THE COST OF HANDLING AND STORING GRAIN
IN MANITOBA COUNTRY GRAIN ELEVATORS

A Thesis

Presented to

The Faculty of Graduate Studies and Research

University of Manitoba

In Partial Fulfilment

of the Requirements for the Degree

Master of Science

by

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May 1967

ACKNOWLEDGMENTS

The author wishes to express his deep debt of gratitude to all those persons to whom he is indebted in the preparation of this thesis.

Special thanks go to his thesis supervisor, Professor Om P. Tangri, whose kind words, constructive criticisms and encouragement made the undertaking and completion of this work a pleasant memory. I would also like to thank Professor A.W. Wood and Professor A.K. Storgaard who took time from their busy schedules not only to read the draft but also to offer invaluable suggestions. Many thanks go out to my fellow graduate students and the secretarial staff of the Department of Agricultural Economics who helped in many technical matters.

Financial assistance was provided by the Department of Agricultural Economics and is gratefully acknowledged.

Thanks are also due to Mr. Niel Longmuir who graciously consented to undertake the drawing of the figures.

Last but by no means least I would like to express my sincerest appreciation to Mr. S. Searle Jr., Mr. W. MacDonnell and to Mr. J. Candlish for their undivided attention in matters concerning the collection of data at their respective companies.

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ABSTRACT

THE COST OF HANDLING AND STORING GRAIN IN MANITOBA COUNTRY GRAIN ELEVATORS

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1967

Branch line abandonment as proposed by the Royal Commission on Transportation in 1961 has concerned farmers, grain handling firms and others who are dependent upon the services provided by the railways. To the grain elevator companies rail line abandonment will mean a loss of revenue producing sites. In order for these firms to make rational decisions about the size and location of grain elevators, information on the cost of handling and storing grain is essential. This study was set up to analyze the cost structure of the Manitoba grain elevator industry for the crop years 1961/62, 1962/63 and 1963/64. The basis for the study is cost and grain handlings for the above three year period. The mathematical tool employed to discover functional relationships is regression analysis.

The study was designed to discover the average cost for the entire industry for this period as well as to analyze what effect size, utilization and annex capacity have upon the cost structure.

In order to study the effect of size it was necessary to stratify the grain elevators into five size groups. Costs were then studied for each group as well as for the industry as a whole.

Major findings of the study are:

1. The estimated total average cost of handling and storing grain for the entire industry, during this period, was 9.54 cents per bushel per year with a standard error of 2.39 cents.
2. The most important single cost reducing factor in the grain elevator industry is the handling to capacity ratio.
3. For the industry as a whole the average per bushel cost of handling and storing grain decreases by one-half cent when the annex to capacity ratio increases by ten per cent.
4. For the industry as a whole the average per bushel cost of handling and storing grain decreases by approximately three-tenths of a cent when the utilization of the plant increases by ten per cent.

CHAPTER I

INTRODUCTION

(A) SETTING FOR THE PROBLEM

The application for railway branch line abandonment is a current matter of concern affecting the entire grain industry of Western Canada. The railway companies contend that some branch lines have become uneconomic to maintain because of the low density of traffic on them. They argue, therefore, that they must either abandon these lines or be subsidized for the continued use of the uneconomic lines.

The low density of traffic on many branch lines is partly the result of the advances made in highway construction, and trucks which are capable of carrying a large payload. If there is an adequate network of good roads, the advantage that trucks have over rail, for relatively short hauls, is a low handling charge attributable to fixed facilities. This point is shown in Figure 1 below.[1] Overhead costs are substantially less for trucks than for railroads, whereas the opposite is true for the variable hauling cost. The result is that trucking operations have a competitive advantage over railroads for relatively short hauls.

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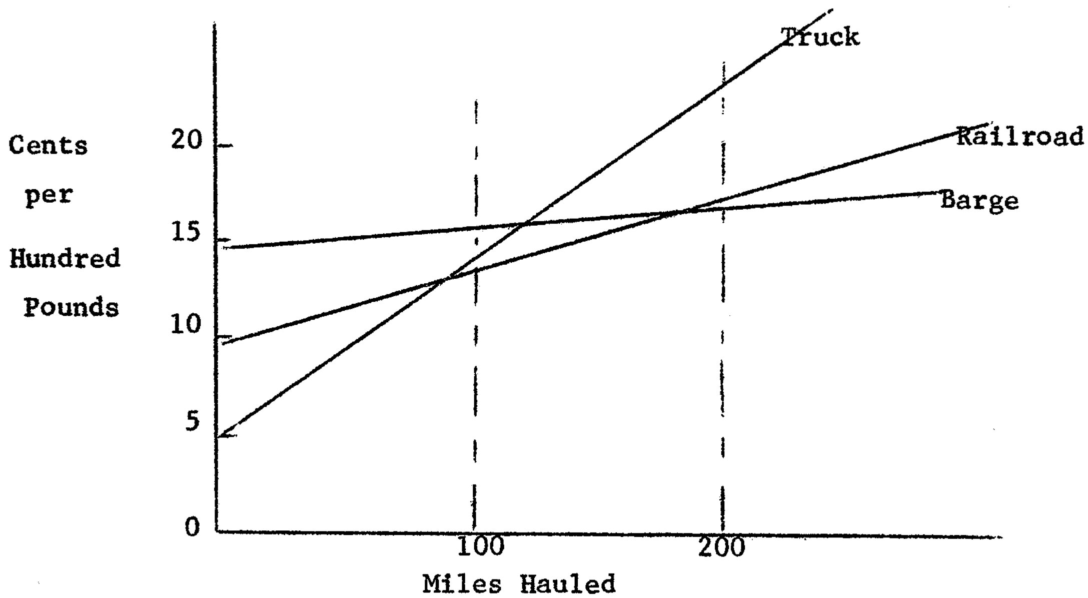
[1] C.P. Kindleburger, International Economics, Third Edition, Richard D. Irwin, Inc., Homewood, Illinois 1963, p. 145.

Figure I - Effect of Length of Haul Upon Average Cost of Hauling



Abandonment is of concern not only to the railroad companies but also to government agencies, farmers and farm organizations and last, but not least, to the grain elevator companies. Farmers and farm organizations are concerned with branch line abandonment because it will create hardships on towns and villages which rely upon the railways and may also force some farmers to drive unduly long distances in order to arrive at the nearest elevator unaffected by abandonment. The following passages are representative of farm organization views on the subject.

> We want to be sure that any decision made regarding the abandonment of branch lines takes into consideration, not only the dollar and cent effects on the railways, but also the economic and social effects on rural people and their communities. It must not be permitted to happen that farmers are left out in the

> wilderness having to drive unduly long distances to get to the closest place of business.[2]
>
> This policy (of abandonment on the part of the railways) will cause hardships in some communities and create difficulties in transporting goods to markets in other areas .... Every attempt (should) be made by the Manitoba Government to provide all weather market roads for farmers in these areas prior to abandonment of the branch line.[3]
>
> We recommend that the government and Board of Transport Commissioners insist that a long range plan for abandonment and relocation of displaced elevators and other facilities should be developed that will embrace in one plan the operations of both railways.[4]

The grain elevator companies are concerned about railway line abandonment since it will mean the loss of revenue producing sites plus a possible loss of aggregate patronage if a producer, under changed circumstances, should select a site at which any particular grain elevator company is not represented. Since the grain elevator industry operates as a regulated oligopoly[5], the average revenue or demand curve for the services of any particular firm, at

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[2]Submission to the Government of Canada by the National Farmers Union, Jan. 31, 1962 as quoted by 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, March 1963, pp. 42-43.

[3]*Ibid.*, p. 43, Presentation to the Premier and Members of the Cabinet by the Manitoba Federation of Agriculture, Feb. 3, 1961.

[4]*Loc. cit.*

[5]The industry is termed oligopolistic since there is only a small number of independent grain elevator companies and because there are limited substitutes to handling and storing grain other then at country elevators.

a given site, is perfectly elastic.[6] If it is assumed that the average total cost curve of any grain elevator is a monotonic decreasing function of total grain handled, over all ranges of handling, then in order for grain elevator firms to maximize profits, it is essential that they maximize their total handling. It follows then that no firm would wish to lose a present or potential customer because of rail line abandonment. The grain elevator companies would tend to resist a change unless they were represented at every point and could be confident in not losing a patron because of any changes.

The government and its agencies are concerned with the problems of all parties involved since it either determines or negotiates the returns allocated to the various interested parties. Besides, the social and political implications of rail line abandonment may be too important for the governments at the municipal, provincial and national levels to either treat the issue in strictly economic terms or take a neutral position of non-interference.

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[6]The demand curve is perfectly elastic since the service rates are fixed regardless of the total amount of grain handled.

(B) OBJECTIVES AND SCOPE OF THE STUDY

The grain elevator industry is a necessary and integral part of the marketing system for Western Canada's large cereal grain crops. Over the past twenty years, technical advances in agricultural machinery, seed and fertilizer have enabled or forced farmers to plant larger crops, undertake more diverse enterprises and to perform farm operations more quickly than ever before. The operators of country grain elevators in turn are continually pressed to provide faster, cheaper and more efficient handling and storing facilities. In planning any changes in the size and location of grain elevators, therefore, the need for reliable information on costs pertaining to the major factors of handling and storing grain will be crucial for the elevator industry if the proposed rail line abandonment is carried through, either partly or completely.

Specifically, questions arising out of the present problems are:

1) To what extent will rail line abandonment take place?
2) How will this affect the farmers and communities of the abandoned lines?
3) What changes, if any, must the grain elevator companies make in order to cope with the grain handling and delivery problems which may arise due to rail line abandonment?

These are questions of great concern and importance to all those who will be affected, either directly or indirectly, by any program of rail line abandonment.

The third problem has been estimated, to some extent, by

Lagace.[7] Lagace based his estimates of the amount of capacity that must be replaced on the basis of various handling to capacity ratios that would be achieved in the event of abandonment. It should be noted that the definition of a grain elevator's handle differs between Lagace's thesis and this study. In the former it is defined as the volume of grain received at country elevators from producers.[8] In the present study, as defined on page 12, the amount handled includes the grain placed into the elevator plus the amount taken out; the sum of which is divided by two. The difference between the two definitions, can be up to one-half the capacity of the country elevator.

Lagace shows that in Manitoba 105 points or 68.2 per cent of the total number of Manitoba points, will be affected either directly or indirectly by proposed railway branch line abandonment.[9]

Under the various handling to capacity ratios considered by Lagace, the following table shows his estimates of lost capacity that would have to be replaced.[10] These figures are estimates for Manitoba only, although Lagace developed estimates for all three prairie provinces.

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[7]Lagace, *op. cit.*, pp. 69-79.

[8] *Ibid.*, p. 12.

[9]*Ibid.*, p. 30.

[10]*Ibid.*, pp. 72-78.

TABLE I

RECONSTRUCTION MADE NECESSARY BY BRANCH LINE ABANDONMENT AS ESTIMATED BY LAGACE

	Handling-Capacity Ratio		
	4.0	3.0	2.0
% Reconstruction of lost capacity	15.3	35.4	98.5
Reconstruction in Millions of bushels	1.5	3.6	9.9

It is unfortunate that the estimates do not go beyond a handling to capacity ratio of four. A ratio of five might show that no reconstruction would be necessary. Historically, a ratio of four or greater, as pointed out by Lagace, is rare. He shows that only 3.8 per cent of the grain elevators achieved such a high handling to capacity ratio.[11] In the present study this group accounts for approximately thirteen per cent of all observations of handling to capacity ratios. It is possible that grain elevators can be operated more efficiently with a higher handling to capacity ratio. One of the purposes of this study is to investigate this point.

In view of the complex and multi-faceted situation confronting the grain industry today, this study is designed to focus attention on one aspect, and perhaps the most important aspect, of the over-all problem of railway branch line abandonment, namely, the grain elevator industry itself. Specifically, we will examine the cost of handling and storing grain in Manitoba country grain elevators.

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[11] *Ibid.*, p. 56.

Empirical results contained in other studies[12] have shown that economies of scale exist in the grain elevator industry. Therefore, assuming a uniform handling to capacity ratio for all elevators, the larger elevators will have a lower average total cost for handling and storing grain than will smaller elevators. By relaxing the assumption of a fixed handling to capacity ratio, it would seem that large capacity elevators will achieve low costs of handling and storing grain with a smaller turnover[13] than will low capacity elevators. This seems to be due to the high degree of fixity in the total cost of operating grain elevators. Some evidence of this is given on pages 70-71.

The degree of utilization[14] of the fixed facilities will also have an important bearing upon the average total cost of handling and storing grain. In other words the per bushel total cost of handling and storing grain will be affected not only by the amount of grain handled in a fiscal year, but also by the degree of utilization of the grain elevator.

This study examines the cost-output relationships as they existed in the grain handling years 1961/62, 1962/63 and 1963/64.[15]

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[12] United States Department of Agriculture. Costs of Storing Reserve Stocks of Corn. Market Research Report No. 93. Washington, D.C., June 1955. Also see Washington Agricultural Experiment Station. Handling-Storing Costs of Country Grain Warehouses in Washington. Bulletin No. 536. Washington State College, June 1952.

[13] Turnover is used synonymously with handling to capacity ratio.

[14] The degree of utilization refers to the average monthly inventory of any particular grain elevator relative to its capacity.

[15] The grain handling year begins in August and ends in July of the next year.

More specifically, the following relationships are examined:

1) How costs are affected by different handling to capacity ratios.
2) How costs are affected by the utilization of the available space.
3) How costs are affected by the amount of annex space available.
4) How costs are affected by the size of an elevator.

In addition to examining the above relationships, the study also attempts to supply answers to the following questions:

1) Depending upon the total handling expected at any grain elevator, what is the most efficient size of elevator for that site?
2) Assuming that some grain elevators, due to rail line abandonment, will have to be relocated, of the various possible relocation sites, where should the affected elevators be placed?

An important theoretical construct which would help answer some, and perhaps most of the major questions posed above, is the long run average cost or planning curve. The long run average cost curve, as defined by Stigler, is "the lowest curve touching the short-run average cost curves."[16] In mathematical terms, it is called the envelope of the short-run average cost curve.

Regression techniques are used in order to obtain the least squares estimates of the partial regression coefficients which explain variation in total cost of handling and storing grain in country elevators. The analysis makes it possible to estimate the probable

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[16] G.J. Stigler, <u>The Theory of Price</u>, Revised Edition, The Macmillan Co., New York, 1952, p. 141.

variations in cost resulting from changing the values of any one or all of the independent variables. It is therefore possible to estimate the planning curve for the grain elevator industry by holding all independent variables constant at certain specified levels while allowing the capacity measure to increase up to and including the largest size contained within the sample. It should be noted, however, that any curve developed by regression analysis is, by its very nature, only an estimate of the true planning curve of the industry for two main reasons:

1) Since regression analysis is an averaging process, the curve so developed must also be an average of the available cost data. The coefficient of determination (R^2) having a value of unity would be highly unlikely in a study such as this because the data were collected from grain elevators built in different time periods and of differing technologies. Therefore, a statistical curve, estimating the true planning curve, obtained through regression analysis will be composed of both positive and negative deviations. If there are any negative deviations, apparently the curve cannot represent the true planning curve since there must be a plant which has a cost level below that represented by the planning curve. This would contradict the definition.
2) As stated earlier, the planning curve is the locus of the most efficient or least cost plants. It is highly unlikely, however, that a random selection of grain elevators would contain only the most efficient plants.

Therefore, unless both conditions one and two above were satisfied simultaneously, the curve developed by regression analysis is, at best, only a close approximation of the true planning curve of the industry.

(C) DEFINITIONS

It is useful at this point to explain some of the terminology that will be used throughout the thesis.

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

Site; a location of any one particular country grain elevator.

Capacity; relates to the total rated storage space available at any particular country grain elevator.

Handling[17]; is equal to the amount of grain placed into the elevator plus the amount of grain taken out of the elevator and the sum divided by two.

Handling to capacity ratio; is the handling, as defined above, divided by the rated capacity of the grain elevator.

Annex; additional storage space which is, in most cases, attached to the main elevator house by augers.

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

Grain; refers to wheat, oats and barley.

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[17] The term "handle" is often used for handling by persons in the trade.

(D) DATA: SOURCE AND COLLECTION

The cost and handling data collected for this study are for the province of Manitoba. Since the collection of the data necessitated visits to the head offices of the contributing companies, similar trips to the other two large grain producing provinces were not necessary nor were they feasible, considering time and resource limitations. However, since the system of handling and storing grain is fairly similar in all three prairie provinces, the cost estimates developed for Manitoba in this project might be reasonably comparable to those in the other two prairie provinces.

The method of sample selection has a great bearing upon the reliability of the results of any study based upon statistical methods. If no information is available for the population parameters, which is likely to be the case for most cost studies, it is necessary to run a pilot study in order to obtain estimates of the parameters. To obtain the sample size necessary for the degree of reliability desired, the correct procedure would be to calculate the variance of each cost element, thereby allowing the element of greatest variance to determine the sample size required. Although the above method of sample size selection is the correct one, time and cost considerations often make it difficult to follow this procedure completely. The method followed for the present study, therefore, was to select a sample and then work back to discover the degree of confidence of the estimated coefficients. Although the method is not entirely statistically valid, it is an economic necessity. An important question that must be considered is: would the time and cost involved in following the proper statistical methods add anything significant to the study? In many cases the answer is probably no. This is because the pilot study is actually large enough to allow for the degree of confidence desired, even though the research worker is deciding upon the confidence level after, rather than before, examining the data.

The method of verifying what degree of confidence may be attributed to the sample is explained below. The formula used for calculating the sample size necessary for a given degree of confidence is:

$$N = \frac{t^2 s^2}{d^2}$$

where:

N = sample size

t = student "t" book value

s^2 = variance in the sample of any particular cost element for any strata

d = chosen margin of error

This calculation has been carried out for all ten cost categories used in the study and for each of the five strata within a category for various values of "t" and "d". The values of "t" used are 0.95, 0.90, 0.80 and 0.70 confidence levels. The values of "d" (margin of error) used are 5%, 10%, 15% and 20%. By calculating all possible combinations of "t" and "d", it can be found what values of the sample size are necessary for these combinations. Appendix A, page 96, shows one example of this calculation. It was decided to omit the cost category, interest on investment, from this type of calculation because the method of calculating this cost item lent itself to high variance. It was calculated on the basis of the undepreciated value of the asset. Since the sample contained grain elevators of different ages, the high variance was an indication of the different ages of elevators rather than the cost involved in operating elevators of different sizes.

The cost item which demands the largest sample size for any particular combination of "t" and "d" will determine the level of confidence which the selected sample would allow. By following the calculation, as explained above, this cost item is "Repairs", for the strata less than 40,001 bushel capacity. The degree of confidence is 70 per cent that the sample mean does not differ by more than 25 per cent from the population mean.

In Manitoba there are approximately 675 country grain elevators. The method of sampling used in this study could be referred to as a two stage purposive technique. The first stage was to reduce the population from 675 to 499 grain elevators. This was done by selecting the three major grain companies in Manitoba and thereby limiting the sample to come from this group. This was done to facilitate the collection of data and to minimize the effects of differences in accounting practices between the various contributing firms. It was also felt that this group of 499 elevators would provide an adequate or representative cross section of cost and handling data.

The second stage of the sample selection was to choose fifty-one out of the remaining 499 elevators. The fifty-one elevators selected ultimately yielded 140 observations, since the data was collected for a three year period. Thirteen observations were unavailable because of a lack of adequate data. The sample of fifty-one elevators was chosen with the use of a random number table[18], and

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[18] R.D.G. Steel and J.H. Torrie, Principles and Procedures of Statistics, McGraw-Hill Book Co., Inc., Toronto 1960, p. 428.

was proportional with respect to the size distribution of the population as well as the distribution of ownership of grain elevators amongst the three companies from which data was obtained. The distribution is shown in Tables II and III.

The method of sample selection with the use of random number tables is as follows. Assume that the population consists of ten elevators and that the desired sample size is three. Assign a number from one to ten to each of the elevators. The first three numbers in the random table are:[19] eighty-six, thirty-five and twenty-six. Now multiply as follows:

$$10 \times 0.86 = 8.6$$

$$10 \times 0.35 = 3.5$$

$$10 \times 0.26 = 2.6$$

Rounding off to the nearest whole number, the sample will consist of the grain elevators numbered nine, four and three. The above figures are only an example of the procedure followed and therefore do not correspond to the actual sample.

Upon selection of the sample, it was found that in some cases, certain grain elevators had to be replaced because of two main reasons:

1) Cost and handling records were not available for that particular grain elevator.[20]

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[19] Loc. cit.

[20] This situation occurs when there is more than one elevator at a point and the cost and handling data correspond to the point rather than to any particular grain elevator.

2) The grain elevator was not considered typical or representative of those in the industry.[21]

TABLE II

PROPORTION OF ELEVATOR POPULATION AND OF SAMPLE BY FIRM

Firm	% of Population[22]	% of Sample
A	69.0	67.0
B	26.0	27.0
C	5.0	6.0
Total	100.0	100.0

TABLE III

PROPORTION OF ELEVATOR POPULATION AND OF SAMPLE BY SIZE STRATIFICATION

Size Stratification in Bushels	% of Population	% of Sample
<40,001	23.0	20.7
40,001 - 60,000	28.2	26.4
60,001 - 80,000	16.2	13.1
80,001 - 100,000	13.6	16.4
>100,001	19.0	23.4
Total	100.0	100.0

[21] Discussion of the sample with informed persons in the trade supported this decision.

[22] The term population in these tables refers to the 499 grain elevators considered for the selected sample rather than to the 675 elevators that exist in Manitoba.

The time period of the study is the crop years 1961/62, 1962/63 and 1963/64. The purpose of using three years data for the study was to develop cost estimates which would depict normal conditions of handling and storing grain. The crop years 1961/62 and 1962/63 were years of low and high grain handlings respectively. In Manitoba, the total production of wheat was 34 million bushels in 1961/62 and 80 million bushels in 1962/63. The corresponding figure for the 1963/64 crop year was 61 million bushels[23] and it is considered a normal year. Although the choice of using three years of data is somewhat arbitrary, the difficulty of obtaining complete records prior to the crop year 1961/62, necessitated this decision.

Of the independent variables used in the study, only one presented a problem in collection. This was the measure of per cent utilization of the grain elevator. Per cent utilization was estimated by dividing the average monthly inventory figure by the capacity of the grain elevator. However, in the case of the largest data-contributing firm, the figure for average monthly inventory was not readily available. The method of arriving at this figure was to add to the beginning monthly inventory (stocks as of July 31 of the previous crop year) all receipts of grain for that month and subtracting from this total all shipments of grain out of the elevator for that month. The

[23]Source: Yearbook of Manitoba Agriculture, Manitoba Department of Agriculture and Conservation, Winnipeg, Manitoba. Although these figures are only for wheat, it is felt that since wheat is the largest crop produced in Manitoba that uses the country elevator system, the figures were indicative of the relative magnitudes of total grain moving through the country elevators for the years of the study.

monthly figures were then summed up and divided by twelve to calculate the average monthly inventory. Perhaps better results could be achieved by analyzing monthly figures for costs and handling, but the current accounting methods in the trade do not permit the use of this method.

Cost accounting which is carried out by many large industrial concerns attempts at even finer breakdowns than monthly cost and output figures. The idea behind modern cost accounting procedures is to attach a cost to each unit of output. This is really the accountant's attempt to estimate the economist's "marginal cost" which indicates the cost attributable to each additional unit of output. However, such finely divisible accounting practices are not followed by the grain elevator industry, probably because the cost of keeping such records would be greater than the possible benefits. If such records were available then statistical studies, such as the present one, would not have to be carried out in an attempt to examine the cost structure of the grain elevator industry.

CHAPTER II

(A) A BRIEF HISTORICAL SKETCH OF PRODUCER GRIEVANCE WITH THE GRAIN ELEVATOR INDUSTRY AND OTHER MEMBERS OF THE GRAIN TRADE[1]

The grain elevator industry of Western Canada was an object of complaint among farmers before such legislations as the Canada Grain and Wheat Board Acts. These Acts provided for negotiation of elevator charges, as well as the marketing of grains on behalf of producers. This is not to imply that there are no shortcomings in the present system. However, under the Canadian Wheat Board controls, grain producers are assured that the elevator industry is operated on a competitive basis. This is because the services performed by grain elevators have fixed and uniform charges. In essence, the grain elevator companies lease out their facilities to the Canadian Wheat Board at the agreed rates. It may be said then, that even though the structure of the elevator industry is oligopolistic, with a limited number of independent firms, its conduct in some of the important dimensions is perfectly competitive. Due to the norms of conduct set and/or supervised by the Wheat Board, therefore, the organization of the elevator industry can be characterized by a hybrid mixture of regulated oligopoly and competitive behaviour. The structure and conduct of an industry can act as the main determinants of its performance and are therefore of great importance with respect to public policy. Market structure, as defined by Bain,

[1]A great deal of the information in this section is developed from a course on grain marketing given by Dr. A.W. Wood of the Department of Agricultural Economics, University of Manitoba.

refers to "those characteristics of the organization of a market which seem to influence strategically the nature of competition and pricing within the market."[2] Market conduct of sellers, as defined by Bain, "concerns the composite of acts, practices, and policies of sellers used in arriving at and in some way coordinating their several decisions as to what prices to charge, what outputs to produce, what selling costs to incur, what product designs to offer and so forth."[3] The Canadian government has promoted competition in the grain elevator industry by adopting a policy which focuses upon the conduct of the industry. That is, by setting rates for the services performed within the grain elevator industry the government has ensured that such practices as;

1) cooperation between firms to fix prices, or
2) existing firms selling at low prices for a period of time to ease competitors out of the industry; will not take place.

The government has adopted this corrective-conduct policy rather than of direct intervention with the structure of the industry.

Throughout the period of the settlement of the west, prairie farmers had various grievances with or without foundation, not only against the elevator industry but also against the milling companies, the railways, the banking system and the Winnipeg Grain Exchange.

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[2] J.S. Bain, Industrial Organization, John Wiley and Sons, Inc., 1962, p. 7.

[3] Ibid., p. 266.

Grain producers felt that competition in the grain marketing industry was impaired by the following conditions.[4]

1) Prevalence of a high degree of concentration of ownership of elevator lines throughout the west.

2) The nature of the mechanism established by the powerful elevator lines for the maintenance of price uniformity amongst themselves.[5]

3) Action of the Canadian Pacific Railway to encourage the construction of standard elevators.[6] Through this action it was alleged that the Canadian Pacific Railway would ensure a virtual monopoly for anyone who would build a standard elevator at any particular site. It was further alleged that farmers or other businessmen who had flat warehouses at a site were being unfairly treated with respect to boxcar allotment.

More specifically, throughout the period of the late 1800's and early 1900's, the following complaints were made by grain producers against the elevator companies:

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[4] V.C. Fowke, Canadian Agricultural Policy, University of Toronto Press, 1946, p. 244.

[5] Producers felt that the establishment of the North West Grain Dealers Association and their habit of sending out one telegram announcing the daily prices to all agents at a point did not allow for adequate competition in grain prices at that point.

[6] A standard elevator was one which was built to store at least 25,000 bushels of grain and that was mechanically operated.

1) low prices for grain

2) short weighing

3) excessive dockage

4) improper grading

5) mixing and substitution of grains

6) refusal to supply bins

In general the producers felt that there was great pressure placed upon elevator agents to make their particular sites a going concern and that discriminatory practices against producers were inevitable.

As to the terminal elevators, the following allegations provided the basis for complaints about:

1) excessive dockage

2) undercleaning

3) mixing of grains

Producers argued that these practices depressed their returns because it reduced the average quality of grains in each grade that would be sold in the world markets.

The milling companies which operated country elevators were also charged by the producers with depressing the price of wheat and other grains. The producers contended that the millers took the choice carloads of grain within a grade for their own mills and thereby left lower quality grain for the world market. Thus, the actions of both the millers and the terminal elevators, according to producers, tended to depress the price of grain resulting in lower producer returns.

The banks also came under fire from grain producers for their practice of calling in agricultural loans early in the fall. This meant that many producers had to sell their grain at harvest time when the markets were glutted and prices were low.

Producers' resentment of the open market method of grain pricing was largely borne by the Winnipeg Grain Exchange since this was the mechanism which linked world prices to Western Canada and hence determined the returns to grain producers. Speculation was an element in the futures trading market that producers distrusted immensely. The producers felt that speculators could influence the market to serve their own ends. Speculation was criticized by producers for two further reasons:

1) It was believed that speculators could by working only a few minutes reap great profits, whereas producers had to toil for months to receive next to nothing.

2) They were convinced that speculation served no useful purpose.

Neither of these two points are generally valid as no one speculator operating, for example, in Winnipeg, could significantly affect world prices and because speculation does serve as a means to reduce price fluctuations. Although this is not universally accepted it has been used as an argument in favour of speculation. Be that as it may, by removing futures trading in wheat, the Canadian Wheat Board has completely replaced private speculation by public speculation on behalf of producers who bear group risk of price change. This is one of the few functions that has been completely replaced with the introduction of the Canadian Wheat Board method of wheat marketing.

The above brief description is by no means exhaustive of producer agitation but it does serve as an indication of the nature of producer discontent.

Complaints against the grain elevator companies were largely dispelled in the early 1900's by either legislation, such as the Manitoba Grain Act, or through the establishment of producer owned grain elevators. Many additional steps were taken both by the producers and governments, at all levels, in order to strengthen the position of the producers.

The final step in the control of wheat marketing was the re-introduction of the Canadian Wheat Board in 1935. The first Wheat Board was set up in 1919-1920, in order to apply wartime controls to the marketing of wheat in Canada. It was set up as a compulsory national pool and was the sole selling agency. No open trading was allowed in wheat on the Winnipeg Grain Exchange, and existing grain handling institutions acted only as agents of the Board while receiving and shipping wheat at fixed service margins.

The Board set an initial price for wheat to producers and gave participation certificates which would be valued according to the final price received by the Board in world markets. The initial reaction of producers was that this scheme was in the interest of consumers rather than the producers and hence they resisted this method of marketing.[7] However, when the full redemption value of the participation certificates was realized at forty-eight cents per bushel, the producers who first resisted the establishment of the Board, were now resisting the abandonment of the Board.

However, the situation under which the Board was set up no longer existed and the Board was therefore dissolved in August of 1920. In 1935, the Wheat Board was started once again due to the agitation of wheat producers. Actually the 1935 Wheat Board, as

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[7] H.S. Patton, Grain Growers Cooperation In Western Canada, Harvard University Press, 1928, p. 197.

conceived, was to encompass a complete nationalization of the grain marketing industry but in reality it became a buffer between the producers and the free market system. Since the delivery of wheat to the Board was optional, producers used this mechanism when prices were low on the free market. In essence, therefore, there were two methods of marketing wheat in Canada: the open market and the Canadian Wheat Board. This dual system lasted until 1943. With free market prices high, at this time, the Wheat Board was not receiving enough wheat to meet its obligations.[8] On September 7, 1943, the free market system for marketing wheat was closed down and the Board system, which was first used in 1919-20, was reinstated.

To the grain elevator companies this meant that once again they became agents of the Canadian Wheat Board. They performed the functions of handling and storing wheat, on behalf of the Board, at fixed service charges.

[8] Canada was committed to deliver wheat to Britain under Mutual Aid and also under bulk purchasing agreements.

(B) THE CANADIAN WHEAT BOARD AND THE GRAIN ELEVATOR INDUSTRY: THEORETICAL ANALYSIS

From the standpoint of economic theory, the control of the grain elevator industry means that tariff charges for handling and storing grain must achieve two broad and diverse objectives:

1) The charges for handling and storing grain must be at such a level that allows for a fair return[9] to the grain elevator industry.

2) Since the charges are paid by the producers, the charges must be fair as considered from the producers' point of view.

The control of the grain elevator industry with respect to service charges by the government, which followed many years of producer discontent, was introduced for the purpose of assuring a competitive grain handling system so that producers would feel confident of being treated fairly and equally. Economic theory would describe the present system of grain marketing as a monopoly, since the Canadian Wheat Board owns all the wheat delivered to grain elevators and controls the sale of all Canadian wheat.[10] The grain elevator industry, since it operates on set commission rates, acts as a perfectly competitive industry with respect to the pricing of its services. In

[9] A fair return would be defined as that return to the factors of production which allows them to remain in operation and is at least as great as their next best opportunity.

[10] An exception to Board ownership or control is the interfarm sale of wheat which may be conducted between producers.

addition, the grain elevator companies are placed in a position where they could have little say in the price a producer receives for his grain.[11]

Since the power to price services as well as wheat does not lie in the hands of the grain elevator companies, the producers demand curve for the use of the elevator facilities may be assumed to be perfectly elastic. This means that regardless of how much grain a producer delivers to a particular elevator, the per unit cost to the producer for the services performed by the elevator is unchanged.

It could well be argued that the demand curve for grain elevator facilities is not perfectly elastic to the extent that there is differentiation in the service which agents provide and also because differences exist among the internal operations of the various companies in the trade. In the latter case, the industry is comprised of cooperatives, joint-stock and private companies. These various types of financial organizations result in producer preferences with respect to the type of organization they wish to patronize. However, with respect to the cost of the services performed by the grain elevator companies, the industry could well be assumed as perfectly competitive.

The effect of imposing a fixed price upon the services performed is shown in the following diagram.

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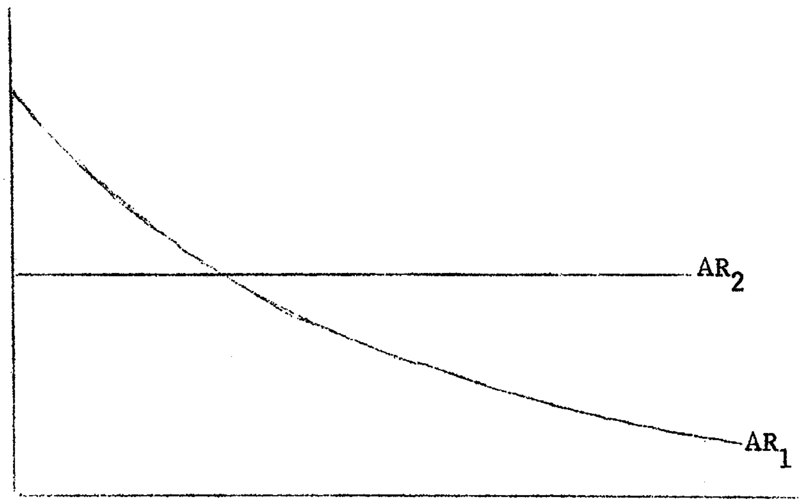
[11]Actually the elevator agent has an important influence on the price since his decision as to grade and dockage are often accepted as final by the producer.

Figure II - Producer Demand Functions For Elevator Services Under Fixed (AR_2) and Negotiable (AR_1) Charges

Price of the Service



Amount of Service

The sloping average revenue, or demand curve (AR_1), shows the shape of the producers' demand curve for the services of grain elevators, with no restrictions as to the price of the services and no collusion to fix prices by the elevator companies. The horizontal curve (AR_2) shows the shape of the producers' demand curve with a fixed service charge as negotiated by the Canadian Wheat Board. The effect is that all producers are assured of being charged the same amount for the services performed by the grain elevator companies. Theoretically, before the charges were fixed, the grain elevator companies could have charged different rates to different producers depending upon the individual producers demand function for the same services. Producers who could bargain better than others could possibly have obtained preferential treatment at the expense of other producers.

In economic terminology, the grain elevator companies could have practiced both first and third degree discrimination. First degree discrimination is the ability to charge each producer as high a price as possible for the service performed. Third degree discrimination is the practice of getting as much as possible for the service between sub-markets rather than between each producer. Although both forms of discrimination are highly unlikely in a service trade such as the grain elevator industry, third degree discrimination is more likely than first. This is so because of the varying degrees of competitive structure which exist between and within elevator points. At some points there are several companies represented whereas at others there may be only one firm.

In the early 1900's, when producers hauled grain by horse and wagon, it was essential that they patronize the nearest point. Under such conditions it was possible to practice third degree discrimination. Today however, apart from the Wheat Board controls, large trucks and good roads make such practices highly unlikely.

It is not necessary that an elevator agent charge different prices for services performed, in order to discriminate between producers, since the same result could be achieved by manipulating grade and dockage estimates. The present system which places restrictions on the amount of overages and underages of grades of grain that an elevator is allowed to report, along with government inspection of grain, if desired by the producer, makes any discrimination between producers very difficult.

In economic theory regarding the control of monopoly or oligopoly prices, the objective of such control is to either restrict profit rates or to obtain maximum output from the firm or firms. This is necessitated by the fact that firms, in other than perfectly competitive industries, face a downward sloping demand curve. If one assumes that a monopolist and a perfect competitor have average total cost curves of the same shape and height, then because of the slope of the demand curve, the monopolist will produce less than a firm under perfect competition. This is illustrated by the following set of diagrams.

Figure III Price and Quantity Relationships Under Perfect Competition

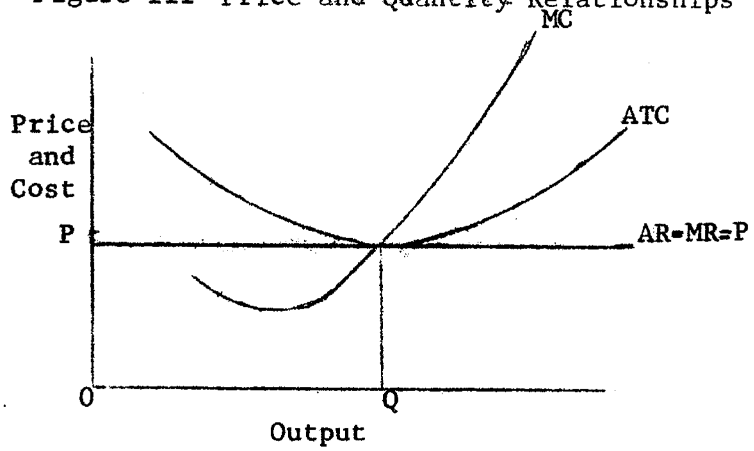
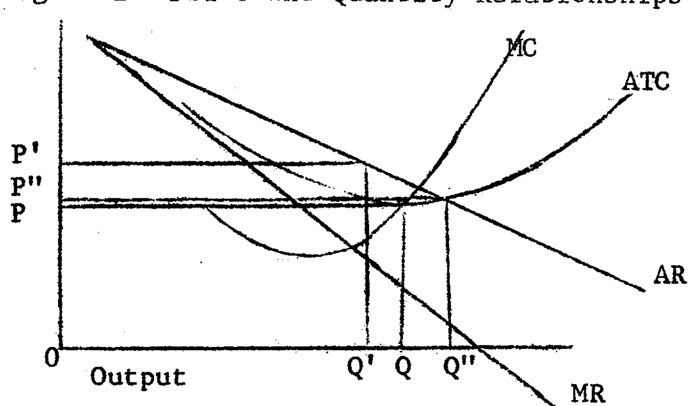


Figure IV Price and Quantity Relationships Under Monopolistic Competition



In Figure IV, the lowest price that could be effectively imposed upon the monopolist would be that at which the average total cost is equal to the demand price. At this regulated price, P", output of the monopolist is maximized at Q".

The effect of monopoly control, through price regulation, will depend upon the shape of the average total cost curve and the position of the demand curve relative to it. Joan Robinson shows the case of both a rising and falling average cost condition.[12] Mrs. Robinson points out that under the condition of falling average cost, a statutory fixed price can induce competitive output from a monopolist but it can not do so if the monopolist is operating under conditions of rising average cost. This is due to the difference in the position of the equality of marginal cost and marginal revenue.[13] Figures V and VI show the two cases of falling and rising cost, respectively.[14]

Figure V - Falling Average Cost

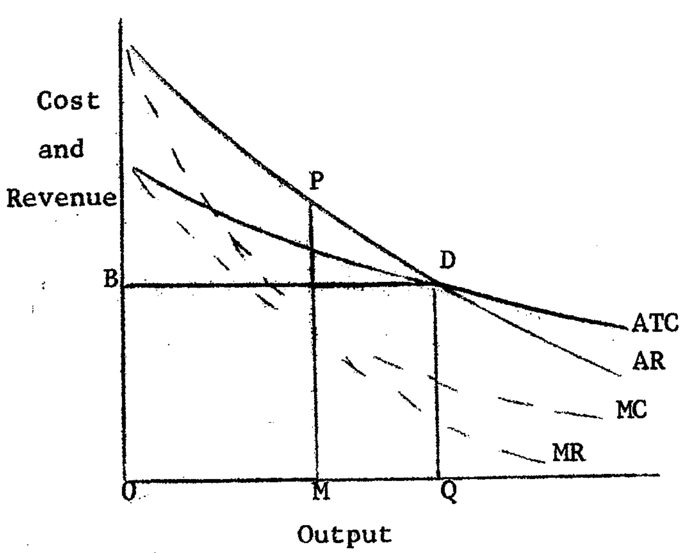
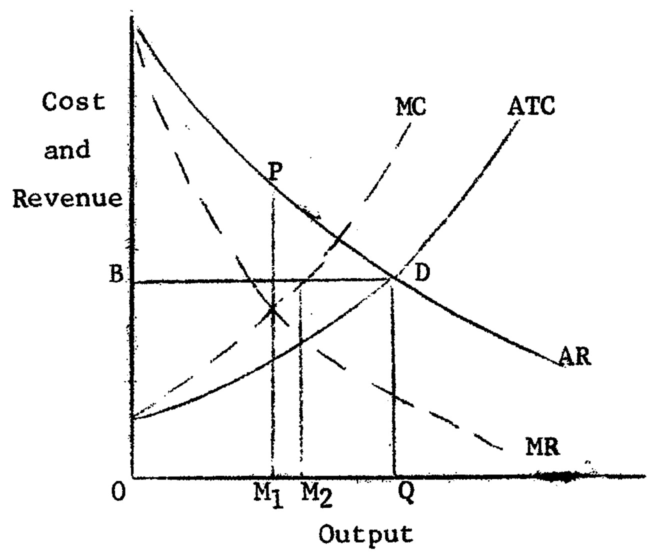


Figure VI - Rising Average Cost



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[12] J. Robinson, The Economics of Imperfect Competition, Macmillan and Co. Ltd., 1961, pp. 161-163.

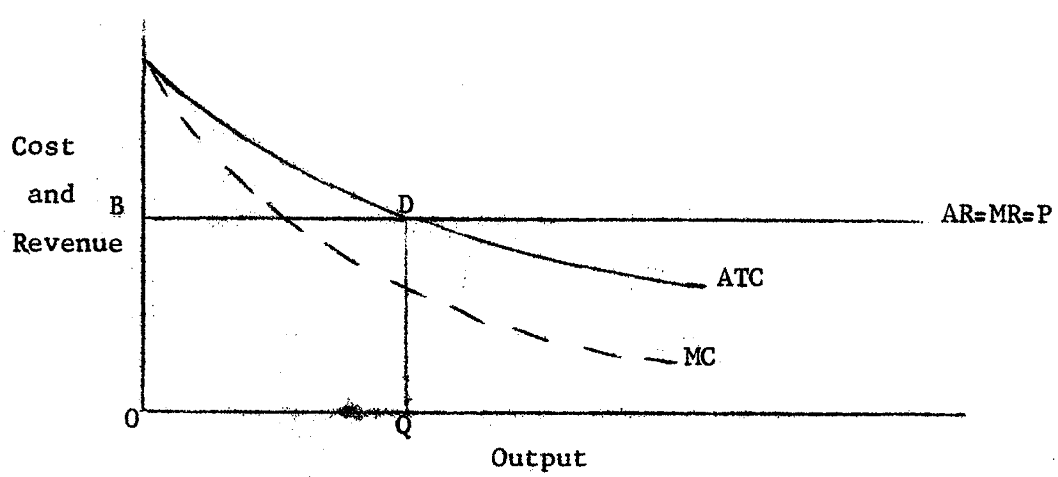
[13] An implicit assumption behind this statement is that the firm attempts to maximize net revenue. A necessary condition for profit maximization is that marginal cost equals marginal revenue.

[14] Op. cit., pp. 161-162.

The above diagrams represent the situation for a monopolist (that is for a single seller of a product) but it does not adequately represent the position of the grain elevator companies in Manitoba. In Figures V and VI the demand or average revenue curves contain a kink at the point where average revenue equals average cost. That is the demand curve becomes BDAR. This is not the case, however, for the grain elevator industry. The demand curve continues horizontally for any range of possible output, since handling and storing charges are fixed by the Canadian Wheat Board so that not even a lower charge than that stipulated by the Wheat Board is possible.

In Figure VI no changes are necessary because if the firm is attempting to maximize net revenue, under the regulated price, it will produce at output OM_2 (the point at which marginal cost equals marginal revenue). If the firm attempts to maximize output, with no abnormal profits, it would produce at output OQ (the point at which average revenue equals average cost). Figure V must undergo a change since output can be expanded beyong OQ. Figure VII below, illustrates this point.

Figure VII - Output Decision Under Price Regulation



Not only would the firm operate at output OQ, but it would also attempt to increase production beyond this point because this is the region of above normal profits. At output levels up to Q, at the regulated price, the firm incurs losses; at output OQ the firm is breaking even (since average total cost equals average revenue); beyond output OQ the firm earns better than normal profits. How far the firm will continue to produce will depend upon the capacity of the plant and the shape of the average total cost curve. If the average total cost curve continues to decline up to capacity output, then the firm will produce, with increasing profits, to that point. Even if the average total cost curve rises slightly it could be profitable to produce up to the full capacity level.

Capacity is a very difficult concept to define for the grain elevator industry. In relating capacity to yearly cost, it cannot be so simple a concept as that defined on page 12 . This definition (page 12) would be usable if the maximum handling to capacity ratio possible for any one grain elevator was unity. This obviously is not the case, since grain elevators are capable of turning over their storage capacity many times throughout the year. In the sample selected for this project, one grain elevator, for example, had a handling to capacity ratio of greater than seven.

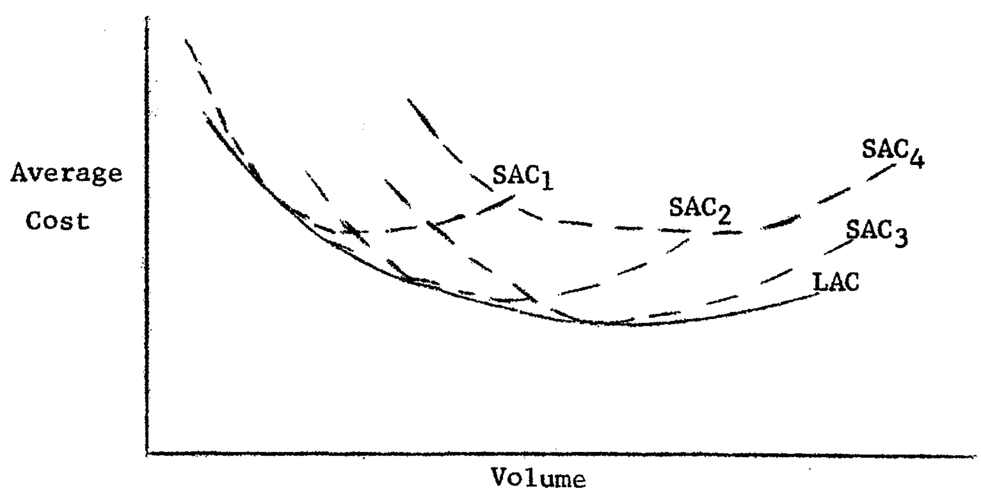
Before the Canadian Wheat Board became the sole selling agency for Western-Canadian grown wheat, the grain elevator companies had grain merchandising as one of their functions. The purpose of any one grain elevator was to move as much grain as possible into a shipping position (terminal elevators). It does not seem likely therefore that any grain elevator would restrict acceptance of grain. However this does not completely invalidate the relevance of economic theory to the problem on hand because there could be instances, even though hypothetical, where an elevator agent would refuse to accept grain or at least favour one producer over another. If a particular grade of grain was in great demand in the world markets and a farmer wished to deliver an off-grade that would take up valuable space, the agent could refuse to accept the grain hoping to attract the grain with a high demand. This would in all likelihood be a bad business practice for the grain elevator, but it would also depend upon the customer. If, for example, the producer was a faithful patron, this kind of treatment by the elevator agent would be unlikely. If a farmer delivered an off-grade that would take up only a small part of the storage bin and leave the rest unused, it might be less costly not to receive the grain at all. The above hypothetical arguments along with the fact that agents were more free than they are today to manipulate grades and dockage give a strong case for assuming that the demand curve for the use of grain elevator facilities was downward sloping. Under the Canadian Wheat Board, however, the demand for these facilities can be said to have become perfectly elastic with respect to the cost of services to the producers.

CHAPTER III

(A) A CRITICAL REVIEW OF LITERATURE

Cost-output relationships have been in the past, and will no doubt continue to be in the future, a source of controversy among economists. Much of the controversy lies in the development of the long run average cost or planning curve of an industry. The planning curve of an industry is the envelope of the lowest possible average cost curves for any output level. This relationship is depicted in Figure VIII below.

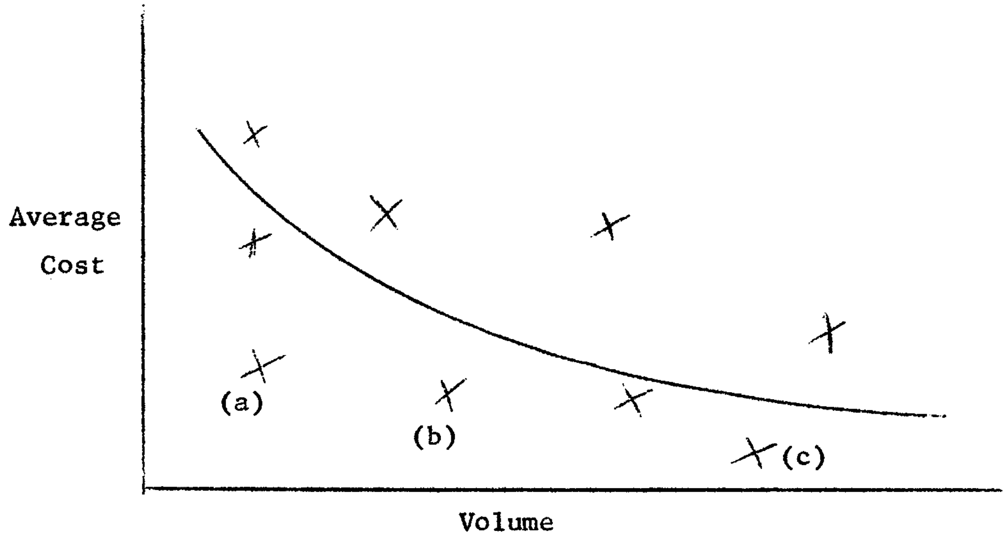
Figure VIII - Development of the Long Run Average Cost Curve From Several Short Run Average Cost Curves



The long run average cost curve (LAC) is tangent only to those short run average cost curves which are the most efficient for any given level of output. The importance in the development of such a curve lies in the future planning of efficient resource use in an industry.

Depending upon the nature of the desired results, methods ranging from the engineering-economic approach to regression analysis have been used with varying degrees of success. The engineering-economic approach, budgeting methods and various kinds of programming techniques are used to design plants of least cost operation, whereas regression techniques, which cannot achieve this result adequately, are used to obtain only an average relationship of cost-output data. It seems understandable, therefore, why an increasing number of economists are using the engineering-economic, budgeting or mathematical programming methods rather than regression analysis to estimate long run average cost (planning) curves. The extremely limited case where regression analysis could develop an accurate planning curve would be if all the data collected were of minimum cost enterprises and happened to fit a smooth, known functional relationship. This situation is most unlikely to occur. The curve developed by regression analysis is neither a long run average nor a planning curve in that it does not reveal the true cost economies available for firms of various sizes. This point is obvious from Figure IX showing the scatter of points and the fitted regression line.

Figure IX - Fitting a Regression Line to Cost-Volume Data



Points (a), (b) and (c) which lie below the fitted regression line are more likely to, but will not necessarily, fall upon the actual planning curve, than those points which lie above (a), (b) or (c). A better estimate of the planning curve could be constructed by joining all of the lowest points. Even then one cannot be absolutely sure that this is the true planning curve for the industry. It may be "theoretical humbug" to be so cautious in the development of an empirical planning curve; nonetheless if there was at least one output level at which one of the existing firms did not attain the minimum cost possible, then in strictest theoretical terms the curve could not be regarded as the true planning curve.

Statistical cost functions have been criticized mainly for the linear bias they are believed to impart to the true cost-output relationship. If the total cost curve is linear, then the industry operates under constant marginal cost over the entire observable range of output, which is a limited case in the marginal theory of the firm. Although constant returns to scale is a part of marginal theory, it is not generally thought to exist over the entire observable range of output but rather at most only over a small portion of the output scale. It is not intended here to enter into a comprehensive discussion of linear total cost curves and the marginal theory of the firm since excellent accounts of this controversy are available in published literature.[1] However, since many cost-output studies have yielded a linear total cost function, some of the more pertinent criticisms may be noted here.

A major criticism of statistical cost functions arises from the stochastic nature of economic data. The critics argue that due to the stochasticity of data, one cannot assert that any particular statistical cost-output relationship reflects the "true" cost-output situation. The argument is valid and it must be contended with if results of such studies are to be taken with any measure of confidence. One possible method of ironing out the stochastic nature of the data is to take an "N" year average of the cost and output data for each firm rather than to take only one year's data where chance variance is highly probable.

Staehle[2] suggests that the sources of linear bias lie in the various indexes used to make adjustments for factor prices in the

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[1]See for example H. Apel, "Marginal Cost Constancy And Its Implications", American Economic Review, Vol. 38, Dec. 1948, No. 5 pp. 870-885. R. Ruggles, "The Concept Of Linear Total Cost-Output Regression", American Economic Review, Vol. 31, June 1941, No. 2, pp. 332-335. R.H. Rowntree, "Note on Constant Marginal Cost", American Economic Review, Vol. 31, June 1941, No. 2, pp. 335-338.

[2]H. Staehle, "The Measurement of Statistical Cost Functions", Readings in Price Theory, Stigler and Boulding editors, Vol. VI, 1952, pp. 264-279.

application of a selected set of prices for the actual inputs, and in the selection of the time period for which accounting data are taken. Johnston[3] shows, however, that in regression analysis there is just as great a chance of introducing a curvilinear bias as there is of introducing a linear bias into the cost-output relationship. The type of bias will in fact, as shown by Johnson, depends upon the shape of the "true" cost function. If the true function were linear, the bias would be towards curvilinearity, whereas there is a linear bias only if the "true" total cost function was concave from below.[4]

Stigler's argument against linear total cost functions is that, "if marginal costs were constant over a wide range of outputs and then rose steeply for each firm the output of the competitive industry would vary in the short run chiefly through variations in the number of plants in operation and hardly at all through variations in the rate of output of plants that stay in operation. But this is the opposite of the facts."[5] Johnston contends that this does not give a conclusive test of marginal theory. Instead it provides a test of a three part hypothesis:[6]

1) Perfect competition prevails so that entrepreneurs determine output by the equality of price and marginal cost.

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[3] J. Johnston, <u>Statistical Cost Analysis</u>, McGraw-Hill, New York 1960, pp. 170-176.

[4] <u>Ibid</u>., p. 176.

[5] G. Stigler, <u>The Theory of Price</u>, Revised Edition, Macmillan Co. New York, 1952, p. 167.

[6] <u>Op. cit</u>., p. 183

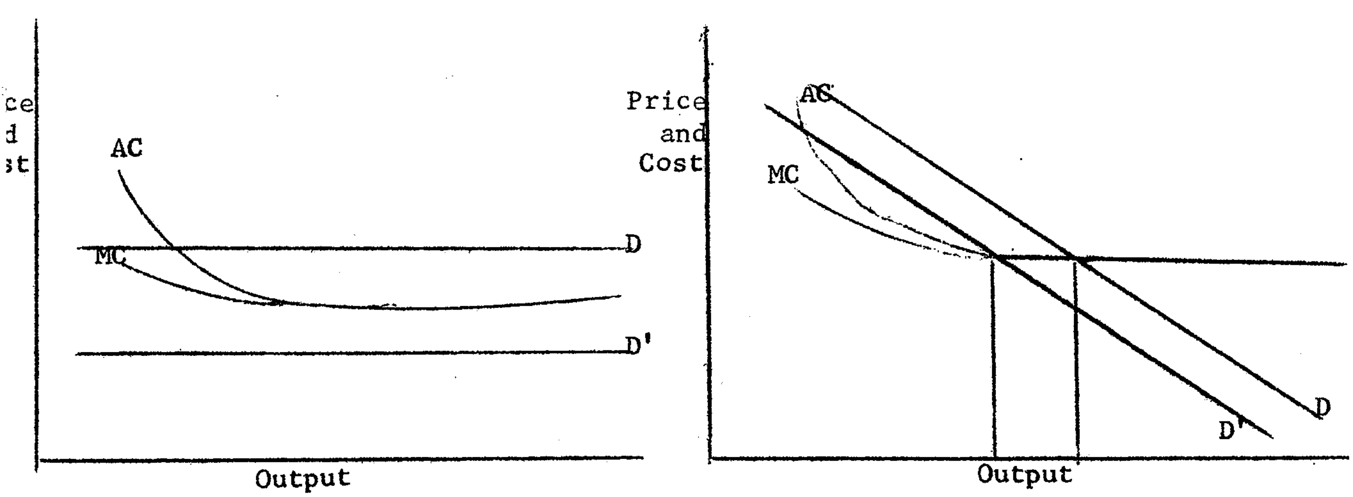
2) Marginal cost is constant up to a high output rate for each firm.

3) The level of constant marginal cost varies between firms. Stigler's argument is theoretically possible but it holds little practical value since it tacitly assumes a perfectly elastic demand curve for all firms. This is unlikely since consumer preference, brand names and other results of product differentiation make this condition virtually impossible. If, therefore, the market situation is something less than perfectly competitive (if for example firms face downward sloping demand curves) then it is possible that all firms could face, in a recession, demand curves that have shifted to the left. This will result in all firms contracting output rather than some with high cost structures dropping completely out of competition. This is shown below in Figure X.

Figure X

Part A
Why Firms Would Drop Out of an Industry Under Perfect Competition

Part B
Why Firms Would Not Drop Out of an Industry Under Imperfect Competition



In part A of Figure X when the demand curve is perfectly elastic and drops from D to D^1, firms with a cost structure as shown will leave the industry because at no output level can the firm either make a profit or break even. In part B, however, with a demand curve something less than perfectly elastic, the firm will cut back its output rather than drop out of the industry.

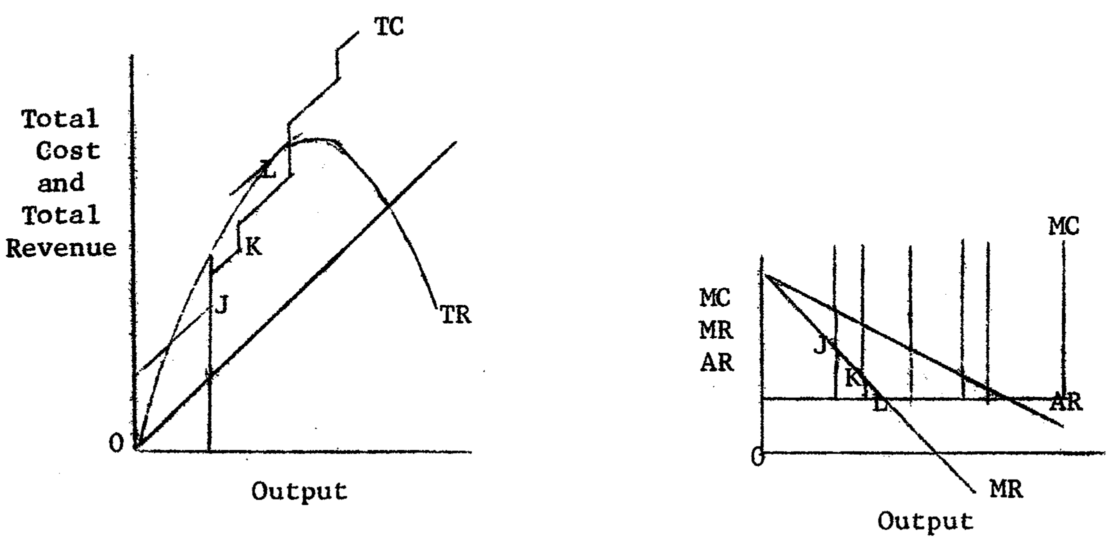
The use of a simplified approach equating marginal cost to marginal revenue is in itself a spurious concept. There can be no argument that to maximize net revenue this condition is necessary if the cost and revenue functions have normal properties. However the real world entrepreneurs in contrast to their textbook counterparts must operate in a highly complex world marred by uncertainties and a number of structural and institutional imperfections. Output decisions under these circumstances must be based upon future expectations of prices, demand, factor supplies, inventories and last, but not least, the strategies of rival firms. The important point is that output decisions are not determined entirely by the simple static conditions underlying the traditional cost and revenue theory of the firm. These decisions must be made in the light of the dynamic elements which surround any entrepreneur and his product.

Before continuing with the Johnston-Stigler arguments, it would be useful to show a case, as represented by Brems[7], where the equality of marginal cost and marginal revenue will not yield maximum net revenue. He shows this to be the case when, as is true in most

[7] H. Brems, "A Discontinuous Cost Function", American Economic Review, Vol. XLII 1952, pp. 577-586.

production situations, the durable factors of production cannot be varied continuously but can be purchased and used only in a few discrete sizes. The cost functions developed under these conditions will contain kinks, each kink arising at the point where an additional unit of the durable factor is added to increase production. Brems uses the following diagrams to illustrate the above and to show that profits are not necessarily maximized where marginal cost equals marginal revenue.[8]

Figure XI - Why Profits are not Necessarily Maximized when Marginal Revenue Equals Marginal Cost



[8] Ibid., p. 580.

The kinks at points J, K, and L along the total cost function represent the output levels at which an additional unit of the durable factor is added to the plant. Therefore the total cost function rises vertically by some finite amount (the cost of the durable factor) above its original path. At this point, the marginal cost of production becomes infinite. The marginal cost function is therefore either a constant value (X) or is infinite. If one were to follow marginal analysis, profits would be maximized where marginal cost equals marginal revenue and production would continue up to point L. However, in examining all the corner points, like J and K, it is found that production at point J yields greater profits than at point L. Therefore, when a cost function contains kinks, it is essential to examine all the corner positions in order to locate the maximum maximorum position of profits. The condition for profit maximization then is not simply that marginal cost equals marginal revenue but that the firm must operate at that output level which lies somewhere within the limits where marginal cost is less than marginal revenue and marginal cost is greater than marginal revenue.

Johnston's criticism of Stigler, though valid in a general sense, may be unfair due to the difference in specific contexts of their writings. Johnston discusses statistical cost curves in the realm of industry analysis whereas Stigler is speaking of individual firms. Regression analysis can give only an average of the available cross section or time series data. By analyzing individual firm data we cannot infer that this result also holds for the entire industry. Stigler, by inferring that since the marginal cost curve of an individual firm is constant therefore marginal cost is constant for the entire industry, commits the fallacy of composition.

Yet another criticism of cost-output regression studies has been with respect to the manner of handling depreciation figures. The use of straight line rather than succeesive approximation has been said to impart a linear bias to the total cost function. This argument is well founded but not necessarily universal. If in fact use (wear and tear) depreciation is linearly related to output then no linearity bias arises. If a use depreciation is considered then the method of straight line depreciation would understate total cost in a period of high output but overstate it in a period of low output.[9] By using successive approximations, however, we run into the problem of having to use accounting book values for depreciation which have their own inherent inaccuracies. First there is the problem, in a study of this type, of plants being built in different time periods. Second there is the problem of over and under valuation between plants depending upon their profitability. The purpose of depreciation to an accountant is to accumulate sufficient funds so that a plant can be replaced at the end of its stipulated life. If a plant has been operating profitably there is a tendency for the profits to be capitalized into the "book value" of the plant. If the plant has been operating unprofitably then the "sunk" funds will be paid out only what they can earn. For these reasons calculation of depreciation (also interest on investment) becomes

[9] Johnston, p. 184.

difficult and generally a straight line basis is used. On this point, Johnston[10] suggests that some fixed minimum sum should be allocated for output levels from zero to one hundred per cent capacity plus a variable charge based on actual output. In the grain elevator industry this concept would be difficult to apply because the capacity of an elevator is not easily defined. If grain is moving both into and out of elevators, capacity could be determined by elevator size, size of the leg or other piece of machinery, or by the number of working hours in a day. Furthermore, what variable charge would be the proper one in order to depreciate a piece of equipment to the end of its useful life?

Statistical cost functions may or may not impart a linearity bias to cost-output relationships, as the previous paragraphs have explored. The question of greater importance is that if they do impart a linear bias, does this bias seriously limit the practical conclusions of the study? This will depend upon the amount of the bias and the accuracy desired.

In defence of the linear statistical cost-output approach, Johnston lists three important points:[11]

1) In the majority of cases where statistical tests have been applied, the hypothesis of a linear total cost function has not been rejected.

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[10] <u>Ibid</u>., p. 185.

[11] <u>Ibid</u>., p. 170.

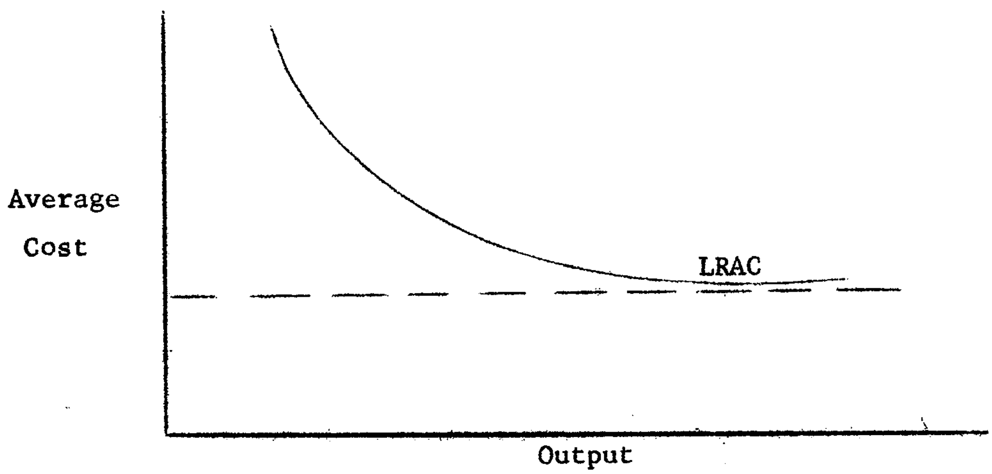
2) In most of the cases, no statistically significant improvement on the linear hypothesis is achieved by the inclusion of a second or higher degree term in output.

3) Supplementary tests, such as the examination of incremental cost ratios, usually confirm the linear hypothesis.

With these points in mind, it appears as if much of the criticism directed at straight line total cost curves arises from a preconceived idea of what a typical cost curve should look like. Whenever, therefore, a statistical cost function is linear, it appears that the facts have contradicted logical theory. This is not necessarily so. Merely because a regression analysis of cross section reveals a linear relationship, there is no reason to assume that either the average cost curve of each firm, or the long run average cost curve for the industry must be linear. To assume the former would be to commit the fallacy of division. To assume the latter would be to misunderstand the limitations of regression analysis. It is not necessary that regression snalysis exactly represent either the shape or the height of the long run average cost (planning) curve. This would depend to a large extent upon the value of the coefficient of determination. The higher the value the greater the degree of confidence that may be placed upon the functional relationship used to explain cost variation.

The typical long run average cost curve is visualized as falling downward to the right, reaching a minimum and then beginning to rise again. In any one study, however, over the observable range of output, the planning curve may not show a tendency to rise. Instead, it may approach assymptotically some horizontal imaginary line above the output axis. This is shown in Figure XII below.

Figure XII - The Long Run Average Cost Curve



In fact, enough empirical evidence exists to support the contention that the above type of long run average cost curves are more common in real life than the text book U-shaped type. For example, a United States Department of Agriculture study made by Dachtler _et_. _al_.,[12] obtained a cost curve of this type using regression analysis. This same type of result was also obtained by Bressler[13] who used the building block approach to an economies of scale problem.

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[12] United States Department of Agriculture, Agricultural Marketing Service Market Research Report No. 93, _Costs of Storing Reserve Stocks of Corn_, June 1955.

[13] R.G. Bressler, Jr., "Research Determination of Economies of Scale", _Journal of Farm Economics_, Vol. XXVII No. 3, August 1945, pp. 526-539.

Bressler provides a further argument for an average cost curve which having reached an apparent minimum becomes asymptotic to the output axis. In discussing previous studies he notes that cost varied more in the small volume plants than in the large. This seems to indicate that there is a greater range of economies available to the low volume plants than in larger size plants. This argument does not solve the problem of whether or not the average cost curve should rise, but it does give added strength to the notion that the curve tends to level off after some level of output.

One of the major criticisms of statistical cost-output relationships, as mentioned previously, is the unreliability of the functional relationship due to the stochastic nature of economic data. In studies of grain elevators by Jorgens and Snodgrass,[14] and Dachtler *et. al.*, analysis was based on only one year's data. Should the year selected for the study turn out to be either a high or low cost year, due to external factors, such as the size of total crop, amount of grain moved out of elevators, or the weather, then the reliability of the cost estimates may be seriously marred. The present study uses a three year sample of data in order to normalize the data and increase the reliability of results. In the study conducted by Dachtler *et. al.*, it was mentioned that the year used was a normal one with respect to yields and total crop output.

In the study by Jorgens and Snodgrass, data were collected for

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[14] J.R.S. Jorgens and D. Snodgrass, *Handling-Storing Costs of Country Grain Warehouses in Washington*, Washington Agricultural Experiment Stations, Bulletin No. 536, June 1952.

1946-47 and 1947-48 separately. With a linear function they obtained values of the coefficient of determination (R^2) for the two years as follows: 0.575 for 1946-47 and 0.269 for 1947-48. These values of (R^2) indicate that only 57.5 per cent and 26.9 per cent of the variation in total costs have been explained by the independent variables. The accuracy of any cost predictions must therefore be questioned very seriously, at least in the crop year of 1948. It is difficult to know, when using regression analysis, whether or not the functional relationship, so developed, is the correct one. In this case we are not only unsure of the accuracy of the functional relationship, but also of the level and slope of the average cost curves.

The study of Dachtler *et. al*., using a function that was curvilinear in one of the independent variables, obtained an R^2 value of 0.988. This means that the function was able to explain 98.8 per cent of the variation in total cost of the elevators in the sample. With such a high level of R^2 we are able to place much greater confidence in the cost estimates which come out of the study than is the case of the Jorgens-Snodgrass study.

It would appear that in the study by Jorgens and Snodgrass an important independent variable may well have been omitted. Upon examination of the independent variables used in both studies it was found that in the study by Dachtler *et. al*., average monthly inventory was used as an independent variable, while it was not used in the study of Jorgens and Snodgrass. The simple correlation coefficient between total cost and average monthly inventory was found to be 0.939 in the study of Dachtler *et. al*. This shows that there is a high degree of correlation between the two variables so that the independent variable, average monthly inventory, is quite important in explaining the variation in total cost. It is important to note that the independent variables used in both studies, other than the average monthly inventory as used in the study by Dachtler *et. al*., are either the same or nearly the same. It is reasonable to conclude, therefore, that the inclusion of average monthly inventory as one of the independent variables would have improved the study of Jorgens and Snodgrass. One cannot be absolutely sure, however, that this would have increased the value of R^2 since the study by Dachtler *et. al*., used a curvilinear model whereas the model used by Jorgens and Snodgrass was linear.

A point of note coming out of the study by Dachtler *et. al*., is concerned with the value of R^2 and the use of total cost or average cost as the dependent variable. It is pointed out that the statistically significant R^2 value may not have the same meaning when we use the total cost rather than average cost as the dependent variable. This is so because as long as any costs are variable there is some relationship between volume and total cost whereas there may be little or no relationship between volume and average cost. If this is so, then, when using total cost as the dependent variable we should hope to obtain an R^2 value that is more than merely statistically significant. The study by Jorgens and Snodgrass used average cost as the dependent variable whereas the study by Dachtler *et al*., used total cost as the dependent variable. In this study, functions using both total and average cost will be used as dependent variables.

Statistical cost-output relationships, especially those using a linear function, have been a source of controversy between economists, as this chapter has hoped to show. As Johnston has pointed out, the linear function has proven to be statistically significant in many cases even though this seems to contradict traditional economic theory. A study conducted by French, Sammet and Bressler[15] has put forward a clear explanation of why the linear total cost function has proven to be adequate. The reason given is that statistical studies based on accounting data cannot or at least do not differentiate between the time and rate dimensions of increasing plant production in the short run.[16] Production increases in the rate dimension are represented by a normal production function and is therefore curvilinear, whereas increases in output in the time dimension are linear.

> If rates of plant output are held constant and total output varied by varying the number of hours worked per day of week, the uniform level of intensification in the rate sense can be expected to produce constant marginal cost. This will be true even though the cost function may be curvilinear in the rate dimension. The linear total cost functions obtained in a number of empirical studies apparently have resulted largely from variation of this type, although this has not always been made clear in the reports.[17]

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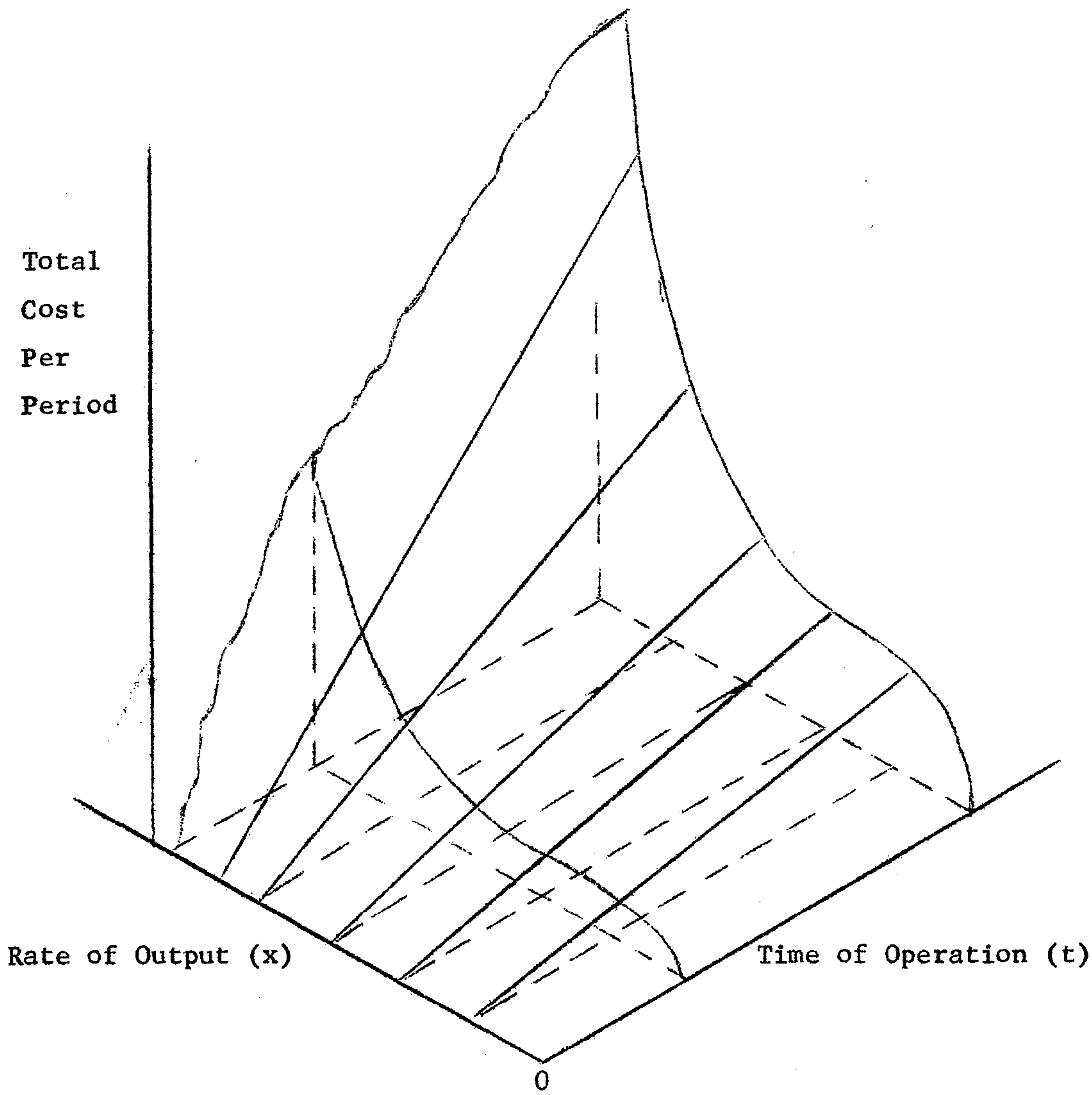
[15] B.C. French, L.L. Sammet, and R.G. Bressler, "Economic Efficiency in Plant Operations With Special Reference to the Marketing Of California Pears", Hilgardia, Vol. 24, No. 19, July 1956.

[16] Ibid., p. 548.

[17] Ibid., p. 548.

This is shown in the following diagram.[18]

Figure XIII - Total Cost as Affected by the Time and Rate Dimensions



[18] Ibid., p. 560.

The importance of the study by French, Sammet and Bressler lies, among other things, in the clear exposition of both the time and rate dimension of output variation in the short run. This type of analysis is limited to the case study method and could not be incorporated into a regression model because of the large number of observations necessary in the latter.

It is a characteristic of the grain elevator industry that both time and rate dimension are important variations in its operations. In the fall of the year (harvest time) the grain elevators are extremely busy and operate for many hours a day at a rapid rate. At other times of the year both the time of operation and the rate of operation will vary from moderate to slack. Accounting data and regression analysis cannot differentiate these possible variations. This is not a weakness of statistical cost-output studies since they are designed generally to show the average level of cost for the industry as a whole rather than for specific characteristics of any one plant. Therefore regression analysis is a useful tool for explaining the overall level of costs with the implicit assumption that variations in the time and rate dimension will continue in the same fashion as they prevailed for the period under study.

(B) MODELS

Multiple regression models are used to explain the effect of certain variables on the cost structure of the country grain elevator industry in Manitoba.

The models are:

1) $Y = f\ (W_1\ W_2\ W_3\ W_4)$

where: Y = total cost in dollars

W_1 = total amount of grain put into the grain elevator in a fiscal year

W_2 = total amount of grain taken out of the grain elevator in a fiscal year

W_3 = average monthly inventory

W_4 = average unused capacity

2) $Z = f\ (X_1\ X_2\ X_3)$

where: Z = average cost in dollars

X_1 = handling to capacity ratio

X_2 = annex to capacity ratio

X_3 = per cent utilization

Model 1) attempts to explain the variation in total cost whereas model 2) attempts to explain the variation in average cost.

In fitting regression equations to economic data many types of functions may be used to find a good fit to the data. Such functional relationships as linear, Cobb-Douglas, quadratic, cubic, quartic, and a host of others may be used. The problem for the research worker is to choose one that is both statistically and economically relevant. Models are generally constructed by first estimating the possible shapes of curves with the use of scatter diagrams. Fortunately, high speed computers make it possible to test the appropriateness of different models.

If a model were to be accepted on strictly statistical grounds then the model which yielded the highest coefficient of determination (R^2) would be accepted. However the difficulty here is that a statistically acceptable model (yielding the highest R^2 value) may not necessarily be a good economic model in that it may not explain adequately the phenomenon (for example a total cost function) under consideration. It is conceivable, in certain cases, that a circle could provide the best fit. From the standpoint of economic theory it would be hardly acceptable as an explanation of variation in the total cost function under study. Likewise an "economic" equation forced to statistical data may yield a low R^2 value and hence may be statistically insignificant as an explanation of cost variations. Therefore some common ground must be struck so that the model chosen is acceptable on statistical as well as economic grounds.

Linear models for both total and average cost will be tried initially in order to see if they can significantly explain cost variation. As remarked earlier, linear functions to explain cost variation are generally unacceptable to economists because:

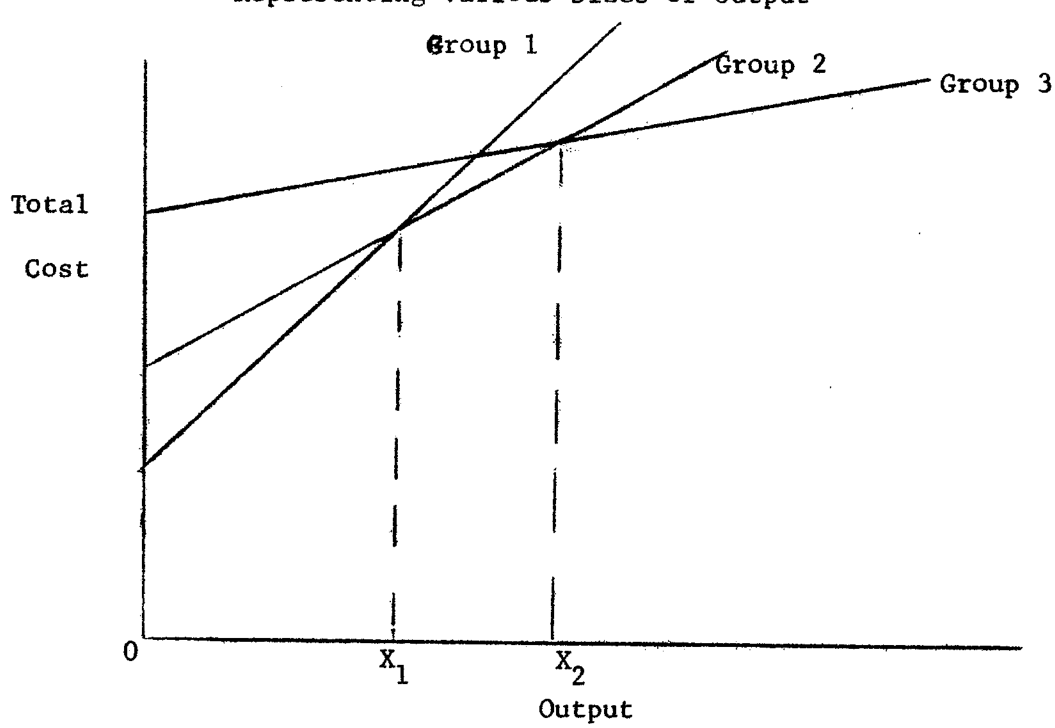
1) In the case of a linear total cost function, marginal cost must be constant at all levels of output. Economists do not usually believe this to be the general case.

2) In the case of a downward sloping linear average cost curve, the extension of the curve indicates that average cost must at some point decline to zero. This does not appear realistic.

The first argument is valid provided marginal cost is, in fact, variable for the population from which the sample is selected. The second argument is generally invalid because the point at which the average cost curve would become zero is usually beyond the range which the functional relationship is permitted to predict.

It may be possible, however, to represent cost functions as a group of straight line segments, rather than as one continuous function. With this in mind the data was analyzed as five independent stratum. Figure XIV shows how the total cost function might appear as composed of straight line segments.

Figure XIV - Total Cost Curve Developed By Straight Line Segments Representing Various Sizes of Output



The above diagram shows that up to output OX_1, group 1 sized elevators would be used to result in the lowest total cost of operation whereas for outputs between X_1 and X_2, group 2 sized elevator would be used, and so on. It is hoped that this type of result will be determined by the model.

The choice of the stratum sizes is a subjective one and could bias the results since the slopes of the various fitted functions could change as the size of the stratum were changed.

CHAPTER IV

DISCUSSION ON COSTS

The grain elevator industry as it exists in Manitoba today comprises many different sizes, ages and types of elevators. This attribute of the industry makes it difficult to study the overall cost structure of the industry.

In the sample selected for analysis, the grain elevators are of different ages, different stages of repair and different locations in Manitoba. All these factors will cause random cost variation that is unexplainable with the use of the models. In most cost studies, therefore, the sample is selected so that random cost variation is minimized or, alternatively, the cost data is corrected for such variation. These adjustments are not crucial for this study because the object is to examine the costs of the elevator industry as they actually exist. In fact, one might even argue that such adjustments or corrections of the cost data are not only unnecessary for our purpose but they may even distort the true cost estimates.

All grain elevators in the sample are of the gravity type. This means that the storage bins are arranged in such a way that the grain moves back to the elevating mechanism by gravity. Thus the grain movement in such elevators is controlled by mechanical and gravitational means, involving no manual labour. Although the basic design of all grain elevators is similar, there are specific differences which, although not explained by the model, may cause cost variation.

The total storage capacity of any particular site is broken up into two parts:

1) the main elevator house capacity

2) the annex capacity

Annexes have different operating characteristics ranging from fully automated to hand operated. The most recent design for annexes is one that is built up as bins with augers spanning the length of the annex, both on the top and the bottom of the bins. This allows for complete mechanical operation of the annex. Grain is brought into this annex from the main elevator house along the top auger and dropped by gravity into the desired bin. Grain is removed from the annex by first dropping the grain, by gravity, into the bottom auger which transports the grain back to the main elevator house for shipping. There are other arrangements such as one stationary auger or a movable auger which allows for semi-automatic operations. Also in existence are, what are known as, temporary annexes. Some of these are holdovers from the early 1940's when grain elevator companies were given concessions[1] to encourage them to build storage space to handle the large crops and the large carryovers which resulted from the loss of the European markets.

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[1]Two year write off for depreciation charges and guaranteed storage rates for two years were the concessions given to grain elevator companies which built additional, temporary, storage capacity.

This type of annex is not attached to the main house and is manually worked. None of this type of annex is built today. In some cases, it was found that the so called annex was actually an old elevator house which has been converted to an annex. The handling of grain is then done through another house to which the annex is joined by means of augers. The various designs of annex may or may not affect the cost of handling and storing grain significantly. However, it is not the purpose of this project to analyze this particular aspect of possible cost variation. As shown in Model 7 on page 55, the amount of annex capacity in relation to the total capacity will be tested to see if the relationship has a significant effect upon costs.

Another concept that makes it difficult to estimate costs is the age of an elevator. This is because throughout the useful life of a grain elevator parts of it may be completely rebuilt or replaced due to wear and tear or obsolescence. In a grain elevator which on the whole may be quite productive and profitable, a particular piece of equipment may become obsolete and hence be replaced by equipment of advanced technology. The equipment which has been replaced may itself be perfectly functional and placed into another elevator whose equipment must be replaced. In many cases, detailed records of such shifts and changes in machinery are not available. Due to all such reasons which make it difficult to define accurately the age of an elevator, difficulties arise in attempting to develop cost estimates of depreciation and interest on investment.

The two main functions of a country grain elevator are to handle and store grain. Other functions, such as cleaning and drying grains, are considered as necessary parts of the two main functions of operating the elevator for any particular fiscal year. Since the elevator companies act only as agents of the Canadian Wheat Board, the function of merchandising or grain trading is no longer in their hands.[2] Under the agreement reached by the grain elevator companies and the Canadian Wheat Board, however, the elevator companies receive a one cent commission to compensate them for the loss of earnings from the merchandising function.

All cost data for this study were collected from head offices and were taken from yearly accounting records. For one of the companies, which contributed data, since adequate information was not available for the fiscal year 1961-62, the cost and handling data were collected only for the fiscal years 1962-63 and 1963-64. This meant that twelve observations could not be collected. For one other elevator a single observation, for the fiscal year 1961-62, was unavailable. With the thirteen missing observations, therefore, the sample of fifty-one grain elevators gave rise to 140 observations. It is on these observations that the study is based.

[2]The term grain here refers only to wheat, oats, and barley since other grains are merchandised by the elevator companies.

The cost data were broken down into ten divisions some of which may be considered operating while others are non-operating. Since the accounting data cover a full twelve months operation, the criterion used for classifying costs into operating or non-operating components was whether or not a particular cost was a direct out of pocket expense for that twelve month period. Since the cost items depreciation and interest on investment are "book" costs rather than direct or out of pocket expenses they are considered non-operating. All other costs are therefore called operating costs. The following table shows the breakdown of cost items into operating and non-operating components.

TABLE IV

BREAKDOWN OF COSTS INTO OPERATING AND NON-OPERATING COMPONENTS

Operating	Non-Operating
Salaries	Depreciation
Power, light and fuel	Interest on investment
Repairs	
Bonds and Insurance	
Share of general head office expense	
Agents expenses	
Miscellaneous	
Municipal Tax	

Appendix B, page 97, shows the mean, range and variance for all cost items and for each stratum.

Of the operating cost items, salaries and the share of general head office expense were the two largest items. Salaries would include the salary of the agent at the site plus any seasonal help used. No breakdown of the two was collected. Although salaries rose gradually with the increase in the size of the operation, it appears that the reason for higher salaries in most cases is the experience of the agent plus the importance of the site itself. The item, share of general head office expense depends primarily upon the amount of grain handled at any particular site. The cost data for this item, as others, was taken directly from head office accounting records. The details of how each of the three firms calculated this cost were not investigated.

Expenses of the agent would include such items as: car liners, rodent proofing and draying charges. The miscellaneous expense item includes any licences which were necessary, telephone and postage, and in general a catch-all for non-classified expenses. The operating expense of municipal tax was taken directly from accounting records and is in general a function of the size of the operation and the value of the site itself.

Various methods are available for the calculation of depreciation values. Some of the more common methods are the straight line, sinking fund, and the present value of future annual returns. One other method would be to use the "book" or accounting values.

These values are at times of little use because it is not uncommon for firms to depreciate investments more rapidly than the useful life would justify and then to carry the investment at zero or very low values after it has been completely depreciated. Also it is an accounting practice to appreciate or depreciate investment values with respect to the profitability of the investment. If the investment has been operating at a profit, there is a tendency for the profit to be capitalized into the "book" values. On the other hand, if the venture has been unprofitable the "sunk" funds will be paid back at the rate of their earnings.

The straight line method of calculating depreciation was used in this project for two main reasons. Firstly, the straight line method is simple to calculate because the yearly value of depreciation is independent of the age of the structure. Secondly, the assumption of a constant depreciation figure for grain elevators does not appear to be unreasonable. This seems to be the case because there is a slow rate of obsolescence in this industry, as compared to, for example, the automobile industry.

In order to calculate the depreciation figure for each elevator and for each year, a valuation of the site had to be obtained. There were several alternatives available for arriving at a valuation:

1) A current per bushel cost to build an elevator of various sizes was available. By multiplying this figure by the desired capacity, for any particular site, a current replacement value can be obtained.

2) Insurance values which represent the estimated value of the buildings and equipment were also available. These valuations are not the value of building new facilities, as in the above estimate, but are rather current values of existing facilities.

3) Since grain elevators are of different types and sizes, and they use various types of equipment, the building block method of evaluating each elevator could be attempted.

The second method of evaluating the site was used, since the insurance value placed on the facilities was an estimate of each individual production unit. Method one was rejected because it could not give individual valuation of existing facilities. The third method was not used because of the lack of adequate information available on all elevators and because of the great length of time that would be required to evaluate a sample of fifty-one grain elevators in this manner.

In order to calculate annual depreciation, it was necessary to obtain an estimate of the expected life of a grain elevator. This is a difficult concept because the life of an elevator will depend upon the extent of its use each year, the amount of money that is put back into the elevator in repairs each year and perhaps the greatest problem is that the building and equipment will in all likelihood depreciate at different rates. At any rate, an estimated life expectancy of any site was decided upon by discussing this problem with informed persons in the grain elevator industry. After consultations with these people it was decided to use thirty-three years as the life expectancy of an average grain elevator.

The formula for arriving at yearly depreciation estimates using the straight line method is:[3]

$$Da = \frac{Dn}{N}$$

where:

Da = annual depreciation

N = estimated useful or service life

D_n = total depreciation during its service life.

At the end of its service life, a zero salvage value was applied to the grain elevators. This is an arbitrary decision but, then, any other salvage value would also be arbitrary.

As a point of departure, the following formula shows the annual depreciation rates if a salvage value is applied:[4]

$$Da = \frac{D_N}{N} = \frac{V_o - V_s}{N}$$

where:

V_o = original value of the site

V_s = salvage value

The only difference between the two approaches is that in the second case the salvage value is subtracted from the total amount to be depreciated through the life of the capital investment.

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[3] C.R. Young, An Introduction To Engineering Economics, University of Toronto Press, Toronto 1959, p. 61.

[4] Loc. cit.

In accumulating a depreciation fund through time, it should be realized that the fund itself is a source of interest revenue but is not treated as such when depreciation is calculated on a straight line basis. This means that by the time the capital investment has been fully written off, the amount accumulated in the depreciation fund is greater than the amount of the investment itself. For a large capital investment that is depreciated over several years this amount could be substantial. Although the enterprise benefits from the potential earnings of the fund, it is not given credit for the earnings.

Compensation for these earnings could be arrived at either by decreasing the size of yearly depreciation for the same total length of time or by decreasing the time period over which the capital investment will be written off.[5]

Interest on investment is another difficult aspect of estimating the total cost function. The purpose of having this as an item of cost is that any undepreciated portion of a capital investment is really a liquid asset that could be put to other uses. Hence these funds could be earning interest for which they must be charged a cost. In economic terms, the interest that could be earned is an opportunity cost to the enterprise. Interest on investment is calculated in this study as six per cent of the undepreciated value of the asset.

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[5]*Ibid.*, p. 62.

An implicit assumption underlying this method should be pointed out here. It is assumed that the value of the asset is paid off at the same rate at which it is depreciated. This may or may not be a realistic assumption, but it was nevertheless essential because of the paucity of readily available data and because of the tremendous amount of work necessary to analyze, closely, all fifty-one grain elevators in the sample under study.

Other costs in operating grain elevators such as shrinkage and quality deterioration were not included in total cost since estimates of these factors were not available.

CHAPTER V

EMPIRICAL RESULTS

The cost data were analyzed, with the use of regression techniques, in terms of both average cost and total cost for the fiscal grain handling years 1961/62, 1962/63 and 1963/64. The data were also broken down further into two groups: the first group excluded depreciation and interest on investment as costs, the second group included these as costs. The purpose for including depreciation and interest on investment as costs was to give estimates, for each of the strata, of current total costs in the industry. The reason for leaving these two costs out of the cost data was to discover if there exists a pattern of economies of scale for the industry vis-a-vis operating expenses.

A suitable functional relationship could not be found for the total cost data and therefore the analysis was continued only with respect to average cost. Total cost estimates are easily obtained, however, by multiplying the average cost calculated from the appropriate equation, by the amount of grain handled. Several functions, such as linear, quadratic and Cobb-Douglas, were used in an attempt to explain variation in total cost, but none yielded satisfactory results. Although most of the models attempted resulted in high R^2 values, none yielded consistently significant "t" values for the coefficients of the independent variables. This meant that the independent variables used were not important in explaining variation in total cost. This would seem to demonstrate, but by no means conclusively, that total cost is relatively fixed in the grain elevator industry. It is not proof in itself since variables other than the ones attempted here, might be found that would explain variation in total cost. This is unlikely, however, since the variables examined in this study seem to include those most likely to explain variation in total cost.

Several models were also used to explain variation in average cost. The model selected was:

$$AC = a + b_1 x_1 + b_2 x_1^2 + b_3 x_2 + b_4 x_3$$

where:

AC = average cost of handling and storing grain

X_1 = handling to capacity ratio

X_2 = annex to capacity ratio

X_3 = per cent utilization of the elevator

The squared term was used in an attempt to fit an average cost function that would be consistent with conventional economic theory and would at the same time be statistically significant. The squared term, if its coefficient were positive and significant, would have the tendency to turn the average cost function in an upward direction. A linear function was first attempted as a fit to the data but was considered unsatisfactory since average cost, in one of the strata, reached a zero level at an output level actually attained in that size group. Such an estimate of average cost could not be taken seriously. In the linear function, however, it was noticed that the independent variable, handling to capacity ratio, was highly significant in each strata. It was decided then to attempt to fit the data using a squared term for handling to capacity ratio. The results of using this model are shown below. The estimated average cost equations using all cost elements are denoted as AC_2. The estimated average cost equations which do not consider depreciation and interest on investment are denoted as AC_1.

TABLE V

ESTIMATE OF AVERAGE COST EQUATIONS BY SIZE STRATA

Stratum (in bushels)	Model Equation Number	Estimated Equation (coefficients[1] are in dollars)
<40,001	(1)	$AC_1 = .2354-.0568X_1+.0047X_1^2-.0595X_2-.0312X_3$ (.0114) (.0014) (.0500) (.0250)
40,001-60,000	(2)	$AC_1 = .1705-.0464X_1+.0045X_1^2-.0085X_2-.0059X_3$ (.0066) (.0011) (.0077) (.0083)
60,001-80,000	(3)	$AC_1 = .2413-.0835X_1+.0108X_1^2-.0357X_2-.0336X_3$ (.0098) (.0017) (.0305) (.0158)
80,001-100,000	(4)	$AC_1 = .1791-.0668X_1+.0077X_1^2-.0114X_2-.0110X_3$ (.0099) (.0017) (.0177) (.0215)
>100,000	(5)	$AC_1 = .2158-.1041X_1+.0197X_1^2-.0344X_2-.0030X_3$ (.0120) (.0036) (.0158) (.0118)
<40,001	(6)	$AC_2 = .2896-.0765X_1+.0066X_1^2-.0167X_2-.0357X_3$ (.0161) (.0020) (.0710) (.0288)
40,001-60,000	(7)	$AC_2 = .2276-.0617X_1+.0063X_1^2-.0311X_2-.0160X_3$ (.0093) (.0014) (.0110) (.0118)
60,001-80,000	(8)	$AC_2 = .3202-.1155X_1+.0151X_1^2-.0404X_2-.0426X_3$ (.0134) (.0024) (.0410) (.0220)
80,001-100,000	(9)	$AC_2 = .2829-.0975X_1+.0108X_1^2-.0109X_2-.0343X_3$ (.0138) (.0026) (.0254) (.0300)
>100,000	(10)	$AC_2 = .3466-.1700X_1+.0332X_1^2-.0801X_2-.0111X_3$ (.0179) (.0053) (.0232) (.0173)

[1]All coefficients have been rounded off to four places. Standard errors are shown in brackets below the value of the coefficient.

Table VI shows the level of significance of the coefficients, the R^2 value of each equation and the level of significance of the F ratio. The first five sets of figures belong to the model denoted as AC_1 and the last five to model AC_2.

TABLE VI

SIGNIFICANCE LEVELS OF THE MODEL*

Model Equation Number	X_1	X_1^2	X_2	X_3	R^2	"F" Ratio
1	.001	.010	.300	.200	.755	.005
2	.001	.001	.300	.500	.906	.005
3	.001	.001	.300	.050	.936	.005
4	.001	.001	N.S.	N.S.	.871	.005
5	.001	.001	.050	N.S.	.904	.005
6	.001	.001	N.S.	.300	.718	.005
7	.001	.001	.010	.200	.883	.005
8	.001	.001	.400	.100	.934	.005
9	.001	.001	N.S.	.300	.895	.005
10	.001	.001	.010	N.S.	.914	.005

*N.S. means that the coefficient is not significant even at the fifty per cent level. In examining Model Equation Number 1 the R^2 value of 0.755 means that 75.5% of the variation in average cost is explained by the model. The "F" ratio value of 0.005 means that in only 5 cases in 1000 the model will not explain the average cost structure of this size group. The significance levels of the independent variables X_1, X_1^2, X_2 and X_3 show the probability that the value of the co-efficient is not greater than zero. For example in Model Equation Number 1 the significance level of the independent variable X_1(0.001) shows that in only 1 case in 1000 will the value of the coefficient not be greater than zero. Therefore the X_1 coefficient is highly significant in explaining variation in average cost. The rest of the table is interpreted in the same manner.

In order to examine the average cost structure of the overall industry, rather than for each strata separately, the same model was used by combining all 140 observations in one equation. The results are as follows.

TABLE VII

ESTIMATES OF AVERAGE COST EQUATIONS FOR ALL OBSERVATIONS

Model Equation Number	Estimated Equation (coefficients are in dollars)
(11)	$AC_1 = .2041 - \underset{(.0039)}{.0519X_1} + \underset{(.0006)}{.0047X_1^2} - \underset{(.0070)}{0.0491X_2} - \underset{(.0082)}{.0170X_3}$
(12)	$AC_2 = .2765 - \underset{(.0051)}{.0777X_1} + \underset{(.0007)}{.0075X_1^2} - \underset{(.0091)}{.0503X_2} - \underset{(.0105)}{.0282X_3}$

Table VIII shows the significance levels of the coefficients in equations (11) and (12).

TABLE VIII

SIGNIFICANCE LEVELS OF THE MODELS

Model Equation Number	X_1	X_1^2	X_2	X_3	R^2	"F" Ratio
11	.001	.001	.001	.050	.763	.005
12	.001	.001	.001	.010	.793	.005

An interesting difference between Tables VI and VIII is that when the data are run as one strata rather than as five, the coefficients of the independent variables X_2 and X_3 become more highly significant. This is probably due to the increase in the degrees of freedom. Also the fact that the R^2 values are not generally so large in Table VIII as they are in Table VI shows that there is greater variance in examining all the data rather than the data for any particular size strata.

Using equation 12 one can calculate the estimated average cost of handling and storing grain for the years 1961/62, 1962/63 and 1963/64. The figures for the values of X_1, X_2 and X_3 are the mean values taken from Appendix C.

$$
\begin{aligned}
AC_2 &= .2765 - .0777X_1 + .0075X_1^2 - .0503X_2 - .0282X_3 \\
&= .2765 - .0777(2.423) + .0075(2.423)^2 - .0503(.400) - .0282(.592) \\
&= .2765 - .1883 + .0440 - .0201 - .0167 \\
AC_2 &= \$0.0954
\end{aligned}
$$

Therefore the cost of handling and storing grain in Manitoba country grain elevators was approximately nine and one-half cents per bushel during the period under study. The standard error is 2.39 cents per bushel.

Appendix C also shows the average total cost (AC_2) of handling and storing grain within each strata for the years 1961/62, 1962/63 and 1963/64. There is a downward trend in average cost from the first to the third strata. After the third strata the average cost begins to rise again. The rise in average cost may be attributed to two factors. First, it will be noticed that the handling to capacity ratio consistently falls between strata going from the smallest capacity plants to the largest. If the ratios were kept constant then costs might consistently fall. This will be shown later in this chapter. Second, in calculating AC_2 figures it was mentioned previously that these figures contained estimates for depreciation and interest on investment. Since many of the grain elevators in the larger capacity strata are relatively new plants or at least have had some recent construction done, the interest on investment figure tends to be quite large for some of these plants. These items of cost could then distort the operating economies available to large plants. Therefore one should also examine the AC_1 estimates which do not take into account the cost items depreciation and interest on investment. Examining the estimates for AC_1 in Appendix C the average cost falls for the first four strata and rises for the fifth. It would appear then that from the operating cost point of view, the strata 80,001-100,000 is, on the average, the most efficient group of grain elevators in Manitoba. Efficiency is used here in the sense that this group of elevators on the average attained the least cost of handling and storing grain for the three year period 1961/62, 1962/63 and 1963/64.

With the use of equations 1 to 10 it is possible to examine how the average cost of handling and storing grain varies with respect to the handling to capacity ratio and with respect to amounts of grain handled. The results are shown in Figures XV through XVIII, pages 79 to 82 . Figures XV and XVI show AC_2, the costs which include depreciation and interest on investment, as it is affected by the handling to capacity ratio and total handling respectively. Figures XVII and XVIII show AC_1, the costs which do not include depreciation and interest on investment, as it is affected by the handling to capacity ratio and total handling respectively. In all Figures the handling to capacity ratios and the total grain handling for each strata are those which have been actually achieved by grain elevators in each of the strata studied. In calculating the average costs for Figures XV to XVIII the values for the independent variables X_2 and X_3 were held at their arithmetic means as indicated in Appendix C. Appendices D and E show the average cost estimates for Figures XV and XVII and Figures XVI and XVIII respectively. Figure XV shows that if all grain elevators were to achieve the same handling to capacity ratio, the largest elevators attain the least cost of operations up to a handling to capacity ratio of approximately two and a half. After this ratio, the group ranging from 80,001 to 100,000 bushels capacity attains the least cost of operations. Figure XVII shows approximately the same results as Figure XV except that in Figure XVII the last two strata maintain approximately the same average cost up to a handling to capacity ratio of two. After this point the second last strata again is the most efficient from a cost standpoint. The fact that in Figure XVII the average costs of operating the last two stratum of elevators are almost equal whereas in Figure XV costs are lower in the larger strata indicating that the costs of depreciation and interest on investment are relatively high in the 80,001-100,000 group relative to the last strata.

Figures XVI and XVIII show the various costs of handling and storing grain for the separate strata as the handling increases up to 300,000 bushels. Actually the first two strata extend only up to

220,000 bushel and 250,000 bushel handlings because these are the maximum handling of these strata respectively. The range of handlings for all strata are shown in Appendix F. By examining Figure XVI, it can be seen that up to handlings of around 220,000 bushels the elevators in the smallest strata achieve the lowest average cost. Between handlings of 220,000 to 280,000 bushels, the strata 60,001-80,000 bushel capacity achieves the least cost of handling and storing grain. By tracing these least cost regions of handlings, it is possible to obtain an estimate of the planning curve for the grain elevator industry. A similar procedure could be followed for Figure XVIII. This would yield an estimate of the planning curve without regard to the costs of depreciation and interest on investment in the industry.

There are limitations to this analysis which are important and should be cited. The most important limitation in deriving an estimate of the planning curve in this fashion is the implicit assumption that the cost structure that prevailed for the three year period under study will continue. In estimating the planning curve for the industry it would appear that the strata containing elevators of capacity less than 40,000 bushel capacity attain least cost for handlings up to 220,000 bushesl. Since the average elevator in this group has a capacity of approximately 30,000 bushels[2], it means that these elevators must maintain a handling to capacity ratio of approximately seven per year in order to maintain their cost advantage. At such a high turnover it does not seem likely that the cost structure will remain the same. Repairs would more than likely

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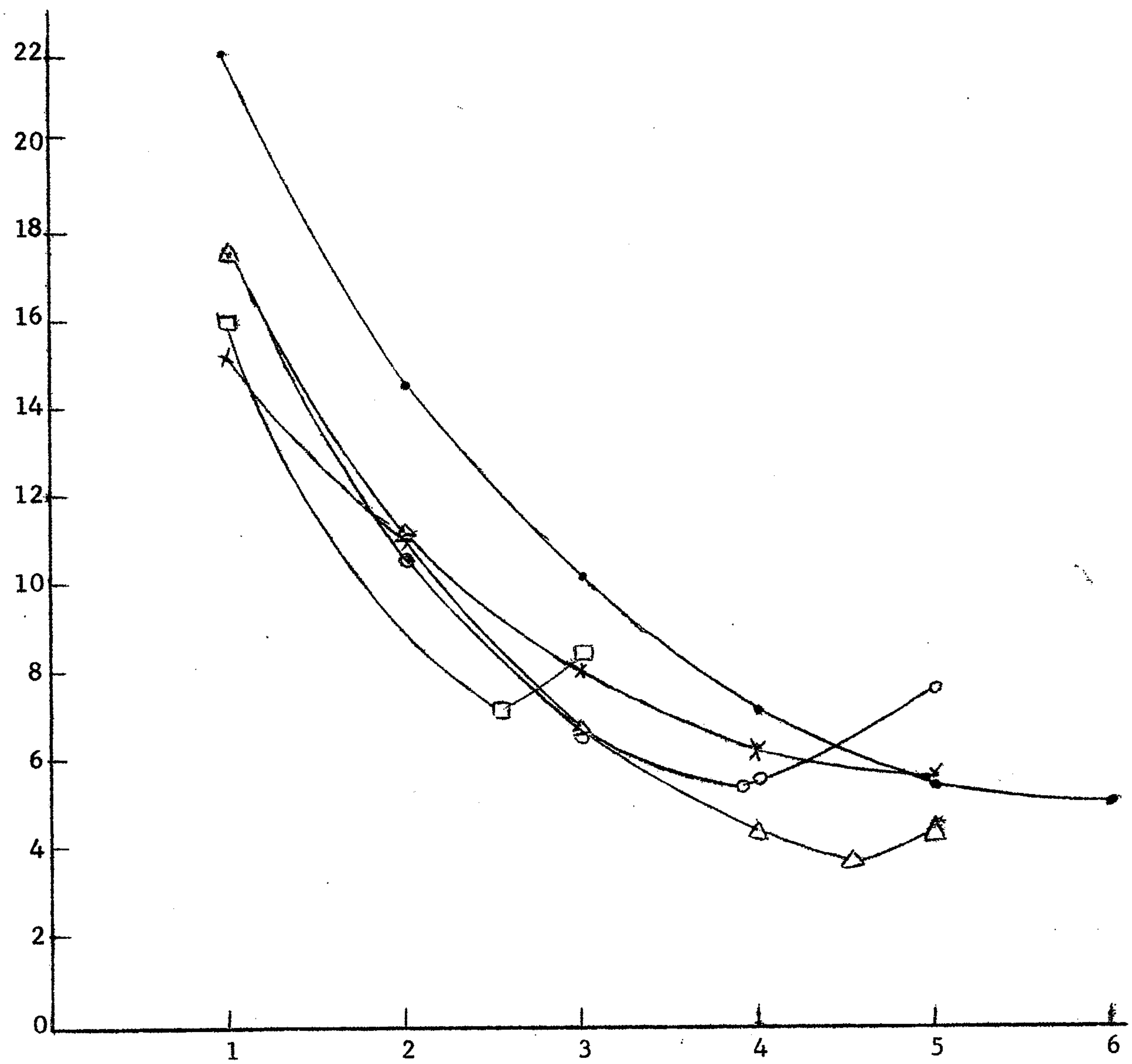
[2]See Appendix G.

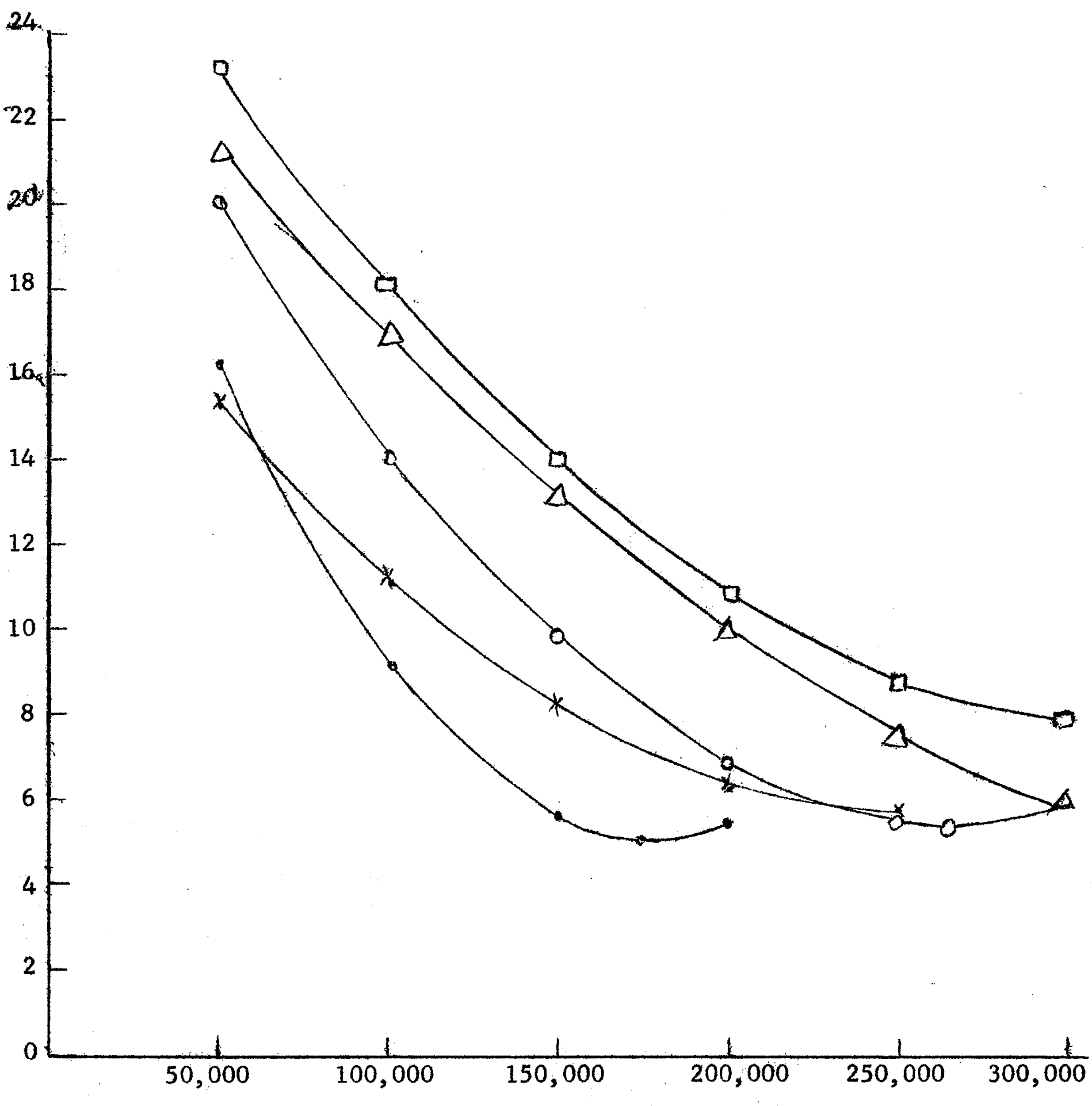
Figure XV - Average Cost (AC_2) of Grain Elevators of Various Capacities As Affected By A Varying Handling To Capacity Ratio



Legend: (Capacity in bushels)

- •—• <40,001
- x—x 40,001-60,000
- o—o 60,001-80,000
- △—△ 80,001-100,000
- □—□ >100,000

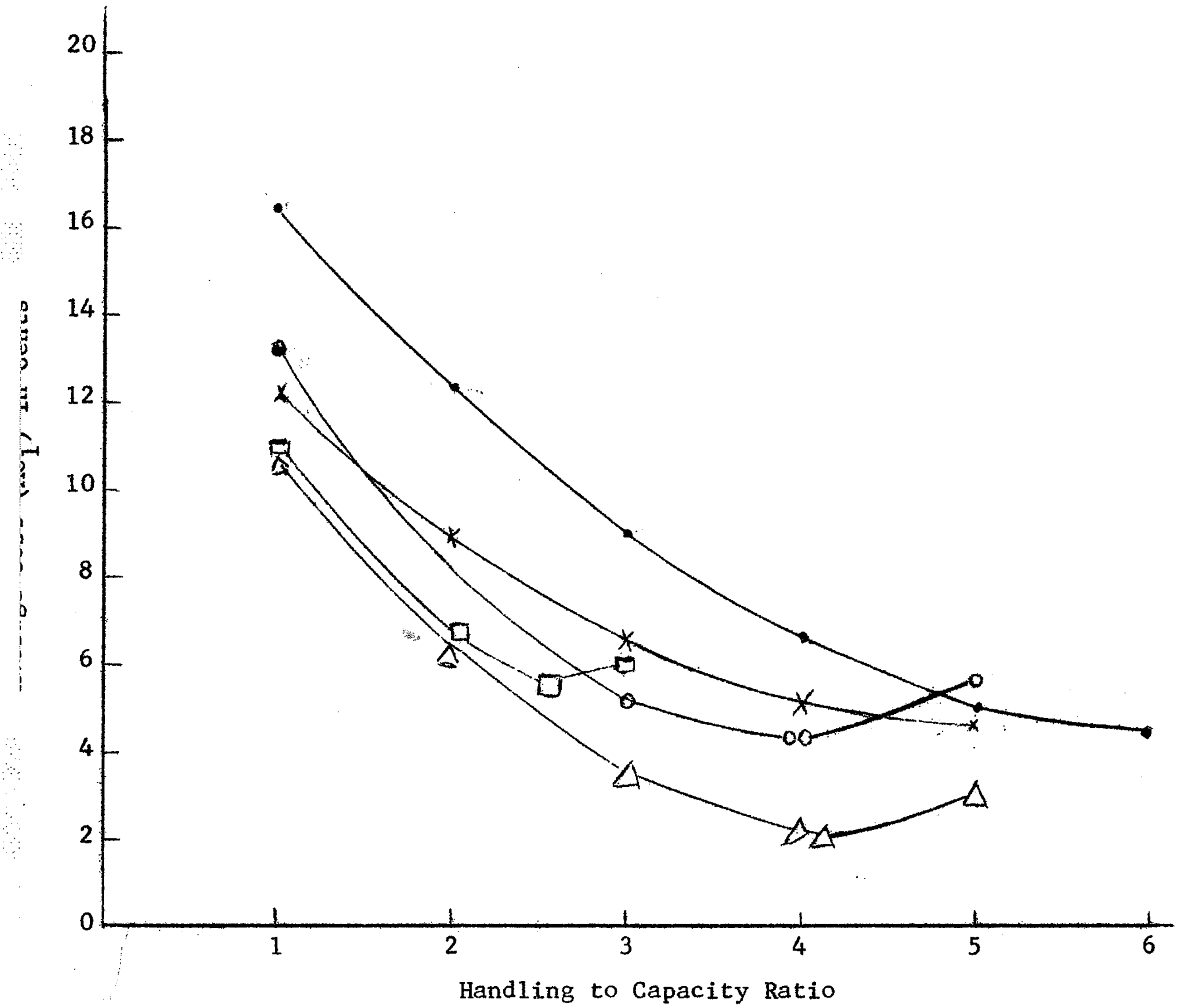
Figure XVI - Average Cost (AC_2) of Grain Elevators of Various Capacities As Affected By Levels of Handling



Legend: (Capacity in Bushels)

- <40,001
- 40,001-60,000
- 60,001-80,000
- 80,001-100,000
- >100.000

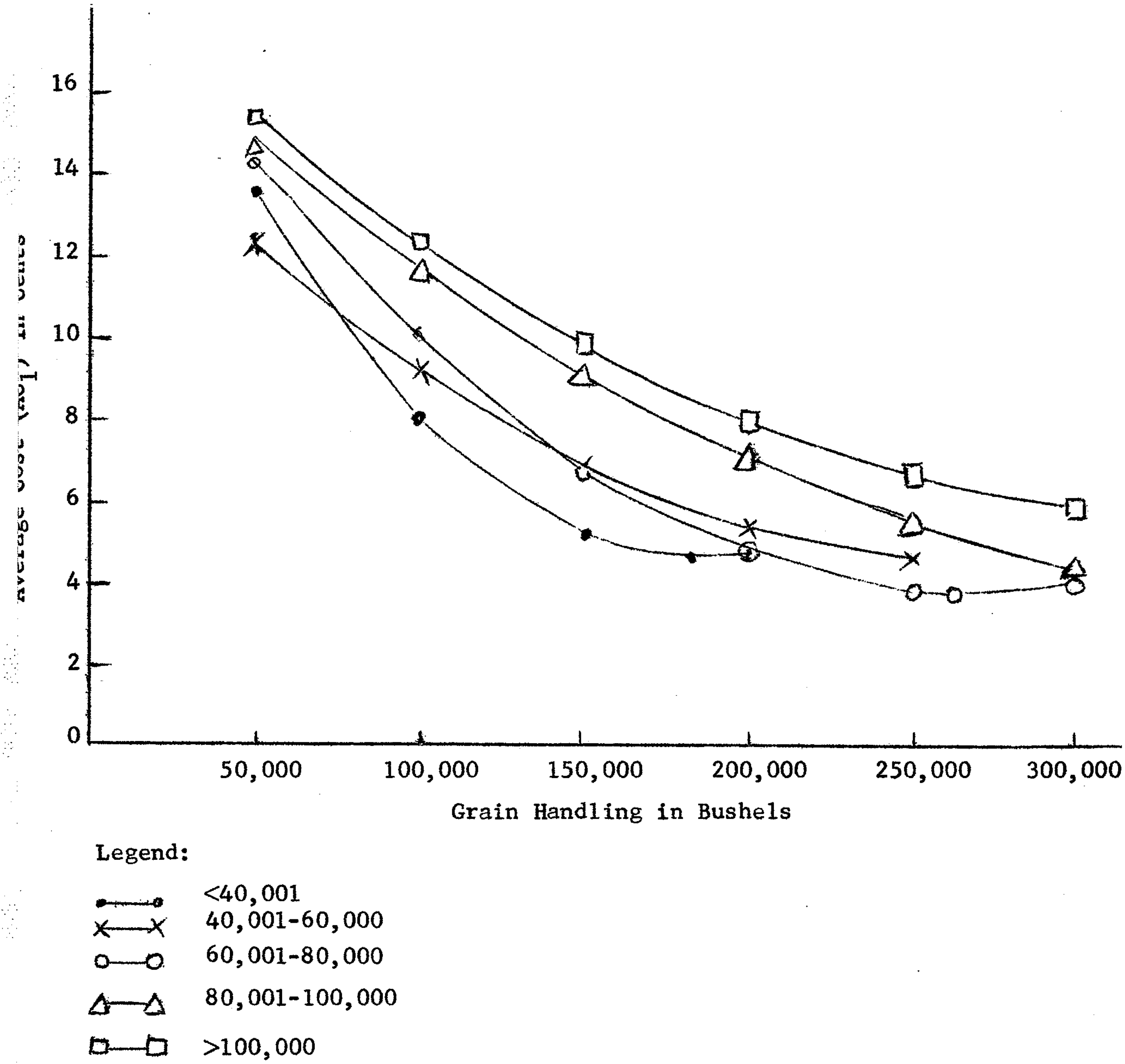
Figure XVII - Average Cost (AC_1) of Grain Elevators of Various Capacities As Affected By A Varying Handling To Capacity Ratio



Legend: (Capacity in Bushels)

- <40,001
- 40,001-60,000
- 60,001-80,000
- 80,001-100,000
- >100,000

Figure XVIII - Average Cost (AC_1) of Grain Elevators of Various Capacities As Affected By Levels of Handling

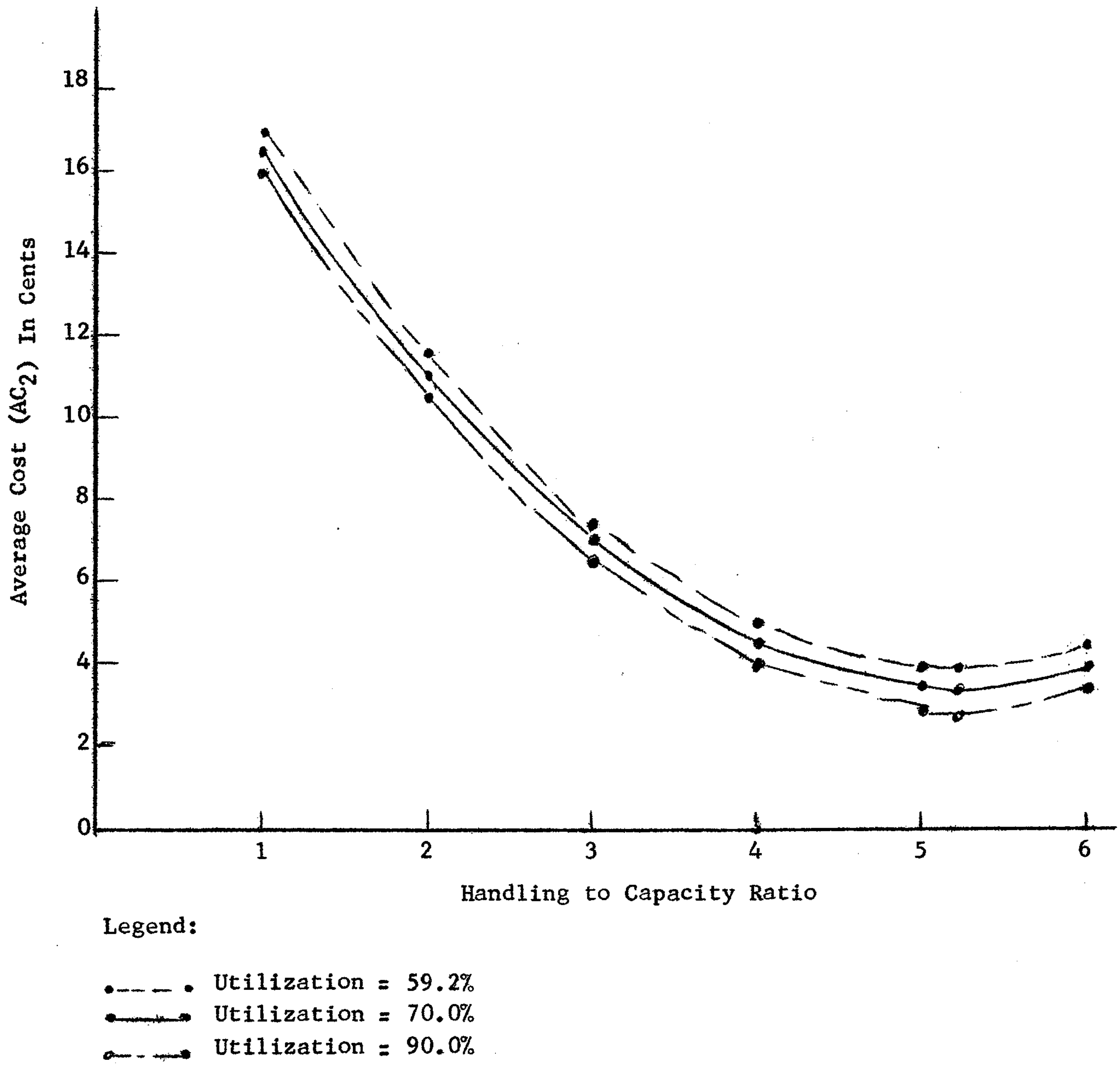


increase substantially over the life of the elevator. This problem cannot be handled in a study such as this because in using accounting data it is often the case that repairs for a particular year do not correspond to the output for that year, but are really the result of previous years outputs. Therefore in planning for an elevator that would have to handle approximately 200,000 bushels per year it is likely that a larger elevator would be more economical in the long run. Another reason for this lies in the manner of depreciation calculation. It is possible that a grain elevator that maintained a handling to capacity ratio of around seven should be depreciated much more quickly than those which operated with a ratio of three or four. Depreciating this group of elevators over a shorter period than the thirty-three years used in this study would raise the average cost curve of this strata. Their cost advantage would then probably extend over a smaller range.

Figure XIX, page 84, shows the effect of per cent utilization of the plant upon the average cost of handling and storing grain for various levels of the handling to capacity ratio. The curves have been drawn using equation 12 . The value of the independent variable X_2, was taken as the mean value for all observations from Appendix C. The calculations were not made for levels of utilization beyond ninety per cent. Utilization of the facilities of grain elevators beyond that level is unlikely because:

1. Grain elevators must keep a certain amount of space available for rotating grain stocks.

Figure XIX - The Effect On Cost of Different Degrees of Utilization For Given Handling To Capacity Ratios



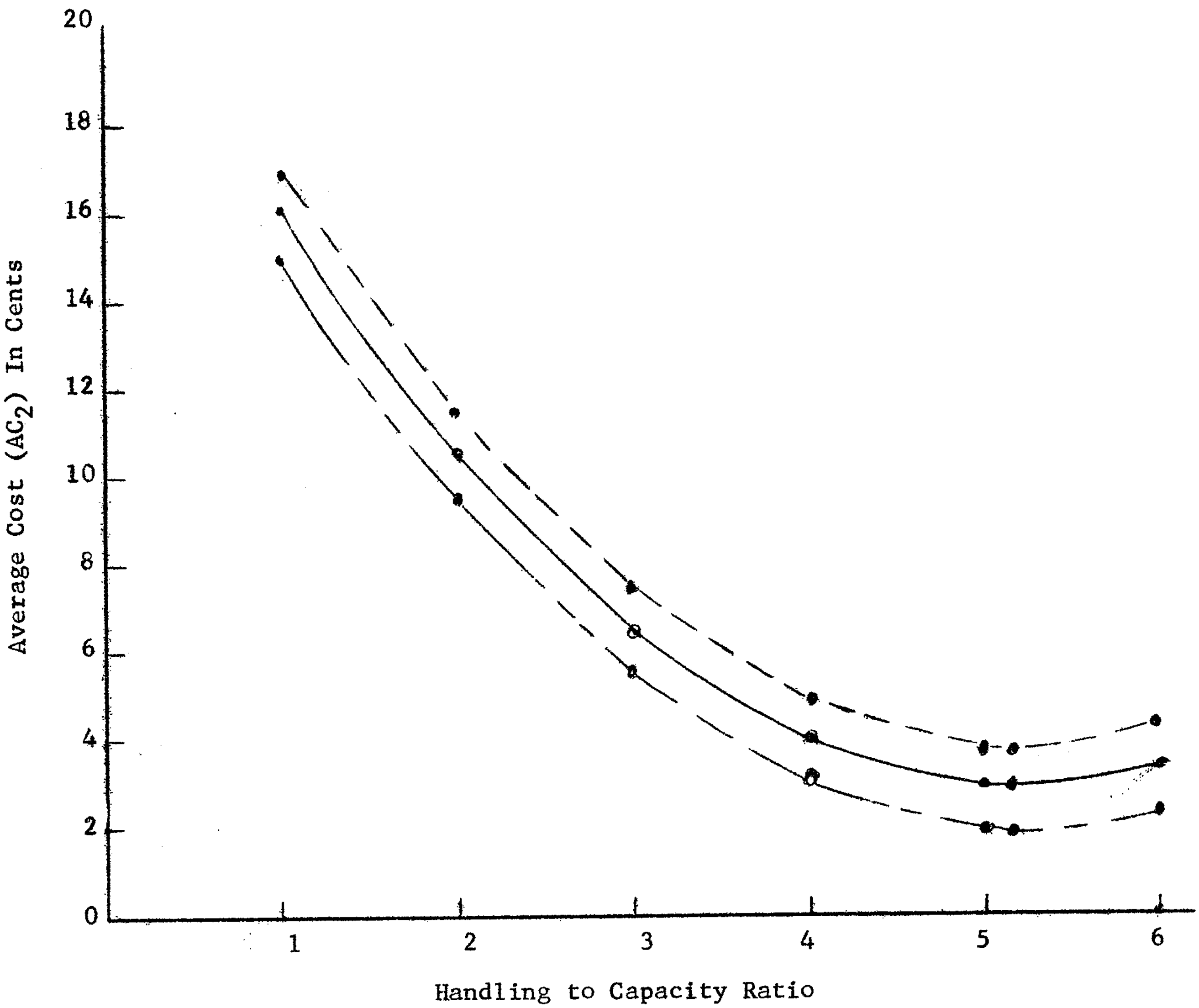
2. Receipts and shipments of grain are not simultaneous and therefore some empty space is inevitable.
3. Bins holding odd grains are unlikely to be completely filled.

Since the model selected was linear with respect to per cent utilization of the elevator, the traces for various utilization values are parallel to each other. As the degree of utilization was increased from 0.592 to 0.700 the average cost of handling and storing grain decreased by $0.0030. As the degree of utilization is increased from 0.700 to 0.900 the average cost of handling and storing decreased by $0.0057. These figures represent only the average position of the industry, and do not apply to any particular strata. Calculations for each strata can be made with the use of equations 1 - 10.

Figure XX, page 87, shows the effect of changing the annex to capacity ratio upon average cost for various handling to capacity ratios. Equation 12 was used to estimate the average cost at different levels of the annex to capacity ratio and handling to capacity ratio. The value of the independent variable X_3, was taken as the mean value for all observations from Appendix C. As the annex to capacity ratio is increased the average cost of handling and storing grain decreases for any given level of the handling to capacity ratio. Since the relationship between average cost and the annex to capacity ratio is linear the curves are parallel to each other as was the case in Figure XIX. As the annex to capacity was raised from 0.400 to 0.600 the average cost decreased by $0.0101. As the ratio was raised from 0.600 to 0.800 the average cost decreased by $0.0101. These values apply for all handling to capacity ratios. Appendices H and J show the numerical values for Figures XIX and XX respectively.

By examining the trace of the 0.400 annex to capacity ratio in Figure XX we find that for the industry as a whole the optimum handling to capacity is 5.18 with an average cost of handling and storing of 3.63 cents per bushel. The important point here is the showing of the cost economies available, when compared to the current industry mean of 9.54 cents per bushel with a ratio of 2.423, to the industry with an increased handling to capacity ratio.

Figure XX - The Effect On Cost of Different Annex To Capacity Ratios For Given Handling To Capacity Ratios



Legend:

Annex to Capacity Ratio = 0.400

Annex to Capacity Ratio = 0.600

Annex to Capacity Ratio = 0.800

CHAPTER VI

CONCLUSION

(A) SUMMARY

As shown in Appendix C, the study has revealed that the average total cost (AC_2) of handling and storing grain in Manitoba country grain elevators for the period under study was 9.54 cents per bushel per year. It also shows that the most important single factor which affects the average cost of handling and storing grain in Manitoba country grain elevators is the handling to capacity ratio. The larger the turnover of the elevator the less the average cost of handling and storing grain. It appears that the relationship of turnover to average cost is curvilinear rather than linear. This seems to be the case because in testing both models the curvilinear one yielded higher R^2 values for each strata and also because the coefficients of the independent variables were more highly significant in the curvilinear model. The study further has shown how costs are affected by the size of an elevator (Appendix D), the amount of grain handled (Appendix E), the degree of utilization of space (Appendix H), and the annex to capacity ratio (Appendix J), for the three year period under observation.

The effect of the independent variables, annex to capacity ratio and per cent utilization upon the average cost of handling and storing grain is difficult to generalize when examining individual strata. This is because the coefficients of the variables range from highly significant (one per cent level) to not significant at even the fifty per cent level. However in all cases average cost was inversely proportional to both the annex to capacity ratio and per cent utilization. This means that as the values of either or both variables increase the average cost of handling and storing grain decreases. When the 140 observations were run together (equation 12), the coefficients of these variables were all highly significant. As stated in the previous chapter, this is probably due to the increase in the degrees of freedom. The average situation for the entire industry is that as the per cent utilization is increased by ten per cent the average cost of handling and storing grain decreases by approximately three-tenths of a cent. Estimates for the effect of the per cent utilization on the average cost are shown in Figure XIX. The curves in Figure XIX were all estimated from equation 12 .

By applying equation 12 it can also be established that by increasing the annex to capacity ratio by ten per cent, the average cost of handling and storing decreases by approximately one-half cent. How large the annex to capacity ratio can get before handling difficulties reduce the technical efficiency of a grain elevator is a problem requiring separate study. This ratio, as shown in Appendix C reaches a mean of 0.621 in the largest strata. In the data collected the highest ratio observed was 0.861. This was in an elevator of 114,000 bushels capacity which means that 98,000 bushels of the total is annex space. Traces of various annex to capacity ratios are shown in Figure XX.

From Figures XVI and XVIII it is difficult to estimate a planning curve for the grain elevator industry. This is because observations of handlings above 300,000 bushels were very few for the large sized elevators. Although one elevator had grain handlings over 500,000 bushels, there was a lack of data between 300,000 and 500,000 bushel handlings. Since there could not be any intra stratum comparisons made at such large handlings, cost estimates were extended only up to a handling of 300,000 bushels. By examining Figures XVI and XVIII it would appear that economies of scale exist in the grain elevator industry since the average cost curves for the larger stratum are still falling up to handlings of 300,000 bushels.

Figures XV and XVII and Appendix D show how the average cost of handling and storing is affected by the handling to capacity ratio. For the reason explained in Chapter V, if one wishes to examine the operating economies available, Figure XVII is the more appropriate. Figure XVII indicates that if all grain elevators in the province were to attain the same turnover ratio then the second last stratum (80,001-100,000 bushel capacity) is the most efficient with respect to cost. In examining Figures XV and XVII, one must be careful to keep in mind that when the handling to capacity ratios are held constant for each strata, the handling between strata varies. Alternatively, in Figures XVI and XVIII when the handling is kept constant the handling to capacity ratio between strata varies.

In examining the cost structure of the grain elevator industry as it existed for the three year period 1961/62, 1962/63 and 1963/64

(Figure XVI), the most efficient groups of grain elevators for various handlings are the first, third and fourth stratum. It is unfortunate that more observations of elevators with handlings of 400,000 and 500,000 bushels did not appear in the random sample selected. Since the average cost curves for the two largest stratum are falling[1] at handlings of 300,000 bushels, one can speculate that they would quite likely continue to fall beyond this level of handling.

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[1] Examine Figures XVI and XVIII

(B) POLICY IMPLICATIONS

Appendix C while showing the average cost at which the industry has operated for the period under study reveals a further point of interest. The mean handling to capacity ratio consistently falls between strata from the smallest to the largest size whereas the mean utilization consistently rises from the smallest to the largest size. Both phenomena are partly due to the fact that grain elevators while being positioned at relatively close distances to each other therefore limit the total handling available at each site. The decision of the individual companies to build at the various points also limits the handling available to each of the elevators at a particular site. If the larger elevators were able to maintain the same handling to capacity ratios as the smaller ones, savings in these charges are very likely.

The average cost estimates shown in Figures XV through XVIII suggest that as grain elevators increase their handling to capacity ratio they decrease their average cost of handling and storing. By examining the cost levels that are attainable in Figure XVI and the average cost levels that are realized in each strata as shown in Appendix E[2], it would appear that grain elevators in all strata are not worked to their fullest potential. That is, the level of handlings at which they operated on the average for the three year period did not permit them to attain the least cost of handling and storing grain. Variation in yearly handlings, which is the result of variation in total grain production for Manitoba, is one reason

[2]Compare Figure XVI with column AC_2 of Appendix E and Figure XVIII with column AC_1 of Appendix E.

why elevators cannot always be operated at least cost. Another possible reason is that there is overcapacity in the grain elevator industry. That is, there are too many grain elevators in Manitoba so that the handling available for each is not adequate to allow them to achieve the available economies. This seems to be especially true in the largest group of elevators where the average handling to capacity ratio was only slightly greater than one and a half.[3] In this respect abandonment will allow adjacent grain elevators to increase their handlings and thereby decrease their average cost of handling and storing. This is true for the industry on the average. However, rail line abandonment, as it has been proposed, may not lead to the most efficient over all system since it has not been proposed on the basis of allowing elevators to attain handlings which would tend to minimize the average cost of handling and storing grain. The proposed rail line abandonment is based on the contention that some branch lines are uneconomic to operate because of the low density of traffic on them. The two problems are related, but the solution of one will not necessarily and simultaneously offer a solution for the other. If rail line abandonment is carried out to the extent that has been proposed for Western Canada, a serious look should be taken at the cost economies available for increased handlings before taking any policy action toward the reconstruction of lost capacity.

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[3]See Appendix C.

(C) LIMITATIONS OF THE STUDY AND RECOMMENDATIONS FOR FURTHER STUDY

This study has given an estimate of the planning curve of the industry. It is estimated by examining the least cost of grain elevator required for various grain handlings as shown in Figure XVI, page 80 . However, the study was not able to examine whether the cost structure would change significantly if handling to capacity ratios as large as five or six were reached year after year. Although this is an important problem, the probability of its solution in the near future is extremely low because cost and handling records are not available for more than three to five years back and also because historically no grain elevators have continuously maintained such high handling to capacity ratios.

The study has examined only the cost of operating grain elevators. It has not looked at the service provided by the various sized elevators. Figure XVI on page 80 shows that in order to handle 200,000 bushels in a year, an elevator in the smallest strata attains (through a large handling to capacity ratio) the least cost of handling and storing. However this raises the question whether such a large handling to capacity ratio creates any delivery problems for farmers hoping to deliver grain to that elevator. At harvest time when the farmers' time is valuable, is there a significant difference in the time required to service a farmer in various sized elevators? A small saving realized through a high handling to capacity ratio may well be offset by other services that larger elevators may offer. It is suggested that a case study of a small number of grain elevators of various sizes could detect some advantages or disadvantages of the different elevators which a study based on accounting data cannot examine.

The study suggests that economies of scale exist in the elevator industry. It also suggests that increased turnover would probably yield economies that have not yet been achieved by many of the large sized elevators. However, an increase in the size of grain elevators as well as an increase in the handling to capacity ratio of these elevators must result in fewer facilities available to producers. Any policy that would result in larger but fewer elevators must examine carefully the added cost to the producer of transporting his grain to the available facilities. Since the producer pays the cost of getting the grain to the elevator plus the service charges at the elevator, it would be to his advantage to have a marketing system that would simultaneously minimize the total marketing bill, It is suggested, therefore, that a study which would determine the size and location of grain elevators and would at the same time minimize the sum of the costs of handling, storing and delivery be undertaken in order to give an overall plan for the grain industry in Manitoba or Western Canada.

APPENDIX A

SAMPLE SIZES NECESSARY FOR VARIOUS VALUES OF "t" AND "d".

THESE FIGURES REPRESENT THE COST CATEGORY SALARIES

FOR THE SIZE STRATA <40,001 BUSHELS

t / d	0.95	0.90	0.80	0.70
0.05	37	26	16	11
0.10	10	7	4	3
0.15	5	3	2	2
0.20	3	2	1	1

where: $\bar{X} = 3347$

$S^2 = 259,724$

APPENDIX B

COST BREAKDOWNS BY STRATUM FOR YEARS 1962-64

Cost Item	Stratum in bushels	Mean in dollars	Range in dollars	Variance in dollars
Salaries	<40,001	3,347	1,839-4,293	259,724
	40,001-60,000	3,764	3,125-4,960	147,040
	60,001-80,000	3,933	3,393-4,589	187,674
	80,001-100,000	4,268	3,380-6,008	381,413
	>100,000	4,382	3,427-7,050	458,951
Power, Light and Fuel	<40,001	200	35- 334	7,010
	40,001-60,000	297	14- 610	20,844
	60,001-80,000	462	263- 954	40,053
	80,001-100,000	469	276- 657	12,439
	>100,000	547	294-1,241	32,290
Repairs	<40,001	251	62- 502	75,135
	40,001-60,000	323	5- 826	34,655
	60,001-80,000	312	45- 524	24,056
	80,001-100,000	380	211- 604	50,516
	>100,000	438	45-1,168	81,342
Bonds and Insurance	<40,001	164	11- 368	9,582
	40,001-60,000	219	52- 431	7,790
	60,001-80,000	268	115- 390	7,816
	80,001-100,000	310	211- 500	7,037
	>100,000	378	136- 760	24,975
Share of general Head Office Expense	<40,001	2,502	1,061-6,097	1,408,966
	40,001-60,000	3,553	1,895-5,635	1,112,084
	60,001-80,000	3,838	1,756-7,127	9,541,473
	80,001-100,000	5,282	1,717-8,992	2,897,559
	>100,000	5,366	1,501-9,322	3,071,773

APPENDIX B (cont'd.)

COST BREAKDOWNS BY STRATUM FOR

YEARS 1962-64

Cost Item	Stratum in bushels	Mean in dollars	Range in dollars	Variance in dollars
Agents Expenses	<40,001	215	37- 481	11,363
	40,001-60,000	229	29- 500	8,848
	60,001-80,000	235	170- 396	3,912
	80,001-100,000	302	134- 552	20,121
	>100,000	306	72- 545	24,842
Miscellaneous	<40,001	205	35- 857	38,212
	40,001-60,000	265	6-1,513	64,526
	60,001-80,000	372	90- 901	130,446
	80,001-100,000	751	34-1,597	183,503
	>100,000	537	183-1,620	193,339
Depreciation	<40,001	986	627-1,597	237,783
	40,001-60,000	1,723	961-2,355	127,585
	60,001-80,000	2,253	1,376-2,554	184,136
	80,001-100,000	2,723	2,493-2,922	19,120
	>100,000	3,118	2,669-3,839	118,295
Interest on Investment	<40,001	283	0-2,122	402,263
	40,001-60,000	377	0-2,384	382,577
	60,001-80,000	1,099	473-2,336	300,402
	80,001-100,000	1,327	54-3,139	746,586
	>100,000	2,013	79-3,557	1,946,609
Municipal Tax	<40,001	524	324- 965	37,714
	40,001-60,000	648	386-1,581	72,796
	60,001-80,000	1,118	903-1,535	50,145
	80,001-100,000	1,143	617-1,766	115,609
	>100,000	1,900	761-6,842	1,822,608

APPENDIX C

THE AVERAGE GRAIN ELEVATOR IN EACH STRATUM FOR THE FISCAL YEARS 1962-64

Stratum in bushels	Mean Handling to Capacity Ratio (X_1)	Mean Annex to Capacity Ratio (X_2)	Mean Utilization (X_3)	AC_2 Calculated from Model in Dollars	AC_1 Calculated from Model in Dollars
<40,001	3.204	0.056	0.485	0.0950 (0.0360)	0.0833 (0.0266)
40,001-60,000	2.638	0.341	0.572	0.0888 (0.0114)	0.0857 (0.0081)
60,001-80,000	2.510	0.474	0.580	0.0816 (0.0164)	0.0633 (0.0118)
80,001-100,000	2.161	0.555	0.593	0.0967 (0.0220)	0.0579 (0.0158)
>100,000	1.550	0.621	0.708	0.1053 (0.0148)	0.0782 (0.0100)
Mean for all observations	2.423	0.400	0.592	0.0954 (0.0239)	0.0762 (0.0181)

APPENDIX D

COST ESTIMATES IN DOLLARS FOR FIGURES XV AND XVII

Stratum in bushels	Handling to Capacity Ratios											
	1		2		3		4		5		6	
	AC_1	AC_2	AC_1	AC_2	AC_1	AC_2	AC_1	AC_2	AC_1	AC_2	AC_1	AC_2
<40,001	.1649	.2015	.1222	.1448	.0889	.1013	.0650	.0710	.0505	.0539	.0454	.0500
40,001-60,000	.1223	.1524	.0894	.1096	.0655	.0794	.0506	.0618	.0447	.0568	-	-
60,001-80,000	.1322	.1760	.0811	.1058	.0516	.0658	.0437	.0560	.0574	.0764	-	-
80,001-100,000	.1072	.1699	.0635	.1048	.0352	.0613	.0223	.0394	.0298	.0391	-	-
>100,000	.1079	.1522	.0629	.0818	.0573	.0778	-	-	-	-	-	-

APPENDIX E

COST ESTIMATES IN DOLLARS FOR FIGURES XVI AND XVIII

Stratum in bushels	Handlings (in bushels)											
	50,000		100,000		150,000		200,000		250,000		300,000	
	AC_1	AC_2	AC_1	AC_2	AC_1	AC_2	AC_1	AC_2	AC_1	AC_2	AC_1	AC_2
<40,001	.1357	.1625	.0802	.0901	.0507	.0541	.0471	.0544	-	-	-	-
40,001-60,000	.1239	.1546	.0918	.1127	.0680	.0825	.0525	.0639	.0452	.0568	-	-
60,001-80,000	.1427	.2008	.0993	.1407	.0672	.0968	.0464	.0687	.0368	.0562	.0385	.0595
80,001-100,000	.1323	.2069	.1155	.1634	.0907	.1264	.0703	.0956	.0544	.0714	.0432	.0535
>100,000	.1534	.2257	.1211	.1733	.0950	.1316	.0755	.1010	.0624	.0810	.0558	.0720

APPENDIX F

RANGE IN HANDLING IN BUSHELS IN EACH STRATA

Stratum (in bushels)	Largest Handle	Smallest Handle
<40,001	223,563	25,049
40,001-60,000	255,038	54,363
60,001-80,000	320,194	43,738
80,001-100,000	524,193	45,646
>100,001	305,410	53,977

APPENDIX G

AVERAGE SIZE OF GRAIN ELEVATOR IN EACH STRATA

Stratum (in bushels)	Capacity (in bushels)
<40,001	30,100
40,001-60,000	52,200
60,001-80,000	69,100
80,001-100,000	92,000
>100,000	123,700

APPENDIX H

THE EFFECT ON COSTS OF DIFFERENT DEGREES OF UTILIZATION FOR GIVEN HANDLING TO CAPACITY RATIOS

Degrees of Utilization	Handling to Capacity Ratio					
	1	2	3	4	5	6
0.592	.1695	.1143	.0741	.0490	.0387	.0435
0.700	.1665	.1113	.0711	.0460	.0357	.0405
0.900	.1608	.1056	.0654	.0403	.0300	.0348

APPENDIX J

THE EFFECT ON COSTS OF DIFFERENT ANNEX TO CAPACITY RATIOS FOR GIVEN HANDLING TO CAPACITY RATIOS

Annex to Capacity Ratio	Handling to Capacity Ratio					
	1	2	3	4	5	6
.400	.1695	.1143	.0741	.0490	.0387	.0435
.600	.1594	.1042	.0640	.0389	.0286	.0334
.800	.1493	.0941	.0539	.0288	.0185	.0233

APPENDIX K

HIGH AND LOW AVERAGE TOTAL COSTS (AC_2) ATTAINED BY GRAIN ELEVATORS IN EACH STRATA AND THE CORRESPONDING HANDLING TO CAPACITY RATIO

Stratum (in bushels)	High ATC in dollars	H/C	Low ATC in dollars	H/C
<40,000	0.3189	0.812	0.0489	6.388
40,001-60,000	0.1725	1.536	0.0486	4.723
60,001-80,000	0.2446	0.636	0.0559	4.438
80,001-100,000	0.2840	0.496	0.0440	4.543
>100,000	0.2628	0.376	0.0643	2.825

APPENDIX L

ANALYSIS OF VARIANCE OF THE REGRESSION OF AVERAGE TOTAL COST ON X_1, X_1^2, X_2 AND X_3 IN TERMS OF OVERALL REGRESSION AND INDIVIDUAL REGRESSION BY SIZE STRATIFICATION

Source	Degrees of Freedom	Sums of Squares	Mean Sum Squares
Total	140	.29324	
Reduction to Overall Regression	4	.21687	
Residual	136	.07637	
Reduction Due to Separate Regressions	20	.23866	
Residual For Separate Regressions	120	.05458	.000454
Added Reduction Due to Separate Regressions	16	.02179	.001362

$F_{16,120} = \frac{.001362}{.000454} = 3.00$ Significant at .005

Therefore the stratification by size groups has a significant effect upon variance reduction

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