A SIMULATION STUDY OF GRAIN ASSEMBLY FROM FARM TO ELEVATOR AT SIX ELEVATOR POINTS IN ALBERTA

by

RICHARD AUSTIN GROUNDWATER

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Department of Agricultural Economics

The University of British Columbia
Vancouver 8, Canada

Date August 26, 1968

ABSTRACT

The Canadian grain trade is faced with the prospect of change. It is therefore important to analyze the system for current efficiency and for efficiency under alternative configurations of physical facilities, alternative methods of operating, and alternative regulations. This study is concerned with a somewhat narrow subject, that of grain movement from the farm to elevator. Total costs associated with the assembly of grain were estimated at six elevator points: for the current configuration of facilities, after changes in number and capacity of elevators, after changes in farm storage capacity, after changes in hauling distance and truck size, and after changes in elevator location.

The technique of simulation was used, and a model was constructed to provide a simulator of the system. The model was by necessity, simple, incorporating data to represent crop production, farm storage cost, ground storage cost, hauling cost, elevator cost, and rail shipments. Each change necessitated an additional computer run to determine the costs resulting from the change. It was concluded that a model using the technique of simulation could be constructed for the entire grain marketing system to capture the essence of the interdependencies.

Ten experiments were conducted to estimate the costs associated with alternative configurations. The resulting

estimates indicated that the current configuration is inefficient and that lower costs would occur following: (1) reduction in the number of elevators at each point, (2) a reduction in the number of points, (3) a reduction in farm storage capacity, and (4) by an increase in farm truck size.

The cost of assembling grain with the current configuration was estimated to be 24.38 cents per bushel. It is possible given the validity of the model to reduce these costs to 13.76 cents per bushel by decreasing the number of elevators at each point, reducing farm storage capacity, and increasing farm truck size.

The complete response surface was not mapped because of the great number of potential permutations, hence only ten discrete experiments were completed. However, indications were that one of the more important ways to achieve a lower per bushel cost of assembly is to increase the volume of grain through a fixed capacity country elevator system. It is important to examine these results in terms of the limited scope of the study for not all costs were accounted. That is, there may be external costs to the rest of the economy due to interdependence.

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CHAPTER I

INTRODUCTION

Introduction. The broad issue which faces the Canadian grain trade is resource allocation. The four allocation decisions are (1) what goods and services are to be produced, (2) how will the goods and services be produced, (3) how will the goods and services be distributed in space, and (4) how will the division of an economy's resources in time between future and current consumption be made. The manner in which all the complex decisions are simultaneously and continuously made and the way they interact to determine the resulting pattern of resource allocation is the key feature of economic life.

The current allocation of resources in the grain trade was largely determined in the first half of the twentieth century. The present boxcars, railroad branch lines, grading system, marketing institutions, freight rates, country elevators, and farm resource allocation structures have been inherited. Advances in technology have made many of the physical facilities appear obsolete[1], resulting in request for new institutions, regulations, and attitudes. In conjunction with the obsolescence of physical facilities, changes in international trade and the domestic economy may invalidate the grain marketing status quo.

This study is concerned with the movement of grain from farmer to country elevator, that is, with the costs involved

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[1]D. Suderman, "The Price of Obsolescence", The Family Herald, June 13, 1968, p.18.

in the assembly of grain, and the facilities that would be required to move the grain. Grain assembly from farm to elevator is only a small part of the total system composing the grain trade, but it is a very important step in the marketing system. The farmer bears a large share of the costs accruing to the system, and thus any improvements or changes in the system will reflect wholly or partially upon the farmer. Unfortunately, the overall system must be examined in its entirety, in a manner that captures the essence of the simultaneous, continuous, and interacting decisions made in the system. The interdependencies within the system are obvious, and in capturing this fundamental aspect, any externalities can be examined for the possibility of internalization by the system[2]. The movement of grain to the West Coast has been examined, with recommendations asserting that closer cooperation within a flexible system of controls for grain movement from the prairies to the ships could eliminate most of the recent grain export problems at the West Coast[3]. However, not only is a technological examination required, that is, an examination of production efficiency, but also required is an examination of the institutions, sales policies, and the objectives of both the grain trade and agriculture. This is the broad framework in which the grain trade could be examined. It is perhaps unwieldy, but substantial analysis

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[2]Compensation is a difficult problem in welfare economics and this has not been mentioned in the discussion.

[3]Kates, Peat, Marwick and Co., West Coast Commodity Transportation Study, Part 1: The Transportation and Handling of Grain Short-Term Recommendations (Canada: Dep't. of Transport, 1967), pp. 1-11.

of all aspects of the system is likely to be very productive since only through analysis can major error be avoided.

As this study incorporates only a small part of the system in a manner to represent the interactions, suboptimization is likely to occur. Secondly, the technique neither seeks an optimum nor could one be sure of obtaining an optimum[4].

The assembly of grain from field to elevator, although a small segment of the total system, is very complex and its analysis requires many assumptions.

The study is organized to provide a discussion of some of the important institutions involved, the difficulties involved in studying such a large system, and to indicate the nature of the model and data used. The results, however, are conditional on the assumptions, data, and techniques used.

Statement of the Problem. Capital expenditures will be made in the grain industry, and consequently physical facilities for the movement of grain will change. The movement of grain from farms to export position at least cost requires efficient grain handling systems and determination

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[4]There are two problems --one economic and one statistical-- which are dealt with by the following authors. K. Lancaster and R.G. Lipsey, "The General Theory of Second Best", Review of Economic Studies (Vol XXIV (1), No. 63), p. 11; W.C. Cochran and G.M. Cox, Experimental Designs, Second Edition (New York: John Wiley and Sons, Inc., 1957), pp.335-369.

of an ideal system requires the prediction of future requirements[5]. The entire system should be examined in a manner that includes all interactions. A smaller problem was undertaken in this thesis. The problem was to examine the assembly of grain from farm to elevator and determine the costs of grain assembly when changes could be made in elevator capacity, elevator location, farm storage capacity, hauling distance, truck size, and rail shipments.

Importance of the Problem. Contemplated changes in the grain trade justify a careful examination of the system from an economic viewpoint to prevent repetition of historical mistakes. In order to make better decisions the interactions among the economic units should be analyzed including both private and social costs and benefits[6]. A flexible and efficient marketing structure would enhance the opportunity for exports, increase net returns to producers, and permit the railways and the remainder of the system to operate on a sound economic basis[7].

The technique of simulation is here advocated for the examination of grain assembly. Simulation is thought useful because the complexity of the system can be incorporated, and alternative physical facilities can be explored.

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[5] R.J. Kristjanson, "Introductory Remarks", Proceedings of the Grain Transportation Workshop, Grain Transportation Committee (Minaki, Sept. 6-8, 1967), p.2.

[6] C. Gilson, "The Economic Effect of Rail Abandonment in the Prairie Provinces", Proceedings of the Sixth National Farm and Business Forum, The Winnipeg Chamber of Commerce, March 25-6, 1965, pp.4-15.

[7] Efficiency in this context refers to efficiency of production which is the assembly of factors of production in such a manner as to produce the greatest possible output at least cost.

One component of the system is the movement of grain from farm to elevator where a simulation model might be useful to estimate the consequences of changing the physical facilities.

The concept of efficiency is used for evaluation of the system. A reduction of one cent per bushel when considering the movement of many millions of bushels per year is of significant magnitude. In the area considered in this study, such a saving would mean approximately 27 thousand dollars per year.

Hypotheses. The hypotheses used in this study were:

(1) a. The technique of simulation provides a tool for the examination of grain assembly from farm to country elevator.

(2) a. The current configuration of grain assembly from farm to country elevator is efficient.

b. Lower total cost of grain assembly will not result from a change in (1) truck size, (2) elevator capacity, (3) farm storage capacity, (4) hauling distance, and (5) temporal distribution of rail shipment.

Objectives. The objectives were: (1) to develop a simulation model and (2) to find whether both the technique and model were useful to evaluate the assembly of grain from farm to elevator. The model developed would be a representation of the system considered in this thesis. The model was to incorporate important components and decisions representing grain assembly and was used to estimate the costs of grain assembly under different configurations of physical facilities to determine whether the present system is efficient, and indicate the direction of change that might reduce the cost of grain assembly.

Criteria. The criterion that is used to test the hypothesis of efficiency and to indicate a lower cost arrangement of commercial elevator capacity, elevator location, farm bin capacity and truck size is least cost. If it is assumed that a given amount of grain must be handled, then it follows from the theory of the firm that there is a configuration of elevators, farm bins, distances, and truck size which will provide a least cost solution for the particular output. The situation is one in which a production level is given, and the cost of production is to be minimized.

Define the production function to be

$$(1)\quad Q = f(x_1, x_2, x_3, \ldots, x_n)$$

where x_1 is size of elevator, x_2 is size of farm storage, x_3 is truck size, x_4 is distance, and so on. For any given output level Q^*, the ideal system tends to produce Q^* as cheaply as possible.

The expenditure is

$$(2)\quad M = P_1X_1 + P_2X_2 + \ldots + P_nX_n$$

The optimum system involves minimizing M subject to the output level Q^* and given the function (1). The method of Lagrange multipliers leads to equations (3), (4), and (5).

$$(3)\quad f(x_1, x_2, \ldots, x_n) - Q^* = 0$$

$$(4)\quad M_\lambda = P_1X_1 + P_2X_2 + \ldots + P_nX_n + \lambda(f(x_1, x_2, x_n) - Q^*)$$

Taking the partials and setting them equal to zero we obtain

$$\frac{\partial M_\lambda}{\partial x_1} = P_1 + \lambda\frac{\partial f}{\partial x_1}$$

$$(5)\quad \frac{\partial M_\lambda}{\partial \lambda} = f(x_1, x_2, \ldots, x_n) - Q^* = 0$$

and simplifying,

$$(6)\quad P_1 = -\lambda\frac{\partial f}{\partial x_1}$$

$$P_2 = -\lambda\frac{\partial d}{\partial x_2}$$

$$P_i = -\lambda\frac{\partial f}{\partial x_i}$$

In classical terms this simply states that the marginal products of factor i is set proportionate to its price. The first partial derivatives $\frac{\partial M_\lambda}{\partial x_i}$ determine the system's expansion pattern.

System (6) does not convey any information about the average cost other than the physical plant will operate a plant size which is appropriate for its anticipated output, that is, has minimum average cost for that output.

The one dimension that has not been mentioned and is important in this study is time. Grain production is not constant but varies from year to year whereas the criteria mentioned above apply under a given level of output. But given one level of output, a least cost configuration would be determined only for that output whereas the system handles a different amount of grain each year. Capital theory might be applied, but the method used was to look for a minimum in the total cost of handling the quantity of grain, determined from historical data, over a period of fifteen years[8]. Thus if it were possible to find a configuration that provided a total cost less than the cost in the existing system, then the existing configuration would be inefficient.

Scope. This study deals with the movement of grain from the farm to the railroad in a limited area. The location is that of an area in the Peace River region of Alberta encompassing approximately 760,000 acres[9]. The town of Grande Prairie is the eastern boundary and the town of Hythe is the western boundary. Dimsdale, Wembley, Huallen, and Beaverlodge, moving east to west, comprise the other points. There are six shipping points involving twenty-five elevators with a capacity of 2,265,400 bushels.

There are 1,650 farms holding Canadian Wheat Board permits in the area. Average farm size was 470 acres. Crops included wheat, oats, barley, rye, flaxseed and rapeseed with a sizeable acreage of forage crops used for seed production

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[8]Optimizing over time is a difficult problem and is not fully explored. See J.M. Henderson and R.E. Quandt, Microeconomic Theory A Mathematical Approach (New York: McGraw-Hill Book Co., Inc., 1958), pp. 240-252.

[9]Appendix II Table LXXVI.

or hay, although only the first five are considered relevant to this study. As in most grain growing areas there are numerous farm storage bins of various shapes and made of various materials. The average farm storage capacity was eighteen bushels per cultivated acre.

The farm component then includes crop production, farm storage, and the movement of grain to the elevator in accordance with Canadian Wheat Board quotas. The elevator receives the grain, performing the function of the initial buyer. The elevator company then acts in accordance with export markets as required by the Canadian Wheat Board and loads grain into railroad box cars to be shipped to the required destination.

The study involves grain production entering the queue, grain in farm storage, and grain in elevator storage in the queue, with the railroads removing grain from the elevator, effectively removing grain from the queue. The cost of the facilities within this closed-loop system are recorded by the model and accrued as total costs to the system.

The study is general in the sense that the model describes a general process which could be changed to incorporate new knowledge or adapted to other regions. The empirical results are conditional upon the validity of assumptions and data used[10].

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[10] The importance of the assumptions are discussed in M. Friedman, "The Methodology of Positive Economics", Essays in Positive Economics (Chicago: The University of Chicago Press, 1953), pp.3-43.

Limitations. There are definite limitations to the technique, model, and data. There is no theory of simulation, so that each simulation study must be interpreted as to the purpose, procedure, and applicability of using the technique. There are other techniques which might be applied to analyze grain assembly; however, the advantages and disadvantages of these possible techniques have not been investigated in this study. No model of any sort reproduces or represents the real situation in all of its detail. The model used in this study is not an exception. There are a great number of decisions made in the assembly of grain, but the exact nature of these decisions was unknown, requiring a great deal of simplification. The expansion of knowledge concerning the grain trade will provide models that are precise analogues of grain assembly. Data limitations also forced the use of simplifying assumptions. Use of the efficiency criterion presupposes the existence of a least cost configuration. The determination of an efficient system is very difficult due to the complexity of the system and because the technique of simulation does not seek an optimum. The simplifications used may preclude use of relevant variables in the determination of a least cost system. The aggregation of numerous firms complicates the problem and criteria, as does the dimension of time.

The assumptions should be questioned. Whether the model adequately reflects reality or not, is unknown[11]. It is

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[11] Lack of data prevented a more complex model from being developed as well as precluding adequate testing of the model.

assumed that the technique and the model provide a useful tool for the examination of grain assembly from farm to elevator.

Definitions. There are several words which will be used quite often in this study. It may be useful to define such words to prevent ambiguity.

Simultion was the technique used in the study to estimate grain assembly costs.

Simulator refers to the model used in a specific simulation.

Computer run is the output obtained from the computer model as a consequence of a particular set of assumptions used as parameters and inputs.

Proxy refers to a substitute set of numbers or events used to represent the real world in a simulator.

Design variables are variables which can be changed from one configuration or run to another in which case the numerical values act as parameters.

Monte Carlo is simulated sampling, that is, replacing the universe of items by its theoretical counterpart, and then sampling from this theoretical population using random numbers.

Country Elevator is a public country elevator in which grain is accepted from a farmer and initial payment is made under agreement with the Canadian Wheat Board, stored, or discharged.

Capacity of a country elevator is the actual storage capacity in bushels as reported in "Grain Elevators in Canada" and published by the Canada Department of Agriculture.

Handling-to-capacity ratio for a period of time "t" is the ratio obtained by summing the number of bushels of grain placed in the elevator in t and the number of bushels of grain removed in t divided by twice the rated capacity.

Annex is the additional storage space attached to the main elevator house.

Annex-to-capacity ratio is the annex capacity divided by the total rated capacity of the elevator.

A Crop year begins August 1st of year(t) and ends July 31st of year (t + 1).

Receipts is the volume of grain received at country elevators for a given crop year reported in the "Summary of Country Elevator Receipts at Individual Prairie Points" compiled and published by the Statistics Branch of the Board of Grain Commissioners for Canada.

Throughput is the amount of grain shipped from a particular elevator in a given crop year.

Throughput-to-capacity ratio is the throughput, as defined above, divided by the rated capacity of a country elevator.

Utilization of space refers to the proportion of storage being used at a particular time, that is, the amount stored divided by capacity at time t.

Point or Elevator point is a location where one or more country grain elevators exist.

Farm storage refers to bins available on a farm to store grain, and capacity measured in bushels.

Ground storage is the temporary piling of grain on the ground.

Haul distance is the average distance from farm or ground storage to the elevator point.

Truck capacity is the maximum box capacity of a truck expressed in bushels[12].

A Configuration is a physical arrangement of elevators, farm bins, hauling distances, and truck capacities existing in the region under study or in a computer run.

Grain assembly cost is the sum of elevator cost, hauling cost, farm storage cost, ground storage cost, and farm handling cost.

This chapter has introduced the problem and the nature of this study. The remaining chapters discuss the grain trade further, introduce the technique and model used in the study, the data used in the model, results of the model, and conclusions to this study.

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[12]See, K.B. Young, An Analysis of the Cost of Assembling Grain by Farm Trucks in Manitoba (Research Report No. 11, Department of Agricultural Economics, University of Manitoba, October, 1966), p. 7.

CHAPTER II

RESOURCE ALLOCATION

In the broadest sense, the welfare of a society depends upon the satisfaction of all its consumers. Such a statement is based upon ethical beliefs or value judgements which cannot be provided, and cannot be measured. The concept is narrowed by using the restricted notion of economic welfare[1]. The size of national income is measurable but not useful by precluding noneconomic dimensions of welfare. The size, divisions and method of slicing of the economic pie are three dimensions of national welfare, making it difficult to define a single index for the broad objective. Efficiency expresses the objective of maximization of the size of the economic pie which provides the fundamental principle of economic efficiency[2]. This objective is discussed as an overall goal in relation to resource allocation. The use of the concept and the criteria for measurement in this thesis are then discussed.

The system required for movement of Canadian grain from the farmer to the ultimate consumer is one of great complexity.

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[1]A survey of welfare economics has been made by: E.J. Mishan, A Survey of Welfare Economics, 1939-59 (Vol. I of Surveys of Economic Theory. 3 vols.; New York: St. Martin's Press, 1967), pp. 154-222.

[2]The use of the efficiency objective may not always be desirable. The relevance of this objective has been discussed by: S.A. Marglin, "Objectives of Water-Resource Development: A General Statement", Design of Water-Resource Systems, A. Maass, M.M. Hufschmidt, R. Dorfman, H.A. Thomas, Jr., S.A. Marglin; G.M. Fair et al (Cambridge: Harvard University Press, 1962), pp. 17-87.

The numerous firms and individuals forming this system act independently, subject to regulation and economic influences. The nature of this chapter is to indicate, very briefly, the nature of the economic influences, their relevance, their importance to the system, and in addition to evaluate the present system and postulated changes.

Resource Allocation. Microeconomic theory, dealing with the consumer and firm, determines the normative pattern of resource allocation through a set of product and factor markets. Two other extensions are required. These are firstly an indication of the complex interactions between markets, and secondly an indication of the extent to which two different patterns of resource allocation can be compared.

Determining normative distribution of inputs to the production of various commodities and the distribution of commodities among consumers is a general equilibrium problem[3]. Resources transferred to one industry are presumably removed from another. This is the essential feature of an economy if resources are available in limited quantity. The essential feature of general equilibrium theory is the interrelationships which exist between the industries of an economy. It is not possible to say that more of a commodity is a good thing as the decrease in quantity of a good (a) may be more valuable to the economy than the increase of good (b) given a specific criterion.

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[3]W.J. Baumol., Economic Theory and Operations Analysis (Second Edition; Englewood Cliffs: Prentice-Hall, Inc., 1965), p.355.

Thus the optimal allocation of resources between two items can only be determined by evaluating the relative demands and production costs. Essentially optimal output of one good can be determined only in comparison with another commodity which competes for the economy's scarce resources. The implications of the theory are clearly relevant to the discussion of grain marketing, where the system is complex and is composed of many individuals, firms, and institutional arrangements. Even under the limitations of this study, the theory is relevant as it indicates not only the difficulty of adequate analysis, but the importance of considering the interactions between individuals in this study and in the economy. There are probably several changes in the grain marketing system which could be advocated when considering the system a separate entity, but would be to the disadvantage of the rest of the economy.

Input-output analysis and macroeconometric models have been used to render the theory operational although data requirements have been very difficult to overcome. Unfortunately, the theory is not an adequate engine of analysis, however, it does provide a framework which should be kept in mind when dealing with complex problems of resource allocation.

Welfare Economics. Welfare economic theory provides a theoretical framework for policy decisions although fundamental philosophical problems exist. Essentially welfare economics is a general equilibrium problem as it is concerned with different resource allocations. Marginal conditions can be set up which must be satisfied to be useful to indicate the specific decisions required for allocation[4]. They are inadequate as operational concepts since data limitations are major problems. Obviously, neither the theory of welfare economics or general equilibrium will provide answers to specific questions but will provide an implicit framework for economic analysis--a theoretical guide to consider when dealing with the grain handling system.

Efficiency. Economic efficiency can be defined as the productive arrangement of an economy such that the welfare of consumers is maximized[5]. This, however, is really a Top Level Optimum which requires the equating of the subjective rate of substitution of all individuals to the rate of transformation for all pairs of goods in the economy[6]. The particular locus of efficiency points which are required by the hypothesis in this study is that of production. This is defined as the distribution of resources such that "....it is not possible to produce any more of a good without producing less of some other good ..."[7]. In other words, output cannot be increased by a mere rearrangement of inputs. This is nothing more than a

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[4]For details of the marginal conditions and the specific decisions which must be met see A. P. Lerner, The Economics of Control (New York: The Macmillan Co., 1946).

[5]O. Eckstein, Water Resource Development: Economics of Project Evaluation (Cambridge: Harvard University Press, 1958), p.23.

[6]Mishan, op. cit., p.164.

[7]Ibid.

technological requirement as it only refers to the most efficient method of production, that is, least cost, and avoids all problems of income distribution. However, the requirement does not preclude externalities.

Assumptions and Problems. The competitive model is usually assumed to meet the requirements of efficiency. The producers must be profit maximizers and operate under conditions of decreasing returns. Technical externalities between different firms must not exist. Perfect markets are required for the model as is the assumption that produced goods are marketable. Resources are considered mobile, and are employed reflecting opportunity costs. Income distribution is considered appropriate.

These assumptions are presupposed in the study. Although the assumptions may be invalid, they provided a theoretical framework. The major problem was the assumption of mobility of resources. The country elevator and farm bin are essentially immobile. The structure represents largely fixed overhead costs, and cannot be easily moved. Other inputs used by the system under study are perhaps not immobile but are sticky in their mobility. Another way of viewing this is to say that the resources may have no alternative uses, or that the uses are limited.

One other problem remains, that of income distribution. Although it does not enter explicitly into this study, it is of importance in a much broader aspect.

Economic models can be divided into two parts;

(1) the part describing the structural system and the relationships among the variables, and (2) a part which evaluates the consequences of any choice of variables in terms of a measure of desirability. It is this latter part which must be focused upon. Economic efficiency is often used by economists to express the size of the economic pie which is superior to national income. Economic welfare is the objective but it cannot be translated into an operational objective. It is not clear that efficiency is an adequate measuring rod, as it excludes noneconomic dimensions of welfare and implies society is completely indifferent to the recipient of income. The question is whether or not Canadians are solely concerned with efficiency, and if not, what is the objective. This is extremely important when discussing the grain trade, for many individuals are involved in the system, and not least of these are the farmers. Are they concerned with efficiency alone or are they really concerned with distribution? If they are concerned with distribution then the objective function must be formulated in such a manner which evaluates methods and changes in economy. Means of affecting distribution can be glibly talked about, and it is quite likely that the method of slicing the economic pie is as important as division and size of pie. In other words, the individuals comprising the trade, the farmers in particular, may not simply accept lump sum payments with an efficient system, but other methods which will effect the proper distribution must be

found. This is immensely more difficult than simply determining the size of the slice.

The objective determination has another aspect: that of the viewpoint taken. Clearly, a regional or provincial viewpoint will differ from that of the economy. In the case of the grain handling system, the viewpoint is extremely important, as it is largely an activity based in the prairie provinces. Questions such as rail abandonment may mean very little to other areas in Canada, and they might quite possibly feel the problem of rail abandonment is only a figment of imagination. By taking their regional standpoint, it might be decided that the lines should be abandoned so that resources can move to their own areas. This should not be taken seriously, as it is only a hypothetical example; but it is a difficulty found throughout the literature on cost-benefit analysis.

Efficiency of production has been chosen as the objective. This objective can be formulated in terms of alternative or opportunity costs[8]. Efficiency can be defined as the ratio of actual output to maximize output from given resources. To achieve a value of unity, the value of the marginal product of each input is equal to its alternative cost, which indicates that outputs are produced at least cost. This concept of least cost was used in this study as the criterion to measure efficiency. The total cost of assembling grain to the six elevator points provides the

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[8]G.J. Stigler, <u>The Theory of Price</u> (revised edition; New York: The Macmillan Co., 1952), pp. 101-106.

measuring rod, given the assumptions of the competitive model as previously stated and that the total cost represents the alternative costs of the factors used. The inputs used by the farmer and elevator industry seem relatively competitively priced, and if the costs determined in the study reflect opportunity cost, the assumption is realistic. A reduction of total cost, by assuming a different configuration would indicate that the present configuration is inefficient as the same output, that is, grain handled by the system could be achieved using fewer resources. Although it is conceptually possible to find minimum cost, it is in reality impossible to find given the current state of data. This will be discussed further in a later chapter. It is important to restate that the criterion and objective are subject to constant technology which precludes new methods of storing and handling grain. These advances in technology are important, but do not invalidate the analysis of this study. If the advances can be used economically, then they will simply be used.

Efficiency of production is an important concept. It is operational, and provides a basis for further research, that is, the system can be studied to indicate why it is inefficient and how to provide the proper regulation to move the system to the efficiency locus[9].

General equilibrium and welfare economics have been briefly mentioned, indicating that this study of a limited

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[9]For an excellent paper discussing the failure of a market system see F. Bator, "Anatomy of Market Failure", <u>Quarterly Journal of Economics</u> LXXII (1958), pp.351-379.

system involving many individuals is a difficult matter. The interrelationships that exist are important, and they cannot be examined in isolation. Welfare economics, with all its theoretical problems, provides a useful framework, and provides a basic objective of efficiency. Even though strict assumptions accompany the objective, it is used. The criteria used in the study was least total cost. There are difficulties in the acceptance of the objective and criterion, but they seem to be the best available. The minimum cost point cannot be found, but the mere indication of inefficiency is a very important economic concept as further study is called for to find the reasons and provide incentives to move the system in the correct direction[10].

[10] The problem of second best has been assumed away.

CHAPTER III

THE GRAIN TRADE IN WESTERN CANADA

The grain trade in Canada has evolved through time as a major factor in Canadian economics and history. The present system is a complex combination of public and private enterprises working together in the marketing of Canadian grain. Whether it is the best method is difficult to determine and depends on the criteria used to evaluate the system. There are both advocates and critics of the system, as with most economic institutions[1].

I. GRAIN MARKETING IN THE HISTORY OF WESTERN CANADA

A brief glimpse of the general marketing system provides a background to the remainder of the study. The study is bounded by limitations as designated in the definition: "Marketing is the performance of all business activities involved in the flow of goods and services from the point of initial production until they are in the hands of the ultimate consumer"[2].

Marketing includes all such activities whereas only the most obvious and important activities will be discussed here.

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[1]E.W. Tyrchniewicz and Om P. Tangri, "Grain Transportation in Canada: Some Critical Issues and Implications for Research," Canadian Journal of Agricultural Economics, XVI:1 (February 1968), pp.85-97.

[2]R.L. Kohls, Marketing of Agricultural Products, (second edition: Macmillan, 1961), p.6.

The grain marketing system in existence today involves a combination of private and public agencies to meet the requirements of the trade. This complex system can be described as an evolutionary response to requirements of the economy and growth through the many faces of Canadian history.

A great deal has been written from many points of view about these requirements through time..

The confederation of Canada in 1867 provided government impetus for the development and growth of the new nation. Fowke refers to such impetus as a national policy.

> The National Policy was defined as a collective term covering those policies which after the middle of the nineteenth century were directed in a complementary fashion toward the creation of a transcontinental Canadian Nation.[3]

As in most instances, politics is intertwined with economics, with the net result being the settlement and establishment of a great grain producing area in the prairie provinces.

> The economic imperative of the national policy, as contrasted with its political or territorial requirements, was the establishment of a new frontier of investment opportunity which would be attached commercially and financially to the eastern provinces. Although by no means clearly foreseen in the early decades of the national policy, effective occupation of the central plains as required for the preservation of Pacific frontage and a doorway to the Orient, eventuated in the establishment of the wheat economy. This, in turn, provided the new economic frontier of investment opportunity without which the first century of the national policy would have been but an empty political dream.[4]

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[3]V.C. Fowke, The National Policy and the Wheat Economy (Toronto: University of Toronto Press, 1957), p.281.

[4]Ibid., p.283.

The creation of the grain production area of the prairies was of a very complex nature, with many dependent relationships, much like a Markov chain process wherein timing is important in linking the important events in a chain-like manner.

As Fowke states: "Railway, land, and immigration policies were inextricably interrelated in the creation of the wheat economy"[5].

The development and growth of the Canadian west was not smooth and uneventful. Looking at the microcasm of the grain trade alone, the evolution of the trade was hammered and tempered to the crisis at the moment, and then amended or changed when the next crisis arose. In effect, it was and remains today, a giant system with feedback for change.

Federal regulation of the grain trade was initiated in 1888 when grades were established for Western Spring wheat. The Winnipeg Grain and Produce Exchange was established in 1887 and incorporated in 1891 for the centralization of the grain trade, and to establish ideal conduct for the trade.

Another statute of Canada passed in 1889 provided for a Western Standards Board for governing inspection of grain.

Legislation in 1889 created an Inspection District of Manitoba for further inspection of grain in transit at Winnipeg, giving the opportunity of reinspection at the terminal if a farmer was not satisfied with the grade received. By the end of the nineteenth century, general grain legislation covered

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[5]Ibid., p.283.

inspection of weights and measures, definition and inspection of the grades of grain, and inspection of elevator scales. Most of these regulations were passed as a consequence of grain dealers' representations, although they were of benefit to the farmer[6].

There were two grievances that farmers held against the Canadian Pacific Railway. Freight rates were one of the major complaints, as rates were higher in the west than the east. The C.P.R. argued that rate discrimination was justified. However the railroad lost its monopoly in 1888. The appointment of a railway rates commission in 1894 finally culminated in the well-known Crow's Nest Pass Agreement of 1897, still partially in effect. Basically, it provided farmers with low cost transportation for grain and supplies. Although many concessions were given to the railroad, most of the stipulations of the agreement have been renounced. However, export grain is still transported at statutory Crow's Nest rates which appear to be relatively low[7].

The second complaint of farmers was that monopoly powers given by the C.P.R. to firms for the construction of country elevators of a standard size[8] led to high costs and lack of competition. These complaints culminated in the appointment of a commission in 1899. Recommendations were incorporated into the Manitoba Grain Act. Although the act

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[6]H.S. Patton, Grain Growers' Cooperation in Western Canada (Cambridge, Harvard University Press, 1928), pp.27-28.

[7]Report of the Royal Commission on Transport (Ottawa: Queen's Printer and Controller of Stationery, 1961), pp. 371-379.

[8]Size greater than 25,000 bushels.

provided for loading platforms, adequate inspection, impartial distribution of cars, and a commissioner to investigate complaints there was poor enforcement, and the act was amended in 1903 to prevent inequitable box-car distribution. During this period, farm organizations were formed which attempted to obtain farmer control of the grain trade. These farmers turned their attention to the elevator systems and began cooperative action through the operation of elevators in 1912. This movement led to the U.G.G. in 1917 (an amalgamation of Alberta and Manitoba elevators) with the Saskatchewan company remaining independent. The Winnipeg Exchange provided one of the other targets, becoming a political issue in which farmers had considerable power[9].

The result was the Canada Grain Act of 1912 referred to by MacGibbon as 'the Magna Charta of the Canadian grain grower'[10]. This Act consolidated the Manitoba Grain Act and the Manitoba Inspection Act, and created the Board of Grain Commissioners.

By the eve of World War I, the Canadian government had become practised in the adjustment of policy in the face of changing conditions wrought in western Canada. The war period was no exception as the federal government provided legislation for government marketing in cooperation with the United States[11].

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[9]D.A. MacGibbon, The Canadian Grain Trade (Toronto: Macmillan, 1932), p.49.

[10]Ibid., p.375.

[11]N.W. Menzies, Canadian Wheat Board and the International Wheat Trade (Ph.D. Thesis, London School of Economics, 1956), pp.93-98.
D.A. MacGibbon, The Grain Trade (Toronto: University of Toronto Press, 1932), pp.57-61.

Postwar conditions forced continuing government action in grain marketing for the retention of export markets. The result was the Canadian Wheat Board of 1917, formed in a similar manner to that of Australia's marketing agency. The Board was charged with the responsibility of acting as a monopolist for the marketing of wheat in the domestic and export markets. Farmers received an initial payment (the minimum price) and participation certificates entitling the farmer to share in the surplus monies accruing from pooled sales of wheat above that of the initial price[12]. The Board ceased activity in 1920 although provisions were that the body could act in situations which warranted the use of the government agency. Conditions of 1921-23 gave rise to farmer demands for the revival of the Board[13]. These demands were refused, consequently, dynamic farm leaders such as McPhail, Saprio, and Henry Wise Wood formed provincial pools which acted as sales agents for the producer under a yearly contract. As such, the pools were extremely successful, expanding activities to include operation of their own line elevators. Policies of direct selling and stability of payment induced farmer patronage, but overextension of financial organization resulted in bankruptcy in 1930. Federal authority was used to underwrite credit (which was paid back) with the stipulation that McFarland be placed in charge of a quasi-public holding and stabilization board--essentially a central selling agency.

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[12]Menzies, op. cit., pp. 98-108.

[13]Ibid., pp. 109-122.

Although the Exchange was under attack by the farmers, the Royal Commission on Trading in Grain Futures reported in 1931 that the Exchange was innocent of the charges. The depression was a severe blow to the trade even though Canada obtained a preferred position in the British market for wheat, and supported the International Wheat Agreement of 1933.

An emergency Wheat Board was formed in 1935 to liquidate surplus stocks[14]. The Board was a voluntary agency with only a minimum floor price underwritten by the government. Farmers had the alternative of selling in the open market if the open market price was higher than the floor price plus expected returns on the participation certificate. The federal government appointed the Royal Grain Inquiry Commission under Mr. Justice Turgeons. His report centered on inadequacies of the market, but recommendations hinted at the continuance of the board. The government elected to adopt the major parts of the report but ran into such strong objections from farmers that the Board was retained. Producers wanted income stability as provided by the Board, rather than the economic ideals of free trade advocated by Turgeons. Stocks of wheat were increasing rapidly due to the loss of the European markets; and to increase livestock production, the government initiated production contols of wheat in 1941. The controls limited the amount of wheat the Board would receive, and compensation payments were made by the Department of Agriculture. By 1947 total subsidies paid out, 1941-47, amounted to over $400,000,000 for the various

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[14]The Act gave wide powers to the Board for complete control of the marketing of wheat in the unproclaimed Sections 9 to 11 and 16.

programs to limit wheat acreage and promote diversification.

Further government intervention, the closing of the free market system, during 1943 provided the Board with complete powers in the marketing of grain in order to meet Canadian committments abroad, and to control inflationary tendencies in the economy. At the close of World War II, it was evident that the producers desired price stability and some guarantee of returns.

> Thus partly as a result of the experiences of the early nineteen-thirties, and partly as a result of the war, Canada appeared to be drifting into a system of state trading for one of its most important commodities.[15]

The British Wheat Agreement of 1946 provided security to the farmer against a post-war slump, even though total returns were lower than could have been obtained in the open market. A comprehensive programme of marketing through international arrangement was agreed to in 1949.

The C.W.B. control was extended to oats and barley on August 1, 1948. The Board, with minor amendments, remains the same today as it was in 1949--the sole agency in the marketing of Western Canadian grains.

The Prairie Grain Advance Payments Act of 1957 provides cash advance on farm stored grain through the C.W.B. The Temporary Wheat Reserve Act of 1956 provides payment of storage and interest on C.W.B. stocks in commercial storage.

There is much left to be said. The history can be analyzed from various viewpoints, such as marketing structure,

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[15] D.A. McGibbon, Canadian Grain Trade 1931-1951 (Toronto: University of Toronto Press, 1952), p.59.

policy, development, growth, politics. The above analysis is only a bird-eye view leaving many important details out, and yet indicating some of the more important changes.

II. SECTORS INVOLVED IN THE GRAIN MARKETING SYSTEM

The Canadian government is basically the marketing authority for Canadian grain, whereas private enterprise provides the physical facilities required in the trade as shown in Figure 1. The initial link in the chain is the production of grain by the farmer. The next link, the country elevator system, includes both farmer owned cooperatives and privately owned country elevators. The country elevators arose from historic and economic pressure. Their function is to receive, grade, store, blend, ship, and pay the farmer initial prices for his grain.

The next link in the sequence is that of the railroad companies transporting the grain from the primary producer to export position. Also involved in the transportation of grain are trucks which remove grain from the country elevator and deliver to the certain specialized markets; however such shipments are of relatively small magnitude.

The next physical facility involves the point of final domestic delivery. In most instances this facility is at the port, where grain is handled for the export markets. There are also important domestic markets, for example, brewers, flour mills, and feed mills.

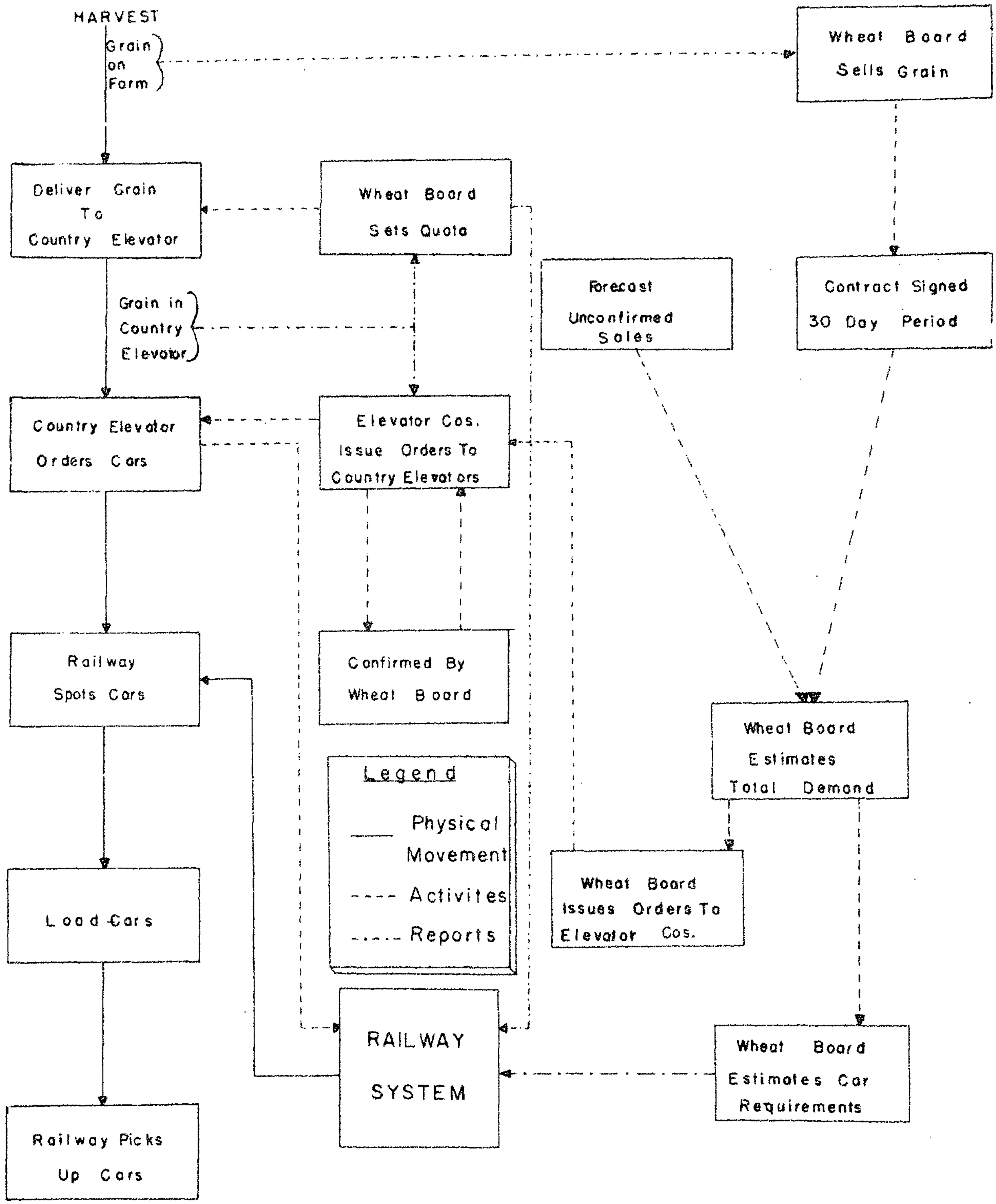

Figure I. Grain control system

Source. Kates, Peat, Marwick, & Co., "The Transportation and Handling Grain Short-Term Recommendations," Part One of the West Coast Commodity Study, Prepared for Department of Transport, Gov't of Canada (Toronto: May, 1967).

Thus, four important sectors are involved--the farmer, the country elevator system, the transportation system, and the final terminal. Interacting upon all four sectors are the overall market institutions. This includes the Winnipeg Grain Exchange providing facilities for the trading of grain.

The government is involved in grain trade firstly through the Canadian Wheat Board, which acts as the sole agency for the marketing of wheat, oats, and barley produced in Western Canada. It thus interacts with the farmer, elevator, railroad, and terminal marketing position, and secondly; the Board of Grain Commissioners, which regulates the grading and transportation of grain. This latter body is older than the Canadian Wheat Board, being formed with the passage of the Canadian Grain Act of 1912.

The Department of Trade and Commerce is also actively engaged in the grain trade via the export of grain in the capacity of a body collecting information, internationally, for use by the Canadian Wheat Board and in government to government trading.

III. A BRIEF RESUMÉ OF THE ACTIVITIES OF THE CANADIAN WHEAT BOARD

The Canadian Wheat Board was established under the Canadian Wheat Board Act of 1935. The Act defines the object of the Board as the "marketing in an orderly manner, in interprovincial and export trade of grain grown in Canada."[16] The Board undertakes the marketing of wheat, barley, and oats grown in the designated area, which includes Manitoba, Saskatchewan, Alberta, and parts of British Columbia and Ontario, on behalf of the producers.

Organization. The Board is a crown agency but is governed by its own Act of Incorporation. Although the five members, which form the nucleus of the Board, are appointed by the government, the Board has jurisdiction over its officials and staff, none of whom are civil servants. The operations of the board are financed by guaranteed bank credit, owning no capital assets other than the head office building in Winnipeg. All facilities required for movement of grain are contributed by parties to mutual agreement and act as agents of the Board in performing their special functions. As such, the Board has extremely great power in the grain trade as it has the sole authority to buy, take delivery of, store, transfer, sell, ship, or otherwise dispose of grain.

Handling Agreement. Each year the Board meets with the representatives of the elevator companies for the negotiation of a grain handling margin, that is, the charge for handling a bushel of grain and the storage charge on the grains. The bargaining is probably similar to that involved in bilateral monopoly, as the Board attempts to provide minimum marketing costs, while the elevator companies desire

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[16] Dominion Bureau of Statistics, Canada Year Book 1963-64 (Ottawa: Queen's Printer and Controller of Stationery, 1964), p.878.

a high rate of earning and to be able to maintain their physical plant at a high degree of efficiency. The economic model of bilateral monopoly is however not completely applicable as three major elevator companies are cooperatively owned by farmers. Appropriate model of behaviour in such circumstances is just being developed in the literature[17]. The joint stock company may also have different objectives, as both organizations are farmer owned.

When agreement is reached, "...the elevator companies become agents of the Board to receive, store, and ship grain for the Board."[18] The elevator accepts the farmer's grain for delivery to the Board in terminal position, and pays the initial price minus handling charges and rail tariff. The company is then reimbursed by the Board at time of delivery at export position.

In 1966-67 the handling margin was 5 1/4 cents per bushel for wheat and barley and 4 cents per bushel for oats. The country elevator and terminal storage rates were 1/30 of a cent per bushel per day for wheat, oats, and barley.

Initial and Final Payments. Initial payments are established annually on the basic grade of each grain by an Order in Council. The Board then sets prices according to

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[17] E.D. Domar, "The Soviet Collective Farm as a Producer Cooperative", American Economic Review, LVI (September 1966), pp.734-57; P.G. Holmberger, "Cooperative Enterprise as a Structural Dimension of Farm Market", Journal of Farm Economics, XLVI (August 1964), pp.603-17; Joan Robinson, "The Soviet Collective Farm as a Producer Cooperative", American Economic Review, LVII (March 1967), pp.222-223; and W.Y. Oi and E.M. Clayton, "A Peasant's View of a Soviet Collective Farm", American Economic Review, LVIII:1(March 1968),pp.37-59.

[18] L.D. Nesbitt, Tides in the West (Saskatoon: Modern Press, 1960), p.323.

the differentials between the remaining grades of each grain. These prices are essentially floor prices for each grade of grain. The initial payment is the gross price received by the producer at the elevator. Initial payment, minus handling and rail tariffs, yields payment to the farmer. The final payment is usually made in the following crop year. For instance, the 1964-65 final payment was paid in February and March of 1966. Interim payments are sometimes made immediately following the close of the crop year. The basic account is handled in the following manner: Wheat Sold minus Wheat Acquired = Surplus. From this initial surplus all charges incurred by the Board, such as storage (after the first 15 days) and internal administration, are subtracted leaving a positive or negative quantity. If the former exists, final payments are made, whereas the government pays the deficit if the latter occurs.

An interesting model could be build using expectation regarding the final payment as the basis for deciding whether or not to sell grains through the Board or dispose of them locally.

Delivery Quotas. The Board establishes quotas throughout the year. Quotas are specified amounts of grain which can be delivered to the designated point, based upon specified acreage[19]. The major purpose is "to prevent chaotic congestion and excessive queuing that could result..."[20].

[19] Specified acreage includes wheat, oats, barley, summerfallow, rye, and cultivated land producing eligible forage crops.

[20] A.W. Wood, "Technological Changes in Processing, Marketing, and Distribution and their impact upon Canadian Agriculture", Canadian Journal of Agricultural Economics, X:1 (1962), p.56.

Queuing at harvest time could readily occur, as there is no incentive for producers to store grain if the grain is to be sold through the C.W.B. The farmer would attempt to sell all grain as it is harvested, as the price remains constant throughout the crop year, and by delayed sale, would forego interest which would accrue from the early sale of grain. The method of pooling provides an incentive to ship directly as a farmer would effect a change in the incidence of costs applicable to his grain.

The quota does not place restrictions upon production. It provides a partial solution to equitable distribution of available elevator space to each farmer. The farmer is given the opportunity to ship an amount of grain which is a function of his quota. The quota is essentially bounded by empty elevator space--largely a reflection of the availability and distribution of box cars, and the amount of grain in export position and rate of export sale. (Even though a quota is open, a farmer may not be able to deliver as the elevator(s) may be congested.)

At the beginning of each crop year, a farmer must select a delivery point which cannot be changed during the duration of a crop year. He is permitted to deliver grain to any elevator at the chosen point. At the same time, a unit quota is set based upon the farm unit rather than size. Subsequent quotas are based on specified acreage. The quotas are then periodically increased according to the space available at individual points. The farmer can haul immediately to fill his quota, e.g. one bushel per specified acre of any grain, or deliver at any time amounts to bring total deliveries equal to the accumulated quota. Flax and rapeseed, however, have a special quota as they are handled by the Canadian Wheat Board, but not marketed. Depending upon bin space, an elevator agent can refuse different kinds or grades of grain.

The Canadian Wheat Board attempts to raise quotas uniformly throughout the country. This is difficult or impossible at times depending upon the particular kinds and grains required at export position. The farmers have the opportunity to foil the scheme, as they do not have to ship the various kinds or grades on demand, nor are they required to fill their quota at any time[21]. It is possible for individuals to thwart the system by shipping grain for other producers, receive some payment, and feed or sell his own grain through other channels. Such actions are illegal.

There are three procedures used to increase the specified acreage delivery quotas[22]. (1) The Key Agent at each point can wire the Wheat Board asking for a quota increase after consulting with the other agents at the point. The quota is increased immediately if the wire is signed by the key agent or all agents. (2) If there is no request, the Wheat Board may increase the quota when there is sufficient space at the point to take in grain deliverable

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[21]Trychniewicz and Tangri, <u>op</u>. <u>cit</u>., p. 87.

[22]J.L. Leibfried, Personal Communication, March 12, 1968.

on the present quota plus 50 percent of the potentially deliverable on a one bushel per specified acre increment. All points are checked each Thursday to see if quotas can be raised by this method. Checks are made at any time a report by a Wheat Board Inspector indicates the quota can be increased at a point. (3) The last method checks the second policy if a request is made by any agent at a point. If this is not possible, then all agents at the point are contacted to see if they will agree to an increase as outlined by the first method.

The effectiveness of the quota system can be questioned. Obviously, there are faults in the system as indicated by farmer reactions. The elevator companies are allowed to exert certain powers to prevent quota increases. The philosophy of attempting to keep all quotas equal can also be questioned. Resource allocation is affected, and it is quite likely the system creates differential pressure for adjustment between regions and individuals[23]. However, until results of a complete analysis show advantages and disadvantages, and provide better alternatives, such criticism only invites research.

Grain Movement. The movement of grain from country points to terminal position involves the Canadian Wheat Board, the grain handling companies, and the railroads. The

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[23] A.W. Wood, "Technological Changes in Processing, Marketing, and Distribution and their impact upon Canadian Agriculture", Canadian Journal of Agricultural Economics, X:1 (1962), p. 56; Tyrchniewicz and Tangri, loc. cit.

main instrument of control is the shipping order[24]. The basic method of allocating the orders between companies is based on the amount of business earned by each elevator company in the last twelve months, that is, a twelve month moving average of receipts. The order is an instruction issued by the Board to the elevator company to ship a specified quantity and grade of a given grain from a country elevator to terminal position.

The Wheat Board estimates the amount of grain to be moved from the country by destination and grade on the basis of sales and space available at the terminals and other forward positions. The shipping orders are sent to the elevator companies who then allocate these orders to individual country elevators. Allocation decisions are based on the quota levels, available storage space at their elevators, stocks in store, their competitive position at each point, and their particular operating problems. The agents at a point notify the railroad agent of the car requirements and the destination of shipments. The agent forwards the information through the appropriate channels with the Chief Dispatcher initiating an appropriate distribution of empty box cars to the country elevators. Decisions regarding the car distribution are not always carried out in this manner by line officials, as the top management of the companies involved often make many of the decisions.

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[24] Grain Transportation Technical Group, Shipping Orders (Technical Report No. 1, October, 1967), pp.1-23.

The elevator then loads the car in accordance with the shipping order, although the order, boxcar, and actual shipment do not always coincide. This lack of compliance by agents appears to be a considerable problem.

The railroads and Wheat Board work closer together than indicated, even though the railroad is guided by only two documents issued by the Wheat Board--a general four month statement and a weekly report of quota levels at various points.

The majority of shipping orders can be classified into five types.

(1) General orders are issued to elevator companies without any instructions, and the companies allocate the orders as they wish. Such orders are common in the early part of the crop year, before quota level policies are in effect but are issued when a particular grain and grade are required, ignoring quota levels.

(2) Modified general orders enable stations to reach the existing quota levels, and are used to equalize quotas across the country. They are allocated at the grain companies' discretion but are subject to cancellation unless stations requiring assistance receive them.

(3) Selected Station Orders state the points which require assistance because of low quota levels, and equalize the quotas at the end of the year.

(4) Mill orders are issued to ship grain from selected points to the flour mill.

(5) Orders for flax and rapeseed are issued on request by producers, subject to sale or available space.

In addition there are four directives classified into special order types.

(1) "Order 100" is a permit issued by the Board of Grain Commissioners to ship tough and damp grain.

(2) "Order 500" is an emergency order when a certain grade of grain is required at the terminal. Such orders have priority over all other orders.

(3) "Congested Elevator Order" is requested by individual elevators. Order 1000 is for two boxcars when an elevator or elevator company at a point is filled within 4,000 bushels of working capacity, and no other orders are held. The grain shipment must be the highest priority possible on the Wheat Board's preference list.

An elevator operator may apply for the first two boxcars available at a point if his elevator is congested and if he is in possession of shipping orders.

(4) "Over-quota permits" from the Board are required to ship grain, e.g. malting barley, outside the existing quota level.

The minimum time required from evaluation of stocks by the Wheat Board to the loading of a car is five and a half days while the maximum is forty-four days[25].

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[25] Grain Transportation Technical Group, Shipping Orders, Technical Report No. 1 (Winnipeg: Grain Transportation Technical Group, October, 1967), p. 10.

The Grain Transportation Technical Group is studying ways of improving the system[26].

Marketing. Once the grain reaches terminal or export position, it is applied to sales, or becomes available for sale. The Board reimburses the elevator company for the grain plus storage and interest. The grain has been essentially marketed by the Board although private agencies have provided the necessary facilities. Each segment acts as an agent for the Board including the shipping and exporting agencies. Exporters seek buyers of Canadian grain, and make necessary arrangements through the Board to obtain the desired grain. Master sales agreements are made by the Board on a government-to-government basis, in which case the exporters engage in fulfilling supplementary contracts. However, the Board does not engage in direct competition with the agents since the merchandising of grain, in particular wheat, requires the knowledge of all parts of the grain trade.

The merchandising and pricing of grain are difficult to separate as different functions. Pricing is very complex as price is a function of competitors' prices, qualities and quantities of grain, differential prices between export positions, differential ocean freight rates, and foreign exchange rates. The price is announced each day in the market place, the Winnipeg Grain Exchange, and

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[26] R.L. Kristjanson, "Introductory Remarks", Proceedings of the Grain Transportation Workship Minaki, Sept. 6-8 (Winnipeg: Grain Transportation Committee, 1967), pp.1-2.

is the price at which the Board will provide grains to its agents for domestic and export sales.

Barley and oat prices are largely determined in the future market. Rye, flax, and rape are accepted by the elevator system but are not merchandised by the Wheat Board although the Board administers specified quotas on the delivery of flax and rape.

The Board makes sales at the daily asking price, but also provides a deferred pricing policy on export sales thus providing flexibility in fixing the final price. The purchasers can choose the market price on any day from the time of booking the wheat up to and including a specified number of market days after calling for the grain, or completion of loading at Pacific ports.

Sales Promotion. The Board depends largely upon personal contact with buyers of Canadian grain using the export agents, trade commissioners, sales missions, and its own employees located in major importing countries. The Board also invites officials from importing countries to tour Canada, as guests of the Board. Other media such as films, brochures, and displays are used in sales promotions.

> Canadian Government policy on grains, does not operate to impose patterns of production, specific goals, or objectives. The aim is to maintain flexibility in production and encourage voluntary adjustments on the part of farmers to changing economic conditions and grain markets. To this end, Government policy endeavors to maintain a fully operative and effective grain marketing, handling, storage and shipping system and a system of grading designed to maintain Canada's reputation for high quality

grain crops. In addition, Canada endeavors to co-operate with other countries in world problems affecting grains and in food aid programs.[26]

IV. FUNCTIONS OF THE BOARD OF GRAIN COMMISSIONERS FOR CANADA

Following recognition of the need to regulate grading and transportation, the Board of Grain Commissioners was established under the authority of the Canada Grain Act of 1912. This newly formed organization was charged with the responsibility of maintaining grade standards and controlling movement of grain, in order to maintain Canada's competitive position in world markets. The Board administers the Canada Grain Act, providing general supervision over the physical handling of grain in Canada.

The quasi-judicial and administrative body of three is appointed by government and reports to the Minister of Agriculture.

Inspection and Grading. The inspection branch establishes a Committee on Western Grain Standards to select standard samples for the statutory and commercial grades required. Milling and baking tests are used for establishment of wheat grades. The grades are established by the committee and then samples are distributed to importing countries by the inspection branch.

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[26] Canada Department of Agriculture, "Canadian Grains Policy", Canadian Farm Economics (Vol. II:1, June 1967), p.22-23.

The grade and dockage of grain is assessed by the country elevator when grain is received from the producer. If disagreement arises, a sample is forwarded to an inspector whose decision is normally final, and subject only to appeal under the Grain Appeal Tribunal; with the grain delivered subject to grade and dockage.

The agent places an unofficial loading sample in each car shipped for grade checking purposes providing advance information to terminal elevators and/or at shippers' request. Automatic sampling devices provide the final sample during car unloading, and each car is then officially certified as to the grade and dockage content. Inspectors safeguard the quality of grain until loaded providing "certificates final"--universally accepted as proof of a grade.

Weighing. The Board supervises the weighing of all grain received into or shipped from licensed terminal elevators. All scales are inspected and certified as are new facilities. Weights of grain are tabulated to prevent shortages and averages outside of the tolerance levels.

Statistics Division. The Board requires taking and reporting of certain data. Stocks and handlings of all elevators are reported. Using these figures, the Board issues statistics indicating the storage and movement of grain within the elevator system. All grain must carry insurance which is certified by this division. The division is responsible for collection of the one percent levy under the Prairie Farm Assistance Act, unless the producer is covered under the Crop Insurance Act.

Transportation of grain is regulated by the licensing of all elevators which engage in the receipt or discharge of western grain. Grain cannot be transported except from or to licensed elevators, and restrictions are placed upon established grade names all of which must be specified by the Canada Grain Act.

The branch is also responsible for enforcing Section 127 of the Canada Grain Act, requiring public terminals, semi-public terminals, and eastern elevators to issue warehouse receipts or transfer receipts. Such receipts are issued for grain taken into store and are registered, specified to grade and quantity, with the Board. The receipts are cancelled when the represented grain is shipped out. Fees are charged for this service as given in the Canada Grain Act.

<u>Government Terminals</u>. The Board manages and operates five semi-public terminal elevators at Moose Jaw, Saskatoon, Calgary, Edmonton, and Lethbridge, and one terminal elevator at Prince Rupert. Grain may be stored, cleaned, and dried before being moved to terminal position at rates subject to a maximum tariff allowed by the Board.

In addition the Board carries out research work on various grain problems. This provides accurate information regarding the quality of grain produced, and indicates which new varieties should be licensed. Basic research is carried out regarding different processing techniques and other advanced research regarding the chemistry of grain, which may prove useful.

The Board has authority to inquire into matters relating to the grading and weighing, dockage and shrinkage deductions, unfair or discriminatory operation of elevators providing the necessary policing of grain handling. Although basically acting administrator of the Canada Grain Act, the Board is constantly working in partnership with other sectors in the industry to provide better services and methods of handling grain.

CHAPTER IV

SIMULATION AND THE GRAIN ASSEMBLY MODEL

The complex and interdependent problems within the Canadian grain trade call for a technique to encompass the system and a method to objectively examine the alternative physical configurations as well as changes in institutions and markets. Simulation is a stochastic technique within which all facets of the system can be incorporated and thus it is a system useful in general appreciation and understanding. The technique of simulation will be described as a general concept and as applied to grain assembly from farm to elevator. The particular model developed in this study is presented in the logic diagram; and the computer program is presented in Appendix I.

Simulation--A Definition. The concept of simulation is not new: the word simulation means "to feign, to look, or act like"[1] and is an ancient approach to the study and use of models[2]. The early uses were usually physical scale models from which properties and behaviour of the real object

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[1] C.L. Barnhart (ed.), Thorndike-Barnhart Comprehensive Desk Dictionary (Deluxe Edition; Garden City: Doubleday and Company, Inc., 1957) II, 721.

[2] G.H. Orcutt, "Simulation of Economic Systems", The American Economic Review, Vol. L, No. 5 (December 1960), 894.

could be inferred. Simulation has been used in training pilots, so that their behaviour in real circumstances would be the same as that under simulated conditions in their training. Aircraft design is tested with models in wind tunnels and pilot plants are used to study complex chemical processes. These are examples of simulation techniques. The extensive use of simulation for economics, business management, and other social sciences has occurred only recently, largely with the development of high speed digital computers[3].

Definitions of simulation are broad and usually vague. Popular usage often refers to the assumption of the appearance of something without having its reality[4]. The word simulation is used in a variety of ways, and other words are used to define activities which are specialized uses of a simulation approach, for example, gaming and Monte Carlo. Orcutt states: "Simulation is a general approach to the study and use of models."[5] Shubik states: "A simulation of a system or an organism is the operation of a model or simulator which is a representation of the system or organism."[6] It is further explained: "In a simulation,

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[3]Analogue simulation has been used such as the hydraulic model of a macroeconomic system at the London School of Economics.

[4]R.E. Dawson, "Simulation in the Social Sciences", Simulation in Social Sciences, H. Guetzkow, editor (Englewood Cliffs: Prentice-Hall, Inc., 1962), pp. 1-2.

[5]Orcutt, op. cit. p.893.

[6]M. Shubik, "Simulation of the Industry and the Firm", The American Economic Review, Vol. L, No. 5 (December, 1960), 909.

either the behaviour of a system or the behaviour of the individual components is taken as given. Information concerning the behaviour of one or the other is inferred as a result of the simulation."[7]

Clarkson and Simon state: "Simulation is a technique for building theories that reproduce part or all of the output of a behaving system."[8] The process of simulation involves the construction of a model of a system indicating the processes, reflecting the knowledge of and interest in the system[9]. Any individual simulation run yields results that are specific and might be thought of as an experiment performed on the model[10]. The specific results would then be used inductively to infer general relationships.

Models and Simulation. There is no simple statement which, in defining a model, satisfactorily captures the essence of the many aspects of a model. Orcutt states: "A model of something is a representation of it designed to incorporate those features deemed to be significant for one or more specific purposes."[11] Even though the assumptions are abstractions of reality, conclusions can be derived which have relevance to the real world.

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[7] Ibid.,p.910.

[8] G.P.E. Clarkson and H.A. Simon, "Simulation of Individual and Group Behaviour", The American Economic Review, Vol. L, No. 5 (December, 1960),p.920.

[9] Ibid.

[10] Orcutt, op. cit.,p.894.

[11] Ibid.,p.897.

Various languages can be used by economists for the model: prose, geometry, mathematics, or computer programs. The choice of language depends upon the complexity of the model and the need of the scientist, whereas the degree of abstraction depends upon the types of questions which the model is designed to answer. Simulation studies often require the use of a digital computer; thus the logical language is an appropriate computer language. A good analogy to a simulation language is a set of maps differing in detail. Each map is appropriate for a different purpose.

Models may be used for explanation, prediction, or control. A prediction is made before the empirical phenomenon is observed, whereas an explanation starts from the empirical observation and explains the occurrence of the phenomenon. It is conceptually possible that predictions can be made without adequate explanation, but if scientific standards demand a model to provide explanation as well as prediction, then Friedman's billiard player model is unsatisfactory[12]. For the purpose of control, a model of prediction is required. However, the changes consequent on the prediction may alter basic relationships which previously led to accurate predictions, and in the future predictions may thus be less accurate[13]. Cohen and Cyert provide seven

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[12] M. Friedman, "The Methodology of Positive Economics", Essays in Positive Economics (Chicago: The University of Chicago Press, 1953), p. 21.

[13] K.J. Cohen and R.M. Cyert, Theory of the Firm: Resource Allocation in a Market Economy (Englewood Cliffs: Prentice-Hall, Inc., 1965), pp.24-25.

steps in the development of a model: (1) define the problem; (2) formulate a preliminary model; (3) collect empirical data; (4) estimate the parameters; (5) subject the model to preliminary tests; (6) test the model further; (7) accept or reject the model[14].

The usefulness of simulation in model building is that (1) simulation allows the study of models with large numbers of components, variables and relations among all forms, (2) sensitivity analyses can be made, (3) different levels of aggregation can be tested, and (4) simulation or Monte Carlo techniques can be useful in multivariate statistical techniques[15].

Various approaches can be taken in building a computer model. Orcutt lists four: (1) building block approach; (2) block recursive models; (3) replication of components, and (4) treatment of components as probability samples[16]. The building block approach is a simple procedure that breaks a large process into several individual processes, allowing extensive testing of each small part before assembling into one large program. Block-recursion provides a sequential process, allowing the use of digital computers. Replication of components reduces the number of individual components by using a few major types that operate similarly but may take on different values. In other words a basic behaviour or operating characteristic is assumed for numerous components,

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[14] Ibid., pp.27-28.

[15] Orcutt, op. cit.,p900-901.

[16] Ibid.,p.901-902.

but each individual component may be initialized with different values and operated under different parameters. Using components as probability samples relates to very large systems, where millions of individual components could be conceptualized. It can be thought of as a process not unlike that of a sample survey.

Advantages of Simulation. Simulation can be used even though there may be difficulties in duplication of environment, mathematical formulation, lack of analytical solution techniques, or experimental impossibilities. The reasons for using simulation are numerous and depend upon the nature of the problem[17]. Building a simulation model of a process requires a systematic gathering of pertinent data. The breakdown of a process into building blocks allows incorporation of skills, opinions, or information of many people plus indicating the important variables and their relationships which may have been hidden. Simulation models can show the meaning and implications of proposed policy changes, and can enable people to understand a complicated process. Assuming a valid model, the technique is an inexpensive way of examining many alternatives in a system--the cost involved in actually making the changes and waiting to see which performs best is avoided. Another advantage is that a valid model can generate a great deal of data, thus allowing a high degree of flexibility in analysis

[17] For further discussion see G.W. Morgenthaler, "The Theory and Application of Simulation in Operations Research", Progress in Operations Research, R.L. Ackoff, editor (Publications in Operations Research No. 5; New York: John Wiley and Sons, Inc., 1961), pp.372-375.

of the system. A simulation model presents a dynamic situation over time. Different time periods or rates of time can be used for separate components. Bottlenecks and difficulties in timing operations can often be "pin-pointed" with a simulation model. A very important advantage of simulation is that the analyst is forced to appreciate and understand all facets of the system, for unless he does, the model will not work. There remains a problem as the system may work wrong, but the analyst may not know it without a full understanding. The technique is easier to use than conventional mathematical techniques because it does not require sophisticated mathematical proficiency.

Simulation is used to examine problems in the general areas of (1) training personnel, (2) designing systems or specific equipment, (3) controlling systems, and (4) forecasting[18]. Simulation procedures are used to (1) train people for their duties in a complex system, (2) learn about the operation of a complex system, and (3) experiment with proposed changes. Shubik gives four potential contributions of simulation as: (1) a data-organizing device; (2) a tool for planning; (3) a computational aid and alternative to analysis in theory construction; and (4) an econometric device to produce models based on empirical investigation[19].

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[18]Orcutt, <u>op</u>. <u>cit</u>.,p.895-897.

[19]Shubik, <u>op</u>. <u>cit</u>.,p.912-913.

Simulation techniques have been used to study a wide range of problems[20]. A bibliography on simulation for the years 1960 through 1964 contained 948 papers, articles, and books; yet was thought to represent only 15 to 20 per cent of the available literature[21]. Each article deals with a particular problem and each must be examined in the perspective of the problem.

This does not mean that simulation is the only tool, let alone the best tool for every problem. The technique has certain disadvantages. For instance, each variant of the problem must be solved by a separate computation which is expensive in terms of computer time.

Location of Simulation Surface. The second weakness is that the technique of simulation is not an optimizing tool. Each iteration or answer pertains to only the selected combination variables. The computer is able to perform repetitive calculations with such speed that there is a possibility of generating an optimum answer. However, the possible combinations of variables and the magnitude of each variable conceptually provide an infinite set of possibilities. Thus an optimum answer is not necessarily

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[20] See M. Shubik, "Bibliography on Simulation, Gaming, Artificial Intelligence, and Allied Topics", Journal of American Statistical Association, Vol. LV (Dec., 1960), pp.738-751.

[21] I.B.M., Bibliography on Simulation (International Business Machines, Ltd., 1960).

produced. Since there are not infinite graduations of the variables, an optimum answer is probable. But since there are still numerous possibilities, some method must be employed in selecting combinations which will efficiently use both the computer's and researcher's time. The method must justify confidence that the answer selected approximates the theoretical best combination.

The optimum answer depends upon the objective function or criteria used. The function can be exceedingly complex or very simple. A generalized function would be $y = f(X_{iu})$ where $u = 1, 2, \ldots, n$, and represents N variables in the experiment, $i = I, \ldots, K$, and represents K levels of each variable. The function f is called the response surface. The problem is to find the level at which each of the x variables should be set in order to maximize f. As response y is affected by a number of quantitative factors x_i and experiments are carried out to find the level of each x_i, a method must be developed to seek optimum levels of each variable. It would also be of considerable use to learn how y varies near the optimum for several reasons[22]:

(1) it may not be feasible to set each variable at an optimum level, that is a combination at less than optimum may be feasible, and perhaps even optimal in economics[23];

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[22] W.G. Cochran and G.M. Cox, Experimental Designs (Second edn.; New York: John Wiley and Sons, Inc., 1957), p.355.

[23] W.J. Baumol, Welfare Economics and the Theory of the State (Second edn.; London: G. Bull and Sons, Ltd., 1965), pp.25-31.

(2) several variables may be very important and a less-than-optimum level of one may favourably affect characteristics of another[24];

(3) the shape of the response surface near the optimum may provide an indication of the underlying process; and

(4) there may not be a true maximum in conditional experiments, so that regions of higher response may be desired.

The two categories of available sampling methods are random sampling and systematic sampling. In the former method, values are simply drawn by chance from the population of values of the variables. Systematic sampling selects values of the variables using some ordering principle. Although the latter is conceptually attractive, the two methods are useful and both should be incorporated into the analysis. The nature of the experiment determines the method required. When a large number of designs are to be examined in one large experiment, random sampling is suitable, whereas when a small number of designs are to be tested in a narrow experiment, systematic sampling is useful.

Systematic sampling can be carried out by several methods but four seem useful. They are: (1) the uniform-grid or factorial method; (2) the single factor method; (3) the method of marginal analysis; and (4) the method of steepest ascent.

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[24] One may wish to consider other things in the real world.

The uniform-grid or factorial sampling method considers the relevant range of each variable by using uniformly spaced values. The size of the sample consequently depends on the number of variables and the number of values of each variable. If m = number of variables and n = number of values of each variable, the size of the sample is n^m. The sample size rises exponentially with the number of variables, thus a manageable sample size often requires a very coarse grid.

The method is powerful in that the response surface is mapped using a relatively small sample. The effectiveness is related to the topography of the surface, as the smaller the slope and rounder the hills, the closer the method approximates the maximum point. The higher the hill, the greater the likelihood of finding the peaks. A jagged surface with sharp curves makes it difficult to see the highest hills and thus requires the help of other techniques to find the highest hill; and the advantage of simplicity in the simulation technique is lost. In fact, *a posteriori* sampling may be needed. Since other techniques may not find the appropriate hill, *a posteriori* sampling must be used unless *a priori* reason precludes the possibility of local optimums.

Single factor sampling is the most obvious method. All values of the n-1 variables are held constant while values of the remaining variable are altered unit by unit until there is no improvement. _A priori_ values are used to find an optimum point. Unfortunately, in adjusting one variable at a time, the solution may not be optimal for all n variables taken together. Thus successive readjustment is required, making the method long and tedious--especially if interdependence is expected or found. If the variables are independent, the method is appropriate. The technique is useful when approaching the optimum or when other variables are expected to remain at a given level and some idea of what changes would occur if the particular variable could change, is known.

Marginal analysis alters two variables at a time and the remaining n - 2 are held constant, acknowledging interdependence and providing information regarding the direction of desired change. Small changes allow for the use of linear estimation although a change must be great enough to provide different values of the objective function. The usefulness is biased towards systems with few variables or where there are important pairs of _a priori_ and _a posteriori_ variables. Use is made of this method when at an optimum or close to an optimum point, to derive information about the major variables and magnitude of interrelations.

The method of steepest ascent is an iterative technique that moves sequentially on the shortest path up the response surface[25]. The advantage of the strategy is that

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[25]For further details and information regarding the subject see Cochran and Cox, _op. cit._, pp.357-365.

it includes the relationships of variables, although it suffers the possibility that the true summit may be missed if the response surface contains several hills. An unknown response surface requires careful calculation and checks to overcome discontinuities and unknown hill shapes.

Random sampling simply chooses values at random similar to the grid method. The difficulty is that the sample size is larger in order to adequately describe the surface. The sample size can be calculated without knowing the distribution of the values of the objective function. However, some knowledge is required on an a priori basis to be able to determine the probability of obtaining a value falling in a region close enough to the optimum to be useful. That is, let (θ_b = prob $(x \leq b)$). Then $1 - \theta_b^m$ (m is the number of observations) is the probability that at least one will be greater than b. But b and its probability must be a priori.

The approach is useful in a narrow sense, but the possibility of missing the optimum seems great, especially if the surface is jagged.

The final point is that a combination of sampling methods is an effective strategy. The general topography might be obtained by the uniform grid and random method. Promising portions can then be studied by intensifying the random or grid method, or by the single factor, marginal analysis, or steepest ascent methods. The methods used depend on the type of experiment, computer program, analytical sophistication, and on the available time, money, and computer, for experimentation and analysis.

Simulation for Grain Assembly. The technique of simulation seems applicable in the study of grain assembly from farm to country elevator. The system is a complex one involving the production of grain by farmers, storage of the grain in farm bins or commercial elevators, the movement of grain from the farm to elevator, and the shipment of grain by box cars from the elevator. Institutional arrangements are involved although indirectly. The decisions regarding the amount of storage space required is interdependent with decisions regarding rail shipments, elevator capacity, and farm storage bins plus the time dimension. The Monte Carlo technique is used to provide a yearly variability in crop production and rail shipments. The model developed in this study does not include all the advantages of simulation, but rather the system is simplified to use the existing data. However, the model and the data requirements indicate that a much more complex and thorough model would be a better representation of reality but a great deal of knowledge is needed. It is not expected that the existing model would be used as an input to a larger system but the building block approach to a large scale system requires knowledge of the system studied.

Two computer languages were used, GPSS III and

Fortran. The former was found to be difficult and unwieldy although a suitable language for the problem. Fortran was used as it is a simple language which is universally used, and the computer program developed can be interpreted easily by most people. Computer time was also less than required for GPSS III.

The Grain Assembly Model. The basic idea of the model was to take six areas, one at a time and simulate the production, storage, and shipment of grain each week for any number of years. The costs of moving the grain from the farm to the box car are tabulated. The network diagram is shown in Figures 2A, 2B, 2C, and the computer model as a Fortran program in Appendix I.

The model determines grain production each week. This grain is then stored in the various storage facilities by setting up decision blocks determining the amounts of grain to enter each facility. The rail shipments were exogenous and remove grain by using a set of decisions blocks to determine the amounts of grain shipped.

Grain production was simulated using the Monte Carlo technique. Shipments of grain by box car are modified by the same value to show correspondence between production and shipment. However rail shipments are further modified using Monte Carlo once more to provide for a variation in shipments independent of crop production. At the beginning of each production year, carryover of grain is

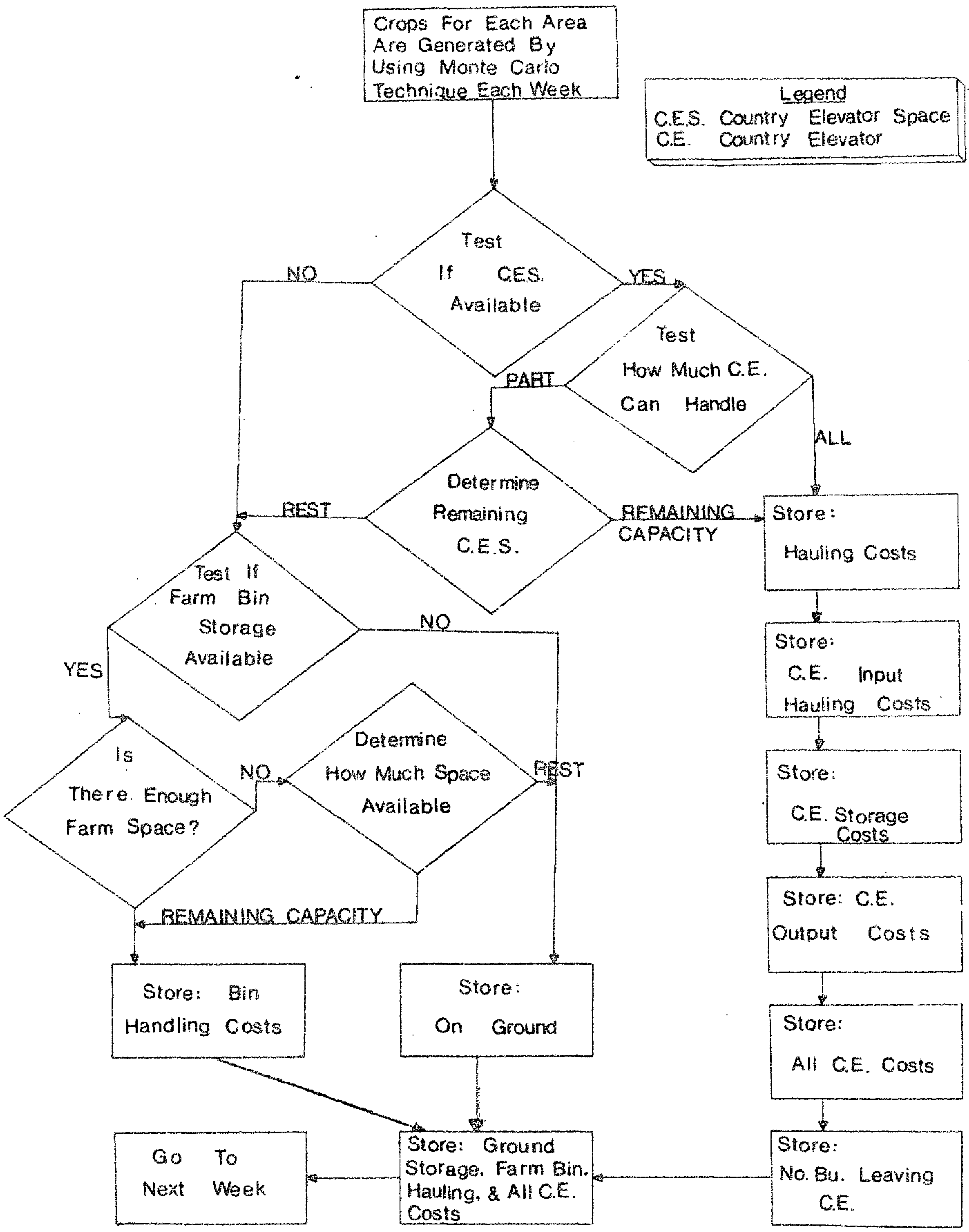

Figure 2A. Grain storage- field to storage

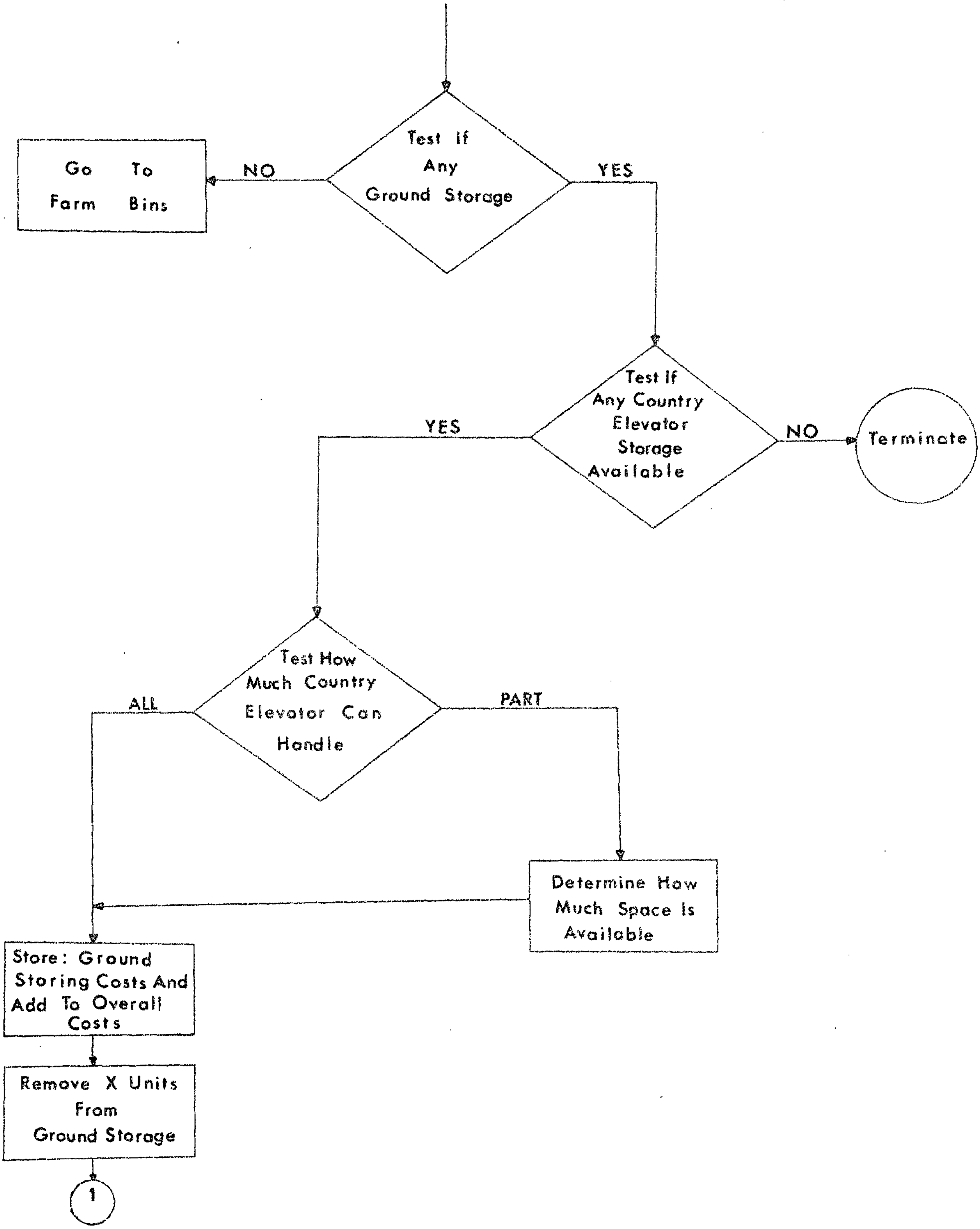

Figure 2B. Ground storage to commercial elevator

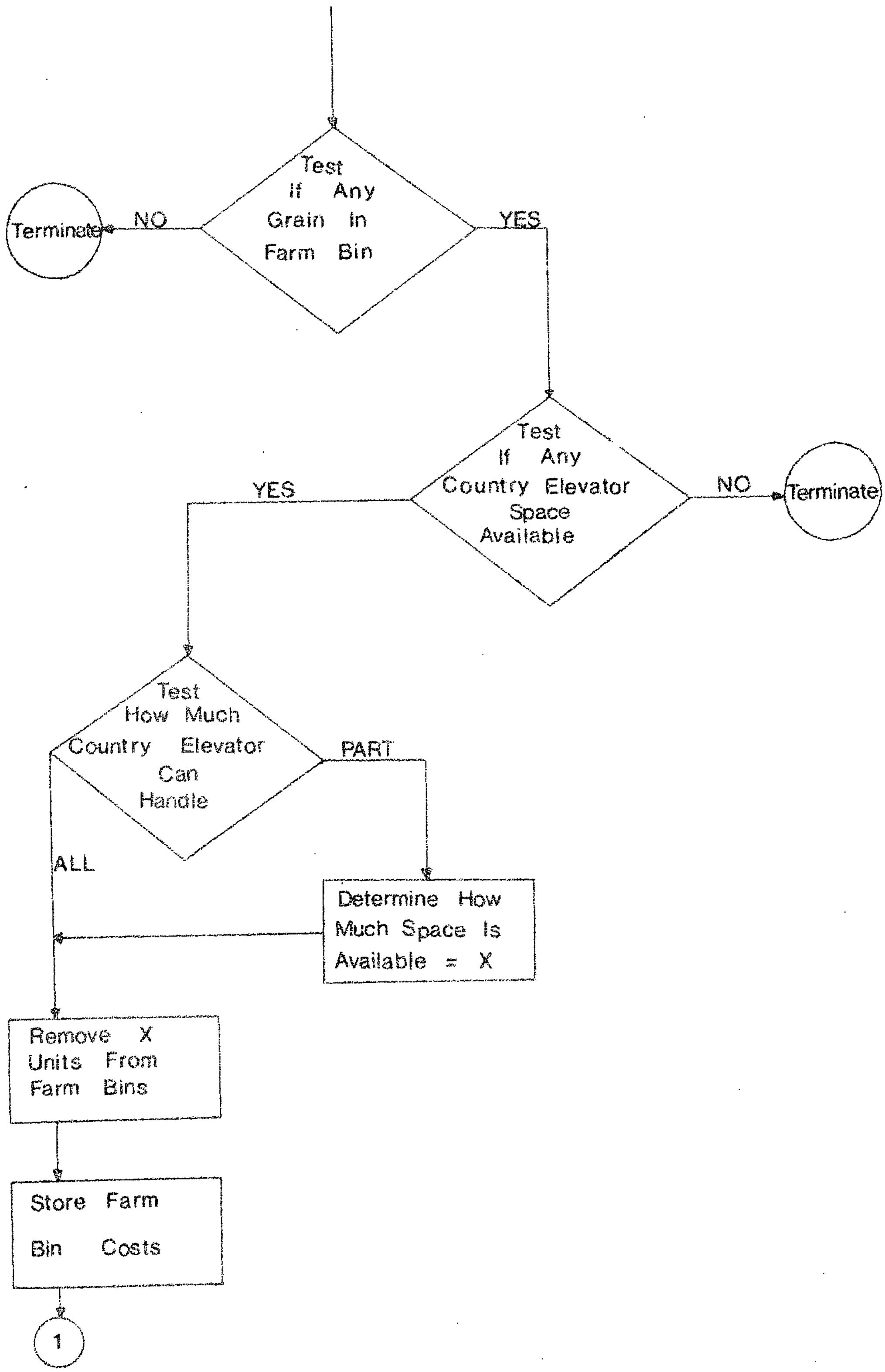

Figure 2C. Bin storage to commercial elevator subtracted from the elevators and the result becomes available space. The counters are then set at zero. The crop is stored in commercial elevators, farm bins, or on the ground with priorities one, two, and three respectively. The space available is diminished in the elevators and farm bins according to the grain which is entered.

Once the grain is stored, rail shipments reduce the amount of grain stored in field storage, farm bins, and then the elevator. This means that the elevators are constantly full, but also provides a method for the movement of grain. Ground stored grain is moved whenever rail shipment capacity is provided, and grain stored in farm bins is moved after all ground stored grain has been shipped. The method, albeit clumsy, can be thought of as removing grain from the elevator, with the resulting space being filled with grain from ground storage and from farm bin storage after all ground-stored grain is removed. The flow diagram shows all grain removed from the elevator, which is then filled from field, ground storage and then from farm bins the following week rather than the procedure used. However, it was accepted to provide a method to move grain from the system.

It was thought that farmers would first ship grain from the field. Any grain stored on the ground would be shipped at the earliest opportunity, followed by grain stored in the farm bins. The method that was accepted may bias cost upwards during the harvesting period as a variable cost comprising a charge at the bin and a charge for handling. However, it could be argued that the costs of trucking grain directly from the combine may be considerably greater than those charged. The method will affect elevator costs in that one cost equation including utilization of space at the elevator. However, all experiments use the same program so that the results will be comparable, and the bias may not be selective. As two other cost equations are used which do not incorporate the utilization value, elevator costs can be determined which are not biased by the programming method. The costs of ground storage were determined weekly, but the costs of farm bin storage, hauling, and commercial elevator storage were determined yearly.

Crop production is based on the long term average of elevator receipts and on the aggregate production of each area. The variability of crop production is random, that is, there is no particular sequence of the size of crop production.

Commercial storage is aggregated into one equivalent elevator for each area, however one cost equation uses ratios, which do not create any problem since the other two cost equations require capacities, in which case the average size of elevator at each point is used. As the model essentially moves grain to the elevator whenever space is available, the elevator tends to be filled to capacity at all times. Thus there are two problems in the elevator component. The first is that one would like to treat each elevator independently. The second is that elevators are not filled to capacity at all times but rather are filled according to the elevator ownership, the quota, and the farmers' reasons for shipping.

Farm bin storage is also aggregated for each area. The difficulties in assessing costs for such storage are discussed in the next chapter, where a fixed and variable cost was determined.

Ground storage costs represent the upper limit of costs, as the only method considered is that of piling the grain directly on the ground.

The cost of ground storage includes grain losses which are calculated for wheat, barley, and oats. The prices charged were purposely higher than would probably be experienced to provide an upper limit to costs.

The model does not keep track of each bushel of grain but considers all grain on the ground to undergo the same rate of deterioration and thus the same cost per week regardless of the length of time the grain has been on the ground. The costs are constant for relatively long periods of time between which discontinuities exist. The model determines the cost of ground storage each week. Total cost is the sum of the weekly costs.

The truck size is arbitrarily set in each computer run. The number of miles is determined by dividing the total bushels moved by the truck size. The cost of trucking was determined by a per bushel mile cost specific to both distance and truck size.

The cost of augering the grain is a variable cost obtained by multiplying the number of bushels shipped to the elevator by a constant.

The model is not sophisticated. The limitations could be overcome by acquiring greater knowledge of the system. If the model were to closely represent reality, the detail required would be immense[26]. It was decided that the model developed was appropriate to determine the costs of the system under the present circumstances. Although there are definite limitations to the model, a great deal of analysis would be required to provide better decision rules.

The technique of simulation has been discussed in this chapter. The advantages and disadvantages have been indicated. The technique seemed appropriate for the study of grain assembly from farm to elevator, and a model was developed to determine some of the costs involved[27]. The model is essentially heuristic in that the results cannot be proved. The flow diagram is shown in Figures 2A, 2B, 2C, and the actual computer program is presented in Appendix I.

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[26] For an interesting hypothesized model regarding the whole gamut of production and marketing see R.H. Day, "Dynamic Coupling, Optimizing, and Regional Interdependence", _Journal of Farm Economics_ Vol. VIL, No. 2, p442-450.

[27] Various social costs have not been determined, which may play a significant role in the feasible changes in the grain trade.

CHAPTER V

COST AND DATA ESTIMATES FOR THE SIMULATION MODEL

This chapter involves the description of components needed in the model system and an explanation of the methods and assumptions used in deriving the numerical values. An attempt has been made to explicitly state all assumptions. Data used in each component is presented in the appendix.

The area under study comprises six grain delivery points: Grande Prairie, Dimsdale, Huallen, Beaverlodge, and Hythe. The total area of the region is approximately 760,000 acres[1]. It lies within census division number fifteen, and Alberta crop reporting district number seven. Where information was not specific to the area, data specific to the census district or crop reporting district were used. If no data specific to the classes above were available, provincial and then Prairie data were used.

The time periods explictly considered were crop years 1955-56 to 1964-65 inclusive, but several pieces of data not derived from the time boundary above were used in this model.

The basic unit of time used within the model is a week. Weekly data is then summed into yearly statements for study and comparison purposes. The model components considered in this chapter are: (1) crop production; (2) farm storage

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[1]Acres specified in C.W.B. permit books, 1965 (See Appendix II Tables LXX, LXXI, LXXII, LXXIII, LXXIV, LXXV, and LXXVI).

costs; (3) ground storage costs; (4) average hauling distance and hauling costs; (5) rail hauling frequency; and (6) country elevator costs.

I. CROP PRODUCTION

In this section a procedure is developed for the generation of a series of numbers to be used as a proxy for crop production. A series of numbers was required for each elevator point. Numbers represent crop production and exhibit the proper mean, standard deviation, trend, proportion entering the elevator each year, and the time distribution of harvesting. The grains considered were wheat, oats, barley, rye, and flax. Although rapeseed has exhibited a spectacular growth in acreage since 1961 (Appendix II, Tables LXX, LXXI, LXXII, LXXIII, LXXIV, and LXXV), it was excluded because there were only two observations of receipts for each point; because no data were available regarding the time of harvest; and because rapeseed was not an important component of grain handled for the majority of crop year considered. Grass and legume seed were also excluded as appropriate data were not available.

Total Production. The only data available regarding the amount of grain entering the elevator system were elevator receipts by station[2]. The first step was to examine these values for a time trend over the period 1943-44 to 1964-65 (Table 1). Dimsdale was the only station for which a positive

[2] Summary of Country Elevator Receipts at Individual Prairie Points Crop Years 1955-56 to 1964-65 (Statistics Division, Board of Grain Commissioners for Canada, Ottawa: Queen's Printer and Controller of Stationery, 1956 to 1965).

TABLE I

TIME TREND OF TOTAL RECEIPTS OF ALL GRAINS
AT COUNTRY ELEVATORS
1943-44 TO 1964-65[a]

Point	Standard Error Y	A	B	Standard Error of B	F-Ratio
Dimsdale	53,531.20	123,246.89	5,739.81	1,798.92	10.18**
Grande Prairie	228,891.31	498,136.87	3,969.87	7,691.93	0.27
Huallen	31,463.40	131,563.57	-1,193.83	1,057.33	1.27
Hythe	224,975.63	706,989.78	-5,917.18	7,560.34	0.61
Wembley	106,088.42	379,196.05	5,431.23	3,565.17	2.32
Beaverlodge	163,467.41	644,405.36	-6,556.77	5,523.59	1.41

Simple regression $Y = A + BX$ Y = crop receipts at elevators (bushels)
X = Time (years)

[a]Source of data: Board of Grain Commissioners for Canada, Summary of Country Elevator Receipts at Individual Prairie Points Crop Years 1943-44 to 1964-65 (Ottawa: Queen's Printer and Controller of Stationery, 1944 to 1965).

**Significance level 0.01.

coefficient significant at the one percent level was observed. The absence of an increasing trend is not explained for other points. All points, with the exception of Wembley, had a positive time trend for both cultivated and total acreage (Table II), over the period 1955-56 to 1964-65. Substitution of one crop for another at Dimsdale for 1955-56 to 1964-65 show a positive time coefficient for wheat only. The test is rather inconclusive because the time series for elevator receipts is much longer than that for acreages. Both Grande Prairie and Wembley had positive time coefficients for total receipts although neither was significant. Whether or not the extra receipts at Dimsdale were obtained at the expense of receipts at Grande Prairie and Wembley was not known. It was decided that the trend for Dimsdale would not be explicitly incorporated. However, by using the long term averages for elevator receipts to provide estimates of the average crop production, the importance of the trend may not be as great and perhaps neglected as an approximation as shown in Table III. Receipts at country elevators were assumed to have been harvested during the same crop year. The major crops grown in the region under study are oats and barley comprising on the average, sixty to eighty percent of the acreage devoted to the five crops considered as shown in Table IV. However, the weighed average of the production of grain receipts each year versus potential production (yield of each crop, as shown in Appendix Tables, LXXVII, LXXVIII, LXXIX, and LXXX, multiplied by the respective acreages for

TABLE II

TIME SERIES OF ACREAGES 1955-56 TO 1964-65[a]

$Y = A + BX$[b]

Name	Standard Error of Y Acres	A Acres	B Acres	Standard Error of B Acres	F-Ratio
A. GRANDE PRAIRIE					
Wheat	3,722.28	5,987.45	1,777.77	354.91	25.09**
Oats	3,630.68	24,597.49	-607.04	346.17	3.07
Barley	2,855.13	24,057.07	704.47	272.23	6.70*
Rye	248.70	613.78	-49.15	23.71	4.30
Summer Fallow	1,870.81	16,553.56	626.16	178.37	12.32**
Forage	4,113.33	20,421.20	828.35	392.19	4.70
Flax	1,918.26	7,438.18	-215.73	182.90	1.39
Other	884.22	-158.29	481.11	84.31	32.57**
Uncultivated	1,973.28	73,333.20	2,941.57	188.15	244.44**
Cultivated	2,584.22	91,437.40	5,731.19	246.40	541.03**
Total Acres	3,517.79	164,770.59	8,672.77	335.41	668.70**
B. DIMSDALE					
Wheat	995.09	736.60	463.17	94.88	23.83**
Oats	428.86	5,871.87	-322.34	40.89	62.14**
Barley	757.40	5,374.62	128.65	72.22	3.17
Rye	223.06	143.20	-7.06	21.26	0.11
Summer Fallow	621.68	5,119.16	2.52	59.28	0.00
Forage	607.38	4,658.73	118.09	57.92	4.16
Flax	269.02	869.60	-13.78	25.65	0.29
Other	240.04	930.80	-56.07	22.89	6.00*
Uncultivated	542.04	10,716.93	-45.84	51.68	0.79
Cultivated	863.97	23,086.93	471.80	82.38	32.80**
Total Acres	1,176.57	33,803.85	425.96	112.18	14.42**
C. WEMBLEY					
Wheat	2,027.90	4,428.96	495.63	193.35	6.57*
Oats	1,591.77	12,083.76	-778.08	151.77	26.28**
Barley	1,089.72	11,508.54	70.91	103.90	0.47
Rye	284.67	461.22	-40.35	27.14	2.21
Summer Fallow	1,259.85	12,549.34	-89.39	120.12	0.55
Forage	2,965.74	14,643.63	-121.55	282.77	0.18
Flax	704.17	2,353.56	26.44	67.14	0.16
Other	382.84	759.67	-8.08	36.50	0.05
Uncultivated	961.88	28,482.76	-364.45	91.71	15.79**
Cultivated	1,099.64	56,830.96	81.21	104.85	0.60
Total Acres	1,592.19	84,950.09	-237.77	151.81	2.45

Name	Standard Error of Y Acres	A Acres	B Acres	Standard Error of B Acres	F-Ratio
D. HUALLEN					
Wheat	603.08	718.91	153.95	57.50	7.17*
Oats	514.32	5,099.69	-244.10	49.04	24.78**
Barley	298.77	1,389.84	172.30	28.49	36.58**
Rye	105.24	239.95	-24.95	10.03	6.18*
Summer Fallow	595.40	3,224.07	94.88	56.77	2.79
Forage	883.22	4,311.22	44.01	83.21	0.27
Flax	264.92	1,145.76	-48.40	25.26	3.67
Other	258.04	739.56	51.52	24.60	4.39
Uncultivated	450.15	9,201.67	-207.81	42.92	23.44**
Cultivated	678.86	16,019.45	395.18	64.72	37.28**
Total Acres	413.22	25,526.58	158.28	39.40	16.14**
E. BEAVERLODGE					
Wheat	1,635.76	5,297.33	9.31	155.96	0.00
Oats	2,840.11	21,666.27	-789.14	270.79	8.49*
Barley	2,805.42	6,973.07	1,309.75	267.49	23.98**
Rye	102.77	60.33	19.76	9.80	4.07
Summer Fallow	3,533.66	20,601.58	-148.95	336.92	0.20
Forage	5,733.67	34,537.60	630.40	550.50	1.31
Flax	1,503.45	3,077.24	344.40	143.35	5.77*
Other	458.78	1,809.35	-0.80	43.74	0.00
Uncultivated	3,025.13	56,061.51	1,003.76	288.44	12.11**
Cultivated	3,025.13	91,290.90	1,969.55	235.29	70.07**
Total Acres	4,904.92	147,352.41	2,973.31	467.67	40.42**
F. HYTHE					
Wheat	1,554.77	1,538.96	295.95	148.24	3.99
Oats	4,624.02	24,917.78	-464.42	440.88	1.11
Barley	2,716.12	13,927.09	616.32	258.97	5.66*
Rye	274.11	766.56	-78.93	26.13	9.12*
Summer Fallow	2,674.28	18,634.34	299.06	254.98	1.38
Forage	5,452.53	29,518.31	1,047.83	519.88	4.06
Flax	712.81	266.69	204.90	67.96	9.09*
Other	602.67	1,133.73	107.41	57.46	3.49
Uncultivated	4,456.87	52,709.23	1,643.13	424.95	14.95**
Cultivated	2,465.35	88,809.32	2,675.22	235.06	129.53**
Total Acres	6,694.29	140,918.56	4,318.35	638.28	45.77

[a]Source: Data provided by courtesy of the Statistics Branch, Board of Grain Commissioners for Canada (Unpublished).

**Significance level 0.01
*Significance level 0.05

[b] Y = Crop acres; A = Intercept; B = Regression coefficient; X = Time in years.

TABLE III

MEANS AND STANDARD DEVIATIONS OF ELEVATOR RECEIPTS FOR EACH POINT 1943 TO 1965[a]

Point	Annual Mean (bushels)	Annual Standard Deviation (bushels)
Grande Prairie	676,200	282,100
Dimsdale	183,500	64,170
Wembley	436,200	109,400
Huallen	119,000	31,670
Beaverlodge	575,600	166,000
Hythe	690,300	189,000

[a]Source of Data: Board of Grain Commissioners for Canada, Summary of Country Elevator Receipts at Individual Prairie Points Crop Years 1955-56 to 1964-65 (Ottawa: Queen's Printer and Controller of Stationery, 1956 to 1965).

TABLE IV

CROP ACREAGES BY PERCENT OF TOTAL ACRES

SEEDED TO FIVE GRAINS

Year	Wheat	Oats	Barley	Flax	Rye
A. GRANDE PRAIRIE					
1955	17.51	32.87	41.54	6.89	1.19
1956	14.65	33.98	36.18	14.75	0.44
1957	12.41	37.02	37.97	11.17	1.43
1958	13.70	35.01	43.84	7.38	0.07
1959	20.19	28.96	40.44	9.92	0.49
1960	23.01	28.55	39.96	8.22	0.26
1961	27.22	30.39	33.40	8.77	0.22
1962	27.03	31.30	32.47	9.03	0.17
1963	26.98	23.09	42.22	7.52	0.19
1964	34.30	22.38	36.84	6.01	0.47
1965	29.94	17.52	49.97	4.51	0.06
Mean	22.45	29.19	39.35	7.74	0.45
B. DIMSDALE					
1955	18.41	37.49	37.67	5.98	0.45
1956	11.89	40.90	40.10	7.04	0.07
1957	10.08	37.74	35.43	5.74	1.01
1958	11.67	36.64	48.52	2.90	0.27
1959	18.35	26.30	48.59	6.55	0.21
1960	21.87	25.72	41.22	5.92	5.27
1961	29.05	25.69	38.46	6.08	0.72
1962	35.56	22.84	35.51	6.09	-
1963	33.10	19.20	40.20	7.50	0.00
1964	38.55	18.82	38.93	3.70	-
1965	31.30	12.50	53.60	2.60	0.00
Mean	23.62	27.62	42.57	5.46	0.73
C. WEMBLEY					
1955	19.41	36.06	37.01	6.49	1.03
1956	16.27	39.56	35.21	8.83	0.13
1957	17.95	32.53	38.32	7.63	3.57
1958	16.70	26.70	49.70	6.52	0.38
1959	20.24	22.73	45.36	10.63	1.04
1960	27.11	22.49	42.06	7.60	0.74
1961	34.51	22.60	35.05	7.38	0.46
1962	30.00	25.40	34.60	10.00	-
1963	27.90	19.10	41.10	11.89	0.01
1964	37.93	15.95	38.24	7.32	0.56
1965	27.60	9.40	56.00	6.82	0.18
Mean	25.06	24.77	41.15	8.28	0.74

Year	Wheat	Oats	Barley	Flax	Rye
D. HUALLEN					
1955	13.10	52.26	18.86	13.25	2.53
1956	11.55	57.91	15.09	15.09	0.44
1957	13.95	48.05	22.78	10.17	5.05
1958	10.81	46.62	35.71	6.32	0.54
1959	13.48	46.67	27.45	10.85	1.55
1960	17.84	45.01	25.74	10.10	1.31
1961	21.85	40.58	27.21	10.03	0.33
1962	24.15	39.29	28.83	7.73	-
1963	28.81	30.81	30.17	10.21	-
1964	28.53	29.98	33.09	8.40	-
1965	19.90	25.11	49.95	5.04	-
Mean	18.54	42.03	28.63	9.74	1.07
E. BEAVERLODGE					
1955	18.26	48.77	25.84	6.91	0.22
1956	11.80	54.28	22.12	11.54	0.26
1957	10.72	49.43	27.22	12.07	0.56
1958	9.01	48.29	35.90	6.63	0.17
1959	11.43	42.30	33.99	12.11	0.17
1960	15.33	40.04	31.94	12.27	0.42
1961	15.64	40.18	30.46	13.41	0.31
1962	14.51	36.53	33.79	14.67	0.50
1963	9.77	30.25	44.31	15.10	0.57
1964	13.63	30.95	42.57	11.99	0.86
1965	8.20	23.44	53.95	14.08	0.33
Mean	12.57	40.41	34.74	11.89	0.40
F. HYTHE					
1955	8.00	48.78	37.06	1.26	2.90
1956	5.42	63.04	28.98	2.27	0.29
1957	5.45	57.76	32.52	2.74	1.53
1958	3.94	54.71	39.81	0.94	0.60
1959	4.13	45.73	48.28	0.91	0.95
1960	5.89	47.02	43.05	3.66	0.38
1961	7.62	53.64	34.70	3.69	0.35
1962	8.04	50.47	35.60	5.78	0.11
1963	6.80	46.94	40.57	5.62	0.07
1964	14.36	41.67	39.91	3.90	0.16
1965	9.76	31.90	53.32	4.92	0.10
Mean	7.23	49.24	39.62	3.24	0.68

a. Source: Data provided by courtesy of the Statistics Branch, Board of Grain Commissioners for Canada (Unpublished).

each elevator point) varies from 0.47 at Hythe to 0.57 at Wembley, as shown in Table V. The correlation coefficients between the yields of grain and the elevator receipts are positive as shown in Table VI, with coefficient for wheat and flax being significant at the five percent level at all points.

The proportion of grain receipts to total potential production for each point shows no significant correlation with time but coefficients were positive and significant between points as shown in Table VII. There was no significant time trend of these proportions, as shown in Table VIII. Standard deviations of these proportions were not large, and would be much less if the 1958-59 observations were disregarded. The indications were that total production was positively correlated with the average crop yield for census district 15, and a tendency for grain to be shipped to the elevators during the same crop year. Although much of the grain is fed or sold through other channels than the Canadian Wheat Board, it was assumed that wheat, rye, and flax production was shipped to the elevators. Although receipts at the elevators by kind of grain were not available, oats and barley can be easily fed or sold, whereas it was assumed that little wheat, rye, or flax would be fed or sold for feed. Oats and barley would be shipped to fulfill the remainder of the grain delivered to the elevator each year and it was assumed shipments would be in proportion to the oats and barley shipped each year in census division 15 as shown in Table IX.

TABLE V

PERCENTAGE[a] OF TOTAL CROP ENTERING THE COMMERCIAL ELEVATOR SYSTEM[b]

Year	Percentage					
	Grande Prairie %	Dimsdale %	Wembley %	Huallen %	Beaverlodge %	Hythe %
1955/56	37.11	37.41	43.51	32.13	37.23	34.20
1956/57	33.04	36.10	40.95	33.19	37.30	35.75
1957/58	35.71	44.24	51.21	37.41	43.02	39.96
1958/59	72.04	81.29	100.00	64.37	65.15	77.32
1959/60	37.95	43.11	52.33	35.44	37.63	39.31
1960/61	40.16	55.93	53.62	38.33	39.24	40.90
1961/62	48.41	64.17	60.73	52.48	47.43	50.14
1962/63	45.64	47.52	60.15	53.69	47.52	41.81
1963/64	43.30	49.19	54.20	50.44	38.77	34.11
1964/65	43.50	57.55	55.47	34.03	42.21	39.54
Average	43.68 ±11.02	51.65 ±13.69	57.22 ±16.29	43.15 ±11.18	43.55 ±08.56	43.00 ±12.92

[a]"Percentage" is defined as receipts at the country elevator points divided by the sum of wheat, oats, barley, flax and rye acres multiplied by average crop yields for census District No. 15.

[b]Source of Data: Board of Grain Commissioners for Canada, Summary of Country Elevator Receipts at Individual Prairie Points Crop Year 1955-56 to 1964-65 (Ottawa: Queen's Printer and Controller of Stationery, 1956 to 1965); Census yield data courtesy of Farm Economics Branch, Alberta Department of Agriculture, Acreage data courtesy of Statistics Branch, Board of Grain Commissioners for Canada (Unpublished).

TABLE VI

CORRELATION COEFFICIENTS BETWEEN RECEIPTS AND YIELDS

(BARLEY, OATS, WHEAT, FLAX AND RYE)

1956-57 to 1964-65[a]

Name	Grand Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe
Barley	0.61	0.73	0.72	0.66	0.77	0.68
Wheat	0.69	0.74	0.71	0.68	0.70	0.73
Oat	0.62	0.72	0.72	0.68	0.85	0.68
Flax	0.75	0.84	0.82	0.77	0.83	0.83
Rye	0.56	0.72	0.46	0.34	0.38	0.47

Values of correlation coefficients significantly different from zero are given by R.A. Fisher, Statistical Methods for Research Workers (Thirteenth Edition, Edinburgh: Oliver and Boyd Ltd., 1958) p.209, as follows: 5% (0.67); 2% (0.75); 1% (0.80).

[a]Source of Data: Yield data provided by courtesy of Farm Economics Branch, Alberta Department of Agriculture; Board of Grain Commissioners for Canada, Summary of Country Elevator Receipts at Individual Prairie Points, Crop Years 1955-56 to 1964-65 (Ottawa: Queen's Printer and Controller of Stationery, 1956 to 1965).

TABLE VII

CORRELATION COEFFICIENTS BETWEEN PROPORTION OF GRAIN ENTERING THE ELEVATOR AND TOTAL PRODUCTION FOR THE SIX AREAS 1955-56 TO 1964-65[a]

Beaverlodge	Dimsdale	Grande Prairie	Huallen	Hythe	Wembley	Time
1.0000						
.8619	1.0000					
.9547	.9158	1.0000				
.8409	.7494	.8575	1.0000			
.9577	.8898	.9497	.7633	1.0000		
.9648	.9049	.9822	.8362	.9610	1.0000	
-.0669	-.3371	-.1841	-.3057	.0287	-.1451	1.0000

[a]Source: Table V.

TABLE VIII

TIME TREND OF PROPORTION OF GRAIN ENTERING THE ELEVATOR AS COMPARED TO TOTAL PRODUCTION FOR THE YEARS 1955-56 TO 1964-65[a]

Area	Std.Error Y	Intercept	Reg. Coeff.	Std. E of R Coeff.	F Prob.
Grande Prairie	3.1564	7.7088	-5.0568	9.5449	.6148
Dimsdale	3.0234	9.3505	-7.4550	7.3614	.3428
Wembley	3.1773	7.0431	-2.6967	6.5019	.6892
Huallen	3.0576	9.0722	-8.2805	9.1187	.3937
Beaverlodge	3.2041	6.5275	-2.3653	12.4765	.8322
Hythe	3.2100	5.2111	.6719	8.2794	.8963

[a]Source: Table V.

TABLE IX

BARLEY AND OATS RECEIPTS (AS TOTAL BUSHELS BARLEY AND OATS) IN CENSUS DIVISION NUMBER 15 - 1955/56 TO 1964/65[a]

Year	Barley %	Oats %
1955/56	57.0	43.0
1956/57	59.0	41.0
1957/58	49.0	51.0
1958/59	69.0	31.0
1959/60	75.0	25.0
1960/61	73.0	27.0
1961/62	70.0	30.0
1962/63	70.0	30.0
1963/64	77.0	23.0
1964/65	79.0	21.0

[a]Source of Data: Canada, Dominion Bureau of Statistics and Board of Grain Commissioners for Canada, Canada Grain Trade (Ottawa: Queen's Printer and Controller of Stationery, 1956 to 1965).

Total crop production was calculated each year for each point by multiplying the yield of each crop (from Census Division Number 15 data) by its respective acreage. The production considered in this study consisted of the bushels of wheat, flax, and rye produced plus the appropriate bushels of oats and barley to equal grain receipts at the six elevator points.

Time of Harvesting. Estimates of the percentage of wheat, oats, barley, and flax harvested each week for Grande Prairie, Dimsdale, Wembley, Beaverlodge, and Hythe were obtained from the Alberta Wheat Pool as shown in Appendix II Table LXXXI. Unfortunately, not all values were indicated and some extrapolation was required for the remaining weeks. These were estimated using the Quarterly Bulletin of Agricultural Statistics. As records for one point were not available, the average proportion of composite crop harvested per week was used for Huallen as shown in Table X. These values were used to estimate the total bushels of grain produced each week which would be shipped to the elevator in the same crop year.

Method of Aggregation. The method of combining acreages, yields, and harvesting rates into a single series for each point to represent crop production is presented below in equation form.

TABLE X

AVERAGE PROPORTION OF COMPOSITE CROP HARVESTED EACH WEEK

FIRST 15 WEEKS OF CROP YEAR

Averages for Period 1955 to 1964[a]

Week	Grande Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe
1	.0079	.0263	.0107	.0124	.0093	.0153
2	.0049	.0307	.0134	.0112	.0006	.0066
3	.0516	.0493	.0541	.0598	.0373	.1069
4	.0527	.0984	.0675	.0681	.0863	.0357
5	.0661	.0609	.0563	.0579	.0575	.0485
6	.1116	.1429	.1015	.1005	.0655	.0809
7	.0951	.1067	.1204	.1337	.1577	.1884
8	.1405	.1283	.1889	.1521	.1393	.1631
9	.1238	.1082	.0834	.1040	.1185	.0860
10	.0396	.0436	.0693	.0579	.1082	.0287
11	.0933	.0677	.0746	.0721	.0650	.0600
12	.0899	.0628	.0758	.0778	.0787	.0818
13	.0521	.0414	.0297	.0407	.0315	.0487
14	.0558	.0328	.0399	.0395	.0284	.0406
15	.0151	-	.0145	.0123	.0162	.0088
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

[a] Source of Data: Calculated using equation number VI.

I (Acreage ijk) (Yield ijk) = Bushels ijk

where i = flax, rye, and wheat

j = Grande Prairie, Dimsdale, Wembley, Beaverlodge, and Hythe

k = Crop year

II Elevator Receipts_{jk} - $\Sigma_i \text{Bushel}_{ijk} = R_{jk}$

(Percent Oat Receipts_{jk}) (R_{jk}) = O_{jk}

(Percent Barley Receipts_{jk}) (R_{jk}) = B_{jk}

$R_{jk} = O_{jk} + B_{jk}$

$\Sigma_i \text{Bushels}_{ijk} + R_{jk}$ = Elevator Receipts_{jk} = Bushels produced_{njk}

III (Percent Harvest $_{nwjk}$) (Bushels Produced_{njk}) = Crops produced_{nwjk}

where n = flax, rye, wheat, oats, and barley

w = week

j,k as above

IV Σ_n(Crops Produced_{nwjk}) = Production_{wjk}

V (Production_{wjk})/(Elevator Receipts_{jk}) = Relative Bushels_{wjk}

VI Σ_k(Relative Bushels_{wjk})/k = (Average proportion of composite Crop $\text{Harvest})_{wj}$

VII ((Average Proportion Composite Crop $\text{Harvest})_{wj}$/Average Elevator Receipts 1943-64) = Average bushels per week per point.

Equation I is used to provide the physical quantities of wheat, rye, and flax produced each year at each point.

Subtraction in Equation II determines the bushels of barley and oats to be shipped to the elevator points each year which equates production each crop year and receipts for that same crop year. The number of bushels of oats and barley were calculated by using the proportion of oats to barley received at country elevators in Census District 15 each crop year. The next step (Equation III) involves the amount harvested each week by grain and by point to determine the crops produced, that is, a value is found for each kind of grain for each point every week. The following Equation IV converts bushels of each kind of grain into a single value expressed as bushels for each week for each point. Equation V expresses the bushels produced as a proportion of the composite crop harvested each week. These values are then averaged over the ten years of observations providing the average proportion of the composite crop harvested each week. The final equation converts the values back into bushels, but uses the twenty-two year average grain receipts value for each elevator point.

Although this seems a complicated method for obtaining a time distribution of crop production, it is an attempt to allocate the proper weight to the different crops produced, and to provide a series which reflects the changing acreages of crops produced. It would be desirable to incorporate the variable influence of weather. To do so would also require an approach similar to the one above, to generate the crops produced. Unfortunately, this would require a great deal more knowledge and would add a great deal of complexity to the model[3].

Variability of crop production was introduced as a yearly phenomenon to represent the changing values of grain receipts at the elevator points. The method used was to find a series of index numbers with a mean of one and a standard deviation of 0.3102 to represent crop production. As each elevator point had a mean of one, the variances were subjected to the Bartlett's test. The null hypothesis was that the variances of all elevator points were homogenous, and it was not rejected at the five percent point of the chi square distribution. This indicated that the model values could have been generated from the sample. Thus the series for each elevator point were pooled, and a probability density function was formed. This frequency function was then used via the Monte Carlo technique to generate a value used to multiply the average crop production for each elevator point. The empirical frequency function was used although the normal distribution could fit the data as shown in Table XI[4]. An interesting study

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[3] R.H. Day, "Dynamic Coupling, Optimizing and Regional Interdependence", Journal Farm Economics VIXL: 2, p.442-450.

[4] M.H. Yeh and L.D. Black, Weather Cycles and Crop Production (Winnipeg: University of Manitoba, Department of Agricultural Economics and Farm Management, Technical Bulletin 8, November, 1964).

at Manitoba uses Fourier series to estimate crop yields, but the method was not used in this study as the yield data was not sufficiently extensive, and much of the crop produced did not enter commercial elevators. Thus the variability of receipts at the country elevators are used to provide variability of crop production, although no cycles are represented.

In summary, crop acreages, crop yields, and harvesting rates provided an average composite bushel production each week for each area. Variability of production was provided by an empirical index of elevator receipts, using the Monte Carlo technique.

TABLE XI

COMPARISON OF RECEIPTS WITH NORMAL DISTRIBUTION AND WITH NEGATIVE BINOMEAL DISTRIBUTION - 1943/44-1964/65[a]

Receipts/$\bar{X}$ in 20 Equalized Classes	Observed Frequency	Theoretical Normal Distribution	Theoretical Negative Binomial Distribution
.38	3 }5	1.92	.60
.46	2	3.05	2.29
.54	4	4.64	5.11
.62	8	6.60	8.43
.70	17	8.86	11.48
.78	7	10.73	13.49
.86	10	12.48	14.41
.94	14	13.59	14.20
1.02	14	13.80	13.10
1.10	9	13.03	11.42
1.10	11	11.63	9.55
1.26	12	9.73	7.69
1.34	7	7.53	5.96
1.42	6	5.50	4.50
1.50	2	3.71	3.29
1.58	1	2.36	2.36
1.66	3 }8	1.45	1.68
1.74	0	.78	1.15
1.82	1	.42	.79
1.90	1	.22	.53
Chi-squares (Pooling first two cells and last six cells)		11.66	13.62
Degrees of freedom		17	17

$\bar{X} = 1.00$

$\sigma = .3102$

[a]Source of Data: Board of Grain Commissioners for Canada, Summary of Country Elevator Receipts at Individual Prairie Points Crop Year 1955-56 to 1964-65 (Ottawa: Queen's Printer and Controller of Stationery, 1956 to 1965).

II. FARM STORAGE

An estimation of farm storage costs and capacities was needed in the simulation model. Casual observation in the region suggested there was a great deal of storage capacity available as farm granaries. The simulation program was written so that it was possible to keep track of both fixed costs and variable costs of farm storage, made up of a yearly charge, that is, fixed cost regardless of the amount of grain stored and a variable cost per bushel grain. As a detailed analysis of the farm storage was not undertaken for the region, this study does not provide a complete picture of the actual storage costs. A general but limited discussion of reasons and costs of farm storage precedes the determination of cost to provide a proper perspective for the model and costs which have been assumed[5].

General Considerations. The climate of Alberta is important in influencing methods and costs of grain storage, and in the farm decisions regarding capacity of farm granaries. Cereal grains can be safely stored with minimum care, given that: (1) Storage bins exclude moisture and rodents, (2) Bins are sprayed with insecticides before grain storage, (3) grain has a moisture content below

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[5] J.T. Davis and B.L. Brooks, Economics of On-the-Farm Grain Storage (Washington Agricultural Experimental Station, Circular 473, February 1967) and L.S. Thompson, Economics of Grain Storage on Montana Farms (Bozeman: Montana State College and Agricultural Experimental Station, Technical Bulletin 511, 1955).

fourteen per cent, and (4) periodic checks are made for problems such as heating. Similarly, climatic conditions provide fluctuating crop yields. The climate of Alberta is responsible for the small number of crops that can be successfully grown, consequently, the harvesting period is relatively short. Both fluctuating yield and short harvest periods create difficulty in determining optimum storage capacities at the farm and commercial elevator. The short harvest period suggests possible bottlenecks occurring at the farm and commercial elevator. Variability of yield implies average values are inadequate for decision making and the fluctuating crop yields create difficulty of high utilization of farm and elevator storage capacity, *ceteris paribus*.

Farm Storage Advantages. Farm storage does have several advantages over commercial storage. Movement of grain from field to farm storage requires a mode of transportation which does not preclude the use of unlicensed vehicles and drivers, prohibited on public roads but adequate for the farm. Partial loads which may not be appreciated by an elevator operator can easily be handled and stored at the farm. Farm granaries also allow separate binning of grain for purposes such as seed and feed. Furthermore, farm storage allows harvesting at nights and on holidays. Tough, damp, or wet grain can be handled at the farm, whereas elevators might be hesitant in accepting such grain.

Time is very important when harvesting. Frequently an extra truck and extra labour would be required to enable the farmer to harvest continuously due to the loss if a queue formed at an elevator, and the distance from field to elevator. In conjunction with the time factor there is the possibility of hauling grain to commercial elevators during the slack periods of summer and winter. Decisions regarding the magnitude of farm storage space capacity would be strongly influenced by the availability of storage space at the commercial elevator when required.

Requirements for feed and seed are important in stimulating grain storage at the farm. Farm storage makes the sales channel more flexible as a farmer may sell feed grain to truckers or feeders. Grain which is to be used on-farm or sold as seed demands farm storage for the separate binning of given varieties, and to have an inventory of grain available for sale.

Farm storage of grain as reserves may provide income stability for various contingencies. The ability to store grain over a period of time may benefit the farmer by providing flexibility in reporting income tax. The facilities, themselves, may be of importance in income tax calculations due to accelerated depreciation schedules.

Disadvantages of Farm Storage. There is an obvious, although difficult to measure, risk that farm stored grain may shrink, deteriorate, or simply be lost through the use of poorly constructed bins. Loss of grain through theft may be small but not unheard of in situations where bins are located in isolated areas. Physical handling of grain several times may cause damage to grain, especially when specific grains such as malting barley are subject to damage. The magnitude of damage occurring is probably small but the cost of handling must also be considered.

Grain stored in commercial elevators would always be available for sale to the Canadian Wheat Board, or to other firms buying grain from elevators. The sale can be transacted immediately, whereas farm stored grain would require both time and transportation facilities to bring it to this particular market. The importance of this aspect is not known, and is probably quite small in face of the present marketing institutions. As elevators enter into an agreement with the Canadian Wheat Board regarding storage and handling costs, there may be certain incentives for elevator companies to reserve elevator capacity in expectations of grain being sold to the Board. The Canadian Wheat Board, in its attempt to control the movement of grain through quotas and shipping orders, may not desire that elevators store grain on behalf of the farmer[6]. However, caution is advised as it was not known if farmers use commercial elevators to store grain, and if they do, the volume of grain stored in this manner.

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[6]C. Gislason, "How Much Has the Canadian Wheat Board Cost the Canadian Farmers?", Journal of Farm Economics XLI: 3, August 1959, pp.584-599.

Another disadvantage of farm storage is that there are no price incentives to store wheat, barley, oats, and thus the farmer would avoid costs associated with farm storage by shipping grain from field to elevator[7]. The prices for these major grains are set yearly, no price advantages are available, and the sooner the farmer can ship grain, the less risk he incurs in storing grain under the existing regulations.

In summary the advantages of farm storage are:[8]

(1) Convenience

(a) Use of unlicensed trucks and drivers.

(b) Ability to store small loads and to store grain separately for feed, seed, and other situations.

(c) Continuous harvesting when commercial elevators are closed.

(d) Flexibility in handling tough, damp, or wet grain.

(e) Saving of time, labour, and capital due to distance and/or queues at elevators.

(f) Use of slack labour to haul grain at non-critical times, that is, between harvesting and planting.

(g) Lack of commercial storage space at harvest time.

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[7] A.W. Wood, "Technological Changes in Processing, Marketing and Distribution and their Impact on Canadian Agriculture", Canadian Journal of Agricultural Economics, X: 1, 1962, p.56.

[8] Davis and Brooks, op. cit., pp.3-7; Thompson, op.cit., pp.25-32.

(2) Storage of feed and seed for immediate and future needs.

(3) Market flexibility.

(4) Reserves for contingencies.

(5) Income tax.

and the disadvantages are:

(1) Risk of grain storage from damage, deterioration, theft, and excess handling.

(2) Difficulty of shipping grain when desired.

(3) Inability to sell grain immediately.

(4) No increase in price.

These influences are interrelated, and difficult to disentangle without a much more comprehensive study. _A priori_ it is clear that there are trade-offs between the advantages and disadvantages, but the identification of these would be difficult under the set of regulations and circumstances which exist presently. It is not clear whether analysis would be more or less difficult if changes were made in the marketing system. However, under any circumstances, nature and economic forces do not provide any easy determination of an optimal physical or economic farm bin storage capacity.

Farm Storage Costs. Total cost of farm storage can be broken into fixed and variable cost. Fixed costs or annual use costs do not change with output and they include depreciation, interest on investment, and insurance on the building. These costs accrue whether the facilities are used or not, and usually form the major component of total cost[9]. Utilization of the facilities has an important influence upon the average cost per bushel of grain stored[10]. This reflects declining average fixed costs as volumes increase. The maximum utilization rate would be one given that the storage units were filled at harvest each year, and not refilled until the next fall. Variable costs include handling, insurance on grain, shrinkage, and deterioration. These are costs that vary with the actual number of bushels stored in that unit.

A short run average cost curve was determined by researchers using budgeting to provide an economy of scale curve[11]. The cost data involved various sizes of round steel bins and steel quonset buildings as indicated in Figure 3. A similar fall in costs occurs as capacity increases, as illustrated in Table XII.

The curve, is of course based upon a different climatic and cost situation than prevails in Alberta, but the general shape may well apply.

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[9] Davis and Brooks, _op. cit._, pp. 18-19.

[10] E.M. McDonald and J.H. McCoy, _Costs of Storing Reserve Stocks of Wheat at Country Elevators and on Farms in Kansas_, Agricultural Marketing Service, United States Department of Agriculture, Marketing Research Report No. 124 (June 1956), pp.16-20.

[11] _Ibid._, pp.22-23.

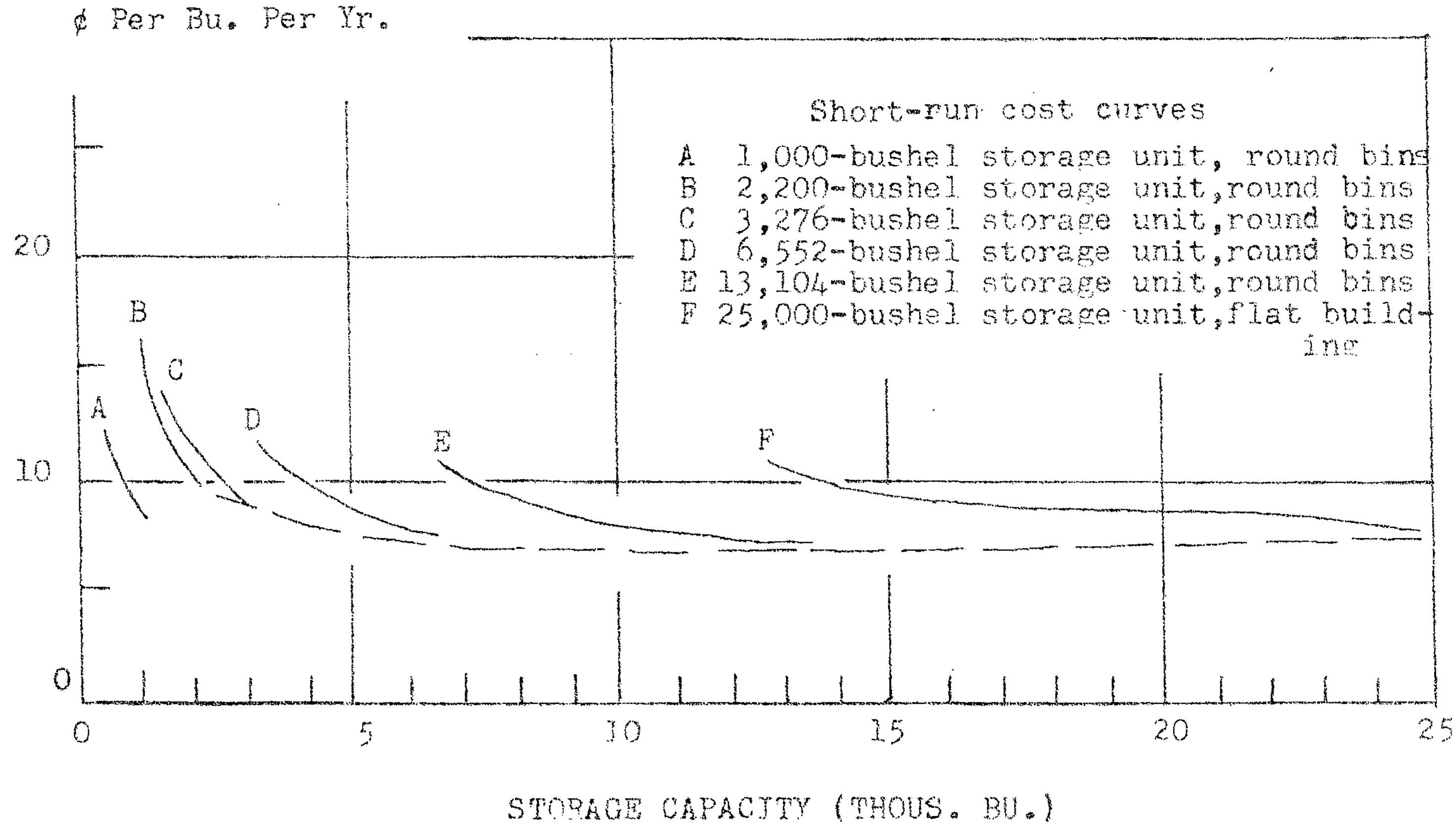

Figure 3. Short-run average cost curves and economy-of-scale curve of farm storage.

Source: E.M. McDonald and J.M. McCoy. Costs of Storing Reserve Stocks of Wheat at Country Elevators and on Farms in Kansas. Agricultural Marketing Source, United States Department of Agriculture, Marketing Research Report No.124. Washington, June 1956.

Another approach may be taken. It is possible to compare costs of grain storage on a per bushel investment basis. The values obtained were determined under the assumption that the capacity is fully used although it does not require that the grain be stored for a specific time period. If variable costs remain constant over different structures, and if depreciation rates are similar then the cheapest per bushel capacity could be chosen. This is a very rough approach, as the assumptions are strict and do not hold under all circumstances. The various costs of construction are shown in Table XII.

In summary, there are three influences upon farm storage costs. These are the type of bin, size of storage capacity, and the degree of utilization.

Determination of Costs. There was no information regarding the types, capacities and costs of farm storage bins for the six shipping points considered in this study. The bin chosen as appropriate for costing purposes was a 1,350 bushel steel bin that cost 515.70 dollars. The price included a wood floor, labour, and mileage for a contractor. The fixed cost per year was assessed at 38.65 dollars per bin. This figure includes depreciation and interest on investment as shown in Table XIII.

Insurance on the building was not included as the bin is steel, however risks other than fire could be considered.

TABLE XII

INVESTMENT COST PER BUSHEL STORAGE CAPACITY OF WOODEN, ROUND STEEL, AND QUONSET BUILDINGS

	Capacity	Cost/Bushel
Wooden Bins	1,882	.25[a]
	1,000	.30[b]
	1,000	.275[c]
	1,440	.23[d]
Steel Bins (Round)	1,350	.37[e]
	1,650	.34[e]
	2,700	.30[e]
	3,300	.28[e]
	500	.57[f]
	1,000	.41[f]
	1,250	.37[f]
	1,500	.35[f]
	2,050	.35[f]
	2,400	.32[f]
	2,750	.31[f]
	3,000	.31[f]
	1,450	.487[g]
	3,000	.366[g]
	5,010	.330[g]
	6,700	.325[g]
	10,000	.268[g]
	55,000	.229[g]
Quonset	19,975(51 x 48 3/4 ft.)	.348[g]
	24,480(51 x 59 ft.)	.321[g]
	28,985(51 x 69 1/4 ft.)	.300[g]
	7,588(32 feet wide)	.37[h]
	10,930 "	.31[h]
	14,302 "	.27[h]
	17,604 "	.26[h]
	21,578(40 feet wide)	.27[h]
	30,278 "	.23[h]
	38,978 "	.21[h]
	47,678 "	.20[h]

[a]L.S. Thompson, op. cit., p.16. Cost of materials for a wooden frame granary 1951.

[b]Appendix II, Table LXXXII

[c]Appendix II, Table LXXXIII

[d]Appendix II, Table LXXXIV

[e]Appendix II, Table LXXXIV

[f]Thompson, loc. cit. List price plus concrete foundation wall.

[g]Davis and Brooks, op.cit. Includes list price, concrete floor, plus erection cost.

[h]Thompson, loc.cit. Arched roof type steel building including steel lining, concrete floor, and foundation wall.

TABLE XIII

THE FIXED COST OF A 1,350 BUSHEL STEEL BIN FOR FARM STORAGE

	$
1,350 bu. steel bin	328.70
Floor	100.00
Labour	80.00
Mileage (assume 20 miles @ $.35/mile)	7.00
Total Cost[a]	515.70
Depreciation @ 5%	25.79
Interest on Investment @ 5% on 1/2 Value	12.89
Annual Total Fixed Cost Per Bin[b]	38.68

[a]Cost provided courtesy of the United Farmers of Alberta Cooperative, Calgary, Alberta, 1967.

[b]Does not include insurance on building or grain, maintenance, or other operating expenses.

The steel bin may not be applicable, but was chosen as (1) maintenance costs are low compared to wood bins, (2) fire insurance need not be included, and (3) a price was easily established. No consideration was taken of the land cost in determining fixed costs.

Materials handling equipment was considered as a variable cost. Most farmers used portable augers, and such equipment would not be used unless grain was handled. Perhaps initial cost could be prorated for grain sold at country elevators, sold in other channels, and for grain used for feed and seed, but it seems quite difficult. If the equipment were an integral part of grain storage facilities, then obviously fixed costs must be assessed. An augur cost of 1.417 cents per bushel was budgeted, as indicated in Table XIV.

Insurance of the grain was not included as it was thought that few farmers actually insure grain. Insurance might be considered for hazards such as fire. There is another aspect that requires consideration which encompasses all risks associated with farm storage. Any damage, deterioration, or losses which can occur in farm storage of grain are incurred by the farmer. These losses are largely caused by poor management, whereas the commercial elevator operator is a specialist in grain storage. The extensiveness or occurrences of such losses are not known, but they are borne by someone. For instance, shrinkage has not been included as no relevant information

TABLE XIV

FARM HANDLING EQUIPMENT COSTS[a] ($)

(a) Auger	250.00	Life ten years	
		(1) Depreciation @ 10%	25.00
		(2) Interest on investment @ 5%	12.50
(b) Engine	150.00		
		(1) Depreciation @ 20%	30.00
		(2) Interest on investment @ 5%	7.50
		(3) Maintenance and Repairs	10.00
Total Cost			85.00
Cost per bushel assuming 6,000 bushels			1.417 ¢/bushel

[a] Estimated courtesy of the Department of Agricultural Engineering, University of Alberta, 1966.

exists. Perhaps shrinkage rates established by the Board of Grain Commissioners might be adequate, although there would be a change of double-counting such costs.

Other variable costs relating to farm storage such as labour, trucking expense from the field, gas and oil, and insecticides were not included as these costs were assumed to be relatively small and in any event are not available. The trucking expenses from the field were not included as the cost occurs regardless if the grain is stored at the farm or shipped to an elevator.

An approximation was made in an attempt to evaluate these costs. A charge of one-half cent per bushel was attributed directly to grain entering farm storage. A further charge of .583 cents, estimated from a study made in the state of Washington, was charged to grain moving from farm storage[12].

Thus the total variable cost was .025 dollars per bushel. Fixed costs were .0286 dollars per bushel (storage capacity used once per year). The total cost is only .0536 dollars per bushel. This compares with a total cost of 9.07 cents per bushel reported in a Washington study[13]. The assumed total variable cost for this study was .0048 dollars less than that for a 3,000 bushel round steel bin in the above mentioned study, whereas the calculated fixed cost was 3.23 cents less than in Washington as shown in Table XV.

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[12] Davis and Brooks, op. cit., p.18.

[13] Ibid., p.18.

TABLE XV

TOTAL ANNUAL COST PER BUSHEL FOR GRAIN STORAGE IN 3,000, 5,000, 25,000 BUSHEL ROUND STEEL BINS AND 20,000 BUSHEL QUONSET, 3/4 FULL AND FULL AT COMPLETION OF HARVEST[a]

	Storage Cost (cents/bu.)							
	Round Steel						Quonset	
	3,000 bu.		5,000 bu.		25,000 bu.[d]		20,000 bu.[d]	
	Full	3/4 Full	Full	3/4 Full	Full	3/4 Full	Full	3/4 Full
Total Fixed Expense[b]	6.09	8.02	2.20	3.00	3.31	4.58	4.06	5.35
Total Variable Cost[c]	2.98	2.98	2.98	2.98	2.98	2.98	2.98	2.98
Total Cost	9.07	11.00	7.84	9.58	6.29	7.56	7.04	8.33

[a]Source: J.T. Davis and B.L. Brooks, Economics of on-the-farm Grain Storage (Washington Agricultural Experiment Station, Circular 473 (Feb. 1967) pp.23-24.

[b]Interest at 5%, depreciation at 4%, taxes, and insurance including auger and electric motor.

[c]Labour for loading in and out of bin, treating and conditioning, truck expense from field to storage, maintenance and operation, insurance on grain, and shrinkage.

[d]Total Investment of $7,500.

An estimate of the physical capacity of the storage space in the six shipping points was required. A survey made interviewing 41 farmers who provided the number of cultivated acres and total farm storage capacity was used[14]. The farmers were randomly chosen, and the survey terminated when the cumulated average capacity per cultivated acreage appeared to remain stable. The simple regression model, $Y = a + bX$ where Y equals storage capacity and X equals cultivated acreage, was used to analyze the data. The estimated equation was:

$$Y = \underset{(3782.57)}{388.96} + \underset{(2.10)}{17.00}X \qquad R^2 = .6382$$

F ratio (for the B coefficient) = 68.80 with 1 and 39 degrees of freedom.

The average storage capacity per cultivated acre was 18.16 bushels. Some farmers reported a value indicating the total storage capacity that could be made available, as well as the normal capacity. The equation in this case was:

$$Y_2 = \underset{(3777.83)}{534.53} + \underset{(2.10)}{18.04}X_2$$

F ratio = 74.13 1 and 39 d.f. $R^2 = .6553$

The average was 19.08 bushels storage capacity per cultivated acre.

Both equations have very significant coefficients, and capacity was reasonably well explained by cultivated acreage.

To obtain total fixed cost of farm storage for each shipping point, the cultivated acreage (1965) was multiplied by the average bushel capacity per cultivated acre to obtain total capacity as shown in Table XVI. The value was 18,

[14]This study was undertaken by Larry Kane, Research Assistant, 1966. The original data is presented in Appendix II Table LXXXV.

being rounded off to the nearest bushel. As only a proportion of grain harvested was shipped through commercial elevators per year, the rest was fed to livestock or sold through other channels. The total capacity was multiplied by the weighted ten year average proportion of grain entering the elevator as shown in Table XVI to obtain an estimate of storage capacity used for grain sold through commercial elevators. The values obtained were then divided by the assumed size of farm bin, 1,350 bushels, to find the number of farm bins corresponding to the farmers served by each shipping point. The number of farm bins per shipping point was multiplied by the fixed cost per bin to obtain fixed costs shown in Table XVII.

The total farm capacity was compared to the average potential and 1965 potential crop size. It was found that in both cases the shipping points had more storage capacity than productive capacity except at Dimsdale when the 1965 crop size was used as in Table XVIII. When estimated carryover is added to the 1965 crop size, there is less capacity than total bushels to be stored although Beaverlodge provides the exception in this case.

Farm carryover was estimated by calculating the average carryover per acre of each crop for Alberta, shown in Table XIX. These values, multiplied by the respective averages for each crop and shipping point, provided a total farm carryover value. Once again, the values were multiplied by the average proportion of potential crop entering commercial

TABLE XVI

FARM STORAGE CAPACITY ESTIMATED FOR EACH AREA AND BIN CAPACITY USED FOR GRAIN TO BE SOLD THROUGH COUNTRY ELEVATORS[a]

Point	Cultivated Acreage 1965	Bushel Capacity Per Cult. Acre, 1965	Total Farm Storage Capacity	Capacity Used for Grain Sold
	Acres	Bushels	Bushels	Bushels
Grande Prairie	154,463	18.0	2,780,334	1,214,728
Dimsdale	28,505	18.0	513,090	265,011
Wembley	56,949	18.0	1,025,082	586,552
Huallen	20,825	18.0	374,850	161,748
Beaverlodge	115,547	18.0	2,079,846	905,773
Hythe	113,311	18.0	2,039,598	877,027

[a]Source: Table V and Appendix II Table LXXVI.

TABLE XVII

FIXED FARM STORAGE COST BY AREA[a]

Point	Capacity	Average Bin Size (Assumed)	No. Bins	Cost/Bin $	Total Cost $
	Bushels	Bushels			
Grande Prairie	1,214,728	1,350	900	38.67	34,803.00
Dimsdale	265,011	1,350	196	38.67	7,579.32
Wembley	586,552	1,350	435	38.67	16,821.45
Huallen	161,748	1,350	120	38.67	4,640.40
Beaverlodge	905,773	1,350	671	38.67	25,947.57
Hythe	877,027	1,350	650	38.67	25,135.50

[a]Source: Table XIII and XVI.

TABLE XVIII

FARM STORAGE CAPACITY PRODUCTION AND PER POTENTIAL BUSHEL PRODUCTION (WHEAT, OATS, BARLEY, FLAX, AND RYE) FOR TEN YEAR AVERAGE OF CROPS FOR 1965[a]

Area	Average Potential Crop Bushels	Potential Crop 1965 Bushels	Total Farm Capacity Bushels	Capacity / Av. Crop	Capacity / Potential Crop 1965	Capacity / Potential Crop 1965 plus Carry-over
Grande Prairie	1,982,016.5	2,562,152	2,780,334	1.40	1.09	.90
Dimsdale	400,446.8	526,112	513,090	1.28	0.98	.81
Wembley	803,486.4	949,903	1,025,082	1.28	1.08	.88
Huallen	255,144.9	326,106	374,850	1.47	1.15	.95
Beaverlodge	1,235,977.0	1,606,513	2,079,846	1.68	1.30	1.08
Hythe	1,457,230.2	1,969,844	2,039,598	1.40	1.04	.87

[a]Source: Tables V, XVI, and Appendix II Tables LXX, LXXI, LXXII, LXXIII, LXXIV, LXXV, LXXVII, LXXVIII, LXXIX, and LXXX.

elevators as shown in Table XX. This was a method of pro-rating carryover attributable to the grain which would be sold to the elevator company or Canadian Wheat Board. These values were subtracted from the original capacities as prorated, to provide an estimate of farm storage space that could be used in any crop year as shown in Table XXI. As this grain could be stored at the elevator for the farmers, the rate of off-farm shipments was not known, and the reasons for farm storage were not explicitly known, it was assumed for purposes of cost calculation that the farm carryover would remain constant at the calculated yearly average carryover.

Summary. This section has involved consideration of the various influences and decisions involved in farm storage. Although a thorough study was not made, an attempt was made to approximate the costs involved in farm storage. A small survey provided an estimate of the magnitude of farm storage in the shipping points under study. This plus budgeted costs provided the basis for estimating the costs of farm storage. Carryover was included, but did not influence costs as the carryover incorporated by reducing only the physical capacities.

TABLE XIX

AVERAGE CROP YEAR END CARRYOVER ON FARMS OF WHEAT, OATS, BARLEY, FLAX[a], AND RYE[b] PER CROP ACRE OF SAME YEAR (1955-64)[c]

Wheat	7.05 bu./acre
Oats	10.60 bu./acre
Barley	6.28 bu./acre
Rye	2.50 bu./acre
Flax	.50 bu./acre

[a]Crop Year 1963-64

[b]Crop Year 1963-64

[c]Source: Alberta Department of Agriculture, Farm Economics Branch, Statistics of Agriculture for Alberta 1955, ..., 1964 (Edmonton: Farm Economics Branch 1956 to 1965).

TABLE XX

TOTAL CARRYOVER OF WHEAT, OATS, BARLEY, FLAX AND RYE AS ESTIMATED IN EACH OF THE SIX REGIONS[a,b]

	Total Bushels	Proportion Grains Shipped	Proportion Bushels[c] Carryover
Grande Prairie	529,300	.4369	231,251
Dimsdale	108,960	.5165	56,278
Wembley	213,773	.5722	122,321
Huallen	68,113	.4315	29,391
Beaverlodge	322,055	.4355	140,255
Hythe	382,814	.4300	164,610

[a]Source: Table V and Table XIX and Appendix II Tables LXX, LXXI, LXXII, LXXIII, LXXIV, and LXXV.

[b]Sum (Acreages multiplied by average carryover of each crop).

[c]Proportion bushels estimates bushels carryover which would be held for sale through commercial elevators.

TABLE XXI

TEN YEAR AVERAGE FARM STORAGE CAPACITY AVAILABLE FOR CROP PRODUCTION FOR THE INDIVIDUAL POINTS[a]

Point	Effective Storage Capacity (Bushels)
Grande Prairie	983,477
Dimsdale	208,733
Wembley	464,231
Huallen	132,357
Beaverlodge	765,518
Hythe	712,417

[a]Source: Table XVI and Table XX.

III. TEMPORARY GRAIN STORAGE

Introduction. Prairie farmers use a wide variety of buildings for grain storage. These buildings range from sophisticated structures, incorporating complex material-handling procedures, to simple wooden bins. Grain is also stored on the ground.

There are several methods advocated for temporary grain storage, ranging from the use of empty sheds and other buildings to the simplest method of all--the dumping of grain into conical piles directly on the ground. There is little information regarding costs or extent of temporary storage.

No quantitative study regarding the costs of storing grain by such methods can be made. However, one experiment has been conducted to find the physical loss of grain over a seven month time period as shown in Table XXII. Using this information, plus several assumptions, a relationship was developed for use in this model.

Agricultural extension services recommend several possible methods for emergency or temporary storage[15]. These methods include:

(1) Sheds and other buildings,

(2) Temporary plywood bins,

(3) Temporary wooden bins,

(4) Snow fencing and heavy paper,

(5) Woven wires and straw or sheaves,

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[15] Alberta Department of Agriculture, Agricultural Engineering Section, Temporary Grain Storage, August 1965.

TABLE XXII

GRAIN LOSSES IN TEMPORARY GRAIN STORAGE[a]

Crop	Method of Storage	Amt. Bus. on Oct. 14/52	Amt. Bus. on June 1/53	Loss %	Wgt/1000 Kernels 1952	Wgt/1000 Kernels 1953	Wgt/meas. Bus. 1952	Wgt/meas. Bus. 1953	Comm. Grade 1952	Comm. Grade 1953
Wheat	open pile	501.0	460.5	8.8	27.3	26.5	58.0	58.0	#5	#5
Wheat	covered	501.0	497.5	0.7	30.4	29.7	60.0	60.5	#4	#4
Oats	open pile	511.0	407.0	20.3	26.0	26.1	41.0	40.0	Ext.1	Feed
Oats	covered	419.0	409.0	2.4	26.3	26.4	41.5	40.0	Ext.1	Feed
Barley	open pile	472.0	443.0	8.8	38.9	37.2	47.5	50.0	1 Feed	1 Feed
Barley	covered	388.0	384.0	1.0	37.1	36.7	47.5	47.0	1 Feed	1 Feed

[a]Source: Provided in correspondence with Canada Department of Agriculture Research Brahc, Experimental Farm, Scott, Saskatchewan.

(6) Baled straw or hay and wire ties, and

(7) Open piles.

Sheds are often used as the first alternative, as the building provides adequate shelter from the weather. The temporary wood and plywood bins are simply structures to retain grain by minimizing the surface area exposed.

Snow fencing is often used to encircle open-topped piles. A circular shape is formed with the fencing, with heavy vapor paper or heavy plastic as the lining. Woven wire is used in a similar manner,but requires a stronger lining. In both cases, the circumference used is not generally more than fifty to sixty feet.

Baled hay or straw is used for temporary grain storage construction. The bales are simply placed lengthwise in a circular fashion and bound with wire ties. Several layers can be used, although a height of more than four bales is not recommended.

Finally the grain may be augered into conical piles. Farmers have been observed using this method in areas near the region under study[16]. Polyethylene is usually recommended to serve as a ground sheet, preventing spoilage of the grain layer closest to the ground. In all cases the grain should form a smooth conical top so that little rain damage occurs and it can be covered if possible. This method uses very little labour and investment.

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[16] F. Graves, District Agriculturist, Personal Communication, Spirit River, Alberta, February 1967.

Multipurpose buildings which function as grain storage structures when required are becoming important, although little is known about the magnitude of such storage[17]. The important point is that the above methods provide large storage capacities at low construction costs.

Costs of Ground Storage. Three assumptions are used: (1) the grain is simply piled into conical heaps, (2) the use of ground storage is the resultant of a lack of available storage capacity, that is, farm bins, and (3) the farmer attempts to remove ground stored grain at the earliest opportunity. Ground storage was chosen as it is the simplest method, uses no materials, and because some information is available. The difficulty is that cost is a function of several variables in addition to time. Some of the obvious factors are soil moisture, condition of the grain, geometry of the pile, neatness of the pile, weather, rodents, and kinds of grain. The geometry of the grain piles is important as the ground area covered by grain increases with the square of the radius, and the volume increases as a cubic function of the radius divided by three, given a forty-five degree angle--approximately correct as the angle of inclination of grain. Cost is not a simple function of time but rather a complicated function of time involving other variables. Such a function was only conceptualized, but a simple relationship between time and cost was needed so that ground storage costs could be estimated.

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[17] J.L. Reid, Senior Extension Engineer, Personal Communication, Edmonton, Alberta, April 4, 1967.

An experiment was conducted at the experimental farm at Scott, Saskatchewan as shown in Table XXII. Barley, wheat, and oats were stored in two ways during the period October, 1952, to June, 1953. An open pile with no protection was used as one alternative, while the other method used snow fencing lined with oat sheaves and covered the grain with oat sheaves. The first method resulted in a weight loss of 20.3 percent in oats, 8.8 percent in barley and 8.8 percent in wheat. Barley and oats suffered a decrease in quality, as indicated by a one unit reduction in grade possessed. The loss of weight resulted largely from sprouting and moulding at the bottoms of the piles. The large weight loss in oats was partially due to birds and rabbits which disturbed the conical shape of the pile, possibly a chance phenomenon, and to the kernel shape which allowed water to penetrate rather than run off.

The second method provided surprisingly good protection as the weight loss was 3.4 percent for oats, 1.0 percent for barley, and 0.7 percent for wheat. Oats declined one grade. Little was lost due to birds and rodents, but light loss occurred from moulding and sprouting caused by strong winds shifting the covering sheaves.[18]

These values support an estimate by the District Agriculturist's office at Calgary of a ten percent weight loss in uncovered piles without a ground sheet. It was their hypothesis that little damage occurs if grain is

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[18] The grain that appears to be stored on the ground at minimum cost is barley.

stored a short period of time although fall rains could cause damage. Winter months would involve little damage, but spring breakup would cause considerable damage.

Since the relationship between time and ground storage cost is not known, various hypothetical functions could be used. The relation might be described as an exponential function or as a function in either Common or Naperian logarithms. However, a straight line might predict just as well as other functions. A reasonable function is perhaps a sigmoid-like function. In the following a conical pile without groundsheet or other protection has been assumed. The particular sigmoid-like function assumed is illustrated in Figure 4.

The figure is presented as four linear segments with segments AB and BC determined from the information supplied by the study mentioned above. The slopes were weighted by one and two respectively, that is the rate of damage during March to June is twice that of October to March. The cost of the storage was determined by taking the ten year average of the final realized prices of barley, wheat, and oats and multiplying by the respective weight loss of the grains. Resultant values were then weighed by the ten year average of the types of crops shipped from Census Division number fifteen[19], and summed to provide the composite cost of storing grain on the ground for time AC. The other two segments, OA and CD, were simply determined

[19]These values were not available for the region under study. The data is shown in Appendix II Table LXXXVI.

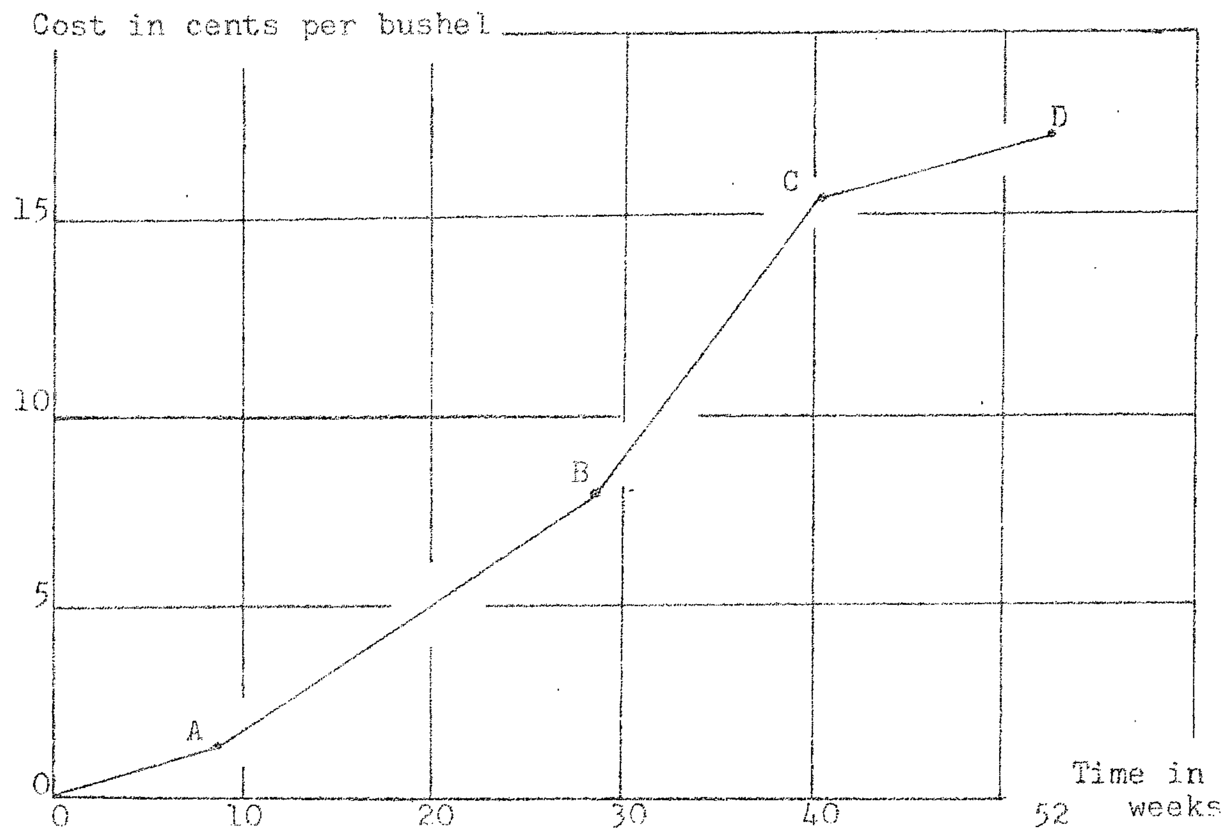

Figure 4. Ground storage as a cost function of time.

by taking one-half of the weekly charge determined for segment AB. The calculations were as follows:

Sum (Percent deterioration of grain i)(Average Price grain i)(Average percent receipts grain i) equals Total Composite cost per bushel equals 14.112, where i equals oats, wheat, and barley, as shown in Table XXIII and Table XXIV.

Cost per week October to March (20 weeks) = (5/11 x 14.112)/20 = .321 cents

Cost per week March to June (12 weeks) = (6/11 x 14.112)/ 12 = .641 cents

Cost per week August to October and June to August = 1/2 (.321) = .160 cents

The total cost of ground storage for one year is thus 17.31 cents per composite bushel.

The computations used the percent loss in weight but did not include the grade loss as the prices were ten year final realized price averages of number one Northern wheat, number two Western oats, and number three Canada six-row barley. This approach was taken as the price change of oats and barley was not considered important when losing a grade, and an upper bound for the cost of ground storage was desired.

The rationale for the procedure is that little deterioration takes place from August to October. Moisture from fall rains or early snow could seep into the pile and allow damage during the period October to March. The high

TABLE XXIII

CANADIAN WHEAT BOARD PAYMENTS FOR #1 NORTHERN WHEAT, #2 CANADIAN WESTERN OATS, AND #3 CANADA 6-ROW BARLEY[a]

(Total Realized Price)

Year	Wheat ($)	Oats ($)	Barley ($)
1955/56	1.609	79.8	108.8
1956/57	1.588	65.0	102.0
1957/58	1.621	67.4	103.3
1958/59	1.596	69.5	100.7
1959/60	1.590	77.1	98.2
1960/61	1.795	74.2	104.5
1961/62	1.910	77.2	128.0
1962/63	1.874	71.8	113.2
1963/64	1.974	69.2	117.8
1964/65	1.887	77.2	126.0
MEAN ($)	1.74	0.73	1.10

[a]Source of Data: Canadian Wheat Board, Report of the Canadian Wheat Board Crop Year 1965-66 (Winnipeg, January, 1967) Appendix, Table XXII, p.19.

TABLE XXIV

COSTS OF GRAIN DETERIORATION FOR GROUND STORAGE[a]

Grain	Deterioration %	Av. Price $	Cost ¢	Crop Prod'n %	Composite Cost ¢
Wheat	8.8	1.74	15.312	0.35	5.35920
Barley	8.8	1.10	9.68	0.20	1.93600
Oats	20.3	0.73	14.819	0.46	6.81674
			TOTAL COMPOSITE COST PER BUSHEL		14.1119

[a]Source of Data: Table XXII and Table XXIII.

rate of deterioration takes place during the spring break-up as shown by segment BC. The remaining segment, CD, is the same rate as postulated in segment OA.

A priori, the intercept should be greater than zero, as there is some grain lost regardless of time due to the problem of removal. The second error lies in segment AB, as the winter months are usually cold enough to prevent most types of damage, and therefore the rate of deterioration might approach zero.

The combination of slope, time, and cost provides a weekly per bushel cost using each hypothesized linear segment as a rectangular distribution. The lack of sufficient information regarding grain losses, and the amount of grain actually stored by such a method limit the preciseness that is desired. The assumptions provide one method, albeit simple, to estimate the upper bound of ground storage costs. More research into the economics and biological aspects of ground storage would be useful.

IV. FARM TO COUNTRY ELEVATORS. HAULING COSTS.[20]

The proposed simulation model requires the estimation of the hauling costs associated with the movement of grain from farm to country elevator. Any change in elevator configuration would affect grain hauling distances and hence hauling costs, and consequently, grain marketing costs.

Trucking Costs. The basic assumption is that farm trucks are essential in the assembly of grain from farm to country elevator. The cost of hauling grain from field to farm bin has not been dealt with explicitly, as grain must necessarily move an initial distance regardless of where the grain is shipped. There are exceptions but the magnitude is unknown.

Truck hauling costs are important when comparing various methods of moving grain. Trucks are competitive with railroads for short distances[21]. However the statutory rail rates for grain and the nature of grain have prevented serious truck competition other than for very short distances[22],

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[20] A Canadian study which deals exclusively with this subject is K.B. Young, An Analysis of the Cost of Assembling Grain by Farm Trucks in Manitoba, Research Report No. 11, Department of Agricultural Economics, University of Manitoba, October, 1966.

[21] R.L. Kohls, Marketing of Agricultural Products (Second Edition; New York: The Macmillan Company, 1961) pp.238ff; E.M. Hoover, The Location of Economic Activity (New York: McGraw-Hill Book Company, Inc., 1948) pp.19-21.

[22] Report of the Royal Commission on Transportation (Queen's Printer and Controller of Stationery: Ottawa, 1962) Vol. 111, p. 48.

that is farm to elevator. The problem is that such limited use of trucks may not be socially appropriate when all social costs are examined.

Assuming such difficulties away, the problem here is to obtain quantitative estimates for grain transport costs. Various approaches, such as budgeting costs or using commercial rates (See Appendix II Tables LXXXVII, LXXXVIII, LXXXIX, and XC), were obtained to provide estimates.

A study by K.B. Young[23] was chosen as a model for data needed here. The costs, as reported by Young, are generally lower than the suggested minimum commercial rates (Appendix II Table LXXXVII), although no truck capacities are indicated for commercial rates. It was decided that Young's costs would be applicable in this study as it deals exclusively with farm trucks, and provides the important dimension of capacity which would otherwise be neglected. Although it cannot be said that Young's estimated costs are equal to the underlying parameters in this study, they do appear reasonable in that good predictions can be made which appeal to a priori reasoning. The pitfalls and limitations of the study have been carefully lineated by Young. The information used is found on page ninety-six of his study. The truck size and cost will be listed under the assumptions of each different configuration.

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[23]Young, op. cit.

Distance. The use of the above mentioned study requires two parameters, namely truck size and distance to the elevator. The first may be assumed in this model, an assumption which can be varied, that is, a design variable. The second, distance, is a parameter that changes with different elevator configurations. The problem of determining distance causes considerable distress as many assumptions must be made which are not wholly realistic. The first assumption is that average distance will serve as an approximation for distance, and that a mathematical formula will provide the necessary average distance. The mathematical methods involve further assumptions (1) that the supply areas has a rectangular road grid requiring that such roads do exist and are homogeneous, and (2) that the supply area has uniform density with respect to crops. Various shapes of the supply area can be visualized such as a circle[24], diamond[25], elongated hexagon[26], or rectangle. The rectangle was chosen as it is simple and provides a shape which is logical in the region where railroads run

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[24]B.C. French, "Some Considerations in Estimating Assembly Cost Functions for Agricultural Processing Operations", Journal of Farm Economics, XLII: 4 (November, 1960), p.771.

[25]Ibid., p.772.

[26]B.G. Lagace, Some Implications of Railway Branch Line Abandonment for Location and Capacity of Country Elevators in Western Canada (Unpublished Master's Thesis, The University of Manitoba, Winnipeg, March 1963), pp. 16-21.

in east-west directions considerable distances apart, and the topography does not permit the hexagonal shape to exist as it does elsewhere. The calculation of average distance travelled leads to the formula: average distance equals the sum of two sides divided by four. (See Appendix II Table XCI for derivation).

The minimum distance between elevator points was determined, shown in Table XXV, and used as the radius to bring each elevator point to a common base line, that is, all elevator points lie on the same east-west line. The values were divided by two, providing the midpoint between the elevators, shown in Table XXVI. The value obtained by adding the mileage between an elevator point and its midpoints, lying to the east and west, provide the east-west dimension of the hypothetical rectangle. The remaining side is found by dividing the land area, that is the number of sections, by the east-west dimension obtained above. The east-west mileages for Grande Prairie and Hythe were slightly extended. Both are large points located at ends of base line, and distances were not clearly established. The adjustment reduces the north-south distance of the respective rectangles, with the major change being made for Grande Prairie. The dimensions and average distances are shown in Table XXVII.

Knowledge of only the total acreages as specified by the permit books at each point, does not provide the information regarding the exact location of farmers, so

TABLE XXV

MINIMUM DISTANCE BETWEEN DELIVERY POINTS IN MILES[a]

	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe
Grande Prairie	8.25				
Dimsdale		6.50			
Wembley			5.50		
Huallen				6.50	
Beaverlodge					9.75

[a]Source: Department Lands and Forests, Alberta (Aerial Survey Section, Technical Division, Edmonton, 1962), Sheets $83\ \frac{m}{2}$, $83\frac{m}{3}$, $83\frac{m}{5}$.

TABLE XXVI

MIDPOINT DISTANCE BETWEEN DELIVERY POINTS IN MILES[a]

	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe
Grande Prairie	4.13				
Dimsdale		3.25			
Wembley	3.25		2.75		
Huallen		2.75		3.25	
Beaverlodge			3.25		4.88

[a]Source: Table XXV.

TABLE XXVII

DIMENSIONS OF RECTANGLE AND AVERAGE DISTANCE
BY DELIVERY POINT 1965[a]

	Midpoint Distance West	Midpoint Distance East	Number of sq.mi.	East-West Distance[b]	North-South Distance[c]	Average Distance[d]
Grande Prairie	4.13	5.87[e]	400.99	10.00	40.10	12.53
Dimsdale	3.25	4.13	60.43	7.38	8.19	3.89
Wembley	2.75	3.25	126.38	6.00	21.06	6.77
Huallen	3.25	2.75	42.25	6.00	7.04	3.26
Beaverlodge	4.88	3.25	281.48	8.13	34.62	10.69
Hythe	5.12[e]	4.88	273.81	10.00	27.38	9.35

[a]Source: Table XXVI and Appendix II Table LXXVI.

[b]Sum of Midpoint Distance West and Midpoint Distance East.

[c]Number of Square Miles divided by East-West distance.

[d]East-West distance plus North-South distance divided by four.

[e]Adjusted.

that the two adjustments are minor. Each elevator point was then located at the geometrical centre of its respective rectangle for simplicity. The dimensions of each rectangle for each point are shown in Figure 5.

The method is not completely satisfactory as the assumptions are restrictive. Some of the more obvious difficulties are nonexistence of some roads, cultivated acreage may be concentrated near elevator points, and minimum distance may not be the only factor influencing farmers to deliver grain to a particular point. Farmers may change delivery points yearly, basing their decision on factors other than minimum distance[27]. The desired distance would be the sum of the actual distances travelled by farmers[28]. Although this method is possible, it would be expensive and perhaps not be useful for predictions. Another general method considered was to use coordinate points for each square mile of land, which required the knowledge of the amount of grain hauled from each particular piece of land, and sum the distance travelled by each farmer. However, data was not available. Any measurement makes various assumptions, and variables such as road conditions and time of hauling may not be easily incorporated but yet be important in determining

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[27] E.B. Riordon, Spatial Competition and Division of Grain Receipts Between Country Elevator Points (Unpublished Master's Thesis, University of Manitoba, February 1965).

[28] R.T. Miller, D. Zasada, and J.W. Channon, "The Economic Base of Central Butte Grain-Growing Region of South-Central Saskatchewan", <u>Canadian Farm Economics</u>, II 6 (February, 1968). pp.22-23.

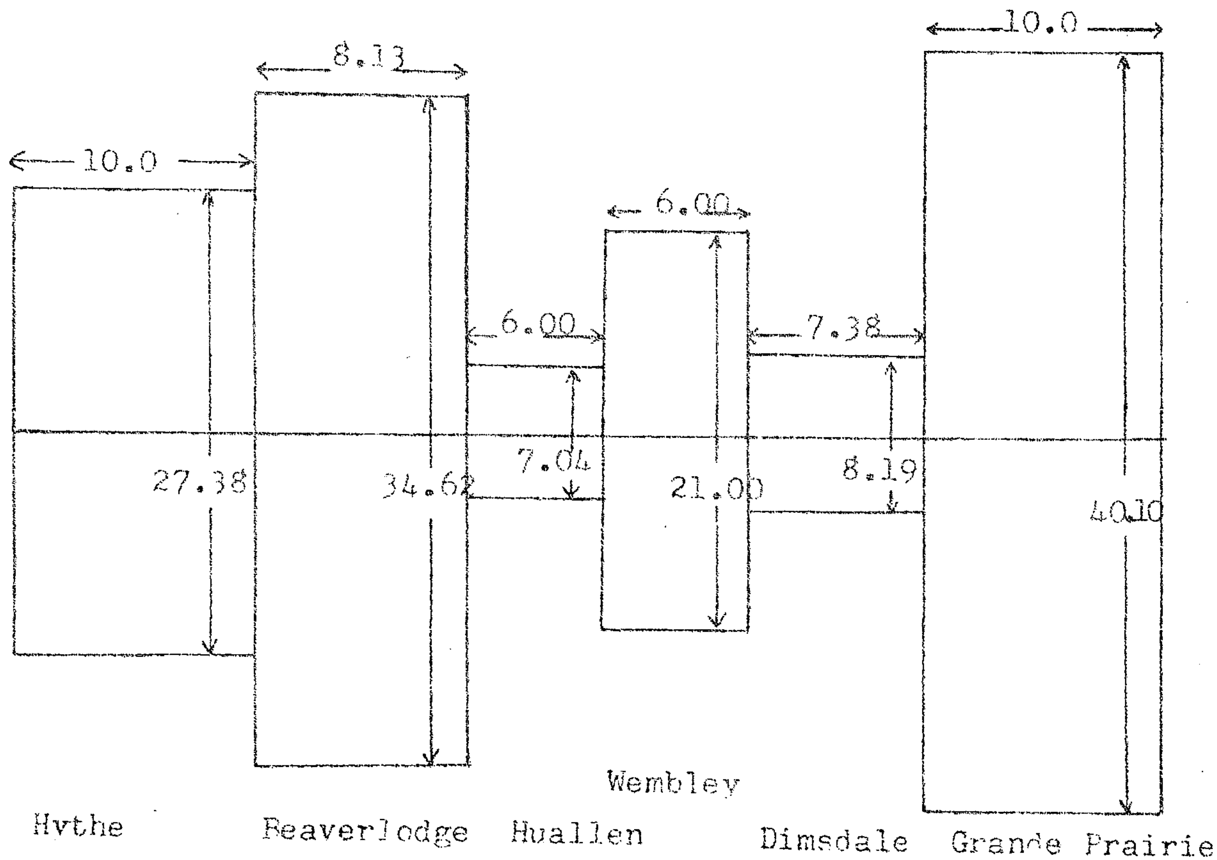

Figure 5. Hypothetical Boundaries of the six areas for use in the simulation model. (Note: all figures in miles).

distance. Thus any method has its limitations and advantages, depending upon the problem to be examined.

The movement of grain from farm to elevator is a complex matter, but a very important one. This study uses two variables, truck capacity and average distance, to obtain the cost of hauling grain by farm truck to the elvator. The truck capacity is an unknown parameter and is set by assumption. The costs of farm trucks have been examined in a study at the University of Manitoba[29]. The average distances are calculated by a very simple formula which is useful in that it uses a minimum of information and may predict as well as other techniques.

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[29]Young, loc. cit.

V. RAIL SHIPMENTS

The simulation model involves the movement of grain through the system. Generally, the grain is shipped from elevator points by rail. Movement of grain by truck from elevator points is considered negligible and the focus is upon railroad box cars. The movement of box cars to elevator points is a complex matter, with several influences acting simultaneously, making it both difficult to understand box car movement and difficult to derive a simulator series of numerical values.

The problem is to find a series of numerical values for each week throughout the crop year for each elevator point. The values would be used in the model to represent the number of bushels of grain moved by rail out of the elevator system. In order to make the simulation as realistic as possible, the values should exhibit a seasonal pattern characteristic of each point, a dimension or size corresponding to the crop size for the year in question, and a variance characteristic of the weekly and yearly shipments for each point.

The only data that was available provided weekly shipments from one elevator company at five stations for ten years. Such information is not sufficient for precise determination of the parameters above. Assumptions were made in order to use the available data. The method is outlined below.

Method

(1) $\sum_{k} S_{ikm} / \sum_{m} \sum_{k} S_{ikm} = \bar{S}_{im}$

(2) $\sum_{i} \bar{S}_{im}/10 = \bar{\bar{S}}_{m}$

(3) $\bar{\bar{S}}_{m}$ (Average Elevator Receipts)$_i$ = R_{mi}

(4) $R_{mi}(C)(Y) = \hat{R}_{mi}$

i = elevator point — i = 1, ..., 5

m = week — m = 1, ..., 52

k = crop year — k = 1955-56, .., 1964-65

$\bar{S}_{im}$ = Average proportion of crop shipped per week per point

$\bar{\bar{S}}_{m}$ = Average proportion of crop shipped per week for all points combined

R_{mi} = Average rail shipment per week per point in bushels

C = Crop size value (See crop production)

Y = Yearly exogenous value

R_{mi} = Rail shipment per week per point in bushels for given year

The yearly exogenous value was determined by finding a frequency function using the yearly rail shipments and yearly elevator receipts for Western Canada for years 1950-51 to 1965-66. The method used was as follows:

(5) Rail Shipment$_k$ - Grain Receipts$_k$ = Deviation$_k$

(6) Deviation$_k$/Rail Shipment$_k$ = $\pm Z_k$

(7) $\pm Z_k + a = \pm \bar{Z}_k(0)$

(8) $\pm \bar{Z}_k(0) + 100. =$ Index (1)

(9) Derive frequency function

k = Crop year

$\pm Z_k$ = relative deviation using rail shipments as base

a = correction factor

$\pm \overline{Z}_k(0)$ = relative deviations with a mean of 0.

Index(1) = Index of number with a mean of one which indicates values greater than or less than the average shipment.

The first step (equation 1) defined for each point the weekly proportion or percentage of grain shipped as an average for the ten years. A weekly average for the combined elevator points was obtained by using equation 2 as shown in Table XXVIII. The third equation was used to convert weekly proportions into bushels per week for each elevator point. Equation 4 was used to increase or decrease weekly shipment through multiplication by a value to indicate an exogenous variable reflecting the availability of box cars. The derivation of the exogenous values are shown in equations 5 to 9. The deviations were divided by rail shipments (equation 6) to indicate the relative deviations. Thus the deviations are expressed in terms of bushel shipments to disassociate the values from elevator receipts. Equations 7 to 9 were used to convert the deviations to an expected value of zero, and then to an index with a mean of one. This index is then used to provide a frequency function for the Monte Carlo techniques as shown in Table XXIX. Seasonal shipment patterns were approximated by

TABLE XXVIII

PROPORTION OF ANNUAL SHIPMENTS MADE EACH WEEK FOR ONE ELEVATOR COMPANY[a]

Week[b]	Proportion	Week	Proportion
1	.022	27	.029
2	.019	28	.012
3	.014	29	.017
4	.010	30	.018
5	.024	31	.015
6	.015	32	.026
7	.013	33	.015
8	.029	34	.018
9	.022	35	.014
10	.025	36	.020
11	.030	37	.016
12	.025	38	.018
13	.029	39	.013
14	.025	40	.015
15	.022	41	.019
16	.026	42	.015
17	.024	43	.018
18	.019	44	.014
19	.026	45	.019
20	.016	46	.018
21	.013	47	.011
22	.031	48	.014
23	.025	49	.010
24	.022	50	.090
25	.028	51	.015
26	.023	52	.015

[a]Source: Individual elevator company data provided by a confidential source and equations 1, 2, 3, and 4.

[b]Week one begins August 1 and week fifty-two ends July 31.

TABLE XXIX

RELATIVE FREQUENCY OF EXOGENOUS RAIL SHIPMENTS FROM AN EXPECTED VALUE OF ONE[a]

Class Width	Midpoint	Frequency	Relative Frequency
.755 - .855	.805	1	.0625
.855 - .955	.905	2	.125
.955 - 1.055	1.05	8	.500
1.055 - 1.155	1.155	4	.250
1.155 - 1.255	1.205	1	.0625

[a]Source: Board of Grain Commissioners for Canada. Annual Report of the Board of Grain Commissioners for Canada. (Ottawa: Queen's Printer and Controller of Stationery, 1951-1966) and Equations 5, 6, 7, 8, and 9.

using the data and manipulating as indicated above. Although a distinct pattern was desirable for each point, a common pattern was used for all six points. Obviously, the shipments from one elevator company for one year was not sufficient to identify all underlying parameters. Such variables as market share, head office decisions, and types of grain handled influenced the available data. The averaging process may yield an appropriate forecast. It is assumed that a seasonal pattern in fact exists, whereas the shipments may be a random process in the real world.

The six elevator points considered in this study lie on the same rail line, and it seemed plausible that the railroad company would attempt to supply box cars to the individual points at one time, rather than supplying cars to each point at different times. The elevator companies probably attempt to distribute shipping orders to their respective elevators at all points to meet competition. The quota system would also be used in such a way as to equalize quotas at these six stations. Although farmer deliveries to the elevator companies and points were not known, it appeared likely that receipts and stocks of grain by variety and grade would be similar in the six points. Of course, these calculated values are only a priori possibilities, and therefore, are assumed to be true until empirical evidence becomes available to prove them false.

The rail shipments were equated to grain receipts.

The first problem was to determine the direction of the causal relationship. It was assumed in the model that crop production and hence elevator receipts determined the size of shipments. This assumption seemed appropriate, at least over a period of several years. The correlation coefficients between total yearly shipments at a point and the receipts at a point were positive although not always significantly nonzero as shown in Table XXX.

With this limited information, it was assumed that the method would adequately predict. However, it was not appropriate to assume that shipments would exactly equal grain receipts at an elevator point. It was thought that variables exogenous to crop production at elevator points exist and affect the size of shipments. Information regarding total grain shipments and total elevator receipts was available, and was used as mentioned in Equations 5 to 9 and Table XXVIII. The distribution of rail shipments with a mean of one was an attempt to indicate variables such as the availability of box cars and the export market.

A series of values have been constructed to represent seasonal patterns of rail shipments, the amount of grain produced, and random fluctuations of yearly shipments. Whether or not these values are representative of historic experience was not of interest. The study required only that the grain move out of the elevator in such a manner as to allow the elevator points to receive historic average grain receipts over a period of n years.

TABLE XXX

MEANS, STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS OF ANNUAL RECEIPTS BY STATION AND SHIPMENTS FOR ONE ELEVATOR COMPANY 1955-56 TO 1964-65[a]

Station	Mean (Bushels)	Standard Deviation (Bushels)	Correlation Coefficients
Grande Prairie	851,100	261,900	.8556*
Elevator Co.	270,800	73,730	
Dimsdale	208,800	64,770	.7320**
Elevator Co.	88,710	26,520	
Wembley	441,800	99,940	.2953
Elevator Co.	141,800	49,650	
Beaverlodge	528,900	154,100	.6666**
Elevator Co.	101,500	72,610	
Hythe	609,000	167,700	.3731
Elevator Co.	199,600	67,940	

[a]Source: Data on elevator points provided by Board of Grain Commissioners for Canada, Statistics Branch, Country Elevator Receipts at Individual Prairie Points Crop Years 1955-56 to 1964-65 (Ottawa: Queen's Printer and Controller of Stationery, 1956 to 1965). Individual elevator company data provided by a confidential source.

*Significant at .01.

**Significant at .05.

VI. HANDLING AND STORAGE COSTS IN COUNTRY ELEVATORS

An estimation of the costs of handling and storing grain at an elevator was required to determine the costs of grain assembly. Two multiple linear regressions were determined for use in this study and use was made of an equation from a Manitoba study[30]. The problem in using these equations was that the cost of handling and storage was aggregated, rather than separated. The present location and capacity of elevators have been largely inherited from the past. The economic rationale involved in the historic development, and in the current operation of the elevator system remains complicated, and largely unresolved, leaving several unanswered questions. A very brief examination of the system is made, followed by an empirical investigation of elevator costs in Alberta.

<u>Viewpoint</u>. The grain marketing system in Canada is sufficiently complicated that the viewpoint taken by the researcher must be clearly defined. The viewpoint of an individual assessing the positive and negative effects of a given system may be different from other individuals or from the community as a whole. The outlook of a firm could differ from that of a provincial or federal authority. Similarly the farmer's viewpoint is probably different from

[30] D. Zasada and Om P. Tangri, <u>An Analysis of Factors Affecting the Cost of Handling and Storing Grain in Manitoba Country Elevators</u> (University of Manitoba, Department of Agricultural Economics, Research Report No. 11, Winnipeg: July, 1967).

that of the Canadian Wheat Board. A negative aspect of the system to farmers could well be of benefit to the grain marketing system or to the nation. The viewpoint taken in this section is usually that of a producer, and little attention is given to the system as a whole, or to the national economy in the sense of cooperation among the firms in the system, or advantages or disadvantages of the present system to the Canadian Wheat Board and railways.

Growth and Development of Country Elevators. The grain marketing system in Western Canada handles the grain as a bulk commodity. This approach to handling was a borrowed American innovation which contributed to a low cost method of handling a large quantity of grain, an important influence in the development of commercial agriculture in Western Canada[31]. The basic techniques remain the same although technical innovations have been made, maintaining Canada's comparative advantage in grain production[32].

The growth in numbers of elevators and points was integrally linked with the growth of operating track mileage of the railroads. The expansion of elevator points reached a peak in the 1930's or early 1940's. Similarly the number of elevators increased until 1933. But the storage capacity is still increasing even though the number of delivery points

[31] D.A. MacGibbon, The Canadian Grain Trade (Toronto: The MacMillan Co. of Canada Ltd., 1932), pp.85-86; A.W. Wood, "Technological Changes in Processing, Marketing and Distribution and their Impact on Canadian Agriculture", Canadian Journal of Agricultural Economics (Vol. X, No. 1, 1962) p.59.

[32] Wood, loc.cit.

and number of elevators are decreasing. The growth of storage capacity was parallel to the number of elevators until 1940, when temporary annexes were built. The large carryover of grain in the 1950's and an Income Tax Regulation providing accelerated depreciation on storage space, spurred a rapid growth of storage capacity. Storage capacity has increased steadily, resulting in a total capacity of 386 million bushels. McLeod has observed:

> It is interesting to note that in 1923-24 a wheat crop of 450 million bushels was handled through elevators having total storage capacity of less than 140 million bushels, yet in 1959-60 a crop of similar size was handled through an elevator system with a total storage capacity of nearly 400 million bushels.[33]

The elevators have been geographically located so that the estimated average length of farm haul is, respectively, 5 3/4, 6, and 7 1/4 miles in Manitoba, Saskatchewan, and Alberta (excluding the Peace River region)[34]. History can be adduced to explain the locations by the distances a horse and wagon could travel in a day. It is also argued that the freight rate structure provided an incentive for firms to build as many elevators in each zone as possible, contributing to the small and numerous firms[35]. The competitive aspect of the elevator business has been mentioned

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[33] A.D. McLeod, "Handling Grain in Country Elevators", _Proceedings of the Grain Transportation Workshop_ (Minaki: Sept. 6-8, 1967), p.43.

[34] J.W. Channon, Towards a Revitalized Economy in Western Canada (unpublished paper presented to Saskatchewan Branch of the Canadian Agricultural Economics Society, Regina, Feb. 16, 1968), p.5.

[35] _Ibid._, p.6.

as an influence in maintaining the current configuration of elevators, as all companies continue to operate uneconomical plants[36].

The elevator industry is primarily engaged in the handling and storing of grain. The extensiveness and importance of sideline activities have not been investigated. The function as a supplier of inputs to primary agriculture may only be a method of spreading overhead, primarily labour, but it could become an integral and important part of the industry.

The handling and storage of grain are the basic services offered by commercial elevators. If the costs of handling and storage are separable, as regulations imply, there is little empirical analysis describing the dimensions of these costs. Rational formulation of economic regulations requires knowledge of these costs. Members of the industry concede that current prices for these services are not in accordance with costs, that is, handling costs are greater while storage costs are lower than regulated charges, resulting in an emphasis being placed on construction of storage capacity[37].

Elevator companies act as agents for the Canadian Wheat Board. Through the system of pooling grain, where price remains constant, the farmers incentive to store grain is destroyed, although the delivery quota prevents the farmers

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[36]McLeod, op.cit., p.45.
[37]Ibid., p.54.

from delivering all grain at harvest[38]. The farmer is forced to build farm storage, although there is no reason why the present elevator system, with or without expansion, could not store grain on behalf of the producer on a large scale basis. The advantages stated for farm storage, however, may explain why elevators do not expressly provide this service or farmers do not use the service.

Finding optimal location of any proposed elevator requires a great deal of information. Exclude all determinants other than that of predicting the amount of grain to be handled and stored, there would remain a complex and detailed analysis. Some of the more important data required for analysis of optimal location are provided in the list below.[39]

(1) Grain Production

(a) Trends in yearly production of the various grains, to provide a guide to future production.

(2) Disposition of Grain Produced

(a) Seed requirements

(b) Feed

(1) Livestock production and trends

(2) Feed requirements for the livestock produced

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[38] Wood, op.cit., p.56.

[39] P.S. Richey and T.D. Johnson, Factors to be Considered in Locating, Planning, and Operating Country Elevators, Production and Marketing Administration, United States Department of Agriculture, Marketing Research Report No. 23 (Washington, U.S. Government Printing Office, June, 1952), pp.67-68.

(c) Amounts and kinds of grain sold from the farm

(1) to elevators

(2) to seed and feed merchants

(3) to local grain processors

(4) to truckers or firms outside the area

(5) to other farmers in the area

(3) Marketing Facilities and Structures

(a) Amounts and Kinds of Storage available

(1) private and public storage capacities

(2) market movement capacity of existing grain handlers

(b) Handling practices for grain currently used

(4) Grain Imports

(5) Grain prices and margins prevailing in the marketing and processing of grain

(6) Seasonal and yearly grain prices to farmers

(7) Seasonal grain harvesting and movement of grain from farm and elevators

(8) Deterioration of grain in storage

These eight determinants would be used to estimate the volume of grain to be handled and stored by the elevator. The list of data requirements is not exhaustive, as the marketing of grain is very complex with the estimation of the input; that is, the volume of grain, being only one part of the knowledge which would be useful in the decision making matrix of elevator location. A more realistic viewpoint might be that of the total system. Such a viewpoint would include the very important aspect of transportation[40].

The country elevator system as it exists today, appears to be suffering a historical misallocation of resources. It appears chaotic, but the rigidity and piecemeal approach of the whole grain marketing system take equal blame for the present difficulties. The elevator companies probably did not act irrationally in the construction of the facilities, but rather responded to economic incentives provided by the rest of the economy. Although there may have been suboptimization within the firms and industry, the industry is suboptimal from the view of the total system, that is, external economies of the system were not captured or dissipated by the individuals composing the system. The situation of today requires extensive change, however it must be recognized that an ideal configuration for conditions of today may not be optimal in the future. Essentially, the dynamic conditions involved makes future planning difficult. Projection of future grain shipments have been made, and the results indicate an approximate increase of 32[41], 52[42], or 62 percent[43]

[40]For a more detailed statement, see Wood, op. cit., p.59; McLeod, op.cit., p.55-57; E.W. Tyrchniewicz and Om P. Tangri, "Grain Transportation in Canada: Some Critical Issues and Implications for Research", Canadian Journal of Agricultural Economics (Vol. XVI, No. 1, 1968); W. Isard, Location and Space-Economy (Cambridge: The M.I.T. Press, 1956), pp.77-119.

[41]H.F. Bjarnason, "Marketing Possibilities for Grain", Proceedings of the Grain Transportation Workshop (Minaki: Sept. 6-8, 1967), p.25.

[42]H.F. Bjarnason, "Projecting Canadian Grain Shipments", Canadian Journal of Agricultural Economics (Vol. XVI, No. 1, 1968), p.77.

[43]Ibid., p.84.

up to a possibility of 87 percent in grain shipments by 1980 over the five year average (1961-1966) of 534 million bushels. Nevertheless these are only forecasts. If capital accumulation is necessary for economic growth, then obsolescence is an integral feature and it becomes difficult to determine in dimensions of time, magnitude, and location, the correct or approximate changes required by the commercial elevator system. Rapid and radical adjustment is not easy, and perhaps not economic due to the length of life of elevators and railway equipment.

Cost Studies in the U.S.A. and Canada. The economic aspects and relationships of country elevators have been reported in several studies in the United States. Although the numerical values are not the parameters for Canada, their general results are probably applicable.

Efficiency of resource allocation in various activities of Kansas country elevators was evaluated to indicate the effects of policy on the industry[44]. A Cobb-Douglas function was fitted by least squares to provide marginal productivities, substitution rates, and returns to scale in a static analysis. Marginal productivities indicated efficiency could be increased by using additional operating expenses and capital services. Transfer of current resources would

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[44] P.L. Kelly, J.H. McCoy, H. Tucker, and V.T. Altau, Resource Returns and Productivity Coefficients in Central and Western Kansas Country Elevators of Modern Construction, Agricultural Exp.Stat. and Kansas State College of Agriculture and Applied Science, Technical Bulletin No. 88 (Manhattan, March, 1957).

not increase efficiency. Increasing returns to scale were evident in sideline and storage activities, whereas constant returns to scale were in evidence in merchandising and total plant functions.

Several studies have involved investigation of cost-volume relationships in country elevators through budgeting analysis of elevators, or by an engineering-economic approach to budget costs. A study in the spring wheat area of the U.S.A. involved engineering estimates and case studies to present a method of allocating costs between elevator functions, and to investigate cost-volume relationships among six elevator models ranging from 100 to 380 thousand bushels capacity[45]. The volume of grain handled and stored was very important in determining costs per bushel. Thus in construction of an elevator, it is better to underestimate than to overestimate volumes, although flexible design should be incorporated to allow for expansion if necessary. Equipment, however, should have a greater capacity than required if increased volume in the future is envisaged. Sidelines were important in preventing under-employment of labour, and in establishing loyal customers. Turnover in relation to capacity and utilization of capacity have an important influence on cost, as does capacity itself. However there was much variation in costs among various types of structures, and cost-volume relationships change at

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[45] F.P. Yager, Country Elevators--Cost-Volume Relations in the Spring Wheat Belt, Farmer Cooperative Service, United States Department of Agriculture, Service Report No. 63 (Washington: Sept. 1963).

different rates for different structures. However, size alone was an important cause of variation in fixed cost. Different sizes of elevators exhibited their own particular advantages and disadvantages, but smaller elevators had a higher storage cost because of a fixed cost per bushel disadvantage. Variable costs were very important in influencing handling costs whereas fixed costs represented a greater proportion in costs of storing. Storage costs ranged from a low of 9.21 cents per bushel year in an elevator with a capacity of 155 thousand bushels and storing a volume of 85,250 bushels to a high of 17.92 cents per bushel year in an elevator using fifty-five percent of its rated capacity (100,000 bushels) for storage. However elevators with capacity of 380 thousand bushels had storage costs ranging from 9.98 to 10.53 cents per bushel year. Merchandising costs per bushel reached a minimum (4.27 cents) for the 380,000 bushel elevator model when a volume of 1,400 thousand bushels were handled. The maximum cost was 15.41 cents per bushel when merchandising 145,000 bushels in a 100,000 bushel elevator. These values were obtained under strict assumptions, and provide only relative estimates.

A study conducted in the Winter Wheat belt using a budget approach involving six elevator models from 20 to 600 thousand bushels capacity provided results similar to those reported in Yager's study[46]. There were definite cost advantages to the largest elevator. In order to operate at

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[46]T.E. Hall, W.K. Davis, and H.L. Hall, New Local Elevators Cost-Volume Relations in the Hard Winter Wheat Belt, Farmer Cooperative Service, United States Department of Agriculture, Service Report No. 11 (Washington: May, 1955).

the same cost per bushel as elevator size increased, the required volume decreased. Storage costs per bushel capacity, when fully utilized, in the large elevator were one half the cost of the small elevator. The researchers also found that variable costs remained relatively constant over the various elevator sizes.

In a more recent study, it was reported that a trade-off exists between size and factors affecting use, of which cost-rate over time is extremely important in the merchandising of grains[47]. However, the rate of substitution was not determined; and it was not suggested what compromise should be made between a large plant for harvest season use and a smaller plant to reduce total annual overhead costs.

MacDonald and MacKay found that even at full utilization, large firms had cost advantages[48]. It was found that two-thirds of the decrease in storage costs occurred between 100,000 and 300,000 bushel elevators when comparing plants from 100,000 to 700,000 bushels. An equation was estimated by linear regression to estimate storage costs.

$$(1)\quad \hat{Y} = 1940.70 + \underset{(.00895)}{.0674X_1} + \underset{(.01388)}{.0378X_2}$$

b_1 significant to 1%

b_2 significant to 5%

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47 V.L. Sorenson and C.D. Keyes, Cost Relationships in Grain Plants, Michigan State University, Agricultural Exp. Sta. & Dept. of Agricultural Economics, Technical Bulletin No. 292 (East Lansing:1963).

48 E.M. McDonald and J.H. McCoy, Costs of Storing Reserve Stocks of Wheat at Country Elevators and on Farms in Kansas, Agricultural Marketing Service, United States Department of Agriculture, Marketing Research Report No. 124 (Washington: June, 1956).

where $\hat{Y}$ = total cost

X_1 = size of elevator R^2 = .8461

X_2 = unused capacity

In a Manitoba study it was reported that the averaged combined cost of handling and storing of grain was 9.54 ± 3.29 cents per bushel[49]. The most important influence in reducing average cost was the increase of handling to capacity ratio although increase in the utilization of capacity and annex-to-capacity ratios was found to reduce cost. The linear regression including interest and depreciation on the pooled observations was:

$$\text{(2) Average cost (\$/bu.)} = .2765 - \underset{(.0051)}{.0777X_1} + \underset{(.0007)}{.0075X_1^2} - \underset{(.0091)}{.0503X_2} - \underset{(.0105)}{.0282X_3}$$

$$R^2 = .793$$

where X_1 = handling to capacity ratio

X_2 = annex to capacity ratio

X_3 = per cent utilization of the elevator

Throughout these studies there was an emphasis on volume, capacity use, and the economies of scale. There exists a trade-off between capacity[50], volume, and utilization with the influences of time interacting. Essentially then, volume is the major influence of cost and the single parameter most useful for adequate planning.

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[49] Zasada, op.cit., pp.70-86.

[50] M.L. Manuel, "Agri-Business Firms Need to Grow", Kansas Agricultural Situation (Vol. XL, No. 11, 1964), pp.4-5.

A 1966 U.S.D.A. publication contains a report of a study involving the cost of handling and storing grain at commercial elevators in the United States by areas, types, and kinds of construction[51]. The average costs for handling and storing grain at country elevators using four categories per bushel costs were reported: (1) Out-of-pocket costs (no interest or depreciation) 6.9 cents; (2) total cost which includes the firms own figures for depreciation and interest 10.4 cents; (3) short-term competitive rates reflecting out-of-pocket cost of the marginal firms 8.0 cents; and (4) long-term competitive rates based on total costs including interest and depreciation on replacement values 13.5 cents. Storage costs alone averaged 5.4 cents per bushel using cost category two and increased to 6.7 cents per bushel by category four. The average cost of receiving grain by truck was 2.1 and 2.3 cents per bushel with cost types two and four respectively. Using the same categories, average costs of 2.9 and 3.2 cents per bushel were reported to load and ship rail cars. Thus, total handling costs--exclusive of storage--were reported to be 5.0 to 6.8 cents per bushel.

Data. Non-random accounting records from 57 country elevators were obtained. The locations of the elevators were geographically dispersed throughout Alberta. All costs were obtained for years 1958-59 and 1964-65 for all

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[51] Costs of Storing and Handling Grain in Commercial Elevators, 1964-65 (Economic Research Service No. 288, United States Department of Agriculture, Washington, 1966).

57 elevators, providing 114 observations. However, not all observations were useable. The reason for the decrease in observations was that not all costs were available for each elevator. The 101 observations were obtained in the category of costs which did not include non-operating costs, whereas the two categories including these costs had 100 observations, as the historic cost of construction was not available for one elevator.

The cost was very similar to Zasada's, and the same definitions of operating and non-operating costs were used[52]. The operating costs, for the Alberta elevators, did not include a share of general head office expenses nor was shrinkage and deterioration included. The method of calculating costs for depreciation and interest on investment was considerably different in the Zasada study from that used in this study[53].

Building costs or acquisition costs were available. The latter would include rent. It was assumed that acquisition costs would approximate building costs for the year of the purchase. Three types of costs were calculated for the elevators: (1) operating costs, (2) standardized depreciation and interest upon original acquisition costs, and (3) replacement costs[54]. Preparation of standardized cost involves an attempt to estimate book costs, that is the value carried on the books. A depreciation rate of 6

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[52]Zasada, op.cit., p.63.

[53]Ibid., pp.64-69.

[54]Economic Research Service No. 288, op.cit., p.1 and 26.

percent for half the original acquisition cost was calculated for each elevator. Replacement costs were determined by using a series of index numbers to update original costs to 1964-65[55]. This method serves as a basis for estimating costs applicable to induce new investment or reinvestment. Interest and depreciation rates were the same as those used in estimating standardized book costs.

The other information which was collected provided throughput, that is the amount of grain shipped out of an elevator in a particular year, and the total capacity of the elevators.

Empirical Results. The combined average cost of storing and handling grain for all elevators was estimated as 14.22 $\pm$ 8.43 cents per bushel, as shown in Table XXXI. This cost includes depreciation and interest on investment on the estimated replacement cost of each elevator. The average cost per bushel as estimated by strata was extremely high for elevators of less than 40,000 bushels capacity, and similar for the stratas 40,000 to 59,999, 60,000 to 99,999 and over 100,000, being 12.06, 12.26, and 12.36 cents per bushel respectively. However, the average cost per bushel decreased as capacity increased when standardized book and operating costs were used. This indicates that a large fixed cost is associated with the replacement costs. The average standardized cost of all elevators was estimated at 9.92 cents per bushel whereas Zasada found an average

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[55] Ibid., p.28.

TABLE XXXI

MEANS AND STANDARD DEVIATIONS OF TOTAL AND AVERAGE COST

BY STRATUM AND COST CATEGORY

Category	Stratum Capacity in Bushels	Mean $	Standard Deviation $	Mean $/bushel	Standard Deviation $/bushel
Replacement Costs	39,999	9,506.10	1,418.70	.1958	.1323
	40,000-59,999	11,094.60	1,872.20	.1206	.0412
	60,000-99,999	14,555.00	3,445.60	.1226	.0489
	100,000	23,502.80	5,910.30	.1236	.0443
	All Elevators	14,453.90	6,364.90	.1422	.0843
Standardized Book Costs	39,999	6,788.50	1,318.20	.1366	.0865
	40,000-59,999	8,471.10	1,585.00	.0926	.0344
	60,000-99,999	10,739.70	2,999.90	.0891	.0349
	100,000	14,134.00	3,247.30	.0706	.0248
	All Elevators	9,931.80	3,632.10	.0992	.0569
Operating Costs	39,999	5,557.50	1,297.20	.1093	.0639
	40,000-59,999	6,288.30	933.50	.0684	.0232
	60,000-99,999	7,457.20	1,826.70	.0641	.0280
	100,000	9,685.70	2,431.40	.0501	.0160
	All Elevators	7,190.70	2,278.10	.0740	.0441

[a]Source of Data: Calculated from data provided by confidential source.

of 9.54 cents per bushel. The throughput to capacity ratio of the stratas were lowest for the large elevators whereas the highest ratio occurred in the strata of 40,000 to 59,999 bushels capacity, as shown in Table XXXII, indicating that a lower average cost could occur in elevators with capacity greater than 100,000 bushels. The average elevator capacity in the sample was 69,848 bushels with a throughput to capacity ratio of 1.93 as shown in Table XXXII.

The equations were estimated for the three types of costs mentioned using all observations. The observations were then stratified into four sub-groups with respect to capacity. These groups were formed by classifying elevators as 0 to 39,999, 40,000 to 59,999, 60,000 to 99,999 and 100,000 or greater bushels capacity. Two equations were selected for use in the model. The equations are presented in Table XXXIII for both pooled and stratified data. One other equation is briefly examined although it was not used in the model.

Estimation of Cost Functions. The technique of linear regression was used to estimate several equations as shown in Appendix II Tables XCII to CVI. Two of these equations were chosen for use in the model. Unfortunately, available data did not conform to the ideal data requirements, implying the possibility of bias and distortion for estimation of the real cost equation[56].

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[56] J. Johnston, Statistical Cost Analysis (New York: McGraw-Hill Book Co., 1960), pp.26-30.

TABLE XXXII

MEANS AND STANDARD DEVIATIONS OF CAPACITY, THROUGHPUT, AND THROUGHPUT/CAPACITY BY STRATUM[a]

Stratum	Variable	Mean	Standard Deviation
All Elevators	Throughput(bus.)	127,637	84,158
	Capacity(bus.)	69,848	38,569
	Throughput/Capacity	1.93	.84
39,999	Throughput(bus.)	63,613	29,045
	Capacity(bus.)	33,074	2,996
	T/C	1.98	1.01
40,000 - 59,999	Throughput (bus.)	100,150	30,372
	Capacity (bus.)	48,652	7,584
	T/C	2.19	.66
60,000 - 99,999	Throughput (bus.)	139,580	65,802
	Capacity (bus.)	48,652	7,584
	T/C	1.90	.87
100,000	Throughput (bus.)	216,262	103,092
	Capacity (bus.)	130,144	24,369
	T/C	1.66	.68

[a]Source of Data: Calculated from data provided by confidential source.

TABLE XXXIII

ESTIMATION OF TOTAL COST AND AVERAGE COST EQUATIONS BY SIZE OF ELEVATOR
Evaluated at Replacement Costs

Stratum (bu.)	R^2	Equation	Obser-vations	F-Ratio
1. All Elevators	.8579	$X_1^a = 3689.9 + .02383\ X_2^b + .11055\ X_3^c$ (2424.2) (.00426) (.00930) 5.5942**** 11.8918****	100	292.7517
2. <39,999	.2883	$X_1 = 130.2 + .01592\ X_2 + .25287\ X_3$ (1245.7) (.00881) (.08537) 1.8075* 2.9619**	27	4.8612
3. 40,000-59,999	.5446	$X_1 = 2110.3 + .02283\ X_2 + .13766\ X_3$ (1325.2) (.00957) (.03831) 2.3869** 3.5929**	23	11.9535
4. 60,000-99,999	.4877	$X_1 = 384.3 + .02571\ X_2 + .14434\ X_3$ (2566.8) (.00811) (.06208) 3.1706**** 2.3250**	27	11.4246
5. >100,000	.6066	$X_1 = 4197.1 + .02627\ X_2 + .10469\ X_3$ (3887.7) (.00949) (.04016) 2.7670*** 2.6066***	23	15.4221
1. All Elevators	.9465	$X_9^d = -3.01609 - 0.23350\ X_2 \quad 0.79288\ X_3 \quad 71.07558\ X_{11}^e$ (.03855) (.07597) (2.14044) -6.05751****10.43626****33.20607****	100	566.1659

TABLE XXXIII (Continued)

Stratum (bu.)	R^2		Obser-vations	F-ratio
2. < 39,999	.9769 2.13713	X_9 = -1.84357 - 0.48472 X_2 + 3.01240 X_3 67.70872 X_{11} (.22698) (1.46989) (3.67216) -2.13554** 2.04940* 18.43840****	27	324.3595
3. 40,000-59,999	.9212 1.24484	X_9 = -0.17655 - 0.23116 X_2 + 1.40533 X_3 + 68.74903 X_{11} .18521 .36230 11.30579 -1.24811 3.87894**** 6.08015****	23	74.0732
4. 60,000-99,999	.8864 (1.75342)	X_9 = 2.60193 - 0.18520 X_2 + .81704 X_3 + 67.95126 X_{11} (.09142) (.42568) (10.86389) -2.02584** 1.91938** 6.25478****	27	59.7977
5. > 100,000	.7351 (2.45135)	X_9 = 2.83405 - 0.10449 X_2 + 0.37162 X_3 123.8894 X_{11} (.12995) (.27771) (48.17792) -.80407 1.33812 2.57150***	23	17.5782

*	.05	a Total Cost in dollars x 1.E-04
**	.025	b Throughput in bushels x 1.E-04
***	.01	c Capacity in Bushels x 1.E-04
****	.005	d Average cost in cents per bushel
		e 1/Throughput in bushels x 1.E-04

The models used were:

X_1 = Total Cost = $f(X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_{10}, X_{11}, X_{12})$

X_9 = Average Cost = $f(X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_{10}, X_{11}, X_{12})$

where X_1 = Total cost
X_2 = Throughput
X_3 = Capacity
X_4 = Throughput/Capacity
X_5 = Throughput^2
X_6 = Throughput^3
X_7 = Capacity^2
X_8 = Capacity^3
X_9 = Average cost
X_{10} = log capacity
X_{11} = 1/Throughput, and
X_{12} = (Throughput/Capacity)^3

The regressors were tried in various combinations, and stepwise regression was used to determine which combinations would provide high coefficients of determination and significant coefficients. The equations were then, of course, individually estimated by least squares[57]. The statistical assumptions of linear regression are quite stringent, and no doubt, there are violations in this study. The most serious problem, in the broad sense, is that of specification[58]. However, the problems were ignored because the theoretical corrections are difficult to apply, and the extent of the bias was unknown.

The first equation explains total cost as linear in throughput and capacity. The estimated equations are shown in Table XXXIII. The coefficients are all significant

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[57] A.S. Goldberger, Econometric Theory (New York: John Wiley & Sons, Inc., 1964) pp. 194-197.

[58] Ibid., pp.192-194, 231-236, 267-272, 282-284; Johnston, op. cit. pp.32-38; J. Johnston, Econometric Methods (New York: McGraw-Hill Book Co. Ltd., 1963), p.229.

at the 0.05 level for all strata. When all observations are pooled, the equation (1) has a coefficient of determination of .8579. However, the total cost within stratas was not as well explained as in the pooled equation. When replacement costs were used, the capacity coefficient was larger than when standardized book costs or non-operating costs were used as shown in Appendix II Tables XCVII to CVI. The average cost curve is L-shaped, and marginal costs are linear and constant. This does not mean that a U-shaped average cost curve could not exist, as costs may rise when firms are very large, but no relevant observations exist. Average cost decreases as throughput increases. Essentially, then, the volume of grain handled and stored becomes the important variable in the reduction of costs. The use of existing elevators would be less expensive than adding to storage capacity.

The second equation explains average cost as a function of throughput, capacity, and the reciprocal of throughput[59]. The estimated equations, shown in Table XXXIII, have very high coefficients of determination. However, the estimated coefficients are not all significant at .05 for all strata. The throughput coefficient is negative, indicating a decreasing average cost as throughput is increased. Interpolation beyond the range of the values in the data is extremely dangerous in this model for average cost can be negative, given sufficient throughput.

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[59]J. Johnston, Statistical Cost Analysis (New York: McGraw-Hill Book Co., 1960), p.12, citing H.T. Davis, The Theory of Econometrics (Bloomington: Principia Press, 1941), p.125.

Average cost as explained by throughput and throughput squared is shown in Table XXXIV. The curves are, of course, U-shaped. The R^2 values are greater for the strata's than for the pooled observations, indicating the lack of a curvilinear relationship in the pooled data. The average cost curves of the two previous models confirm the hypothesis that the pooled data show a decreasing average cost curve which does not increase at extreme levels of throughput, if capacity is held constant. An interesting result of the equations for the four strata was that the minimum average cost would be obtained at throughput to capacity ratios of 3.31, 2.87, 3.47, and 3.45 for strata 2, 3, 4, and 5, respectively. The averages determined from the data were lower than the above ratios. The minimum costs were 5.68, 3.71, 6.53, and 5.72 cents per bushel for stratas 2, 3, 4, and 5, respectively[60].

The difficulty in the interpretation of the results was that the estimated equations do not represent short run or long run cost curves. Both cross-sectional and time series data were used, a procedure which does not provide estimates of the true underlying cost curves. The result is a hybrid curve inadequately representing any theoretical function[61]. The hybrid cost curves do, however, indicate general cost relationships.

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[60] The average capacity in each strata was used.

[61] A.A. Walters, "Production and Cost Functions: An Econometric Survey", Econometrica (Vol. XXXI No. 1-2, 1963), p.48; M. Friediman, Price Theory A Provisional Text (Chicago: Aldine Publishing Co., 1965), pp.139-147.

TABLE XXXIV

ESTIMATES OF AVERAGE COST BY SIZE STRATA USING REPLACEMENT COSTS

		Average Cost[a]		Throughput[b]	Throughput^{2}[c]	F-ratio
1.	All	$.4417\ X_9$	$= 28.29769$	$- 1.58241\ X_2$	$+ 0.02624\ X_3$	38.3670
		6.36652		(.21091)	(.00489)	
				-7.50289	5.36858	
2.	< 39,999	$.8665\ X_9$	$= 62.86898$	$- 10.44568\ X_2$	$+ .47661\ X_5$	77.8723
		(5.03095)		(1.11063)	(.07395)	
				-6.30548	6.44544	
3.	40,000-59,999	$.8440\ X_9$	$= 35.9537$	$- 3.90565\ X_2$	$+ 0.13952\ X_5$	54.1099
		(1.70743)		(.61941)	(.03043)	
				-6.30548	4.58527	
4.	60,000-99,999	$.8157\ X_9$	$= 27.91793$	$- 1.68026\ X_2$	$+ 0.03297\ X_5$	53.1245
		2.18574		(.26496)	(.00795)	
				-6.34149	4.14893	
5.	> 100,000	$.6825\ X_9$	$= 25.83556$	$- 0.89692\ X_2$	$+ 0.01040\ X_5$	21.4967
		(2.6159)		(.20549)	(.00356)	
				-4.36450	2.92272	

[a] Average cost in cents per bushel

[b] Throughput in bushels x 1.E-04

[c] Throughput in (bushels x 1.E-04)^{2}

Empirical Results in the Simulation Model. The first two equations in Table XXXIII were used in the model, as well as the average cost curve estimated by Zasada, Equation 2[62]. The latter equation required the use of the average annex to capacity ratios determined for Manitoba. The handling-to-capacity ratio was determined weekly, and the average computed in the model. The difficulty in use of this variable was that grain moved to the elevators each week in a direct relation to the space available at the elevators, and consequently, the ratio of handling to capacity was greater than that found in the real world.

The model was programmed so that the total capacity of all elevators at a point was used, rather than the capacity of each separate elevator. This simplified the model, and since the grain receipts by each elevator were not known, the aggregation procedure did not involve loss of information.

The average size of elevator for the six shipping points was 90,616 bushels with total capacity of 2,265,400 bushels as shown in Table XXXV. Four elevators at Grande Prairie have an average capacity of 154,375 bushels while Dimsdale, Wembley, Huallen and Hythe have average capacities of 42,667, 87,750, 30,000, 77,683, and 107,133 respectively. The four companies represented at the points are the Alberta Wheat Pool, Alberta Pacific Grain Company[63], National Grain

[62] Zasada, op.cit., p.74.

[63] This elevator company has been amalgamated with Federal Grain Ltd.

TABLE XXXV

ELEVATOR CAPACITIES OF AFFILIATED COMPANIES BY LOCATION, 1965[a]

Station	Affiliation	Capacity (bushels)
Grande Prairie	A.W.P.	110,000
	A.P.G.	137,000
	N.G.L.	136,500
	U.G.G.	234,000
Total	4	617,500
Mean		154,375
Dimsdale	A.W.P.	40,000
	A.W.P.	28,000
	U.G.G.	60,000
Total	3	128,000
Mean		42,667
Wembley	A.W.P.	111,000
	A.P.G.	91,000
	U.G.G.	92,000
	U.G.G.	57,000
Total	4	351,000
Mean		87,750
Huallen	A.P.G.	30,000
	A.P.G.	30,000
Total	2	60,000
Mean		30,000
Beaverlodge	A.W.P.	120,000
	A.P.G.	75,000
	N.G.L.	65,000
	U.G.G.	76,000
	U.G.G.	67,000
	U.G.G.	63,100
Total	6	466,100
Mean		77,673
Hythe	A.W.P.	135,000
	A.P.G.	87,000
	N.G.L.	110,000
	U.G.G.	139,000
	U.G.G.	92,000
	U.G.G.	79,800
Total	6	642,800
Mean		107,133
Total for All Points	25	2,265,400
Mean		90,616

[a]Source: Board of Grain Commissioners for Canada. Grain Elevators in Canada for Crop Year 1965-66 as at August 1, 1965. (Canada Department of Agriculture, Ottawa: Queen's Printer and Controller of Stationery, 1965).

Limited and United Grain Growers Ltd. with 6, 6, 3, and 10 elevators respectively as shown in Table XXXVI. The average size of elevator owned by the respective firms was 90,666, 75,000, 103,833, and 93,990 bushels. The ratio of the ten year average receipts divided by capacity were 1.39, 1.64, 1.25, 1.79, 1.14, and 0.94 for Grande Prairie, Dimsdale, Wembley, Huallen, Beaverlodge, and Hythe respectively as shown in Table XXXVII.

The estimated equations predict that a lower average cost could be obtained by increasing the volume of grain handled, without expanding elevators, and the quadratic functions indicate a throughput-to-capacity ratio of approximately three would be required to minimize average costs. However, if the potential crop is divided by capacity the ratios increase to 3.23, 3.13, 2.27, 4.16, 2.63, and 2.27 for the six points. These larger ratios would decrease average cost. This may indicate that expected grain receipts were based on total crop production.

Carryover or stocks in store at each point and for two companies at five points is shown in Table XXXVIII. The stocks were substantial as indicated by determining the bushels stored per bushel capacity values. They were .60, .79, .84, .83, .74, and .71 for Grande Prairie, Dimsdale, Wembley, Huallen, Beaverlodge, and Hythe respectively while the values for the United Grain Growers were .68, .71, .83, .49, and .64 at the same points. There is no explanation why the latter company has less carryover but would allow

TABLE XXXVI

TOTAL ELEVATOR CAPACITY BY AFFILIATED COMPANIES[a]

Affiliation	Number	Capacity (bushels)	Average (bushels)
A.W.P.	6	544,000	90,666
A.P.G.	6	450,000	75,000
N.G.L.	3	311,500	103,833
U.G.G.	10	939,900	93,990

[a]Source: Board of Grain Commissioners for Canada, Grain Elevators in Canada for Crop Year 1965-66 as at August 1, 1965 (Canada Department of Agriculture, Ottawa: Queen's Printer and Controller of Stationery, 1965).

TABLE XXXVII

ELEVATOR CAPACITY VS. 10 YEAR AVERAGE RECEIPTS AND 10 YEAR CROP POTENTIAL PRODUCTION[a]

Area	Elevator Capacity (Bushels)	10 yr. Average of receipts (Bushels)	10 yr. Potential Crop[b] (bushels)	Receipts/ Capacity	Poten./ Capacity
Grande Prairie	617,500	850,900	1,982,017	1.39	3.23
Dimsdale	128,000	208,821	400,447	1.64	3.13
Wembley	351,000	441,763.5	803,486	1.25	2.27
Huallen	60,000	107,407	255,145	1.79	4.16
Beaver-lodge	466,100	528,888	1,235,977	1.14	2.63
Hythe	642,800	609,020	1,457,230	0.94	2.27

[a] Source: Board of Grain Commissioners, Grain Elevators in Canada for Crop Year 1965-66 as at August 1, 1965 (Canada Department of Agriculture, Ottawa: Queen's Printer and Controller of Stationery, 1965); Data for acreages supplied courtesy of the Board of Grain Commissioners, Unpublished, 1966

[b] Potential crop was determined by multiplying the acres of oats, wheat, barley, flax, and rye by the average yields for Census District 15.

TABLE XXXVIII

TOTAL STOCKS OF ALL GRAINS IN STORE ON JULY 31[a]

Point	Affiliation	Average Total Bushels in Store	Average Bushels in store per bu. capacity
Grande Prairie	ALL[b]	370,667	.60
	A.W.P.[c]	94,646	.86
	U.G.G.[d]	159,402	.68
Dimsdale	ALL	100,778	.79
	A.W.P.	57,577	.85
	U.G.G.	42,356	.71
Wembley	ALL	296,333	.84
	A.W.P.	97,413	.88
	U.G.G.	123,538	.83
Huallen	ALL	49,889	.83
Beaverlodge	All	346,444	.74
	A.W.P	106,933	.89
	U.G.G.	99,971	.49
Hythe	ALL	457,556	.71
	A.W.P.	103,022	.76
	U.G.G.	198,270	.64

[a]Source: Data provided by the courtesy of the Canadian Wheat Board, Alberta Wheat Pool, and United Grain Growers.

[b]All elevators at the point for years 1955, 1957-1964.

[c]Alberta Wheat Pool for years 1957 to 1964.

[d]United Grain Growers for years 1957 to 1964.

farmers to deliver a great deal more grain to this company in the first part of the new crop year.

In this section an attempt has been made to provide a brief background to the elevator industry and its problems. Equations were estimated by linear regression to provide costs of handling and storing grain. Although the industry merits a great deal more analysis and discussion, other authors have covered the subject in greater detail than was warranted here.

CHAPTER VI

RESULTS

The previous chapters have outlined the simulation model, computer model, and the data required in the model. In this chapter, the results from the computer model are presented. Ten runs, that is, experiments, were made using a single factor approach to the sampling. This approach was taken to provide data of possible alternative configurations. The first experiment provides the status quo or benchmark estimate of the cost of grain assembly. The next four focus on the reduction of elevator capacity. The sixth and seventh experiments involved reduction of farm bin space and in the latter, truck size was increased. The remaining three experiments reduce the number of elevator points.

Experiment One. The first run provides the benchmark, that is, the costs of grain assembly as they presently exist. The estimates include the costs as discussed in the previous chapter, including farm bin costs, ground storage costs, farm handling costs, hauling costs, and elevator costs. There are three different total costs associated with the country elevators, defined as
(1) Average cost = f(handling-to-capacity ratio, annex-to-capacity ratio, per cent utilization of the elevator);

(2) total costs = f(throughput, capacity); and (3) Average cost = f(throughput, capacity, 1/throughput), but only the first total elevator cost was used to compute the total cost of grain assembly. The remaining two total costs for country elevators were obtained from estimated equations determined in this study, and provide estimates which are also applicable to country elevator costs. The assumed design variables for the initial run are shown in Table XXXIX. Crop production, rail shipments, crop and rail modifiers, and ground storage costs are presented in the computer model as shown in Appendix I.

The results of run one are presented in Table XL, XLI, and XLII. Grain shipments out of each point are less than the calculated long term average of grain receipts which resulted from a sampling technique involving only fifteen years, rather than a very large number of years. The Monte Carlo technique requires a large sample to provide the full probability distribution, however, all runs employ the same number of years providing comparable estimates. Grain shipments for Dimsdale and Huallen, which are the smallest points in terms of volume of grain, were quite close to the long term average of grain receipts being less than historic averages by 10,000 and 8,000 bushels per year respectively. The other four points are 30 to 40,000 bushels less than the long term average receipts.

TABLE XXXIX

ASSUMED VALUES OF DESIGN VARIABLES FOR THE INITIAL ESTIMATE OF GRAIN ASSEMBLY COSTS

	Grande Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe
Total Elevator Capacity ('00 bu.)	6,175	1,280	3,510	600	4,661	6,428
Number of Elevators	4	3	4	2	6	6
Average Size ('00 bu.)	1,543.75	426.67	877.5	300	766.83	1,071.33
Annex-to-Capacity Ratio[a]	0.621	0.341	0.555	0.056	0.474	0.621
Carryover (bu.)	370,667	100,778	296,333	49,889	346,444	457,556
Farm Storage Capacity	983,477	208,733	464,231	132,357	765,518	712,417
Total Farm Storage Costs ($)	34,803	7,579	16,821	4,640	25,948	25,136
Truck Capacity (bu.)	150	150	150	150	150	150
Average Distance (mi.)	12.5	3.9	6.8	3.3	10.7	9.4
Cost of Hauling (cents/bu.mi.)[b]	.399	.483	.441	.506	.410	.423

[a] D. Zasada and Om P. Tangri, An Analysis of Factors Affecting the Costs of Handling and Storing Grain in Manitoba Country Elevators, University of Manitoba, Department of Agricultural Economics, Research Report No. 13 (Winnipeg: July, 1967), p.99.

[b] K.B. Young, An Analysis of the Cost of Assembling Grain by Farm Trucks in Manitoba, University of Manitoba, Department of Agricultural Economics, Research Report No. 11 (Winnipeg: October, 1966), p.96.

The handling-to-capacity ratios are quite small ranging from 0.614 at Hythe to 1.860 at Huallen. These ratios provide a good summary statistic to describe the volume relationship of country elevators, as the average cost per bushel of grain shipped declines in close correspondence with an increase of this ratio.

The per bushel cost was determined for the three cost estimates by using the number of bushels shipped. The per bushel cost of the country elevators range from a low of 12.40 cents at Huallen to 14.58 cents at Hythe with an average of 14.21 cents for the six areas. The second estimate of elevator cost was greater per bushel and gave more weight to the average size of elevator, that is, a smaller elevator had a greater per bushel cost than a large elevator <u>ceterus</u> <u>paribus</u> unless the volume of grain shipped per bushel capacity was greater in the small elevator. The third estimate of elevator cost was similar to the second estimate in placing emphasis on the average size of elevator. The standard deviations from average cost were lower for the latter two cost estimates.

The hauling costs were proportional to the average distance of the farmers from the country elevator point. The costs ranged from 4.96 cents per bushel at Grande Prairie to 1.67 cents at Huallen.

Farm storage costs were composed largely of fixed costs, and exhibited little variation of average cost per year. The costs ranged from 4.20 cents per bushel at Hythe to 5.74 cents at Grande Prairie.

Farm handling costs showed a great deal of variance for average costs, largely depending upon the amount of grain which could be shipped directly from field to elevator. The cost per bushel ranged from 1.05 to 1.77 at Grande Prairie and Huallen respectively.

Total cost of grain assembly ranged from 20.42 cents per bushel at Huallen to 26.31 cents at Grande Prairie.

The average cost in cents per bushel for all six regions was equal to elevator costs 14.21, hauling 3.89, farm storage 4.90, farm handling 1.37, and total 24.38. The percentage of the overall cost for the four separate costs were elevator 58.3, hauling 16.0, farm storage 20.1, and farm handling 5.6 percent. The total cost of the assembly of grain for the six areas was 9,212,025 dollars in the fifteen year time span used or 618,935 dollars per year. These total costs provide the basis for comparison with alternative configurations.

TABLE XL

SUMMARY OF THE AVERAGES (15 YEARS) OBTAINED FOR THE SIX AREAS (EXPERIMENT 1)[a]

	Grande Prairie	Dimsdale	Wembley	Huallen	Beaverlodge	Hythe
Grain shipments (bus.)	635400	172400	409900	111900	542500	648700
Standard Deviation (bus.)	165000	44770	106400	29060	138100	168400
Handling/Capacity	1.027	1.343	1.167	1.860	1.156	.614
Standard Deviation	.246	.322	.282	.456	.276	.804
Elevator Cost 1 ($)	92540	23760	56320	13880	77220	94320
S.D. ($)	12360	2566	6750	1015	9593	12840
Elevator Cost 2 ($)	98170	29330	63330	116680	86550	108700
S.D. ($)	3931	1067	2536	692	3346	4014
Elevator Cost 3 ($)	100300	29900	58880	18700	80170	99900
S.D. ($)	12610	1629	5385	788	6811	10640
Hauling Cost ($)	31520	3231	12230	1857	23600	25620
S.D. ($)	7026	720	2762	432	5260	5764
Farm Storage Cost ($)	36470	8284	18540	5136	27910	27200
S.D. ($)	747	213	512	137	648	765
Ground Storage Cost ($)						
S.D.						
Farm Handling Cost ($)	6675	2819	6887	1982	7861	8273
S.D. ($)	2988	853	2075	574	2593	3059
Total Cost ($)	167200	38100	93980	22860	136600	155400
S.D. ($)	22700	4233	11800	2043	17700	21970

[a]Calculated from the simulation model.

TABLE XLI

ACCUMULATED TOTALS FOR GRAIN ASSEMBLEY OF THE SIX AREAS

(EXPERIMENT 1)[a]

	Grade Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe	Total
Grain shipment (bus.)	9531000	2586000	6148500	1678500	8137500	9703500	37785000
Elevator cost 1 ($)	1388100	356400	844800	208200	1158300	1414800	5370600
Elevator cost 2 ($)	1472550	439950	949950	250200	1298250	1630500	6041410
Elevator cost 3 ($)	1504500	448500	883200	280500	1202550	1498500	5817750
Hauling cost ($)	472800	48465	183450	27855	354000	384300	1470870
Farm storage cost ($)	547050	124260	278100	77040	418650	408000	1853100
Ground storage cost ($)							
Farm handling cost ($)	100125	42285	103305	29730	117915	124095	517455
Total ($)	2508075	571410	1409655	342825	2048865	2331195	9212025

[a]Calculated from the simulation model.

TABLE XLII

COST PER BUSHEL

(EXPERIMENT 1)[a]

	Grande Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe	Total	
	¢	¢	¢	¢	¢	¢	¢	%
Elevator cost 1	14.56	13.78	13.74	12.40	14.23	14.58	14.21	58.3
Elevator cost 2	15.45	17.01	15.45	14.91	15.95	16.80	15.99	
Elevator cost 3	15.79	17.34	14.36	16.71	14.78	15.44	15.40	
Hauling cost	4.96	1.87	2.98	1.67	4.35	3.96	3.89	16.0
Farm storage cost	5.74	4.81	4.52	4.59	5.14	4.20	4.90	20.1
Ground storage cost								
Farm handling cost	1.05	1.64	1.68	1.77	1.45	1.28	1.37	5.6
Total cost	26.31	22.10	22.93	20.42	25.18	24.03	24.38	100.0

[a]Calculated from the simulation model.

Experiment Two. The variable changed in this run was elevator capacity. The smallest elevator was eliminated from each point giving a new total capacity of 507,500, 100,000, 294,000, 30,000, 403,000, and 563,000 for Grande Prairie, Dimsdale, Wembley, Huallen, Beaverlodge, and Hythe respectively with average elevator capacities of 169,167, 50,000, 98,000, 30,000, 403,000, and 563,000 bushels. Carry-over values were recalculated using 0.6003, 0.7873, 0.8443, 0.8315, 0.7433, and 0.7118 bushels carryover per bushel capacity for the six areas. The results from this new configuration are presented in Tables XLIII, XLIV and XLV. The per bushel cost for the elevator decreased in each area with Dimsdale and Huallen having the greatest reduction in cost largely due to an increased handling-to-capacity ratio whereas the other points showed a cost reduction due to a slight increase in both handling-to-capacity ratio and average size of elevator. The hauling costs remained the same as in experiment one and farm storage costs increased slightly. The farm handling costs increased for each point, a reflection of the smaller amount of grain being shipped directly to the elevator. The percentages of the components forming total cost of the six areas indicate the nature of the change. Elevator costs decrease while hauling costs, farm storage costs, and farm handling costs increase in percentage form. The total cost for the fifteen years was 8,673,030 dollars, 538,995 dollars less than the estimated costs of experiment one.

TABLE XLIII

SUMMARY OF THE AVERAGES (15 YEARS) OBTAINED FOR THE SIX AREAS

(EXPERIMENT 2)[a]

	Grande Prairie	Dimsdale	Wembley	Huallen	Beaverlodge	Hythe
Grain shipments (bus.)	635400	172400	409900	111900	542500	648700
Standard Deviation (bus.)	165000	44770	106400	29060	138100	168400
Handling/Capacity	1.249	1.719	1.391	3.720	1.339	1.149
Standard Deviation	.298	.416	.337	.935	.312	.275
Elevator Cost 1 ($)	83580	20170	50790	7049	69150	88360
S.D. ($)	9033	1396	4735	318	6894	10480
Elevator Cost 2 ($)	82320	22540	53340	9673	75890	96150
S.D. ($)	3931	1067	2536	692	3346	4014
Elevator Cost 3 ($)	92310	22560	51630	10040	71890	92130
S.D. ($)	10440	1282	4540	202	5942	9649
Hauling Cost ($)	31520	3231	12230	1857	23600	25620
S.D. ($)	7026	720	2762	432	5260	5764
Farm Storage Cost ($)	36730	8318	18590	5160	28000	27350
S.D. ($)	747	214	511	135	649	780
Ground Storage Cost ($)						
S.D. ($)						
Farm Handling Cost ($)	7691	2698	7085	2078	8219	8856
S.D. ($)	2988	873	2110	592	2598	3119
Total Cost ($)	159500	34690	88690	16140	129000	150200
S.D. ($)	19250	3007	9805	1060	14900	19570

[a]Calculated from the simulation model.

TABLE XLIV

ACCUMULATED TOTALS FOR GRAIN ASSEMBLEY OF THE SIX AREAS

(EXPERIMENT 2)[a]

		Grande Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe	Total
Grain shipment	(bus.)	9531000	2586000	6148500	1678500	8137500	9703500	37785000
Elevator cost 1	($)	1253700	302550	761850	105735	1037250	1325400	4786485
Elevator cost 2	($)	1234800	338100	800100	145095	1138350	1442250	5098695
Elevator cost 3	($)	1384650	338400	774450	150600	1078350	1381950	3862215
Hauling cost	($)	472800	48465	183450	27855	354000	384300	1470870
Farm storage cost	($)	550950	124770	278850	77400	420000	410250	1862220
Ground storage cost	($)							
Farm handling cost	($)	115365	44520	106275	31170	123285	132840	553455
Total	($)	2392815	520305	1330425	242160	1934535	2252790	8673030

[a] Calculated from the simulation model.

TABLE XLV

COST PER BUSHEL

(EXPERIMENT 2)[a]

	Grande Prairie ¢	Dimsdale ¢	Wembley ¢	Huallen ¢	Beaver-lodge ¢	Hythe ¢	Total ¢	Total %
Elevator cost 1	13.15	11.70	12.39	6.30	12.75	13.66	12.67	55.1
Elevator cost 2	12.97	13.07	13.01	8.64	13.99	14.86	13.49	
Elevator cost 3	14.53	13.09	12.60	8.97	13.25	14.24	10.22	
Hauling cost	4.96	1.87	2.98	1.66	4.35	3.96	3.89	17.0
Farm storage cost	5.78	4.82	4.54	4.61	5.16	4.23	4.93	21.5
Ground storage cost								
Farm handling cost	1.21	1.72	1.73	1.86	1.52	1.37	1.46	6.4
Total cost	25.11	20.12	21.64	14.43	23.77	23.22	22.95	

[a]Calculated from the simulation model.

<u>Experiment Three</u>. Elevator capacity was changed by removing an elevator from each point with the exception of Huallen which remains with one elevator. The new total capacity was 371,000, 60,000, 203,000, 336,000, and 476,000 bushels at Grande Prairie, Dimsdale, Wembley, Beaverlodge, and Hythe respectively with an average capacity of 185,500, 60,000, 101,500, 84,000, and 119,000 bushels. Carryover for each point was recalculated using the same ratio as in experiment two. The results from this alternative configuration are presented in Tables XLVI, XLVII, and XLVIII. The elevator cost on a per bushel basis declines in all five areas although the cost for Beaverlodge and Hythe did not decline as rapidly as Grande Prairie, Dimsdale, and Wembley. The two estimated equations of elevator cost derived in this study gave higher costs per bushel than did the equation derived for Manitoba elevators, except for the second estimated cost for Grande Prairie. Again, the second equation showed the influence of size by estimating a lower per bushel cost for large elevators and the third equation placed greater emphasis on the volume of grain handled, although both the increased size and the handling-to-capacity provide the lower costs. The farm storage cost on the per bushel basis increased slightly due to the additional use of farm bins, as does the farm handling cost increase due to the reduction of elevator space, forcing the farmer to use farm bin storage. The total per bushel cost varies

from 14.43 at Huallen to 22.74 at Grande Prairie. The overall cost for the six areas combined is 20.88 cents per bushel with the percentage of total cost decreasing for the elevator and, correspondingly, increasing for the remaining cost categories. The cost reduction from the current configuration is 1,322,415 dollars for the time period considered.

TABLE XLVI

SUMMARY OF THE AVERAGES (15 YEARS) OBTAINED FOR THE SIX AREAS

(EXPERIMENT 3)[a]

		Grande Prairie	Dimsdale	Wembley	Huallen	Beaverlodge	Hythe
Grain shipments (bus.)		635400	172400	409900	111900	542500	648700
Standard Deviation (bus.)		165000	44770	106400	29060	138100	168400
Handling/Capacity		1.709	2.867	2.081	3.720	1.606	1.359
Standard Deviation		.409	.710	.539	.935	.385	.326
Elevator Cost 1	($)	66920	11940	36160	7049	61050	80230
S.D.	($)	3795	1097	1795	318	4215	7577
Elevator Cost 2	($)	63540	14430	39590	9673	64790	82840
S.D.	($)	3932	1067	2536	692	3346	4014
Elevator Cost 3	($)	76730	13130	38710	10040	62610	83090
S.D.	($)	5079	541	1829	202	4564	7949
Hauling Cost	($)	31520	3231	12230	1857	23600	25620
S.D.	($)	7026	720	2762	432	5260	2764
Farm Storage Cost	($)						
S.D.		759	210	499	135	647	802
Ground Storage Cost	($)						
S.D.							
Farm Handling Cost	($)	8992	3147	7410	2078	8632	9452
S.D.	($)	3037	896	2120	592	2628	3208
Total Cost	($)	144500	26690	74470	16140	121400	142800
S.D.	($)	13260	856	5021	1060	12000	16640

[a]Calculated from the simulation data

TABLE XLVII

ACCUMULATED TOTALS FOR GRAIN ASSEMBLEY OF THE SIX AREAS

(EXPERIMENT 3)[a]

	Grande Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe	Total
Grain shipment (bus.)	9531000	2586000	6148500	1678500	8137500	9703500	37785000
Elevator cost 1 ($)	1003800	179100	542400	105735	915750	1203450	3950235
Elevator cost 2 ($)	953100	216450	593850	145095	971850	124260	4122945
Elevator cost 3 ($)	1150950	196950	580650	150600	939150	1246350	4264650
Hauling cost ($)	472800	48465	183450	27855	354000	384300	1470870
Farm storage cost ($)	555750	125490	280050	77400	421650	412500	1872840
Ground storage cost($)							
Farm handling cost ($)	134880	47205	111150	31170	129480	141780	595665
Total ($)	2167230	400260	1119050	242160	1820880	2142030	7889610

[a]Calculated from the simulation model.

TABLE XLVIII

COST PER BUSHEL

(EXPERIMENT 3)[a]

	Grande Prairie ¢	Dimsdale ¢	Wembley ¢	Huallen ¢	Beaver-lodge ¢	Hythe ¢	Total ¢	Total %
Elevator cost 1	10.53	6.93	8.82	6.30	11.25	12.40	10.45	50.0
Elevator cost 2	10.00	8.37	9.66	8.64	11.94	12.81	10.91	
Elevator cost 3	12.08	7.62	9.44	8.97	11.54	12.84	11.29	
Hauling cost	4.96	1.87	2.98	1.66	4.35	3.96	3.89	18.6
Farm storage cost	5.83	4.85	4.55	4.61	5.18	4.25	4.96	23.8
Ground storage cost								
Farm handling cost	1.42	1.83	1.81	1.86	1.59	1.46	1.58	7.6
Total cost	22.74	15.48	18.17	14.43	22.38	22.08	20.88	

[a]Calculated from the simulation model.

Experiment Four. The change made in this experiment is again, elevator capacity. Dimsdale, Wembley, and Huallen remained the same as in experiment three. Grande Prairie was changed to 280,000 bushels total capacity rather than to 234,000 bushels, the size of the largest elevator in this point. The reason was that the handling-to-capacity ratio which would result would be greater than the observations used in estimating the equations. One elevator was removed from both Beaverlodge and Hythe so that the remaining total capacity was 271,000 and 384,000 bushels respectively with the average elevator capacity being 90,333 and 128,000 bushels. The new carryover values were again recalculated. The results of the experiment are presented in Tables XLIX, L, and LI. The elevator cost on a per bushel basis declined for Grande Prairie, Beaverlodge, and Hythe for all three equations. The hauling costs remain the same as in experiment one, although farm storage and farm handling costs increased due to the increased utilization of farm bins and less direct hauls of grain from the field to elevator. The total cost on a per bushel basis ranged from 14.43 cents at Huallen to 20.54 cents at Beaverlodge with the overall average for the six areas being 19.44 cents per bushel. Again, the percentage of total cost increased for hauling costs, farm storage costs, and farm handling costs and elevator cost decreased. The total combined cost for grain assembly for the fifteen years was 7,343,565 dollars--1,868,460 dollars less than the current configuration.

TABLE XLIX

SUMMARY OF THE AVERAGES (15 YEARS) OBTAINED FOR THE SIX AREAS (EXPERIMENT 4)[a]

		Grande Prairie	Dimsdale	Wembley	Huallen	Beaverlodge	Hythe
Grain shipments (bus.)		635400	172400	409900	111900	542500	648700
Standard Deviation (bus.)		165000	44770	106400	29060	138100	168400
Handling/Capacity		2.263	2.867	2.081	3.720	1.993	1.683
Standard Deviation		.540	.710	.539	.935	.480	.405
Elevator Cost 1	($)	50230	11940	36160	7049	50510	68580
S.D.	($)	3665	1097	1795	318	2213	3951
Elevator Cost 2	($)	49790	14430	39590	9673	53910	68980
S.D.	($)	3932	1067	2536	692	3346	4014
Elevator Cost 3	($)	67130	13130	38710	10040	52170	71910
S.D.	($)	11170	541	1829	202	2587	5096
Hauling Cost	($)	31520	3231	12230	1857	23600	25620
S.D.	($)	7026	720	2762	432	5354	5764
Farm Storage Cost	($)	37270	8366	18670	5160	28220	27660
S.D.	($)	763	210	499	135	669	810
Ground Storage Cost	($)						
S.D.	($)						
Farm Handling Cost	($)	9882	3147	7410	2078	9091	10090
S.D.	($)	3052	896	2120	592	2727	3239
Total Cost	($)	128900	26680	74470	16140	111400	132000
S.D.	($)	8182	856	5021	1060	8710	12500

[a]Calculated from the simulation model.

TABLE L

ACCUMULATED TOTALS FOR GRAIN ASSEMBLEY OF THE SIX AREAS

(EXPERIMENT 4)[a]

	Grande Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe	Total
Grain shipment (bus.)	9531000	2586000	6148500	1678500	8137500	9703500	37785000
Elevator cost 1 ($)	753450	179100	542400	105735	757650	1028700	3367035
Elevator cost 2 ($)	746850	216450	593850	145095	808650	1034700	3545595
Elevator cost 3 ($)	1006950	196950	580650	150660	782550	1078650	3796350
Hauling cost ($)	472700	48465	183450	27855	354000	384300	1470870
Farm storage cost ($)	559050	125490	280050	77400	423300	414900	1880190
Ground storage cost($)							
Farm handling cost ($)	148230	47205	111150	31700	136365	151350	625470
Total ($)	1933530	400260	1117050	242160	1671315	1979150	7343565

[a]Calculated from the simulation model.

TABLE LI

COST PER BUSHEL

(EXPERIMENT 4)[a]

	Grande Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe	Total	
	¢	¢	¢	¢	¢	¢	¢	%
Elevator cost 1	7.91	6.93	8.82	6.30	9.31	10.60	8.91	45.8
Elevator cost 2	7.84	8.37	9.66	8.64	9.94	10.66	9.38	
Elevator cost 3	10.56	7.62	9.44	8.97	9.62	11.12	10.05	
Hauling cost	4.96	1.87	2.98	1.66	4.35	3.96	3.89	20.0
Farm storage cost	5.87	4.85	4.55	4.61	5.20	4.28	4.98	25.6
Ground storage cost								
Farm handling cost	1.56	1.83	1.81	1.86	1.68	1.56	1.65	8.6
Total cost	20.29	15.48	18.71	14.43	20.54	20.40	19.44	

[a]Calculated from the simulation model.

<u>Experiment Five</u>. This experiment concludes the changing of elevator capacities, as Grande Prairie, Dimsdale, Wembley, and Huallen remain the same as in experiment four. The total capacity at Beaverlodge and Hythe is changed by simulating the removal of one elevator from each point, leaving two elevators per point with an average capacity of 98,000 and 137,000 bushels respectively. The total capacity was 196,000 and 274,000 bushels for the two points. Carryover was recalculated for these two points using the ratios given for experiment two. Results of the computer run are presented in Tables LII, LIII, and LIV. The elevator costs on a per bushel basis decreased to 6.23 cents at Beaverlodge and 7.45 cents at Hythe. The two remaining elevator cost estimates were higher as expected. The farm storage and farm handling costs are greater for this run than for the current configuration (experiment one). The total per bushel cost for the six regions varies from 14.43 cents at Huallen to 20.29 cents at Grande Prairie. The combined cost for the six areas was 18.03 cents per bushel which is 6.35 cents less than in experiment one or approximately 26 per cent less than the current configuration. The total combined cost for the fifteen years was 6,810,825 dollars which is 2,401,200 dollars less than value estimated for the current configuration. The percentages are 41.3, 21.6, 27.7 and 9.4 percent for elevator, hauling, farm storage, and farm handling costs.

TABLE LII

SUMMARY OF THE AVERAGES (15 YEARS) OBTAINED FROM THE SIX AREAS

(EXPERIMENT 5)[a]

		Grande Prairie	Dimsdale	Wembley	Huallen	Beaverlodge	Hythe
Grain shipments (bus.)		635400	172400	409900	111900	542500	648700
Standard Deviation (bus.)		165000	44770	106400	29060	138100	168400
Handling/Capacity		2.263	2.867	2.081	3.720	2.751	2.359
Standard Deviation		.540	.710	.539	.935	.676	.568
Elevator Cost 1	($)	50230	11940	36160	7049	33810	48180
S.D.	($)	3665	1097	1795	318	4568	4096
Elevator Cost 2	($)	49790	14430	39590	9673	41930	53130
S.D.	($)	3932	1067	2536	692	3346	4014
Elevator Cost 3	($)	67130	13130	38710	10040	36260	52020
S.D.	($)	11170	541	1829	202	3980	4550
Hauling Cost	($)	31520	3231	12230	1857	23600	25620
S.D.	($)	7026	720	2762	432	5354	5764
Farm Storage Cost	($)	37270	8366	18670	5160	28320	27870
S.D.	($)	763	210	499	135	656	819
Ground Storage Cost	($)						
S.D.							
Farm Handling Cost	($)	9882	3147	7410	2078	9505	10950
S.D.	($)	3052	896	2120	592	2758	3310
Total Cost	($)	128900	26690	74470	16140	95240	112600
S.D.	($)	8182	856	5021	1060	4543	6410

[a]Calculated from the simulation model.

TABLE LIII

ACCUMULATED TOTALS FOR GRAIN ASSEMBLEY OF THE SIX AREAS

(EXPERIMENT 5)[a]

	Grande Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe	Total
Grain shipment (bus.)	9531000	2586000	6148500	1678500	8137500	9703500	37785000
Elevator cost 1 ($)	753450	179100	542400	105735	507150	722700	2810535
Elevator cost 2 ($)	746850	216450	593850	145095	628950	796950	3128145
Elevator cost 3 ($)	1006950	196950	580650	150600	543900	780300	3259350
Hauling cost ($)	472800	48465	183450	27855	354000	384300	1470870
Farm storage cost ($)	559050	125490	280050	77400	424800	418050	1884840
Ground storage cost ($)							
Farm handling cost ($)	148230	47205	111150	31170	142575	164250	644580
Total ($)	1933530	400260	1117050	242160	1428525	1689300	6810825

[a]Calculated from the simulation model.

TABLE LIV

COST PER BUSHEL

(EXPERIMENT 5)[a]

	Grande Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe	Total	
	¢	¢	¢	¢	¢	¢	¢	%
Elevator cost 1	7.91	6.93	8.82	6.30	6.23	7.45	7.44	41.3
Elevator cost 2	7.84	8.37	9.66	8.64	7.73	8.21	8.28	
Elevator cost 3	10.56	7.62	9.44	8.97	6.68	8.04	8.63	
Hauling cost	4.96	1.87	2.98	1.66	4.35	3.96	3.89	21.6
Farm storage cost	5.87	4.85	4.55	4.61	5.22	4.31	4.99	27.7
Ground storage cost								
Farm handling cost	1.56	1.83	1.31	1.36	1.75	1.69	1.71	9.4
Total cost	20.29	15.48	18.71	14.43	17.55	17.41	18.03	

[a]Calculated from the simulation model.

Experiment Six. In this run, farm storage is reduced to 75 per cent of the original farm storage capacity, while elevator capacities, haul costs, and farm handling costs remain the same as in experiment five. The new effective capacity, that is, total bin space minus farm carryover, was 679,695, 142,480, 317,593, 91,920, 539,075, and 493,160 bushels for the areas of Grande Prairie, Dimsdale, Wembley, Huallen, Beaverlodge, and Hythe respectively with the total cost being 26,102, 5,685, 12,606, 19,451, and 18,832 dollars for the same areas.

The results of run six are presented in Tables LV, LVI, and LVII. The difference between run five and run six was 1.12 cents per bushel for the combined per bushel cost of the six areas. There was a small amount of ground storage for the areas of Dimsdale, Wembley, Huallen, and Hythe although the per bushel cost was small being .03 cents to .05 cents, not enough to increase or equal total per bushel cost in the areas. The total cost in each area ranges from 13.39 cents per bushel at Huallen to 18.92 cents at Grande Prairie. The total saving for the fifteen years was 2,831,475 dollars compared to experiment one, and 430,275 dollars less than run five.

TABLE LV

SUMMARY OF THE AVERAGES (15 YEARS) OBTAINED FOR THE SIX AREAS

(EXPERIMENT 6)[a]

		Grande Prairie	Dimsdale	Wembley	Huallen	Beaverlodge	Hythe
Grain shipments (bus.)		635400	172400	409900	111900	542500	648700
Standard Deviation (bus.)		165000	44770	106400	29060	138100	168400
Handling/Capacity		2.262	2.867	2.081	3.720	2.751	2.359
Standard Deviation		.541	.710	.539	.935	.676	.568
Elevator Cost 1	($)	50230	11940	36160	7049	33810	48180
S.D.	($)	3665	1097	1795	318	4568	4096
Elevator Cost 2	($)	49790	14430	39590	9673	41930	53130
S.D.	($)	3932	1067	2536	692	3346	4014
Elevator Cost 3	($)	67130	13130	38710	110040	36260	52020
S.D.	($)	11170	541	1829	202	3980	4550
Hauling Cost	($)	31520	3231	12230	1857	23600	25620
S.D.	($)	7026	720	2762	432	5354	5764
Farm Storage Cost	($)	28570	6427	14310	3965	21830	21400
S.D.	($)	763	140	283	84	656	550
Ground Storage Cost	($)		49	194	40		186
S.D.	($)		3147	468	2078		487
Farm Handling Cost	($)	9882	3147	7410	2078	9505	10950
S.D.	($)	3052	896	2120	592	2758	3310
Total Cost	($)	120200	24800	70300	14990	88740	106300
S.D.	($)	8182	864	5102	1080	4543	6685

[a]Calculated from the simulation model.

TABLE LVI

ACCUMULATED TOTALS FOR GRAIN ASSEMBLEY OF THE SIX AREAS

(EXPERIMENT 6)[a]

	Grande Prairie5	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe	Total
Grain shipment (bus.)	9531000	2586000	6148500	1678500	8137500	9703500	37785000
Elevator cost 1 ($)	753450	179100	542400	105735	507150	722700	2810535
Elevator cost 2 ($)	746850	216450	593850	145095	628950	796950	3128145
Elevator cost 3 ($)	10069500	196950	580650	150600	543900	780300	3259350
Hauling cost ($)	472800	48465	183450	27855	354000	384300	1470870
Farm storage cost ($)	428550	96405	214650	59475	327450	321000	1447530
Ground storage cost ($)		735	2910	600		2790	7305
Farm handling cost ($)	148230	47205	111150	31170	142575	164250	644580
Total ($)	1803030	371910	1054560	224835	1331175	1595040	6380550

[a]Calculated from the simulation model.

TABLE LVII

COST PER BUSHEL

(EXPERIMENT 6)[a]

	Grande Prairie ¢	Dimsdale ¢	Wembley ¢	Huallen ¢	Beaver-lodge ¢	Hythe ¢	Total ¢	Total %
Elevator cost 1	7.91	6.93	8.82	6.30	6.23	7.45	7.44	44.0
Elevator cost 2	7.84	8.37	9.66	8.64	7.73	8.21	8.28	
Elevator cost 3	10.56	7.62	9.44	8.97	6.68	8.04	8.63	
Hauling cost	4.96	1.87	2.98	1.66	4.35	3.96	3.89	23.0
Farm storage cost	4.50	3.73	3.49	3.54	4.02	3.31	3.83	22.7
Ground storage cost		.03	.05	.04		.03	.02	0.1
Farm handling cost	1.56	1.83	1.81	1.86	1.75	1.69	1.71	10.2
Total cost	18.92	14.38	17.15	13.39	16.36	16.44	16.91	

[a]Calculated from the simulation model.

Experiment Seven. Two variables were changed in this computer run. Farm bin storage capacity was halved while farm truck capacity was increased to 500 bushels for each point. The new effective farm storage capacity is 376,113, 76,228, 170,995, 51,483, 312,632, and 273,904 bushels with the yearly fixed cost assessed at 17,385, 3,796, 8,401, 2,317, 12,895, and 12,561 dollars for Grande Prairie, Dimsdale, Wembley, Huallen, Beaverlodge, and Hythe respectively. The hauling cost becomes 0.172, 0.209, 0.191, 0.219, 0.177, and 0.183 cents per bushel mile for the areas as listed above.

The results of run seven are presented in Tables LVIII, LIX, and LX. The per bushel cost for the six regions combined shows a decrease of 3.15 cents from that of experiment six and a decrease of 10.62 cents from that of experiment one, almost one half of the cost. Ground storage costs increased but did not increase to the extent as to raise the combined cost of farm storage and ground storage above that of the farm storage costs of experiment one. The hauling costs were substantially reduced on the average cost per bushel for the region as a whole, from 4.08 to 1.68 cents. The total cost of 5,197,530 dollars is 4,014,495 dollars less than that of experiment one.

TABLE LVIII

SUMMARY OF THE AVERAGES (15 YEARS) OBTAINED FOR THE SIX AREAS (EXPERIMENT 7)[a]

		Grande Prairie	Dimsdale	Wembley	Huallen	Beaverlodge	Hythe
Grain shipments (bus.)		635400	172400	409900	111900	542500	648700
Standard Deviation (bus.)		165000	44770	106400	29060	138100	168400
Handling/Capacity		2.262	2.867	2.081	3.720	2.751	2.359
Standard Deviation		.541	.710	.539	.935	.676	.568
Elevator Cost 1	($)	50230	11940	36160	7049	33810	48180
S.D.	($)	3665	1097	1795	318	4568	4096
Elevator Cost 2	($)	49790	14430	39540	9673	41930	53130
S.D.	($)	3932	1067	2536	692	3346	4014
Elevator Cost 3	($)	67130	13130	38710	10040	36260	52020
S.D.	($)	11170	541	1829	202	3980	4550
Hauling Cost	($)	13590	1398	5296	804	10190	11080
S.D.	($)	3028	332	1252	196	2379	2493
Farm Storage Cost	($)	19540	4256	9426	2625	14760	14260
S.D.	($)	343	29	49	21	117	85
Ground Storage Cost	($)	554	1047	2559	670	1093	3013
S.D.	($)	1203	1189	2903	760	1870	3853
Farm Handling Cost	($)	9882	3147	7410	2078	23600	30420
S.D.	($)	3052	896	2120	592	5354	17890
Total Cost	($)	93800	21790	60850	13230	69360	87480
S.D.	($)	4694	1326	5496	1418	2553	5822

[a]Calculated from the simulation model.

TABLE LIX

ACCUMULATED TOTALS FOR GRAIN ASSEMBLEY OF THE SIX AREAS

(EXPERIMENT 7)[a]

	Grande Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe	Total
Grain shipment (bus.)	9531000	2586000	6148500	1678500	8137500	9703500	37785000
Elevator cost 1 ($)	733450	179100	542400	105735	507150	722700	2810535
Elevator cost 2 ($)	746850	216450	593850	145095	628950	796950	3128145
Elevator cost 3 ($)	1006950	196950	580650	150660	543900	780300	3259350
Hauling cost ($)	203850	20970	79440	12060	152850	166200	635370
Farm storage cost ($)	293100	63840	141390	39375	221400	213900	973005
Ground storage cost ($)	8310	15705	38385	10050	16395	45195	134040
Farm handling cost ($)	148230	47205	111150	31170	142575	164250	644580
Total ($)	1406940	326820	912765	198390	1040370	1312245	5197530

[a]Calculated from the simulation model.

TABLE LX

COST PER BUSHEL

(EXPERIMENT 7)[a]

	Grande Prairie ¢	Dimsdale ¢	Wembley ¢	Huallen ¢	Beaver-lodge ¢	Hythe ¢	Total ¢	Total %
Elevator cost 1	7.91	6.93	8.82	6.30	6.23	7.45	7.44	54.1
Elevator cost 2	7.84	8.37	9.66	8.64	7.73	8.21	8.28	
Elevator cost 3	10.56	7.62	9.44	8.97	6.68	8.04	8.63	
Hauling cost	2.14	.81	1.29	.72	1.88	1.71	1.68	12.2
Farm storage cost	3.08	2.47	2.30	2.35	2.72	2.20	2.58	18.8
Ground storage cost	.09	.61	.62	.60	.20	.47	.35	2.5
Farm handling cost	1.56	1.83	1.81	1.86	1.75	1.69	1.71	12.4
Total cost	14.76	12.64	14.85	11.82	12.78	13.52	13.76	

[a]Calculated from the simulation model.

Experiment Eight. This experiment combines the two points of Wembley and Huallen. One elevator of 203,000 bushels was situated at Wembley, requiring that grain be hauled from the area of Huallen to Wembley, which means that the average distance to the elevator is 7.76 miles for Huallen, raising the cost per bushel mile to 0.431 cents. One other change is made by assuming one elevator at the points of Beaverlodge and Hythe, although the total capacity remains the same. Otherwise, the experiment is the same as run number six, that is, truck size is 150 bushels for each point, elevator capacity remains the same at all points with the exception of Huallen, and farm storage capacity remains the same.

The results are presented in Tables LXI, LXII, and LXIII. Grande Prairie remains the same in run eight as in run six, as does Dimsdale. The per bushel cost of elevators is reduced from run six for Wembley and slightly increased for Huallen, where the costs are prorated by the proportion of grain shipped from each area. The hauling cost is also increased for Huallen, and thus the total per bushel cost was 1.84 cents greater than in run six although 5.19 cents per bushel less than in experiment one due to use of a large elevator with adequate volume--more than compensating for the increased distance. The cost of grain assembly at Wembley declined due largely to the increased use of the remaining elevator. Elevator costs decreased for all three estimates for Beaverlodge due to the increased size of elevator. The first elevator cost estimate for Hythe did not change from experiment six as the first equation does not consider capacity explicitly, rather only through the handling-to-capacity ratios. The latter two estimates, derived for Alberta elevators and discussed in the previous chapter, do take capacity into account and reduce the per bushel cost. The overall average cost per bushel for the region was 16.52 cents which is less than for experiment six, and 7.86 cents less than for experiment one--the estimate for the current configuration. The total cost for the region was 6,240,195 for the fifteen years which is 2,971,830 dollars less than the current configuration, that is, experiment one.

TABLE LXI

SUMMARY OF THE AVERAGES (15 YEARS) OBTAINED FOR THE SIX AREAS

(EXPERIMENT 8)[a]

		Grande Prairie	Dimsdale	Wembley	Huallen	Beaverlodge	Hythe
Grain shipments (bus.)		635400	172400	409900	111900	542500	648700
Standard Deviation (bus.)		165000	44770	106400	29060	138100	168400
Handling/Capacity		2.262	2.867	2.503		2.751	2.357
Standard Deviation		.541	.710	.612		.675	.568
Elevator Cost 1	($)	50230	9521	26740	7296	32020	48180
S.D.	($)	3665	1669	3449	940	4985	4096
Elevator Cost 2	($)	49790	14430	30300	8268	38240	49440
S.D.	($)	3932	1067	2536	692	3346	4014
Elevator Cost 3	($)	67130	13130	30840	8417	34880	63160
S.D.		11170	514	7363	2009	11650	13050
Hauling Cost	($)	31520	3231	12230	3740	23600	25620
S.D.	($)	7026	767	2891	891	5510	5764
Farm Storage Cost	($)	28570	6426	14310	3961	21830	21400
S.D.	($)	763	140	283	91	656	550
Ground Storage Cost	($)		49				186
S.D.	($)		128				487
Farm Handling Cost	($)	9882	3147	7410	2040	9505	10950
S.D.	($)	3052	896	2120	585	2758	3310
Total Cost	($)	120200	24790	60690	17040	86960	106300
S.D.	($)	8182	349	2256	727	4116	6439

[a]Calculated from the simulation model.

TABLE LXII

ACCUMULATED TOTALS FOR GRAIN ASSEMBLEY OF THE SIX AREAS

(EXPERIMENT 8)[a]

	Grande Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe	Total
Grain shipment (bus.)	9531000	2586000	6148500	1678500	8137500	9703500	37785000
Elevator cost 1 ($)	753450	179100	401100	109440	480300	722700	2646090
Elevator cost 2 ($)	746850	216450	454500	124020	573600	741600	2857020
Elevator cost 3 ($)	1006950	196950	462600	127755	523200	947400	3264855
Hauling cost ($)	472800	48465	183450	56100	354000	384300	1499115
Farm storage cost ($)	428550	96390	214650	59415	327450	321000	1447455
Ground storage cost($)		735				2790	3525
Farm handling cost ($)	148230	47205	111150	30600	142575	164250	644010
Total ($)	1803030	371895	910350	255555	1304325	1595040	6240195

[a]Calculated from the simulation model.

TABLE LXIII

COST PER BUSHEL

(EXPERIMENT 8)[a]

	Grande Prairie ¢	Dimsdale ¢	Wembley ¢	Huallen ¢	Beaver-lodge ¢	Hythe ¢	Total ¢	%
Elevator cost 1	7.91	6.93	6.52	6.52	5.90	7.45	7.00	42.4
Elevator cost 2	7.84	8.39	7.39	7.39	7.05	7.64	7.56	
Elevator cost 3	10.56	7.62	7.52	7.52	6.43	9.76	8.64	
Hauling cost	4.96	1.87	2.98	3.34	4.35	3.96	3.97	24.0
Farm storage cost	4.50	3.73	3.49	3.54	4.02	3.31	3.83	23.2
Ground storage cost		.03				.03	.01	.1
Farm handling cost	1.56	1.83	1.81	1.82	1.75	1.69	1.70	10.3
Total cost	18.92	14.38	14.81	15.23	16.03	16.44	16.52	

[a]Calculated from the simulation model.

Experiment Nine. The next step was to combine three points into one large one, leaving four relatively large points. In this experiment Dimsdale shipped all grain to Wembley. The average distance to the elevator point at Wembley was 8.75 miles and the cost per bushel-mile was .423 cents with truck size remaining at 150 bushels. The elevator capacities in all points remains the same as in experiment eight, as do the remaining variables.

The results are presented in Tables LXIV, LXV, and LXVI. All costs remain the same for Grande Prairie, Beaverlodge, and Hythe. The elevator costs, on a per bushel basis, are extremely low, 4.11 cents per bushel using the first estimate and 6.15 cents using the second estimate. The costs are prorated to each area according to the proportion of grain they ship. The third equation becomes useless at such a handling-to-capacity ratio as 3.403, providing negative costs. Hauling costs increase for Dimsdale but not great enough to overwhelm the reduction in elevator costs. Loader (handling) costs increase slightly in Dimsdale and Huallen but not as much as expected, and farm storage costs remain constant. These costs were expected to show greater change possibly indicating the program was insensitive to such changes, or the method of determining these values gave a downward bias. Ground costs were again almost negligible. The total cost was 15.96 cents per bushel, lower than run eight, and 8.42 cents less than run one, resulting from the huge lowering of elevator costs in the points of Dimsdale, Wembley, and Huallen. The total cost for fifteen years was 3,181,830 dollars less than the cost for experiment one.

TABLE LXV

ACCUMULATED TOTALS FOR GRAIN ASSEMBLEY OF THE SIX AREAS

(EXPERIMENT 9)[a]

	Grande Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe	Total
Grain shipment (bus.)	9531000	2586000	6148500	1678500	8137500	9703500	37785000
Elevator cost 1 ($)	753450	105930	252450	68760	480300	722700	2383590
Elevator cost 2 ($)	746850	158700	378300	103065	573600	741600	2702115
Elevator cost 3 ($)	1006950				523200	947400	
Hauling cost ($)	472800	95235	183450	56100	354000	384300	1545885
Farm storage cost ($)	428550	96525	214650	59475	327450	321000	1447650
Ground storage cost ($)		1020	2910	585		2790	7305
Farm handling cost ($)	148230	48390	111150	31170	142575	164250	645765
Total ($)	1803030	347100	764610	216090	1304325	1595040	6030195

[a]Calculated from the simulation model.

TABLE LXIV

SUMMARY OF THE AVERAGES (15 YEARS) OBTAINED FOR THE SIX AREAS

(EXPERIMENT 9)[a]

		Grande Prairie	Dimsdale	Wembley	Huallen	Beaverlodge	Hythe
Grain shipments (bus.)		635400	172400	409900	111900	542500	648700
Standard Deviation (bus.)		165000	44770	106400	29060	138100	168400
Handling/Capacity		2.262		3.403		2.751	2.357
Standard Deviation		.541		.839		.675	.568
Elevator Cost 1	($)	50230	7062	16830	4584	32020	48180
S.D.	($)	3665	1708	4069	1109	4985	4096
Elevator Cost 2	($)	49790	10580	25220	6871	38240	49440
S.D.	($)	3932	1065	2539	692	3346	4014
Elevator Cost 3	($)	67130				34880	63160
S.D.	($)	11170				11650	13050
Hauling Cost	($)	31520	6349	12230	3740	23600	25620
S.D.	($)	7026	1560	2890	913	5510	5764
Farm Storage Cost	($)	28570	6435	14310	3965	21830	21400
S.D.	($)	763	126	283	84	656	550
Ground Storage Cost	($)		68	194	39		186
S.D.	($)		170	468	97		487
Farm Handling Cost	($)	9882	3226	7410	2078	9505	10950
S.D.	($)	3052	909	2120	592	2758	3310
Total Cost	($)	120200	23140	50970	14410	86960	106300
S.D.	($)	8182	1016	1707	555	4116	6439

[a]Calculated from the simulation model.

TABLE LXVI

COST PER BUSHEL

(EXPERIMENT 9)[a]

	Grande Prairie ¢	Dimsdale ¢	Wembley ¢	Huallen ¢	Beaver-lodge ¢	Hythe ¢	Total ¢	Total %
Elevator cost 1	7.91	4.10	4.11	4.10	5.90	7.45	6.31	39.0
Elevator cost 2	7.84	6.14	6.15	6.14	7.05	7.64	7.15	
Elevator cost 3	10.56				6.43	9.76		
Hauling cost	4.96	3.68	2.98	3.34	4.35	3.96	4.09	25.6
Farm Storage cost	4.50	3.73	3.49	3.54	4.02	3.31	3.83	24.0
Ground storage cost		.04	.05	.03		.03	.02	.1
Farm handling cost	1.56	1.87	1.81	1.86	1.75	1.69	1.71	10.7
Total cost	18.92	13.42	12.44	12.87	16.03	16.44	15.96	

[a]Calculated from the simulation model

<u>Experiment Ten</u>. The purpose of this experiment was to determine the costs of grain assembly when all points except one are closed down. The point chosen to remain open was Grande Prairie, the eastern boundary of the region. The average distances to the elevator points were 12.53, 10.75, 20.65, 23.14, 37.70, and 45.53 for Grande Prairie, Dimsdale, Wembley, Huallen, Beaverlodge and Hythe respectively with a per bushel mile cost of 0.399, 0.410, 0.371, 0.363, 0.298 and 0.298 cents. The latter two costs were the rates as recommended by the Alberta Motor Transport Association. The capacity of the elevator point at Grande Prairie was 900,000 bushels with an average of 300,000 bushels per elevator.

The results of the experiment are presented in Tables LXVII, LXVIII, and LXIX. The per bushel cost for elevators was 5.82, 6.77 and 7.53 cents for the three cost estimates. The farm storage, farm handling, and ground storage costs remain similar to those of the last two experiments. Hauling costs increase as the distance increases and become the major cost of grain assembly. The total per bushel costs for points other than Grande Prairie are greater than the costs associated with all experiments excluding runs one and two. Even in run two the costs are lower for Huallen, although otherwise greater for the other points. However, the costs are less for each point in the region under this configuration than for the current configuration, that is, experiment one. The saving in total cost over the fifteen years is 1,580,175 dollars giving a per year cost of 20.20 cents versus 24.38 cents for experiment one.

Ten experiments were made to determine a small part of the response surface. The response surface was not fully explored as the permutations and combinations that could be examined would take a great deal of time. The per bushel cost for the region are presented in Figure 6 for the ten experiments. A very brief description accompanies each experiment to provide a quick summary of the results of the experiments made in this chapter. In this chapter grain assembly costs were estimated for ten different configurations. Results of each experiment are summarized and presented in three tables to indicate the yearly averages, variation, total costs, and cost per bushel.

TABLE LXVII

SUMMARY OF THE AVERAGES (15 YEARS) OBTAINED FOR THE SIX AREAS

(EXPERIMENT 10)[a]

		Grande Prairie	Dimsdale	Wembley	Huallen	Beaverlodge	Hythe
Grain shipments (bus.)		635400	172400	409900	111900	542500	648700
Standard Deviation (bus.)		165000	44770	106400	29060	138100	168400
Handling/Capacity		2.793					
Standard Deviation		.682					
Elevator Cost 1	($)	37020	10050	23860	6508	31480	37700
S.D.	($)	5849	4196	3770	1028	4974	5955
Elevator Cost 2	($)	43100	11690	27770	7574	36640	43880
S.D.	($)	3933	1068	2537	692	3347	4009
Elevator Cost 3	($)	47970	13010	30910	8135	40790	48840
S.D.	($)	14650	3972	9440	2499	12460	14910
Hauling Cost	($)	31520	7462	31240	9345	60440	80740
S.D.	($)	7026	2044	7579	2241	14130	27150
Farm Storage Cost	($)	28580	6281	14330	3963	21830	21430
S.D.	($)	759	106	263	89	656	503
Ground Storage Cost	($)		820	241	33		235
S.D.	($)		1045	560	84		593
Farm Handling Cost	($)	9882	3449	7570	2051	9520	11210
S.D.	($)	3052	895	2163	588	2759	3358
Total Cost	($)	107000	28060	77240	21900	123300	151300
S.D.	($)	5233	3706	10310	1971	12720	18340

[a]Calculated from the simulation model.

TABLE LXVII

ACCUMULATED TOTALS FOR GRAIN ASSEMBLEY OF THE SIX AREAS (EXPERIMENT 10)[a]

	Grande Prairie	Dimsdale	Wembley	Huallen	Beaver-lodge	Hythe6	Total
Grain shipment (bus.)	9531000	2586000	6148500	1678500	8137500	9703500	37785000
Elevator cost 1 ($)	555300	150750	357900	97620	472200	565500	2199270
Elevator cost 2 ($)	646500	175350	416550	113610	549600	658200	2559810
Elevator cost 3 ($)	719550	195150	463650	122025	611850	732600	2844825
Hauling cost ($)	472800	111930	468600	140175	906600	1211100	3311205
Farm storage cost ($)	428700	94215	214950	59445	327450	321450	1446210
Ground storage cost ($)		12300	3615	495		3525	19935
Farm handling cost ($)	148230	51735	113550	30765	142800	168150	655230
Total ($)	1605030	420930	1158615	328500	1849050	2269725	7631850

[a]Calculated from the simulation model.

TABLE LXIX

COST PER BUSHEL

(EXPERIMENT 10)[a]

	Grande Prairie ¢	Dimsdale ¢	Wembley ¢	Huallen ¢	Beaver-lodge ¢	Hythe ¢	Total ¢	%
Elevator cost 1	5.83	5.83	5.82	5.82	5.80	5.83	5.82	28.8
Elevator cost 2	6.78	6.78	6.77	6.77	6.75	6.78	6.77	
Elevator cost 3	7.55	7.55	7.54	7.27	7.52	7.55	7.53	
Hauling cost	4.96	4.33	7.62	8.35	11.14	12.48	8.76	43.4
Farm storage cost	4.50	3.64	3.50	3.54	4.02	3.31	3.83	19.0
Ground storage cost		.48	.06	.03		.04	.05	.2
Farm handling cost	1.56	2.00	1.85	1.83	1.75	1.73	1.73	8.6
Total cost	16.84	16.28	18.84	19.57	22.72	23.39	20.20	

[a]Calculated from the simulation model.

Experiment Ten

Elimination of five points.
Grande Prairie remains
with elevator capacity
of 900,000 bushels
Cost: 20.20 ¢/bu.

Experiment Nine

Elimination of two points.
Reamining three points as in Experiment Six.
Cost: 15.96 ¢/bu.

Experiment Eight

Elimination of one point.
Remaining four points
as in Experiment Six.
Cost: 16.52 ¢/bu.

Experiment Seven

Increase truck capacity
to 500 bushels.
Decrease farm storage
capacity by one-half.
Elevator capacity
as in Experiment Six.
Cost: 13.76 ¢/bu.

Experiment One

Current configuration.
Cost: 24.38 ¢/bu.

Experiment Six

Reduce farm storage
capacity by 75%.
Elevators as in
Experiment Five.
Cost: 16.91¢/bu.

Experiment Two

Eliminate six elevators.
Cost: 22.95 ¢/bu.

Experiment Three

Eliminate eleven elevators.
Cost: 20.88 ¢/bu.

Experiment Four

Eliminate twelve elevators
and reduce capacity
at Grande Prairie to
280,000 bushels.
Cost: 19.44 ¢/bu.

Experiment Five

Eliminate fourteen elevators
leaving Grande Prairie
at 280,000 bushels.
Cost: 18.03 ¢/bu.

Figure 6. The ten experiments and estimated cost per bushel for the region of grain assembly as determined by the simulation model.

CHAPTER VII

SUMMARY AND IMPLICATIONS FOR FURTHER RESEARCH

The previous chapters have involved examination of the general background of the grain trade, the computer model, the costs used for the components in the simulation model and estimated the costs of grain assembly for alternative configurations. The number of alternative configuations is infinite, and rather than using a sampling method to examine the response surface of costs, selected alternatives were chosen largely with respect to the assumed feasibility of achieving any given alternative under real world conditions. A good deal of attention was focused upon the country elevators since their operation costs constitute a large portion of the total assembly costs, and since more information was available about the elevators than other components and since the information was reliable, and decisions regarding farm storage relied heavily upon the size and behaviour of elevators. Little experimentation was attempted with trucking costs, as the choice of truck size is interrelated with other farm management decisions. It was noted that an increase of truck capacity did decrease assembly costs, and that additional costs rising from increased distance could be partially compensated by using larger trucks. This brings in many questions regarding the use of average distance, roads, and commercial truck service which are recognized but not dealt with. In examining farm storage an assumption was used regarding the costs of a specific storage bin, because there was a great deal of ignorance concerning the use, types and costs of alternative bins.

It was assumed that farm handling costs remained constant throughout the experiment. Variations in ground storage costs were minor throughout, thus no trade-off between farm bins and ground storage was established. This may indicate that farmers have more farm bin space than optimum, or the assumptions regarding the temporal distribution of off-farm grain shipments were not wholly correct.

The reduction of the number hence the capacity of the elevators was examined in the first five experiments. The results confirmed that the null hypothesis of an efficient system could be rejected, and lower costs resulted simply by reducing the number of elevators. The estimated total assembly costs on a per bushel basis were 24.38 cents for the current configuration (run one), 22.95 cents for experiment two, 20.88 for the third run, 19.44 cents for the fourth experiment, and 18.03 cents under the fifth set of assumptions. The number of elevators left was 1, 1, 2, 1, 2, and 2 at the points of Grande Prairie, Dimsdale, Wembley, Huallen, Beaverlodge, and Hythe respectively which operated at handling-to-capacity ratios of two or greater. On a yearly basis, the savings would be 35,933, 88,161, 124,564 and 160,080 dollars for the region as compared to the current configuration for experiments 2, 3, 4, and 5 respectively. If the choice criterion were to have involved the second estimate of costs to minimize the total cost of grain assembly, the per bushel costs would have been higher, but the savings would have been of roughly the same magnitude. The costs could have been further reduced by decreasing still further the total capacity of elevators, but it was thought that results indicated the general direction of movement toward optimum.

The next reduction of costs occurred by reducing the amount of farm storage to 0.75 of the original capacity which reduced the per bushel cost to 16.91 cents, and a yearly saving 188,765 dollars over the current configuration or 28,685 dollars over experiment five. The next step was to decrease farm capacity by half of the original capacity which brought the total per bushel cost for the region down by 1.25 cents to 15.85 cents. Truck size was increased to 500 bushels which reduced the total cost to 13.76 cents per bushel, the result of experiment seven.

The final three experiments were concerned with the amalgamation of elevator points. Runs eight and nine were concerned with the elimination of the small points Dimsdale and Huallen. Huallen was eliminated by simulating shipment of all grain to Wembley, decreasing the per bushel costs for the region and for Wembley. Although the cost to Huallen was more than in run two, the increased hauling costs were not sufficient to overcome cost savings in Wembley. A greater reduction on a per bushel basis would have occurred if the second elevator costs estimate would have been used to calculate total costs of grain assembly. Nevertheless, the method of estimating total cost indicated a decline in costs for the region when a small shipping point was eliminated.

The additional elimination of Dimsdale as a shipping point by simulating movement of all grain to Wembley, further reduces the cost of grain assembly in the region. The combination of Huallen, Dimsdale and Wembley yields a large handling-to-capacity ratio. Unfortunately, the elevator cost function was not well specified for high handling-to-capacity ratios so extensive amalgamation of elevator points cannot be accurately explored if capacities are held constant. The per bushel costs of elevators were very low, 4.10 cents, which reduces the total grain assembly costs for the three areas, and the total cost for the region. However, the indication is that costs would be reduced by amalgamation of points, and the reduction of elevator costs would compensate for the greater hauling costs.

The next experiment, run ten, which simulated shipment of all grains to one point, Grande Prairie, provided surprising output. Total grain assembly costs were less than for those for the current configuration. Elevator capacity was extrapolated beyond the observations used in estimating the cost equations, and a low cost was incurred by the elevators. A capacity of 900,000 bushels was chosen to approximately coincide with the elevator capacity proposed in an elevator rationalization scheme by Barnett-McQueen Company, Ltd.[1] In their study, the elevator was to be 925,000 bushels with an average turnover of three. The annual cost of operating an elevator was estimated at 137,812 dollars, using a construction cost of 1.25 dollars per bushel capacity. Using Zasada's estimate, the comparable cost was 146,618 dollars and the second estimate of cost, determined in this study was 170,654 dollars. Using the second equation for elevator costs and assuming an average capacity of 900,000 bushels reduces the total elevator cost to 163,200 dollars. All estimates in this study are greater than the Barnett-McQueen estimates, so that results reported here may be thought to be conservative. The cost could have been further reduced by assuming less farm storage capacity, and larger farm trucks. The validity of simply reducing costs by the above methods yields questionable basis for policy though more spectacular results could have been obtained.

The timing of rail shipments and location of elevator points was not studied. In the first case,

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[1] V.B. Cook, _A Paper on the Grain Industry of Manitoba-Saskatchewan-Alberta_ Fort William: Barnett-McQueen Company Limited, Engineers and Constructors, December, 1962).

elevator costs were not sensitive to the abrupt changes in the timing of operations, the feasible rates of handling were not known, the storage costs were not known for an elevator, and little was known regarding the farmer's reaction to changes in shipments. The relocation of elevator points was conceptually possible, but perhaps infeasible. At any rate no examination of adjustment paths or policies was undertaken.

No strong statements can be made regarding the results as the model is heuristic, that is, it aids in discovery but no proof is provided for the correctness of the outcome. The first hypothesis, that simulation would be a useful technique to study grain assembly, was accepted. The technique appears to be a very rich way of examining the grain assembly problem. The quantity of data required for an adequate model used for prediction and control was not determined.

The second hypothesis that grain assembly in the region is efficient could be negated assuming that the results adequately reflect the costs involved in grain assembly. The second part of the hypothesis could also be negated as changes in truck size, elevator capacity, farm storage capacity, and hauling distance provided a lower cost under the assumptions used in the experiments. As explained previously, temporal changes in rail shipments were not examined, leaving a part of the hypothesis untested.

There is likely a dichotomy between the accounted costs in the study and costs that would be incurred by the real system. No apology is given for the divergence, if any, as a considerable amount of work remains to be done if such costs are to be found and examined. One further limitation of the study was that conceptually the study involves partial equilibrium. Ideally, the whole grain marketing system would be examined for the interdependent relations rather than one small region. For instance, the reduction of elevator capacity lowered costs, but what would be the consequences to the Wheat Board, railways, and national economy? Greater amounts of commercial storage space might then be advocated under a global analysis rather than the reduction of capacity as suggested here.

The regional system might be considered inefficient from the viewpoint of this study. The reduction of elevator space, reduction of the number of points, and increase of truck size reduced costs. The increased distance to elevators did not result in increased costs, but rather a decrease took place by increased use of given elevators. This indicates that a good deal of change can take place, and be of benefit to the farmer and even to elevator companies. The question of compensation or the accrual of these savings and their distribution was not considered. The effect upon railroads was not examined nor was the effect to elevator companies examined. The important point is that a great deal of research into the problems of grain marketing would be fruitful for all parties concerned, and all parties must be willing to cooperate. Objectives must be defined explicitly, and all aspects examined to adequately cope with problems and suggest feasible and profitable change.

This study was concerned with the movement of grain from the farmer to the box car. A simple simulation model was built and used to examine alternative configurations. The results indicated that savings could occur under different configurations. The method of effecting the alternatives and the feasibility of the alternatives was not examined. Further research is required, not only for the implementation, but from a broader viewpoint, examining all aspects of the grain trade.

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APPENDIX I

FORTRAIN PROGRAM OF THE SIMULATION MODEL

OF GRAIN ASSEMBLEY

PLEASE RETURN TC FORESTRY/AGRICULTURE BUILDING

JOB NUMBER 01007 CATEGCRY F USER'S NAME- R GROUNDWATER USER'S PROJECT-

JOB START 11HRS 00MIN 45.3SEC V9M011 OFF-LINE BG366 DATE 08/01/68

```
$JCB   C1CC7       GRCUNDWATER

$FORTRAN

                    DIMENSION IFWK(6),ICWK(6),FCOEF(6),SMCD(100),FCAROV(6)
                    DIMENSION CRAP(6,52),SR(6,52),ITEMP(25)  ,SHMOD(6),CAROV(6)
                    DIMENSION CROP(6,52),CSA(6),FBA(6),RS(  52),       HC(6),FSC(6)
                    DIMENSION         S UM(6),SUM1(6),SUM2(6),IGT(6)
                    DIMENSION X2(6) ,ELCAP(6),AA(6)
                    DATA X2/.621,.341,.555,.056,.474,.621/
                    DATA SHMOD/3.665,1.0,2.377,.649,3.136,3.762/
                    DATA FCOEF/34803.,7579.,16821.,4640.,25948.,25136./
                    DATA FCAROV/0.,C.,0.,0.,0.,0./
                    DATA ELCAP/15437.5,4266.7,8775.0,3000.0,7768.3,10713.3/
                    DATA AA/4.,3.,4.,2.,6.,6./
                    DUMMY=RANDN(.1234561)
              C
              C     CROPS AND RAIL SHIPMENTS READ AND STORED IN WEEKS
              C
                    DO 50 I=1,6
                    READ(5,1)(CROP(I,J),J=1,52)
                    WRITE(6,3)(CROP(I,J),J=1,52)
                    DATA CAROV/37066.7,10077.8,29633.3,4998.9,34644.4,45755.6/
           50       CONTINUE
                    READ(5,1)RS
                    WRITE(6,1)RS
            1       FORMAT(13F6.1)
                    READ(5,2)CSA,FBA,      FSC,SMOD
                    WRITE(6,2)CSA,FBA,FSC,SMOD
              C
              C     CSA-COMMERCIAL STORAGE AVAILABLE
              C     FBA-FARM BINS AVAILABLE
              C     RS- RAIL SHIPMENTS/WK
              C     CROP-CROP/WEEK
              C     FC-ELEVATOR COSTS
              C     GC-HAUL COSTS
              C     FSC- FARM STORAGE COSTS
              C     GSC-GROUND STORAGE COSTS
              C     CS-COMMERCIAL STORAGE PRESENTLY AVAILABLE
              C     IGT- GROUND TIME IN WEEKS FOR FIELD STORAGE
              C     KROP -VARIBLE CROP
              C     IFWK- NO.WEEKS IN FARM STORAGE
              C     ICWK- NO.WEEKS IN COMM STORAGE
                  2 FORMAT(6F10.3)
            3       FORMAT(1X,13F8.1)
                    KI=1
                    DO 999 KP=1,25
          999       ITEMP(KP)=0
                    REAL KROP
          777       TOTAL=0.
                    P=RAND(0.0)
                    M=P*100.
                    IF (M.EQ.0)M=100
                    CC=RAND(0.0)
```

```
      IF(0..LE.CC.AND..06.GT.CC) SYMCD=1.2
      IF(.06.LE.CC.AND..31.GT.CC) SYMOD=1.1
      IF(.31.LE.CC.AND..82.GT.CC) SYMOD=1.0
      IF(.82.LE.CC.AND..95.GT.CC) SYMCD=0.9
      IF(.95.LE.CC.AND.1..GE.CC) SYMCD=0.8
  666 DO 51 I=1,6
      BEGIN=CAROV(I)
      OUT=0.
      AIN=0.
      OUTIN=0.
      OUT1=0.
      AIN1=0.
      TOT=0.
C      SUM- KEEPS TRACK OF GRAIN /YEAR
C     SUM1KEEPS TRACK OF GRAIN THRU  FARM STORAGE
C      SUM2-KEEPS TRACK OF FIELD STORAGE COSTS
      Z=0.
      SUM(I)=0.
      SUM1(I)=0.
      SUM2(I)=0.
      IGTI(I)=0.
      IFWK(I)=0
      ICWK(I)=0
C     CARRYOVER IS REVMOVEDFROM AVAILABLE COMMERCIAL SPACE
      FB=FBA(I)-FCAROV(I)
      CS=CSA(I)-CAROV(I)
      FBT=FB
      CST=CS
      FS=0.
      DO 963 J=1,52
      RR=RS(J)*SMOD(M)*SHMOD(I)*SYMCD
      SR(I,J)=RR
      KROP=CROP(I,J)*SMOD(M)
      CRAP(I,J)=KROP
C
C     NO CROP IMPLIES NO STORAGE NECESSARY-GO TO RAILS
C
      IF(KROP.EC.C.)GC TO 55
      SUM(I)=KROP+SUM(I)
C
C     CHECK VS COMMERCIAL STOEAGE
C
      IF(KROP.GT.CS) GO TO 11
      AIN=AIN+KROP
      AIN1=KROP
      CS=CS-KROP
      GO TO 55
   11 KROP=KROP-CS
      AIN=AIN+CS
      AIN1=CS
      CS=0.
C
C      WHAT CANNOT GO INTO CS CHECKED AGAINST FARM BIN STORAGE
C
      IF(KROP.GT.FB)GC TO 12
      FB=FB-KROP
      SUM1(I)=SUM1(I)+KROP
      GO TO 55
   12 SUM1(I)=SUM1(I)+FB
```

```
      KROP=KROP-FB
C
C     ALL LEFT GOES INTO FIELS STORAGE
C
      FB=0.
      FS=FS+KROP
C
C      RATE IS COST /WEEK,FACT(TIME)IS DEFINING FUNCTION
C
   55 IF(FS.NE.0.)GO TO9879
      IGT(I)=0
      RATE=0.
      GO TO 988
 9879 IGT(I)=IGT(I)+1
      ITI=IGT(I)
      RATE=FACT(ITI)
  988 GBC=FS*RATE
      SUM2(I)=SUM2(I)+GBC
C
C     NO RAIL SHIPMENT GET NEXT WEEKS CROP
C
      IF(RR.EQ.0.)GO TO 52
C
C     TAKE FIELD STORAGE OFF FIRST
C
      IF(FS.LT.RR)GO TO 13
      OUTIN=OUTIN+RR*2.
      FS=FS-RR
      GO TO 53
   13 IF(FS.NE.0.)RR=RR-FS
      OUTIN=OUTIN+FS*2.
      FS=0.
C
C     TAKE FARM BIN  STORAGE
C
      FB=FB+RR
      IF(FB.LE.FBA(I))OUTIN=OUTIN+RR*2.
      IF(FB.LE.FBA(I)) GO TO 53
      OUTIN=OUTIN+(FBA(I)-FB+RR)*2.
      RR=FB-FBA(I)
      FB=FBA(I)
C
C     TAKE COMMERCIAL STORAGE
C
      RTEMP=CSA(I)-CS
      CS=CS+RR
      IF(CS.LE.CSA(I))OUT=OUT+RR
      IF(CS.LE.CSA(I))CUT1=RR
      IF(CS.LE.CSA(I))GO TO 54
      OUT=OUT+CSA(I)-CS+RR
      CUT1=CSA(I)-CS+RR
      CS=CSA(I)
      SP(I,J)=RTEMP
      GO TO 52
C     TABULATE NO. WEEKS IN STORAGE
   53 IF(FS.NE.0.)IFWK(I)=IFWK(I)+1
      IF(FB.NE.FBA(I).AND.FS.EQ.0.)IFWK(I)=IFWK(I)+1
   54 IF(CS.NE.CSA(I))ICWK(I)=ICWK(I)+1
      IF(J.EQ.52)FCARCV(I)=FBA(I)-FB
```

```
      RR=0
 52   Z=Z+BEGIN-OUT1+AIN1
      BEGIN=CSA(I)-CS
 963  CONTINUE
      X1=(OUTIN+AIN+OUT)/2.
      X1=X1/CSA(I)
      X3=Z/52.
      X3=X3/CSA(I)
      WRITE(6,68) KI,I
 68   FORMAT(1H1,4HYEAR,I5,10X,4HAREA,I5)
      WRITE(6,30)(CRAP(I,J),J=1,52)
 30   FORMAT(12H CROP / WEEK/(4F12.2))
      WRITE(6,31)(SR(I,J),J=1,52)
 31   FORMAT(20H RAIL SHIPMENTS/WEEK/(4F12.2))
      PRINT1191,IFWK(I),ICWK(I),IGT(I)
 1191 FORMAT(5X,20HNO. WEEKS FARM STORE,I4,23H   NO. WEEKS COMM STORE,I4
     1, 26H      NO. WEEKS FIELD STORE,I4)
      WRITE(6,35)               FSC(I)
 35   FORMAT(55H RATES FOR COMMERCIAL-FARM COSTS FOR EACH 10 BUSHELS    /
     1                                                          23H FARM ST
     2ORAGE COST/UNIT,F10.0/32H 1 UNIT=10 BUSHELS,COST IN DOLLA)
      WRITE(6,26)I,SUM(I),SUM1(I),CSA(I),FBA(I)
 26   FORMAT(30X,4HAREA,I2///10X,20H TOTAL GRAIN IN AREA,F10.2/10X,
     130H TOTAL GRAIN THROUGH FARM BINS,F10.2/10X,16H AVAILABLE SPACE,F1
     20.2/10X,20H FARM BINS AVAILABLE,F10.2)
      WRITE(6,987)CST,FBT
 987  FORMAT(10X,40H COMMERCIAL SPACE(EFFECTIVE FOR STORAGE),F15.5/
     110X,32H FARM BINS EFFECTIVE FOR STORAGE,F15.5)
C
C     TABULATE COSTS
C
      TOUT=OUT+OUTIN/2.
      SAIN=AIN+OUTIN/2.
      CALL HALCST(COST1,SAIN,HAUD,KI,I)
       COST2=SUM1(I)*FSC(I)+FCOEF(I)
      COST3=(OUTIN/2.)*.2
C
C   GRAIN COSTS IN COMMERCIAL BIN ADD LAST YEARS CARRYOVER OUTPUT COST
C     SUBTRACT PRESENT YEARS CARRYOVER OUTPUT COST
C
      CAROV(I)=CSA(I)-CS
      WRITE(6,292)X1,X3,CAROV(I),FCAROV(I)
      FBC=.2765-.0777*X1+.0075*X1**2-.0503*X2(I)-.0282*X3
      FBC=FBC*((OUTIN+AIN+OUT)/2.)*10.
      FBC1=(3690.+.2383*TOUT/AA(I)+1.1055*ELCAP(I))*AA(I)
      FBC2=(3.01609-.0002335*(TOUT/AA(I))+.00079288*ELCAP(I)
     1     +71075.58*(AA(I)/TOUT))*TOUT*.1
      SUM2(I)=SUM2(I)*.01
      TOT=TOT+SUM2(I)+COST1+COST2+FBC+COST3
      TOTAL=TOTAL+TOT
 29   FORMAT(18H          BIN COST IS,F10.0,10X,F10.0,10X,F10.0)
 27   FORMAT(25H HAUL COST IS               ,F15.0/,20H FARM STORE BIN COST
     1,F10.0/18H GROUND STORE COST,F10.0/16H LOADER ETC COST,F10.0)
      WRITE(6,321)HAUD
 321  FORMAT(10X,6 H HAUD ,F10.1         )
 292  FORMAT(5X,3H X1,F15.5,2X,3H X3,F15.5,10H CARRYOVER,F15.5/
     115H FARM CARRYOVER,F15.5)
      WRITE(6,236)SAIN,TOUT
 236  FORMAT(10X,19H TOTAL GRAIN HAULED,F15.5/20H TOTAL GRAIN SHIPPED,/
```

```
      1F15.5)
      WRITE(6,25)FBC ,FBC1,FBC2
      WRITE(6,27)COST1,COST2,SUM2(I),COST3
      WRITE(6,453)TOT
  453 FORMAT(20H TOTAL COST FOR AREA,F10.0)
51     CONTINUE
      WRITE(6,28)TOTAL
   28 FORMAT(26H TOTAL COST FOR 6 AREAS I5,F15.0)
      WRITE(6,400)SAIN,TCUT
  400 FORMAT(10X,19H TOTAL GRAIN HAULED,F15.5/20H TOTAL GRAIN SHIPPED,/
     1F15.5)
C
C     GET A NEW YEAR
C
  682 KI=KI+1
      IF(KI.LE.15)GO TO 777
      STOP
      END

      FUNCTION FACT(ITI)
      DIMENSION COST(52)
      DATA COST/1.6,1.6,1.6,1.6,1.6,1.6,1.6,1.6,3.2,3.2,3.2,3.2,3.2,3.2,
     3.2,3.2,3.2,3.2,3.2,3.2,3.2,3.2,3.2,3.2,3.2,3.2,3.2,3.2,6.4,6.4,
     6.4,6.4,6.4,6.4,6.4,6.4,6.4,6.4,6.4,6.4,1.6,1.6,1.6,1.6,1.6,1.6,
     1.6,1.6,1.6,1.6,1.6,1.6/
      FACT=COST(ITI)
      RETURN
      END

      SUBROUTINE HALCST(SUM1,SUM,HAUD,IJ,IP)
      DIMENSION AVEDIS(6),COST(6)
      DATA AVEDIS/12.5,3.9,6.8,3.3,10.7,9.4/
      DATA COST/.0399,.0483,.0441,.0506,.0410,.0423/
      AVETRK=15.
      BNOTR=SUM/AVETRK
      DIST=BNOTR*AVEDIS(IP)
      HAUD=DIST
      SUM1=AVEDIS(IP)*SUM*COST(IP)
      RETURN
      END
$ENTRY
```

```
                              EXECUTION
   534.2   331.3  3489.1  3563.5  4469.6  7546.2  6430.5  9500.4  8371.6  2677.7  6308.8  6078.9  3522.9
  3773.1  1021.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   170.7   563.4   904.7  1805.8  1117.6  2622.4  1958.1  2354.5  1985.6   800.1  1242.4  1152.5   759.8
   601.9   312.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   466.8   584.5  2360.0  2944.5  2455.9  4427.7  5252.1  8240.3  3638.1  3023.0  3254.2  3306.6  1295.6
  1740.5   632.5     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   147.5   133.3   711.8   810.6   689.2  1196.2  1591.4  1810.4  1237.9   689.2   858.2   926.0   484.4
   470.2   146.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   535.3    34.5  2146.8  4567.1  3309.5  3769.6  9076.6  8017.5  6820.4  6227.6  3741.1  4529.7  1813.0
  1634.6   932.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   952.7   455.6  7379.5  2464.4  3348.0  5584.6 13006.0 11259.0  5936.7  1981.2  4141.9  5646.8  3361.8
  2802.7   607.5     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
403.7 348.7 256.9 183.5 440.4 275.3 238.6 532.2 403.7 458.8 550.6 458.8 532.2
458.8 403.7 477.1 440.4 348.7 477.1 293.6 238.6 568.9 458.8 403.7 513.8 422.1
532.2 220.2 312.0 330.3 275.3 477.1 275.3 330.3 256.9 367.0 293.6 330.3 238.6
275.3 348.7 275.3 330.3 256.9 348.7 330.3 201.9 256.9 183.5 165.2 275.3 256.9
61750.000 12800.000 35100.000  6000.000 46610.000 64280.000
98347.700 20873.300 46423.100 13235.700 76551.759 71241.700
    0.050     0.050     0.050     0.050     0.050     0.050
    0.380     0.380     0.460     0.460     0.540     0.540
    0.540     0.620     0.620     0.620     0.620     0.620
    0.620     0.700     0.700     0.700     0.700     0.700
    0.700     0.700     0.700     0.700     0.700     0.700
    0.700     0.700     0.780     0.780     0.780     0.780
    0.780     0.860     0.860     0.860     0.860     0.860
    0.860     0.860     0.860     0.940     0.940     0.940
    0.940     0.940     0.940     0.940     0.940     0.940
    0.940     0.940     1.020     1.020     1.020     1.020
    1.020     1.020     1.020     1.020     1.020     1.020
    1.020     1.100     1.100     1.100     1.100     1.100
    1.100     1.100     1.180     1.180     1.180     1.180
    1.180     1.180     1.180     1.180     1.260     1.260
    1.260     1.260     1.260     1.260     1.260     1.260
    1.260     1.340     1.340     1.340     1.340     1.340
    1.420     1.420     1.420     1.420     1.420     1.500
    1.500     1.660     1.660     1.860
```

APPENDIX II

TABLES

TABLE LXX

ACREAGES DETERMINED FROM CANADIAN WHEAT BOARD PERMIT BOOKS 1955-1956 TO 1965-1966

GRANDE PRAIRIE[a]

Year	No. of Permits	Wheat	Oats	Barley	Rye	Summer Fallow	Forage Crops	Specified[b]	Flaxseed	Rapeseed	Other Crops	Uncultivated Land	Total Acres
1955	445	10,879	20,419	25,801	744	16,340	22,000	74,183	4,263	N/A	800	75,000	176,246
1956	473	9,970	23,122	24,614	301	21,013	15,000	79,020	10,022	"	652	81,289	185,983
1957 1957	469	8,175	24,371	25,000	944	17,572	21,835	97,897	7,335	"	966	80,550	186,748
1958	485	8,834	22,736	28,463	50	19,248	28,014	107,611	4,575	"	777	84,225	197,188
1959	502	14,206	20,622	28,792	350	16,705	27,475	108,325	7,051	"	2,013	87,470	204,859
1960	516	15,996	19,882	27,834	187	21,139	28,452	113,524	5,705	"	4,254	92,240	215,903
1961	534	20,269	22,744	24,998	166	21,435	31,013	120,625	6,548	"	3,619	93,533	224,430
1962	554	22,748	26,488	27,475	151	21,205	25,797	123,864	7,626	3,185	2,365	99,782	236,950
1963	553	23,357	20,165	36,870	168	22,155	22,781	125,706	6,558	4,983	5,231	100,128	242,606
1964	566	28,936	18,994	31,267	407	20,783	25,509	126,070	5,090	17,209	4,722	104,242	257,333
1965	554	18,734	10,965	30,009	40	25,821	31,428	116,997	2,809	30,044	4,613	102,170	256,633

[a]Data provided by courtesy of the Statistics Branch, Board of Grain Commissioners for Canada. (Unpublished).

[b]"Specified acreage", means the sum of the wheat, oats, barley, rye, summer fallow, and forage crop acreages. However, for the years 1955 and 1956 forage crop acreage was not included.

TABLE LXXI

ACREAGES DETERMINED FROM CANADIAN WHEAT BOARD PERMIT BOOKS 1955-1956 TO 1965-1966

DIMSDALE[a]

Year	No. of Permits	Wheat	Oats	Barley	Rye	Summer Fallow	Forage Crops	Specified[b]	Flax-seed	Rape-seed	Other Crops	Uncultivated Land	Total Acres
1955	72	2,516	5,137	5,162	62	4,951	5,000	17,829	816	N/A	1,000	10,000	34,645
1956	76	1,649	5,674	5,555	10	5,480	3,814	18,368	974	"	400	10,950	34,506
1957	79	1,408	5,268	6,340	142	4,370	5,039	22,567	797	"	742	11,257	35,363
1958	77	1,476	4,633	6,135	35	5,948	5,966	24,193	363	"	948	11,044	36,584
1959	81	2,710	3,885	7,177	32	4,529	5,663	23,966	964	"	1,040	10,569	36,569
1960	75	3,015	3,546	5,681	727	5,065	5,450	23,484	813	"	332	9,849	34,473
1961	73	4,067	3,597	5,384	101	5,022	5,944	24,115	848	"	495	9,755	35,213
1962	73	5,009	3,272	5,087	-	6,257	4,984	24,609	871	52	414	9,862	35,893
1963	76	5,556	3,231	6,745	-	5,380	5,063	25,975	1,224	75	526	10,760	38,560
1964	76	6,647	3,324	6,874	-	4,564	5,728	27,297	651	617	260	10,648	39,473
1965	74	4,373	1,750	7,472	-	4,911	6,389	24,895	335	2,930	345	10,167	38,672

[a]Data provided by courtesy of the Statistics Branch, Board of Grain Commissioners for Canada. (Unpublished).

[b]"Specified acreage", means the sum of the wheat, oats, barley, rye, summer fallow, and forage crop acreages. However, for the years 1955 and 1956 forage crop acreage was not included.

TABLE LXXII

ACREAGES DETERMINED FROM CANADIAN WHEAT BOARD PERMIT BOOKS 1955-1956 TO 1965-1966

WEMBLEY[a]

Year	No. of Permits	Wheat	Oats	Barley	Rye	Summer Fallow	Forage Crops	Specified[b]	Flax-seed	Rape-seed	Other Crops	Unculti-vated Land	Total Acres
1955	207	6,352	11,800	12,109	399	11,785	11,600	42,385	2,118	N/A	400	28,500	85,003
1956	202	5,184	12,639	11,248	44	13,943	11,323	43,058	2,813	"	1,000	28,225	85,419
1957	207	6,256	9,653	11,372	1,062	11,324	15,384	54,051	2,257	"	1,076	27,188	84,642
1958	198	4,290	6,839	12,719	100	13,196	16,823	53,967	1,729	"	429	25,062	81,187
1959	195	5,672	6,367	12,707	292	11,003	16,994	53,035	2,973	"	297	25,954	82,259
1960	193	7,479	6,207	11,605	205	11,489	17,583	54,568	2,091	"	999	27,214	84,872
1961	192	9,808	6,423	9,959	132	12,107	15,928	54,357	2,731	"	900	27,274	85,262
1962	182	9,308	7,891	10,732	-	11,569	12,073	51,573	3,049	261	612	26,298	81,798
1963	191	9,259	6,341	13,622	7	13,881	9,406	52,516	3,896	1,140	1,339	25,018	83,909
1964	183	12,566	5,297	12,696	188	9,887	11,298	51,932	2,450	4,050	502	24,591	83,525
1965	173	6,166	2,111	12,505	41	11,959	14,646	47,428	1,527	7,725	269	23,933	80,882

[a]Data provided by courtesy of the Statistics Branch, Board of Grain Commissioners for Canada. (Unpublished).

[b]Specified acreage means the sum of the wheat oats, barley, rye, summer fallow, and forage crop acreages. However, for the years 1955 and 1956 forage crop acreage was not included.

TABLE LXXIII

ACREAGES DETERMINED FROM CANADIAN WHEAT BOARD PERMIT BOOKS 1955-1956 TO 1965-1966

HUALLEN[a]

Year	No. of Permits	Wheat	Oats	Barley	Rye	Summer Fallow	Forage Crops	Specified[b]	Flax-seed	Rape-seed	Other Crops	Unculti-vated Crops	Total Acres
1955	64	1,200	4,786	1,728	232	3,184	4,000	15,130	1,212	N/A	600	8,900	25,942
1956	63	1,041	5,218	1,360	40	4,052	3,000	11,711	1,351	"	929	8,521	25,522
1957	63	1,143	3,935	1,866	414	2,341	5,716	15,415	831	"	940	8,573	25,759
1958	64	792	3,413	2,614	40	4,005	5,295	16,159	461	"	996	8,454	26,070
1959	62	1,148	3,975	2,338	132	3,897	4,426	15,916	923	"	1,381	8,490	26,710
1960	62	1,425	3,595	2,056	105	4,306	5,289	16,776	805	"	971	8,322	26,874
1961	61	1,940	3,602	2,415	30	4,090	4,836	16,913	888	"	909	7,983	26,693
1962	62	2,242	3,647	2,676	-	3,604	4,430	16,599	715	22	658	8,266	26,260
1963	61	2,946	3,151	3,085	-	3,669	3,465	16,316	1,042	199	1,532	7,466	26,555
1964	62	2,962	3,112	3,435	-	3,705	4,441	17,655	871	1,231	1,344	6,711	27,812
1965	58	1,230	1,552	3,087	-	4,874	5,430	16,173	310	3,066	1,276	6,217	27,042

[a]Data provided by courtesy of the Statistics Branch, Board of Grain Commissioners for Canada. (Unpublished).

[b]Specified acreage means the sum of the wheat, oats, barley, rye, summer fallow, and forage crop acreages. However, for the years 1955 and 1956 forage crop acreage was not included.

TABLE LXXIV

ACREAGES DETERMINED FROM CANADIAN WHEAT BOARD PERMIT BOOKS 1955-1956 TO 1965-1966

BEAVERLODGE[a]

Year	No. of Permits	Wheat	Oats	Barley	Rye	Summer Fallow	Forage Crops	Specified[b]	Flax-seed	Rape-seed	Other Crops	Uncultivated Land	Total Acres
1955	370	6,925	18,491	9,797	87	17,030	38,000	52,330	2,614	N/A	2,000	60,000	154,944
1956	365	5,179	23,811	9,705	116	27,134	24,074	65,945	5,051	"	1,000	56,491	152,561
1957	353	4,172	19,236	10,594	218	16,514	36,977	87,711	4,690	"	2,560	55,506	150,467
1958	361	2,918	16,273	12,098	60	18,996	34,414	93,879	2,226	"	2,029	57,268	155,762
1959	372	4,597	17,145	13,777	69	18,806	39,858	94,287	4,901	"	1,594	61,576	162,358
1960	371	5,699	15,092	12,039	162	20,531	41,639	95,242	4,613	"	2,175	63,672	165,702
1961	382	6,506	16,763	12,708	130	21,849	40,059	98,015	5,591	"	1,405	65,029	170,060
1962	390	7,258	18,613	17,220	255	22,338	34,280	99,964	7,464	250	1,381	67,899	177,095
1963	390	5,530	17,116	25,069	323	18,052	34,160	100,250	8,536	867	1,742	68,354	179,749
1964	354	6,862	15,574	21,423	433	14,724	36,137	95,153	6,016	2,602	1,969	62,531	168,271
1965	369	2,847	8,132	18,717	115	20,813	49,922	100,546	4,878	8,128	1,995	64,599	180,146

[a]Data provided by courtesy of the Statistics Branch, Board of Grain Commissioners for Canada (Unpublished).

[b]"Specified acreage", means the sum of the wheat, oats, barley, rye, summer fallow, and forage crop acreages. However, for the years 1955 and 1956 forage crop acreage was not included.

TABLE LXXV

ACREAGES DETERMINED FROM CANADIAN WHEAT BOARD PERMIT BOOKS 1955-1956 TO 1965-66

HYTHE[a]

Year	No. of Permits	Wheat	Oats	Barley	Rye	Summer Fallow	Forage Crops	Specified[b]	Flax-seed	Rape-seed	Other Crops	Uncultivated Land	Total Acres
1955	413	3,482	21,151	16,939	1,259	16,471	30,000	59,302	528	N/A	1,670	54,000	145,500
1956	415	2,287	27,135	12,473	125	24,737	23,000	66,757	973	"	1,492	54,756	147,025
1957	411	2,286	24,185	13,618	641	17,196	31,825	89,751	1,139	"	1,592	51,270	143,752
1958	451	1,546	22,023	16,035	245	18,500	38,975	97,364	362	"	1,335	60,542	159,603
1959	457	1,737	19,688	20,782	413	18,475	39,798	100,935	424	"	1,830	62,354	165,543
1960	459	2,369	19,739	18,072	160	21,442	43,359	105,246	1,530	"	1,010	65,610	173,396
1961	455	3,308	23,278	15,061	152	22,493	40,259	104,551	1,595	"	1,094	66,962	174,202
1962	467	4,236	26,654	18,804	59	21,788	33,347	104,888	3,047	464	1,601	71,491	181,501
1963	460	3,749	25,874	22,362	42	22,295	32,956	107,278	3,087	625	3,294	69,907	184,191
1964	448	8,028	23,295	22,312	92	18,286	37,032	109,045	2,174	2,537	1,979	69,429	185,164
1965	422	3,190	10,422	17,417	35	23,033	43,307	97,404	1,598	11,646	2,663	61,927	175,233

[a]Data provided by courtesy of the Statistics Branch, Board of Grain Commissioners for Canada. (Unpublished).

[b]"Specific acreage" means the sum of the wheat, oats, barley, rye, summer fallow, and forage crop acreages. However, for the years 1955 and 1956 forage crop acreage was not included.

TABLE LXXVI

ACRES, NUMBER OF PERMITS, AVERAGE FARM SIZE, AND NUMBER OF SECTIONS (640 ACRES) BY DELIVERY POINT, 1965[a]

	Total Acres	Number of Permits	Average Farm Size[b]	Sections
Grande Prairie	256,633	554	463	400.99
Dimsdale	38,672	74	523	60.43
Wembly	80,882	173	468	126.38
Huallen	27,042	58	466	42,25
Beaverlodge	180,146	369	488	281.48
Hythe	175,238	422	415	273.81
TOTAL	758,613	1,650		1,185.3
AVERAGE			470.5	

[a]Source: Appendix II Tables LXX, LXXI, LXXII, LXXIII, LXXIV, LXXV.

[b]Rounded to closest acre.

TABLE LXXVII

YIELDS BY CENSUS DIVISIONS 1956-1965 (ALBERTA)[a]

OATS

Census Division	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
1	53.9	34.8	42.3	27.6	19.4	4.4	14.7	29.1	29.9	45.5
2	61.0	45.0	51.7	51.7	40.4	28.4	47.2	46.3	47.6	59.6
3	44.3	31.9	36.2	40.0	38.1	30.9	34.6	52.9	36.6	50.7
4	43.9	22.0	21.9	22.6	14.4	7.1	30.9	42.5	23.3	37.9
5	54.1	38.2	45.7	47.2	37.9	25.9	35.7	61.4	52.2	57.2
6	46.3	37.1	51.4	45.1	34.1	35.8	46.9	68.3	52.8	60.8
7	45.4	24.6	22.3	20.1	35.3	29.0	50.7	60.3	32.0	41.8
8	47.8	36.7	50.7	40.5	44.6	33.2	46.7	66.2	54.3	53.2
9					Included with #6					
10	49.5	29.4	23.9	28.9	43.4	37.4	54.1	54.2	31.1	47.3
11	51.0	37.3	43.5	47.6	48.9	42.5	55.7	51.3	40.8	53.4
12	47.1	34.0	17.2	43.1	44.4	39.0	32.2	38.5	27.2	39.5
13 14	47.8	39.2	36.4	44.9	40.7	46.6	46.4	40.5	46.0	36.1
15	46.0	39.8	25.0	34.0	37.0	45.7	48.0	26.4	46.4	30.3
Province	48.7	34.4	34.5	37.9	40.3	36.9	46.5	51.2	40.5	47.3
Prairie Provinces	46.2	30.4	32.0	33.9	38.5	25.2	45.0	48.6	40.8	48.2

[a]Source of Data: Census yield data provided by courtesy of Farm Economics Branch, Alberta Department of Agriculture; Data for Prairie Provinces in Canadian Wheat Board, Report of the Canadian Wheat Board: Crop Year 1965-66 (Winnipeg: January 1967), Appendix, Table 11, p.2.

TABLE LXXVIII

YIELDS BY CENSUS DIVISIONS 1956-1965 (ALBERTA)[a]

BARLEY

Census Divisions	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
				-Bushels-						
1	41.3	27.4	30.5	22.6	15.0	4.8	8.4	16.8	26.4	39.7
2	48.8	37.8	43.9	43.9	34.5	22.7	30.8	37.3	41.2	47.9
3	38.1	27.1	39.7	34.8	26.9	27.5	33.8	47.8	37.0	46.9
4	31.3	15.9	14.7	16.9	10.8	6.3	20.2	36.4	16.9	32.8
5	42.0	31.3	38.1	39.2	31.9	21.0	27.4	51.9	44.4	48.8
6	35.7	28.8	38.9	34.0	30.0	27.4	33.1	49.4	42.2	44.5
7	34.1	19.1	18.8	18.2	28.8	24.1	36.9	47.9	24.4	34.2
8	33.4	25.2	34.2	30.9	32.8	24.1	33.6	44.3	35.2	31.0
9				Included with #6						
10	30.7	20.6	17.7	22.4	30.2	28.0	35.1	38.8	22.2	33.1
11	32.7	24.4	28.8	32.9	30.2	28.1	34.4	33.4	28.2	29.3
12	27.3	22.8	11.4	31.8	24.1	27.1	18.6	25.0	18.0	27.5
13 14	30.4	27.4	25.3	31.2	24.2	30.4	27.8	26.6	31.0	24.3
15	30.4	26.8	16.4	26.6	27.2	34.1	32.8	15.1	30.5	24.1
Province	33.6	25.8	27.8	30.5	28.7	26.9	31.3	34.9	32.4	33.9
Prairie Provinces	32.0	22.7	25.4	27.1	28.0	19.8	31.0	36.0	30.1	35.2

[a]Same source as in Table **LXXVII.**

TABLE LXXIX

YIELDS BY CENSUS DIVISIONS 1956-1965 (ALBERTA)[a]

WHEAT

Census Divisions	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
					-Bushels-					
1	26.5	19.3	18.6	13.1	7.6	2.3	4.6	8.1	15.1	20.3
2	31.2	24.4	26.8	27.6	20.5	12.5	18.3	19.8	24.5	28.8
3	23.1	18.4	25.3	21.4	17.1	14.9	18.0	25.3	22.3	27.3
4	22.0	12.6	10.7	11.1	7.0	4.6	7.4	22.0	11.4	19.2
5	28.4	22.0	25.0	26.1	21.2	13.6	15.9	30.4	29.7	30.9
6	23.4	22.5	28.8	25.8	22.1	19.1	22.2	32.7	30.6	29.7
7	25.3	16.0	15.0	14.8	20.6	17.2	20.9	34.6	20.4	23.0
8	25.1	20.7	27.2	23.3	24.9	16.2	26.2	34.7	31.3	27.4
9				Included with #6						
10	27.2	18.4	19.0	20.5	27.3	23.2	29.9	32.3	20.4	24.6
11	28.5	24.4	27.7	30.2	29.3	23.8	33.3	28.3	28.8	30.4
12	25.3	21.1	14.8	25.9	25.8	22.9	19.0	20.0	13.1	17.9
13 14	26.8	23.5	23.9	27.2	24.6	26.0	24.1	21.9	25.3	23.2
15	23.5	10.9	14.0	20.3	22.3	26.6	25.1	10.4	22.8	17.6
Province	26.5	19.1	20.4	20.9	19.8	15.8	19.2	25.1	22.3	25.3
Prairie Provinces	25.0	17.8	17.3	17.9	20.8	10.6	20.8	26.0	19.9	22.7

[a]Same source as in Table LXXVII.

TABLE LXXX

YIELDS BY CENSUS DIVISIONS 1956-1965 (ALBERTA)[a]

FLAXSEED, RAPESEED, FALL RYE, SPRING RYE

	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
A. FLAXSEED											
Peace River	10.6	9.0	7.6	8.0	8.9	12.9	10.6	6.5	10.8	8.6	9.9
Prairie Provinces	11.5	5.5	8.7	8.3	8.9	6.8	11.0	12.5	10.1	12.5	11.3
B. RAPESEED											
Peace River	NA	NA	NA	11.8	12.1	18.2	13.8	9.5	13.7	9.1	14.0
C. FALL RYE											
Peace River	NA	18.5	15.1	18.6	23.2	22.0	23.0	14.4	27.4	24.3	25.9
D. SPRING RYE											
Peace River	NA	17.5	17.5	15.0	19.0	17.0	15.0	17.5	14.3	19.7	18.8
E. RYE											
Prairie Provinces	17.0	14.0	12.4	16.7	14.6	15.8	15.8	18.3	16.7	15.7	18.4

[a]Same source as in Table LXXVII.

TABLE XXXI

PERCENT CROP HARVESTED EACH WEEK - 1953 TO 1965[a]

		WHEAT					OATS				
	Week	Grande Prairie	Dimsdale	Wembley	Beaverlodge	Hythe	Grande Prairie	Dimsdale	Wembley	Beaverlodge	Hythe
1953	5	-	-	-	-	-	-	-	-	-	-
	6	-	-	5	-	10	-	3	10	-	-
	7	-	5	-	-	-	-	-	-	10	15
	8	5	5	-	60	-	10	7	10	10	15
	9	-	-	-	-	-	-	-	-	-	-
	10	15	30	20	20	20	20	20	15	15	20
	11	40	30	30	15	35	30	30	20	20	30
	12	30	30	30	5	30	30	30	30	30	30
	13	10	F[c]	15	F	5	10	10	15	15	F
1954	5	-	-	-	-	-	-	-	-	-	-
	6	-	-	-	-	-	-	1	-	-	-
	7	-	3	-	-	-	-	4	-	-	-
	8	-	2	-	5	-	-	5	-	-	-
	9	5	-	-	10	-	-	-	-	-	-
	10	-	-	10	50	-	-	5	40	-	-
1955	4	-	-	-	-	-	-	1	-	-	-
	5	5	5	10	5	-	15	9	15	5	5
	6	35	25	15	20	20	45	15	15	65	25
	7	25	35	55	55	50	20	20	20	10	20
	8	-	20	12	20	10	-	35	45	5	25
	14	20	15	8	F	10	20	20	5	15	20
	15	15	F	F	F	10	F	F	F	F	5
1956	6	-	-	-	-	-	-	-	-	-	-
	7	-	-	5	-	-	-	20	20	5	-
	8	20	5	20	30	15	20	20	20	25	20
	9	20	5	15	30	15	20	20	20	30	20
	11	20	40	30	25	30	20	10	20	20	20
	12	20	15	20	15	15	20	20	15	15	20
	13	20	35	10	F	25	20	10	5	5	20
	14	F	F	F	F	F	F	F	F	F	F

	Week	Grande Prairie	Dims-dale	Wem-bley	Beaver-lodge	Hythe	Grande Prairie	Dims-dale	Wem-bley	Beaver-lodge	Hythe
1957	5	-	-	-	-	-	-	-	-	-	-
	6	-	-	5	-	-	-	-	5	-	-
	7	-	15	5	25	10	-	15	15	25	20
	8	30	20	20	30	10	20	35	20	20	20
	9	30	25	20	15	5	60	50	40	40	20
	12	15	10	10	15	40	20	F	20	15	25
	13	25	30	30	15	35	F	F	F	F	15
	15	F	F	F	F	F	F	F	F	F	F
1958	2	-	-	55	-	-	-	-	-	-	-
	3	15	25	10	-	40	20	50	25	2	60
	4	10	25	5	5	10	15	25	25	13	10
	5	-	-	5	15	15	-	-	25	45	-
	6	5	-	-	-	10	5	-	-	-	5
	7	-	-	5	5	5	10	-	5	5	10
	11	20	10	10	20	10	20	15	10	15	10
	12	20	10	5	15	5	10	10	10	10	5
	13	20	20	5	30	5	20	F	F	10	F
	14	10	10	F	10	F	F	F	F	F	F
1959	4	-	-	-	-	-	-	-	-	-	-
	5	5	-	-	-	-	5	30	5	1	5
	6	20	50	20	-	20	10	20	15	-	20
	7	5	-	5	-	20	5	-	10	-	35
	8	15	10	25	5	10	35	-	15	4	20
	9	5	-	-	10	-	-	-	-	20	-
	10	25	-	15	35	-	5	-	25	45	-
	14	20	20	20	20	20	20	20	15	15	10
	15	5	20	15	30	30	20	30	15	15	10

	Week	Grande Prairie	Dimsdale	Wembley	Beaverlodge	Hythe	Grande Prairie	Dimsdale	Wembley	Beaverlodge	Hythe
1960	4	-	-	-	-	-	-	-	-	-	-
	5	5	10	-	-	-	20	30	-	-	-
	6	15	10	5	2	15	40	25	5	5	25
	7	20	15	35	58	15	20	30	15	70	25
	8	55	40	40	20	30	20	15	60	15	25
	9	5	25	20	20	30	F	F	20	10	15
	10	F	F	F	F	10	F	F	F	F	10
1961	3	-	-	-	-	-	-	15	15	5	-
	4	15	55	60	40	-	20	30	55	45	20
	5	10	5	10	10	25	10	30	-	15	20
	6	-	-	-	-	-	-	-	-	-	-
	7	40	20	30	20	40	30	15	20	15	30
	8	15	15	F	15	15	30	10	10	20	30
	9	20	5	F	15	20	10	F	F	F	F
	10	F	F	F	F	F	F	F	F	F	F
1962	5	-	-	-	-	-	-	-	-	1	-
	6	5	-	-		5	5	-	5	1	5
	7	5	10	2	10	5	20	30	5	14	20
	8	15	15	38	29	15	15	15	70	54	35
	9	55	65	30	35	50	30	45	15	10	25
	10	10	5	20	10	15	15	5	5	10	10
	11	10	5	10	15	10	15	5	-	10	5
	12	-	-	-	-	-	-	-	-	-	-
1963	2	-	-	-	-	-	1	-	-	-	-
	3	2	1	-	-	-	7	-	-	-	5
	4	2	4	-	-	-	7	-	-	5	10
	5	8	15	20	-	-	5	10	10	5	5
	6	3	45	30	20	0	5	40	10	30	10
	7	5	-	-	-	-	-	-	-	-	-
	8	15	5	10	10	-	-	-	5	-	10
	9	-	-	-	-	-	-	-	-	-	-
	10	5	5	5	5	5	2	5	2	3	4
	11	40	20	20	30	35	33	35	33	27	26
	12	20	5	15	35	60	40	10	40	30	30

	Week	Grande Prairie	Dimsdale	Wembley	Beaverlodge	Hythe	Grande Prairie	Dimsdale	Wembley	Beaverlodge	Hythe
1964	7	-	-	-	-	-	-	-	--	-	-
	8	10	-	-	-	5	20	3	5	10	15
	9	10	-	-	-	10	5	2	-	10	10
	10	10	35	40	50	5	5	20	45	20	5
	11	10	10	10	15	10	15	10	12	10	10
	12	25	30	20	15	30	15	30	20	20	20
	13	25	25	20	20	30	20	15	18	20	15
	14	10	F	10	F	10	20	20	F	10	25
	15	-	F	-	F	-	-	-	F	-	-
1965	4	-	1	-	-	-	-	-	-	-	-
	5	-	-	-	-	-	-	5	-	2	-
	6	-	-	-	-	-	-	-	-	-	-
	7	-	1	-	-	-	-	5	-	-	-
	8	-	5	1	5	-	10	10	15	10	10
	9	10	3	9	10	-	10	5	10	13	-
	10	60	65	50	40	40	55	55	55	50	70
	11	30	25	30	25	60	25	20	10	15	15
	12	F	F	10	20	F	F	F	10	10	5
			BARLEY					FLAX			
1953	5	2	-	5	5	-	-	-	-	-	-
	6	6	10	25	15	10	-	5	-	-	-
	7	2	20	5	5	15	-	-	-	-	-
	8	15	50	40	55	25	-	25	-	40	-
	9	-	-	-	-	-	-	-	-	-	-
	10	25	10	20	10	15	15	10	10	10	10
	11	50	10	5	10	35	30	25	35	20	40
	12	F	F	F	F	F	30	20	30	30	30
	13	F	F	F	F	F	25	15	25	F	20
1954	5	-	-	-	-	-	-	-	-	-	-
	6	-	10	-	1	5	-	-	-	-	-
	7	-	10	-	-	-	-	-	-	-	-
	8	10	5	25	10	10	-	-	-	-	-
	9	10	10	-	-	5	-	5	-	-	-
	10	-	5	35	-	-	-	-	-	-	-

	Week	Grande Prairie	Dims-dale	Wem-bley	Beaver-lodge	Hythe	Grande Prairie	Dims-dale	Wem-bley	Beaver-lodge	Hythe
1955	4	10	10	20	25	10	-	-	-	-	-
	5	40	30	10	50	20	-	-	-	-	-
	6	25	20	30	-	25	-	-	-	-	-
	7	5	35	25	20	30	30	10	0	5	10
	8	-	5	10	5	5	-	-	5	5	5
	14	20	F	5	F	10	30	30	40	30	40
	15	F	F	F	F	F	40	60	55	60	45
1956	6	20	10	-	10	5	-	-	-	-	-
	7	20	10	25	20	50	-	-	-	-	-
	8	25	25	25	25	20	15	-	-	-	20
	9	25	25	25	25	20	15	5	10	5	20
	11	10	15	15	20	5	20	20	20	15	30
	12	F	15	10	F	F	30	20	30	20	10
	13	F	F	F	F	F	20	25	15	30	20
	14	F	F	F	F	F	F	30	25	30	F
1957	5	-	-	-	-	-	-	-	-	-	-
	6	25	25	20	20	10	-	-	5	-	-
	7	10	10	15	25	15	-	-	-	-	-
	8	35	40	40	35	30	5	15	10	5	-
	9	10	5	20	20	15	5	25	15	10	-
	12	20	20	5	F	20	25	25	30	25	10
	13	F	F	F	F	10	30	30	20	40	40
	15	F	F	F	F	F	35	5	20	20	50
1958	2	5	50	10	1	10	-	-	-	-	-
	3	45	20	30	14	85	-	-	-	-	15
	4	25	30	20	65	3	-	25	10	5	5
	5	-	F	20	10	-	-	-	15	5	-
	6	5	F	10	-	2	2	-	60	-	5
	7	-	F	5	5	F	-	-	-	10	10
	11	10	F	5	5	F	18	10	5	10	10
	12	10	F	F	F	F	10	10	10	10	15
	13	F	F	F	F	F	30	20	F	25	20
	14	F	F	F	F	F	40	35	F	35	20

	Week	Grande Prairie	Dims-dale	Wim-bley	Beaver-lodge	Hythe	Grande Prairie	Dims-dale	Wim-bley	Beaver-lodge	Hythe
1959	4	-	10	5	2	-	-	-	-	-	-
	5	25	30	-	8	10	-	-	-	-	-
	6	45	40	25	-	20	2	30	10	-	-
	7	10	10	10	-	50	-	-	-	-	-
	8	-	-	25	10	10	5	-	-	-	-
	9	-	-	-	20	-	-	-	-	-	-
	10	-	-	10	50	-	35	-	-	10	-
	14	20	10	25	10	10	20	20	30	20	30
	15	F	F	F	F	F	38	50	60	70	70
1960	4	5	5	-	-	-	-	-	-	-	-
	5	25	25	15	-	10	-	5	-	-	-
	6	30	15	35	20	10	10	5	-	2	-
	7	20	30	20	70	40	30	30	5	48	-
	8	20	25	15	10	30	40	40	60	10	30
	9	F	F	15	F	10	20	20	20	20	40
	10	F	F	F	F	F	F	F	15	20	30
1961	3	40	40	80	50	40	-	-	-	-	-
	4	40	45	5	30	20	-	25	2	5	-
	5	10	5	5	10	15	10	15	18	5	-
	6	-	-	-	-	-	-	-	10	-	-
	7	10	10	10	10	15	15	10	10	10	15
	8	F	F	F	F	10	10	10	10	10	10
	9	F	F	F	F	F	40	30	20	50	40
	10	F	F	F	F	F	25	10	30	20	35
1962	5	-	-	-	3	3	-	-	-	-	-
	6	15	25	20	7	7	-	-	-	-	-
	7	15	25	5	20	20	-	10	-	5	-
	8	15	15	65	50	40	15	15	5	5	-
	9	45	35	5	15	20	10	65	5	50	60
	10	10	F	5	5	10	25	10	30	25	20
	11	-	-	-	-	-	25	-	40	10	10
	12	-	-	-	-	-	25	-	20	5	10

	Week	Grande Prairie	Dims-dale	Wim-bley	Beaver-lodge	Hythe	Grande Prairie	Dims-dale	Wim-bley	Beaver-lodge	Hythe
1963	2	5	1	1	-	-	-	-	-	-	-
	3	10	3	1	10	10	2	-	-	-	-
	4	9	6	4	-	10	-	-	-	-	-
	5	16	5	10	-	5	3	3	-	-	-
	6	-	60	15	15	10	1	-	-	2	-
	7	-	-	-	-	-	-	-	-	3	-
	8	10	-	10	10	10	2	-	-	-	-
	9	-	-	-	-	-	-	-	-	-	-
	10	5	5	5	5	5	5	5	5	5	5
	11	40	20	34	30	30	27	32	35	30	35
	12	5	F	20	30	20	60	60	60	60	60
1964	7	-	1	-	2	-	-	-	-	-	-
	8	10	9	10	8	10	-	-	-	-	-
	9	10	-	5	5	5	-	-	-	-	-
	10	10	40	35	15	10	10	10	15	25	5
	11	25	15	15	10	25	40	15	15	10	5
	12	20	15	15	30	15	30	35	30	30	40
	13	20	20	15	15	25	15	30	30	25	25
	14	5	F	5	15	10	5	10	10	10	15
	15	-	F	-	-	-	-	-	-	10	10
1965	4	1	25	20	2	5	-	-	-	-	-
	5	-	-	-	8	-	-	-	-	-	-
	6	-	-	-	-	-	-	-	-	-	-
	7	-	-	-	-	-	-	-	-	-	-
	8	-	-	30	10	10	-	-	-	10	10
	9	9	5	10	10	-	10	20	10	10	-
	10	60	60	30	50	70	35	20	10	30	40
	11	30	10	5	10	5	55	60	70	40	30
	12	F	F	5	10	10	F	F	10	10	20

[a]Source: Data provided by courtesy of Alberta Wheat Pool compiled from the crop reports of the elevator agents.

[b]"-" means zero

[c]"F" means harvest complete.

TABLE LXXXII

ESTIMATED CAPITAL COSTS OF FARM GRANARIES

Granary Charge (standard size)

If granary investment for the grain crop has not been recorded, use the following schedule to calculate interest and depreciation charges:

Rate: for large buildings

Wooden Granary Storage, wood floor - Use 30¢[b] per bu. for every 1,000 bu. or part.

Wooden Granary Storage, concrete floor - Use 35¢[b] per bu. for every 1,000 bu. or part.

Steel Granary Storage, wooden floor - Use 23¢[b] per bu. for every 1,500 bu. or part.

Depreciation rate wood	5%	(20 year life)
Depreciation rate steel	5%	(20 year life)[c]
Stationary Steel	3%	(33 year life)

[a]Source: K. Porter, Straight-Line Depreciation, (Farm Economics Branch, Alberta Department of Agriculture, 1962).

[b]Construction cost.

[c]Large steel building.

TABLE LXXXIII

ESTIMATED YEARLY CHARGE FOR WOODEN BIN IN ALBERTA[a]

Bin Average cost for 1,000 bushel bin is $275.00.
Life expectancy is 25 years.
Cost per bushel capacity is $0.28.

(1)	Depreciation @ 10%	27.50
(2)	Interest on Investment @ 5%	13.75
(3)	Minimum maintenance and repair	5.00
(4)	Insurance	2.00
	Total Yearly Cost	48.25

[a]Source: Courtesy of the Department of Agricultural Engineering, University of Alberta, Edmonton, Alberta.

TABLE LXXXIV

PRICE OF STEEL BINS AT CALGARY, ALBERTA (1967)[a]

Item		Cost	Cost Per Bushel Capacity in $[b]
1,350 bus. steel bin		$320.00	
Floor		100.00	
Labour		80.00	
	Total	$500.00	.37
1,650 bus. steel bin		$373.00	
Floor		100.00	
Labour		90.00	
	Total	$563.00	.34
2,700 bus. steel bin		$541.00	
Floor		157.00	
Labour		110.00	
	Total	$808.00	.30
3,300 bus. steel bin		$635.00	
Floor		157.00	
Labour		120.00	
	Total	$912.00	.28
1,440 bus. Basic Wooden bin (Round Plywood)		$290.00	
Labour		35.00	
	Total F.O.B. Calgary	$325.00	.23

Mileage $0.35 per mile for contractor both ways.

[a]Source: Courtesy of the United Farmers of Alberta Co-operative Limited, 1119--1st St. S.E., Calgary, Alberta.

[b]Excluding mileage.

TABLE LXXXV

ON-FARM STORAGE CAPACITY[a]

Observation	Cultivated Acreage	Storage Capacity (bushels)	Maximum Capacity (bushels)
1	129	7,000	
2	320	6,000	
3	320	5,000	7,000
4	480	10,000	
5	800	10,000	
6	320	5,000	
7	960	18,000	22,000
8	480	9,000	
9	320	3,000	
10	320	6,000	
11	320	4,500	
12	640	12,000	16,000
13	1,200	20,000	
14	320	6,500	
15	1,480	35,000	
16	470	10,000	
17	160	2,000	
18	480	4,800	
19	480	6,000	7,000
20	960	6,000	7,000
21	480	6,000	9,000
22	640	7,800	10,200
23	600	8,000	
24	555	4,000	
25	320	6,000	
26	320	10,000	
27	160	5,500	
28	640	8,000	
29	200	4,000	
30	320	7,000	
31	480	8,400	
32	289	7,200	9,000
33	420	6,000	
34	600	12,000	
35	340	7,500	
36	765	20,000	
37	300	7,000	
38	870	12,000	
39	500	13,000	
40	820	21,000	
41	470	16,000	
TOTAL	21,048	382,200	
AVERAGE	513	9,321.95	

[a]Source: Survey conducted by Larry Kane, Research Assistant, 1966.

TABLE LXXXVI

GRAIN RECEIPTS AT COUNTRY ELEVATORS

(CENSUS DISTRICT NUMBER FIFTEEN)[a]

Year	Wheat[b] (bushels)	Oats (bushels)	Barley (bushels)
1955/56	4,808,380	3,490,979	4,670,891
1956/57	5,202,622	4,425,788	6,293,373
1957/58	3,456,091	3,789,880	6,045,829
1958/59	2,589,308	2,644,039	5,736,547
1959/60	6,861,956	2,804,284	8,473,957
1960/61	7,048,647	3,230,090	8,892,606
1961/62	8,651,957	4,678,736	10,560,214
1962/63	7,332,323	4,222,511	9,986,993
1963/64	4,466,103	1,621,186	7,187,724
1964/65	7,621,164	2,092,403	9,426,104
TOTALS	59,038,551	32,999,896	77,274,238

Percentage of Total Wheat = 34.87

Oats = 19.49

Barley = 45.64

[a]Source of Data: Canada, Dominion Bureau of Statistics and Board of Grain Commissioners for Canada, Canada Grain Trade (Ottawa: Queen's Printer and Controller of Stationery, 1956 to 1965).

[b]Includes Durham.

TABLE LXXXVII

COMMERCIAL GRAIN HAULING RATES BY TRUCK (ALBERTA) 1967[a,b]

	Wheat		Oats		Barley	
Distance[c]	Cents per bushel	Cents per bushel mile[d]	Cents per bushel	Cents per bushel mile[d]	Cents per bushel	Cents per bushel mile[d]
1	2.5	2.5	1.75	1.75	2.0	2.0
2	2.75	1.375	2.0	1.00	2.25	1.125
3	3.0	1.0	2.25	.75	2.5	.833
4	3.25	.812	2.5	.625	2.75	.688
5	3.50	.700	2.75	.55	3.0	.600
6	3.75	.625	3.0	.50	3.25	.542
7	4.0	.571	3.25	.464	3.5	.500
8	4.25	.531	3.5	.438	3.75	.469
9	4.50	.500	3.75	.417	4.0	.444
10	4.75	.475	4.0	.400	4.25	.425
11	5.0	.455	4.25	.386	4.5	.409
12	5.25	.437	4.5	.375	4.75	.369
13	5.5	.425	4.75	.365	5.0	.385
14	5.75	.411	5.0	.357	5.25	.375
15	6.0	.400	5.25	.350	5.5	.367
16	6.25	.391	5.5	.344	5.75	.359
17	6.50	.382	5.75	.338	6.0	.353
18	6.75	.375	6.0	.333	6.25	.347
19	7.0	.368	6.25	.329	6.5	.342
20-29	7.0	.350	6.5	.325	6.75	.338
30-49	10.0	.333	6.75	.298	8.0	.321
50-69	12.0	.318	7.	.284	10.	.307
70-109	15.0	.304	9.	.272	13.	.293
110-159	18.0	.292	11.	.260	16.	.281
160-220	21.0	.280	13.	.250	19.	.270

[a]Source: Alberta Shippers Guide (Twenty-first edition: Alberta Motor Transport Association, 1967), p.181.

[b]Minimum charges for miles actually hauled. Where topography of district is of a rolling nature, one-half cent per bushel may be added to above schedule.

[c]Mileage to be computed from loading point to delivery point over the route travelled.

[d]Divide cents per bushel by distance.

TABLE LXXXVIII

COMMERCIAL HAULING CHARGES BY TRUCK FROM FARM TO COMMERCIAL ELEVATOR: DAWSON CREEK AREA[a]

Miles	Cents/bushel[b]
0 - 10	4 1/2
10 - 15	5
15 - 20	7
20 - 30	8
30 - 40	9
40 - 50	12

[a]Source: Guy Lapage, Supt. Nat. Grain Co., Dawson Creek, B.C.

[b]Approximate charges of commercial truckers.

TABLE LXXXIX

COMMERCIAL TRUCK RENTAL RATES[a,b]

Charge[c]	Time
$ 3.75	per hour
17.00	per ten-hour day
20.00	per twenty-four hour day
75.00	per five-day week
85.00	per seven-day week
255.00	per month

[a]Source: Shaw Truck Rentals, Calgary, Alberta.

[b]Fifteen foot grain box on a three-ton truck with hoist. The approximate capacity is 300 bushels.

[c]Plus gas plus $ .16 per mile.

TABLE XC

FARM TRUCKING COSTS[a,b]

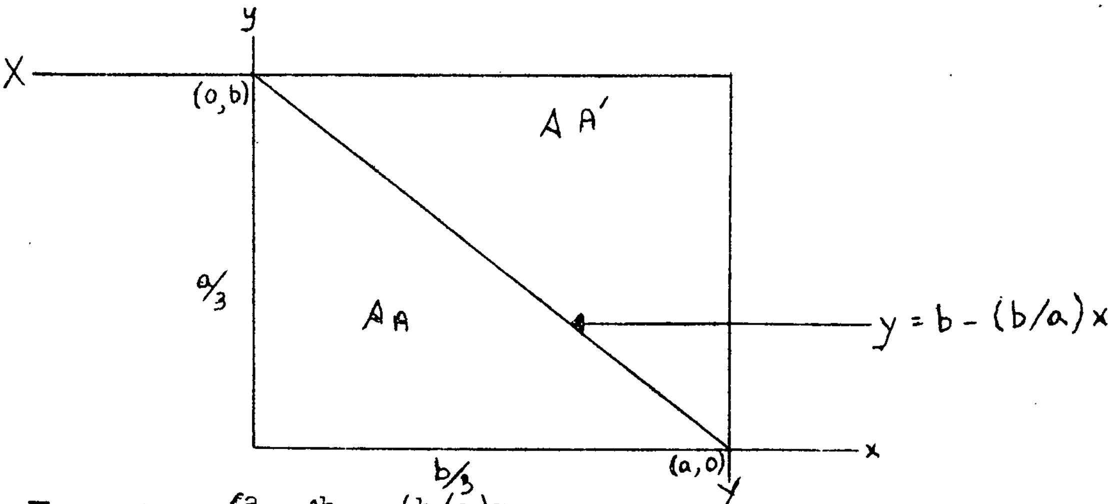
1. Average cost of truck	$3,000.00	
2. Depreciation @ 20%		$ 600.00
3. Maintenance and repairs		200.00
4. Insurance		37.00
5. License		40.00
6. Gasoline @ 25¢/mile @ 2,500 miles/yr.		62.00
7. Oil		30.00
8. Interest on investment @ 5%		150.00
		$1,120.00/year
Total Cost $1,120.00/year/2,500 miles		44.8¢/mile
Grain hauling share of mileage 35 return trips to elevator 20 x 35 Total Cost (700 miles x .448 dollars/mile) Cost per bushel		 $ 331.60 $ .0523

[a]Source: Courtesy of the Department of Agricultural Engineering, University of Alberta, 1967.

[b]Estimates based on the sale of 6,000 bushels.

TABLE XCI

DERIVATION OF FORMULA FOR CALCULATION OF AVERAGE DISTANCE FOR THE SIMULATION MODEL[a]



$$\bar{D} = 2/ab \int_0^a \int_0^{b - (b/a)x} (x + y)\, dy\, dx$$

$$= 2/ab \int_0^a (xy + y^2/2)_0^{b - b/ax}\, dx$$

$$= 2/ab \int_0^a x(b - b/ax) + 1/2\,(b - b/ax)^2\, dx$$

$$= 2/ab \left[bx^2/2 - bx^3/3a + 1/2\,(b^2xx - 2b^2/a \cdot x^2/2 + b^2/a^2 \cdot x^3)\right]_0^a$$

$$= 2/ab \left[a^2b/2 - ba^3/3a + (b^2a/2 - b^2a^2/2a + b^2a^3/6a^2\right]$$

$$= 2/ab \left[a^2b/6 + b^2a/6\right]$$

$$= (a + b)/3$$

i.e. the sum of the distances of the centroid from the axes

From 2 for Δ A

$$\bar{D} = (a + b)/3$$

Similarly for Δ A'

$$\bar{D} = a + b/3 \text{ referred to XY axes}$$

$$= - (a + b)/3 + (a + b) \text{ referred to xy}$$

$$= 2(a + b)/3$$

Therefore for area A + A'

$$\bar{D} = 1/2\ \left[(a + b)3 + 2(a + b)3\right]$$

$$= (a + b)/2$$

[a]This derivation was contributed by Miss Ann Brailsford, Assistant, Department of Agricultural Economics, University of British Columbia, 1968.

EXPLANATION OF LEGEND USED FOR TABLES XCII TO CVI

a. Variable

	1	(Total Cost in Dollars) 1.OE-04
	2	(Throughput in Bushels) 1.OE-04
	3	(Capacity in Bushels) 1.OE-04
	4	(Throughput ÷ Capacity)
	5	$((\text{Throughput in Bushels})(1.0E\text{-}04))^2$
	6	$((\text{Throughput in Bushels})(1.0E\text{-}04))^3$
	7	$((\text{Capacity in Bushels})(1.0E))^2$
	8	$((\text{Capacity in Bushels})(1.0E\text{-}04))^3$
	9	Average cost in cents per bushel
	10	Log capacity
	11	1 ÷ (Throughput in bushels)(1.OE-04)
	12	$(\text{Throughput} \div \text{Capacity})^3$
	13	

N = Number of observations

R^2 = Coefficient of determination

S.E. = Standard error of estimate

a = Intercept

Dep = Dependent

Indep = Independent

b = Regression coefficient

S_b = Standard error of the regression coefficient

t = Computed 't' value

TABLE XCII

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COST FOR ELEVATORS VALUED AT REPLACEMENT COST

(All Elevators)[a]

1	2	3	4	5	6	7	8	9
N	R^2	S.E.	a	Variable Dep.	Variable Indep.	b	S_b	t
100	.6507	.3781	.6667	TC	T	.0610	.0025	13.5108
100	.8120	.2774	.4067	TC	C	.1487	.0072	20.5752
100	.0000	.6397	1.4471	TC	T/C	-.0009	.0770	-.0115
100	.8579	.2424	.3690	TC	T	.0309	.0040	6.6932
					C	1.6026	.1717	9.3368
100	.6524	.3791	.6094	TC	T	.0692	.0126	5.5121
					T^2	-.0002	.0002	-.7014
100	.7966	.2900	1.1144	TC	T	.0746	.0038	19.4905
					T/C	-.3219	.0386	-8.3418
100	.8380	.2588	.1323	TC	C	.1535	.0069	22.3979
					T/C	.1248	.0317	3.9416
100	.8137	.2790	.9663	TC	T	.1020	.0099	10.2879
					T/C	-.3473	.0381	-9.1182
					T^2	-.0007	.0002	-2.9733
100	.8613	.2407	.5945	TC	T	.0483	.0082	5.9162
					T^2	-.0006	.0002	-3.3424
					C^2	.0060	.0005	12.0219
100	.8630	.2393	.4188	TC	T	.0302	.0054	5.6039
					C	.0776	.0114	8.5300
					$(T/C)^3$	-.0035	.0019	-1.8930
100	.8497	.2519	.3511	TC	C	.1260	.0269	4.6785
					T/C	.0633	.0399	1.5867
					T^2	.0003	.0001	2.2499
					C^2	.0003	.0016	.2045
100	.8720	.2362	.6968	TC	T	.0540	.0330	1.6381
					C	.0459	.1128	.4066
					T/C	-.1299	.0728	-1.7843
					T^2	.0002	.0013	.1235
					T^3	-.0000	.0000	-.8909
					C^2	-.0028	.0120	-.2327
					C^3	.0003	.0004	.7423

Table XCII (Continued).

100	.4417	6.3665	28.2977	AC	T	-1.5824	.2109	-7.5029
					T^2	.0262	.0049	5.3686
100	.5135	5.9740	26.3271	AC	T	-1.9244	.2178	-8.8368
					C	.8646	.2297	3.7635
					T^2	.0275	.0040	5.9829
100	.6121	5.3344	29.8837	AC	T	-4.0776	.4229	-9.6410
					T^2	.1562	.0204	7.6459
					T^3	-.0017	.0003	-6.4936
100	.9465	1.9810	3.0161	AC	T	-.2335	.0386	-6.0575
					C	.7929	.0760	10.4363
					1/T	71.0756	2.1404	33.2061
100	.7069	4.6610	38.4224	AC	T	-4.6478	.3836	-12.1165
					C	.9982	.1800	5.5447
					T^2	.1669	.0180	9.2913
					T^3	-.0019	.0002	-7.9188
100	.7108	4.6303	42.5312	AC	T	-3.5028	.3808	-9.1999
					T/C	-3.6267	.6370	-5.6934
					T^2	.1395	.0180	7.7550
					T^3	-.0016	.0002	-6.7341

[a]TC - (Total cost in dollars) 1.0E-04
AC = Average cost in cents
T = (Throughput in bushels) 1.0E-04
C = (Capacity in bushels) 1.0E-04
T/C = (Throughput Capacity)
T^2 =((Throughput in bushels)(1.0E - 04))^2
T^3 = ((Throughput in bushels)(1.0E-04))^3
C^2 = ((Capacity in bushels)(1.0E-04))^2
C^3 = ((Capacity in bushels)(1.0E-04))^3
$(T/C)^3$ = (Throughput Capacity)^3
LC = Log capacity
1/T = 1 (Throughput in bushels)(1.0E-04)
N = Number of observations
R^2 = Coefficient of determination
SE = Standard error of estimate
a = Intercept
Dep = Dependent variable
Indep. = Independent variable
b = regression coefficient
S_b = Standard error of the regression coefficient
t = computed "t" value

TABLE XCIII

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COSTS FOR ELEVATORS VALUED AT REPLACEMENT COSTS

(Less Than 40,000 Bushels Capacity)[a]

1 N	2 R^2	3 S.E.	4 a	5 Variable Dep.	6 Indep.	7 b	8 S_b	9 t
27	0.0282	0.1426	0.8985	TC	T	0.0082	0.0096	0.8511
27	.1736	.1315	-5.6392	TC	LC	1.4587	.6364	2.2920
27	.0013	.1446	.9405	TC	T/C	.0051	.0281	.1818
27	.2883	.1246	.0130	TC	T	.0159	.0088	1.8075
					C	.2529	.0854	2.9619
27	.2726	.1259	-7.3883	TC	T	.0162	.0090	1.8072
					LC	1.8230	.6419	2.8402
27	.3008	.1235	.8467	TC	T	.1104	.0344	3.2061
					T/C	- .3028	.0990	-3.0590
27	.4769	.1091	.2160	TC	T	.0438	.0124	3.5378
					C	.1572	.0818	1.9209
					$(T/C)^3$	- .0044	.0015	-2.8794
27	.8665	5.0310	62.8690	AC	T	-1 .4457	1.1106	-9.4052
					T^2	.4766	.0740	6.4454
27	.9769	2.1371	-1.8436	AC	T	- .4847	.2270	-2.1355
					C	3.0124	1.4699	2.0494
					1/T	67.7087	3.6722	18.4384
27	.9746	2.2409	84.8704	AC	T	-23.7549	1.4328	-16.5800
					T^2	2.5399	.2110	12.0352
					T^3	- .0884	.0089	-9.8980
27	.8720	5.0312	51.0999	AC	T	-10.4688	1.1109	-9.1236
					C	3.4703	3.4737	.9990
					T^2	.4856	.0745	6.5188
27	.8715	5.0411	63.0422	AC	T	-9.3865	1.5750	-5.9597
					T/C	-3.9952	4.2040	- .9503
					T^2	.4968	.0771	6.4451
27	.9778	2.1427	75.7322	AC	T	-23.6402	1.3713	-17.2434
					C	2.6330	1.4816	1.7771
					T^2	2.5271	.2019	12.5159
					T^3	- .0876	.0086	-10.2319
27	.9768	2.1923	84.7489	AC	T	-22.9201	1.5192	-15.0874
					T/C	-2.6134	1.8335	-1.4253
					T^2	2.5311	.2066	12.2535
					T^3	-0.0875	0.0088	-9.9807

[a]Source: See Table XCII.

TABLE XCIV

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COST FOR ELEVATORS VALUED AT REPLACEMENT COSTS

(40,000 to 59,999 Bushels Capacity)[a]

1 N	2 R^2	3 S.E.	4 a	5 Variable Dep.	6 Indep.	7 b	8 S_b	9 t
23	0.2506	0.1659	0.8004	TC	T	0.0309	0.0116	2.6499
23	.3890	.1498	-6.8827	TC	LC	1.7070	.4669	3.6562
23	.0298	.1888	1.0019	TC	T/C	.0491	.0612	0.8027
23	.5446	.1325	.2110	TC	T	.0228	.0096	2.3869
					C	.1377	.0383	3.5929
23	.5287	.1348	-6.0508	TC	T	.0236	.0097	2.4349
					LC	1.4788	.4305	3.4352
23	.2816	.1664	.8544	TC	T	.0395	.0149	2.6480
					T/C	- .0640	.0689	- .9295
23	.5465	.1357	.2230	TC	T	.0245	.0115	2.1367
					C	.13412	.0412	3.2574
					$(T/C)^3$	- .0009	.0031	- .2827
23	.8440	1.7074	35.9537	AC	T	-3.9057	.6194	-6.3055
					T^2	.1395	.0304	4.5853
23	.9212	1.2448	- .1766	AC	T	- .2312	.1852	-1.2481
					C	1.4053	.3623	3.8789
					1/T	68.7409	11.3058	6.0802
23	.8686	1.6078	46.7977	AC	T	-8.0566	2.2769	-3.5385
					T^2	.6089	.2505	2.4306
					T^3	- .0162	.0086	-1.8861
23	.8959	1.4309	29.1156	AC	T	-3.6964	.5235	-7.0607
					C	1.2945	.4205	3.0787
					T^2	.1253	.0259	4.8333
23	.8468	1.7362	36.2353	AC	T	-3.8331	.6419	-5.9712
					T/C	- .4207	.7189	- .5822
					T^2	.1387	.0310	4.4789
23	.9268	1.2330	40.8781	AC	T	-8.3485	1.7477	-4.7768
					C	1.3749	.3635	3.7825
					T^2	.6519	.1924	3.3875
					T^3	- .0181	.0066	-2.7552
23	.8696	1.6453	46.6751	AC	T	-7.8986	2.3673	-3.3365
					T/C	- .2591	.6873	-0.3770
					T^2	.5956	.2588	2.3016
					T^3	-0.0157	0.0088	-1.7770

[a]See Table XCII.

TABLE XCV

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COST FOR ELEVATORS VALUED AT REPLACEMENT COSTS

(60,000 to 99,999 Bushels Capacity)[a]

1 N	2 R^2	3 S.E.	4 a	5 Variable Dep.	6 Indep.	7 b	8 S_b	9 t
27	0.3723	0.2784	1.0095	TC	T	0.0320	0.0083	3.8510
27	.2784	.2985	-16.7036	TC	LC	3.7345	1.2025	3.1057
27	.2482	.3047	1.0807	TC	T/C	.1976	.0688	2.8729
27	.4877	.2567	.0384	TC	T	.0257	.0081	3.1706
					C	.1443	.0621	2.3250
27	.4926	.2555	-11.5361	TC	T	.0257	.0081	3.1831
					LC	2.5982	1.0893	2.3852
27	.4973	.2588	1.0685	TC	T	.0925	.0284	-2.2209
27	.5311	.2509	.3350	TC	T	.0554	.0219	2.5354
					C	.0671	.0806	0.8331
					$(T/C)^3$	- .0127	.0087	-1.4581
27	.8157	2.1857	27.9179	AC	T	-1.6803	.2650	-6.3415
					T^2	.0330	.0080	4.1489
27	.8864	1.7534	2.6019	AC	T	- .1852	.0914	-2.0258
					C	.8170	.4257	1.9194
					1/T	67.9513	10.8639	6.2548
27	.8466	2.0370	33.7214	AC	T	-3.1142	.7104	-4.3837
					T^2	.1312	.0462	2.8383
					T^3	- .0014	.0009	-2.1527
27	.8379	2.0940	22.2175	AC	T	-1.7803	.2600	-6.8464
					C	.9073	.5114	1.7743
					T^2	.0849	.0077	4.5339
27	.8347	2.1146	28.1617	AC	T	-1.3012	.3466	-3.7547
					T/C	-2.8544	1.7564	-1.6251
					T^2	.0325	.0077	4.2189
27	.8678	1.9340	28.0584	AC	T	-3.1874	.6756	-4.7176
					C	.8856	.4724	1.8747
					T^2	.1313	.0439	2.9931
					T^3	- .0019	.0009	-2.2281
27	.8650	1.9539	33.9065	AC	T	-2.7275	.7171	-3.8035
					T/C	-2.8102	1.6230	-1.7315
					T^2	.1298	.0443	2.9263
					T^3	-0.0019	0.0009	-2.2229

[a]See Table XCII.

TABLE XCVI

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COST FOR ELEVATORS VALUED AT REPLACEMENT COSTS

(Greater than 100,000 Bushels Capacity)[a]

1 N	2 R^2	3 S.E.	4 a	5 Variable Dep.	6 Indep.	7 b	8 S_b	9 t
23	0.4730	0.4392	1.4976	TC	T	0.0394	0.0091	4.3415
23	.4561	.4462	0.2187	TC	C	.1638	.0390	4.1961
23	.1685	.5516	1.7562	TC	T/C	.3573	.1732	2.0628
23	.6066	.3888	.4197	TC	T	.0263	.0095	2.7670
					C	.1047	.0402	2.6066
23	.5904	.3967	-14.4260	TC	T	.0286	.0094	3.0503
					LC	3.1632	1.3210	2.3945
23	.5978	.3931	1.7614	TC	T	.0735	.0159	4.6201
					T/C	- .6013	.2414	-2.4907
23	.5975	.3932	- .2652	TC	C	.1591	.0345	4.6176
					T/C	.3278	.1236	2.6517
23	.6292	.3873	0.8174	TC	T	.0521	.0258	2.0182
					C	.0480	.0668	0.7256
					$(T/C)^3$	- .0315	.0293	-1.0751
23	.6825	2.6159	25.8356	AC	T	- .8969	.2055	-4.3649
					T^2	.0104	.0036	2.9927
23	.7351	2.4514	2.8341	AC	T	- .1045	.1300	-0.8041
					C	.3716	.2777	1.3381
					1/T	123.8894	48.1779	2.5715
23	.7022	2.5992	33.6506	AC	T	-1.9456	.9570	-2.0331
					T^2	.0501	.0356	1.4083
					T^3	- .0004	.0004	-1.1217
23	.7057	2.5842	20.5188	AC	T	- .8131	.2143	-3.7944
					C	.3717	.3041	1.2223
					T^2	.0081	.0040	2.0118
23	.6999	2.6094	24.6489	AC	T	- .5750	.3690	-1.5581
					T/C	-2.2916	2.1845	-1.0490
					T^2	.0070	.0048	1.4363

Table XCVI (Continued).

23	0.7348	2.5200	29.0845	AC	T	-2.0925	0.9331	-2.2426
					C	0.4485	.3015	1.4874
					T^2	.0567	.0348	1.6296
					T^3	- .0000	.0004	-1.4070
23	.7414	2.4884	36.1316	AC	T	-2.0154	.9171	-2.1995
					T/C	-3.7061	2.2431	-1.6523
					T^2	.0670	.0356	1.8818
					T^3	-0.0007	.0004	-1.7007

[a]See Table XCII.

TABLE XCVII

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COST FOR ELEVATORS VALUED AT STANDARDIZED BOOK COST

(All Elevators)[a]

1 N	2 R^2	3 S.E.	4 a	5 Variable Dep.	6 Indep.	7 b	8 S_b	9 t
100	0.7346	0.1881	0.5211	TC	T	0.0370	0.0023	16.4687
100	.6638	.2117	0.4573	TC	C	.0767	.0055	13.9088
100	.0265	.3602	0.8564	TC	T/C	.0708	.0434	1.6339
100	.8094	.1602	.4190	TC	T	.0242	.0028	8.6101
					C	.0379	.0061	6.1718
100	.7849	.1702	.6712	TC	T	.0416	.0023	18.4956
					T/C	- .1079	.0226	-4.7666
100	.7612	.1793	.1539	TC	C	.0820	.0048	17.2756
					T/C	.1380	.0219	6.2919
100	.7933	.1677	.6121	TC	T	.0525	.0060	8.8036
					T/C	- .1181	.0229	-5.1561
					T^2	- .0003	.0001	-1.9723
100	.7952	.1669	.4863	TC	T	.0350	.0057	6.1793
					T^2	-.0002	.0001	-1.8145
					C^2	.0018	.0004	5.2619
100	.8104	.1606	.4314	TC	T	.0258	.0036	7.1342
					C	.0347	.0077	4.5153
					$(T/C)^3$	- .0009	.0013	-0.7036
100	.8120	.1608	0.1991	TC	C	.1136	.0172	6.6088
					T/C	.0594	.0255	2.3329
					T^2	.0004	.0001	4.9865
					C^2	- .0034	.0010	-3.2852
100	.8205	0.1588	0.1245	TC	T	.0094	.0143	0.6588
					C	.1800	.0661	2.7208
					T^2	.0008	.0007	1.1415
					T^3	- .0001	.0000	-1.1960
					C^2	- .0152	.0077	-1.9586
					C^3	.0005	.0003	1.7266
100	0.5174	3.9911	20.1332	AC	T	-1.1395	.1322	-8.6186
					T^2	0.0186	0.0031	6.0740

Table XCVII (Continued)

100	0.5472	3.8861	19.2775	AC	T	-1.2880	0.1417	-9.0922
					C	0.3754	.1494	2.5122
					T^2	.0192	.0030	6.4061
100	.5866	3.7129	22.2219	AC	T	- .9476	.1320	-7.1792
					T/C	-2.0328	.5070	-4.0094
					T^2	.0158	.0029	5.4638
100	.6798	3.2680	27.7590	AC	T	-2.7818	.2591	-10.7360
					T^2	.1042	.0125	8.3214
					T^3	- .0011	.0002	-6.9764
100	.9212	1.6215	3.8100	AC	T	- .1369	.0316	-4.3386
					C	.3241	.0622	5.2109
					1/T	46.0595	1.7521	26.2890
100	.7244	3.0477	27.0831	AC	T	-3.0455	.2508	-12.1420
					C	.4617	.1177	3.9218
					T^2	.1091	.0117	9.2898
					T^3	- .0012	.0002	-7.8154
100	0.7263	3.0370	28.9849	AC	T	-2.5156	.2497	-10.0732
					T/C	-1.6795	.4178	-4.0197
					T^2	.0964	.0118	8.1734
					T^3	-0.0011	0.0002	-6.9632

[a]Source: See Table XCII.

TABLE XCVIII

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COST FOR ELEVATORS VALUED AT STANDARDIZED BOOK COST

(Less than 40,000 Bushels Capacity)[a]

1 N	2 R^2	3 S.E.	4 a	5 Variable Dep.	6 Indep.	7 b	8 S_b	9 t
27	0.1386	0.1248	0.5714	TC	T	0.0169	0.0084	2.0059
27	.0700	.1296	-3.2090	TC	LC	.8606	.6273	1.3719
27	.0665	.1299	[illegible]	TC	T/C	.0337	.0252	1.3348
27	.3124	.1138	-.1010	TC	T	.0228	.0080	3.8301
					C	.1920	.0780	2.4626
27	.3206	.1131	0.5321	TC	T	.0944	.0315	2.9959
					T/C	-.2298	.0901	-2.5353
27	.3927	.1092	.0221	TC	T	.0396	.0124	3.2014
					C	.1340	.0819	1.6358
					$(T/C)^3$	-.0027	.0015	-1.7437
27	.8472	3.5192	41.7359	AC	T	-6.7968	.7769	-8.7487
					T^2	.3119	.0 17	6.0302
27	.9557	1.9357	-1.3878	AC	T	-.2777	.2056	-1.3507
					C	2.2150	1.3313	1.6638
					1/T	44.1525	3.3260	13.2750
27	.9572	1.9020	56.2475	AC	T	-15.5752	1.2161	-12.8076
					T^2	1.6728	.1791	9.3386
					T^3	-0.0583	.0076	-7.6916
27	.8540	3.5131	33.1770	AC	T	-6.8136	.7757	-8.7835
					C	2.5237	2.4256	1.0405
					T^2	.3185	.0520	6.1222
27	.8538	3.5162	41.8655	AC	T	-6.0039	1.0986	-5.4652
					T/C	-2.9910	2.9323	-1.0200
					T^2	.2270	.0538	6.0826
27	.9614	1.8474	49.4026	AC	T	-15.4938	1.8233	-13.1044
					C	1.9722	1.2774	1.5439
					T^2	1.6633	.1741	9.5540
					T^3	-.0577	.0074	-7.8218
27	0.9604	.8710	56.1507	AC	T	-14.9103	1.2965	-11.5005
					T/C	-2.0817	1.5647	-1.3304
					T^2	1.6658	.1763	9.4495
					T^3	-0.0576	0.0075	-7.6964

[a]See Table XCII.

TABLE XCIX

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COST FOR ELEVATORS VALUED AT STANDARDIZED BOOK COST

(40,000 to 59,999 bushels capacity)[a]

1	2	3	4	5	6	7	8	9
N	R^2	S.E.	a	Variable Dep.	Variable Indep.	b	S_b	t
23	0.0708	0.1564	0.7081	TC	T	0.0139	0.0110	1.2649
23	.2314	.1422	-4.3717	TC	LC	1.1147	.4431	2.5146
23	.0340	.1594	.7498	TC	T/C	.0445	.0517	0.8604
23	.2780	.1413	.2891	TC	T C	.0082 .0079	.0102 .0408	.8024 2.3960
23	.0714	.1602	.7016	TC	T T/C	.0129 .0076	.0143 .0663	.8970 .1149
23	.2829	.1444	.2730	TC	T C $(T/C)^3$	.0059 .1026 .0012	.0122 .0439 .0033	.4820 2.3418 .3598
23	.7558	1.7334	25.2797	AC	T T^2	-2.4287 .0761	.6288 .0309	-3.8622 2.4630
23	.8038	1.5939	5.6740	AC	T C 1/T	-.5367 1.1254 31.0414	.2371 .4639 14.4759	-2.2633 2.4260 2.1447
23	.7595	1.7646	28.7404	AC	T T^2 T^3	-3.7535 .2259 - .0052	2.4989 .2749 .0094	-1.5020 .8216 - .5484
23	.8079	1.3773	19.7208	AC	T C T^2	-2.2506 1.0523 .0645	.5771 .4635 .0286	-3.9137 2.2704 2.2576
23	.7657	1.7420	24.8466	AC	T T/C T^2	-2.5403 .6471 .0773	.6441 .7213 .0311	-3.9442 .8971 2.4883
23	.8143	1.5932	24.0812	AC	T C T^2 T^3	-3.9831 1.0821 .2597 .0067	2.2583 .4697 .2487 .0085	-1.7638 2.3040 1.0445 -.7904

TABLE XCIX (Continued)

23	0.7714	1.7678	29.0779	AC	T	-4.1881	2.5436	-1.6465
					T/C	.7126	.7385	0.9649
					T^2	.2625	.2780	.9441
					T^3	-0.0064	0.0095	-0.6703

[a] See Table XCII.

TABLE C

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COST FOR ELEVATORS VALUED AT STANDARDIZED BOOK COST

(60,000 to 99,999 Bushels Capacity)[a]

1 N	2 R^2	3 S.E.	4 a	5 Variable Dep.	 Indep.	7 b	8 S_b	9 t
27	.5478	.2057	.6030	$\overline{TC}$	T	0.0337	0.0061	5.5034
27	.1771	.2775	-11.5373	TC	LC	2.5936	1.1180	2.3199
27	.4355	.2299	.6417	TC	T/C	.2279	.0519	4.3917
27	.5757	.2034	.1877	TC	T C	.0311 .0617	.0064 .0492	4.8364 1.2548
27	.5845	.2012	.6332	TC	T T/C	.0648 - .2441	.0220 .1670	2.9378 -1.4621
27	.5980	.2022	.0023	TC	T C $(T/C)^3$	.0125 .1100 .0079	.0176 .0649 .0070	.7105 1.6944 1.1308
27	.7919	1.6552	20.8047	AC	T T^2	-1.3422 .0289	.2007 .0060	6.6893 4.8059
27	.8206	1.5701	1.5679	AC	T C 1/T	-.0721 .4846 52.0962	.0819 .3812 9.7279	-.8806 1.2714 5.3554
27	.8023	1.6480	23.2042	AC	T T^2 T^3	-1.9351 .0695 - .0008	.5747 .0374 .0007	-3.3670 1.8596 1.1002
27	.8101	1.6153	17.1283	AC	T C T^2	-1.4067 .5851 .0301	.2006 .3945 .0059	-7.0131 1.4834 5.0822
27	.8043	1.6395	20.9453	AC	T T/C T^2	-1.1236 -1.6465 .0286	.2687 1.3618 .0060	-4.1816 -1.2091 4.7988
27	.8199	1.6082	19.5193	AC	T C T^2 T^3	-1.9827 .5762 .0696 -.0008	.5618 .3928 .3928 .0007	-3.5292 1.4670 1.9084 1.9170
27	0.8145	1.6324	23.3115	AC	T T/C T^2 T^3	-1.7110 -1.6283 .0687 -0.0008	.5991 1.3560 .0370 0.0007	-2.8561 -1.2008 1.8547 -1.0960

[a]See Table SCII.

TABLE CI

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COST FOR ELEVATORS VALUED AT STANDARDIZED BOOK COST

(Greater than 100,000 Bushels Capacity)[a]

1 N	2 R^2	3 S.E.	4 a	5 Variable Dep:	6 Indep.	7 b	8 S_b	9 t
23	0.7321	0.1720	0.8305	TC	T	0.0270	0.0036	7.5759
23	.4212	.2529	.2879	TC	C	.0865	.0221	3.9089
23	.3844	.2608	.9203	TC	T/C	.2965	.0819	3.6216
23	.7846	.1580	.4595	TC	T	.0224	.0039	5.8085
					C	.0360	.0163	2.2067
23	.7830	.1586	.9231	TC	T	.0329	.0064	6.0604
					T/C	- .2109	.0974	-2.1651
23	.7847	.1621	.4723	TC	T	.0233	.0108	2.1518
					C	.0342	.0277	1.2348
					$(T/C)^3$	-.0010	.0123	-.0826
23	.7857	1.2026	15.8092	AC	T	-.5708	.0945	-0.0424
					T^2	.0069	.0016	4.2315
23	.8813	.9185	-.0930	AC	T	.0232	.0487	.4772
					C	.0867	.1040	.8335
					1/T	104.6024	18.0522	5.7944
23	.8644	.9815	24.5443	AC	T	-1.7429	.3614	-4.8232
					T^2	.0513	.0134	3.8187
					T^3	- .0005	.0002	-3.3200
23	.7919	1.2161	14.2791	AC	T	-.5467	.1008	-5.4214
					C	.1070	.1431	.7475
					T^2	.0063	.0019	3.3154
23	.7861	1.2329	15.7174	AC	T	-.5459	.1744	-3.1307
					T/C	-.1774	1.0322	..1719
					T^2	.0067	.0023	2.9108
23	.8816	.9422	22.6879	AC	T	-1.8027	.3429	5.1671
					C	.1824	.1128	1.6172
					T^2	.0540	.0130	4.1509
					T^3	- .0005	.0001	-3.6939
23	.8817	.9418	25.4669	AC	T	-1.7689	.3471	-5.0960
					T/C	-1.3784	.8490	-1.6236
					T^2	.0576	.0135	4.2776
					T^3	0.0006	.0002	-3.8154

[a]See Table XCII.

TABLE CII

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COST FOR ELEVATORS VALUED AT OPERATING COST

(All Elevators)[a]

1	2	3	4	5	6	7	8	9
				Variable				
N	R^2	S.E.	a	Dep.	Indep.	b	S_b	t
101	0.7436	0.1159	0.4210	TC	T	0.0234	0.0014	16.9454
101	.5301	.1570	.4170	TC	C	.0432	.0041	10.5679
101	.0539	.2227	.5971	TC	T/C	.0634	.0267	2.3755
	.7638	.1118	.3872	TC	T	.0193	.0020	9.8474
					C	.0124	.0043	2.8940
101	.7669	.1111	.4846	TC	T	.0254	.0015	17.3127
					T/C	- .0461	.0147	-3.1275
101	.6651	.1332	.1934	TC	C	.0472	.0035	13.3728
					T/C	.1019	.0162	6.2849
101	.7672	.1116	.4768	TC	T	.0268	.0040	6.7623
					T/C	- .0474	.0152	-3.1214
					T^2	- .0001	.0001	-0.3869
101	.7575	.1139	.4271	TC	T	.0204	.0039	5.2875
					T^2	- .0001	.0001	- .1305
					C^2	.0006	.0002	2.3371
101	.7702	.1109	.4072	TC	T	.0219	.0025	8.7564
					C	.0072	.0053	1.3569
					$(T/C)^3$	- .0014	.0009	-1.6379
101	.7642	.1129	.2771	TC	C	.0637	.0120	5.2934
					T/C	.0306	.0178	1.7129
					T^2	.0004	.0001	6.3507
					C^2	- .0024	.0007	-3.3104
101	.7732	.1119	.4241	TC	T	.0162	.0101	1.6023
					C	- .0035	.0464	- .0752
					T^2	- .0001	.0005	- .1599
					T^3	.0001	.0001	.6642
					C^2	.0037	.0054	.6801
					C^3	- .0002	.0002	- .9555
101	.5772	2.8980	15.8054	AC	T	- .9423	.0960	-0.8178
					T^2	.0155	.0022	6.9559
101	0.5852	2.8853	15.4556	AC	T	-1.0018	.1050	-9.5380
					C	.1511	.1107	1.3656
					T^2	0.0157	0.0022	7.0675

101	0.6217	2.7553	17.0931	AC	T	-0.8270	0.0980	-8.3928
					T/C	-1.2670	.3750	-3.3785
					T^2	0.0138	.0022	6.3731
101	.7512	2.2347	21.9694	AC	T	-2.2674	.1771	-12.8015
					T^2	0.0845	.0086	9.8765
					T^3	-0.0009	.0001	-8.2349
101	.9238	1.2370	3.3216	AC	T	-0.0794	.0240	-3.3114
					C	0.1124	.0473	2.3752
					1/T	35.3974	1.3355	26.5042
101	.7681	2.1686	21.6434	AC	T	-2.3945	.1785	-13.4171
					C	0.0211	.0836	2.6463
					T^2	0.0869	.0084	10.4051
					T^3	-0.0010	.0001	-8.7012
101	0.7777	2.1231	22.6851	AC	T	-2.1124	.1744	-12.1136
					T/C	-0.9855	.2910	-3.3865
					T^2	0.0800	.0082	9.7169
					T^3	-0.0009	0.0001	-8.2082

[a]See Table XCII.

TABLE CIII

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COST FOR ELEVATORS VALUED AT OPERATING COSTS

(Less Than 40,000 Bushels Capacity)[a]

1	2	3	4	5	6	7	8	9
N	R^2	S.E.	a	Variable Dep.	Indep.	b	S_b	t
27	0.2117	0.1175	0.4250	TC	T	0.0206	0.0079	2.5912
27	.0396	.1296	.2708	TC	C	.0862	.0849	1.0151
27	.1287	.1235	.4647	TC	T/C	.0461	.0240	1.9215
27	.3348	.1101	- .1319	TC	T	.0254	.0078	3.2638
					C	.1591	.0755	2.1076
27	.3428	.1095	.3922	TC	T	.0853	.0305	2.7962
					T/C	- .1920	.0877	-2.1878
27	.2891	.1155	.2790	TC	T	.0316	.0124	2.5553
					C	.0286	.0786	0.3644
					$(T/C)^3$	- .0022	.0016	-1.3399
27	.8295	2.7436	31.3640	TC	T	-4.9299	.6057	-8.1394
					T^2	.2248	.0403	5.5747
27	.9381	1.6901	1.4289	TC	T	- .2555	.1515	-1.6867
					C	1.2699	1.0157	1.2502
					1/T	31.3649	2.7819	11.2746
27	.9341	1.7422	41.8079	TC	T	-11.2476	1.1140	-10.0970
					T^2	1.2042	.1641	7.3391
					T^3	- .0420	.0069	-6.0431
27	.8378	2.7342	24.4505	TC	T	-4.9435	.6037	-8.1883
					C	2.0386	1.8877	1.0799
					T^2	.2301	.0405	5.6836
27	.8376	2.7359	31.4694	TC	T	-4.2853	.8548	-5.0134
					T/C	-2.4314	2.2815	-1.0657
					T^2	.2371	.0418	5.6675
27	.9395	1.7079	36.1083	TC	T	-11.1798	1.0931	-10.2275
					C	1.6422	1.1810	1.3905
					T^2	1.1963	.1610	7.4325
					T^3	- .0414	.0068	-6.0783
27	0.9384	1.7227	41.7252	TC	T	-10.6795	1.1938	-8.9462
					T/C	-1.7785	1.4407	-1.2345
					T^2	1.1982	0.1623	7.3821
					T^3	-0.0413	0.0069	-6.0010

[a]See Table XCII.

TABLE CIV

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COST FOR ELEVATORS VALUED AT OPERATING COSTS

(40,000 to 59,999 Bushels Capacity)[a]

1 N	2 R^2	3 S.E.	4 a	5 Variable Dep.	6 Indep.	7 b	8 S_b	9 t
23	0.2198	0.0084	0.4845	TC	T	0.0144	0.0059	2.4323
23	.1116	.0901	-1.5055	TC	LC	.4559	.2807	1.6241
23	.0050	.0953	.6008	TC	T/C	.0101	.0309	0.3255
23	.2790	.0831	.3526	TC	T	.0126	.0060	2.1018
					C	.0308	.0240	1.2819
23	.2986	.0820	.5274	TC	T	.0212	.0073	2.8932
					T/C	- .0508	.0339	-1.4988
23	.3547	.0807	.3901	TC	T	.0179	.0068	2.6260
					C	.0197	.0245	.8046
					$(T/C)^3$	- .0028	.0019	-1.4926
23	.8161	1.0412	19.0393	AC	T	-1.9092	.3777	-5.0550
					T^2	.0635	.0186	3.4210
23	.8785	.8685	2.2580	AC	T	- .1245	.1292	- .9639
					C	.3225	.2528	1.2761
					1/T	37.9779	7.8873	4.8151
23	.8563	.9442	26.8276	AC	T	-4.8906	1.3370	-3.6578
					T^2	.4006	.1471	2.7231
					T^3	- .0116	.0050	-2.3068
23	.8242	1.0445	17.5228	AC	T	-1.8629	.3821	-4.8751
					C	.2871	.3069	.9354
					T^2	.0603	.0189	3.1883
23	.8463	.9766	19.5621	AC	T	-1.7746	.3611	-4.9147
					T/C	- .7812	.4044	-1.9318
					T^2	.0620	.0174	3.5580
23	.8677	.9310	25.3609	AC	T	-4.9629	1.3197	-3.7607
					C	.3407	.2745	1.2411
					T^2	.4112	.1453	2.8301
					T^3	-.0121	.0050	-2.4314
23	0.8784	0.8925	26.5085	AC	T	-4.4798	1.2842	-3.4884
					T/C	- .6737	.3729	-1.8068
					T^2	.3660	.1404	2.6073
					T^3	-0.0105	0.0048	-2.1797

[a]See Table XCII.

TABLE CV

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COST FOR ELEVATORS VALUED AT OPERATING COSTS

(60,000 to 99,999 Bushels Capacity)[a]

1 N	2 R^2	3 S.E.	4 a	5 Variable Dep.	6 Indep.	7 b	8 S_b	9 t
28	0.4486	0.1382	0.4810	TC	T	0.0187	0.0041	4.5992
28	.1330	.1733	-6.0284	TC	C	1.3930	.6974	1.9973
28	.3463	.1505	.5131	TC	T/C	.1244	.0335	3.7114
28	.4716	.1380	.2536	TC	T C	.0173 .0347	.0043 .0332	4.0279 1.0427
28	.4716	.1308	.2510	TC	T C $(T/C)^3$	.0170 .0353 .0001	.0121 .0047 .0049	1.4093 .7901 .0233
28	.8193	1.2375	16.2503	AC	T T^2	-1.1272 .0246	.1496 .0045	-7.5345 5.4749
28	.8979	.9493	.6330	AC	T C 1/T	-.0087 .1847 48.8947	.0489 .2296 5.8684	-.1782 .8045 8.3318
28	.8672	1.0828	20.4852	AC	T T^2 T^3	-2.1655 .0956 - .0014	.3765 .0244 .0005	-5.6521 3.9107 -2.9417
28	.8236	1.2481	14.7931	AC	T C T^2	-1.1517 .2300 .0251	.1543 .3033 .0046	-7.4633 .7584 5.4808
28	.8243	1.2456	16.3153	AC	T T/C T^2	-1.0139 - .8487 .0245	.2042 1.0332 .0045	-4.9660 - .8214 5.3987
28	.8712	1.0895	19.0628	AC	T C T^2 T^3	-2.1864 .2227 .0958 - .0014	.3796 .2648 .0246 .0005	-5.7555 .8411 3.3867 -2.9154
28	0.8720	1.0861	20.5405	AC	T T/C T^2 T^3	-2.0524 - .8320 .0953 -0.0014	.3970 .9010 .0245 .0005	-5.1698 -0.9235 3.8860 -2.9267

[a]See Table XII.

TABLE CVI

SUMMARY TABULATIONS OF REGRESSION ANALYSIS OF TOTAL AND AVERAGE COST FOR ELEVATORS VALUED AT OPERATING COSTS

(Greater than 100,000 Bushels Capacity)[a]

1 N	2 R^2	3 S.E.	4 a	5 Variable Dep.	6 Indep.	7 b	8 S_b	9 t
23	0.8265	0.1037	0.5049	TC	T	0.0214	0.0021	10.0034
23	.1640	.2276	-5.9088	TC	C	1.3464	.6634	2.0296
23	.6380	.1497	.4929	TC	T/C	.2860	.0470	6.0840
23	.8276	.1059	.5440	TC	T C	.0219 -.0038	1.0026 .0109	8.4774 -.3477
23	.8401	.1046	.4221	TC	T C $(T/C)^3$	.0140 .0136 .0096	.0070 .0179 .0079	2.0091 .7587 1.2194
23	.7314	.8676	10.2872	AC	T T^2	- .3599 .0044	.0682 .0012	-5.2811 3.7378
23	.8828	.5881	-.2624	AC	T C 1/T	.0617 -.0464 81.0771	.0312 .0666 11.5577	1.9778 -.6963 7.0150
23	.8689	.6219	17.7279	AC	T T^2 T^3	-1.3584 .0422 -.0004	.2290 .0085 .0001	-5.9322 4.9590 -4.4631
23	.7319	.8893	10.5658	AC	T C T^2	- .3643 - .0195 .0045	.0737 .1047 .0014	-4.9404 -0.1861 3.2902
23	.7460	.8656	10.6796	AC	T T/C T^2	- .4664 .7578 .0056	.1224 .7246 .0016	-3.8098 1.0459 3.4590
23	.8710	.6339	17.3107	AC	T C T^2 T^3	-1.3718 .0410 .0428 -.0004	.2347 .0759 .0088 .0001	-5.8450 .5403 4.8949 -4.4046
	.8692	.6382	17.8076	AC	T T/C T^2 T^3	-1.3606 - .1192 .0428 -.0004	.2352 .5752 .0091 .0001	-5.7842 -0.2073 4.6908 -4.1167

[a]See Table XCII.