 2 and 3 remain constant and cost 1 increases, grain transportation rationalization will decrease on-farm prices per bushel marketed. It can be argued with equal validity, however, that if rationalization does not take place, costs 2 and 3 will not remain constant but can be expected to increase causing on-farm grain prices to decrease. In the long-run, however, with or without rationalization, elevator operating and rail costs will increase as a result of new labor contracts and cost increases for other factors of production. However, with rationalization, future cost increases, which would have occurred otherwise, may be expected to be postponed with perhaps the magnitude of those increases lessened. One cannot conclude, therefore, that the aggregate or net effect of grain transportation rationalization would necessarily be a dis-benefit to grain producers, agriculture or the Canadian economy generally without considerable in-depth analysis, a type of which is proposed in this study.

From a public policy point of view, grain transportation rationalization is a desirable objective if resultant benefits exceed resultant costs. Like most means of grain transportation rationalization, the abandonment of uneconomic branch lines has both a cost and a benefit. The primary cost, as already mentioned, is borne by the grain producer. The benefit, however, is shared by all Canadians including the grain producer, in that transportation resources will be more effectively allocated hopefully resulting in the more efficient, less costly, transport of agricultural and other products. In addition, Canadians generally will benefit through a reduction in publicly funded subsidies paid to the railways in financial support of uneconomic branch lines.

In a sense, the grain transportation and handling system in Canada has been self-rationalizing for many years. That is, it is commonly recognized that there has been significant progress in the techniques used in grain assembly, handling and distribution since the turn of the century. While in aggregate these technological advances have resulted in a more efficient movement and handling of Canadian grain, they have largely been uncoordinated, independent occurrences. Nevertheless, the grain transportation and handling system has been and is self-rationalizing. The approach to rationalization can assume an alternative form, however. The alternative form involves the coordination and direction of the self-rationalization process and inducing rationalization through designed policy measures. This type of rationalization requires that grain transportation and handling be considered as a system composed of the collection of grain by farmers, the handling of grain in country elevators and the distribution of grain by railways.

POTENTIAL CONTRIBUTIONS OF THE SYSTEMS APPROACH TO GRAIN TRANSPORTATION RATIONALIZATION

Kuhn has defined a system as:

> a set of interrelated parts or operations, designed to accomplish clearly defined objectives or purposes. Inherent is this idea of <u>wholeness</u>, that is to say, of parts combined into a whole which is different from more or less than, the individual units or parts. The parts

may be collaborating or complementary, as in a power grid or manufacturing process. Or they may be in rivalry, as in the famous competitive systems model in economics.[2]

The systems approach may be differentiated from other techniques of analysis depending on the degree to which the *ceteris paribus* assumption is used and adhered to. Systems analysis requires that the *ceteris paribus* condition be minimized. As a result, the systems approach is extremely demanding, requiring a thorough and complete understanding of the system under analysis. The use of the systems approach to transportation problems specifically and regional economics generally is not new.[3] The challenge is adapting the analysis to the chosen system.

Several authorities in the field of grain transportation, whether socially, politically or economically motivated have stressed the necessity and desirability of conceiving grain transportation rationalization in the systems context and refer to rationalization by railways via wholesale branch line abandonment as "the piece-meal approach", "non-coordinated", "partial" and "the cookie-cutter method". Relating directly to the central issue of this study,

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[2]Tillo E. Kuhn, "New Approaches to Transport Research and Planning" in *Proceedings of the Colloquium Series on Transportation, 1968-1969*, Vol. 2, Center for Transportation Studies, University of Manitoba, Winnipeg, Manitoba, August, 1969, p. 28.

[3]See Kuhn, *ibid.*, especially his bibliography.

Tyrchniewicz and Tangri have stated:

> we submit that what is needed is a hard objective evaluation of the total grain transportation system vis a vis the long run requirements that will challenge the system. Perhaps the greatest payoff in grain transportation research would be to develop a simulation model of the whole Canadian industry. Essentially this would involve the building of a computer model which would come as close as possible to duplicating the system under which grain moves from the farm right through to its export or domestic destination. A very necessary aspect of such a model would be to include the constraints placed upon the grain marketing system by regulatory agencies such as the Wheat Board and the Board of Grain Commissioners. Once such a model was developed, it would be a fairly simple matter to determine the bottlenecks in the system.[4]

Other authorities have taken similar positions regarding the systems approach.[5]

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[4]E. W. Tyrchniewicz and Om P. Tangri, Grain Transportation in Canada: Some Critical Issues and Implications for Research, Occasional Paper No. 2, Center for Transportation Studies, University of Manitoba, Winnipeg, Manitoba, August, 1968, p. 14.

[5]For in-depth discussions of the systems approach see: D. N. Chorafas, Systems and Simulation, Academic Press: New York, 1965, and D. J. Wilde and C. S. Beightler, Foundations of Optimization, Prentice-Hall: Englewood Cliffs, New Jersey, 1967. For specific comments and applications see: Tillo E. Kuhn, "New Approaches to Transport Research and Planning" in Proceedings of the Colloquium Series on Transportation, 1968-1969, Vol. 2, op. cit.; J. A. McDonald, "The Total Systems Approach to Transportation Problems" in Proceedings of the Colloquium Series on Transportation, 1967-1968, Vol. 1, Center for Transportation Studies, University of Manitoba, Winnipeg, Manitoba, June, 1968; Tillo E. Kuhn and Norman D. Lea, Engineering-Economic Systems Analysis for Transport Planning in Dahomey, West Africa, 48th Annual Meeting of the Highway Research Board, National Research Council, National Academy of Sciences, Washington, D. C., 1969; Charles W. Gibbings, President, Saskatchewan Wheat Pool, Address, Regina, Saskatchewan, November 13, 1967; Submission by the Canadian Federation of Agriculture, to the Government of Canada, Regarding Policy on Railline Abandonment, Ottawa,

Some of the more obvious potential contributions of the systems approach to grain transportation rationalization include: (1) a co-ordinated and objective treatment of the many and diverse facets of the problem, (2) the means of locating and identifying bottlenecks in the flow of grain from the farm to export and domestic markets, (3) induced or simulated changes of either a technical or policy nature which may be made in one transportation component or sub-system and their resultant effects on other stages and the general performance of the entire system measured, and (4) the means of identifying existing policy conflicts which may be used as an aid in formulating a general policy of grain transportation.

OBJECTIVES AND SCOPE OF THIS STUDY

The general objective of this study is to develop a framework in which rationalization of the grain transportation system in Western Canada can be analyzed.

The specific objectives are: (1) to review the political and economic impetus for rationalizing the grain transportation and handling system in Western Canada, (2) employing the systems approach to develop a conceptual model for rationalizing the collection, handling and

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[5]continued

August 14, 1962; <u>Submission of Saskatchewan Wheat Pool to the Royal Commission on Transportation in Canada, 1960</u>.

distribution of grain in Western Canada at a regional level, (3) to empirically apply this model and utilize its information in assessing the impact of railway branch line abandonment and elevator closures, (4) to stimulate various changes in the techniques of collecting grain to country elevators, and (5) to simulate and evaluate the benchmark systems developed by the Grains Group.

The scope of this inquiry views the grain transportation system as being composed of grain collection by truck, grain handling in country elevators and grain distribution by railways. On-farm transportation (from combine to granary), farm storage, port terminal operations, inland water and ocean movements as components of the global system while ignored in this study are recognized as vital components of the global system. The analysis is constrained in two respects: (1) it considers only that grain which moves directly from farms to country elevators,[6] and (2) it examines grain handling and transportation rationalization in the context of a specified, bounded production region.

The bounded production region under analysis in this study is the Boissevain grain growing area of Southwestern Manitoba. This region is approximately 3,000 square miles in size and contains about 2,200 farmers and 67 country elevators.

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[6]This movement accounted for approximately 90 percent of the entire grain flow in 1968-1969.

During the last several crop years, grain production in the region has averaged around 10 to 11 million bushels.

The conceptual model for this study is based on the principle of minimizing the total cost of collecting, handling and distributing grain, subject to certain specified constraints. The quantitative method employed will be broadly speaking, a modified "Stollsteimer location model."[7] To best satisfy the stated objectives, the following modifications will be made to this basic framework: (1) the model will be designed to simulate the characteristics of grain transportation in Western Canada, (2) a grain collection cost function will be included, (3) a grain distribution function will be included, (4) technical and institutional restraints will be introduced via simulation, (5) existing country elevator facilities will either be considered as (a) a restraint in the model where the objective function would be to utilize these existing facilities or (b) just another possible location for the constructing of new elevators.

ORGANIZATION OF THE REMAINDER OF THE THESIS

Chapter II describes the underlying impetus for rationalizing the grain handling and transportation system

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[7]The basic framework is described in J. F. Stollsteimer, "A Working Model for Plant Numbers and Locations," Journal of Farm Economics, Vol. 45, No. 3, August, 1963, pp. 631-645.

in Western Canada. Information is presented on historic developments and changing economic conditions. In addition, a review is made of the major recommendations of the Grains Group Report. Chapter III presents the conceptual model to be used in the analysis. Data requirements, assumptions and problems encountered concerning computation and estimation difficulties are discussed in Chapter IV. Chapter IV also contains a description of the study area. The application of the model and empirical results are presented in Chapter V. A summary of findings and implications for farmers, grain companies, railways, the Grains Group report and for rationalization procedures are discussed in Chapter VI. Chapter VI also contains discussions concerning limitations of the study and suggestions for further research. The appendices contain a review of conceptual and empirical models in location theory (Appendix A) and systems analysis (Appendix B) and detailed information regarding the effect of rail line abandonment on individual delivery points in the study area (Appendices C through G). In addition, an appendix is included which summarizes the results of the various simulations performed in this study (Appendix H).

CHAPTER II

THE IMPETUS FOR RATIONALIZING THE GRAIN HANDLING AND TRANSPORTATION SYSTEM IN WESTERN CANADA

HISTORIC DEVELOPMENTS

Early in the history of railroading in Western Canada a system of branch rail lines was developed. These main line off-shoots were, and still are, referred to as feeder lines. The purpose of the feeder line was to provide additional freight and was considered essential to the maintenance of the main line. In reality, while the railways were pushing their main lines westward and constructing branch lines they were not only establishing the rail network but also the pattern of development for the Canadian West. The thought of populating the West was really not a rational idea until the railways were established. In the presence of a railway the vast undeveloped agricultural land, minerals and lumber were opened to exploitation for the profit of the railways and the Canadian economy generally. Besides the obvious economic gains which would be made through this early transportation development the extensive rail network would significantly contribute to Canada's social and political unity. Considering the large geographic area to be serviced and the existing techniques of collecting, handling and distributing the predominantly raw resource products of the West, the extent of the rail construction was necessary and rational.

It is difficult to determine the exact philosophy under which early railway management operated. It appears, however, that it must have been rather optimistic, especially in regards to its operations in the West. There was good reason for this optimism. Railways first became established in the West during the last quarter of the 19th century. The only overland competition railways had for several decades was horse and wagon. Depending on distance, time, volume and weight requirements, there was virtually no competition to the railways on the Prairies.

After considerable national political and financial encouragement, it became evident that the railway had developed into a monopolistic giant. Users of the railway found that they were totally ineffectual in negotiating with the railway for changes. The only organization capable of effective influence was the federal government. To guard against the railway's abuse of its publicly sponsored monopolistic position on the Prairies, legislative controls were instituted. In the absence of competition, railways initiated a system of freight rates based on value of service. Under this system of rate making, differential prices are charged in proportion to the market value of the product shipped. Utilizing this technique, railways could charge low rates on low valued bulk commodities such as grain and minerals and still cover their full costs by charging high rates on high valued goods such as clothing, hardware and machinery. This method is commonly called cross-subsidization. This system was condoned and unofficially approved by the federal government as a stimulant to the development of the nation.

To insure that this beneficial rate structure on Western grain would be in existence "forever" the Canadian Pacific Railway (C.P.R.) entered into a contract with the federal government. The contract called for the Canadian Pacific to construct and operate a railway through the Crows Nest Pass on the eastern boundary of British Columbia to the developing mineral area in the Kootenay Valley of southern British Columbia and to guarantee that the movement of grain grown in the Western Prairie provinces would be protected as to costs of transport on its way from farm to export position. To fulfill its part of the contract, the federal government paid the C.P.R. a cash subsidy of $11,000 a mile up to a maximum of $3,630,000 and a grant of 3,755,733 acres of British Columbia land. This contract was entered into the statutes of Canada as law and is known as the Crows Nest Pass Agreement of 1897.

There were several good economic reasons for the C.P.R. to enter into the contract, the most obvious of which include: (1) the cash and land grants, (2) the economic potential of the Kootenay Valley, (3) the C.P.R. was satisfied with charging rates on grain which were lower than those postulated in the agreement, and (4) the C.P.R. had no reason to believe that their monopolistic position would ever be in real jeopardy and the benefits of cross-subsidization lost. In general, the railways did not anticipate the rapid and extensive change which was to take place in the transportation environment in Canada. Within thirty years, the transportation environment in Canada would change from one of almost pure monopoly to one of extreme competition in the movement of certain commodities. The rail plant, service and rate policies of the railways developed for an economy largely dependent on the production of primary products would have to be rationalized to conform to the demands of a modern, industrialized economy.

The Canadian Pacific Railway played a very significant role in the historic development of the country elevator system in Western Canada. During 1882 to 1890 the number of elevators and flat warehouses in Western Canada increased from six to almost 200. Grain production during this same period climbed from one million bushels to 16 million bushels. To a large extent, this expansion may be attributed to two significant occurrences: The first is the opening up of transportation in 1883 by the Canadian Pacific Railway from Winnipeg to the head of the Great Lakes. Once this land barrier was overcome, Western grain producers were able to export their grain to Great Britain and other countries via the St. Lawrence River. The second factor which enabled new elevator construction to keep pace with increased grain production was the announcement and implementation of a C.P.R. policy:

> In order to assist the purchasing and export of the farmers' grain, the Canadian Pacific Railway offered to grant a monopoly of the shipping of grain in the district to any persons who would build a standard elevator according to C.P.R. standards on C.P.R. land, by giving the elevator the sole right to handle and ship grain at that point at reasonable charges to the farmers. This gave the elevator owner some assurance that he might have at least sufficient volume of grain to handle to warrant the expenditure of his capital. There seems to be no question that, had this monopoly not been granted at that time to elevators in each district, that nothing like a sufficient number would have been built, in which event farmers would have suffered severely.[8]

Despite the discontinuance of this monopoly offer, the country elevator industry continued to expand until the mid 1950's when almost 5,500 elevators were scattered throughout the three Canadian Prairie provinces of Alberta, Saskatchewan and Manitoba. The present total is approximately 4,500. Interestingly enough, rail line abandonment could reduce this number by over 50 percent. Clearly the role of the railway in the past as well as the future development of the grain transportation and handling system in Western Canada cannot be minimized.

CHANGING ECONOMIC CONDITIONS

While grain transportation rationalization, as an end,

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[8] H. G. L. Strange, A Short History of Prairie Agriculture, Published by Searle Grain Company Limited, Winnipeg, Manitoba, 1954, p. 45.

is deemed desirable by most individuals and groups directly and indirectly involved in the collection, handling and distribution of western grains, the means of rationalization is a highly contentious subject. Several means of rationalization have in the past and are currently being employed by producers, elevator companies and railroad management. Grain producers attempt to economize their delivery operations by adopting more efficient forms of hauling grain which may mean the purchase of bigger trucks, co-operating with neighboring farmers in sharing delivery responsibilities or hiring a custom trucker. There has been evidence that elevator companies are allowing some facilities to become fully depreciated without any plans for the replacement of these facilities. There is also an indication that elevator companies are co-operating in their rationalization plans where companies concede delivery points to each other, creating location monopolies. The rationalization method used by railways is branch line abandonment.

The impetus behind all these efforts toward rationalization is primarily cost orientated: Producers are concerned with minimizing their total costs of grain delivery; elevator companies rationalize those elevators out of their system where revenues are non-compensatory; similarly, railways make application to abandon branch lines that are non-compensatory. Perhaps the reason that certain country elevators and branch lines are non-compensatory to their owners is more a result of legislation than economic inefficiencies. If elevator companies had complete control over their charges for handling and storing grain and railway management had similar control over grain freight rates, technological change would likely continue but the impetus underlying the desire and necessity for system grain transportation rationalization would largely disappear or at least be substantially lessened. Elevator and railway companies currently are legislatively restrained in the setting of grain handling, storage and transportation rates. Specifically, the Canada Grain Act empowers the Canadian Grain Commission (formerly Board of Grain Commissioners) to determine maximum handling and storage charges and grain freight rates are firmly entrenched in the statutory Crows Nest Pass Agreement.

One of the terms of reference for the Royal Commission on Transportation of 1951 was to consider the claim of the Canadian Pacific Railway that the Crows Nest Pass rates on export grain were unremunerative. However, the Royal Commission failed to reconcile this problem to the satisfaction of the C.P.R. What amounted to a demand by the C.P.R. for higher freight rates on grain was refused by the Commission. The Commission concluded that the Crows Nest Pass rates, being statutory, were only within the jurisdiction of Parliament. However, the Commission did pass along the following advice:

> the day of ill conceived and therefore excessive construction seems to have gone by, and our people can feel reasonably assured that from now on no railway

> ventures will be undertaken excepting after thorough investigation of each project, and always with due regard to the financial commitments involved.[9]

This advice was hardly relevant to the current question: Are railways entitled to a reasonable return on their investment devoted to the transportation of grain? If the answer is no, as implied by the conclusions of the Royal Commission of 1951, would railways be permitted to minimize the costs of its grain operations, that is, rationalize via branch line abandonment? If this freedom is also denied, the railway's objective of full compensation for services rendered comes into direct conflict with public welfare goals. Currie comments on such political dilemmas as follows:

> . . . The main body of the report of the Royal Commission of 1951 displays the confusion of objective which has characterized the history of transportation in Canada almost from the beginning. The Commission does not seem to have considered all the implications involved in the question: are transportation services to be regarded as business institutions like department stores, factories, or farms, or are they to be looked upon as almost eleemosynary agencies wherein the cost-revenue relationship is subordinate to the welfare of the public?[10]

The significant legislative result of the Royal Commission of 1951 was the adoption of a national freight-rates policy for Canada. This policy embodied the concept of freight rate equalization across Canada on any kind or class

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[9] Report of the Royal Commission on Transportation, 1951, the Queens Printer, Ottawa, p. 131.

[10] A. W. Currie, Canadian Transportation Economics, University of Toronto Press; Toronto, 1967, p. 15.

or freight. The geographic exception to this equalization policy was the Atlantic provinces. In addition, rates on export, import, competitive traffic and export rates on grain from Western Canada were given legislative immunity.

The equalization theory was successful for only a short time. During the 1950's, railway companies increasingly felt the combined pressure of tougher competition, business recessions and rising labor and supply costs. The result was a demand for higher freight rates. During the years 1948-1958, fourteen general increases were approved by the Board of Transport Commissioners permitting rates to be raised by 155 percent.[11] Early in 1959, the railways asked for another 12 percent increase. The equalization theory proved not to be a long-run solution to the problems of the railways. A change in government would see yet another Royal Commission on Transportation.

The decade of the sixties saw the development of federal transportation policy for Canadian railways.[12] The initial movement toward the formation of a national transportation policy for Canada was the establishment of the

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[11] Ibid., pp. 16-17.

[12] For an excellent historical review of this decade, see R. H. D. Phillips, "The Wheat Pools and Development of Federal Transportation Policy for Canadian Railways 1960-70," Canadian Journal of Agricultural Economics, Vol. 19, No. 1, July, 1971, pp. 118-129.

MacPherson Royal Commission on Transportation in May, 1959. The general philosophy of the Commission was based on the premise that competition within the transportation industry was necessary and desirable. The objective of the Commission was to therefore create a new legal environment in which the railways could effectively compete with other modes of transportation.

The recognition of the competitive evolution that had taken place in the transportation industry formed the premise of the MacPherson Commission:

> . . . We became convinced very early in our work that a process which had been underway for some years before had, since the end of World War II, wrought a fundamental change in the character of the transportation environment in Canada, and, moreover, that it was this transformation which underlay the varied problems with which we had been called upon to deal. Previous to this change taking place the environment was one in which the railways possessed a monopoly or near-monopoly position in the transportation market. The present environment, on the other hand, is no longer monopolistic and the railways are engaged in a vigorous competitive struggle for the available traffic with a number of alternative forms of transport.[13]

The transportation environment in Canada evolved from both the supply and demand side. As the Canadian economy changed its emphasis from resource exploitation to finished product manufacturing, the demands for transportation changed. Comments by the MacPherson Commission concerning this point are quoted at length here:

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[13] Royal Commission of Transportation in Canada, 1961, *op. cit.*, p. 1.

These new conditions arose, in particular, in connection with the rapid growth of secondary manufacturing industry which created a greatly increased demand for specialized transportation services such as pick-up and delivery and for fast and flexible shipping schedules geared to meet the requirements of both shipper and consignee. Secondary industries, moreover, were prone to pay considerable attention to problems associated with internal costs and inventory control which led to an emphasis upon the concept of total costs of distribution rather than simply line-haul rates and, as a consequence, reinforced the demand for more specialized and flexible transport services. In addition, the tendency of secondary industries to locate at or near major markets meant that short-haul rather than long-haul movements became characteristics of their transportation requirements. In brief, the new kind of demand for transportation which began to develop in the second quarter of the twentieth century proved to be of a type to which the railways were not entirely suited--and which, particularly in the area of services, they were not always able or willing to meet.

The limited ability of the railways to meet this new demand situation was a factor which coincided with, and gave added stimulus to, developments that were taking place on the supply side of transportation. During the nineteen-twenties and -thirties, steady technological advances had been made in the design and operating efficiency of the motor vehicle....heavy trucking became a practical proposition....Along with these technological advances in trucking came a substantial improvement in the road and highway system, particularly in the more populated areas of the country.

Progress in the field of aviation, improvements in motor bus operations, the development of highly efficient pipeline facilities for the bulk movement of gas and oil, all helped to cut into the traffic which traditionally had been the domain of the railways and to hamper their efforts to obtain new traffic.[14]

In conjunction with the deteriorating competitive position of the railways and the resulting effect on revenues, general operating and internal costs were rising.

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[14] *Ibid.*, pp. 3-4.

In addition to these difficulties, the railways are faced with statutory fixed freight rates on a significant portion of the traffic they were able to retain and intense public resistance to rail plant rationalization. Presented in this light, the complexity and seriousness of the economic problem is brought into perspective.

There has been considerable debate and conjecture that allowing the railways to solve their economic problems would simply create problems for Western grain producers. For example, permitting the railways to establish grain freight rates according to their calculations of what the full cost would be to transport the grain, would seriously damage the competitive position of Canadian grains in the world market if there was any attempt to pass along the added cost in the form of higher grain prices. In many cases, associated with the abandonment of a branch line is the discontinuance of an elevator, requiring farmers to deliver their grain a longer distance and incur higher collection costs. Several groups representing farmers presented submissions to the MacPherson Commission. All of them considered the Crows Nest Pass rates non-negotiable. Similarly, most of the groups, considered the issue of branch line abandonment negotiable and, in some instances, desirable. The general attitude was cautious but the concession was made that abandonment of uneconomic and virtually unused branch lines should be considered provided proper safeguards were established, proper notice given and the proper people were brought into the discussion.

The reasoning behind this attitude on the part of Western farmers was quite logical: They realized that there must be significant losses associated with the maintenance of the massive network of branch lines in the Prairies and that these costs must be reflected in the general rate level. Farmers, realizing that the net income they receive for their grain sales is less freight charges and the price they pay for machinery, canned and packaged food stuffs, clothing, household furnishings, and the like includes shipping charges, will want to minimize the total cost the sum of inbound and outbound charges of the transportation services he uses. Further, Prairie producer representatives argued that abolition of the Crows Nest Pass Rates would be extremely detrimental to Canadian agriculture directly, and indirectly the Canadian economy and the railways themselves, in that the Crows Nest Pass rates were an insurance that Canadian grain would be able to compete in export markets to the benefit of not only the farmer but Canadians and the railways.

Currie summarized the major findings of the MacPherson Royal Commission as follows:

> The Commission found four major areas--uneconomic passenger services, unprofitable branch lines, statutory and related rates on grain, and statutory free transportation--where obligations associated with public regulation and attitudes inhibited the railways' competitive ability and inflicted a burden on the users of railway services. Consequently, subsidies were

> called for in these areas until such time as the obligations were removed.[15]

It is important to note that the intent of the adjustment subsidy, while being paid directly to the railways, was to minimize community and industrial dislocations arising out of branch line abandonment. That is, it was the obligation of affected communities and industries to rationalize themselves during this adjustment period when the subsidy was being paid to the railways. On the premise that there is "no doubt about the ultimate necessity of consolidating rail plant to conform to those functions which can still be performed profitably by rail,"[16] the Commission recognized that

> . . . the institutional and social considerations associated with the railways' historic role as instruments of national policy and because of the close economic ties of certain industries to the rails, an abruptly implemented programme of rail line abandonment will cause dislocations which would not be in the interests of the community as a whole.[17]

The Commission also recognized that due to the necessity to rationalize the rail plant,

> the Government of Canada may, because of its interest in the well-being and welfare of the nation, choose to accept some suggestions which can be made for the assistance of industries which will find it necessary to do considerable relocation in the light of the necessity to abandon many railway branch lines.[18]

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[15] Currie, op. cit., p. 19.

[16] Royal Commission on Transportation, Volume 1, March 1961, Queen's Printer, Ottawa, p. 19.

[17] Ibid.

[18] Ibid.

It is interesting to note that no explicit consideration is given to communities adversely affected by branch line abandonment. It is also interesting to recognize that when the federal government grants a subsidy of this nature the people of Canada assume and publicly acknowledge their responsibility.

In their joint submission before the MacPherson Commission, the Canadian Pacific Railway and the Canadian National Railway attacked the Crows Nest Pass rates. Following is the last paragraph in this joint submission:

> In the submission of the railways it is clear that inadequate revenue from the movement of the Western Canadian grain crop to export position is contrary to the public interest and the solution of the problem created by the fixed rates on this traffic is basic to a solution of the problems relating to railway transportation in Canada.[19]

The battle lines were drawn and the alternatives obvious. There was common agreement that the railways had to rationalize. The Commission visualized the rail system of the future as a

> . . . system in which the uneconomic portions would be small, kept in existence either because of the national necessity to provide a certain level of service in certain areas regardless of commercial considerations, or kept in existence at the discretion of railway management for reasons of their own.[20]

The begging question was how to turn this vision into

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[19]See Phillips, op. cit., p. 119.

[20]Royal Commission on Transportation, March 1961, ibid.

reality. The railways argued that this ideal would only be obtainable if the Crows Nest Pass rates were eliminated. The implication was that if they could not be eliminated, a subsidy would have to be paid and consequently the Commission would have to compromise its overall objective of creating a competitive environment in the transportation industry of Canada. Like its 1951 predecessor, the MacPherson Royal Commission left unresolved the Crows Nest Pass rates issue:

> . . . We will recommend that losses associated with the obligation to carry grain and grain products to export positions at a rate set by statute, which must of necessity now be recovered from other shippers, should in future be borne by the Parliament of Canada, who in its wisdom sets the statutory rate. In this way Parliament remains the sole judge of whether or not the grain industry can bear rates higher than it presently bears for its movements to export positions.[21]

While the railways had to concede at least temporary defeat on the statutory grain rates issue, they took the recommendations of the Commission concerning branch line abandonment as a blank check and by 1965 had made application to abandon a total of 3,725 miles of track in the three Prairie provinces representing approximately 20 percent of all the trackage owned by the Canadian Pacific and Canadian National Railways in the Prairies.[22] Provincial governments, elevator companies and farm organizations were extremely concerned. In 1962 the Saskatchewan government reacted to

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[21] *Ibid.*, p. 22.

[22] Phillips, *op. cit.*, p. 122.

the actions of the railways by encouraging the formation of "branch line retention committees" and organized the Regina Conference on Rationalization with its announced purpose of formulating "a common policy in regard to the proposed plans of the railways for massive abandonment of branch lines in Western Canada."[23] Of particular interest to this study are the following recommendations to come out of the Regina Conference:

> 1) to call for an immediate stop in the present piecemeal consideration of rail abandonment.
> 2) to urge from the federal government a clear statement of its acceptance of responsibility and of its intended policy.
> 3) to call for initiation by the federal government of a planned rationalization program, the implementation of which includes immediate study to take into account the general interests of the Canadian economy and the special interests of the transportation media, the Prairie sector, and the agricultural industry.
> 4) to recognize publicly the need for a rationalization program and admission by each participating organization of responsibility to work toward solution of the problems.[24]

It was obvious that factions within the grain handling industry were organizing in opposition to each other. To avoid possible damage to the industry, the federal government called a meeting for Ottawa in early 1963. The Ottawa meeting, which came to be known as the "Ottawa Moratorium" was chaired by the Honorable Leon Balcer, the Minister of Transport, and attended by Cabinet associates, the Minister

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[23] Ibid.

[24] Ibid.

of Agriculture, the presidents of the C.N.R. and C.P.R. and representatives of the Prairie Wheat Pools, the United Grain Growers and the Northwest Line Elevators Association. Phillips termed the meeting "extremely important because it allowed the government, the railway companies, and the grain industry to reach an agreement that remained unchallenged through the critical year while new legislation was being drafted."[25] The Ottawa meeting made the following announcement:

> 1) that the railways would request the Board of Transport Commissions not to proceed with either new or current applications for abandonment until new legislation was enacted or Parliament was dissolved. This came to be known as the Moratorium or voluntary freeze on abandonments, and it has been in continuous force since.
>
> 2) that the government proposed to introduce legislation at the current (1963) session of Parliament providing for "a planned approach to railline abandonment."
>
> 3) that there is reason to expect that the proposed legislation will provide authority for the Board of Transport Commissioners in its regulatory function to take a longer-term view of the picture of individual branch lines, with power to defer abandonments on a planned basis.[26]

During the temporary truce provided by the Ottawa moratorium, new legislation was formulated. After considerable debate, Bill C-231 given the title the National Transportation Act, was proclaimed in October 1967. In January of 1968 the new Canadian Transport Commission (CTC)

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[25] Phillips, op. cit., p. 124.

[26] Ibid.

undertook one of its most challenging responsibilities: to determine railway costing criteria and regulations which would be employed in branch line abandonment applications. Contained in the CTC proposal was a requirement that the Canadian Pacific Railway and the Canadian National Railway prepare and publish a costing manual describing their costing methods and procedures.

On the basis that the Canadian Transport Commission acted outside of its jurisdiction, the Canadian Pacific Railway appealed to the Supreme Court seeking to upset the CTC costing order. The provinces, the Federal government, and the Wheat Pools were all in opposition to the CPR appeal. In late October, 1970, the Supreme Court rejected the C.P.R. Appeal.

In addition to its power to define and determine justifiable costs for the purposes of branch line abandonment, the Canadian Transport Commission also has the power to defer the rationalization of railway plant by having the federal government pay subsidies in the amount of loss incurred by the railway. As a further impediment to railway efforts of rationalization the National Transportation Act

> states that the Governor-in-Council (The Cabinet) may designate branch lines that shall not be abandoned, or designate areas where no abandonments may be authorized, within such periods as the Governor-in-Council may prescribe. During these periods the railways concerned will be entitled to receive a subsidy from the Dominion to cover their operating losses on the lines in question.[27]

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[27]Currie, _op_. _cit_., p. 24.

Currie, in summarizing the effects of the National Transportation Act, states that "the legislation contains provisions for the protection, at public expense, of communities, shippers, and consignees which might be adversely affected by the sudden withdrawal of rail services."[28] There is, however, a time limit to this protection. The subsidies, granted to the railways under the 1967 legislation, were designed to decline annually in accordance with railway rationalization. In anticipation, Phillips states that

> As these subsidies decline (and they are now), the railways may be expected to press more vigorously for other changes. They have already removed some passenger services and increased a large number of freight rates. The next move will certainly be to seek to remove some Prairie branch lines.[29]

The political problem of branch line abandonment is only temporarily dormant. All rail line protection and associated rail subsidies will terminate in 1975. The controversial Crows Nest Pass rates is a classical example of a political problem in transportation policy. At one time the Federal government simply recommended to the House of Commons that the Canadian Transport Commission be allowed to undertake a study of the costs of handling export grain and to suggest what type of subsidies, if any, the railways should

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[28] *Ibid.*

[29] Phillips, *op. cit.*, p. 128.

receive for providing this service. This apparently innocent suggestion was defeated in the House of Commons by a single vote.

THE GRAINS GROUP REPORT AND ITS MAJOR RECOMMENDATIONS

Largely due to extreme pressure from the opposition parties, the federal government (in particular the Honourable Otto E. Lang) in 1969 initiated a series of intensive studies into the grain handling and transportation system of Canada. To perform these studies the federal government established the Grains Group who in turn employed a number of individuals and consulting firms. The Grains Group was composed of a team of experts whose objectives were to coordinate, administer and advise these individuals and consulting firms. Basically, the terms of reference for the group included the economic evaluation of the existing grain handling and transportation system, a rationalized system and the examination of several alternative or "benchmark" systems. More precisely:

> For the existing system, studies were made of country elevators, terminal elevators, grain cleaning, rail operations, farm storage, and farm trucking. The alternatives that have been examined include various degrees and types of change to the country elevator system, the use of unit trains, commercial trucking possibilities, and the feasibility of inland cleaning.[30]

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[30] _Grain Handling and Transportation, Studies in Progress_, Issued under the authority of the Honourable Otto E. Lang, The Queens Printer, Ottawa, August, 1972.

After preliminary discussions with members of the grain transportation and handling system, the results of the Grains Group investigation was made public in August 1972. Its conclusions and recommendations encompass eleven volumes. One volume entitled Grain Handling and Transportation Costs in Canada is particularly important to this study. A summary of its conclusions and major recommendations is included in this section of the study.

The Grains Group identified two types of approaches which could have been followed in developing a cost analysis of grain handling and transportation in Canada. The first was described as "some sort of cost minimizing mathematical procedure" and the second as an "overview or 'top down' approach." The first approach was considered impractical and was rejected on the grounds that

> the number of possible combinations of facilities is so great that the amount of data required by the first approach and the complexity of the cost minimization procedure would preclude obtaining useful results within a realistic time scale.[31]

The overview or top down approach was therefore adopted and used to examine the costs associated with several "specific schemes" or benchmark systems. Once an adequate number of benchmarks were developed and costed "all possible system configurations could be studied from the data developed in

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[31]Grain Handling and Transportation Costs in Canada, Prepared for Grains Group, Office of the Minister, The Honourable Otto E. Lang, The Queens Printer, Ottawa, August, 1971, p. 13.

respect of the specific schemes."[32] It appears that the hypothesis of the Grains Group in selecting this approach is that reasonable cost estimates could be made of intermediate systems by extrapolating between its benchmark systems. The accuracy of these intermediate system cost estimates are, of course, critically dependent upon the accuracy of the cost estimates derived for the benchmark systems and the techniques and assumptions employed in the extrapolation.

The alternative or benchmark grain transportation and handling systems developed, costed, and compared by the Grains Group are:

1) The present system of country elevator and terminal operations;

2) a rationalized country elevator system coupled with light traffic density rail line abandonments;

3) a high throughput country elevator system (consisting of 389 elevators);

4) a high throughput country elevator system coupled with inland terminals (356 elevators and 22 terminals);

5) an inland terminal system to gather all grain in the country (22 terminals only). The full evaluation of this benchmark was aborted in favor of the evaluation of an inland

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[32] Ibid.

terminal system containing 80 to 100 inland terminals.[33]

It is very important to recognize that the cost estimates used by the Grains Group do not represent handling and rail rates charged to farmers. That is, any implied cost savings directly relate to elevator and railway operations. To avoid any ambiguity, the Grains Group summary of findings are presented here in their entirety.

> The susceptibility of the existing grain handling and transportation system to inflationary cost increases indicates that an increased rate of industry rationalization is imperative if costs to the producer are not to rise significantly. In view of the rate of cost increase there is a need for change which should not be delayed.
>
> Given the existing structure and environment of the industry, immediate rationalization could be achieved by the abandonment of light traffic density rail lines and their associated grain handling facilities. It is estimated that such a rationalization . . . could reduce handling costs by 2.3¢ per bushel, at 1969 cost levels, while causing an average increase in farm trucking costs of only 0.7¢ per bushel (including a wage allowance for the increased time of the driver). In addition, the railways estimate a cost saving equivalent to 5.7¢ per bushel arising from the abandonment of the light traffic density lines.
>
> The rationalized system of say 3,600 of the existing structures would have the lowest current cost of the alternatives selected _if rail costs are ignored_ and statutory rates of approximately 12.5¢ per bushel are considered. This is mainly due to the low level of investment in the ageing country elevator system.
>
> Even if railways costs are ignored, the costs of the present type of country elevator can only remain competitive _in future_ if a continued 4% annual rationalization is feasible without significant reinvestment.

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[33] _Ibid_., p. 2.

(This would have to follow an immediate initial 25% reduction.) This would necessarily result in the existence of only 2,298 of these elevators by 1980 and 1,528 by 1990. Such a reduction, if possible would result in 150 million bushels of storage capacity by 1990.

If the cost estimates and unit train rates provided by the railways are accurate, the operation of an inland terminal system of 80 terminals would appear most economical <u>in total</u> since the initial high investment cost would be offset by both handling savings and the forecasted transportation savings potential through the use of unit trains.

It seems unreasonable to expect the existing structures to continue in service over the next twenty years at an ever-increasing intensity of utilization without requiring substantial reinvestment. Given this situation, a time-phased plan of action for replacement of facilities in each catchment area is desirable, for example, the gradual introduction of a system of 80 to 100 inland terminals. Replacement, even with a system of only a few hundred high throughput elevators, would tend to increase handling costs as well as rail transport costs.

The trade-off of increased haulage distance against reduced numbers of facilities appears to be in favour of reduced facilities for the following reasons:

a) In spite of imputing reasonably high mileage costs of trucking, the increased haulage costs tend to be lower than the costs of replacing and staffing large numbers of elevators.

b) Even the reduction to eighty points on the Prairies does not drastically increase mileage in terms of modern concepts, providing these points are well dispersed, geographically.

While the preliminary cost analysis . . . suggests the apparent cost advantages of 80 to 100 inland terminals, there is a need to add to this:

a) a more detailed engineering design and operation feasibility study for inland terminals;

b) engineering studies on a co-ordinated industry basis to assess accurately the useful lives of present elevators in each grain gathering area,

c) coupled with a detailed time phased replacement plan in each catchment area;

d) the cost of related organization change and to the extent possible, a cost/benefit analysis of social change.[34]

The cost analysis performed by the Grains Group therefore indicated that a grain handling and transportation system comprised of 80 to 100 inland terminals would be the least costly of those alternative benchmark systems analysed. Each Inland terminal would contain 2.5 million bushels of storage capacity and would handle an annual volume of 8 million bushels. The handling cost per bushel of grain was estimated at 11.5 cents. The cost of constructing such an elevator would be about $6.8 million. The inland terminal would be serviced by unit train at an estimated cost of 17.7 cents per bushel.[35] The average length of haul for farmers would increase from approximately 7 miles to 28 miles. Collection costs would more than double from 3.3 cents per bushel under the existing system to 7.1 cents per bushel for the 80 inland terminal system.[36]

As of this date, the Grains Group report has generated considerable discussion and debate. The procedures employed and recommendations contained in the report are currently

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[34] Ibid., pp. 5-6.

[35] Ibid., Appendix IV.

[36] Ibid., Appendix VI.

being analyzed by the Canada Grains Council.

CHAPTER III

A CONCEPTUAL MODEL FOR RATIONALIZING THE GRAIN TRANSPORTATION AND HANDLING SYSTEM IN WESTERN CANADA

The purpose of this chapter is to present a possible framework or model for Canadian grain transportation and handling rationalization. Using location theory and systems analysis, the objective of the model is to simulate the rationalization of the collection, handling and distribution of grain in Western Canada.[37] By simulating changes in the organization of the grain collection, handling and distribution system, possible alternative organizations can be viewed and costed.

The basic framework is provided by the "Stollsteimer location model."[38] The "Stollsteimer model" is emphasized here primarily for two reasons: 1) It was instrumental during the conceptual stage of the development of the grain handling and transportation rationalization model to be presented later, and 2) its description provides the basic logic of the mechanics of location analysis and, as such, will

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[37] Conceptual and Empirical Models in Location Theory and Systems Analysis are presented in Appendices A and B respectively.

[38] J. F. Stollsteimer, "A Working Model for Plant Numbers and Locations," op. cit.

hopefully aid in the understanding of the transition involved in moving from the Stollsteimer model to the model developed in this study. With this understanding modifications are made on the Stollsteimer model so that it more nearly reflects the Canadian grain transportation and handling system.

LOCATION THEORY AND RATIONALIZATION

Location theory, as most theories associated with economics, is based upon a set of consistent, rational and logical principles. These principles form the framework for the analysis of spatial phenomena. One of the principles of classical location theory is that producers, not consumers, determine location of production.

> . . . There are reasons to believe that, with some notable exceptions, it is the producers' or the entrepreneur's interest which determines the location not only of production but also of consumption. This is so in spite of the fact that from the point of view of choosing location there is a definite conflict between the interests of consumers and producers.[39]

The implications of this axiom of location theory is not as yet fully understood. The choice of a particular location of a factory is rational to the entrepreneur in terms of minimizing his raw material collection costs and the processing and distribution costs for his product. That is,

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[39] L. Lefeber, Location and Regional Planning, Training Seminar Series 7, Center of Planning and Economic Research, Athens, Greece, 1966, p. 14.

one location is preferred over another on the grounds of solely internal monetary considerations. An interesting situation arises, however, when the location of the factory is considered irrational by society. For example, it may be cost-rational for the entrepreneur to locate on a public waterway to facilitate shipping and to discharge waste yet totally irrational in the eyes of society. If the rational principle of location theory is changed from profit maximization for the entrepreneur to welfare maximization for society, the theory itself is affected to the extent that the entrepreneurs location decisions are restricted and confined to a set given to him by society. This is merely a demonstration as to how and why traditionally accepted principles may be modified to coincide with changing objectives. That is, there are considerable precedences in economics where modifications are made so as to adapt a theory for a particular application. Such an attempt is made in the remainder of this chapter.

The Stollsteimer model

The Stollsteimer model provides the framework whereby the minimization of raw material collection and raw material processing costs determine the optimal number, size and location of processing plants.[40]

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[40] Stollsteimer, *op. cit.*

The Stollsteimer model has, more or less, become a classic in location theory. It attempts to answer such pertinent location questions as: (1) How many plants should we have? (2) Where should our plants be located? (3) How large should each plant be? (4) Where should the raw materials processed in each plant be obtained? (5) What customers should be serviced by each plant? The formalized Stollsteimer model provided answers to all of these questions with the exception of the last one. The data requirements of the model are: (1) Estimated or actual amount of raw material to be assembled for each point or origin (raw material site). (2) A transportation-cost matrix which specifies the cost of transporting a unit of material between each point of origin and each potential plant site. (3) A plant-cost function (or functions) which permits the determination of the cost of processing any fixed total quantity of material in a varying number of plants. (4) Specification of potential plant locations.

The economic objective of the Stollsteimer model is to minimize material collection costs and plant processing costs. Stollsteimer "considers the problem of simultaneously determining the number, size and location of plants that minimize the combined transportation and processing costs involved in assembling and processing any given quantity of raw material produced in varying amounts at scattered production points."[41] Stollsteimer's equation is:

$$\text{MIN TC} = \sum_{j=1}^{J} P_j X_j \Big| L_k + \sum_{i=1}^{I} X_{ij} C_{ij} \Big| L_k$$

where: i = origin

j = plant

TC = total processing and assembly cost

P_j = unit processing costs in plant j ($j = 1 \ldots J \leq L$) located at L_j

X_j = amount of raw material processed at plant j

X_{ij} = quantity of raw material shipped from origin i to plant j located at L_j

C_{ij} = unit cost of shipping material from origin i to plant j located with respect to L_j

L_k = one locational pattern for J plants among the $\binom{L}{J}$ possible combinations of locations for J plants given L possible locations

L_j = a specific location for an individual plant ($j = 1 \ldots J$)

All potential plant sites (L) are selected by the location analyst; from these possible sites the analyst arbitrarily chooses J sites $[\binom{L}{J};\ J \leq L]$. The processing costs for the J plants are summed and added to the summation

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[41] Ibid., pp. 631-632.

of all material collection costs from I raw material sites to the J plants. The variable portion of transportation costs are rather straight forward, being merely a function of distance and volume, that is, the transportation cost of the volume of raw material X moved from raw material site i to processing plant j is simply $X_{ij}C_{ij}$. Plant processing costs can be a function of size of plant and location of plant. Plant cost variations in respect to plant size are influenced by the presence or absence of economies of scale as output increases.[42] If economies of scale exist, the costs per unit of processing decrease as output increases.

The application of the Stollsteimer model is relatively straight forward. The analysis begins with the construction of the transfer cost matrix which is of size I x J with the entries in each J column representing the transfer costs from each origin i to each particular plant site j. Each column vector in the transfer cost matrix is multiplied by a row vector whose elements represent the production of each raw material site. When each plant location column vector is multiplied by the materials row

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[42]Plant location problems with falling average processing costs--the result of assuming economies of scale--has also been analyzed by: Gordon A. King and Samuel H. Logan, "Optimum Location, Number and Size of Processing Plants with Raw Product and Final Product Shipments," Journal of Farm Economics, Vol. 46, February, 1964.

vector, a minimum transportation cost can be found with J, the number of plants, equal to one. Obviously, there are as many possible solutions as there are potential plant sites. When two plants are being considered, all possible combinations of two column transfer vectors are scanned for minimum row elements. These minimum row elements are put into a column vector and multiplied by the materials row vector giving total transfer costs for two plants located at given sites. The same procedure is followed for three plants, four plants, up to J=L. Minimum total transfer (material collection) costs for one plant, for two plants, etc., are plotted on a graph yielding the minimum total transfer cost (TTC) curve. This curve declines continuously as $J \rightarrow L$. These minimum total transfer costs are added to total processing costs resulting in TC = TTC + TPC. The optimum number of plants is then determined by minimizing total costs (TC).

If there is a fixed quantity of raw materials to be processed in the area, and with constant marginal costs for any given plant, the plant-cost function will increase by an amount equal to the intercept value of the plant-cost function with each increase in plant numbers.[43] In the presence of economies of scale, the total processing cost function will increase at an increasing rate as plant numbers

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[43]Stollsteimer, op. cit., p. 636.

increase with just one plant having the lowest total processing costs. A second plant would process less material and be of a smaller size, and have higher per unit processing costs. The Stollsteimer model, in addition to considering economies of scale in plant operations, considers variations in per unit plant costs when plant factor costs vary with location, for example labor costs. These variations in factor prices are accommodated by "adding to each column of the transfer-cost matrix the slope coefficient of the processing-cost function applicable for each particular plant site."[44]

Modifications of the Stollsteimer model

Since Stollsteimer published the results of his work in 1963, several authorities have recognized weaknesses and consequently suggested modifications to the basic "Stollsteimer" framework. The purpose of this section of the chapter is to review some of the more important modifications and criticisms. While this short review is at best superficial, considerable emphasis will be given to a few of these criticisms in subsequent sections.

An important aspect of the Stollsteimer model is that plant size is determined after optimal plant numbers and locations are determined. "The assignment of a given number

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[44]Stollsteimer, *op. cit.*, p. 638.

of plants to a specified set of locations, along with minimization of assembly costs, implies a given size of plant for each location."[45] The number and location of plants determine the allocation of production, and the volume of production in the Stollsteimer model is assumed to represent plant size. The assumption is that for every level of production there exists an economically sized plant; that is, excess capacity cannot exist. The plant cost function is assumed to be linear and continuous in the sense that plant segmentation does not exist. In addition, all factors are completely divisible and there is no discontinuity in the rate of output.

Chern and Polopolus discuss the possibility and rationality of a discontinuous plant cost function. The assumption of a continuous and linear plant cost function has at least three shortcomings:

> First, continuous plant cost functions are often unrealistic when applied to agricultural handling and processing operations. Second, under the implicit assumption in the Stollsteimer model that an identical TPC function exists for each plant, the nature of a linear function limits the impact of the size of individual plants in determining an industry's total plant cost. Third, theoretically the long-run total plant cost goes through the origin. It is reasonable to expect a very small, if any, intercept value if the TPC function is continuous and all factors of production are completely divisible and are therefore treated as variables in the long-run. Hence, the assumption of continuity and linearity is not a

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[45]Stollsteimer, _op_. _cit_., p. 643.

realistic assumption and therefore represents a weakness of the original model.[46]

Chern and Polopolus conclude that use of the Stollsteimer's continuous and linear plant cost function underestimates total plant costs for the industry. In addition, they made the following modifications in the Stollsteimer model:

1) The number of locations are treated independently of the number of plants due to the constraint on maximum plant capacity, and, "multiplant" locations therefore may appear in the results;
2) the effects of plant size on the magnitude of total plant costs are explicitly shown by adopting a discontinuous plant cost function;
3) excess capacity is introduced in determining the optimum solution.[47]

Commenting on the empirical application of the Stollsteimer model, Warrack and Fletcher state that the "operational constraints of the Stollsteimer long-run spatial model have been severe. The data input requirements are large. More serious, for all but small problems the optimization tends to be computationally demanding to the point of infeasibility."[48]

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[46]W. Chern and L. Polopolus, "Discontinuous Plant Cost Function and a Modification of the Stollsteimer Model," American Journal of Agricultural Economics, Vol. 52, No. 4, November, 1970, p. 581.

[47]Ibid., p. 584.

[48]A. A. Warrack and L. B. Fletcher, "Plant-Location Model Sub-optimization for Large Problems," American Journal of Agricultural Economics, Vol. 52, No. 4, November, 1970, p. 587.

Another criticism of the Stollsteimer model is that it determines the number, size and location of plants by minimizing combined transportation and processing costs for only one raw material. If there is more than one raw material to be processed in a single plant, the locational problems become complicated. An extension of the Stollsteimer model to include multiple product processing was undertaken by Polopolus in 1965.[49] The Polopolus

> multiple product model differs from Stollsteimer's model in that aggregate assembly costs are affected by varying locational patterns as the product dimension is increased and that total processing cost varies both with the number of plants and the combination of products handled at each optimum plant location.[50]

Candler, Snyder and Faught made a further modification by considering, in addition to multiple product processing, multiple raw material assembling.[51]

General location theory, and in particular the Stollsteimer model, assumes that given a specified geographic area there are no institutional or structural restraints affecting the least-cost optimal location pattern of plants.

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[49] L. Polopolus, "Optimum Plant Numbers and Locations for Multiple Product Processing," Journal of Farm Economics, Vol. 47, No. 2, May, 1965, pp. 287-295.

[50] Ibid., p. 287.

[51] W. Candler, J. Snyder and W. Faught, "Concave Programming Applied to Rice Mill Location," American Journal of Agricultural Economics, Vol. 54, No. 1, February, 1972, pp. 126-130

One of the prime objectives of location theory is to spatially organize plants so that markets are efficiently allocated among these plants. When there is only one location decisionmaker, spatial organization leads to spatial monopoly. Permitting firms to organize spatial monopolies by necessity leads to the deterioration of the competitive environment in a market. Anti-trust laws can be, and have been, used to preserve a competitive environment. The methods of the Stollsteimer model are compromised when anti-trust laws are invoked limiting the possible location solutions--the least-cost optimal solution may be unattainable. The optimal number, size and location pattern is determined by costs only when institutional constraints are first considered. Bobst and Waananen have presented a location model which includes an institutional restriction on plant concentration and spatial monopolizing of markets.[52]

The Stollsteimer model represents a partial equilibrium approach. That is, Stollsteimer considers only those elements which directly influence production at the plant site. The size, number and location of plants is determined by first considering the production function of single establishments and by observing geographic variation in

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[52]B. W. Bobst and M. V. Waananen, "Cost and Price Effects of Concentration Restrictions in the Plant Location Problem," American Journal of Agricultural Economics, Vol. 50, No. 3, August, 1968, pp.676-686.

costs of the establishment's major inputs and the spatial variation in the demand for its output. The optimal location pattern minimizes the total costs of collecting all important material inputs, minimizes total delivery costs and maximizes production efficiency. The partial equilibrium approach is fundamentally based on four assumptions: (1) all costs are fixed or stable, (2) market demands are given and constant, (3) all other forces are exogeneous variables and considered fixed, and (4) the locational decisions of other firms are not allowed to constrain the analysis.

A GRAIN HANDLING AND TRANSPORTATION RATIONALIZATION FRAMEWORK

Appreciating the basic logic but recognizing the limitations and criticisms of the basic Stollsteimer framework and noting subsequent modifications in that framework, the objective of this section of the study is to construct a mathematical model to represent the grain collection, handling and distribution system in Western Canada at a regional level. The modifications suggested here are designed so that the mathematical model will best represent the system under analysis. Through the remainder of the study the grain handling and transportation rationalization model will be referred to as CHAD, denoting collection, handling and distribution.

Incorporated in CHAD are five basic modifications to the Stollsteimer model. These modifications are: (1) consideration of the grain collection, handling and distribution system; (2) the inclusion of a grain collection function; (3) inclusion of a grain distribution function; (4) consideration of existing facilities; and, (5) introduction of institutional restraints. A brief explanation of these modifications is presented below.

Modification 1: The Collection, Handling and Distribution of Grain

The original Stollsteimer model considered the assembly and processing of a raw material, specifically pears. The first proposed modification of this basic model simply substitutes the collection of grain for the collection of pears, and the handling of grain for the processing of pears. Certainly a liberal interpretation of processing could encompass the function of handling. In addition, grain could be considered as a raw material. Therefore, the first modification is perhaps incidental. But it is certainly necessary to define what is being collected, how it is collected, and how it is being processed.

It is also important to know who is doing the collecting of the raw material, who is doing the processing of the raw material and who is distributing the final product. There are obviously different implications depending on whether these functions are all performed by one entity or whether they are under separate and independent control. Many firms have total control over their collection, handling and distribution systems. However, the opposite is true in grain marketing; farmers perform the grain collection function, elevator companies the grain handling function, and railway companies the grain distribution function. This recognition has paramount importance for system rationalization. If control and ownership of the system is monopolized the rationalization of the system is, theoretically, a great deal easier in that the definition of rationality is universal throughout the system i.e., what is rational for the system is rational for all sub-systems of the system. On the other hand, if each sub-system is independently controlled, rationalization of the system may be much more difficult. If for each sub-system there exists different conditions for rationality, system rationalization will occur in a piece-meal fashion and will likely be sub-optimal. For example, a firm with monopoly control over its collection, handling and distribution system simply minimizes its total costs and organizes and coordinates its system accordingly.

In the collection, handling and distribution of grain the process is complicated. Farmers will desire to minimize their collection costs by insisting that a country elevator be close at hand; elevator companies will desire to minimize handling costs by consolidating grain deliveries into fewer elevators and; railways will desire to minimize grain distribution costs by abandoning non-compensatory branch lines. Rather than having a common and consistent system rationality as the objective function of rationalization there is a set of contradictory sub-system objective functions. If all segments in the system have equal power, system rationalization will simply not occur without some sort of compromise. If the control of one sub-system has a great deal of power relative to other members in the system, system rationalization will occur but under the direction and rationality of the most powerful, e.g., if it is conceded that the railway is most powerful in the grain collection, handling and distribution system, railway and system rationalization become synonymous. Should the railways be allowed to abandon any branch line it recognizes as non-compensatory, railway rationality will be imposed on the system. Similar consequences may be expected if farmers or elevator companies are system controlling forces.

Rather than having one sub-system's philosophy prevail in system rationalization, and recognizing the strength of the railways in relation to unorganized farmers and elevator companies, the Canadian Transport Commission established a legal framework whereby all parties involved in the transportation and handling of grain could contribute toward the formulation of a system which would incorporate the views of all concerned. This framework is generally referred to as branch line abandonment hearings. In the format of branch line abandonment hearings, this first modification recognizes that an accurate portrayal of the grain transportation system must acknowledge the segmentation of the system into self-orientated yet highly interdependent sub-systems.

Modification 2: The Inclusion of a Grain Collection Cost Function

Typically, a transfer-cost matrix is the product of a per unit mile transportation cost and distance. That is, the C_{ij} matrix contains elements which reflect the total cost of transporting one unit of raw material from raw material site i to processing plant j. The Stollsteimer model employs a constant for the per unit mile transportation cost. The only variable factor is distance. The use of a constant would appear appropriate only if the constant reflects a cross-section average cost for all methods of collection and no economies are experienced as distance increases. The constant average cost principle is perhaps most appropriate when the means of collection is controlled by a single enterprise. With only one enterprise responsible for the collection of raw material, the chances are that similar methods, e.g., a fleet of similar trucks, will be used throughout the process of collection. The most obvious example is a processing firm that owns its own trucks or hires a private carrier to collect its raw material.

The constant average cost principle is not applicable, however, in a situation where a wide variety of methods are used in collecting raw material and the conditions of collection are quite variant. This is the situation in the collection of grain in Western Canada. Individual farmers are responsible for delivering grain to country elevators and the average cost of collection may vary widely between farmers depending on several factors. A recent study found that the average cost per bushel-mile in the delivery of grain was a function of the size of the truck, the utilization of the truck, one-way distance to the elevator, age of the truck, and percent of grain miles on paved roads.[53] For example, the average cost per bushel-mile varied from 0.305 cents to 0.711 cents per bushel-mile based on size of truck alone.[54]

Therefore, to better represent the grain collection sub-system in Western Canada, a functional relationship will be used where the dependent variable is average cost per bushel and independent variables similar to those in the

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[53] E. W. Tyrchniewicz, A. H. Butler and O. P. Tangri, The Cost of Transporting Grain by Farm Truck, Research Report No. 8, Center for Transportation Studies, University of Manitoba, Winnipeg, Manitoba, July, 1971.

[54] Ibid., p. 40.

Tyrchniewicz, et al., study. Substituting a functional relationship for a constant permits the simulation of independent variables in the specified function. That is, the values of the variables can be changed in accordance with changing circumstances in grain collection.

Modification 3: The Inclusion of a Grain Distribution Activity

The inclusion of a distribution function is more an addition than a modification to the Stollsteimer model. The Stollsteimer model considered only the collection (assembly) and processing of a raw material. The CHAD model is system orientated in that it considers the combined costs of collection, handling and distribution. An important sub-system of the Canadian grain transportation and handling system is the distribution of grain from country elevators to terminal elevators by the railways.

The cost of this movement can either be the freight rate charged to the farmer or the cost to the railways in providing this service to the farmer. Although more will be said about this later, recognizing a freight rate as a cost may create confusion in interpreting the results of a "cost simulation model."[55]

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[55]See pp. 72-73.

Modification 4: Consideration of Existing Facilities

Existing elevator facilities, under the framework proposed here, may be considered as a restraint in the model where the objective function would be to utilize these facilities to their maximum advantages or they can be ignored and considered as simply a possible location for the construction of a new elevator. This flexibility is built into the CHAD model because there are proponents that argue either that the most efficient country elevator system is yet to be built or that the present system is overbuilt and all that is necessary is to reorganize it using existing facilities. There is considerable rationale underlying both arguments. The proponents for constructing a completely new elevator system argue that a simple "patch-up" of the old system will be extremely costly and money wasted in the long-run. On the other side of the issue are those that contend that the elevator business is little more than a break-even enterprise and therefore the massive amount of capital necessary for new construction simply does not exist in the industry. In other words, the former would suggest that a realistic rationalization model must determine the optimum number, location and size of country elevators, while the latter would contend that all that is necessary is to find the optimum number and location.

Depending on the handling function(s) used, the CHAD model can do both. If existing facilities are to be used and therefore considered as a restraint in the model, a set of equations stratified according to size may be used. These equations estimate the average operating costs for country elevators currently in operation on the Prairies. Since many of these elevators are partly or entirely depreciated, operating costs are likely close estimates of full costs. On the other hand, an estimated average full cost for a newly constructed elevator will emphasize capital costs.

Modification 5: Introduction of Institutional Restraints

While the previous four modifications are primarily technical in nature, this modification provides for the introduction of institutional restraints. With the four previously mentioned modifications, the CHAD model may be used as a means of measuring the effects of past, current, and future Canadian grain transportation policies.

As emphasized earlier, the collection, handling and distribution of grain in Western Canada is highly influenced by the institutional environment in which it operates. One of the objectives of the CHAD model is to quantify the degree of the influence and simulate changes in the institutional environment. Specifically, the influence of the fixed Crows Nest Pass rates on grain and the negotiated handling rates at country elevators will be measured and compared to their respective costs. In addition, branch line abandonment, as a provision in the National Transportation Act, will be simulated.

THE CHAD MODEL AS A SIMULATOR

To a great extent, government policy makers are "managers" of the Canadian grain handling and transportation system. Provincial governments, the Canadian Wheat Board, the Canadian Grain Commission, the Canadian Transport Commission and even Parliament itself, are extensively involved in the collection, handling and distribution of Canadian grain. It is contended that a model which would provide answers to the general question "what will happen if. . .?", as the simulated CHAD model can be designed to do, would be an aid to these "managers" in formulating policy. Goetz emphasized that:

> Rational managerial decisionmaking is a process of finding or inventing alternatives, of projecting or predicting the consequences of each, and of choosing the most attractive set of consequences. Predicting consequences usually is difficult. Experimentation by changing the system and measuring the consequences is forbiddingly expensive and may be irreversible. Here, simulation comes to the aid of managers.[56]

Within the changing institutional environment technological change is also occurring thus affecting the mechanical methods of grain collection, handling and distribution. The

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[56] Billy E. Goetz, Quantitative Methods: A Survey and Guide for Managers, New York: McGraw-Hill, 1965, pp. 461-462.

CHAD model can be adapted to simulate expected technological change over time.

Simulating Institutional Restraints

The procedure used in simulating institutional restraints is quite straightforward. Theoretically, the first step would involve a "run" of the model under the assumption that there are no institutional restraints. An institutionally unrestricted cost solution would result. After recognizing various institutional restraints, these restraints could be imposed on the model one at a time. That is, each subsequent run after the unrestricted run will yield cost solutions permitting the measurement of the effect of each institutional restraint. For example, assume an unrestricted run has been made and further assume that five institutional restraints are recognized as being potentially influential factors. Separate runs are now made for each of the five institutional restraints. The cost solutions of each of these five restraints are compared to the cost solution generated from the unrestricted run. Theoretically, the difference between the unrestricted cost solution and each restricted cost solution would be the pecuniary cost or benefit of the institutional restriction.

An alternative method of simulating institutional restraints is to first create the entire institutional environment. This is accomplished by imposing all of the institutional restraints on the model at one time. This conglomerate run should give the best representation of the current "real world." When this hopefully realistic model of the real world is obtained, institutional simulation may proceed along the following lines: (1) eliminating one or more existing restraints, (2) modifying one or more of existing restraints, (3) incorporating additional new restraints, (4) substituting new restraints for existing restraints, or (5) substituting an entirely new set of restraints for existing restraints.

While the simulation procedure may appear to be straightforward, the application of that procedure may be extremely difficult and subject to error. Many institutional restraints may be non-quantifiable and not adaptable for incorporation into the model. If the incorporation of an institutional restraint is essential for an accurate depiction of the real world system under analysis yet unadaptable to a chosen framework, attempts can be made at substituting a proxy or "dummy" variable which is adaptable. The other alternative is to modify the framework to permit its adoption.

Simulating Technological Change

Over time, technological improvements occur in the means of collecting, handling and distributing grain. One need only mention bigger and faster farm trucks, the vertical lift elevator and covered hopper cars and unit trains. The grain transportation and handling system of the future can be depicted by projecting and simulating technological (as well as institutional) change. While projection is almost always hazardous, insights can be gained into the general direction, magnitude and nature of technological change. In addition, discovering where and how technological change is most effective would have implications on policy decisions, i.e., which technological innovations should be encouraged.

The basic procedure in simulating technological change is quite similar to that of simulating institutional restraints. The difference is that there simply cannot be an "unrestricted" run. The first run must incorporate the current technology of the system. From this point on, changes in technology are simulated. This change can take place in two directions: (1) technological change occurring over time in a particular technique or (2) a complete change from one technique to another. An example of the former would be the adoption of bigger farm trucks by grain producers and an example of the latter would be the substitution of long-haul trucks for rail in the distribution of grain. Ultimately, a comparison can be made between the costs of moving grain by alternative modes.

CHAPTER IV

EMPIRICAL PROCEDURES

PROBLEMS IN SIMULATION

As indicated earlier, the CHAD model has its foundation in a combination of three analytical techniques: location theory, simulation and systems analysis. Each one of these techniques presents unique computational and estimation problems. When combined in the fashion suggested in this study, problems become multi-dimensional. Location theory presents the problem of defining and controlling economic activity in space; simulation becomes hazardous when it is desired to change a parameter outside of a statistically permitted range; and systems analysis requires a comprehensive knowledge of the system under analysis. It should not be surprising, therefore, that with these problems, a rather hazardous computational environment is created. The major problems encountered in this analysis are discussed below.

The Effect of Extended Distances on Collection Cost Estimates

As the number of elevators is decreased, it can be expected that farmers are going to be required to deliver their grain over longer distances. The Tyrchniewicz *et al.* collection cost estimates, to be presented in detail later, are based on average one-way distances to elevators ranging from 0.5 miles to 20.9 miles.[57] That is, the regression coefficients of the Tyrchniewicz *et al*. equation are statistically significant when one-way distances to country elevators are in the 0.5 miles to 20.9 mile range. Yet it can be expected that one-way distances will increase beyond 20.9 miles as the number of elevators is decreased as a result of branch line abandonment. To permit forecasting involving one-way distances greater than 20.9 miles it is necessary to assume that the underlying structure of the average cost regression equations remains unchanged. Croxton, Crowden and Klein emphasize that: "Any forecasting procedure which involves merely the continuation of a curve or the automatic application of a formula, without at the same time requiring a careful consideration of underlying and modifying factors, is hardly to be depended upon, particularly if economic conditions are in a state of flux."[58]

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[57]E. W. Tyrchniewicz, A. H. Butler and O.P. Tangri, *op. cit*., p. 51. (Note: The farm truck equation used in this study is not contained in the Tyrchniewicz *et al*. study. However, the equation is based on observations collected for the Tyrchniewicz *et al*. study.)

[58]F. E. Croxton, D. J. Cowden and S. Klein, *Applied General Statistics*, Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1967, p. 101.

Estimates of a dependent variable are generally invalid in the case of extrapolation beyond observed values of the independent variables. That is, a particular estimating equation is statistically valid only if it contains observed values and, in the case of more than one independent variable, these values are used in their observed combination. Extrapolation is performed therefore when either a value is used which lies outside the observed values for a particular variable or when two or more variables are used in a combination which lies outside the range of the original set.

The error in forecasting a dependent variable from regression analysis is composed of two parts: the first is the standard error of the estimate associated with all regression analyses; and second, if multiple regression, the error associated with the regression plane.[59] The standard error of the estimate is a constant and a parameter of a particular regression equation. The error of the regression plane, however, varies with the particular values

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[59]This same basic approach is presented in Richard J. Foote, _Analytical Tools for Studying Demand and Price Structures_, Agricultural Handbook No. 146, United States Department of Agriculture, Washington, D. C., August, 1958.

of the independent variables. When the independent variables are at their means this error is minimized, i.e., the greatest confidence may be placed in their estimate of the dependent variable. However, as variables diverge from their means, the error associated with the regression plane increases thus widening the confidence limit. The least confidence is attached to observations furthest from their means. Values that lie outside the observable range, of course, are even further from the variable means indicating a relatively large error.

Recognizing the statistical limitations and the comments by Croxton et al., average collection cost estimates are forecast to a limited extent for one-way distances greater than 20.9 miles. As an example of this application, assume a regression equation is estimated relating average cost per bushel-mile to one-way distance to elevator. Further assume that one-way distance to elevator observations lie within the 0.5 miles to 20.9 mile range. The statistically valid portion of this equation will lie between observations at 0.5 miles and 20.9 miles.

It should be noted at this point however, that in all but one simulation--that one being the extreme case where only one elevator location was considered--did average one-way distance to elevator significantly exceed 20.9 miles. Nevertheless, for this exception and in cases where individual farmers were required to travel more than 20.9

miles in other simulations, for lack of a better alternative, it is assumed that the regression coefficients of the collection cost equation hold for distances greater than 20.9 miles.

Problems in Estimating Elevator Handling Costs

The same types of problems encountered in estimating collection costs appear in estimating elevator handling costs. When bushels handled, as an independent variable, is extended beyond the range of the original data, statistically invalid average operating cost estimates could result. Although the data underlying the elevator handling cost equations used in this study had a wide range and consequently was not a serious problem, there were other problems in using the handling cost equations as provided by Tangri, Zasada and Tyrchniewicz.[60] These were: (1) because each equation represents a size strata e.g., 80,000 bushel capacity to 99,999 bushel capacity, and would likely contain many elevators with different operating characteristics, caution must be exercised in applying these cost equations to particular elevators, and (2) these costs do not reflect capital costs and therefore are not full costs.

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

The Choice of Rates Versus Costs

The proposed model is not necessarily a cost minimization model. Collection "costs" may be either represented as a statistically derived average cost per bushel by farm truck or a custom rate charged to the farmer. Elevator handling "costs" may be determined statistically by an equation which considers a size variable or the Canadian Grain Commission fixed rate. Distribution costs may be determined using a cost estimate or the statutory Crows Nest Pass rates. The general objective of cost minimization is the efficient allocation of scarce resources. Therefore, if optimum resource allocation is the objective of the model, the estimation of cost in terms of resources used is essential.

Efficient resource allocation through cost minimization in some economic sectors may be feasible, but in transportation, especially where railways are involved, the effort is likely futile. Railways quote a rate more than likely based on value-of-service rather than cost-of-service pricing practices.[61] Therefore, any transportation cost minimization model which relies on rates rather than true costs is, in fact, a misnomer. What is usually being minimized in such a model is shipper's transportation costs,

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[61]Roy J. Sampson and Martin T. Farris, Domestic Transportation: Practice, Theory and Policy, Boston: Houghton Mifflin Company, 1966, See Part Four.

not the costs of supplying the transportation service to the shipper. A model must be defined in terms of whether rates, resource costs, or a combination of both are being assumed in the model.[62] It is mandatory that the implications of the selection be fully explained as well.

If both rates and costs are obtainable, this problem may be avoided by simply considering both. In the case of the distribution function, estimates of rail costs were available from the Grains Group report for this study and therefore both rail rates and costs are simulated.[63] Grain handling rates are provided annually by the Canadian Wheat Board and handling costs are derived from equations contained in the Tangri, Zasada and Tyrchniewicz study.[64] Collection costs were estimated for farmer-owned and operated trucks from data assembled for a previous study by Tyrchniewicz, Butler and Tangri and for custom truckers from data assembled by Moore.[65,66]

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[62]Only in an environment of perfect competition is resource cost equal to rate (price). This environment cannot be assumed here.

[63]Grain Handling and Transportation Costs in Canada, op. cit.

[64]Tangri, Zasada and Tyrchniewicz, op. cit.

[65]Tyrchniewicz, Butler and Tangri, op. cit.

[66]G. Moore, "A Cost Analysis of Assembling Grain by Commercial Trucks," Unpublished Master of Science Thesis, Department of Agricultural Economics, University of Manitoba, Winnipeg, Manitoba, 1970.

Computational Feasibility

The Stollsteimer long-run spatial model has come under considerable criticism concerning its operational feasibility for large problems. The basic optimizing approach suggested by Stollsteimer is to compute total costs for each possible number of plant locations and for each combinatorial location pattern. For example, assume there are J possible elevator locations in a bounded region and I farmers delivering to these J elevators. The pure Stollsteimer procedure would involve the estimation of total costs for all possible numbers of elevators, j = 1 to J, that is, one elevator, two elevators, three elevators. . . J elevators. In addition, every combination of two elevators at a time, three at a time, . . . J-1 at a time must be costed.

As specific examples, consider two situations. The first involves consideration of only six elevator locations and twenty farmers. Taking one at a time, six at a time and all possible combinations of two, three, four and five at a time, results in 63 estimates of total collection, handling and distribution costs.[67] From these 63, the

[67] In mathematical notation the number of combinations for J elevators is:

$$\sum_{r=1}^{J} \binom{J}{r} = (1+1)^J - 1 = 2^J - 1 = 63$$

minimum cost solution is chosen reflecting the optimum number, size and location of elevators. There appears to be no real computational constraint, and cost in computer time is insignificant. The next stage of analysis involves 29 elevators and say, 6,000 farmers. Using combination mathematics it can be found that just taking twenty elevators at a time results in over one million possible combinations. It becomes quite obvious that as the number of possible elevator locations increases the number of possible combinations increases exponentially, causing perhaps an insurmountable computational problem.

Two methods may be considered to overcome the computational problem. The first is the Warrack and Fletcher suboptimization algorithm.[68] The algorithm is applied to a product distribution model where geographically dispersed market demands are to be supplied from any one or more possible plant locations. The problem is to find the optimum number, size and location of processing plants which would minimize the combined costs of processing and distribution. Realizing that the empirical application of the model would require the consideration of a large number of potential plant sites, Warrack and Fletcher designed the following Algorithm: With TCC denoting total combined

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[68] Allan A. Warrack and Lehman B. Fletcher, "Plant-Location Model Suboptimization for Large Problems," op. cit.

transfer plus manufacturing costs and N the total number of potential plant sites, the formalized steps of the Iterative eliminations approach (IELMA) are

(a) Compute TCCN, TCC_{N-1}, and TCC_{N-2} where the total combined costs refer to all, all but one, and all but two plants.
(b) Test to determine if TCCN > TCC_{N-1}; if so, one plant is to be removed.
(c) If one of the plants eliminated by TCC_{N-2} is the same plant eliminated by TCC_{N-1}, remove that plant.
(d) Let N=N-1 and repeat steps (a) through (c) until plant removals no longer lower total combined costs. The IELMA solution has been reached.[69]

While the iterative eliminations approach "begins with the inclusion of all potential plant locations and eliminates them one by one until a solution is reached" the iterative expansion approach (IEXPA), an alternate suboptimization algorithm, "locates plants one by one, beginning with zero plants."[70] The formal steps of IEXPA algorithm are

(a) Compute TCC_n where the total combined costs refer to the ${}_NC_n$ set of combinations and n=1.
(b) Compute TCC_{n+1}
(c) Test to determine if $TCC_n > TCC_{n+1}$; if so, add the selected plant location and increment n by one.
(d) Repeat steps (b) and (c) until plant additions no longer lower total combined costs. The IEXPA solution has been reached.[71]

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[69] *Ibid.*, p. 588.

[70] *Ibid.*, pp. 588-589.

[71] *Ibid.*, p. 589.

The application of the Warrack and Fletcher algorithm leads to a suboptimal cost solution because under the rules of the IELMA approach once a plant is eliminated in step (c) it can no longer influence or be contained in the final solution; it is simply eliminated from further consideration. On the other hand, under the rules of the IEXPA approach, once a plant is added it continues to influence the entire optimization process and is contained in the final solution.

There are many implications of accepting and implementing a solution which is known to be suboptimal. On the side of suboptimization there is certainly a great deal to be gained in terms of computer cost savings. However, one important point must not be lost sight of: The objective of a spatial model, as discussed here, is to minimize the combined cost of collection, handling and distribution, not to minimize computer costs. The question must be asked, how suboptimal is the solution, and is the savings in computer costs worth it? Warrack and Fletcher comment that 10,000 hours of computer time would be needed to arrive at an optimal solution i.e., consideration of all combinations with forty potential plant sites. At an estimated computer cost of $120 per hour the cost of knowing the optimal solution would be $1.2 million. Whether this additional cost should be incurred or not depends upon the characteristics of the problem; for a multi-million dollar business it may well be worth the additional computer cost.

The original Stollsteimer model is designed to consider all possible location combinations while the Warrack-Fletcher algorithm is designed to eliminate location combinations. However, neither the Stollsteimer or the Warrack-Fletcher computational procedures appear to be relevant for the analysis of Canadian grain transportation rationalization. As a supplement to self-rationalization which is currently occurring in the system, Canadian grain transportation rationalization will take place in the court room during branch line abandonment hearings. It is not necessary to determine the total collection, handling and distribution costs for every possible and often absurd elevator combination as required by the Stollsteimer unrestrained location combinatorial method. In addition, the determination of a suboptimal cost solution is insufficient for once this solution is rejected, for whatever reason, the usefulness of the model ends.

A model with a great deal of flexibility is required, that is, a model that is capable of simulating alternatives in the organization of grain collection, handling and distribution. The CHAD model is presented as a decision-making aid, not a decision-maker. While the computational limit does not realistically permit the determination of total collection, handling and distribution costs for every possible elevator combination, the CHAD model is capable of determining the total cost for any combination of elevators specified a priori. The user of the model can call for any combination of elevators, delivery points or rail lines desired, simply by programming CHAD to select the chosen combinations. For example, the economic consequences of abandoning a particular branch line in a region could be determined by calling for that elevator combination which would include all elevators in the region except for those located on the designated branch line. Similarly, with all other so conceived "relevant" combinations. In effect, each alternative elevator combination would be a simulation run, that is, a simulation of the grain collection, handling and distribution system in a region in the absence of particular elevators.

Problems Associated with the Sensitivity of the Solution

The conclusions of a typical plant location study suggest how many plants there should be, how big each plant should be and where each plant should be located. To say that these are major decisions on the part of a business would be an understatement. The commitment to a particular plant number, location and size configuration has long-run, and in many cases, irreversible, consequences. To a significant degree these decisions made today influence the competitive position of the firm essentially forever. That is, few firms can afford to make plant number, size and location decisions more than once in its lifetime. In fact, such decisions can well determine the lifetime of a firm. The dangers of suggesting or accepting a suboptimal or misinterpreted solution are obvious.

But there is also danger in suggesting or accepting an optimal solution which can only be optimal in the very short-run. That is, the optimum number, size and location of plants today may not be the optimum number, size and location of plants as early as tomorrow. This, in a very elementary way, emphasizes the sensitivity characteristic of an optimum solution.

Basically, the stability of a solution is measured in terms of its sensitivity toward changes in a variety of critical parameters. If a seemingly insignificant change in a parameter results in a solution different from the optimum solution, i.e., a different plant number, size and location configuration, the optimum solution is extremely sensitive and likely unacceptable as a long-run policy. On the other hand, if the optimum solution is stable over large changes in parameters, the solution is insensitive and likely acceptable as a long-run policy. It seems appropriate therefore that each optimum solution be accompanied by a set of sensitivity measures, one measure for each parameter.

In a model which is concerned with collection, handling and distribution, raw material supplies, and final product demands there are several critical parameters, namely regression coefficients of collection cost functions, handling cost functions and distribution cost functions, and quantities supplied and demanded. Changes in any one or a combination of these parameters could cause a change in solution. Sensitivity testing of course cannot be undertaken until a solution is specified. Others have done it in different ways, for different parameters and for different models.[72]

As implied earlier, the method employed in this study does not generate size, number and location solutions as does the Stollsteimer framework or the Warrack-Fletcher algorithms. That is, if existing facilities are considered, the size, number and location of facilities are predetermined. The purpose of the CHAD simulation model is to estimate the costs of grain collection, handling and distribution for each specified set of facilities. Whether a particular specified set of facilities is "optimal" or not depends on social and political constraints as well as economics; the

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[72]See H. I. Toft, P. A. Cassidy, and W. O. McCarthy, "Sensitivity Testing and the Plant Location Problem," American Journal of Agricultural Economics, Vol. 52, No. 3, August, 1970; M. G. Kanbar and H. Neudecker, "Methodology of Spatial Equilibrium Models of the Rice Economy of South India," Artha Vijana, 8, March, 1966; M. G. Kanbar and H. Neudecker, "Sensitivity Analysis and Spatial Equilibrium Models," Econometrica Annual of Indian Journal Economics, 15, 1968; and George W. Ladd and M. Patrick Halvorson, "Parametric Solutions to the Stollsteimer Model," American Journal of Agricultural Economics, Vol. 52, No. 4, November, 1970.

cost of collecting, handling and distributing grain is only one factor influencing the decision.

However, if economics is or should become the deciding factor in the selection of one set of facilities over another, then the sensitivity of the parameters included in the collection, handling and distribution cost functions, assumes an importance. Depending upon the relative weight attributed to economics, the question of rates versus cost could be very important; the use of handling and rail costs rather than handling and rail rates, could swing the power of decision to economics. If this should prove to be the case, rate versus cost estimates become extremely sensitive. For example, depending on whether handling and rail costs are used or handling and rail rates, the decision to abandon a branch line could be different. The handling and rail activities will naturally assume greater importance if costs are used rather than rates. On the other hand, if rates are used, farmer collection costs assume greater importance. If costs are used, it is conceivable that elevator and railway company savings may exceed any additional collection costs incurred by farmers; the decision will be to abandon. If rates are used, on the other hand, added farmer collection costs could exceed elevator and railway company savings; the decision would be not to abandon. While no specific sensitivity testing is performed in this study, all the possibilities mentioned here may be discerned from the empirical results presented in the following chapter.

ASSUMPTIONS

A simulation model, so as to best represent a real world system, should have as little a dependency on simplifying assumptions as possible. Unfortunately, many assumptions are often required to even attempt to simulate a complicated system such as the collection, handling and distribution of grain. However, it is believed that sufficient flexibility has been built into the model to permit its further sophistication by those who desire to do so. The basic underlying assumptions used to simulate the system portrayed in this study are listed below.

1) Farmers who are diverted to other elevators as a result of rationalization minimize their collection costs by delivering or having their grain delivered to the nearest delivery point.

2) All grain delivered to the elevator and handled by the elevator is shipped out. The implied assumption here is that the elevator's beginning inventory is equal to its ending inventory, i.e., amount collected = amount handled = amount shipped out.

3) If a farmer owns a truck it is assumed he uses that truck to deliver grain. If a farmer has more than one truck it is assumed he uses the largest truck to deliver his grain. If a farmer has more than one truck of equal

size he will use the newer truck to deliver his grain.

4) If a farmer is not identified as owning and operating a truck for the purpose of making deliveries, it is assumed he hires a custom trucker to deliver his grain.

5) It is assumed that all grain originates at one location on the farm.

6) Each farmer delivers all of his grain to one delivery point. That is, splitting deliveries between a farmer's preferred (home) point and his alternate delivery point, as provided in the quota system, is assumed not to occur. All deliveries are assumed to be made to specified preferred delivery points.

7) All grain collected and handled in the Boissevain area is shipped out to Thunder Bay.

8) All rail line sections as will be defined are "abandonable" as a unit. The fact that many of these rail sections extend beyond the Boissevain region does not influence the abandonment of that portion which lies within the Boissevain region. For example, abandonment of the "Arcola" line in the study area would result in Pipestone, Reston, Linklater, Sinclair and Newstead delivery points being closed.

9) All farmers identified in the Boissevain region will continue to deliver to elevators located in the Boissevain region as rationalization of the system proceeds. That is, if a farmer's initial delivery point is closed due

to rail line abandonment, his alternate minimum distance delivery point is a delivery point in the Boissevain region.

10) Collection, handling, and distribution costs per bushel are the same for wheat, barley, and oats.

DATA REQUIREMENTS AND SOURCES

This section of the chapter is concerned with detailing the type of information which was required to permit the simulation of the grain collection, handling and distribution system of the Boissevain region.

The type of information supplied permitted the simulation of the grain collection, handling and distribution system in the Boissevain region at two procedural levels. In addition, this information allowed the testing of a critical assumption often used in location models. Basically, each farmer in the Boissevain region designates a delivery point as his primary delivery point. The first simulation procedure recognizes this "revealed preference" of farmers in the choice of their delivery point. The second simulation procedure adopts the classic assumption of location theory, minimum cost through minimum distance.[73] That is, it is assumed under this second method that all farmers minimize their collection costs by delivering their grain to the

[73]One can envision cases when minimum distance will not yield minimum costs e.g., topographic differences, gravel versus paved roads, etc. For purposes of this study, however, these possibilities are ignored.

nearest delivery point. Both of these procedures will be used in simulating the existing grain collection, handling and distribution system in the Boissevain region. As branch lines and delivery points are abandoned through rationalization, the assumption of minimum distance is applied whether the initial simulation procedure is minimum distance or revealed preference.

General Data Requirements and Sources

Each component of the system has unique as well as common data needs. Basic to the model is specification of the number and location of farmers in the chosen geographic area, bushels delivered by each farmer, the identification of delivery points as well as size and number of elevators at these delivery points, the distances between each farmer and each delivery point and the ultimate destination of the bushels collected and handled.

From data supplied by the Canadian Transport Commission, 2,187 farmers were identified as delivering grain to 31 delivery points in the Boissevain region in 1970-71. These 2,187 farmers delivered a total of 8,377,692 bushels of wheat, barley and oats. Distances between each farmer and each delivery point in the Boissevain region were provided by the Canadian Transport Commission.[74]

The cost equation for transporting grain by farm

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[74]Unpublished data, Canadian Transport Commission.

truck was developed using the data base of a previous study by Tyrchniewicz, Butler and Tangri.[75] Similarly, the cost equation for transporting grain by custom truck was developed using the data base of a previous study by Moore.[76] In addition, the average operating cost equations for elevators were developed by Tangri, Zasada and Tyrchniewicz.[77]

Data Requirements of the Grain Collection Process

The purpose of the collection cost function is to estimate the average cost per bushel of delivering grain to the country elevator. Because not all farmers deliver their own grain using their own trucks, it was necessary to estimate two collection cost functions: the average cost per bushel for farmer-owned and operated trucks, and the average cost per bushel of a custom trucker.

Based on a sample of 128 farm trucks for the year 1967-68, the average cost per bushel for farm trucks was found to be significantly dependent upon four variables: (1) age of truck, (2) size of truck measured in terms of gross vehicle weight, (3) one-way distance to elevator and (4) total bushels transported. Each farmer in the Boissevain region that used his own truck has a unique set of values for

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[75] Tyrchniewicz, Butler and Tangri, *op. cit.*

[76] Moore, *op. cit.*

[77] O. P. Tangri, D. Zasada and E. W. Tyrchniewicz, *op. cit.*

these variables and therefore a unique average collection cost per bushel. The estimating equation for farmer-owned trucks is presented in Table I.

TABLE I

AVERAGE COLLECTION COST PER BUSHEL EQUATION FOR FARMER-OWNED AND OPERATED TRUCKS

$$Y_f = 0.22553 + 0.03883X_{1f}^{(*)} + 0.32226X_{2f}^{(**)} - 0.00787X_{4f}^{(**)} - 0.09057X_{5f}^{(**)}$$

$$(0.01630) \quad (0.02781) \quad (0.00259) \quad (0.01761)$$

$R^2 = 0.66$

*Regression coefficient significant at 5 percent level
**Regression coefficient significant at 1 percent level

Standard errors appear in parenthesis below the regression coefficients.

Where:

Y_f = average cost per bushel
X_{1f} = year of truck
X_{2f} = one-way distance to the elevator
X_{3f} = total bushels transported
X_{4f} = X_{2f} X_{3f}; a measure for bushel-miles
X_{5f} = gross vehicle weight

Through information provided by the Canadian Transport Commission, of the 2,187 farmers in the Boissevain region, 1,731 were determined to own and operate trucks. No truck information was available for the reamining 456 farmers. It was therefore assumed that these farmers used a custom trucker to get their grain to the elevator.

A survey of 45 commercial and custom truckers in Manitoba was undertaken for the crop year 1967-68. It is important to note at this point that custom truckers are predominantly area farmers who typically own a larger truck and offer their services as a for-hire grain hauler on a part-time basis. As such, transportation charges for these custom haulers are low, typically covering only out-of-pocket costs. Using this data base, the average cost per bushel for a custom trucker was found to be significantly dependent upon the size of the custom truck in tons, annual truck mileage and one-way distance to the elevator. The mean values of the variables custom truck weight and annual custom truck mileage were substituted into the equation for X_{1c} and X_{2c} respectively so that cost estimates would represent the average custom trucker in the Boissevain region. The estimating equation for custom trucking is presented in Table II.

TABLE II

AVERAGE COLLECTION COST PER BUSHEL EQUATION FOR CUSTOM TRUCKING

$$\text{Log } Y_c =$$

$$0.43252 - \underset{(0.17756)}{0.56333}\text{Log}X_{1c}^{(**)} - \underset{(0.06715)}{0.34312}\text{Log}X_{2c}^{(**)} + \underset{(0.08931)}{0.82398}\text{Log}X_{3c}^{(**)}$$

$R^2 = 0.70$

**Regression coefficient significant at 1 percent level.

Standard errors appear in parentheses below the regression coefficients.

Where: Yc = average cost per bushel for custom hauling

X_{1c}= size of truck in tons
X_{2c}= annual truck mileage
X_{3c}= one-way distance to elevator

And with the substitution of mean values for log X_{1c} (which is 2.8 tons) and log X_{2c} (which is 6,510 miles) the equation becomes:

$$\text{Log } Y_c^* = -0.43835 + 0.82398 \text{Log} X_{3c}$$

The inability of commercial truckers to differentiate between labor and management led Moore to the conclusion that "there were no data available to make an attempt to determine management costs."[78] To incorporate an adequate return on investment and management (10 percent), average cost per bushel (Y_c^*) was multiplied by the constant 1.1.

Data Requirements of the Grain Handling Process

The purpose of the handling function is to estimate the average cost per bushel for operating elevators of various capacities. Tangri *et al*., surveyed 462 country elevators of various sizes for the period 1968-69. From this survey it was determined that the average operating cost of handling a bushel of grain in Prairie elevators was inversely related to the amount of bushels handled.[79] The equations by capacity size strata are presented in Table III.

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[78] G. Moore, *op. cit*., pp. 25-26.

[79] Tangri, Zasada, and Tyrchniewicz, *op. cit*.

TABLE III

AVERAGE OPERATING COST EQUATIONS FOR COUNTRY ELEVATORS OF VARIOUS CAPACITIES

Capacity Size Group (bushels)	Estimated Equation[a]	R^2
1. 80,000 & less	A.O.C. = 2.317 + 701.22(1/x) (49.74)	0.74
2. 80,000 - 99,999	A.O.C. = 2.110 + 816.10(1/x) (63.51)	0.71
3. 100,000 - 119,999	A.O.C. = 1.420 + 1,062.60(1/x) (68.60)	0.76
4. 120,000 - 139,999	A.O.C. = 1.635 + 1,090.23(1/x) (72.00)	0.78
5. 140,000 - 159,999	A.O.C. = 2.636 + 970.54(1/x) (83.79)	0.71
6. 160,000 & greater	A.O.C. = 2.755 + 1,029.18(1/x) (70.91)	0.64

a) A.O.C. denotes average operating costs. Standard errors appear in parentheses below the regression coefficients. All regression coefficients are significant at the 1 percent level. "x" is amount of bushels handled in thousands.

In the collection cost function it was unnecessary to differentiate between elevators at multiple elevator delivery points. However, it becomes necessary to designate individual elevators for the handling cost function so that an appropriate operating cost equation can be identified and applied, thus permitting the simulated abandonment of individual elevators at multiple elevator delivery points if so desired. In addition, another problem arose with multiple elevator managers. It was concluded that if in the event that one elevator company owned two elevators at a delivery point and both were being operated by one manager, these two elevators should be considered as a single unit. The economic rationale behind this decision is that elevator management salary was found to form a very large portion of operating costs.[80] After making appropriate adjustments, i.e., to set number of elevators equal to number of managers, the number of elevator units in the Boissevain region was reduced to 53.

While this revision decreased the number of elevators at many delivery points, it did not resolve the problem of identifying individual elevators at multiple elevator delivery points. The eventual solution was to estimate the average elevator capacity at a multiple elevator delivery point by aggregating elevator capacities and dividing by the number of elevators. This average capacity is then used in choosing the appropriate elevator operating cost equation. Total farmer deliveries to the delivery point are also averaged by the number of elevators at the delivery point and an estimate of the average operating cost made. The average cost estimate of the average capacity elevator with average handlings is then multiplied by total delivery point receipts to get total operating costs for the delivery point. To permit the simulation of the closing down of one or more elevators at a multiple elevator delivery point, new averages

[80] Tangri, Zasada, Tyrchniewicz, _op_. _cit_.

are taken excluding the closed elevators.

An alternative method to this averaging technique was considered which involved allocating grain deliveries to individual elevators at multiple-elevator delivery points on a proportional-capacity basis. That is, if an elevator had 20 percent of the total delivery point elevator capacity, it was assumed this elevator would receive 20 percent of farmer deliveries. The advantage of this approach was that each elevator could be assigned an individualized elevator operating cost equation. However, after manually testing this alternative little advantage was gained over the averaging method in terms of estimating elevator operating costs. In addition, the manual exercise demonstrated that to incorporate the proportional-capacity formula into the computer simulation model presented an extremely complex programming problem. It was concluded that additional programming costs and computer running time appeared to outweigh the marginal benefits. However this is not to say that the proportional-capacity method should be excluded from further refinements of the model; its inclusion would contribute to the realism of the simulation framework.

An alternative handling cost measure is the handling rate charged to farmers by the Canadian Wheat Board. For crop years 1970-71 and 1971-72 this handling rate was 5.75 cents per bushel for wheat and barley and 4.50 cents per bushel for oats. For the purpose of simulation, the rate of 5.75 cents per bushel was assumed to apply to all grains.

Data Requirements of the Grain Distribution Process

The purpose of the distribution function is to estimate the cost of transporting grain from the Boissevain region to Thunder Bay, Ontario. The distribution cost component, depending on the desired result, can either be the cost of distribution to the farmer or the cost of distribution to the railway. If it is the former, Crows Nest Pass rates apply. If the latter, estimates of the railway's cost of transporting grain are required.

Crows Nest Pass rates are published for each delivery point in hundred-weight units. The only modification required to use rail rates in the simulation was to convert from hundred-weights to bushels. The estimation of rail costs, on the other hand is extremely difficult. The reliability of rail cost estimates is almost always questioned depending upon one's viewpoint and the source of the estimates. If the source is the railway itself, rail cost estimates are typically considered to be over-estimated. Rail cost estimates were provided through the publication of the Grains Group results.[81] The source of these estimates were the Canadian Pacific Railway and the Canadian National Railway.

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[81] *Grain Handling and Transportation Costs in Canada*, *op. cit.*

The railways suggested that the average rail cost incurred in transporting a bushel of grain from the Prairies was 29.9 cents per bushel compared to the average Crows Nest Pass rate of 12.5 cents per bushel. Using these Prairie averages, and relating them to the average Crows Nest Pass rate in the Boissevain region of 9.75 cents per bushel, the average rail cost in the Boissevain region was determined to be 23.32 cents per bushel. The Crows Nest Pass rates and rail costs by delivery point are given in Table IV.

The estimated rail costs per bushel shown in Table IV are grain distribution costs under the existing rail distribution system. However, as light density lines are abandoned it can be expected that these costs will decrease. That is, the rail companies have suggested that the cost per bushel to maintain the current light density line system is 5.7 cents or roughly 19 percent of total railway transportation costs (29.9 cents).[82] The cost savings to the railway from abandoning a light density line may therefore be estimated to be 5.7 cents per bushel times the number of bushels delivered to and distributed from delivery points located on light density lines. Said another way, for the Prairies as a whole, for each bushel transferred off a light density line onto a non-light density line results in a

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[82] Ibid., See schedule 5.

TABLE IV

CROWS NEST PASS RATES AND ESTIMATED RAIL COSTS TO THUNDER BAY FOR DELIVERY POINTS IN THE BOISSEVAIN REGION OF MANITOBA

Delivery Point	Crow Rate/Bu.[a] (¢)	Rail Cost/Bu.[a] (¢)
1 Belleview	9.90	23.68
2 Boissevain	8.80	21.05
3 Broomhill	9.90	23.68
4 Coulter	9.90	23.68
5 Cranmer	9.90	23.68
6 Croll	9.35	22.37
7 Dalny	9.90	23.68
8 Dand	9.90	23.68
9 Deloraine	9.90	23.68
10 Elgin	9.90	23.68
11 Fairfax	9.35	22.37
12 Goodlands	9.90	23.68
13 Hartney	9.90	23.68
14 Lauder	9.90	23.68
15 Leighton	9.90	23.68
16 Linklater	9.90	23.68
17 Lyleton	9.90	23.68
18 Medora	9.90	23.68
19 Melita	9.90	23.68
20 Mentieth	9.90	23.68
21 Minto	8.80	21.05
22 Napinka	9.90	23.68
23 Newstead	8.80	21.05
24 Pierson	9.90	23.68
25 Pipestone	9.90	23.68
26 Regent	9.90	23.68
27 Reston	9.90	23.68

TABLE IV (continued)

Delivery Point	Crow Rate/Bu.[a] (¢)	Rail Cost/Bu.[a] (¢)
28 Sinclair	9.90	23.68
29 Souris	9.35	22.37
30 Tilston	9.90	23.68
31 Waskada	9.90	23.68

[a]Based on a composite weight of 55 pounds per bushel

saving of 5.7 cents. This is basically the method used in estimating savings due to rail line abandonment in the CHAD model. That is, from one simulated light density line abandonment to the next the number of bushels diverted to main lines is determined and multiplied by a cost savings per bushel. Assuming that maintenance costs of light density rail lines are proportional to distance from market and therefore proportional to the regions Crows Nest Pass rates, the cost savings per diverted bushel in the Boissevain region was estimated to be 4.4 cents or 19 percent of 23.32 cents. Another alternative would be to assign the constant cost of 5.7 cents per bushel to all light density lines on the Prairies. This alternative was rejected because the 5.7 cents per bushel figure would suggest that a very high proportion of rail costs may be assigned to the cost of maintaining light density lines located near markets. It was believed that the opposite would more than likely be the case in that branch lines near-to-market would tend to have greater accessibility to materials and labor. In any event, the aggregate rail cost savings from the abandonment of a light density line is then distributed throughout the Boissevain region lowering rail distribution costs for each delivery point proportionally.

How much rail distribution costs are lowered depends on whether the diverted bushel ends up on a mainline delivery point in the same rate district or not. If a bushel is diverted from a light density line delivery point located in a low rate district (therefore low cost) to a mainline delivery point located in a high rate district the full 4.4 cent savings will not be realized. The cost savings of the diverted bushel is partially offset by a higher rail distribution cost. On the other hand, a larger saving would occur if not only was the bushel diverted from a light density line delivery point to a mainline delivery point but the mainline delivery point was located in a lower rate (cost) district (i.e., closer to market). The only case in which there would be an exact 4.4 cents per bushel saving is when a bushel is diverted from a light density line delivery point to a mainline delivery point and both are located in equal rate districts.

As an example, assume a bushel is diverted from Minto, Manitoba which is located in a rail cost district of 21.03 cents per bushel to Hartney, Manitoba, which is located in a cost district of 23.66 cents per bushel. Due to the abandonment of the light density "Hartney line" the railway has saved 4.4 cents on this diverted bushel. However, it now costs the railway an additional 2.63 cents (23.66¢ - 21.03¢) to transport this bushel to Thunder Bay. The net savings is therefore only 1.77 cents. On the revenue side things become rather complicated with the introduction of Crows Nest Pass rates. Assuming costs are proportional to Crows Nest Pass rates, the railway was losing 12.23 cents for each bushel transported from Minto to Thunder Bay (21.03 cents - 8.80 cents). For each bushel transported from Hartney to Thunder Bay the railway loses 13.76 cents (23.66 cents - 9.90 cents). By diverting a bushel from Minto to Hartney the railway increases its revenue by 1.10 cents while increasing its costs 1.53 cents. However, due to the abandonment of the "Hartney line" the railway saves 4.4 cents per bushel with the end result being a net savings of 2.87 cents per diverted bushel. The overall net gain of the railway is net cost savings of 2.87 cents per bushel plus additional revenue of 1.10 cents per bushel or 3.97 cents.

Under the afore-stated assumptions and conditions this is the worst that can happen to the railways by rationalization. A diversion to equal cost districts or lower cost districts result in higher savings. Reversing the diversion so that a bushel goes from Hartney to Minto the railway realizes a net savings of 5.93 cents per bushel (1.53 cents + 4.40 cents). The overall gain by the railway in this situation is a net cost saving of 5.93 cents per bushel less loss in revenue of 1.10 cents per bushel or 4.83 cents per bushel.

DESCRIPTION OF THE STUDY AREA

The area selected for the simulation of the grain collection, handling and distribution system is the Boissevain region of Southwestern Manitoba. (See Figure 1.) Data utilized in the simulation were supplied by the Canadian Transport Commission for the crop year 1970-71. This data included information on age and gross vehicle weight of trucks owned by Boissevain farmers in the area and distances between each farm and each delivery point in the study area. There were 2,187 farmers and 31 delivery points included in this study.

General and Agricultural Characteristics

The Boissevain grain-growing region of Southwestern Manitoba covers approximately 3,000 square miles with the province of Saskatchewan bounding in on the West and the United States on the South. The northern and eastern boundaries are formed by including in the study area all farmers with seeded and quota acreage assigned to delivery points within the study area. More specifically, the Boissevain region, as defined here, is composed of the following rural municipalities: Albert, Arthur, Brenda, Cameron, Edward, Glenwood, Morton, Pipestone, Sifton, Whitewater and Winchester. The larger towns in the area are Hartney, Deloraine, Melita, Souris and Boissevain. The population of the study area is approximately 15,000 with

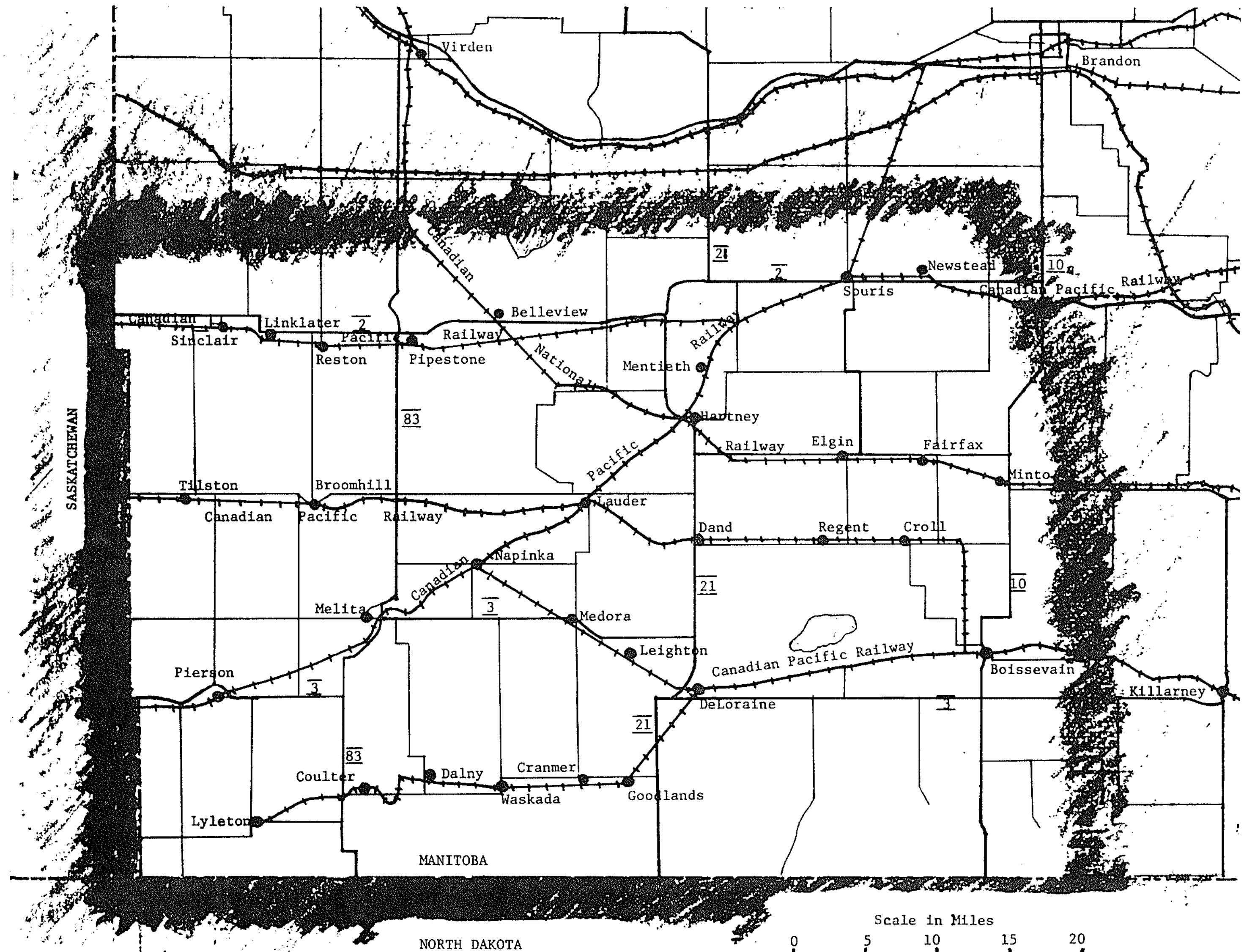

FIGURE 1

THE STUDY REGION: THE BOISSEVAIN GRAIN GROWING REGION OF SOUTHWESTERN MANITOBA more than half of these people living on farms.[83]

Eighty-five percent of the seeded acreage in the region is typically devoted to the production of wheat, oats, barley and flax. For example, during the 1971-72 crop year, 32.3 percent of seeded acreage in the region was wheat, 22.6 percent was barley, 15.7 percent was flax and 14.2 percent was oats.[84] In this regard, the Boissevain region is representative of other grain growing regions in Western Canada. Taking 3,000 square miles as a rough estimate of the geographic size of the Boissevain region, only 300,000 acres of land is not farm land. That is, 85 percent of the Boissevain region is farm land. Of this farm land over half was seeded to wheat, oats, barley, flax, durum, rye, rapeseed and miscellaneous crops, leaving the rest in summerfallow, perennial forage and uncultivated pasture for crop year 1971-72. The typical farm in the study area would be approximately 700 acres in size of which 117 acres would be seeded to wheat, 51 acres to oats, 82 acres to barley,

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[83] For a more in-depth description of the study area see: J. W. Channon, D. Zasada and R. T. Miller, The Boissevain Region of Manitoba, Prairie Regional Studies in Economic Geography No. 2, Economics Branch, Canada Department of Agriculture, Ottawa, 1968.

[84] Production and farm size information were derived from data found in Final Report of Seeded and Quota Acreage Statistics Processed from 1971-72 Producers Permits issued to February 22nd, 1972, Management Information Services Division, The Canadian Wheat Board, February 29, 1972.

57 acres to flax, 57 acres composed of miscellaneous crops and 336 acres summerfallow, perennial forage and uncultivated pasture.

During the period 1965-66 to 1970-71, marketings to country elevators by farmers in the Boissevain region declined from approximately 13.1 million bushels to 11.3 million bushels, a fall of about 13.6 percent. In comparison, total marketings in Manitoba declined 21.3 percent during this same time period, while marketings for all three prairie provinces declined less than one percent. During the crop year 1965-66 the Boissevain region accounted for 10.8 percent of all marketings in Manitoba and 1.7 percent of all prairie marketings. Five years later, in 1970-71, the Boissevain region increased its percentage of Manitoba marketings to 11.8 percent but fell to 1.5 percent of the prairie total.[85]

<u>Farm to Country Elevator Grain Collection Characteristics</u>

Of the 2,187 farmers identified in the Boissevain region, 1,731, or close to 80 percent, delivered their grain using their own truck. The remaining 20 percent were assumed to hire a custom trucker.

Four characteristics were used in describing the

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[85] The statistics in this paragraph were derived from <u>Summary of Country Elevator Receipts at Individual Prairie Points</u>, Statistics Division, Board of Grain Commissioners for Canada, Crop years 1965-66 to 1970-71.

grain collection process in the Boissevain region: (1) total bushels transported, (2) one-way distance to the elevator, (3) year of the truck and (4) gross vehicle weight of the truck. The first two characteristics apply to both farmers who owned their trucks as well as those that used custom trucking. The average bushels transported by farmers who used their own trucks was 4,108 for crop year 1970-71 (Table V), while the average bushels transported for those farmers hiring custom haulers was 2,779. Close to 50 percent of those farmers hiring custom truckers had less than 2,000 bushels to deliver while nearly 50 percent of those farmers using their own truck delivered more than 5,000 bushels during crop year 1970-71.

The average one-way distance for farmers who owned trucks was 5.25 miles and 5.33 miles for those that used custom truckers (Table VI). The distribution among the five distance strata are remarkably similar for both farmer-owned trucks and custom users. Considering all farmers, 43 percent delivered their grain between 3.1 and 6.0 miles, but only 2.5 percent delivered their grain more than 12 miles. There was very little variation in size of truck (as measured by gross vehicle weight) for varying distances.

The last two characteristics, year and gross vehicle weight of trucks, apply only to farmer-owned trucks. The average year of farmer-owned trucks, in the Boissevain region was 1959 (Table VII). Generally, the newer the truck the

TABLE V

AVERAGE NUMBER OF BUSHELS TRANSPORTED AND NUMBER OF TRUCKS FOR FARMERS OWNING TRUCKS AND FARMERS USING CUSTOM TRUCKERS

	Total Bushels Transported							
	0- 2,000	2,001- 4,000	4,001- 6,000	6,001- 8,000	8,001- 10,000	10,001- 15,000	15,001 and over	Total all Trucks
Farmers owning trucks:								
Average bushels transported	1,084	2,918	4,918	6,906	8,828	11,718	21,046	4,108
Number in stratum	492	527	346	183	102	57	24	1,731
Farmers using custom truckers:								
Average bushels transported	1,050	2,866	4,874	6,760	8,609	11,587	15,855	2,779
Number in stratum	216	139	55	27	11	7	1	456

TABLE VI

AVERAGE ONE-WAY DISTANCE, NUMBER OF TRUCKS AND SIZE OF TRUCK FOR FARMERS OWNING TRUCKS AND FARMERS USING CUSTOM TRUCKERS

	One-Way Distance to Elevator					
	0.0-3.0	3.1-6.0	6.1-9.0	9.1-12.0	12.1 and over	Total all Trucks
Farmers owing trucks:						
Avg. one-way distance to elevator	2.01	4.55	7.28	10.16	15.13	5.25
Number in stratum	406	752	406	126	41	1,731
Average size of truck (GVW)	11,166	11,572	11,184	10,417	13,829	11,355
Farmers using custom truckers:						
Avg. one-way distance to elevator	1.86	4.49	7.31	10.10	14.48	5.33
Number in stratum	107	188	106	42	13	456

TABLE VII

AVERAGE YEAR OF TRUCK, NUMBER OF TRUCKS, AVERAGE BUSHELS TRANSPORTED AND AVERAGE SIZE OF TRUCK FOR FARMERS OWNING TRUCKS

	Year of Truck					
	1949 and older	1950-1954	1955-1959	1960-1964	1965 and newer	Total all Trucks
Average year of truck	1947	1952	1957	1962	1967	1959
Number in stratum	208	368	260	322	573	1,731
Average bushels transported	3,213	3,376	4,267	4,459	4,631	4,108
Total bushels transported	668,221	1,242,625	1,109,609	1,435,901	2,653,991	7,110,347
Average size of truck (GVW)	11,061	9,612	12,137	12,117	11,798	11,355

larger was its gross vehicle weight. Also, the newer the truck, the higher was the utilization rate in terms of bushels transported. Approximately 60 percent of the bushels transported by farmer-owned trucks was transported in trucks newer than 1959. Approximately 9 percent of all bushels transported in farmer-owned trucks was transported in trucks older than 1950. The average size of farmer-owned trucks, in terms of gross vehicle weight, was 11,355 pounds (Table VIII). However, close to 50 percent of these trucks were less than 9,000 pounds gross vehicle weight. The newer trucks were generally either very light (0-6,000 pounds gross vehicle weight) or very heavy (22,001 pounds and over gross vehicle weight). As would be expected, the heavier the truck the higher was average bushels transported.

Country Elevator Characteristics

In 1970-71 the Boissevain region as defined here contained 31 delivery points. Situated at these delivery points were 67 country elevators operated by 53 managers (Table IX). This implies that many of the delivery points have more than one elevator and some managers operate more than one elevator.

There are many characteristics which differentiate one elevator or delivery point from another other than location and name. A few of these characteristics are: (1) ownership of the elevator, (2) capacity of the elevator,

TABLE VIII

AVERAGE SIZE OF TRUCK, NUMBER OF TRUCKS, AVERAGE BUSHELS TRANSPORTED AND AVERAGE YEAR OF TRUCK FOR FARMERS OWNING TRUCKS

	Size of Truck (Gross Vehicle Weight)						
	6,000 and less	6,001-9,000	9,001-12,000	12,001-16,000	16,001-22,000	22,001 and over	Total all Trucks
Average size of truck	5,755	7,878	10,262	14,863	19,686	26,581	11,355
Number in stratum	364	466	303	293	244	61	1,731
Average bushels transported	2,976	3,217	3,937	4,598	6,005	8,548	4,108
Average year of truck	1962	1955	1960	1955	1961	1964	1959

TABLE IX

COUNTRY ELEVATOR CHARACTERISTICS OF THE BOISSEVAIN REGION OF MANITOBA 1970-1971

Name of Delivery Point	Ownership of Elevator[a]	Capacity of Elevator	Railway Servicing	No. of Boxcars That Can Be Shunted at One Time
Belleview	MPE	20,000	CN	5
Boissevain	MPE	133,600	CP	6 (with next row)
"	MPE	95,000	CP	
"	P&H	38,000	CP	3
"	NMPS	153,500	CP	4
"	UGG	140,000	CP	7
Broomhill	MPE	24,000	CP	10
Coulter	MPE	50,000	CP	8
Cranmer	UGG	57,000	CP	8 (with next row)
"	UGG	27,000	CP	
Croll	MPE	77,500	CP	6
Dalny	MPE	96,200	CP	11 (with next row)
"	MPE	65,000	CP	
Dand	MPE	57,500	CP	10
Deloraine	FG	117,900	CP	5
"	MPE	97,600	CP	8 (with next row)
"	MPE	55,000	CP	

(continued)

TABLE IX (continued)

Name of Delivery Point	Ownership of Elevator[a]	Capacity of Elevator	Railway Servicing	No. of Boxcars That Can Be Shunted at One Time
Deloraine	UGG	105,000	CP	4
Elgin	MPE	106,700	CN	10
"	NMPS	82,800	CN	8
"	UGG	78,000	CN	5
Fairfax	MPE	81,400	CN	6
"	NMPS	88,800	CN	3
"	UGG	85,000	CN	4
Goodlands	FG	75,500	CP	3
"	MPE	85,900	CP	} 11
"	MPE	82,000	CP	
Hartney	MPE	61,900	CN	} 5
"	MPE	49,500	CN	
"	UGG	105,000	CP	} 16
"	UGG	50,000	CP	
Lauder	MPE	72,700	CP	} 8
"	MPE	22,000	CP	
Leighton	MPE	50,500	CP	6
Linklater	MPE	95,900	CP	10

(continued)

TABLE IX (continued)

Name of Delivery Point	Ownership of Elevator[a]	Capacity of Elevator	Railway Servicing	No. of Boxcars That Can Be Shunted at One Time
Lyleton	MPE	128,200	CP	4
"	UMPS	70,900	CP	5
Medora	MPE	177,200	CP	9
"	UGG	131,000	CP	9
Melita	MPE	124,000	CP	9 (both)
"	MPE	58,000	CP	
"	UGG	119,000	CP	3
Mentieth	MPE	78,200	CP	8
Minto	MPE	113,700	CN	4
"	NMPS	99,500	CN	10
"	UGG	83,000	CN	4
Napinka	MPE	54,500	CP	15 (both)
"	MPE	66,000	CP	
Newstead	UGG	54,000	CP	5
Pierson	MPE	137,500	CP	9 (both)
"	MPE	35,000	CP	
"	NMPS	128,000	CP	6

(continued)

TABLE IX (continued)

Name of Delivery Point	Ownership of Elevator[a]	Capacity of Elevator	Railway Servicing	No. of Boxcars That Can Be Shunted at One Time
Pipestone	MPE	61,600	CP	6
"	UGG	55,000	CP	8
Regent	MPE	88,200	CP	7
Reston	MPE	84,500	CP	8
"	UGG	105,000	CP	4
Sinclair	MPE	151,400	CP	15
"	MPE	25,000	CP	
Souris	MPE	182,600	CP	6
"	MPE	28,000	CP	
"	UGG	320,000	CP	12
Tilston	MPE	106,200	CP	12
"	MPE	57,500	CP	
Waskada	MPE	99,300	CP	11
"	MPE	55,000	CP	
"	NMPS	120,300	CP	11

[a]Elevator company ownership abbreviations:

MPE Manitoba Pool Elevators
UGG United Grain Growers
FG Federal Grain Ltd.
P&H Parrish and Heimbecker Ltd.
NMPS N. M. Paterson and Sons Ltd.

(3) railway servicing the elevator, and (4) an estimate of the length of rail siding available at the elevator. As will be mentioned later, these characteristics could be important as possible constraints in grain transportation rationalization. Another important characteristic of a delivery point is whether it is a competitive point or a non-competitive point. A competitive point has representation from more than one elevator company, while a non-competitive point is a single company monopoly. The Boissevain region has an approximately equal share of both types of points.

Five elevator companies owned and operated the 67 country elevators in the Boissevain region in 1970-71. Of the 67 licensed elevators, Manitoba Pool Elevators owned 42, United Grain Growers 15, N. M. Paterson and Sons 7, Federal Grain 2 and Parrish and Heimbecker 1. Total elevator capacity in the region was 5,880,700 bushels, of which Manitoba Pool owned 57.7 percent, UGG 25.7 percent, N. M. Paterson and Sons 12.7 percent, Federal Grain 3.3 percent and Parrish and Heimbecker less than one percent. In 1970-71 there were 15 competitive points and 16 single company monopolies in the Boissevain region. Of the 16 single company points, 14 were controlled by Manitoba Pool Elevators and two by United Grain Growers.

In recent crop years, close to fifty percent of all bushels handled in the area were handled at the larger delivery points of Boissevain, Deloraine, Elgin, Hartney, Medora, Melita, Pierson and Souris.[86] In addition, 50 percent of area elevator capacity was located at these eight large delivery points. Yet, while these eight large delivery points typically received 50 percent of farmer country elevator marketings, only 27 elevators (less than 40 percent of area total) were located at these points. In other words, 23 delivery points (75 percent of area total) and 40 elevators (60 percent of area total) accounted for the remaining 50 percent of farmer marketings. All eight of the large delivery points mentioned above were competitive points in 1970-71. Over 70 percent of the remaining 23 delivery points, on the other hand, were non-competitive single company monopolies in 1970-71.

Another important characteristic of country elevators is the number of railway grain cars that can be shunted at one time. This parameter would be a measure of the size of railway siding available at a particular elevator and an indication of how much grain can be released from the elevator, loaded into waiting rail cars, and moved to market. Typically, once siding space becomes available, empty rail cars are ordered by elevator company management and delivered by the railway servicing the elevator. In 1968, elevators in the

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[86] Delivery point handling data for crop year 1970-71 may be found in Table XXXV, page 183, column 6.

Boissevain region could handle a maximum of 393 rail cars at any one time, or an average of 12 per delivery point and 6 per elevator. The delivery point with the largest rail car capacity was Elgin, capable of spotting and shunting 23 rail cars at one time. The smallest delivery points were Newstead and Belleview where only 5 rail cars could be handled at one time. The average single company delivery point was capable of shunting 8.5 rail cars at a time, while the average competitive point could shunt 16.5 rail cars at one time.

Railway Characteristics

Like most areas of the Prairies, the Boissevain region contains a complicated web of rail lines--roughly 275 miles of track in 3000 square miles. The railway companies categorize their sections of track as either being light density or not light density. According to their definition a rail line is categorized as light density if, during a year, traffic is less than 100,000 net tons per mile. A non-light density line is usually a main line carrying more than 100,000 net tons per mile per year. If a rail line is light density its economic viability is called to question and legal steps can be initiated toward its eventual abandonment. Using the 100,000 net ton definition, 80 percent of the rail network in the Boissevain region may be categorized as light density. Dependent upon this rail network, at least to some extent, are approximately 15,000 people and 40 communities of various sizes. While both Canadian National Railways and Canadian Pacific Railways operate lines in the Boissevain region, Canadian National operates less than 15 percent of the region's total rail line mileage. The two rail sections it does operate are both light density. The Canadian Pacific operates the only non-light density line in the region.

There are eight rail sections in the Boissevain region, all of which are light density lines with the exception of the C.P.R. owned "Estevan" line (Table X).[87] These sections are defined in regard to their originating delivery point and their terminal delivery point. For the purposes of this study, each section is assumed "abandonable" as a defined rail line unit.

The C.N.R. owned "Belleview" line and the C.P.R. owned "Boissevain" line (as of this date) are unprotected lines and the respective railways have applied for their abandonment to the Canadian Transport Commission. The C.N.R. owned "Hartney" line and the C.P.R. owned "Lyleton" line are protected from abandonment until 1975 under authority of

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[87]The "Napinka" line is not considered as a light density traffic line by the Grains Group. See Exhibit 2 in Grain Handling and Transportation Costs in Canada, Grains Group, August, 1971. The Grains Group might have been influenced by the fact that the larger towns of Boissevain and Deloraine are located on the "Napinka" line.

TABLE X

DEFINITION AND CHARACTERISTICS OF RAIL SECTIONS IN THE BOISSEVAIN REGION AS USED IN THIS STUDY

Rail Section	Delivery Points on Rail Section	Number of Elevators at Delivery Point	Aggregate Elevator Capacity at Delivery Point (Bushels)
Alida (CPR)	Broomhill	1	24,000
	Tilston	2	163,700
Total		3	187,700
Arcola (CPR)	Pipestone	2	116,600
	Reston	2	189,500
	Linklater	1	95,900
	Sinclair	2	176,400
	Newstead	1	54,000
Total		8	632,400
Belleview (CNR)	Belleview	1	20,000
Total		1	20,000
Boissevain (CPR)	Croll	1	77,500
	Regent	1	88,200
	Dand	1	57,500
Total		3	249,800

(continued)

TABLE X (continued)

Rail Section	Delivery Points on Rail Section	Number of Elevators at Delivery Point	Aggregate Elevator Capacity at Delivery Point (Bushels)
Estevan (CPR)	Souris	3	530,600
	Mentieth	1	78,200
	Hartney	2	155,000
	Lauder	2	94,700
	Napinka	2	120,500
	Melita	3	301,000
	Pierson	3	300,500
Total		16	1,580,500
Hartney (CNR)	Minto	3	296,200
	Fairfax	3	255,200
	Elgin	3	267,500
	Hartney	2	111,400
Total		11	930,300
Lyleton (CPR)	Lyleton	2	199,100
	Coulter	1	50,000
	Dalny	2	161,200
	Waskada	3	274,600
	Cranmer	2	84,000
	Goodlands	3	243,400
Total		13	1,012,300

(continued)

TABLE X (continued)

Rail Section	Delivery Points on Rail Section	Number of Elevators at Delivery Point	Aggregate Elevator Capacity at Delivery Point (Bushels)
Napinka (CPR)	Boissevain	5	560,100
	Deloraine	4	375,500
	Leighton	1	50,500
	Medora	2	308,200
Total		12	1,294,300
Boissevain Region Total		67	5,880,700

order in council PC-1967-880 but have been applied for abandonment by the railways after this protection has been withdrawn. While light density lines by definition, the C.P.R. has not made application to abandon its "Napinka," "Alida" or "Arcola" lines.

In terms of percentage of area grain delivered to on-line elevators, the "Napinka," "Alida" and "Arcola" lines were regional growth lines during the period 1965-66 to 1970-71. Grain receipts at elevators situated on the "Napinka" line has increased from 22.4 percent of total area grain receipts in 1965-66 to 23.1 percent in 1970-71; the "Alida" line increased its share of area grain receipts from 4.3 percent in 1965-66 to 4.7 percent in 1970-71; the "Arcola" line had 13.0 percent of total area grain receipts in 1965-66 compared to its 1970-71 share of 14.0 percent. The "Estevan" line, the only non-light density line in the region, increased its share of area grain receipts by more than one percent, from 23.6 percent in 1965-66 to 24.7 percent in 1970-71. However, it is interesting to note that the C.N.R. owned "Hartney" line, designated for abandonment, had a more significant growth in area grain receipts during this six year period than any other rail line in the Boissevain region, from 13.6 percent in 1965-66 to 16.3 percent in 1970-71. In fact, the "Hartney" line, which runs from Minto to Hartney, is the only line which had an absolute increase in area grain receipts during this period. Solely in terms of grain receipts on-line, the threatened "Hartney" line is "better" than the "safe" "Alida" or "Arcola" lines.

If both railways are successful in their currently pending abandonment applications, the "Lyleton," "Boissevain," "Hartney" and "Belleview" lines will be withdrawn from the grain collection, handling and distribution system in the Boissevain region. There will be at least two absolute losses if these lines are withdrawn. The first would be the disappearance of over 100 miles of track or 40 percent of total area rail line. The second absolute loss would involve the dissolution of 13 delivery points, seven of which are competitive points, 27 elevators and over two million bushels of elevator capacity. In addition to these more obvious physical losses there will be cost and distance effects on the collection, handling and distribution system itself.

CHAPTER V

EMPIRICAL RESULTS OF THE SIMULATIONS

Three basic types of simulations are presented in this chapter: (1) Rail line abandonment simulations, (2) simulation of changes in the collection procedure in conjunction with rail line abandonment simulations and (3) simulation of the Grains Group "benchmark" systems in the Boissevain region. In addition, rail line abandonment simulations and simulated changes in the collection procedure are performed with two institutional changes: (1) handling rates and operating costs and (2) rail rates and rail costs. Simulation with the Grains Group benchmark systems incorporates two technological changes: (1) the construction of new elevators and (2) the use of unit trains.

RAIL LINE ABANDONMENT SIMULATIONS

A great deal of flexibility has been built into the CHAD simulation model to allow for the simulated abandonment of entire rail lines, delivery points and/or individual elevators. Once the existing grain handling system is defined, any type of abandonment rationalization situation is possible. In this set of simulations, light density lines are abandoned one at a time until the system is completely rationalized. The abandonments are presented in an order in which they are likely to occur in the "real world" at some future date as a result of branch line abandonment hearings.

The grain collection, handling and distribution system in the Boissevain region is simulated for two years, 1970-71 and 1971-72. As already mentioned, all data pertains to 1970-71 conditions. The same data are assumed to be representative of 1971-72 conditions. Simulating the 1971-72 system under this limitation permitted the evaluation of the impact of elevator company rationalization. That is, the structure of the country elevator system in the Boissevain region had changed significantly from 1970-71 to 1971-72 in that Manitoba Pool Elevators closed down four delivery points for crop year 1971-72. Essentially, the 1970-71 model was rerun with these four delivery points simulated out of the collection, handling and distribution system.

In summary, four simulations are presented: (1) CHAD system 1970-71, revealed preference assumption,[88] (2) CHAD system 1970-71, minimum cost assumption, (3) CHAD system 1971-72, revealed preference assumption, and (4) CHAD system 1971-72, minimum cost assumption. In addition to simulating the existing system, each of the above systems are

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[88]The revealed preference assumption, as previously discussed on page 85, is the procedure where the model directs farmer deliveries to delivery points known to be preferred by the individual farmer.

rationalized by simulating the abandonment of six light density rail lines, one at a time. In addition, once all light density lines are abandoned, an eighth simulation is run excluding all elevators on the remaining main lines that have less than 100,000 bushel capacity. The empirical results are both in terms of the cost of the system to the farmer (using collection costs, handling rates and rail rates) and the cost of the system in terms of resources utilized (collection costs, handling costs and rail costs).

For rationalization simulation 1970-71, the order in which branch lines are abandoned and the resulting delivery points excluded in each simulation run are shown in Table XI. The light density rail lines, as previously defined (see Table X), that are simulated out of the system, i.e., abandoned, for simulations 1 through 8 are:

Sim 1. This is a simulation of the collection, handling and distribution system as it existed for crop year 1970-71 in the Boissevain region. That is, all elevators and rail lines that were in existence in 1970-71 are included in this initial simulation.

Sim 2. This is the first simulation of the abandonment of a light density rail line. This is a simulation of the collection, handling and distribution system in the Boissevain region when the "Belleview" line is abandoned.

Sim 3. Light density lines abandoned: "Belleview" and "Boissevain" lines.

TABLE XI

DELIVERY POINTS INCLUDED IN RATIONALIZATION SIMULATIONS 1970-71

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Belleview	x							
Boissevain	x	x	x	x	x	x	x	x
Broomhill	x	x	x					
Coulter	x	x	x	x				
Cranmer	x	x	x	x				
Croll	x	x						
Dalny	x	x	x	x				
Dand	x	x						
Deloraine	x	x	x	x	x	x	x	x
Elgin	x	x	x	x	x	x		
Fairfax	x	x	x	x	x	x		
Goodlands	x	x	x	x				
Hartney	x	x	x	x	x	x	x	x
Lauder	x	x	x	x	x	x	x	
Leighton	x	x	x	x	x	x	x	
Linklater	x	x	x	x	x			
Lyleton	x	x	x	x				
Medora	x	x	x	x	x	x	x	x
Melita	x	x	x	x	x	x	x	x
Mentieth	x	x	x	x	x	x	x	
Minto	x	x	x	x	x	x		
Napinka	x	x	x	x	x	x	x	x
Newstead	x	x	x	x	x	x	x	
Pierson	x	x	x	x	x	x	x	x
Pipestone	x	x	x	x	x			
Regent	x	x						

TABLE XI (continued)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Reston	x	x	x	x	x			
Sinclair	x	x	x	x	x			
Souris	x	x	x	x	x	x	x	x
Tilston	x	x	x					
Waskada	x	x	x	x				

Sim 4. Light density lines abandoned: "Belleview," "Boissevain," and "Alida" lines.

Sim 5. Light density lines abandoned: "Belleview," "Boissevain," "Alida," and "Lyleton" lines.

Sim 6. Light density lines abandoned: "Belleview," "Boissevain," "Alida," "Lyleton" and "Arcola" lines.

Sim 7. Light density lines abandoned: "Belleview," "Boissevain," "Alida," "Lyleton," "Arcola" and "Hartney" lines.

Sim 8. This simulation includes only those elevators on the remaining lines ("Estevan" and "Napinka") which are greater than 100,000 bushel capacity. The rationale underlying the inclusion of only the larger elevators in the region was the opinion that if existing facilities could form the grain handling system of the future they would likely be the larger units.

CHAD System 1970-71, Revealed Preference Assumption[89]

The revealed preference assumption permits a very accurate representation of the existing grain collection, handling and distribution system in the Boissevain area.

Using elevator handling rates and railway rates, the cost of the grain collection, handling and distribution

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[89]The effect of rail line abandonment on handling and distribution costs, bushels handled and handling-to-capacity ratios is given in Appendix C by delivery point.

system to Boissevain farmers in 1970-71, under revealed preference, was 18.29 cents per bushel (Tables XII and XIV).

After rationalization and assuming handling rates and rail rates remain the same, farmers in the Boissevain region can expect to pay on the average 19.63 cents per bushel for the collection, handling and distribution of their grain. Rationalization would therefore increase farmer's costs on the average 1.34 cents per bushel or a little over 7 percent.

The cost in resources utilized to operate the grain collection, handling and distribution system in the Boissevain region in 1970-71 under the revealed preference assumption was 33.95 cents per bushel or $2,845,211 (Tables XIII and XIV). A rationalized system would cost 29.92 cents per bushel or a saving of 4.03 cents per bushel. After rationalization, collection costs would be 48 percent higher, elevator operating costs 40 percent lower and rail costs 10 percent lower.

Under the revealed preference assumption, Boissevain farmers travel an average of 6.6 miles to the elevator of their choice (Table XV). After all light density rail lines in the Boissevain region have been abandoned, average one-way distance to elevator increases to 11.7 miles.

Table XV and similar tables to follow (Tables XIX, XXIII, and XXVII) indicate the percentage of farmers and bushels diverted as a measure of the disruptive impact of abandoning a particular rail line. For example, with specific reference to Table XV, the abandonment of the "Belleview" line (Sim 2) will cause to divert only 0.8 percent of Boissevain farmers and 0.4 percent of Boissevain bushels to alternative delivery points. Also, to further clarify the interpretation of these tables, the abandonment of the "Lyleton" line (Sim 5) and assuming the prior abandonment of the "Belleview," "Boissevain" and "Alida" lines, will cause to divert 14.4 percent of Boissevain farmers and 12.4 percent of Boissevain bushels. In other words, these percentages are not cumulative from Sim 1 to Sim 8 in the sense that one can add them and get a measure of the total effect of rationalization. Rather they are intermediate measures of the effect of abandoning a particular rail line which occurs within a specified sequence of rail line abandonments. Under the revealed preference assumption the abandonment of the "Arcola" line would be most disruptive in terms of both farmers and bushels.

TABLE XII

COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1970-71, REVEALED PREFERENCE ASSUMPTION, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8 (Handling Rates and Distribution Rates) (Dollars)

Simulation	Collection Costs	Handling Costs	Distribution Costs	CHAD Total Costs
1	242,521	481,717	808,846	1,533,085
2	242,967	481,717	808,846	1,533,531
3	248,319	481,717	808,962	1,538,999
4	245,498	481,717	808,925	1,536,141
5	267,619	481,717	808,925	1,558,262
6	333,218	481,717	808,925	1,623,862
7	357,725	481,717	804,821	1,644,265
8	368,231	481,717	806,808	1,656,757

TABLE XIII

COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1970-71, REVEALED PREFERENCE ASSUMPTION, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8
(Handling Costs and Distribution Costs)
(Dollars)

Simulation	Collection Costs	Handling Costs	Distribution Costs	CHAD Total Costs
1	242,521	667,934	1,934,756	2,845,211
2	242,967	660,922	1,934,756	2,838,646
3	248,319	637,920	1,928,627	2,814,867
4	245,490	619,910	1,923,363	2,788,771
5	267,619	538,328	1,877,248	2,683,195
6	333,218	485,659	1,814,205	2,633,083
7	357,725	402,520	1,747,057	2,507,303
8	368,231	368,579	1,748,456	2,485,266

TABLE XIV

AVERAGE COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1970-71, REVEALED PREFERENCE ASSUMPTION, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8 (Cents/bushel)

Simulation	Collection AC/BU (1)	Handling AC/BU (2)	Distribution AC/BU (3)	Handling Rate/bu. (4)	Distribution Rate/bu. (5)	Farmer Costs (1+4+5)	Resource Costs (1+2+3+)
1	2.89	7.97	23.09	5.75	9.65	18.29	33.95
2	2.90	7.89	23.09	5.75	9.65	18.30	33.88
3	2.96	7.61	23.02	5.75	9.66	18.37	33.59
4	2.93	7.40	22.95	5.75	9.66	18.34	33.28
5	3.19	6.14	22.40	5.75	9.66	18.60	32.02
6	3.98	5.80	21.65	5.75	9.66	19.39	31.43
7	4.27	4.80	20.85	5.75	9.61	19.63	29.92
8	4.40	4.40	20.87	5.75	9.63	19.78	29.67

TABLE XV

THE EFFECT OF RATIONALIZATION ON AVERAGE ONE-WAY DISTANCE, AND DIVERSION OF FARMERS AND GRAIN RAIL LINE ABANDONMENT SIMULATIONS 1-8, REVEALED PREFERENCE CONDITION, 1970-71

	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Average one-way Distance (miles)	6.6	6.7	6.9	6.8	7.9	10.8	11.7	12.1
Percent Diversion								
Farmers	0.0	0.8	4.0	5.3	14.4	17.2	11.0	14.1
Bushels	0.0	0.4	4.2	5.0	12.4	17.0	14.8	15.9

<u>CHAD System 1970-71, Minimum Cost/Distance Assumption</u>[90]

Using elevator handling rates and railway rates, the cost of the grain collection, handling and distribution system to Boissevain farmers in 1970-71 (Sim 1) was $1,506,032 or 17.98 cents per bushel (Tables XVI and XVIII). Approximately 14 percent of this total cost was collection costs, 32 percent handling costs and 54 percent distribution costs. After complete rail line rationalization (Sim 7) and assuming handling rates and rail rates remain the same, the cost of the system to the farmer would be $1,637,285 or 19.54 cents per bushel, an increase of nine percent over pre-rationalization costs. Collection costs would now form

[90]The effect of rail line abandonment on handling and distribution costs, bushels handled and handling-to-capacity ratios is given in Appendix D by delivery point.

22 percent of total system costs.

Using elevator operating costs and railway costs, the cost of the collection, handling and distribution system in the Boissevain region in terms of resources utilized in 1970-71 was $2,825,837 or 33.73 cents per bushel (Tables XVII and XVIII). After rationalization the cost of the system decreases to 29.55 cents per bushel, a saving of 13 percent.

Comparing the cost estimates of this simulation with costs derived using the revealed preference assumption insight can be gained into the cost of a farmer's "revealed preference" for a particular delivery point. Average collection costs per bushel with farmers delivering their grain to their preferred delivery point was 18.29 cents. When farmers deliver to the nearest elevator, on the other hand, as in the case assuming minimum cost/distance, average collection costs are 17.98 cents per bushel. Boissevain farmers therefore willingly incurred an extra collection cost of 0.31 cents per bushel to deliver to the delivery point of their choice.

As can be expected, as rail line rationalization proceeds the average one-way distance to elevator increases. Before rationalization, under the minimum collection cost assumption, the average one-way distance to elevator for

Boissevain farmers in 1970-71 was 5.3 miles. After rationalization (Sim 7) this distance more than doubled to 11.4 miles (Table XIX). In addition, as rail lines are abandoned, delivery points are closed down resulting in farmers and bushels being diverted to their nearest alternative delivery point. In terms of the number of farmers being diverted, the abandonment of the "Lyleton" line would be most disruptive (Table XIX). In terms of bushels, however, the greatest diversion would be caused by the abandonment of the "Arcola" line. Abandoning the "Belleview" line would cause the least disruption in farmer delivery patterns.

TABLE XVI

COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1970-71, MINIMUM COST/DISTANCE ASSUMPTION, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8
(Handling Rates and Distribution Rates)
(Dollars)

Simulation	Collection Costs	Handling Costs	Distribution Costs	CHAD Total Costs
1	213,370	481,717	810,944	1,506,032
2	214,256	481,717	810,944	1,506,918
3	223,377	481,717	811,152	1,516,246
4	230,904	481,717	809,802	1,522,424
5	257,230	481,717	809,802	1,548,750
6	323,883	481,717	809,802	1,615,403
7	350,394	481,717	805,173	1,637,285
8	364,233	481,717	807,625	1,653,576

TABLE XVII

COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1970-71, MIMINUM COST/DISTANCE ASSUMPTION, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8 (Handling Costs and Distribution Costs) (Dollars)

Simulation	Collection Costs	Handling Costs	Distribution Costs	CHAD Total Costs
1	213,370	672,698	1,939,769	2,825,837
2	214,256	665,683	1,939,574	2,819,513
3	223,377	641,524	1,924,999	2,789,901
4	230,904	623,097	1,914,411	2,768,413
5	257,230	539,548	1,860,374	2,657,153
6	323,883	486,698	1,796,941	2,607,523
7	350,394	402,884	1,722,708	2,475,987
8	364,233	367,305	1,728,278	2,459,817

TABLE XVIII

AVERAGE COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1970-71, MINIMUM COST/DISTANCE ASSUMPTION, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8 (Cents/bushel)

Simulation	Collection AC/BU (1)	Handling AC/BU (2)	Distribution AC/BU (3)	Handling Rate/bu. (4)	Distribution Rate/bu. (5)	Farmer Costs (1+4+5)	Resource Costs (1+2+3)
1	2.55	8.03	23.15	5.75	9.68	17.98	33.73
2	2.56	7.95	23.15	5.75	9.68	17.99	33.66
3	2.67	7.66	22.97	5.75	9.68	18.10	33.30
4	2.76	7.44	22.85	5.75	9.67	18.18	33.05
5	3.07	6.44	22.20	5.75	9.67	18.49	31.71
6	3.87	5.81	21.44	5.75	9.67	19.29	31.12
7	4.18	4.81	20.56	5.75	9.61	19.54	29.55
8	4.35	4.38	20.62	5.75	9.64	19.74	29.35

TABLE XIX

THE EFFECT OF RATIONALIZATION ON AVERAGE ONE-WAY DISTANCE, AND DIVERSION OF FARMERS AND GRAIN RAIL LINE ABANDONMENT SIMULATIONS 1-8, MINIMUM COST/DISTANCE ASSUMPTION, 1970-71

	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Average one-way Distance (miles)	5.3	5.4	5.8	6.1	7.5	10.4	11.4	11.9
Percent Diversion								
Farmers	0.0	1.7	8.2	6.5	17.8	17.4	11.8	20.2
Bushels	0.0	1.5	9.5	6.6	14.6	17.1	15.8	21.7

<u>CHAD System 1971-72, Revealed Preference Assumption</u>[91]

As mentioned earlier, the 1971-72 grain collection, handling and distribution system is assumed identical in structure as the 1970-71 system. There is, however, one major difference, the simulated closing down of four delivery points in the existing system as represented by Sim 1. The four points are Belleview, Broomhill, Coulter and Leighton. Once these four delivery points are excluded at the Sim 1 level, light density rail lines are abandoned as before.

It was determined through revealed preference simulation of system 1970-71 that 89 farmers preferred the delivery

[91]The effect of rail line abandonment on handling and distribution costs, bushels handled and handling-to-capacity ratios is given in Appendix E by delivery point.

points of Belleview, Broomhill, Coulter and Leighton. In simulating the system for 1971-72, with the closing down of these four delivery points, these 89 farmers no longer revealed their preference in the model. The model is so constructed that if a preference is not indicated, the farmer is assumed to prefer the delivery point nearest to him. That is, the minimum collection cost/distance assumption is employed. Therefore, for Sim 1 under the revealed preference assumption, 89 farmers have been directed toward their minimum distance elevator. This may partially explain why, after the closing down of four delivery points, collection costs are lower for system 1971-72 than for system 1970-71 (Tables XX and XXII). One implication is that the closing down of some traditional delivery points results in farmers saving collection costs in the amount of 0.09 cents per bushel. It has been demonstrated that farmers in the Boissevain region are willing to incur higher than necessary collection costs for the privilege of delivering to the elevator of their choice (compare Tables XIV and XVIII). The cost of the 1971-72 grain collection, handling and distribution system to Boissevain farmers was estimated to be 18.20 cents per bushel, 0.09 cents per bushel lower than revealed preference system 1970-71. After rationalization, the costs of the two systems are comparable.

As was expected, the closing down of the four delivery points before the beginning of crop year 1971-72 decreased operating costs from 7.97 cents per bushel for system 1970-71 (See Table XIV) to 7.64 cents per bushel for system 1971-72 (Tables XXI and XXII). The aggregate cost of the simulated 1971-72 system is 33.53 cents per bushel. After rail line rationalization, aggregate costs decrease to 29.84 cents per bushel.

The previous cost analysis revealed that the closing of Belleview, Broomhill, Coulter and Leighton resulted in a collection cost savings. One would expect, therefore, that the average one-way distance between farmer and delivery point would be lower for system 1971-72 than for system 1970-71. This is, in fact, the case with the average one-way distance for system 1970-71, Sim 1, being 6.6 miles (See Table XV) and for system 1971-72, 6.3 miles (Table XXIII).

It is interesting to note that the closing of Leighton by Manitoba Pool Elevators lessens the diversion effect in Sim 8 for system 1971-72 compared to system 1970-71. In system 1970-71 the closing of all elevators on remaining lines that were less than 100,000 bushel capacity caused 14.1 percent of area farmers to change their delivery patterns. For system 1971-72 this impact is felt by only 10.2 percent of area farmers. The reason less farmers are affected in 1971-72 than in 1970-71 is that Leighton is located on the secure "Napinka" line: In simulations performed for 1970-71, Leighton was closed due to rail rationalization occurring at Sim 8, in 1971-72 Leighton was closed by elevator company rationalization at the Sim 1 level. In all likelihood, a large percentage of farmers and bushels diverted from Leighton due to elevator company rationalization remained on the "Napinka" line, probably evenly split between Medora and Deloraine. Therefore, the effect of rationalizing Leighton out of the system never shows up for system 1971-72.

TABLE XX

COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1971-72, REVEALED PREFERENCE ASSUMPTION, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8
(Handling Rates and Distribution Rates)
(Dollars)

Simulation	Collection Costs	Handling Costs	Distribution Costs	CHAD Total Costs
1	234,543	481,717	808,846	1,525,107
2	234,543	481,717	808,846	1,525,107
3	240,083	481,717	808,925	1,530,726
4	246,549	481,717	808,925	1,537,192
5	269,499	481,717	808,925	1,560,143
6	335,099	481,717	808,925	1,625,742
7	359,606	481,717	804,821	1,646,146
8	368,231	481,717	806,808	1,656,757

TABLE XXI

COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1971-72, REVEALED PREFERENCE ASSUMPTION, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8
(Handling and Distribution Costs)
(Dollars)

Simulation	Collection Costs	Handling Costs	Distribution Costs	CHAD Total Costs
1	234,543	639,907	1,934,756	2,809,206
2	234,543	639,907	1,934,756	2,809,206
3	240,083	616,838	1,927,896	2,784,817
4	246,549	605,857	1,923,112	2,775,518
5	269,499	530,546	1,876,249	2,676,294
6	335,099	477,877	1,813,205	2,626,181
7	359,606	394,738	1,746,058	2,500,403
8	368,231	368,579	1,750,618	2,487,428

TABLE XXII

AVERAGE COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1971-72, REVEALED PREFERENCE ASSUMPTION, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8 (Cents/bushel)

Simulation	Collection AC/BU (1)	Handling AC/BU (2)	Distribution AC/BU (3)	Handling Rate/bu. (4)	Distribution Rate/bu. (5)	Farmer Costs (1+4+5)	Resource Costs (1+2+3)
1	2.80	7.64	23.09	5.75	9.65	18.20	33.53
2	2.80	7.64	23.09	5.75	9.65	18.20	33.53
3	2.87	7.36	23.01	5.75	9.66	18.28	33.24
4	2.94	7.23	22.95	5.75	9.66	18.35	33.12
5	3.22	6.33	22.39	5.75	9.66	18.63	31.94
6	4.00	5.70	21.64	5.75	9.66	19.41	31.34
7	4.29	4.71	20.84	5.75	9.61	19.65	29.84
8	4.40	4.40	20.89	5.75	9.63	19.78	29.69

TABLE XXIII

THE EFFECT OF RATIONALIZATION ON AVERAGE ONE-WAY DISTANCE, RAIL LINE ABANDONMENT SIMULATIONS 1-8 REVEALED PREFERENCE ASSUMPTION 1971-72

	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Average one-way Distance (miles)	6.3	6.3	6.5	6.8	8.0	10.9	11.8	12.1
Percent Diversion								
Farmers	0.0	0.0	4.1	4.6	14.5	17.2	11.0	10.2
Bushels	0.0	0.0	4.4	4.3	12.6	17.0	14.8	12.0

CHAD System 1971-72, Minimum Cost/Distance Assumption[92]

Using the collection minimum cost/distance assumption, the cost of the simulated 1971-72 system to Boissevain farmers is marginally greater than that of the 1970-71 system. Due to the closing down of four delivery points, collection costs have risen 0.04 cents per bushel (Tables XXIV and XXVI). The aggregate costs for system 1971-72 is 18.01 cents per bushel, only 0.03 cents higher than for system 1970-71. This same cost differential is carried right through to Sim 7 where average cost per bushel is 19.57 cents. The implication is that the closing down of four

[92]The effect of rail line abandonment on handling and distribution costs, bushels handled and handling-to-capacity ratios is given in Appendix F by delivery point.

delivery points (all previously owned by Manitoba Pool Elevators) cost Boissevain farmers on the aggregate a total of $2,513 or a little over one dollar apiece. This cost, of course, is not shared by all farmers, but incurred only by those farmers that once delivered to Belleview, Broomhill, Coulter or Leighton. It was found in simulating the 1970-71 system under the minimum cost/distance assumption that a total of 165 farmers delivered to these four delivery points during Sim 1. These are the farmers that directly incur the additional collection costs of $2,513 as a result of the delivery point closures or an average per diverted farmer of $15.23.

One of the effects of closing down delivery points is that deliveries are concentrated at fewer delivery points. It has been hypothesized that because of such elevator closures operating costs at remaining delivery points are lowered through economies of scale. Evidence in support of this hypothesis is provided by comparing the operating costs for system 1970-71, Sim 1 and system 1971-72, Sim 1 (Tables XXV and XXVI). As a result of forcing greater concentration of deliveries at fewer delivery points, operating costs drop 0.34 cents per bushel. The aggregate cost in resources utilized to operate the simulated 1971-72 system is 33.41 cents per bushel compared to system 1970-71 costs of 33.73 cents per bushel, a net saving of 0.32 cents per bushel.

TABLE XXIV

COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1971-72, MINIMUM COST ASSUMPTION, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8
(Dollars)

Simulation	Collection Costs	Handling Costs	Distribution Costs	CHAD Total Costs
1	216,681	481,717	810,175	1,508,574
2	216,681	481,717	810,175	1,508,574
3	226,245	481,717	809,802	1,517,765
4	233,211	481,717	809,802	1,524,731
5	259,940	481,717	809,802	1,551,460
6	326,594	481,717	809,802	1,618,114
7	353,104	481,717	805,173	1,639,996
8	364,233	481,717	807,625	1,653,577

TABLE XXV

COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1971-72, MINIMUM COST/DISTANCE ASSUMPTION, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8
(Handling Costs and Distribution Costs)
(Dollars)

Simulation	Collection Costs	Handling Costs	Distribution Costs	CHAD Total Costs
1	216,681	644,304	1,937,932	2,798,917
2	216,681	644,304	1,937,932	2,798,917
3	226,245	619,844	1,920,270	2,766,359
4	233,211	608,798	1,913,249	2,755,259
5	259,940	531,404	1,859,045	2,650,390
6	326,594	478,554	1,795,614	2,600,762
7	353,104	394,740	1,721,382	2,469,227
8	364,233	367,305	1,727,441	2,458,980

TABLE XXVI

AVERAGE COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1971-72, MINIMUM COST ASSUMPTION, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8 (Cents/bushel)

Simulation	Collection AC/BU (1)	Handling AC/BU (2)	Distribution AC/BU (3)	Handling Rate/bu. (4)	Distribution Rate/bu. (5)	Farmer Costs (1+4+5)	Resource Costs (1+2+3)
1	2.59	7.69	23.13	5.75	9.67	18.01	33.41
2	2.59	7.69	23.13	5.75	9.67	18.01	33.41
3	2.70	7.40	22.92	5.75	9.67	18.12	33.02
4	2.78	7.27	22.83	5.75	9.67	18.20	32.88
5	3.10	6.34	22.19	5.75	9.67	18.52	31.63
6	3.90	5.71	21.43	5.75	9.67	19.32	31.04
7	4.21	4.71	20.54	5.75	9.61	19.57	29.46
8	4.35	4.38	20.61	5.75	9.64	19.74	29.34

As the 1971-72 system is rationalized, however, this cost differential narrows to 0.09 cents per bushel.

Using the assumption of minimum cost/distance, farmers in the Boissevain region, traveled, on the average, 5.5 miles to their nearest country elevator in 1971-72 (Table XXVII). This is an increase of 0.2 miles from system 1970-71, Sim 1. After complete rationalization (Sim 7) one-way distance is 11.5 miles, very close to that of system 1970-71 (11.4 miles).

There are two causes of farmer and bushel diversion taking place in the simulated system 1971-72. The first diversion is caused by elevator company rationalization (the closing down of four delivery points) and the second is caused by rail line abandonment rationalization.

TABLE XXVII

THE EFFECT OF RATIONALIZATION ON AVERAGE ONE-WAY DISTANCE, AND DIVERSION OF FARMERS AND GRAIN RAIL LINE ABANDONMENT SIMULATIONS 1-8, MINIMUM COST/DISTANCE ASSUMPTION 1971-72

	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Average one-way Distance (miles)	5.5	5.5	5.8	6.2	7.5	10.4	11.5	11.9
Percent Diversion								
Farmers	0.0	0.0	8.6	5.0	17.8	17.4	11.8	14.7
Bushels	0.0	0.0	9.9	4.7	14.6	17.1	15.8	15.8

Typically, the effect of elevator company rationalization is felt at the beginning of the crop year when farmers must make a decision as to where they will divert their deliveries in the event their traditional delivery point is no longer available. If, after the beginning of the crop year, rail lines are abandoned there are additional farmer and bushel diversions. If elevator company rationalization and rail line rationalization do not occur at the same time, it is conceivable that some farmers will be diverted twice within the same crop year.

This appears to be the case should rail rationalization proceed as indicated in Sims 1 through 7. Due to elevator company rationalization, the percentage of farmers on the "Boissevain" line increases from 8.2 percent (See Table IXX, Sim 3) to 8.6 percent (Table XXVII). The effect is that some farmers will be required to change delivery patterns twice, once due to elevator company rationalization and then due to the abandonment of the "Boissevain" line. In a very general sense, this typifies the kind of confusion that can occur in the absence of a coordinated rationalization plan.

SIMULATED CHANGES IN THE COLLECTION PROCEDURES

As mentioned in an earlier section of the study, approximately 80 percent of Boissevain farmers used their own trucks in making deliveries to country elevators. The remaining 20 percent were assumed to use custom truckers. The purpose of this section of the study is to demonstrate the effect on aggregate and average per bushel collection costs of changes in farmer delivery techniques. The simulated change in delivery technique involves the switching from the use of farmer-owned trucks for grain hauling to custom trucks under five different conditions.[93] That is, if a farmer owns and uses a truck he will switch to custom hauling if (1) his truck is less than or equal to 6,000 pounds gross vehicle weight, (2) his truck is less than or equal to 9,000 pounds gross vehicle weight, (3) his truck is as old or older than 1951, (4) his delivery distance is greater than 12 miles or (5) he delivers 2,000 bushel or less.

All of these simulated changes in technique are performed for CHAD system 1970-71 using the revealed preference assumption.

Review of Existing Collection Methods Used in the Boissevain Region for Crop Year 1970-71

To be precise, 1,731 farmers in the Boissevain region were identified as owners of trucks and used them to deliver their grain to a country elevator. The remaining farmers,

[93]After the switch from farm truck to custom truck, if the farm truck is retained by the farmer, overhead costs of owning the truck are transferred from the grain hauling enterprise to other farm enterprises.

456, were assumed to hire a custom trucker. The average gross vehicle weight for farmer-owned trucks was 11,355 pounds; average year of truck 1959, and average bushels delivered 4,108. For those farmers employing a custom trucker, average deliveries were 2,779 bushels. These grain collection characteristics contributed to the average collection cost per bushel of 2.89 cents for the existing system 1970-71 (Table XXVIII). After rail line rationalization (Sim 7), this cost increased 48 percent to 4.26 cents per bushel.

Presented in the next several sections of this chapter are simulations which represent the substitution of custom trucking for farm trucks given a variety of farm truck characteristics. That is, a custom truck is substituted for a farm truck if that farm truck is (1) less than or equal to 6,000 pounds gross vehicle weight, (2) less than or equal to 9,000 pounds gross vehicle weight, (3) older than a 1952 model, (4) used to deliver grain more than 12 miles to a country elevator, or (5) used to transport 2,000 bushels of grain or less during crop year 1970-71. A simulation is performed for each of these five farm truck categories. While a simulation representing a composite of the above farm truck characteristics is not performed, it may be informative to note that if, for example, custom trucking was substituted for all farm trucks in the Boissevain region that were either (1) less than or equal to 9,000 pounds gross vehicle weight, or (2) older than 1952, or (3) were used to transport 2,000 bushels or less during crop year 1970-71, the total number of affected farm trucks would be 1,076, or over 60 percent of all farm trucks in the Boissevain region.[94]

Substitution of Custom Trucks for Farm Trucks Less than or Equal to 6,000 Pounds Gross Vehicle Weight

Assuming all farmers with trucks less than or equal to 6,000 pounds gross vehicle weight (total of 364 or 21 percent) were to switch to the custom trucking of their grain, average collection costs would decline from 2.89 cents to 2.61 cents per bushel yielding a net savings of 0.28 cents per bushel for Boissevain farmers (Table XXVIII). That is, under this changed collection method, collection costs would be 90 percent of current (1970-71) costs. These affected Boissevain farmers on the aggregate would save $23,458 or $64.44 per farmer for crop year 1970-71. After rationalization the saving would be 0.32 cents per bushel over existing collection procedures. This implies that the more rationalized the system becomes the greater the cost saving should farmers with small trucks decide to employ a custom trucker.

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[94]Includes 830 trucks which are 9,000 pounds gross vehicle weight or less, plus 143 trucks which are older than 1952 but greater than 9,000 pounds gross vehicle weight, plus 103 trucks which are used to transport 2,000 bushels of grain or less but are greater than 9,000 pounds gross vehicle weight and newer than 1951.

TABLE XXVIII

THE EFFECT ON AVERAGE PER BUSHEL COLLECTION COSTS GIVEN A CHANGE IN FARMER DELIVERY TECHNIQUE (Cents)

Sim	AC/BU Existing Collection Technique	AC/BU LE 6000 GVW using custom[a]	AC/BU LE 9000 GVW using custom[a]	AC/BU LE 1951 age using custom[a]	AC/BU GT. 12.0 mi. using custom[b]	AC/BU LE 2000 bu. using custom[a]	Combination of GT 9000 GVW LE 1951 GT 12.0 mi. & LE 2000 bu[a,b]
1	2.89	2.61	2.31	2.73	2.77	1.92	1.91
2	2.90	2.62	2.31	2.74	2.77	1.92	1.92
3	2.96	2.68	2.37	2.80	2.81	1.98	2.02
4	2.93	2.65	2.35	2.77	2.76	1.97	2.10
5	3.19	2.91	2.60	3.03	2.91	2.20	2.39
6	3.98	3.66	3.29	3.78	3.37	2.84	3.08
7	4.27	3.95	3.57	4.06	3.53	3.10	3.37
8	4.40	4.07	3.69	4.18	3.63	3.21	3.53

[a] "LE" is used as an abbreviation for "less than or equal."

[b] "GT" is used as an abbreviation for "greater than."

Substitution of Custom Trucks for Farm Trucks Less than or Equal to 9,000 Pounds Gross Vehicle Weight

Many of the comments made in regard to the substitution of custom trucks for farm trucks less than or equal to 6,000 pounds gross vehicle weight apply here as well. The main difference is that collection costs would decrease further. The truck population in the Boissevain region contained 830 trucks or 48 percent of all trucks which were less than or equal to 9,000 pounds gross vehicle weight. Should all of these farmers decide to use custom hauling, the saving over existing techniques of collection would be 0.58 cents per bushel (Table XXVIII). The average savings per affected farmer would be $58.54. Further, if rail rationalization were to proceed as envisioned, this cost differential would widen and when the last light density line is abandoned the net saving would be 0.70 cents per bushel; a saving of over 16 percent in collection costs.

Substitution of Custom Trucks for Farm Trucks Older than 1952

Examination of the truck population in the Boissevain region revealed that 356 trucks or 21 percent were older than 1952. As may be expected, should these farmers decide to use a custom hauling service, the effect on average collection costs are marginal, from 2.89 cents per bushel to 2.73 cents per bushel (Table XXVIII). The average savings per affected farmer would be $37.65. But even under this simulated collection environment, savings can be expected to increase as rationalization proceeds; before rationalization (Sim 1) the cost difference between the existing collection technique and this technique is 0.16 cents per bushel, after rationalization (Sim 7) the cost difference is 0.21 cents per bushel.

Substitution of Custom Trucks for Farm Trucks where One-Way Distance to Elevator is Greater than 12 Miles

At the Sim 1 level (existing grain collection, handling and distribution system) the option of switching farmers who are currently greater than 12 miles from their preferred delivery point to custom trucking appears to be less promising than the previous changes in collection procedures (Table XXVIII). While only 41 farmers are affected at the Sim 1 level, average savings would be $245.19 per farmer. However, as delivery points disappear due to rail line rationalization, more and more farmers find themselves greater than 12 miles from the nearest elevator. Eventually the potential collection cost savings associated with the substitution of custom trucks for farm trucks where one-way distance to elevator is greater than 12 miles surpasses the potential saving of previous changes in collection procedures. If this 12 mile standard is adopted before rail line rationalization, the resultant saving in collection costs would be only 0.12 cents per bushel. However, if after rationalization all farmers more than 12 miles from their delivery point should change their collection procedure from using their own truck to hiring a custom trucker, per bushel savings would be 0.74 cents; a gross savings for Boissevain farmers of $61,995 or a per farmer savings of $28.35.

<u>Substitution of Custom Trucks for Farm Trucks where Farmer Deliveries are 2,000 Bushels or Less</u>

During crop year 1970-71, 492 or 28 percent of Boissevain farmers had deliveries of 2,000 bushels or less. Substituting custom trucks for these farmers' trucks resulted in the greatest collection cost savings; 34 percent lower than existing collection procedures, 26 percent lower than the first procedural change ($\leq$6,000 lbs. GVW), 17 percent lower than the second procedural change ($\leq$9,000 lbs. GVW), 30 percent lower than the third procedural change ($<$1952) and 31 percent lower than the fourth procedural change ($>$12 miles from elevator). The average savings per affected farmer would be $165.17. If, after rail line rationalization (Sim 7), farmers delivering 2,000 bushels or less were to use custom truckers, average collection costs would be 3.10 cents per bushel, 0.43 cents per bushel lower than the next best alternative represented by the substitution of custom trucks for farm trucks where the one-way distance to the nearest elevator was greater than 12 miles (Table XXVIII).

Combination of Techniques: Substitution of Custom Trucks for Farm Trucks when Farm Truck is Less than or Equal to 9000 Pound GVW, Older than 1952 and Used to Deliver 2000 Bushels or Less Greater than 12 Miles

In a sense this final collection technique simulation represents a weighted average of the previous four techniques. As a result, with the exception of the existing system (Sim 1), the collection cost estimates are neither higher nor lower than previous simulations: Not higher because a very large number of trucks are contained in this category (over 1500) and in general, the switch from farm trucking to custom trucking will reduce collection costs; and not lower because collection techniques which have a small effect on reducing collection costs e.g., greater than 12 miles, are added in with collection techniques which have significant impact on reducing collection costs e.g., less than or equal to 2,000 bushels.

The effect of this combination technique at the Sim 1 level (the existing system) is to reduce average collection costs from 2.89 cents per bushel to 1.91 cents per bushel, a savings of 0.98 cents per bushel. Following rationalization, represented by Sim 8, the cost savings of the combination technique over the existing collection technique is 1.19 cents per bushel.

SIMULATING THE GRAINS GROUP "BENCHMARK" SYSTEMS

In 1969 the federal government of Canada launched comprehensive series of studies into the grain handling and transportation system in Canada under the auspices of the Grains Group. These studies were concerned with describing the operations of and estimating the costs of country elevators, terminal elevators, grain cleaning, rail operations, farm storage and farm trucking. The impetus behind this massive effort was public concern over rising costs and other problems plaguing the grain collection, handling and distribution system in Canada. After two years of research by many individuals and organizations, the coordinating body, the Grains Group, published its results and its suggestions as to what actions might be taken immediately and in the future. Volume 10 of this report, prepared by P. S. Ross and partners, entitled _Grain Handling and Transportation Costs in Canada_ is of particular concern to this study.

Volume 10 of the Grains Group report compared the estimated costs of operating five systems of grain transportation and handling:[95]

1) The present system of country elevator and terminal operations,

2) a rationalized country elevator system coupled with light traffic density rail line abandonments,

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[95] _Grain Handling and Transportation Costs in Canada_, _op. cit._, p. 2.

3) a high throughput country elevator system (consisting of 389 elevators),

4) a high throughput country elevator system coupled with inland terminals (356 elevators and 22 terminals),

5) an inland terminal system to gather all grain in the country (22 terminals only). Evaluation of the 22 inland terminal system was aborted in preference to "a broader analysis of an inland terminal system comprising of between 80 and 100 terminals."[96]

The purpose of this section of the study is to compare the results of the CHAD simulation model to those of the Grains Group where legitimately possible. It is important to recognize the main differences between the approach used by the Grain Group and the method developed in this study. The approach employed by the Grains Group involved developing several alternative systems. Once the characteristics of these systems were defined they were evaluated and compared in regard to cost-effectiveness. That is, decisions were made in regard to the specific design of each alternative system. The CHAD model, on the other hand, is designed to reveal and measure the consequences of moving from one alternative system to another. The second main difference is more a reflection of philosophy. CHAD was developed with considerable emphasis on the possibility that the most

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[96] Ibid.

practical and efficient grain collection, handling and distribution system for the 1990's is contained within the existing system. The problem is to isolate it and, if necessary, update it. Three of the four alternative systems suggested by the Grains Group (excluding the aborted 22 inland terminal scheme), on the other hand, involved the construction of new elevators. As will be demonstrated shortly, the CHAD simulation model can easily be adapted to consider the construction of new elevators. The third significant difference is that the Grains Group rationalized at the macro level. That is, they considered all three Prairie provinces, CHAD is currently designed to rationalize at the micro or regional level. The fourth major difference is that the Grains Group included more system components, e.g., port facilities, inland water transport, etc. These components were not rationalized but simply costed and added-on to arrive at an estimate of aggregate system costs. These same component costs can, of course, be added on to CHAD rationalization results as well.

While the results of the Grains Group analysis pertain to the macro or Prairie level, sufficient information is presented in their reports to draw some conclusions regarding what they had in mind for the Boissevain area. For example, it is quite clear that the Grains Group rationalized system in the Boissevain area will contain the "Napinka" and

"Estevan" rail lines.[97] This same rationalized system is represented by CHAD simulation 7.

In addition to contrasting the results of CHAD versus Grains Group for the rationalized system, CHAD will be used to decide the optimum location for the Boissevain regions share of high throughput elevators and terminal elevators. That is, the CHAD model will be used to "evaluate" three of the four alternative benchmark systems presented by the Grains Group as these benchmarks are likely to affect the Boissevain area. The Grains Group also costed the existing system and this will be compared to the simulation of the existing system (Sim 1) using CHAD.

The Existing System

The existing system for the Grains Group (1969 version) contained approximately 5,000 country elevators located at about 1,900 delivery points. Combined storage capacity was close to 400 million bushels. The three Prairie Provinces covered an area of approximately 190,000 square miles.[98] The existing system for the Boissevain area (1970 version) contained 67 country elevators located at 31 delivery points. Combined capacity was 5,880,700 bushels. The Boissevain area is approximately 3,000 square miles in

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[97] *Ibid.*, Exhibit 2.

[98] *Ibid.*, p. 10.

size. The volume of bushels handled through the Grains Group system was 675 million. Data supplied by the Canadian Transport Commission indicated that during crop year 1970-71 the Boissevain system handled approximately 8.4 million bushels of wheat, barley and oats.

CHAD estimated the average collection costs for the existing system in the Boissevain area at 2.89 cents per bushel. The Grains Group estimate for the Prairies as a whole was 3.27 cents per bushel (Table XXIX). In addition to the one-way distance to elevator variation, this difference in collection cost estimates can largely be explained by the fact that 20 percent of Boissevain farmers were assumed to use custom truckers. The costs of operating a custom truck are generally lower than the costs of operating a farm truck. The Grains Group did not include the custom trucking of grain. Elevator operating costs per bushel were 7.97 cents using CHAD and 7.46 cents using the Grains Group analysis. As CHAD's distribution costs are based on Grains Group data, a comparison would provide no insight other than it is less costly to distribute grain from the Boissevain region than from the Prairies generally. To re-emphasize, the Grains Group performed their analysis at the macro level, the results are therefore Prairie averages. A major difference in cost should appear at the rail distribution level, for example, simply because the Boissevain area is closer to its market than the Prairie average. One would expect,

TABLE XXIX

COST OF EXISTING SYSTEM; CHAD AND GRAINS GROUP ESTIMATES (Cents)

	CHAD Estimate	Grains Group Estimate
Collection costs/bu.[1]	2.89	3.27
Handling costs/bu.[2]	7.97	7.46
Distribution costs/bu.[3]	23.09	29.90
Total costs/bu.	33.95	40.63

[1]For Grains Group estimate see Grain Handling and Transportation Costs in Canada, Appendix VI-Schedule 2.

[2]Elevator operation costs include:

Salaries and wages of elevator managers, helpers and casual labor
Fringe benefits
Fuel, light and power
Repairs and maintenance
Telephone and communications
Other variable country elevator expenses
Insurance
Property and business taxes

See Grain Handling and Transportation Costs in Canada, Appendix I-Schedule 3.

[3]CHAD distribution costs are based on the average Boissevain Crows Nest Pass rate of 9.75 cents per bushel. Grains Group distribution costs are based on the average Prairie Crows Nest Pass rate of 12.5 cents per bushel. See Grain Handling and Transportation Costs in Canada, Appendix VIII.

however, that collection and handling costs should be reasonably close if in fact the Boissevain area is a reasonable representative of the Prairies. It should be recalled that the CHAD estimates of average collection costs contains both farm truck and custom trucking data.

The Rationalized System

The Grains Group rationalized system in the Boissevain region is identical to that simulated with CHAD. That is, both rail line rationalization schemes in the Boissevain area contain only two rail lines, the "Estevan" line and "Napinka" line. After the Prairies have been rationalized by the abandonment of light traffic density lines there remains approximately 3,600 elevators located at about 1,300 delivery points. Aggregate system capacity after rationalization would be approximately 300,000,000 bushels.[99] The Boissevain system would be reduced to 31 elevators at 12 delivery points following rail line rationalization. Aggregate elevator capacity in the Boissevain region after rationalization would be approximately 3 million bushels.

The cost of collection under a rationalized Boissevain system would be 4.27 cents per bushel, (Table XXX). The Grains Group estimated that the average cost of farm trucking for the prairies following rationalization would be

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[99] *Ibid.*, p. 18.

3.97 cents per bushel. As a result of rationalization in the Boissevain region, collection costs increase 48 percent. According to Grains Group results, collection costs will only increase 21 percent following the abandonment of light traffic density lines. It was shown in the distance and diversion analysis performed earlier in this study for CHAD system 1970-71, revealed preference assumption, that rationalization (going from Sim 1 to Sim 7) would increase one-way distance to elevator from 6.6 miles to 11.7 miles.

TABLE XXX

COST OF RATIONALIZED SYSTEM; CHAD AND GRAINS GROUP ESTIMATES (Cents)[a]

	CHAD Estimate	Grains Group Estimate
Collection costs/bu.	4.27	3.97
Handling costs/bu.	4.80	5.73
Distribution costs/bu.	20.85	24.20
Total costs/bu.	29.92	33.90

[a]See footnotes at bottom of Table XXIX.

The Grains Group found that the average one-way driving distance for Prairie farmers under the existing system to be about 7 miles.[100] After rationalization the Grains Group

[100]*Ibid.*, p. 10

projects one-way distance to increase to 11.4 miles.[101] Using the Grains Group format, a doubling in average one-way distance to elevator causes a 33 percent increase in collection costs. The CHAD formulation, on the other hand, suggests that a doubling in the average one-way distance to elevator would increase collection costs 62 percent. Dividing the CHAD estimate of additional total collection costs by the additional bushel-miles results in a marginal cost per bushel-mile of 0.269 cents per bushel-mile while the Grains Group estimate of marginal costs per bushel-mile is .158 cents. The difference between the marginal cost per bushel-mile estimates is partly attributable to the fact that the average bushels transported in the Boissevain region in 1970-71 was approximately 3,800 bushels while the Grains Group found that the average annual volume of grain transported per truck in the Prairies was approximately 6,800 bushels. In addition the Grains Group estimate is based on a more restrictive set of additional costs.[102] With one-way distances to elevators being reasonably similar in both studies, bushel-miles in the Boissevain region are much lower than the indicated Prairie average resulting in a higher estimate of marginal cost per bushel-mile. Taking the 650 million bushel marketings used by Grains Group to make their estimates and roughly 190,000 permit book holders on the Prairies, the average marketings per permit book

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[101] *Ibid.*, Appendix VI, p. 9.

[102] *Ibid.*, Appendix VI, p. 3.

would be 3,500 bushels.

Handling costs were estimated to be 4.80 cents per bushel under a rationalized grain handling system using the CHAD simulation model: This represents a decrease of 40 percent over the pre-rationalization system. The Grains Group projected a cost savings of 23 percent, from 7.46 cents per bushel to 5.73 cents per bushel.

The obvious difference between CHAD results and Grains Group results with respect to handling costs may largely be explained by the fact that the Grains Group estimates that on the basis of bushels diverted, only 25 percent of prairie farmers will be affected by rationalization.[103] This is in contrast to the Boissevain area where almost 50 percent of region bushels originate on light traffic density lines. It is not surprising, therefore, that there would be a larger handling cost saving associated with rationalizing the Boissevain region as opposed to Prairie rationalization.

High Throughput Elevator System

As an alternative to the present system the Grains Group envisioned a country elevator system composed of 389 elevators dispersed throughout the three Prairie Provinces.

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[103] *Ibid.*, Appendix VI, p. 11.

Each elevator was designed to have a capacity of 704,000 bushels.[104] In addition, each elevator would have a throughput capacity of 1.5 to 3 million bushels. A cost analysis was undertaken to estimate the cost of operating an elevator with these characteristics. The estimated annual costs per bushel was 15.0 cents for a 3 million bushel throughput.[105]

As an 8.4 million bushel market, the Boissevain area could economically support three of these high throughput elevators. Having size, number and average handling costs predetermined the only chore left was to locate them.

Using the minimum cost/distance assumption, the CHAD simulation model was programmed to estimate the aggregate collection costs for eight alternative combinations of three locations. The following constraints were imposed on the selection of these alternative locations:

1) The delivery point must be on a main line.

2) The delivery point should be located on a provincial trunk highway.

3) The delivery point must be associated with a town which has traditionally experienced a relatively high grain throughput. Seven delivery points in the Boissevain area satisfied these criteria. They were: Boissevain, Deloraine,

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[104] Ibid., p. 19.

[105] Ibid., Appendix II-Schedule I.

Hartney, Medora, Melita, Pierson and Souris.[106] Allowing for some dispersion within the Boissevain area, eight combinations were selected (Table XXXI). All of the delivery points in all of the combinations had handlings greater than 1.5 million bushels except Boissevain in the combination Boissevain-Deloraine-Souris.

The combination Deloraine-Melita-Souris had the lowest estimated average collection costs of 5.68 cents per bushel. This high throughput system of elevators would cost farmers at least an additional 2.79 cents per bushel more in collection costs than they were estimated to be paying under the existing system. The collection cost differential between the high throughput system and the rationalized system is 1.41 cents per bushel. The Grains Group estimated the average per bushel cost of collection with the high throughput system to be 5.87 cents, 1.90 cents per bushel higher than their estimate for the rationalized system.

Combination number eight has rather interesting implications. Choice of the Hartney-Pierson-Souris combination would permit the abandonment of the "Napinka" line, for these three delivery points are all located on the "Estevan" line. Preferring the Hartney-Pierson-Souris combination, however, would increase farmer collection cost

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[106] Hartney is the only point not on a provincial trunk highway. There is good access to it however, on double prime surface road.

TABLE XXXI

ALTERNATIVE LOCATIONS FOR THREE 352,000 BUSHEL CAPACITY HIGH THROUGHPUT ELEVATORS IN THE BOISSEVAIN REGION

Delivery Point Combination	Handlings at each Delivery Point (bu.)	Estimated Aggregate Collection Costs (dollars)	Estimated Average Collection Costs per Bushel (cents)
1 Boissevain	2,617,195		
Pierson	3,648,377	521,560	6.23
Souris	2,112,120		
2 Deloraine	2,839,984		
Melita	3,392,737	475,732	5.68
Souris	2,144,971		
3 Deloraine	3,342,254		
Pierson	2,721,225	485,327	5.79
Souris	2,314,213		
4 Boissevain	1,606,111		
Medora	4,749,328	519,666	6.20
Souris	2,022,253		
5 Boissevain	2,015,973		
Melita	4,527,823	484,606	5.78
Souris	1,833,896		
6 Boissevain	1,405,201		
Deloraine	4,537,048	583,144	6.96
Souris	2,435,443		
7 Boissevain	1,905,517		
Hartney	3,524,232	498,868	5.95
Pierson	2,947,943		
8 Hartney	2,830,527		
Pierson	2,947,943	550,107	6.57
Souris	2,599,222		

by 0.89 cents per bushel.

In addition to the collection cost analysis, a distance analysis was performed for each of these eight delivery point combinations. As expected, the combination Deloraine-Melita-Souris resulted in the lowest average one-way distance. The average distance between each Boissevain farmer and this delivery point combination was 17.08 miles (Table XXXII). Assuming that there would be no reason to prefer one of these three delivery points over another, other than in terms of distance, 35.4 percent of Boissevain farmers would deliver to Deloraine, 43.1 percent to Melita and 21.4 percent to Souris. The Grains Group estimated that the average distance of haul for farmers in the Prairies would be 22.7 miles under the high throughput elevator system.

Inland Terminal System

The Grains Group describes the Inland terminal bench-mark system as being composed of 80 elevators, each with a capacity of 2.5 million bushels. These elevators would be optimally dispersed throughout the prairies such that each would handle an annual volume of 8 million bushels. The handling cost for such an elevator was estimated to be 11.5 cents per bushel.[107] Grain distribution was anticipated to

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[107] *Ibid.*, Appendix IV.

TABLE XXXII

DISTANCE ANALYSIS FOR EIGHT POSSIBLE LOCATION COMBINATIONS FOR THREE HIGH THROUGHPUT ELEVATORS IN THE BOISSEVAIN REGION

Location Combination	Number of Farmers Delivering	Percent of Farmers Delivering	Average One-Way Distance (miles)
1 Boissevain	682	31.2	18.26
Pierson	990	45.3	22.16
Souris	515	23.5	17.50
Average			19.84
2 Deloraine	775	35.4	15.48
Melita	943	43.1	19.27
Souris	469	21.4	15.29
Average			17.08
3 Deloraine	918	42.0	16.46
Pierson	741	33.9	19.82
Souris	528	24.1	17.39
Average			17.08
4 Boissevain	401	18.3	12.21
Medora	1325	60.6	22.54
Souris	461	21.1	17.87
Average			19.66
5 Boissevain	537	24.6	15.31
Melita	1230	56.2	20.31
Souris	420	19.2	13.89
Average			17.85

TABLE XXXII (continued)

Location Combination	Number of Farmers Delivering	Percent of Farmers Delivering	Average One-Way Distance (miles)
6 Boissevain	329	15.0	10.73
Deloraine	1282	58.6	25.15
Souris	576	26.3	24.06
Average			22.69
7 Boissevain	494	22.6	14.54
Hartney	915	41.8	19.34
Pierson	778	35.6	19.36
Average			18.26
8 Hartney	818	37.4	20.47
Pierson	778	35.6	19.36
Souris	591	27.0	23.63
Average			20.93

be accomplished by unit train.

With annual marketings in the 8 million bushel range, the Boissevain area could legitimately support one of these 80 inland terminals. Eight possible delivery points within the Boissevain area were tested as to their location suitability (Table XXXIII). The same criteria were used in selecting these eight delivery points as in the previous high throughput analysis. The exception is Napinka which is included here due to its somewhat central location.

The minimum collection cost location is Medora at 8.63 cents per bushel. A very near alternative is Napinka, reflecting an average cost of 8.80 cents per bushel.

Rationalizing from 31 delivery points to one delivery point increases collection costs by 5.74 cents per bushel or about triple the cost under the existing system. Going from the rationalized system to the inland terminal system increases collection costs 3.83 cents per bushel. At the aggregate prairie level, the Grains Group estimated that the costs of collection under an 80 inland terminal system would be 7.07 cents per bushel, 1.56 cents per bushel lower than the CHAD estimate for the Boissevain region.

The implementation of the inland terminal system permits the adoption of the unit train. The Grains Group suggested that the cost of operating a unit train in Western

TABLE XXXIII

ALTERNATIVE LOCATIONS FOR ONE 2.5 MILLION BUSHEL CAPACITY INLAND TERMINAL IN THE BOISSEVAIN REGION

Delivery Point	Handlings at Delivery Point	Estimated Aggregate Collection Costs (dollars)	Estimated Average Collection Costs per Bushel (cents)
Boissevain	8,377,692	940,546	11.23
Deloraine	8,377,692	758,696	9.06
Hartney	8,377,692	754,327	9.00
Medora	8,377,692	723,204	8.63
Melita	8,377,692	798,474	9.53
Napinka	8,377,692	737,584	8.80
Pierson	8,377,692	1,037,076	12.37
Souris	8,377,692	983,573	11.74

Canada would be 17.7 cents per bushel.[108] The Grains Group further estimated that the combined cost of collection, handling and distribution using the inland terminal system would be 36.27 cents per bushel (7.07 cents per bushel collection, 11.5 cents per bushel handling and 17.7 cents per bushel distribution). The cost of operating the inland terminal system in the Boissevain region, using CHAD, after adjusting unit train costs to reflect distance from market, would be 34.29 cents per bushel (8.63 cents collection, 11.5 cents handling and 14.16 cents distribution).

A distance analysis was performed for each of these eight alternative locations. The optimum location for an inland terminal in terms of minimizing distance was Medora, requiring an average one-way haul of 28.03 miles (Table XXXIV). The Grains Group estimate for average one-way distance to elevator was 28 miles for the inland terminal system.

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[108] Ibid., Exhibit 5.

TABLE XXXIV

DISTANCE ANALYSIS FOR EIGHT POSSIBLE LOCATIONS FOR ONE INLAND TERMINAL ELEVATOR IN THE BOISSEVAIN REGION

Location	Average one-way Distance (miles)
Boissevain	39.87
Deloraine	29.99
Medora	28.03
Melita	31.10
Pierson	41.15
Souris	42.42
Hartney	30.70
Napinka	28.58

A COMPARISON OF CHAD SYSTEM 1970-71, MINIMUM COST/DISTANCE ASSUMPTION, CHAD SYSTEM 1970-71, REVEALED PREFERENCE ASSUMPTION, AND THE "REAL WORLD"[109]

The ultimate test of a simulation model is to select and compare some of its parameters with "real world" parameters. To give credence to the results of a simulation model, the parameters of the model should represent as accurately as possible their real world counterparts.

Three parameters were selected to test the correlation between the CHAD model and the actual grain collection, handling and distribution system in the Boissevain region. The number of farmers delivering to each delivery point, the number of bushels delivered to each delivery point and the handling-to-capacity ratio for each delivery point are critical parameters of the system. All three significantly influence the collecting, handling and distributing of grain within the Boissevain region.

Both the minimum cost/distance assumption and the revealed preference assumption were compared to the actual grain collection, handling and distribution system in the Boissevain region as it existed in 1970-71. The results, by delivery point are presented in Table XXXV. Coefficients of

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[109] For lack of a better term "real world" is used here to describe actual grain collection and handling characteristics as they were in the Boissevain region during crop year 1970-71.

TABLE XXXV

NUMBER OF FARMERS, NUMBER OF BUSHELS AND HANDLING TO CAPACITY RATIOS UNDER CHAD MINIMUM COST/DISTANCE ASSUMPTION, CHAD REVEALED PREFERENCE ASSUMPTION AND "REAL WORLD"

Delivery Point	Predicted Number of Farmers Delivering Under: CHAD, 1970-71 Minimum Cost/Distance	CHAD, 1970-71 Revealed Preference	"Real World" 1970-71[a]
	(1)	(2)	(3)
Belleview[b]	37	17	27
Boissevain	173	229	234
Broomhill	21	25	27
Coulter	55	24	26
Cranmer	52	23	23
Croll	45	20	21
Dalny	49	27	28
Dand	73	34	34
Deloraine	107	167	175
Elgin	75	79	80
Fairfax	35	56	59
Goodlands	104	85	88
Hartney	47	116	137
Lauder	51	37	45
Leighton	53	23	23
Linklater	53	44	44
Lyleton	78	88	92
Medora	69	113	114
Melita	110	149	161
Mentieth	73	22	31
Minto	67	75	75
Napinka	74	49	53
Newstead	63	35	36
Pierson	103	113	122
Pipestone	59	71	98
Regent	62	33	33
Reston	100	106	108
Sinclair	62	54	56
Souris	78	117	121
Tilston	109	89	91
Waskada	51	67	68
Totals	2187	2187	2330

TABLE XXXV (continued)

Delivery Point	Predicted Number of Bushels Delivered Under: CHAD, 1970-71 Minimum Cost/Distance	CHAD, 1970-71 Revealed Preference	"Real World" 1970-71
	(4)	(5)	(6)[c]
Belleview[b]	125,111	35,986	35,057
Boissevain	643,361	879,817	1,131,815
Broomhill	90,598	87,127	108,932
Coulter	119,559	45,357	76,908
Cranmer	196,358	69,855	92,210
Croll	268,577	103,813	129,233
Dalny	200,495	108,181	180,010
Dand	274,850	132,886	140,240
Deloraine	342,013	509,215	747,126
Elgin	377,518	415,803	580,676
Fairfax	214,905	313,687	487,489
Goodlands	288,922	307,134	361,043
Hartney	134,620	357,618	568,385
Lauder	149,026	118,069	169,183
Leighton	229,489	93,631	102,458
Linklater	226,190	179,183	223,790
Lyleton	214,151	247,505	370,245
Medora	348,405	524,017	624,963
Melita	385,954	473,438	690,239
Mentieth	263,266	117,820	207,624
Minto	296,757	360,556	470,216
Napinka	184,764	118,636	177,477
Newstead	323,111	174,077	216,865
Pierson	441,807	502,918	643,147
Pipestone	140,020	214,278	281,383
Regent	250,085	111,819	145,294
Reston	393,557	424,838	524,749
Sinclair	315,317	275,377	332,492
Souris	343,865	488,912	638,500
Tilston	394,699	323,172	426,502
Waskada	200,342	262,967	415,209
Totals	8,377,692	8,377,692[d]	11,299,460[d]

TABLE XXXV (continued)

Delivery Point	Handling to Capacity Ratios Predicted Under: CHAD, 1970-71 Minimum Cost/Distance	CHAD, 1970-71 Revealed Preference	"Real World" 1970-71
	(7)	(8)	(9)
Belleview	6.3	1.8	1.8
Boissevain	1.1	1.6	2.0
Broomhill	3.8	3.6	4.5
Coulter	2.4	0.9	1.5
Cranmer	2.3	0.8	1.1
Croll	3.5	1.3	1.7
Dalny	1.2	0.7	1.1
Dand	4.8	2.3	2.4
Deloraine	0.9	1.4	2.0
Elgin	1.4	1.6	2.2
Fairfax	0.8	1.2	1.9
Goodlands	1.2	1.3	1.5
Hartney	0.5	1.3	2.1
Lauder	1.6	1.2	1.8
Leighton	4.5	1.9	2.0
Linklater	2.4	1.9	2.3
Lyleton	1.1	1.2	1.9
Medora	1.1	1.7	2.0
Melita	1.3	1.6	2.3
Mentieth	3.4	1.5	2.7
Minto	1.0	1.2	1.6
Napinka	1.5	1.0	1.5
Newstead	6.0	3.2	4.0
Pierson	1.5	1.7	2.1
Pipestone	1.2	1.8	2.4
Regent	2.8	1.3	1.6
Reston	2.1	2.2	2.8
Sinclair	1.8	1.6	1.9
Souris	0.6	0.9	1.2
Tilston	2.4	2.0	2.6
Waskada	0.7	1.0	1.5
Average for region	1.4	1.4	1.9

[a]*Final Report of Seeded and Quota Acreage Statistics Processed from 1971-72 Producers Permits issued to February 22nd 1972*, The Canadian Wheat Board, Management Information Services Division, Winnipeg, Manitoba, February 29, 1972.

TABLE XXXV (continued)

[b]Comparing the revealed preference assumption and the real world for number of farmers delivering and number of bushels delivered for the delivery point of Belleview presents a rather obvious inconsistency. Perhaps one explanation as to why the revealed preference assumption indicates 10 less farmers and roughly 900 extra bushels than the real world is that these 10 farmers, while assigned to Belleview, delivered nothing to Belleview and therefore were not included in the original data.

[c]*Grain Elevators in Canada for Crop Years 1970-71*, Board of Grain Commissioners for Canada, Winnipeg, Manitoba,

[d]Revealed preference bushels, as will be explained in the final simulation presented in this study, includes only Wheat Board Grains, that is, wheat, oats and barley. Real world bushels, on the other hand, includes all grain deliveries.

correlation were estimated so as to give some indication as to the relationship between the parameters under the minimum cost/distance assumption, revealed preference condition and the real world. A coefficient of correlation with a value of 1.0 indicates a perfect relationship between variables. The coefficients of correlation are shown in Table XXXVI.

The relationship between the revealed preference condition and real world for all three parameters while not reported here, were found to be very high. The correlation between the real world and CHAD's predictions made under revealed preference proved to be almost perfect for the two parameters, number of farmers delivering and the number of bushels delivered to each of the 31 delivery points in the Boissevain region. Also, under revealed preference, the relationship between CHAD's predictions of delivery point handling-to-capacity ratios and real world handling-to-capacity ratios was also very high. The correlations between CHAD parameters under the revealed preference assumption and those for the real world are in actuality no more than a comparison of data collection and measurement techniques adopted by the respective data suppliers (Canadian Transport Commission and Canadian Grain Commission). However, the correlations do represent a test of the CHAD model in the sense that a grain collection institutional consideration can and was incorporated into the models framework. From a

TABLE XXXVI

COEFFICIENTS OF CORRELATION BETWEEN NUMBER OF FARMERS DELIVERING, NUMBER OF BUSHELS DELIVERED AND HANDLING TO CAPACITY RATIOS (H/C) UNDER THE MINIMUM COST/DISTANCE ASSUMPTION, REVEALED PREFERENCE CONDITION AND REAL WORLD, 1970-71

	Minimum Cost/Distance					
	Farmers delivering		Bushels delivered		H/C ratios	
	Correlation Coefficient	Chi-square	Correlation Coefficient	Chi-square	Correlation Coefficient	Chi-square
Farmers Delivering						
Rev. Pref.	0.81	582.0				
Real World	0.79	503.4				
Bushels Delivered						
Rev. Pref.			0.83	2,293.8		
Real World			0.77	2,763.0		
H/C ratios						
Rev. Pref.					0.60	389.2
Real World					0.46	291.1

statistical standpoint a reasonable relationship of the real world existed for two parameters, number of farmers and number of bushels, using the minimum cost/distance assumption.

Considerable caution must be exercised in interpreting correlation coefficients however. In very simple terms, the coefficient of correlation just tells part of the story, that is, whether the variables correlated rise and/or fall together. No consideration is given to the magnitude of the correlated variables. For example, examination of the values presented in Table XXXVI indicates just how much coefficients of correlation tended to mask some of the glaring discrepancies between the "real world" and the minimum cost/distance assumption. To provide additional information on these relationships, chi-square tests were performed and are presented in Table XXXVI. By simple inspection of these chi-square values it is apparent that there exists very little relationship between the results of the minimum cost/distance assumption and the revealed preference assumption and the "real world" for all three parameters, farmers delivering, bushels delivered and delivery point H/C ratios. In words, the chi-square test performed involved subtracting expected values (either revealed preference or "real world") from corresponding observed values (minimum cost/distance), squaring this difference and dividing by the expected value. These derived values are then added yielding the chi-square estimate for "goodness of fit." There is some question regarding whether this test is applicable to this particular case, but it does contribute some insight into the absolute differences between observed and expected delivery point parameters.

Reviewing the comparisons presented in Table XXXVI should reveal that six percent of the farmers and 25 percent of the bushels in the Boissevain region in 1970-71 are unaccounted for. That is, data are lacking on 143 farmers and 2.9 million bushels. While CHAD is not capable of simulating the existence of an additional 143 farmers (at least not currently), it can be modified to consider the effect of collecting, handling and distributing an additional 2.9 million bushels. Assuming that six percent of Boissevain farmers are unaccounted for due to data collection limitations, irregularities, oversight or for whatever reason and that this six percent would have accounted for six percent of area deliveries and handling, the number of missing bushels is reduced to 19 percent from 25 percent. It was later confirmed by the supplier of the data, the Canadian Transport Commission, that non-Wheat Board grains were not considered in their data collection procedures. Examination of the types of grain delivered to Boissevain elevators during crop year 1970-71 revealed that approximately 70 percent of farmer deliveries to Boissevain elevators were Wheat Board grains.

SIMULATING A CHANGE IN THE VOLUME OF GRAIN COLLECTED, HANDLED AND DISTRIBUTED

As mentioned at the close of the previous section of this study, the Board of Grain Commissioners reported that total handlings for the 31 delivery points in the Boissevain area was approximately 11.3 million bushels during 1970-71.[110] This final simulation depicts the effect on collection, handling and distribution costs for a total handle within the Boissevain region of 11.3 million bushels as compared to 8.4 million bushels used in previous simulations.

This simulation is performed for CHAD system 1970-71, revealed preference assumption. Comparisons are made between the results obtained for the 8.4 million bushel volume and those obtained for the 11.3 million bushel volume.

With 1970-71 grain marketings of 11.3 million bushels, aggregate collection costs are $315,435 or 2.79 cents per bushel (Tables XXXVII and XXXIX). At marketings of 8.4 million bushels collection costs are 2.89 cents per bushel (See Table XIV). A 35 percent increase in bushels collected resulted in a 30 percent increase in total collection costs but a four percent decrease in average collection costs per bushel. The cost of the collection, handling and distribution system to the farmer for system throughput of 11.3 million

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[110] See Footnote b, Table XXXV.

bushels is 18.19 cents per bushel. At the lower 8.4 million bushel throughput, collection, handling and distribution costs were 18.29 cents. After rail rationalization (Sim 7), average collection costs are 4.08 cents per bushel for the 11.3 million bushel throughput compared to 4.27 cents per bushel for the 8.4 million bushel throughput.

The most significant change occurred in handling costs (Table XXXVIII). As a result of increasing bushels handled 35 percent, average handling costs decreased 19 percent from 7.97 cents per bushel to 6.45 cents per bushel. The economic or resource cost of the system with an 11.3 million bushel throughput is 32.33 cents per bushel as compared to 33.95 cents per bushel for the throughput of 8.4 million bushels.

A few generalizations may be drawn from these comparisons. A large increase in bushels collected will decrease average collection costs per bushel only marginally. In this example a 35 percent increase in bushels collected decreased average collection costs per bushel by only four percent. Elevator operating costs, on the other hand, are very responsive to changes in bushels handled. It was shown that a 35 percent increase in handlings decreased average operating costs per bushel by 19 percent. In addition, in terms of average costs, the higher the bushel volume going through the system the larger the potential savings from

TABLE XXXVII

COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1970-71, REVEALED PREFERENCE ASSUMPTION, 11.3 MILLION BUSHELS, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8
(Handling rates and distribution rates)
(Dollars)

Simulation	Collection Costs	Handling Costs	Distribution Costs	CHAD Total Costs
1	315,435	650,295	1,091,935	2,057,665
2	216,017	650,295	1,091,934	2,058,246
3	322,771	650,295	1,092,091	2,065,157
4	319,260	650,295	1,092,041	2,061,596
5	347,849	650,295	1,092,040	2,090,184
6	431,203	650,295	1,092,025	2,173,523
7	461,758	650,295	1,086,480	2,198,533
8	475,017	650,295	1,089,153	2,214,465

TABLE XXXVIII

COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1970-71, REVEALED PREFERENCE ASSUMPTION, 11.3 MILLION BUSHELS, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8 (Handling and Distribution Costs) (Dollars)

Simulation	Collection Costs	Handling Costs	Distribution Costs	CHAD Total Costs
1	315,435	729,978	1,091,935	2,137,349
2	316,017	722,966	2,611,091	3,650,884
3	322,771	699,678	2,603,625	3,626,075
4	319,260	681,421	2,596,522	3,597,204
5	347,849	600,771	2,534,267	3,482,888
6	431,203	546,745	2,449,124	3,427,072
7	461,758	463,070	2,358,464	3,283,293
8	475,017	435,448	2,364,380	3,274,845

TABLE XXXIX

AVERAGE COLLECTION, HANDLING AND DISTRIBUTION COSTS, CHAD SYSTEM 1970-71, REVEALED PREFERENCE ASSUMPTION, RAIL LINE ABANDONMENT SIMULATIONS 1 THROUGH 8
TOTAL BUSHELS COLLECTED, HANDLED AND DISTRIBUTED 11,309,489
(Cents/Bushel)

Simulation	Collection AC/BU (1)	Handling AC/BU (2)	Distribution AC/BU (3)	Handling Rate/bu. (4)	Distribution Rate/bu. (5)	Farmer Costs (1+4+5)	Resource Costs (1+2+3)
1	2.79	6.45	23.09	5.75	9.65	18.19	32.33
2	2.79	6.39	23.09	5.75	9.65	18.19	32.27
3	2.85	6.19	23.02	5.75	9.66	18.26	32.06
4	2.82	6.03	22.95	5.75	9.66	18.23	31.80
5	3.08	5.31	22.40	5.75	9.66	18.49	30.79
6	3.81	4.83	21.65	5.75	9.66	19.22	30.29
7	4.08	4.09	20.85	5.75	9.61	19.44	29.02
8	4.20	3.85	20.91	5.75	9.63	19.58	28.96

rationalization. At an 8.4 million bushel volume, farmer costs are 19.63 cents per bushel after rationalization, at an 11.3 million bushel volume farmer's costs are 19.44 cents per bushel. The average cost in resources utilized for an 8.4 million bushel throughput is 29.92 cents per bushel while for an 11.3 million bushel throughput this cost is 29.02 cents per bushel, a decline of nearly a full cent.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of this last chapter is to summarize the results of the simulations and to suggest implications of these results. Implications and conclusions are drawn in respect to farmers, grain companies, railways, the Grains Group report and the rationalization procedure itself. In addition, some social implications are indicated. The study is concluded with a section detailing the limitations of the study and a section suggesting possible avenues for future research.

SUMMARY OF FINDINGS

The primary objective of the study was to conceptualize, develop, empirically apply and test an economic model which would simulate the collection, handling and distribution of grain in Western Canada at the regional level. The purpose of constructing such a model was to enable the simulation of alternative approaches to grain transportation rationalization. Results were obtained under two different conceptual environments: the first considered a farmer's preference in terms of selecting a delivery point, the second assumed minimum distance to delivery point.

Employing the minimum cost/distance assumption, the average cost to the farmer of the existing (1970-71) grain collection, handling and distribution system in the Boissevain region was estimated to be 17.98 cents per bushel. The cost of collection formed 14 percent of this total cost or 2.55 cents per bushel. After the abandonment of light density lines, collection costs increased to 4.18 cents per bushel. The average one-way distance to the nearest elevator more than doubled from 5.3 miles to 11.4 miles. As a result of rationalization, average elevator operating costs declined from 8.03 cents per bushel to 4.81 cents per bushel. The cost of the existing system in terms of the value of resources utilized was estimated to be 33.73 cents per bushel. Following rail line rationalization this cost fell to 29.55 cents per bushel. In summary, as a result of rail line rationalization, collection costs were increased by 64 percent, country elevator operating costs decreased by 67 percent and railway costs decreased by 11 percent. The net result is that the rationalized system is 12 percent less costly than the existing system.

Adapting the simulation model to farmer's revealed preference for delivery points led to different quantitative conclusions. The cost of the system to the farmer was 18.29 cents per bushel. After rationalization average one-way distance to elevator increased from 6.6 miles to 11.7 miles with average collection costs increasing 48 percent from their pre-rationalization level of 2.89 cents per bushel.

Elevator operating costs declined from 7.97 cents per bushel before rationalization to 4.80 cents per bushel following rationalization. Under the revealed preference condition, the cost in resources utilized fell more than 4 cents per bushel, from 33.95 cents to 29.92 cents per bushel as a result of rail line rationalization, a savings of 12 percent. On the other hand, if handling and rail rates remain the same after rationalization as before rationalization, Boissevain farmers will experience a seven percent increase in their aggregate grain collection, handling and distribution costs.

A second set of simulations was performed in an attempt to measure the impact of elevator company rationalization. Four delivery points were closed following the crop year 1970-71 not as a result of rail line abandonment but as a result of closures by elevator companies. Using 1970-71 data, the 1971-72 elevator system was simulated. Adopting the minimum cost/distance assumption, the effect on collection costs was minimal, yielding an increase of 0.04 cents per bushel.

Collection costs were estimated after simulating a variety of changes in the collection procedure. The simulated changes involved a basic switch in collection technique from farmer-owned and operated trucks to custom trucking. It was determined that if all farmers who owned and operated a truck that was less than or equal to 6,000 pounds gross vehicle weight were to switch to the custom hauling of their grain, the average collection cost under the existing system would decline from 2.89 cents per bushel to 2.61 cents per bushel. Similarly, if the custom trucking of grain was substituted for the collection of grain by trucks that were less than or equal to 9,000 pounds gross vehicle weight, average collection costs were estimated to be 2.31 cents per bushel. Substitution of custom trucks for farm trucks older than 1952 yielded an average cost per bushel of 2.73 cents. The average collection cost per bushel was 2.77 cents once custom trucks were substituted for farm trucks required to travel more than 12 miles to the nearest elevator. The fifth collection procedural change, the substitution of custom trucks for farm trucks where farmer deliveries were 2,000 bushels or less, was the lowest of all changes simulated, 1.92 cents per bushel. All five changes in collection procedures resulted in lower average collection costs than the existing collection procedure following rail line rationalization.

The model was further modified to consider the locating of new elevators. That is, the existing system was ignored and only the collection cost suitability of alternative locations measured. It was determined that the Boissevain area could support at least three of the Grains Groups high throughput elevators. After evaluating eight alternative delivery point combinations, it was determined that the combination Deloraine-Melita-Souris would minimize the costs of collection. This combination also minimized the average driving distance for Boissevain farmers, requiring an average one-way haul for Boissevain farmers of 17.08 miles. The estimated average collection cost for this high throughput elevator system was 5.68 cents per bushel. The optimal location for an inland terminal, in terms of minimizing collection costs, was Medora. Average one-way distance to Medora for Boissevain farmers was estimated to be 28.03 miles, yielding an average collection cost of 8.63 cents per bushel.

To test the effectiveness of the minimum cost/distance assumption and the revealed preference assumption as simulators of the real world, coefficients of correlation were estimated for three critical parameters of the system. The CHAD model under the revealed preference assumption proved to be very accurate in simulating the parameters of the real world. Coefficients of correlation of 0.99 were realized for two of the parameters, number of farmers delivering to each delivery point and number of bushels handled at each delivery point. The relationship between handling-to-capacity ratios at each delivery point for revealed preference and the real world yielded a coefficient of correlation of 0.94. With the exception of the handling-to-capacity parameter, the assumption of minimum cost/distance presented statistically reasonable estimates of their respective real world parameters. The coefficient of correlation between the minimum cost/distance assumption and the real world for number of farmers delivering to each delivery point was 0.79 and for number of bushels handled at each delivery point 0.77. However, it was recognized that considerable caution must be exercised in interpreting these results in that coefficients of correlation tell only part of the story and tend to obscure true relationships.

The final simulation presented in the text involved increasing the volume of bushels collected, handled and distributed within and from the Boissevain area. As a result of increasing the bushel volume 35 percent (from 8.4 million to 11.3 million), average collection costs declined from 2.89 cents per bushel to 2.79 cents per bushel. The effect on average country elevator operating costs was more significant. These fell by more than 1.5 cents from 7.97 cents per bushel at the 8.4 million bushel volume to 6.45 cents per bushel for the 11.3 million bushel volume. As rail lines were simulated out of the system, the difference between collection and operating costs at the 8.4 million bushel volume versus the 11.3 million bushel volume widened. The indication is that the higher the bushel volume the slower the rises in average collection costs per bushel and the faster the fall in average operating costs per bushel as rail line rationalization proceeds. This trend could continue until existing elevator structures could no longer handle additional grain deliveries without considerable re-investment in plant.

CONCLUSIONS AND POLICY IMPLICATIONS

What are the implications of rationalization to the various participants in the system? That is, who will likely benefit from grain transportation rationalization and by how much and at whose expense? It is recognized that the results of the various simulations presented in the previous chapter and the CHAD rationalization model itself could be used to both substantiate and attack various opinions and biases. Some of the more obvious conclusions and implications generated by the CHAD simulation model are presented in the remainder of this section of the chapter.

Conclusions and Implications for Farmers

All participants in the system as well as governments will have to decide whether the costs and benefits of grain transportation rationalization are to be measured in terms of resources utilized or direct costs to the farmer. Some will argue that the cost in resources utilized is the only legitimate criterion in measuring the potential benefits of rationalization while others will assume that handling and rail rates will be unaffected by rationalization while collection costs will certainly rise with the net effect of decreasing on-farm grain prices. Others will recognize the interdependence between farmers, elevator companies and railways and realize that the critical issue is the financial health of the system as a whole.

The results of simulating CHAD system 1970-71 by revealed preference assumption for an 8.4 million bushel volume indicate that rail line rationalization will cause the system to utilize approximately $338,000 less resources than it is currently using. By rationalizing the grain collection, handling and distribution system in the Boissevain area, the railways will save about $200,000 and elevator companies $265,000. To realize this saving, farmers will be required to travel, on the average, an additional 5.1 miles to their elevator and incur an additional $115,000 in collection costs. In terms of resources utilized, in aggregate the benefits of rationalization far out-weigh the costs of rationalization. The Grains Group contended that the least costly system in the long-run would be the inland terminal system. To achieve these long-run benefits, farmers in the Boissevain region, on the average, will be obliged to travel 28 miles to their inland terminal at an additional aggregate cost of close to half-a-million dollars. If handling and storage rates and rail rates are adjusted to reflect full costs, the Boissevain farmer will pay 11.5 cents per bushel to the elevator company for the handling and storage of his grain and 14.2 cents per bushel to the railway for transporting his grain by unit train to Thunder Bay. These figures should be compared to the current cost of the system to the Boissevain farmer of 2.89 cents per bushel collection, 5.75 cents per bushel handling and roughly 9.65 cents per bushel distribution.

Farmers generally recognize but seldom admit, that handling rates do not cover handling costs and that rail rates do not cover rail costs on light density branch lines. Elevator and railway companies are forced to use cross-subsidization within their operations to maintain their services to the grain farmer. Elevator operating costs of handling a bushel of grain in the Boissevain region in 1970-71 was estimated to be 7.97 cents per bushel. The handling rate charged to farmers, on the other hand, was 5.75 cents per bushel. Excluding storage revenue, elevator companies on the average lost 2.22 cents per bushel handled. Railway companies suggest that Crows Nest Pass rates represent only 40 percent of rail costs. The question that farmers must ask themselves is how long can elevator and railway companies continue to incur such losses without one or a combination of the following occurring: (1) public interference caused by the necessity to grant large subsidies; (2) assuming the system is granted subsidies to offset losses, it may be just a matter of time before the question of direct and total public ownership of the system is raised; (3) deterioration of elevator and rail services, perhaps impairing Canada's ability to compete in world markets; and (4) additional grain companies selling out their country elevator operations.

There is considerable question whether any of these occurrences would be in the interest of Prairie farmers. Grain handling and transportation rationalization is presented as an alternative to these measures.

The expected life of a farm truck, or any motor vehicle for that matter, is highly dependent on annual truck mileage; the higher the annual mileage the shorter the economic life of the truck. Trips to the elevator in making grain deliveries form approximately 15 percent of a farm truck's annual mileage. As delivery points are rationalized out of the collection system, distances to alternate delivery points increase. Therefore, due to rationalization, annual farm truck mileage can be expected to increase marginally, decreasing the life of the average farm truck. That is, farm trucks will depreciate faster as a result of grain transportation rationalization.

In addition, certainly one of the deciding factors in purchasing a farm truck, is the delivery requirements of the existing system. One of these requirements is one-way distance to the elevator. The average one-way distance to elevator of 6.6 miles contributes to the explanation as to why close to 50 percent of the farm trucks in the Boissevain region are less than 9,000 pounds gross vehicle weight. Under a rationalized collection system where one-way distance may be as high as 28 to 30 miles, many of these small trucks, regardless of age or condition, may be totally impractical as a means of grain delivery. A farmer who prefers to make his deliveries with his own truck but finds that the truck he currently owns is now insufficient for this purpose has no alternative but to purchase a suitable truck. However, there is considerable doubt as to whether this occurrence should be an assignable cost to grain transportation rationalization. That is, there is reason to believe that any necessary collection technique adjustments are long overdue and would occur with or without rationalization.

Previous simulations indicated that the custom trucking of grain may be an important and profitable alternative to the transporting of grain by farmer-owned and operated trucks. The custom hauler could be a very significant factor in the efficient organization and operation of a rationalized grain collection system. It was further indicated that close to 1,000 farmers could be users of the custom trucking service during and after rationalization.[111] Rationalization may provide the impetus to foster the development of a new modal industry in the Boissevain region. If this should prove to be the case, some interesting policy implications arise. For example, some policies may be required to legally differentiate the custom trucker and his obligations from those of the

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[111]Includes those farmers originally using custom trucking plus farmers who typically deliver 2,000 bushels or less.

individual farmer and commercial trucker in terms of regulation.

Conclusions and Implications for Grain Companies

Rationalization in the Boissevain region could reduce the number of delivery points from 31 to 8. As a result of deliveries being highly concentrated at these several points, the competitive environment among elevator companies will likely change. Should rail line rationalization proceed as depicted earlier, in terms of the number of units remaining, the competitive position of United Grain Growers should improve while that of Manitoba Pool elevators deteriorate.[112] At six of these eight delivery points there would be a duopoly. With a predominantly duopoly market structure and with grain deliveries and therefore revenues being so highly concentrated, it may be expected that elevator companies could have a change in their competitive attitudes toward each other.

The burden of proof is largely on elevator companies as to whether existing facilities can be used to form the grain handling system of the future. If the use of existing facilities is considered the best alternative by elevator companies, some degree of cooperation with the railways may be desirable if the railways and the grain industry are to take advantage of the unit train technology.

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[112] Manitoba Pool Elevators would still control 50 percent of available capacity.

It is a common allegation in the grain handling industry that rates charged to farmers for the handling service provided by the elevator companies do not cover the full costs of handling. It is also quite frequently alleged that the revenue received from storage and port terminal operation subsidizes the losses incurred in handling.

The charge for storing in crop year 1970-71 was 1/30 of a cent per bushel per day or a cent per bushel per month. Storage revenue, of course, is highly dependent upon available elevator capacity. Rationalization will reduce aggregate elevator capacity in the Boissevain region by over 50 percent indicating that, to a significant degree, the ability of elevator companies to cross-subsidize handling rates with storage rates will weaken. However, previous simulations have indicated that rationalization will be very effective in reducing average operating costs. It has been demonstrated that during the latter stages of rail rationalization elevator operating costs could fall below handling rates. The Canadian Grain Commission and the Canadian Wheat Board must be prepared to consider and explain the effect of rationalization on handling and storage rates. Perhaps the best policy that could be adopted by the Canadian Grain Commission, the Canadian Wheat Board and the elevator companies is to open their books and negotiations during the period when rail lines are being abandoned.

Conclusions and Implications for Railways

Just as the railways once insisted during the MacPherson Royal Commission that farmers cannot have both branch lines and Crows Nest Pass rates, the railways cannot expect farmers to pay the costs of rail plant rationalization and full-cost rail rates. That is, grain transportation rationalization should make the arguments concerning the non-compensatory aspect of the Crows Nest Pass rates largely a dead issue for at least several years. Rail plant rationalization is a compromise and it should be explicitly stated as such by all concerned parties.

If rail rationalization proceeds as envisioned in this study and the Grains Group study, the Canadian Pacific will be the only railway servicing the Boissevain area. That is, rationalization very likely could create a regional monopoly for a railway. While railway monopolies are not uncommon on the Canadian Prairies, this situation does place a great deal of responsibility on one company.

Rationalization at the regional level as opposed to the Prairie level has implications for the railways as well. Railways would simply not rationalize their rail network in one region without considering the effects and influences of their rail lines in adjacent regions. These interregional relationships have effects on estimates of rail cost savings from rationalization in that full cost savings from abandoning a particular rail line which extends into adjacent regions are not recognized.

Social Implications

As yet untouched are the social implications of grain transportation rationalization and their potential effects on policy modification and formulation. One of the most important social implications concerns the effect of rationalization on employment in the elevator and railway industries. No estimate has yet been made regarding this cost of rationalization. Rationalization in the Boissevain area could reduce the number of elevators from 53 to 17 with the same effect on elevator managers. While the remaining elevators will certainly absorb some of this displacement by turning their units into 2 or even 3 man operations, many will have to seek jobs elsewhere. As the rail plant is reduced through rationalization, railway companies may find it desirable to retire, without replacement, railway operation and maintenance personnel. Their respective head-office employment, in addition, could be affected.

Implications for the Grains Group Report

The results as well as the approach of the Grains Group differ from those of the CHAD simulation model. While the 80 inland terminal scheme may well be the least-cost most efficient grain handling and transportation system of the future, the real problems are going to be encountered in the movement toward that system. In this sense the CHAD simulation model can serve as a complement rather than a substitute for the Grains Group approach and analysis.

The differences in results generated through the application of CHAD and those derived from the Grains Group analysis, may well imply that the Boissevain region is not in all cases a representative sample of the Prairies. If the Grains Group is "right" for the Prairies and if CHAD is "right" for the Boissevain region of Manitoba, a number of implications can be drawn regarding Prairie and regional rationalization procedures. Rationalizing at the macro or Prairie level may very likely under as well as over estimate the effects of rationalization occurring at certain micro or regional levels. In addition, one cannot draw generalizations about Prairie effects from an analysis depicting regional effects. In other words, a great deal of caution must be exercised if suggested rationalization procedures are to be applied deductively (from Prairie to region) or inductively (region to Prairies).

Conclusions and Implications for Regional Rationalization Procedures

A significant problem to be encountered in grain transportation rationalization concerns the kind of alternatives that can be presented to encourage the participation and cooperation of all participants and organizations which comprise the system.

A rationalized system with handling and rail rates remaining constant and with farmers maintaining pre-rationalization collection procedures, will be more costly to the farmer than the existing unrationalized system. There is, therefore, no direct cost incentive for farmers to willingly yield to the rationalization of the existing system let alone plan for a completely new system for the 1990's. However, the various simulations performed in this study suggest a procedure of rationalization which may provide the necessary cost incentive.

Including the existing system, the rationalization procedure contains nine steps. This procedure relates to CHAD system 1970-71, revealed preference assumption, for the 8.4 million bushel volume. The first step in recognizing the system as it exists or, in other words, "where we are." The cost of this system to the farmer is 18.29 cents per bushel (Table XL).[113] The cost in resources utilized by the system is 33.95 cents per bushel (Table XLI). The second step in the rationalization procedure is to provide custom trucking to all farmers who deliver 2000 bushels or less. This decreases collection costs by 0.97 cents per bushel. Steps three through seven involve the abandonment of rail lines in the following order: (1) "Belleview," (2) "Boissevain," (3) "Alida," (4) "Lyleton" and (5) "Arcola." At the eighth step the "Hartney" line would be abandoned and

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[113] This analysis ignores storage costs and revenues.

TABLE XL

A RATIONALIZATION PROCEDURE:
ITS COST TO THE FARMER
(Cents per Bushel)

Procedural Step	Collection Costs	Handling Costs	Distribution Costs	Total Costs
1	2.89	5.75	9.65	18.29
2	1.92	5.75	9.65	17.32
3	1.92	5.75	9.66	17.33
4	1.98	5.75	9.66	17.39
5	1.97	5.75	9.66	17.38
6	2.20	5.75	9.66	17.61
7	2.84	5.75	9.66	18.25
8	3.10	4.80	9.61	17.51
9	3.21	4.40	9.63	17.24

TABLE XLI

A RATIONALIZATION PROCEDURE:
ITS COST IN RESOURCES
(Cents per Bushel)

Procedural Step	Collection Costs	Handling Costs	Distribution Costs	Total Costs
1	2.89	7.97	23.09	33.95
2	1.92	7.97	23.09	32.98
3	1.92	7.89	23.09	32.90
4	1.98	7.61	23.02	32.61
5	1.97	7.40	22.95	32.32
6	2.20	6.14	22.40	30.74
7	2.84	5.80	21.65	30.29
8	3.10	4.80	20.85	28.75
9	3.21	4.40	20.87	28.48

handling rates adjusted down to elevator operating costs. The ninth step completes the rationalization procedure with the closing down of all elevators on the remaining rail lines which are less than 100,000 bushel capacity. Rail rates throughout the procedure remain the same. The end result is that the rationalized system now costs less than the pre-rationalized system. Farmers in the aggregate save a little more than a cent a bushel. Elevator companies are covering total operating costs with handling revenue.[114] The railways, while still being held to Crows Nest Pass rates, reduce their costs by 2.22 cents per bushel. In aggregate, the rationalized system as suggested reduces collection, handling and distribution costs in the Boissevain region by approximately $500,000.

The next logical step would be to rationalize directly to the high throughput or inland terminal system. The question must be asked at this stage, however, whether it is really necessary. If the rationalized system depicted at the end of the rationalization procedure is capable of collecting, handling and distributing the grain production of the Boissevain region at minimum cost in resources, certainly it should be given the opportunity to do so. The additional investment required to modernize the elevators remaining

[114]Operating costs actually cover the combined costs of handling and storage. Therefore, any revenue received from storage is pure profit.

after rationalization must be compared to the investment required in constructing new elevators.

What will the grain collection, handling and distribution system in the Boissevain area look like after rationalization? If the same procedural steps are taken as were described earlier, the rationalized system will be composed of eight delivery points and 17 elevators with combined capacity of 2,666,800 bushels (Table XLII). All of the remaining points are competitive points with the exception of Napinka. The only elevator company not represented in the rationalized system that was represented in the pre-rationalized system is Parrish and Hiembecker which presently owns a very small elevator in the town of Boissevain. Before rationalization, Manitoba Pool Elevators owned 63 percent of the elevators and 58 percent of the capacity available in the Boissevain region. After rationalization Manitoba Pool Elevators would own 47 percent of the elevators and 49 percent of the capacity. United Grain Growers would increase its percentage of ownership from 22 percent to 35 percent and its share of system capacity from 26 percent to 33 percent. N. M. Paterson and Sons, prior to rationalization own 10 percent of the elevators in the Boissevain region and 13 percent of the system's elevator capacity. If rationalization should proceed as envisioned earlier, N. M. Paterson and Sons will own 2 of the 17 elevators representing 11 percent of area capacity. One

TABLE XLII

DELIVERY POINTS REMAINING AFTER RATIONALIZATION

Delivery Point	Capacity of Elevator	Ownership of Elevator	Number of Rail Cars That Can Be Shunted at One Time
Boissevain	228,600	MPE	6
"	153,500	NMPS	4
"	140,000	UGG	7
Deloraine	152,600	MPE	8
"	117,900	FG[a]	5
"	105,000	UGG	4
Hartney	111,400	MPE	5
"	155,000	UGG	16
Medora	177,200	MPE	9
"	131,000	UGG	9
Melita	124,000	MPE	9
"	119,000	UGG	3
Napinka	120,500	MPE	15
Pierson	172,500	MPE	9
"	128,000	NMPS	6
Souris	210,600	MPE	6
"	320,000	UGG	12

[a]In the spring of 1972 Federal Grain sold out to Manitoba Pool Elevators.

could conclude therefore, that rationalization would create a more competitive environment for elevator companies.

This rationalized system was simulated using CHAD system 1970-71, revealed preference assumption, for an 8.4 million bushel volume. If all farmers who deliver 2,000 bushels or less were to use custom hauling in addition to those already using custom hauling, a total of 948 farmers would require the custom trucking service. As a result, a total of 1.8 million bushels would be delivered to elevators by custom truck. This would result in an average collection cost of 3.21 cents per bushel. Average country elevator operating cost for the rationalized system is 4.40 cents per bushel. Due to rationalization, the delivery point reflecting the lowest average operating cost is Melita at 3.44 cents per bushel (Table XLIII). The point with the highest handling-to-capacity ratio is Pierson where 1.5 million bushels are handled through an aggregate delivery point capacity of 300,500 bushels. The handling-to-capacity ratio is a good indication of the degree of stress placed on any particular elevator. Again, only a detailed appraisal of the potential of each elevator at each of these delivery points will tell whether or not these existing structures can withstand the indicated stress. These handling-to-capacity ratios are not uncommonly high for main rail line elevators and delivery points. Given the projected volumes to be handled at each delivery point, additional investment

TABLE XLIII

DELIVERY POINT HANDLING-TO-CAPACITY RATIO, BUSHELS HANDLED AND AVERAGE HANDLING COSTS

Delivery Point	Handling-to-Capacity Ratio	Bushels Handled	Delivery Point Average Handling Cost (Cents/bushel)
Boissevain	2.8	1,482,576	4.84
Deloraine	2.4	903,887	5.25
Hartney	2.9	773,899	4.45
Medora	3.1	952,194	4.67
Melita	5.0	1,205,632	3.44
Napinka	3.3	401,032	4.35
Pierson	5.1	1,517,657	3.92
Souris	2.2	1,140,815	4.56

will likely be required in extending rail sidings so that more rail cars can be loaded at one time (Table XLII).

Another factor which will likely influence the potential suitability of existing elevators to form the system of the future is the queuing problem. But as can be seen in Table XLIV, the location of the remaining delivery points results in a rather even distribution of both farmers and bushels. While some adaptation will certainly be required, especially at Melita and Pierson, the queuing problem, if there is one, should not be a constraint.

In conclusion, the simulation model developed and applied in this study can be used as a stimulant in grain transportation rationalization. The CHAD simulation model can be used to both determine "where we should go" and "how we should get there." And finally, it provides a basic framework upon which railways, elevator companies, farmer groups and individual farmers can build and sophisticate according to their particular needs and expertise.

As emphasized throughout this study, the CHAD simulation model can be used to its best advantage as a decision-making aid and a negotiation tool. It is firmly believed that grain transportation rationalization is a desirable goal, but with equal vigor, it is believed that rationalization will likely be exceedingly slow and painful unless all participants in the system are provided with the means to participate actively in the formulation and evaluation of

TABLE XLIV

THE DISTRIBUTION OF FARMERS AND BUSHELS AND AVERAGE ONE-WAY DISTANCE BY DELIVERY POINT

Delivery Point	Bushels Delivered	Percent of Bushels Delivered	Number of Farmers Delivering	Percent of Number of Farmers Delivering	Average One-Way Distance to Delivery Point
Boissevain	1,482,576	17.7	354	16.2	11.26
Deloraine	903,887	10.8	279	12.8	9.43
Hartney	773,899	9.2	205	9.4	9.06
Medora	952,194	11.4	226	10.3	9.10
Melita	1,205,632	14.4	368	16.8	15.69
Napinka	401,032	4.8	132	6.0	12.70
Pierson	1,517,657	18.1	380	17.4	16.41
Souris	1,140,815	13.6	243	11.1	9.23
Totals	8,377,692	100.0	2,187	100.0	12.10

the alternatives.

LIMITATIONS OF THE STUDY

When simulating a system, one attempts to minimize the use of assumptions and simplifications. But when that system is as complex as the grain collection, handling and distribution system in Western Canada, compromises must be made, at least during the first attempt at the simulation. For example, the study abstracts from the effects of the quota system on collection, handling and distribution costs. In addition to this institutional abstraction, the study does contain a number of recognizable limitations and, as more of a challenge to future researchers than an apology, they are brought to light here.

Perhaps the most damaging limitations of the study concern the methods adopted in estimating average country elevator operating and rail costs. Average operating costs were estimated by delivery point rather than individual elevators. Basically, the method, as explained earlier, involved dividing the aggregate elevator capacity at the delivery point by the number of elevators at the delivery point thus yielding an average elevator capacity at the delivery point. The appropriate size strata handling cost equation was then selected. Aggregate bushel deliveries to the delivery point were then divided by the number of elevators at the delivery point yielding an average bushel handled for each elevator. This average bushel handle was then inserted into the handling cost equation resulting in an average operating cost per bushel for the delivery point. This average operating cost per bushel was multiplied by total delivery point handlings to get total handling costs for the delivery point. Ideally, one would like to know exactly which elevator got which bushel. The study was entirely dependent upon the Grains Group for estimates of rail costs. And, regretfully, the Grains Group, in turn, was entirely dependent on the railways.

Another limitation of the study stemmed from a limitation of the data. As explained in an earlier section of the study, the data on farmer deliveries did not include non-Wheat Board grains. While this data limitation was partially offset by a simulation, some degree of error was undoubtedly committed by the use of necessary assumptions.

Along this same line, it was deemed expedient to assume all grains homogeneous in terms of weight and volume. The effects of this simplification would show-up in all three of the subsystems of collection, handling and distribution. For example, on the collection side, with oats being lighter in weight than wheat or barley, the costs of transporting a bushel of oats would be less than the cost of transporting a bushel of e.g., wheat. On the handling side, it was assumed the handling rate of 5.75 cents per bushel for wheat and barley applied to the handling of all grain. The handling rate for oats of course is 4.50 cents per bushel. In converting rail rates from hundred-weight to bushel equivalents it was assumed each bushel of grain weighed 55 pounds. This average may be low for wheat but high for oats.

The farm truck equation was developed using the same data base as was used in the Tyrchniewicz *et al.*, study. Unlike the Tyrchniewicz study, only four variables could be used in estimating the average cost of collecting grain by farm truck. The Tyrchniewicz *et al.*, study revealed that the variable annual truck mileage was a very significant variable affecting average cost per bushel. As no information could be obtained regarding this variable for Boissevain farmers, it had to be excluded. As a result, some valuable predictive power was lost. To an even more significant degree, these same limitations apply to the custom trucking equation. There is a further limitation to the custom trucking equation. The variables, annual truck mileage and one-way distance to elevator are obviously highly interrelated and both were included in the equation, yet only one, one-way distance, was varied. One would expect, *ceteris paribus*, that if one-way distance is changed, annual truck mileage must change. Yet, even with these limitations, the two truck cost equations proved to be rather good estimators. It would have been better of course to know the characteristics of the custom truck actually hired by each farmer.

Adoption of the minimum cost/distance assumption is necessary during rail line abandonment simulations as the means of redirecting farmers who, due to rationalization, find their preferred delivery point closed. For a more accurate appraisal of the effects of rationalization it would be beneficial to know each farmer's second, third and even fourth preferred choice.

The time period used in estimating collection costs was 1967-68, handling costs 1968-69, and grain deliveries applied to the period 1970-71. Ideally, all cost estimates should have been derived for the same time period and applied during that same time period. That is, all data used in the analyses should pertain to the same period of time. While the basic structure of the collection and handling functions are believed not to have changed from 1967-68 to 1968-69 significantly, an inflation factor might have been appropriate.

Grain transportation rationalization in addition to having a pecuniary impact, has institutional impacts and implications. These effects and resultant ramifications were not dealt with in any great depth. For example, while discussed in this study, the impact of rationalization on the country elevator market structure in terms of the changing competitive positions of elevator firms, deserves special emphasis and attention.

SUGGESTIONS FOR FURTHER RESEARCH

The simulation model presented in this study is a basic framework. It is well recognized that further sophistication of this basic framework is necessary and desirable. Further, it is sincerely hoped that individuals and groups with the expertise in the areas of collecting, handling and distributing grain would apply their talents toward this further sophistication thus creating a more realistic and therefore effective simulation of grain transportation rationalization.

As emphasized in this study, grain transportation is a social, political and economic system. While policy and institutional restraints were considered, the CHAD simulation model is economic orientated. This leaves open the entire question of the social costs of grain transportation rationalization. The aggregate effect of rationalization must include the costs as well as benefits to rural communities and municipalities. Knowing the social costs of grain transportation rationalization will permit a quantitative and perhaps qualitative comparison to the economic benefits of grain transportation rationalization.

While it has been argued in this study that grain transportation rationalization will likely take place at the regional or micro-system level, it would be extremely beneficial to develop a macro-system simulation model of grain transportation rationalization. One of the most important potential contributions of the macro-system model would be in long-run policy formulation. One can envision the macro-system model being used in developing the basic guideline for the rationalization of the Prairies with the CHAD micro-system model being used to test the suggested macro-system guidelines at the regional level.

Rationalization could reduce the number of delivery points by as much as 75 percent. As a result, the structure of the grain handling industry will obviously be affected. With such a high concentration of deliveries among so few delivery points, some significant economies might be gained if elevator companies cooperated at individual delivery points. It could be economically and physically possible to operate two or even three elevators of different ownership as one unit and perhaps attain the economies of a high throughput elevator. This raises questions concerning the inter-plant transportation of grain and what kind of cooperation between elevator companies would be required. Perhaps the rationalized handling system would necessitate a basic change in the type of ownership the handling industry should assume, e.g., public ownership, monopoly or duopoly at all delivery points. Regardless of the type of ownership of elevators after rationalization, additional investment will be required in updating these structures. The magnitude of this investment and the kind of modifications necessary will be critical in determining whether or not existing elevators will form the handling system of the future.

Other potential areas for future research include: the introduction of the commercial trucking of grain as a possible alternative to railway distribution; a more thorough probe of grain transportation policy and an analysis of these policies as to adaptability and suitability in forming the policy environment for a rationalized grain transportation system; and, finally, an analysis of branch line abandonment hearing courtroom procedures and perhaps suggestions as to how a grain transportation rationalization simulation model may be applied during these proceedings.

BIBLIOGRAPHY

BIBLIOGRAPHY

Board of Grain Commissioners, Summary of Country Elevator Receipts at Individual Prairie Points, Board of Grain Commissioners, Winnipeg, Manitoba. Issues 1965-66 through 1970-71.

Bobst, B. W. and M. V. Waananen, "Cost and Price Effects of Concentration Restrictions in the Plant Location Problem," American Journal of Agricultural Economics, Vol. 50, No. 3, August, 1968.

Canadian Federation of Agriculture, Submission by the Canadian Federation of Agriculture, to the Government of Canada, Regarding Policy on Railline Abandonment, Ottawa, August 14, 1962.

The Canadian Wheat Board, Final Report of Seeded and Quota Acreage Statistics Processed from 1971-72 Producers Permits issued to February 22nd, 1972. Management Information Services Division, Winnipeg, February 29, 1972.

Candler, W., J. Snyder and W. Faught, "Concave Programming Applied to Rice Mill Location," American Journal of Agricultural Economics, Vol. 54, No. 1, February, 1972.

Channon, John. W., D. Zasada, and R. T. Miller, The Boissevain Region of Manitoba, Prairie Regional Studies in Economic Geography No. 2, Economics Branch, Canada Department of Agriculture, Ottawa, 1968.

Chartrand, Robert Lee, Systems Technology Applied to Social and Community Problems, Spartan Books, Washington, D. C., 1971.

Chern, W. and L. Polopolus, "Discontinuous Plant Cost Functions and a Modification of the Stollsteimer Model," American Journal of Agricultural Economics, Vol. 52, No. 4, November, 1970.

Charafas, D. N., Systems and Simulation, Academic Press: New York, 1965.

Croxton, F. E., D. J. Cowden, and S. Klein, Applied General Statistics, Prentice-Hall, Englewood Cliffs, New Jersey, 1967.

Currie, A. W., Canadian Transportation Economics, University of Toronto Press, Toronto, 1967.

Dorfman, R., Paul A. Samuelson, and R. M. Solow, Linear Programming and Economic Analysis, McGraw-Hill, New York, 1958.

Foote, Richard J., Analytical Tools for Studying Demand and Price Structures, Agricultural Handbook No. 146, United States Department of Agriculture, Washington, D. C., August, 1958.

Gibbings, Charles W., Address, Regina, Saskatchewan, November 13, 1967.

Goetz, Billy E., Quantitative Methods: A Survey and Guide for Managers, McGraw-Hill, New York, 1965.

Government of Canada, Grain Handling and Transportation, Studies in Progress, Queen's Printer, Ottawa, August, 1972.

Grains Group, Grain Handling and Transportation Costs in Canada, Queen's Printer, Ottawa, August, 1971.

Hoover, E. M., Location of Economic Activity, McGraw-Hill, New York, 1948.

Hoover, E. M., Location Theory and the Shoe and Leather Industry, Harvard University Press, Cambridge, 1937.

Isard, W., Location and Space-Economy, The Technology Press of Massachusetts Institute of Technology and John Wiley and Sons, New York, 1956.

Kanbar, M. G. and H. Neudecker, "Methodology of Spatial Equilibrium Models of the Rice Economy of South India," Artha Vijana, 8, March, 1966.

Kanbar, M. G. and H. Neudecker, "Sensitivity Analysis and Spatial Models," Econometrica Annual of Indian Journal Economics, 15, 1968.

King, Gordon A. and Samuel H. Logan, "Optimum Location, Number and Size of Processing Plants with Raw Product and Final Product Shipments," Journal of Farm Economics, Vol. 46, February, 1964.

Koopmans, T. C., and Martin Beckmann, "Assignment Problems and the Location of Economic Activities," Econometrica, Vol. 25, No. 1., January, 1957.

Kuhn, Tillo E., and D. Lea., Engineering-Economic Systems Analysis for Transport Planning in Dahomey, West Africa, National Research Council, National Academy of Sciences, Washington, D. C., 1969.

Kuhn, Tillo E., "New Approaches to Transport Research and Planning," Proceedings of the Colloquium Series on Transportation, 1968-69, Volume 2, Center for Transportation Studies, University of Manitoba, Winnipeg, Manitoba, August, 1969.

Ladd, George and M. Patrick Halvorson, "Parametric Solutions to the Stollsteimer Model," American Journal of Agricultural Economics, Vol. 52, No. 4, November, 1970.

Lea, N. D. and Associates Ltd. and Lamaree Valois International Limitee, Dahomey Land Transport, United Nations Development Programme, Toronto, 1968.

Lefeber, L., Allocation in Space, Production, Transport and Industrial Location, Amsterdam-Norht-Holland Publishing Company, Amsterdam, 1958.

Lefeber, L, Location and Regional Planning, Training Seminar Series 7, Center of Planning and Economic Research, Athens, Greece, 1966.

Losch, A., Die raumliche Ordnung der Wirtschaft, G. Fisher, Jena, 1944.

McDonald, J. A., "The Total Systems Approach to Transportation Problems," Proceedings of the Colloquium Series on Transportation, 1967-68, Vol. 1, Center for Transportation Studies, University of Manitoba, Winnipeg, Manitoba, June, 1968.

Moore, G., A Cost Analysis of Assembling Grain by Commercial Trucks, Unpublished Master of Science Thesis, Department of Agricultural Economics, University of Manitoba, Winnipeg, Manitoba, 1970.

Phillips, R. H. D., "The Wheat Pools and Development of Federal Transportation Policy for Canadian Railways 1960-70," Canadian Journal of Agricultural Economics, Vol. 19, No. 1, July, 1971.

Polopolus, L., "Optimum Plant Numbers and Locations for Multiple Product Processing," Journal of Farm Economics, Vol. 47, No. 2, May, 1965.

Rabow, Gerald, The Era of the System, Philosophical Library, Inc., New York, 1969.

Report of the Royal Commission on Transportation of 1951, Ottawa, Queen's Printer, 1951.

Sampson, Roy J. and Martin T. Farris, Domestic Transportation: Practice, Theory and Policy, Houghton Mifflin Company, Boston, 1966.

Samuelson, Paul A., "Spatial Price Equilibrium and Linear Programming," American Economic Review, Vol. XLII, No. 3, June, 1952.

Saskatchewan Wheat Pool, Submission of the Saskatchewan Wheat Pool to the Royal Commission on Transportation in Canada, Ottawa, 1960.

Snodgrass, M. M., and C. E. French, "Simplified Presentation of Transportation Problem Procedure in Linear Programming," Journal of Farm Economics, Vol. XXXIX, No. 1, February, 1957.

Stollsteimer, J. F., "A Working Model for Plant Numbers and Locations," Journal of Farm Economics, Vol. 45, No. 3, August, 1963.

Strange, H. G. L., A Short History of Prairie Agriculture, Searle Grain Company, Limited, Winnipeg, Manitoba, 1954.

Tangri, O. P., D. Zasada, and E. W. Tyrchniewicz, Country Grain Elevator Closures: Implications for Grain Companies, Research Report No. 10, Center for Transportation Studies, University of Manitoba, Winnipeg, Manitoba, January, 1973.

Toft, H. I., P. A. Cassidy, and W. O. McCarthy, "Sensitivity Testing and the Plant Location Problem," American Journal of Agricultural Economics, Vol. 52, No. 3, August, 1970.

Tyrchniewicz, E. W., A. H. Butler, and O. P. Tangri, The Cost of Transporting Grain by Farm Truck, Research Report No. 8, Center for Transportation Studies, University of Manitoba, Winnipeg, Manitoba, July, 1971.

Tyrchniewicz, E. W. and O. P. Tangri, Grain Transportation in Canada: Some Critical Issues and Implications for Research, Occasional paper No. 2, Center for Transportation Studies, University of Manitoba, Winnipeg, Manitoba, August, 1968.

von Thunen, J. H., _Der esolierte Staat in Beziehung auf Landevertschaft and Nationalokonomie_, Hamberg, 1826.

Warrack, A. A., and L. B. Fletcher, "Plant-Location Model Suboptimization for Large Problems," _American Journal of Agricultural Economics_, Vol. 52, No. 4, November, 1970.

Weber, A., _Uber den Standart der Industrien_, 1909.

Wilde, D. J., and C. S. Beightler, _Foundations of Optimization_, Prentice-Hall: Englewood Cliffs, New Jersey, 1967.

Zasada, D. and O. P. Tangri, _An Analysis of Factors Affecting the Cost of Handling and Storing Grain in Manitoba Elevators_, Research Report No. 13, Department of Agricultural Economics, University of Manitoba, Winnipeg, Manitoba, 1967.

APPENDIX A

APPENDIX B

APPENDIX C

APPENDIX D

APPENDIX E

APPENDIX F

APPENDIX G

APPENDIX H

APPENDIX A

CONCEPTUAL AND EMPIRICAL MODELS IN LOCATION THEORY

Since the turn of the century, there has been an exponential growth in the volume of literature concerned with conceptual and empirical models in location theory. This treatment of the literature simply reviews and highlights some of the more significant contributions to the evolution of location theory.

A German economist, von Thunen, is generally considered as the founder of the school of location theory.[1] This first step, as with much ground-breaking analysis, embodied many abstract assumptions. Von Thunen assumed a closed system restricted to the analysis of the location of crop farming given a population distribution. In addition, he assumed that all land within the closed unit was homogeneous in terms of fertility. Taking an analytical approach which later proved not to provide an adequate theory, Weber was the first to attempt to incorporate wages, raw material prices and transport costs as factors influencing the choice for industrial location.[2]

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[1] J. H. von Thunen, Der esolierte Staat in Beziehung auf Landevertschaft and Nationalokonomie, Hamberg, 1826.

[2] A. Weber, Uber den Standort der Industrien, Tubingen, 1909, (Translated, Afred Weber's Theory of Location of Industries, Chicago: University of Chicago Press, 1928.

It was left to Hoover to combine the analytical Weberian approach with contemporary economic theory of the firm.[3] Hoover's work is a classic in partial equilibrium analysis. However, having gone through this initial theoretical barrier, many economists since Hoover have been pursuing what some consider the "final frontier"--the fusion of general equilibrium analysis and location theory. The basic objective was to coordinate the Walrasian tradition in neoclassical economic theory with the consideration of spatial variables. Using market area analysis, Losch was the first to attempt this synthesis of theory.[4] While recognizing Losch's contribution as outstanding, Lefeber comments:

> The assumptions on which he builds his system involve a continuous plain uniformly endowed with raw materials and with uniformly distributed population. Transportation takes place continuously in all directions. These are abstractions that cannot yield a useful first approximation. Furthermore, instead of production functions, he assumes cost relations and makes the price of a good depend on its demand alone. Freight rates are assumed as given. Thus his framework cannot result in a general equilibrium system in the Walrasian sense.[5]

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[3] E. M. Hoover, Location Theory and the Shoe and Leather Industry, Cambridge: Harvard University Press, 1937; and Location of Economic Activity, New York: McGraw-Hill Book Company, Inc. 1948.

[4] A. Losch, Die raumliche Ordnung der Wirtschaft, Jena; G. Fisher, 1944 (Translation The Economics of Location, New Haven: Yale University Press, 1954).

[5] L. Lefeber, Allocation in Space, Production, Transport and Industrial Location, Amsterdam-Norht-Holland Publishing Company, 1958, p. 3.

Two years after the translation and publication of Losch's work, Isard developed an analytical framework which was a generalization of the Weberian approach synthesized with Losch's market area analysis and other related theories.[6] However, in Lefeber's view, the frontier remained intact following Isard's attempt: "[Isard's] analytical framework does not yield the relevant Walrasian marginal conditions of optimality of production. . . ."[7]

Particularly unsatisfied with Isard's treatment of transportation, Lefeber, in 1958, developed a framework in which the total output of transport services is "determined simultaneously with the spatial pattern of production and with the distribution of final goods." Further, "For each such pattern, the total amount of resources and quantity of goods to be shipped defines the exact quantity of transportation demanded, which in turn has to be satisfied by the total output, i.e., the supply of transportation."[8] In other words, transportation is a separate industry and produces an intermediate commodity of space transfer. Recognizing that transportation is a separate, definable industry much like any other, Lefeber incorporated its production process

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[6] W. Isard, Location and Space-Economy, Cambridge: The Technology Press of Massachusetts Institute of Technology and John Wiley and Sons, Inc., New York, 1956.

[7] L. Lefeber, op. cit.

[8] Ibid., p. 11.

directly into the spatial equilibrium framework. Isard assumed that the product at point of production is identical to the product at point of consumption. In fact, as Lefeber points out, when transportation is necessary (when point of production is not the point of consumption) the transportation production process is put into operation and consumes resources. In essence, a product is not a final product until it is at a place where it may be consumed. It can easily be seen that when production and consumption do not take place at the same point in space the role of transportation is critical.

The treatment of transportation as a separate production process represented a major modification of classical location theory. In fact, location analysis and the "transportation problem" became synonymous in economic theory. Several of these related contributions occurred during the early and middle 1950's. Recognized as the first major breakthrough in this area is Samuelson's article depicting a programming model of spatial equilibrium.[9] Koopmans and Beckmann, in a later article, concluded that a general equilibrium of plants in space cannot exist.[10]

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[9] Paul A. Samuelson, "Spatial Price Equilibrium and Linear Programming," American Economic Review, Vol. XLII, No. 3, June 1952.

[10] T. C. Koopmans and Martin Beckmann, "Assignment Problems and the Location of Economic Activities, Econometrica, Vol. 25, No. 1, January, 1957.

By definition an equilibrium is a condition when once obtained there is no incentive or stimulus to deviate from it. Yet, according to Koopmans and Beckmann, the conventional price system when applied to location problems creates such an instability that "there will always be an incentive for someone to seek a location other than the one he holds."[11] Later economists relaxed some of Koopmans and Beckmann's assumptions and were successful in demonstrating that the price system can perform its task as an allocator of plants in space yielding a stable and optimal location solution.[12] In reference to techniques used in solving space equilibria for the transportation problem, Dorfman, Samuelson and Solow and Snodgrass and French have made significant contributions.[13]

Since 1960, much of the work in location analysis has been of a partial equilibrium nature. Even Lefeber, the staunch pursuer of a space general equilibrium, in the mid-1960's would state:

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[11] *Ibid*., p. 69.

[12] See L. Lefeber, *op. cit*.

[13] R. Dorfman, P. A. Samuelson and R. M. Solow, *Linear Programming and Economic Analysis*, McGraw-Hill Book Co., Inc., New York (1958). See especially Chapter 5; and M. M. Snodgrass and C. E. French, "Simplified Presentation of Transportation Problem Procedure in Linear Programming," *Journal of Farm Economics*, Vol. XXXIX, No. 1, (February 1957), pp. 40-51.

> Such general equilibrium analysis must not be expected...to yield meaningful quantitative solutions. The fact that all component units of an economic system must be considered as potentially active over a very large number of locations, necessarily results in a bewildering number of variables and equations, far exceeding that of a system which is composed of the same number of sectors but in which locational problems are neglected.[14]

However, the partial equilibrium approach in which all industrial or firm locations and activities are assumed given save one, proved exceedingly fruitful.

The popularity of partial equilibrium location analysis or industrial location theory has grown rapidly since the early 1960's. It would serve little purpose to review the voluminous work performed in this area during the last decade or so. Rather, specific references are made to several contributions which are particularly relevant to the model and analysis presented in the text.

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[14] L. Lefeber, Location and Regional Planning, Training Seminary Series 7, Center of Planning and Economic Research, Athens, Greece, 1966, p. 15.

APPENDIX B

CONCEPTUAL AND EMPIRICAL MODELS IN SYSTEMS ANALYSIS

The systems approach is a method of understanding and a means toward problem solving. Kuhn has stated that "systems planning simply reflects man's eternal quest to understand and control his environment in accordance with his needs and ambitions."[15] Kuhn and many others have applied this philosophy integrating transport planning and socio-economic developments. In particular, one of these field applications is the Republic of Dahomey land transport study.[16] Given present and future population estimates and production and consumption quantities by region, the "Dahomey" model was used to determine individual commodity surpluses and deficiencies throughout the country. Once surplus and deficit regions were identified, an engineering economic systems analysis was employed to simulate desirable present and future transport demands at a minimum true cost

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[15] Tillo E. Kuhn, "New Approaches to Transport and Research Planning," In Proceedings of the Colloquium Series on Transportation, 1968-69, Vol. 2, Center for Transportation Studies, University of Manitoba, Winnipeg, Manitoba, August, 1969, p. 28.

[16] Dahomey Land Transport, Report prepared for the Republic of Dahomey, the United Nations Development Programme, and the International Bank for Reconstruction and Development, by N. D. Lea and Associates, Ltd., and Lamarre Valois International Limitee, Toronto, Montreal and Cotonou, Dahomey, 1968.

to society.

However, until recently, the systems approach to solving very complex problems has been most successful in the physical sciences. One need only mention the system for landing a man on the moon. In fact, when a complex system is purely physical the necessity for a systems approach is taken for granted. Things become a little more complex however in a man-machine system when the human element is largely unpredictable. If human behavior is predictable, e.g., consumers will maximize satisfaction and producers will maximize profits, the systems approach seems an appropriate tool for the analysis of some social systems, i.e., economics. Furthermore, to complete the relationship, a location decision is but a component of the desire of the entreprenuer to maximize profits. It therefore seems appropriate that location theory form at least a part of a system approach to the analysis of physical-economic problems. That is, problems associated with the collection of resources and the production and distribution of goods by people. The physical-economic systems analysis seems to crumble however when human behavior is not predictable, i.e., when people do not make decisions as if they were utility and profit maximizing machines. Rather than defining human behavior and thus predetermine consumer-producer decisions, the systems analysis, perhaps through simulation, should be capable of enumerating every relevant decision that can be made, and should be able to describe the projected results of all possible sets of decisions. Through decision simulation all affected decisionmakers would be supplied with all the information necessary to enable them to maximize their values, whatever they may be.

While the systems approach to problem solving has been taken for granted for several years by the physical and, to a great extent, biological sciences, only recently has it been recognized as a legitimate method in the analysis of social problems. Some of the more ambitious attempts at applying the systems approach to social problems include: pollution control, the stock market, jury modeling, urban transportation, broadcast commercials, military conscription, racial integration, labor strikes, population planning, law enforcement, administration of justice, manpower and employment planning, educational programs and the achievement of world peace.[17] Perhaps the most heroic conceptual application of the systems approach is Rabow's concept of the society of the future. According to Rabow, adoption of the systems approach in solving societies' problems can be extremely fruitful:

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[17] These social problems are attacked, at least conceptually in: Gerald Rabow, The Era of the System, New York: Philosophical Library, Inc., 1969; and Robert Lee Chartrand, Systems Technology Applied to Social and Community Problems, Washington, D. C.: Spartan Books, 1971.

> In a self-organizing society, perhaps two processes are basic: those related to administering the society toward some goals, and those related to determining what these goals should be. The better the functioning of the society is understood, the more likely it will be that the goals that are selected will be achieved. This is so both because those goals will be selected which are capable of being fulfilled, and because the principles of administering toward selected goals will be better understood. Hence, administration will become more routine with the perfection of the social sciences and the systems approach, while greater effort will be spent on the determination of goals.[18]

Designing society via the systems approach is but a natural extention of the systems methodology. Society, regardless of how haphazard it may appear, is a system and,

> A system is an assembly of components that perform together in an organized manner. A component of a system may itself be a smaller system, sometimes called a subsystem. The systems approach is a method of dealing with complicated systems. It consists essentially of breaking up a systems problem into a number of component or sub-system problems, which when solved together will solve the systems problem. The component or sub-system problems are usually of narrower scope than the overall systems problem and can be tackled by personnel of more specialized ability. It is thus possible to bring all relevant areas of knowledge to bear upon a problem.[19]

To put what is attempted in this study into perspective, consider the following system framework:

System: Society

Sub-system: Economy

Sub^2-system: Transportation

Sub^3-system: Agricultural transportation

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[18] Gerald Rabow, *op. cit.*, p. 47.

[19] *Ibid.*, p. 2.

Sub^{4}-system: Grain transportation

Sub^{5}-system: Western Canadian grain transportation

Sub^{6}-system: Regional Western Canadian grain transportation

The components of the sub^{6}-system would be the collection of grain, the handling of grain and the distribution of grain.

APPENDIX C-1

Bushels Collected, Handled and Distributed by Delivery Point for CHAD System 1970-71, Revealed Preference Assumption Simulations 1 through 8
("A" denotes abandoned in simulation)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Belleview	35,986	A	A	A	A	A	A	A
Boissevain	879,817	879,817	889,415	889,415	889,415	889,415	1,373,322	1,482,576
Broomhill	87,127	87,127	93,844	A	A	A	A	A
Coulter	45,357	45,357	45,357	45,357	A	A	A	A
Cranmer	69,855	69,855	69,855	69,855	A	A	A	A
Croll	103,813	103,813	A	A	A	A	A	A
Dalny	108,181	108,181	108,181	108,181	A	A	A	A
Dand	132,886	132,886	A	A	A	A	A	A
Deloraine	509,215	509,215	579,553	579,553	668,605	668,605	719,231	903,887
Elgin	415,803	415,803	549,465	549,465	549,465	549,465	A	A
Fairfax	313,687	313,687	377,236	383,953	383,953	383,953	A	A
Goodlands	307,134	307,134	307,134	307,134	A	A	A	A
Hartney	357,618	357,618	358,347	358,347	358,347	358,640	524,362	573,899
Lauder	118,069	118,069	161,520	161,520	161,520	161,520	201,029	A
Leighton	93,631	93,631	114,105	114,105	341,367	341,367	341,367	A
Linklater	179,183	179,183	179,183	251,933	251,933	A	A	A
Lyleton	247,505	247,505	247,505	247,505	A	A	A	A
Medora	524,017	524,017	524,017	524,017	758,600	758,600	758,600	952,194
Melita	473,438	473,438	473,438	479,636	618,527	1,198,767	1,198,767	1,205,632
Mentieth	117,820	117,820	117,820	117,820	117,820	213,723	251,961	A
Minto	360,556	360,556	360,556	360,556	360,556	306,556	A	A
Napinka	118,636	118,636	118,636	122,768	250,348	312,435	312,435	401,032
Newstead	174,077	174,077	174,077	174,077	174,077	174,077	541,602	A
Pierson	502,918	502,918	502,918	609,379	833,010	1,517,657	1,517,657	1,517,657
Pipestone	214,278	250,264	250,264	253,561	253,561	A	A	A

APPENDIX C-1 (continued)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Regent	111,819	111,819	A	A	A	A	A	A
Reston	424,838	424,838	424,838	476,655	476,655	A	A	A
Sinclair	275,377	275,377	275,377	441,021	441,021	A	A	A
Souris	488,912	488,912	488,912	488,912	488,912	488,912	637,359	1,140,815
Tilston	323,172	323,172	323,172	A	A	A	A	A
Waskada	262,967	262,967	262,967	262,967	A	A	A	A

APPENDIX C-2

Handling-to-Capacity Ratios for CHAD System 1970-71, Revealed Preference Assumption, Simulations 1 through 8
("A" denotes abandoned in simulation)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Belleview	1.8	A	A	A	A	A	A	A
Boissevain	1.6	1.6	1.6	1.6	1.6	1.6	2.5	2.8
Broomhill	3.6	3.6	3.9	A	A	A	A	A
Coulter	0.9	0.9	0.9	0.9	A	A	A	A
Cranmer	0.8	0.8	0.8	0.8	A	A	A	A
Croll	1.3	1.3	A	A	A	A	A	A
Dalny	0.7	0.7	0.7	0.7	A	A	A	A
Dand	2.3	2.3	A	A	A	A	A	A
Deloraine	1.4	1.4	1.5	1.5	1.8	1.8	1.9	2.4
Elgin	1.6	1.6	2.1	2.1	2.1	2.1	A	A
Fairfax	1.2	1.2	1.5	1.5	1.5	1.5	A	A
Goodlands	1.3	1.3	1.3	1.3	A	A	A	A
Hartney	1.3	1.3	1.3	1.3	1.3	1.3	2.0	2.9
Lauder	1.2	1.2	1.7	1.7	1.7	1.7	2.1	A
Leighton	1.9	1.9	2.3	2.3	6.8	6.8	6.8	A
Linklater	1.9	1.9	1.9	2.6	2.6	A	A	A
Lyleton	1.2	1.2	1.2	1.2	A	A	A	A
Medora	1.7	1.7	1.7	1.7	2.5	2.5	2.5	3.1
Melita	1.6	1.6	1.6	1.6	2.1	4.0	4.0	5.0
Mentieth	1.5	1.5	1.5	1.5	1.5	2.7	3.2	A
Minto	1.2	1.2	1.2	1.2	1.2	1.2	A	A
Napinka	1.0	1.0	1.0	1.0	2.1	2.6	2.6	3.3
Newstead	3.2	3.2	3.2	3.2	3.2	3.2	10.0	A
Pierson	1.7	1.7	1.7	2.0	2.8	5.1	5.1	5.1
Pipestone	1.8	2.1	2.1	2.2	2.2	A	A	A

APPENDIX C-2 (continued)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Regent	1.3	1.3	A	A	A	A	A	A
Reston	2.2	2.2	2.2	2.5	2.5	A	A	A
Sinclair	1.6	1.6	1.6	2.5	2.5	A	A	A
Souris	0.9	0.9	0.9	0.9	0.9	0.9	1.2	2.2
Tilston	2.0	2.0	2.0	A	A	A	A	A
Waskada	1.0	1.0	1.0	1.0	A	A	A	A

APPENDIX C-3

Average Handling Costs by Delivery Point for CHAD System 1970-71, Revealed Preference Assumption, Simulated 1 through 8
("A" denotes abandoned in simulation)
(Cents/bushel)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Belleview	21.80	A	A	A	A	A	A	A
Boissevain	6.59	6.59	6.54	6.54	6.54	6.54	4.81	4.84
Broomhill	10.37	10.37	9.79	A	A	A	A	A
Coulter	17.78	17.78	17.78	17.78	A	A	A	A
Cranmer	12.36	12.36	12.36	12.36	A	A	A	A
Croll	9.07	9.07	A	A	A	A	A	A
Dalny	12.27	12.27	12.27	12.27	A	A	A	A
Dand	7.59	7.59	A	A	A	A	A	A
Deloraine	8.06	8.06	7.28	7.28	6.53	6.53	6.18	5.25
Elgin	9.96	9.96	8.05	8.05	8.05	8.05	A	A
Fairfax	9.91	9.91	8.60	8.49	8.49	8.49	A	A
Goodlands	8.73	8.73	8.73	8.73	A	A	A	A
Hartney	7.73	7.73	7.72	7.72	7.72	7.71	5.79	4.45
Lauder	9.02	9.02	7.16	7.16	7.16	7.16	6.17	A
Leighton	9.81	9.81	8.46	8.46	4.37	4.37	4.37	A
Linklater	6.66	6.66	6.66	5.35	5.35	A	A	A
Lyleton	8.70	8.70	8.70	8.70	A	A	A	A
Medora	6.34	6.34	6.34	6.34	5.19	5.19	5.19	4.67
Melita	8.15	8.15	8.15	8.07	6.57	4.08	4.08	3.44
Mentieth	8.27	8.27	8.27	8.27	8.27	5.60	5.10	A
Minto	8.90	8.90	8.90	8.90	8.90	8.90	A	A
Napinka	10.82	10.82	10.82	10.52	5.99	5.12	5.12	4.35
Newstead	6.35	6.35	6.35	6.35	6.35	6.35	3.61	A

APPENDIX C-3 (continued)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Pierson	6.50	6.50	6.50	5.82	4.97	3.92	3.92	3.92
Pipestone	8.86	7.92	7.92	7.85	7.85	A	A	A
Regent	9.41	9.41	A	A	A	A	A	A
Reston	5.95	5.95	5.95	5.53	5.53	A	A	A
Sinclair	6.49	6.49	6.49	5.09	5.09	A	A	A
Souris	6.97	6.97	6.97	6.97	6.97	6.97	5.98	4.56
Tilston	5.94	5.94	5.94	A	A	A	A	A
Waskada	9.93	9.93	9.93	9.93	A	A	A	A

APPENDIX C-4

Rail Costs by Delivery Point for CHAD System 1970-71, Revealed Preference Assumption, Simulations 1 through 8
("A" denotes abandoned simulation)
(Cents/bushel)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Belleview	23.68	A	A	A	A	A	A	A
Boissevain	21.05	21.05	20.97	20.91	20.36	19.61	18.92	18.92
Broomhill	23.68	23.68	23.60	A	A	A	A	A
Coulter	23.68	23.68	23.60	23.54	A	A	A	A
Cranmer	23.68	23.68	23.60	23.54	A	A	A	A
Croll	22.37	22.37	A	A	A	A	A	A
Dalny	23.68	23.68	23.60	23.54	A	A	A	A
Dand	23.68	23.68	A	A	A	A	A	A
Deloraine	23.68	23.68	23.60	23.54	22.99	22.24	21.55	21.55
Elgin	23.68	23.68	23.60	23.54	22.99	22.24	A	A
Fairfax	22.37	22.37	22.29	22.23	21.68	20.93	A	A
Goodlands	23.68	23.68	23.60	23.54	A	A	A	A
Hartney	23.68	23.68	23.60	23.54	22.99	22.24	21.55	21.55
Lauder	23.68	23.68	23.60	23.54	22.99	22.24	21.55	A
Leighton	23.68	23.68	23.60	23.54	22.99	22.24	21.55	A
Linklater	23.68	23.68	23.60	23.54	22.99	A	A	A
Lyleton	23.68	23.68	23.60	23.54	A	A	A	A
Medora	23.68	23.68	23.60	23.54	22.99	22.24	21.55	21.55
Melita	23.68	23.68	23.60	23.54	22.99	22.24	21.55	21.55
Mentieth	23.68	23.68	23.60	23.54	22.99	22.24	21.55	A
Minto	21.05	21.05	20.97	20.91	20.36	19.61	A	A
Napinka	23.68	23.68	23.60	23.54	22.99	22.24	21.55	21.55
Newstead	21.05	21.05	20.97	20.91	20.36	19.61	18.92	A
Pierson	23.68	23.68	23.60	23.54	22.99	22.24	21.55	21.55

APPENDIX C-4 (continued)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Pipestone	23.68	23.68	23.60	23.54	22.99	A	A	A
Regent	23.68	23.68	A	A	A	A	A	A
Reston	23.68	23.68	23.60	23.54	22.99	A	A	A
Sinclair	23.68	23.68	23.60	23.54	22.99	A	A	A
Souris	22.37	22.37	22.29	22.23	21.68	20.93	20.24	20.24
Tilston	23.68	23.68	23.60	A	A	A	A	A
Waskada	23.68	23.68	23.60	23.54	A	A	A	A

APPENDIX D-1

Bushels Collected, Handled and Distributed by Delivery Point for CHAD System 1970-71, Minimum Cost/Distance Assumption, Simulations 1 through 8
("A" denotes abandoned in simulation)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Belleview	125,111	A	A	A	A	A	A	A
Boissevain	643,361	643,361	691,147	698,894	698,894	698,894	1,295,947	1,405,201
Broomhill	90,598	90,598	160,577	A	A	A	A	A
Coulter	119,559	119,559	119,559	119,559	A	A	A	A
Cranmer	196,358	196,358	196,358	196,358	A	A	A	A
Croll	268,577	268,577	A	A	A	A	A	A
Dalny	200,495	200,495	200,495	200,495	A	A	A	A
Dand	274,850	274,850	A	A	A	A	A	A
Deloraine	342,013	342,013	467,803	467,803	619,771	619,771	682,373	953,961
Elgin	377,518	377,518	625,772	625,772	625,772	625,772	A	A
Fairfax	214,905	214,905	350,209	425,930	425,930	425,930	A	A
Goodlands	288,922	288,922	288,922	288,922	A	A	A	A
Hartney	134,620	135,006	187,978	187,978	187,978	190,031	386,477	796,784
Lauder	149,026	149,026	222,359	222,359	222,359	222,359	263,024	A
Leighton	229,489	229,489	269,583	269,583	517,155	517,155	517,155	A
Linklater	226,190	226,190	226,190	294,979	294,979	A	A	A
Lyleton	214,151	214,151	214,151	214,151	A	A	A	A
Medora	348,405	348,405	348,405	348,405	594,066	594,066	594,066	899,193
Melita	385,954	385,954	385,954	387,546	566,913	1,149,118	1,149,118	1,155,983
Mentieth	263,266	267,320	267,320	267,320	267,320	363,223	393,743	A
Minto	296,757	296,757	296,757	373,866	373,866	373,866	A	A
Napinka	184,764	184,764	184,764	184,764	344,862	407,383	407,383	496,530
Newstead	323,111	323,111	323,111	323,111	323,111	323,111	646,023	A
Pierson	441,807	441,807	441,807	598,743	833,904	1,523,148	1,523,148	1,523,148
Pipestone	140,020	260,691	260,691	260,691	260,691	A	A	A

APPENDIX D-1 (continued)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Regent	250,085	250,085	A	A	A	A	A	A
Reston	393,557	393,557	393,557	409,378	409,378	A	A	A
Sinclair	315,317	315,317	315,317	466,878	466,878	A	A	A
Souris	343,865	343,865	343,865	343,865	343,865	343,865	519,235	1,146,892
Tilston	394,699	394,699	394,699	A	A	A	A	A
Waskada	200,342	200,342	200,342	200,342	A	A	A	A

APPENDIX D-2

Handling-to-Capacity Ratios for CHAD System 1970-71, Minimum Cost/distance Assumption, Simulations 1 through 8
("A" denotes abandoned in simulation)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Belleview	6.3	A	A	A	A	A	A	A
Boissevain	1.1	1.1	1.2	1.2	1.2	1.2	2.3	2.7
Broomhill	3.8	3.8	6.7	A	A	A	A	A
Coulter	2.4	2.4	2.4	2.4	A	A	A	A
Cranmer	2.3	2.3	2.3	2.3	A	A	A	A
Croll	3.5	3.5	A	A	A	A	A	A
Dalny	1.2	1.2	1.2	1.2	A	A	A	A
Dand	4.8	4.8	A	A	A	A	A	A
Deloraine	0.9	0.9	1.2	1.2	1.7	1.7	1.8	2.5
Elgin	1.4	1.4	2.3	2.3	2.3	2.3	A	A
Fairfax	0.8	0.8	1.4	1.7	1.7	1.7	A	A
Goodlands	1.2	1.2	1.2	1.2	A	A	A	A
Hartney	0.5	0.5	0.7	0.7	0.7	0.7	1.5	3.0
Lauder	1.6	1.6	2.3	2.3	2.3	2.3	2.8	A
Leighton	4.5	4.5	5.3	5.3	10.2	10.2	10.2	A
Linklater	2.4	2.4	2.4	3.1	3.1	A	A	A
Lyleton	1.1	1.1	1.1	1.1	A	A	A	A
Medora	1.1	1.1	1.1	1.1	1.9	1.9	1.9	2.9
Melita	1.3	1.3	1.3	1.3	1.9	3.8	3.8	4.8
Mentieth	3.4	3.4	3.4	3.4	3.4	4.6	5.0	A
Minto	1.0	1.0	1.0	1.3	1.3	1.3	A	A
Napinka	1.5	1.5	1.5	1.5	2.9	3.4	3.4	4.1
Newstead	6.0	6.0	6.0	6.0	6.0	6.0	12.0	A
Pierson	1.5	1.5	1.5	2.0	2.8	5.1	5.1	5.1
Pipestone	1.2	2.2	2.2	2.2	2.2	A	A	A

APPENDIX D-2 (continued)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Regent	2.8	2.8	A	A	A	A	A	A
Reston	2.1	2.1	2.1	2.2	2.2	A	A	A
Sinclair	1.8	1.8	1.8	2.6	2.6	A	A	A
Souris	0.6	0.6	0.6	0.6	0.6	0.6	1.0	2.2
Tilston	2.4	2.4	2.4	A	A	A	A	A
Waskada	0.7	0.7	0.7	0.7	A	A	A	A

APPENDIX D-3

Average Handling Costs Per Bushel by Delivery Point, for CHAD System 1970-71,
Minimum Cost/distance Assumption,
Simulations 1 through 8
("A" denotes abandoned in simulation)
(Cents/bushel)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Belleview	7.92	A	A	A	A	A	A	A
Boissevain	8.41	8.41	7.94	7.87	7.87	7.87	5.00	4.95
Broomhill	10.06	10.06	6.68	A	A	A	A	A
Coulter	8.18	8.18	8.18	8.18	A	A	A	A
Cranmer	5.89	5.89	5.89	5.89	A	A	A	A
Croll	4.93	4.93	A	A	A	A	A	A
Dalny	7.89	7.89	7.89	7.89	A	A	A	A
Dand	4.87	4.87	A	A	A	A	A	A
Deloraine	11.20	11.20	8.63	8.63	6.91	6.91	6.43	5.06
Elgin	10.76	10.76	7.33	7.33	7.33	7.33	A	A
Fairfax	13.50	13.50	9.10	7.86	7.86	7.86	A	A
Goodlands	9.18	9.18	9.18	9.18	A	A	A	A
Hartney	17.83	17.83	13.23	13.23	13.23	13.11	7.28	4.37
Lauder	7.59	7.59	5.78	5.78	5.78	5.78	5.21	A
Leighton	5.37	5.37	4.92	4.92	3.67	3.67	3.67	A
Linklater	5.72	5.72	5.72	4.88	4.88	A	A	A
Lyleton	9.73	9.73	9.73	9.73	A	A	A	A
Medora	8.21	8.21	8.21	8.21	5.90	5.90	5.90	4.79
Melita	9.68	9.68	9.68	9.65	7.04	4.19	4.19	3.52
Mentieth	4.98	4.98	4.94	4.94	4.94	4.25	4.10	A
Minto	10.36	10.36	10.36	8.66	8.66	8.66	A	A
Napinka	7.54	7.54	7.54	7.54	4.80	4.31	4.31	3.83
Newstead	4.49	4.49	4.49	4.49	4.49	4.49	3.40	A

APPENDIX D-3 (continued)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Pierson	7.03	7.03	7.03	5.88	4.96	3.91	3.91	3.91
Pipestone	12.33	7.70	7.70	7.70	7.70	A	A	A
Regent	5.37	5.37	A	A	A	A	A	A
Reston	6.26	6.26	6.26	6.10	6.10	A	A	A
Sinclair	6.02	6.02	6.02	4.96	4.96	A	A	A
Souris	8.74	8.74	8.74	8.74	8.74	8.74	6.72	4.55
Tilston	5.36	5.36	5.36	A	A	A	A	A
Waskada	12.52	12.52	12.52	12.52	A	A	A	A

APPENDIX D-4

Rail Costs by Delivery Point for CHAD System 1970-71, Minimum Cost/distance Assumption, Simulations 1 through 8
("A" denotes abandoned in Simulation)
(Cents/bushel)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Belleview	23.68	A	A	A	A	A	A	A
Boissevain	21.05	21.05	20.87	20.78	20.13	19.38	18.62	18.62
Broomhill	23.68	23.68	23.50	A	A	A	A	A
Coulter	23.68	23.68	23.50	23.41	A	A	A	A
Cranmer	23.68	23.68	23.50	23.41	A	A	A	A
Croll	22.37	22.37	A	A	A	A	A	A
Dalny	23.68	23.68	23.50	23.41	A	A	A	A
Dand	23.68	23.68	A	A	A	A	A	A
Deloraine	23.68	23.68	23.50	23.41	22.76	22.01	21.25	21.25
Elgin	23.68	23.68	23.50	23.41	22.76	22.01	A	A
Fairfax	22.37	22.37	22.19	22.10	21.45	20.70	A	A
Goodlands	23.68	23.68	23.50	23.41	A	A	A	A
Hartney	23.68	23.68	23.50	23.41	22.76	22.01	21.25	21.25
Lauder	23.68	23.68	23.50	23.41	22.76	22.01	21.25	A
Leighton	23.68	23.68	23.50	23.41	22.76	22.01	21.25	A
Linklater	23.68	23.68	23.50	23.41	22.76	A	A	A
Lyleton	23.68	23.68	23.50	23.41	A	A	A	A
Medora	23.68	23.68	23.50	23.41	22.76	22.01	21.25	21.25
Melita	23.68	23.68	23.50	23.41	22.76	22.01	21.25	21.25
Mentieth	23.68	23.68	23.50	23.41	22.76	22.01	21.25	A
Minto	21.05	21.05	20.87	20.78	20.13	19.38	A	A
Napinka	23.68	23.68	23.50	23.41	22.76	22.01	21.25	21.25
Newstead	21.05	21.05	20.87	20.78	20.13	19.38	18.62	A
Pierson	23.68	23.68	23.50	23.41	22.76	22.01	21.25	21.25

APPENDIX D-4 (continued)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Pipestone	23.68	23.68	23.50	23.41	22.76	A	A	A
Regent	23.68	23.68	A	A	A	A	A	A
Reston	23.68	23.68	23.50	23.41	22.76	A	A	A
Sinclair	23.68	23.68	23.50	23.41	22.76	A	A	A
Souris	22.37	22.37	22.19	22.10	21.45	20.70	19.94	19.94
Tilston	23.68	23.68	23.50	A	A	A	A	A
Waskada	23.68	23.68	23.50	23.41	A	A	A	A

APPENDIX E-1

Bushels Collected, Handled and Distributed by Delivery Point for CHAD System 1971-72, Revealed Preference Assumption, Simulations 1 through 8
("A" denotes abandoned in simulation)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Boissevain	879,817	889,415	889,415	889,415	889,415	1,373,322	1,482,576
Cranmer	77,969	77,969	77,969	A	A	A	A
Croll	103,813	A	A	A	A	A	A
Dalny	149,042	149,042	149,042	A	A	A	A
Dand	147,354	A	A	A	A	A	A
Deloraine	537,621	620,899	620,899	850,784	850,784	901,410	903,887
Elgin	415,803	549,465	549,465	549,465	549,465	A	A
Fairfax	313,687	383,953	383,953	383,953	383,953	A	A
Goodlands	315,834	315,834	315,834	A	A	A	A
Hartney	357,618	358,347	358,347	358,347	358,640	524,362	773,899
Lauder	118,069	168,274	168,274	168,274	168,274	207,783	A
Linklater	182,036	182,036	251,933	251,933	A	A	A
Lyleton	252,001	252,001	252,001	A	A	A	A
Medora	557,960	573,208	573,208	911,034	911,034	911,034	952,194
Melita	478,044	478,044	479,686	618,527	1,198,767	1,198,767	1,205,632
Mentieth	117,820	117,820	117,820	117,820	213,723	251,961	A
Minto	360,556	360,556	360,556	360,556	360,556	A	A
Napinka	122,768	122,768	122,768	250,348	312,435	312,435	401,032
Newstead	174,077	174,077	174,077	174,077	174,077	541,602	A
Pierson	502,918	502,918	609,379	833,010	1,517,657	1,517,657	1,517,657
Pipestone	253,561	253,561	253,561	253,561	A	A	A
Regent	111,819	A	A	A	A	A	A
Reston	462,688	462,688	476,655	476,655	A	A	A

APPENDIX E-1 (continued)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Sinclair	275,377	275,377	441,021	441,021	A	A	A
Souris	488,912	488,912	488,912	488,912	488,912	637,359	1,140,815
Tilston	357,561	357,561	A	A	A	A	A
Waskada	262,967	262,967	262,967	A	A	A	A

[1]Simulations 1 and 2 are identical. Belleview is the only delivery point abandoned in Sim 2 and it is already closed down in Sim 1.

APPENDIX E-2

Handling-to-Capacity Ratios for CHAD System 1971-72,
Revealed Preference Assumption, Simulations 1 through 8
("A" denotes abandoned in simulation)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Boissevain	1.6	1.6	1.6	1.6	1.6	2.5	2.8
Cranmer	0.9	0.9	0.9	A	A	A	A
Croll	1.3	A	A	A	A	A	A
Dalny	0.9	0.9	0.9	A	A	A	A
Dand	2.6	A	A	A	A	A	A
Deloraine	1.4	1.7	1.7	2.3	2.3	2.4	2.4
Elgin	1.6	2.1	2.1	2.1	2.1	A	A
Fairfax	1.2	1.5	1.5	1.5	1.5	A	A
Goodlands	1.3	1.3	1.3	A	A	A	A
Hartney	1.3	1.3	1.3	1.3	1.3	2.0	2.9
Lauder	1.2	1.8	1.8	1.8	1.8	2.2	A
Linklater	1.9	1.9	2.6	2.6	A	A	A
Lyleton	1.3	1.3	1.3	A	A	A	A
Medora	1.8	1.9	1.9	3.0	3.0	3.0	3.1
Melita	1.6	1.6	1.6	2.1	4.0	4.0	5.0
Mentieth	1.5	1.5	1.5	1.5	2.7	3.2	A
Minto	1.2	1.2	1.2	1.2	1.2	A	A
Napinka	1.0	1.0	1.0	2.1	2.6	2.6	3.3
Newstead	3.2	3.2	3.2	3.2	3.2	10.0	A
Pierson	1.7	1.7	2.0	2.8	5.1	5.1	5.1
Pipestone	2.2	2.2	2.2	2.2	A	A	A
Regent	1.3	A	A	A	A	A	A
Reston	2.4	2.4	2.5	2.5	A	A	A

APPENDIX E-2 (continued)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Sinclair	1.6	1.6	2.5	2.5	A	A	A
Souris	0.9	0.9	0.9	0.9	0.9	1.2	2.2
Tilston	2.2	2.2	A	A	A	A	A
Waskada	1.0	1.0	1.0	A	A	A	A

[1]See footnote on p. 264, Appendix E-1.

APPENDIX E-3

Average Handling Costs by Delivery Point for CHAD System 1971-72
Revealed Preference Assumption, Simulations 1 through 8
("A" denotes abandoned in simulation)
(Cents/bushel)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Boissevain	6.59	6.54	6.54	6.54	6.54	4.81	4.84
Cranmer	11.31	11.31	11.31	A	A	A	A
Croll	9.07	A	A	A	A	A	A
Dalny	9.66	9.66	9.66	A	A	A	A
Dand	7.08	A	A	A	A	A	A
Deloraine	7.72	6.90	6.90	5.48	5.48	5.26	5.25
Elgin	9.96	8.05	8.05	8.05	8.05	A	A
Fairfax	9.91	8.49	8.49	8.49	8.49	A	A
Goodlands	8.54	8.54	8.54	A	A	A	A
Hartney	7.73	7.72	7.72	7.72	7.71	5.79	4.45
Lauder	9.02	6.96	6.96	6.96	6.96	6.04	A
Linklater	6.59	6.59	5.35	5.35	A	A	A
Lyleton	8.59	8.59	8.59	A	A	A	A
Medora	6.11	6.02	6.02	4.77	4.77	4.77	4.67
Melita	8.09	8.09	8.07	6.57	4.08	4.08	3.44
Mentieth	8.27	8.27	8.27	8.27	5.60	5.10	A
Minto	8.90	8.90	8.90	8.90	8.90	A	A
Napinka	10.52	10.52	10.52	5.99	5.12	5.12	4.35
Newstead	6.35	6.35	6.35	6.35	6.35	3.61	A
Pierson	6.50	6.50	5.82	4.97	3.92	3.92	3.92
Pipestone	7.85	7.85	7.85	7.85	A	A	A
Regent	9.41	A	A	A	A	A	A
Reston	5.64	5.64	5.53	5.53	A	A	A

APPENDIX E-3 (continued)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Sinclair	6.49	6.49	5.09	5.09	A	A	A
Souris	6.97	6.97	6.97	6.97	6.97	5.98	4.56
Tilston	5.63	5.63	A	A	A	A	A
Waskada	9.93	9.93	9.93	A	A	A	A

[1] See footnote on p. 264, Appendix E-1.

APPENDIX E-4

Rail Costs by Delivery Point for CHAD System 1971-72
Revealed Preference Assumption
Simulations 1 through 8
("A" denotes abandoned simulation)
(Cents/bushel)

Delivery Point	Sim 1&21	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Boissevain	21.05	20.97	20.91	20.35	19.60	18.91	18.91
Cranmer	23.68	23.60	23.54	A	A	A	A
Croll	22.37	A	A	A	A	A	A
Dalny	23.68	23.60	23.54	A	A	A	A
Dand	23.68	A	A	A	A	A	A
Deloraine	23.68	23.60	23.54	22.98	22.23	21.54	21.54
Elgin	23.68	23.60	23.54	22.98	22.23	A	A
Fairfax	22.37	22.29	22.23	21.67	20.92	A	A
Goodlands	23.68	23.60	23.54	A	A	A	A
Hartney	23.68	23.60	23.54	22.98	22.23	21.54	21.54
Lauder	23.68	23.60	23.54	22.98	22.23	21.54	A
Linklater	23.68	23.60	23.54	22.98	A	A	A
Lyleton	23.68	23.60	23.54	A	A	A	A
Medora	23.68	23.60	23.54	22.98	22.23	21.54	21.54
Melita	23.68	23.60	23.54	22.98	22.23	21.54	21.54
Mentieth	23.68	23.60	23.54	22.98	22.23	21.54	A
Minto	21.05	20.97	20.91	20.35	19.60	A	A
Napinka	23.68	23.60	23.54	22.98	22.23	21.54	21.54
Newstead	21.05	20.97	20.91	20.35	19.60	18.91	A
Pierson	23.68	23.60	23.54	22.98	22.23	21.54	21.54
Pipestone	23.68	23.60	23.54	22.98	A	A	A
Regent	23.68	A	A	A	A	A	A
Reston	23.68	23.60	23.54	22.98	A	A	A

APPENDIX E-4 (continued)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Sinclair	23.68	23.60	23.54	22.98	A	A	A
Souris	22.37	22.29	22.23	21.67	20.92	20.23	20.23
Tilston	23.68	23.60	A	A	A	A	A
Waskada	23.68	23.60	23.54	A	A	A	A

[1]See footnote on p. 264, Appendix E-1.

APPENDIX F-1

Bushels Collected, Handled and Distributed by Delivery Point for CHAD System 1971-72, Minimum Cost/Distance Assumption, Simulations 1 through 8
("A" denotes abandoned in simulation)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Boissevain	643,361	698,894	698,894	698,894	698,894	1,295,947	1,405,201
Cranmer	207,451	207,451	207,451	A	A	A	A
Croll	277,111	A	A	A	A	A	A
Dalny	283,107	283,107	283,107	A	A	A	A
Dand	305,586	A	A	A	A	A	A
Deloraine	435,958	485,697	585,697	888,882	888,822	951,484	953,961
Elgin	377,518	625,772	625,772	625,772	625,772	A	A
Fairfax	247,709	425,930	425,930	425,930	425,930	A	A
Goodlands	298,551	298,551	298,551	A	A	A	A
Hartney	135,006	187,978	187,978	187,978	190,031	386,477	796,784
Lauder	149,026	239,118	239,118	239,118	239,118	279,783	A
Linklater	226,190	226,190	294,979	294,979	A	A	A
Lyleton	234,057	234,057	234,057	A	A	A	A
Medora	432,491	462,613	462,613	825,351	825,351	825,351	899,193
Melita	394,960	394,960	396,552	566,913	1,149,118	1,149,118	1,155,983
Mentieth	267,320	267,320	267,320	267,320	363,223	393,743	A
Minto	346,017	373,866	373,866	373,866	373,866	A	A
Napinka	184,764	184,764	184,764	344,862	407,383	407,383	496,530
Newstead	323,111	323,111	323,111	323,111	323,111	646,023	A
Pierson	449,842	449,842	606,778	833,904	1,523,148	1,523,148	1,523,148
Pipestone	260,691	260,691	260,691	260,691	A	A	A
Regent	250,085	A	A	A	A	A	A
Reston	393,557	393,557	409,378	409,378	A	A	A

APPENDIX F-1 (continued)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Sinclair	315,317	315,317	466,878	466,878	A	A	A
Souris	343,865	343,865	343,865	343,865	343,865	519,235	1,146,892
Tilston	394,699	394,699	A	A	A	A	A
Waskada	200,342	200,342	200,342	A	A	A	A

[1]See footnote on p. 264, Appendix E-1.

APPENDIX F-2

Handling-to-Capacity Ratios for CHAD System 1970-71,
Minimum Cost/Distance Assumption,
Simulations 1 through 8
("A" denotes abandoned in simulation)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Boissevain	1.1	1.2	1.2	1.2	1.2	2.3	2.7
Cranmer	2.5	2.5	2.5	A	A	A	A
Croll	3.6	A	A	A	A	A	A
Dalny	1.8	1.8	1.8	A	A	A	A
Dand	5.3	A	A	A	A	A	A
Deloraine	1.2	1.6	1.6	2.4	2.4	2.5	2.5
Elgin	1.4	2.3	2.3	2.3	2.3	A	A
Fairfax	1.0	1.7	1.7	1.7	1.7	A	A
Goodlands	1.2	1.2	1.2	A	A	A	A
Hartney	0.5	0.7	0.7	0.7	0.7	1.5	3.0
Lauder	1.6	2.5	2.5	2.5	2.5	3.0	A
Linklater	2.4	2.4	3.1	3.1	A	A	A
Lyleton	1.2	1.2	1.2	A	A	A	A
Medora	1.4	1.5	1.5	2.7	2.7	2.7	2.9
Melita	1.3	1.3	1.3	1.9	3.8	3.8	4.8
Mentieth	3.4	3.4	3.4	3.4	4.6	5.0	A
Minto	1.2	1.3	1.3	1.3	1.3	A	A
Napinka	1.5	1.5	1.5	2.9	3.4	3.4	4.1
Newstead	6.0	6.0	6.0	6.0	6.0	12.0	A
Pierson	1.5	1.5	2.0	2.8	5.1	5.1	5.1
Pipestone	2.2	2.2	2.2	2.2	A	A	A
Regent	2.8	A	A	A	A	A	A
Reston	2.1	2.1	2.2	2.2	A	A	A

APPENDIX F-2 (continued)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Sinclair	1.8	1.8	2.6	2.6	A	A	A
Souris	0.6	0.6	0.6	0.6	0.6	1.0	2.2
Tilston	2.4	2.4	A	A	A	A	A
Waskada	0.7	0.7	0.7	A	A	A	A

[1]See footnote on p. 264, Appendix E-1.

APPENDIX F-3

Average Handling Cost per Bushel by Delivery Point for CHAD System 1971-72
Minimum Cost/Distance Assumption, Simulations 1 through 8
("A" denotes abandoned in simulation)
(Cents/bushel)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Boissevain	8.41	7.87	7.87	7.87	7.87	5.00	4.95
Cranmer	5.70	5.70	5.70	A	A	A	A
Croll	4.85	A	A	A	A	A	A
Dalny	6.39	6.39	6.39	A	A	A	A
Dand	4.61	A	A	A	A	A	A
Deloraine	9.14	7.22	7.22	5.31	5.31	5.07	5.06
Elgin	10.76	7.33	7.33	7.33	7.33	A	A
Fairfax	11.99	7.86	7.86	7.86	7.86	A	A
Goodlands	8.94	8.94	8.94	A	A	A	A
Hartney	17.79	13.23	13.23	13.23	13.11	7.28	4.37
Lauder	7.59	5.52	5.52	5.52	5.52	5.03	A
Linklater	5.72	5.72	4.88	4.88	A	A	A
Lyleton	9.08	9.08	9.08	A	A	A	A
Medora	7.12	6.83	6.83	4.99	4.99	4.99	4.79
Melita	9.49	9.49	9.46	7.04	4.19	4.19	3.52
Mentieth	4.94	4.94	4.94	4.94	4.25	4.10	A
Minto	9.19	8.66	8.66	8.66	8.66	A	A
Napinka	7.54	7.54	7.54	4.80	4.31	4.31	3.83
Newstead	4.49	4.49	4.49	4.49	4.49	3.40	A
Pierson	6.95	6.95	5.84	4.96	3.91	3.91	3.91
Pipestone	7.70	7.70	7.70	7.70	A	A	A
Regent	5.37	A	A	A	A	A	A
Reston	6.26	6.26	6.10	6.10	A	A	A

APPENDIX F-3 (continued)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Sinclair	6.02	6.02	4.96	4.96	A	A	A
Souris	8.74	8.74	8.74	8.74	8.74	6.72	4.55
Tilston	5.36	5.36	A	A	A	A	A
Waskada	12.52	12.52	12.52	A	A	A	A

[1] See footnote on p. 264, Appendix E-1.

APPENDIX F-4

Rail Costs by Delivery Point for CHAD System 1971-72
Minimum Cost/Distance Assumption
Simulations 1 through 8
("A" denotes abandoned in Simulation)
(Cents/bushel)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Boissevain	21.05	20.85	20.77	20.12	19.36	18.61	18.61
Cranmer	23.68	23.48	23.40	A	A	A	A
Croll	22.37	A	A	A	A	A	A
Dalny	23.68	23.48	23.40	A	A	A	A
Dand	23.68	A	A	A	A	A	A
Deloraine	23.68	23.48	23.40	22.75	21.99	21.24	21.24
Elgin	23.68	23.48	23.40	22.75	21.99	A	A
Fairfax	22.37	22.17	22.09	21.44	20.68	A	A
Goodlands	23.68	23.48	23.40	A	A	A	A
Hartney	23.68	23.48	23.40	22.75	21.99	21.24	21.24
Lauder	23.68	23.48	23.40	22.75	21.99	21.24	A
Linklater	23.68	23.48	23.40	22.75	A	A	A
Lyleton	23.68	23.48	23.40	A	A	A	A
Medora	23.68	23.48	23.40	22.75	21.99	21.24	21.24
Melita	23.68	23.48	23.40	22.75	21.99	21.24	21.24
Mentieth	23.68	23.48	23.40	22.75	21.99	21.24	A
Minto	21.05	20.85	20.77	20.12	19.36	A	A
Napinka	23.68	23.48	23.40	22.75	21.99	21.24	21.24
Newstead	21.05	20.85	20.77	20.12	19.36	18.61	A
Pierson	23.68	23.48	23.40	22.75	21.99	21.24	21.24
Pipestone	23.68	23.48	23.40	22.75	A	A	A
Regent	23.68	A	A	A	A	A	A
Reston	23.68	23.48	23.40	22.75	A	A	A

APPENDIX F-4 (continued)

Delivery Point	Sim 1&2[1]	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Sinclair	23.68	23.48	23.40	22.75	A	A	A
Souris	22.37	22.17	22.09	21.44	20.68	19.93	19.93
Tilston	23.68	23.48	A	A	A	A	A
Waskada	23.68	23.48	23.40	A	A	A	A

[1]See footnote on p. 264, Appendix E-1.

APPENDIX G-1

Bushels Collected, Handled and Distributed by Delivery Point for CHAD System 1970-71, Revealed Preference Assumption, Volume 11.3 million bushels
Simulations 1 through 8
("A" denotes abandoned in simulation)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Belleview	48,581	A	A	A	A	A	A	A
Boissevain	1,187,736	1,187,736	1,200,691	1,200,691	1,200,691	1,200,691	1,853,907	2,001,384
Broomhill	117,621	117,621	126,689	A	A	A	A	A
Coulter	61,232	61,232	61,232	61,232	A	A	A	A
Cranmer	94,304	94,304	94,304	94,304	A	A	A	A
Croll	140,147	140,147	A	A	A	A	A	A
Dalny	146,044	146,044	146,044	146,044	A	A	A	A
Dand	179,395	179,395	A	A	A	A	A	A
Deloraine	687,434	687,434	782,390	782,390	902,609	902,609	970,954	1,220,216
Elgin	561,331	561,331	741,774	741,774	741,774	741,774	A	A
Fairfax	423,476	423,476	509,267	518,335	518,335	518,335	A	A
Goodlands	414,628	414,628	414,628	414,628	A	A	A	A
Hartney	482,781	482,781	483,765	483,765	483,765	484,160	707,884	1,044,757
Lauder	159,392	159,392	218,051	218,051	218,051	218,051	271,388	A
Leighton	126,401	126,401	154,041	154,041	460,343	460,843	460,843	A
Linklater	241,896	241,896	241,896	340,108	340,108	A	A	A
Lyleton	334,129	334,129	334,129	334,126	A	A	A	A
Medora	707,419	707,419	707,419	707,419	1,024,104	1,024,104	1,024,104	1,285,429
Melita	639,136	639,136	639,136	647,503	835,005	1,618,257	1,618,257	1,627,524
Mentieth	159,056	159,056	159,056	159,056	159,056	288,525	340,146	A
Minto	486,748	486,748	486,748	486,748	486,748	486,748	A	A
Napinka	160,157	160,157	160,157	165,735	337,967	421,784	421,784	541,389
Newstead	235,003	235,003	235,003	235,003	235,003	235,003	731,159	A
Pierson	678,935	678,935	678,935	822,656	1,124,547	2,048,731	2,048,731	2,048,731
Pipestone	289,273	337,854	337,854	342,305	342,305	A	A	A

APPENDIX G-1 (continued)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Regent	150,955	150,955	A	A	A	A	A	A
Reston	573,528	573,528	573,528	643,480	643,480	A	A	A
Sinclair	371,757	371,757	371,757	595,375	595,375	A	A	A
Souris	660,027	660,027	660,027	660,027	660,027	660,027	860,429	1,540,060
Tilston	436,279	436,279	436,279	A	A	A	A	A
Waskada	355,003	355,003	355,003	355,003	A	A	A	A

APPENDIX G-2

Handling-to-Capacity Ratios for CHAD System 1970-71, Revealed Preference Assumption, Volume 11.3 million bushels.
Simulations 1 through 8
("A" denotes abandoned in simulation)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Belleview	2.4	A	A	A	A	A	A	A
Boissevain	2.1	2.1	2.1	2.1	2.1	2.1	3.3	3.8
Broomhill	4.9	4.9	5.3	A	A	A	A	A
Coulter	1.2	1.2	1.2	1.2	A	A	A	A
Cranmer	1.1	1.1	1.1	1.1	A	A	A	A
Croll	1.8	1.8	A	A	A	A	A	A
Dalny	0.9	0.9	0.9	0.9	A	A	A	A
Dand	3.1	3.1	A	A	A	A	A	A
Deloraine	1.8	1.8	2.1	2.1	2.4	2.4	2.6	3.2
Elgin	2.1	2.1	2.8	2.8	2.8	2.8	A	A
Fairfax	1.7	1.7	2.0	2.0	2.0	2.0	A	A
Goodlands	1.7	1.7	1.7	1.7	A	A	A	A
Hartney	1.8	1.8	1.8	1.8	1.8	1.8	2.7	3.9
Lauder	1.7	1.7	2.3	2.3	2.3	2.3	2.9	A
Leighton	2.5	2.5	2.1	3.1	9.1	9.1	9.1	A
Linklater	2.5	2.5	2.5	3.5	3.5	A	A	A
Lyleton	1.7	1.7	1.7	1.7	A	A	A	A
Medora	2.3	2.3	2.3	2.3	3.3	3.3	3.3	4.2
Melita	2.1	2.1	2.1	2.2	2.8	5.4	5.4	6.7
Mentieth	2.0	2.0	2.0	2.0	2.0	3.7	4.3	A
Minto	1.6	1.6	1.6	1.6	1.6	1.6	A	A
Napinka	1.3	1.3	1.3	1.4	2.8	3.5	3.5	4.5
Newstead	4.4	4.4	4.4	4.4	4.4	4.4	13.5	A
Pierson	2.3	2.3	2.3	2.7	3.7	6.8	6.8	6.8

APPENDIX G-2 (continued)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Pipestone	2.5	2.9	2.9	2.9	2.9	A	A	A
Regent	1.7	1.7	A	A	A	A	A	A
Reston	3.0	3.0	3.0	3.4	3.4	A	A	A
Sinclair	2.1	2.1	2.1	3.4	3.4	A	A	A
Souris	1.2	1.2	1.2	1.2	1.2	1.2	1.6	2.9
Tilston	2.7	2.7	2.7	A	A	A	A	A
Waskada	1.3	1.3	1.3	1.3	A	A	A	A

APPENDIX G-3

Average Handling Costs by Delivery Point for CHAD System 1970-71, Revealed Preference Assumption. Volume 11.3 million bushels
Simulations 1 through 8
("A" denotes abandoned in simulation)
(Cents/bushel

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Belleview	16.75	A	A	A	A	A	A	A
Boissevain	5.31	5.31	5.27	5.27	5.27	5.27	3.99	4.30
Broomhill	8.28	8.28	7.85	A	A	A	A	A
Coulter	13.77	13.77	13.77	13.77	A	A	A	A
Cranmer	9.75	9.75	9.75	9.75	A	A	A	A
Croll	7.32	7.32	A	A	A	A	A	A
Dalny	9.80	9.80	9.80	9.80	A	A	A	A
Dand	6.23	6.23	A	A	A	A	A	A
Deloraine	6.39	6.39	5.82	5.82	5.26	5.26	5.00	4.32
Elgin	7.93	7.93	6.51	6.51	6.51	6.51	A	A
Fairfax	7.89	7.89	6.92	6.83	6.83	6.83	A	A
Goodlands	6.89	6.89	6.89	6.89	A	A	A	A
Hartney	6.15	6.15	6.14	6.14	6.14	6.14	4.72	3.72
Lauder	7.23	7.23	5.85	5.85	5.85	5.85	5.12	A
Leighton	7.86	7.86	6.87	6.87	3.84	3.84	3.84	A
Linklater	5.48	5.48	5.48	4.51	4.51	A	A	A
Lyleton	6.99	6.99	6.99	6.99	A	A	A	A
Medora	5.38	5.38	5.38	5.38	4.53	4.53	4.53	4.15
Melita	6.41	6.41	6.41	6.34	5.24	3.39	3.39	2.97
Mentieth	6.73	6.73	6.73	6.73	6.73	4.75	4.38	A
Minto	7.14	7.14	7.14	7.14	7.14	7.14	A	A
Napinka	8.44	8.44	8.44	8.21	4.86	4.22	4.22	2.65
Newstead	5.30	5.30	5.30	5.30	5.30	5.30	3.28	A

APPENDIX G-3 (continued)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Pierson	5.50	5.50	5.50	5.00	4.36	3.58	3.58	3.58
Pipestone	7.17	6.47	6.47	6.41	6.41	A	A	A
Regent	7.52	7.52	A	A	A	A	A	A
Reston	4.96	4.96	4.96	4.65	4.65	A	A	A
Sinclair	5.52	5.52	5.52	4.48	4.48	A	A	A
Souris	5.87	5.87	5.87	5.87	5.87	5.87	5.15	4.09
Tilston	5.11	5.11	5.11	A	A	A	A	A
Waskada	7.78	7.78	7.78	7.78	A	A	A	A

APPENDIX G-4

Rail Costs by Delivery Point for CHAD System 1970-71, Revealed Preference Assumption.
Volume 11.3 million bushels
Simulations 1 through 8
("A" denotes abandoned in simulation)
(Cents/bushel)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Belleview	23.68	A	A	A	A	A	A	A
Boissevain	21.05	21.05	20.97	20.91	20.36	19.61	18.92	18.92
Broomhill	23.68	23.68	23.60	A	A	A	A	A
Coulter	23.68	23.68	23.60	23.54	A	A	A	A
Cranmer	23.68	23.68	23.60	23.54	A	A	A	A
Croll	22.37	22.37	A	A	A	A	A	A
Dalny	23.68	23.68	23.60	23.54	A	A	A	A
Dand	23.68	23.68	A	A	A	A	A	A
Deloraine	23.68	23.68	23.60	23.54	22.99	22.24	21.55	21.55
Elgin	23.68	23.68	23.60	23.54	22.99	22.24	A	A
Fairfax	22.37	22.37	22.29	22.23	21.68	20.93	A	A
Goodlands	23.68	23.68	23.60	23.54	A	A	A	A
Hartney	23.68	23.68	23.60	23.54	22.99	22.24	21.55	21.55
Lauder	23.68	23.68	23.60	23.54	22.99	22.24	21.55	A
Leighton	23.68	23.68	23.60	23.54	22.99	22.24	21.55	A
Linklater	23.68	23.68	23.60	23.54	22.99	A	A	A
Lyleton	23.68	23.68	23.60	23.54	A	A	A	A
Medora	23.68	23.68	23.60	23.54	22.99	22.24	21.55	21.55
Melita	23.68	23.68	23.60	23.54	22.99	22.24	21.55	21.55
Mentieth	23.68	23.68	23.60	23.54	22.99	22.24	21.55	A
Minto	21.05	21.05	20.97	20.91	20.36	19.61	A	A
Napinka	23.68	23.68	23.60	23.54	22.99	22.24	21.55	21.55
Newstead	21.05	21.05	20.97	20.91	20.36	19.61	18.92	A

APPENDIX G-4 (continued)

Delivery Point	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8
Pierson	23.68	23.68	23.60	23.54	22.99	22.24	21.55	21.55
Pipestone	23.68	23.68	23.60	23.54	22.99	A	A	A
Regent	23.68	23.68	A	A	A	A	A	A
Reston	23.68	23.68	23.60	23.54	22.99	A	A	A
Sinclair	23.68	23.68	23.60	23.54	22.99	A	A	A
Souris	22.37	22.37	22.29	22.23	21.68	20.93	20.24	20.24
Tilston	23.68	23.68	23.60	A	A	A	A	A
Waskada	23.68	23.68	23.60	23.54	A	A	A	A

APPENDIX H.--Average and total costs and rates, average one-way distance to elevator, and percent of farmers and bushels diverted for rail line abandonment simulations 1 through 8. CHAD Systems 1970-71 and 1971-72, revealed preference and minimum cost/distance assumption, grain volume 8,377,692 bushels and CHAD System 1970-71, revealed preference assumption, grain volume 11,309,489.

Grain Volume 8,377,692 Bushels		Collection AC/BU (1)	Handling AC/BU (2)	Distribution AC/BU (3)	Handling Rate Rate/Bu (4)	Distribution Rate/Bu (5)	Total Farmer Costs/Bu (Cols. 1+4+5)	Resource Costs/Bu (Cols. 1+2+3)	Avg. One-Way Distance to Elevator	Percent Farmers Diverted	Percent Bushels Diverted
1970-71	Sim										
Revealed	1	2.89	7.97	23.09	5.75	9.65	18.29	33.95	6.6	0.0	0.0
Preference	2	2.90	7.89	23.09	5.75	9.65	18.30	33.88	6.7	0.8	0.4
	3	2.96	7.61	23.02	5.75	9.66	18.37	33.59	6.9	4.0	4.2
	4	2.93	7.40	22.95	5.75	9.66	18.34	33.28	6.8	5.3	5.0
	5	3.19	6.14	22.40	5.75	9.66	18.60	32.02	7.9	14.4	12.4
	6	3.98	5.80	21.65	5.75	9.66	19.39	31.43	10.8	17.2	17.0
	7	4.27	4.80	20.85	5.75	9.61	19.63	29.92	11.7	11.0	14.8
	8	4.40	4.40	20.87	5.75	9.63	19.78	29.67	12.1	14.1	15.9
Minimum	Sim										
Cost/Distance	1	2.55	8.03	23.15	5.75	9.68	17.98	33.73	5.3	0.0	0.0
	2	2.56	7.95	23.15	5.75	9.68	17.99	33.66	5.4	1.7	1.5
	3	2.67	7.66	22.97	5.75	9.68	18.10	33.30	5.8	8.2	9.5
	4	2.76	7.44	22.85	5.75	9.67	18.18	33.05	6.1	6.5	6.6
	5	3.07	6.44	22.20	5.75	9.67	18.49	31.71	7.5	17.8	14.6
	6	3.87	5.81	21.44	5.75	9.67	19.29	31.12	10.4	17.4	17.1
	7	4.18	4.81	20.56	5.75	9.61	19.54	29.55	11.4	11.8	15.8
	8	4.35	4.38	20.62	5.75	9.64	19.74	29.35	11.9	20.2	21.7

APPENDIX H (continued)

	Sim	Collection AC/BU (1)	Handling AC/BU (2)	Distribution AC/BU (3)	Handling Rate Rate/Bu (4)	Distribution Rate/Bu (5)	Total Farmer Costs/Bu (Cols. 1+4+5)	Resource Costs/Bu (Cols. 1+2+3)	Avg. One-Way Distance to Elevator	Percent Farmers Diverted	Percent Bushels Diverted
1971-72 Revealed Preference	1	2.80	7.64	23.09	5.75	9.65	18.20	33.53	6.3	0.0	0.0
	2	2.80	7.64	23.09	5.75	9.65	18.20	33.53	6.3	0.0	0.0
	3	2.87	7.36	23.01	5.75	9.66	18.28	33.24	6.5	4.1	4.4
	4	2.94	7.23	22.95	5.75	9.66	18.35	33.12	6.8	4.6	4.3
	5	3.22	6.33	22.39	5.75	9.66	18.63	31.94	8.0	14.5	12.6
	6	4.00	5.70	21.64	5.75	9.66	19.41	31.34	10.9	17.2	17.0
	7	4.29	4.71	20.84	5.75	9.61	19.65	29.84	11.8	11.0	14.8
	8	4.40	4.40	20.89	5.75	9.63	19.78	29.69	12.1	10.2	12.0
Minimum Cost/Distance	Sim										
	1	2.59	7.69	23.13	5.75	9.67	18.01	33.41	5.5	0.0	0.0
	2	2.59	7.69	23.13	5.75	9.67	18.01	33.41	5.5	0.0	0.0
	3	2.70	7.40	22.92	5.75	9.67	18.12	33.02	5.8	8.6	9.9
	4	2.78	7.27	22.83	5.75	9.67	18.20	32.88	5.0	5.0	4.7
	5	3.10	6.34	22.19	5.75	9.67	18.52	31.63	7.5	17.8	14.6
	6	3.90	5.71	21.43	5.75	9.67	19.32	31.04	10.4	17.4	17.1
	7	4.21	4.71	20.54	5.75	9.61	19.57	29.46	11.5	11.8	15.8
	8	4.35	4.38	20.61	5.75	9.64	19.74	29.34	11.9	14.7	15.8

APPENDIX H (continued)

Grain Volume 11,309,489 Bushels	Sim	Collection AC/BU (1)	Handling AC/BU (2)	Distribution AC/BU (3)	Handling Rate Rate/Bu (4)	Distribution Rate/Bu (5)	Total Farmer Costs/Bu (Cols. 1+4+5)	Resource Costs/Bu (Cols. 1+2+3)
	1	2.79	6.45	23.09	5.75	9.65	18.19	32.33
	2	2.79	6.39	23.09	5.75	9.65	18.19	32.27
	3	2.85	6.19	23.02	5.75	9.66	18.26	32.06
	4	2.82	6.03	22.95	5.75	9.66	18.23	31.80
	5	3.08	5.31	22.40	5.75	9.66	18.49	30.79
	6	3.81	4.89	21.65	5.75	9.66	19.22	30.29
	7	4.08	4.09	20.85	5.75	9.61	19.44	29.02
	8	4.20	3.85	20.91	5.75	9.63	19.58	28.96